STRUCTURAL VULNERABILITY OF ANCIENT DRY MASONRY TOWERS UNDER LATERAL LOADING

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ABSTRACT

STRUCTURAL VULNERABILITY OF ANCIENT DRY MASONRY TOWERS UNDER LATERAL LOADING

In the Antiquity, masters constructed dry masonry towers that were resistant to earthquake potential of their sites. Determination of the authentic characteristics, that play role on structural behavior, developed in antiquity should be the first step of conservation planning. This study aims to identify the structural behavior of dry masonry towers under lateral loading in relation with their characteristics so that decision making phase regarding their restoration projects can be supported. Dry masonry towers in ancient Caria, Pamphylia and Cilicia, which have different ground accelerations, are examined.

Methodology of the study consists of documentation of six case studies with traditional methods, design of hypothetical towers, impact analysis of towers with quasi-static tilt technique, examination of results in terms of collapse angle and failure mechanisms, discussion with the help of the statistical approach, and proposal of a framework for vulnerability rankings and possible failure mechanisms.

As a result, parameters effecting structural resistance in the order of high impact to low are staggering ratio, stone depth, ratio between block length and height, proportional relationship between height and length, opening area, number and position and even distribution of header stones. These parameters have impact on each other; so, sustaining of the qualities regarding all of them should be undertaken in their conservation. Furthermore, it is seen that there was awareness of the necessity for usage of different anti-seismic parameters in different earthquake regions. However, appropriate combination of parameters with each other were not always undertaken possibly because of limitations of local materials, budget, time or masters.

ÖZET

ANTİK KURU YIĞMA KULELERİN YANAL YÜK ALTINDA YAPISAL HASAR GÖREBİLİRLİĞİ

Antikçağ'da, ustalar bulundukları yörenin deprem riskini dikkate alarak dayanıklı kuru yığma kuleler inşa etmeye çalışmışlardır. Yapı davranışında rol oynayan, antik dönemde geliştirilmiş özgün özelliklerin belirlenmesi koruma çalışmalarının planlanmasında ilk adım olmalıdır. Bu çalışma, yapı özellikleri bağlamında kuru yığma kulelerin yanal yük altında yapı davranışını özümseyerek, restorasyon projeleri ile ilgili karar alma aşamalarını desteklemeyi amaçlamaktadır. Bu nedenle, farklı zemin ivmelerine sahip antik Karya, Pamfilya ve Kilikya bölgelerinde bulunan kuru yığma kuleler incelenmiştir.

Çalışmanın yöntemi, geleneksel yöntemlerle kulelerin belgelenmesi, hipotetik kulelerin tasarlanması, *quasi*-statik eğme yöntemi ile kulelerin etki analizinin yapılması, analiz sonuçlarının yıkılma açıları ve hasar mekanizmaları açısından incelenmesi, istatiksel yaklaşım ile tartışma ve kulelerin olası hasar görebilirlik derecelerinin ve hasar mekanizmalarının belirlenebilmesi için taslak önerisinden oluşmaktadır.

Sonuç olarak, yapısal dayanımı etkileyen parametreler; basamaklanma katsayısı, taş derinliği, taş blokların uzunluk ve yüksekliği arasındaki oransal ilişki, yapının yükseklik ve uzunluğu arasındaki oransal ilişki, boşluk alanı, sayısı ve konumu ve atkı taşlarının dağılımı olarak etkinliklerine göre sıralanmaktadır. Ancak, parametreler birbirlerini etkilemektedir, bu yüzden koruma çalışmalarında yapı özelliklerine ilişkin tüm niteliklerin sürdürülmesine dikkat edilmelidir. Ayrıca, çalışma sonucunda farklı deprem bölgelerinde farklı sismik parametrelerin kullanılmasının gerekliliği konusunda farkındalık olduğu görülmüştür. Fakat, yerel malzemelerin, bütçenin, zamanın ya da ustaların sınırlamaları nedeniyle, parametrelerin her zaman birbirleriyle uygun şekilde ilişkilendirilemediği tespit edilmiştir.

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LIST OF ABBREVATIONS

Op.	Opening
Sym.	Symmetrical
Ass.	Asymmetrical
Adj.	Adjacent to corner
Wall p. or W.	Wall profile
Out or o	Opening at out-of-plane position
In or i.	Opening at in-plane position
Col. Angle	Collapse angle
Stag. Ratio	Staggering ratio
s/h	Staggering ratio
bl/bh	Ratio between block length and height
h/l	Ratio between height and length
t/h	Ratio between thickness and height
t/l	Ratio between thickness and length
Vul.	Vulnerability
VS	Vertical splitting
DT	Detachment
2T	Total overturning
Mec.	Mechanism
XRD	X-ray Diffraction
SEM	Scanning Electron Microscope/Microscopy

CHAPTER 1

INTRODUCTION

It is known that ancient dry masonry structures were constructed considering techniques and precautions that were formulated by experiments, and that were to minimize the effect of earthquake (Krikov 1992; Yavuz 2001; Stiros 1995). The determination of these precautions is important for the conservation of integrity of dry masonry buildings. In order to decipher design principles of dry masonry towers against lateral loading; structural and morphological characteristics, material usage and environmental conditions of buildings should be searched.

1.1. Ancient dry masonry towers

The geography in which the above-mentioned dry masonry towers are documented so far is western and southern coasts of Turkey and also coasts of Greece (McNicoll 1997, Morris and, Papadopoulos 2005). In 2000 BC, sea colonies from Greece and Balkan Peninsula had moved to Asia. This migration had caused confusion in Asia Minor and Greece. The period between the migration and the establishment of new cities is known as the Dark Age (1200-800 BC). Greeks spread along the coastal areas in Western, Eastern and Northern Anatolia (Figure 1). Cities in western, southern and northern parts of Anatolia had been established in Archaic period. Ionians established 12 new cities; Miletos, Myus, Priene, Ephesos, Kolophon, Lebedos, Teos, Klazomenai, Phokaia, Chios, Erythrai and Samos. Aeolians established Kyme, Larisa, Neontheikos, Temnos, Killa, Notion, Aigiroessa, Pitane, Aigai, Myrina, Gryneion and Smyrna. Dorians established Halikarnassos, Cnidos, Lindos, Ialysos, Kameiros (in Rhodos) and Kos. There were already settlements in Anatolia, when Greeks came. Lydians conquered Phrygia in 7^{th} century BC. Then, Persians conquered Anatolia in the 6th century BC. Anatolia was under the control of Persians until the invasion of Alexander the Great who was a ruler in the northern part of the Greek peninsula. Alexander the Great had started his military expedition in 334 BC from Gallipolli Penninsula. He had first taken control of Sardes, and then, he moved to the south: Ephesus, Miletos, Tralleis, and then Caria. He followed

the southern coastline of Anatolia. To take control of Phyrygia, he went to Kelainai, Gordion and Ankyra (Akarca 1998, 6-15; Oransay 2012, 111-123).

Figure 1. Greek cities along the Mediterranean and Black Sea after 2000 BC (Source: Benowar 2012)

He crossed Gülek Stait which is known as the door of Cilicia. Then, he took control of Mersin and Tarsus. He continued his attacks to the Syria and Palestine. After his death (323 BC), Hellenistic Kingdoms were established in Anatolia. Both news cities were established, and previous ones were developed (Akarca 1998, 6-15; Oransay 2012, 111-123). Hellenistic kingdoms were Pergamon, Ptolemaios (Southwestern Anatolia), Seleukos (Eastern Anatolia), Galat (Ankyra, Tolistoboglar Pessinus, Trokmeler Tavium), Pontus (Eastern Black Sea), Cappadocia (northern part is independent) and Commagene (Southeastern Anatolia). Bithynia region became independent, since it was not taken by Alexander (Akarca 1998, 6-15; Oransay 2012, 111-123).

In this period known as the Hellenistic period, grid planned cities were surrounded by city walls reinforced with towers. Independent watchtowers in the environs were also provided. In the Roman era, however, these defense structures were only constructed in the zones under military risk (Kaya 2017, 34).

Today, the defense structures are mostly in ruins or altered. In Figure 2, the cities that have sustained their ancient dry masonry towers are illustrated with symbols (Table 1). Ancient dry masonry towers together city walls were constructed in Hellenistic periods (300-400 BC), while individual watch towers were constructed in early Roman Period (133 BC-65 BC) (McNicoll 1997, 8-11; Akarca 1998, 141-148). In Caria, Pamphylia, Lydia and Ionia regions, there are many towers documented together with city walls from the Hellenistic period, while individual towers from the early Roman period are observed in the Cilicia region and southeastern areas (McNicoll 1997, 8-11; Akarca 1998, 141-148).

The towers were built at strategic locations. The city walls passing through the flat terrains were divided by the towers with equal intervals. The city walls passing through the hills were supported by towers at strategic locations. At the borders between sea and land, towers were frequently built (McNicoll 1997, 8-11; Akarca 1998, 141-148). Towers could be square, rectangular, round or polygonal in plan. Rectangular and square towers are more widespread. The first towers were not higher than fortification walls: these were one-storied structures with slit windows. In the beginning of the 4th century, the characteristics of the towers started to change with the invention of the catapult. The height and number of storeys of the towers increased. To increase the shooting range, towers with 3 and 4 storeys were built (app. 13- 14 meters). Square and rectangular openings were used for catapult shots. Small sized square windows were used for lightweight catapults (80x80 cm). Large rectangular windows were used for heavy catapults. The windows had wooden covers. At the ground or first storeys, there were slit windows for watching the enemies and illumination (10-12 cm wide, 1.00 m high).

The tower floors were generally made of wood. The beams were usually placed in holes left in the interior surfaces of the walls of the tower body, or they were placed on the stones projected from the walls. Beam holes were placed at the side walls, rather than the walls facing the enemy. The heights of the upper storeys were less than the lower floors. The connection between the floors was provided by wooden interior ladders.

Figure 2. Distribution of ancient dry masonry towers in Turkey and eastern Greece

Table 1. Number of towers in ancient Hellenistic cities today

Place	Number of towers	Place	Number of towers
Halicarnassus	18 (McNicoll 1997)	Orthosia	1 (Çorbacıoğlu 2008)
Myndos	16 (McNicoll 1997)	Hasanlar	1 (Çorbacıoğlu 2008)
Alinda	19 (McNicoll 1997)	Harpaşa	1 (Çorbacıoğlu 2008)
Alabanda	30 (McNicoll 1997)	Tekekale	1 (Çorbacıoğlu 2008)
Tekekale	2 (McNicoll 1997)	Andros	1 (Moris and, Papadopoulos 2011)
Priene	26 (McNicoll 1997)	Sagalassos	3 (Waelkens and, Lools 2000)
Cnidus	38-40 (McNicoll 1997)	Thasos	33 (Moris and, Papadopoulos 2011)
Erythrae	4 (McNicoll 1997)	Siphons	56 (Moris and, Papadopoulos 2011)
Latmos	115 (McNicoll 1997)	Keos	Over 70 (Moris and, Papadopoulos 2011)
Ephesus	42 (McNicoll 1997)	Naxos	1 (Moris and, Papadopoulos 2011)
Oenoanda	2 (McNicoll 1997)	Chalkidie	1 (Moris and, Papadopoulos 2011)
Perge	39 (McNicoll 1997)	Assos	12 (McNicoll 1997)
Sillyum	4 (McNicoll 1997)	Caunus	6 (McNicoll 1997)
Side	8 (McNicoll 1997)	Elaiussa	11 (Durugönül 1998)
Ceramus	13 (McNicoll 1997)	Apameia	27 (Kaya 2017)
Miletus	9 (McNicoll 1997)	Diocaesareia	1 (McNicoll 1997)
Isium	2 (McNicoll 1997)	Attaulusu	1 (Çorbacıoğlu 2008)

Ground storeys could be filled with stone and soil. Unfilled ground floors were used as storage. There was a door entered from the citadel at the ground level of the towers for service necessity. The terrace roof was inclined slightly towards the two opposite sides in the Hellenistic periods (4th century BC) (McNicoll 1997, 8-11; Akarca 1998, 141-148).

In dry masonry towers, a particular style of masonry could be used due to different reasons. First, aesthetic ideals had an influence. Secondly, sturdiness of the wall against attack of the enemies was considered. Thirdly, cost was effective. Type of stone material available in the site and previous experiences of earthquake effected the wall style as well (McNicoll 1997, 8-11).

1.1.1. Earthquake threat for dry masonry towers

There are many factors threatening the integrity of buildings such as earthquake, landslide, settlement, weathering, vandalism, etc. However, heavy weather conditions may have minimal impact on the integrity of dry masonry towers since large sized and heavy stone blocks are stiffer and more stable against weather conditions, heavy weather conditions mostly cause erosion on stone faces. Similarly, landslide in the environs of the towers is not expected since they are constructed on bed rock. However, earthquake can cause loss of the integrity of the dry masonry towers, since they are vulnerable to lateral loading due to their intrinsic characteristics. Therefore, while discussing vulnerability of dry masonry towers, earthquake threat should be underlined.

The regions in which ancient dry masonry towers have been documented (Caria, Ionia, Lycia, Pamphylia and Cilicia) were overlapped with the map of earthquake hazard (AFAD 2018). This overlapping presents that Lydia, Ionia, Caria and Lycia Regions have the largest ground acceleration values, Pamphylia has medium ground acceleration, and Cilicia has the smallest ground acceleration value (AFAD 2018) (Figure 3).

1.1.1.1. Earthquakes in Caria Region

In 100 km proximity of surrounding area, 180- 190 earthquakes are recorded from 1900 until now. In surrounding of Latmos, between 4 and 5 in magnitude, there are 141 earthquakes. Between 5 and 6, there are 34 and between 6 and 7, 8 earthquakes. In the surrounding of Alinda, between 4 and 5 in magnitude, there are 146 earthquakes. Between 5 and 6, there are 36 earthquakes and between 6 and 7, 7 earthquakes. In ancient periods, there are not recorded earthquakes higher than 6 magnitudes in approximately 100 km proximity of area. Earthquakes higher than 7 magnitudes is approximately 600 km far from the area in the ancient period (BDTİM 2017).

*Increase in ground acceleration from yellow to red color

Figure 3. Ancient regions and earthquake hazard map (Source: AFAD 2018)

Table 2. Previous earthquakes at Caria Region (Source: BDTİM 2017)

YEAR	MAGNITUDE (Richter scale)	Center	YEAR	MAGNITUDE (Richter scale)	Center
304 BC	6-6.9	İzmir, Aydın	1941	6	Denizova
17 BC	6.6	Manisa, Aydın	1941	6	Muğla
26 BC	6.6	Aydın	1952	4.6	Güzeltepe
155 AD	7.3	Fethiye,Mugla,Rhodos	1954	5	Samos
177 AD	7.3	Sisam, Sakız, İzmir	1954	5.4	Bodrum Karabağ
1653	6.6	Aydın	1954	5	Samos
1751	7.3	Sisam	1954	5.5	Samos
1846	6.6	Sisam, Söke	1955	6.8	Atburgazı,Söke,Aydın
1851	6.6	Fethiye,Mugla,Rhodos	1955	5.3	Didim
1873	6.6	Sisam, Söke, Aydın	1955	5.3	Yalıköy
1895	6.6	Aydın	1955	6.8	Aydın, Söke, Balat
1899	6.6	Nazilli, Aydın, Denizli, Uşak	1957	7.1	Fethiye, Rhodos
1904	6.2	Samos	1959	5.9	Köyceğiz, Muğla
1904	6	Özdere	1961	6.3	Rodos
1908	5	Aydın	1966	5.4	Aydın
1918	5.2	Kuşadası	1966	5.2	Aydın
1927	4.5	Kapıkırı	1985	4.3	Nalbantlar
1928	5.2	Torbalı	1989	5.1	Kultak
1928	6.5	Bayındır	1989	5	Kultak
1941	6.5	Zeytin Village, Aydın	1996	5.1	Samos
1941	5.2	Mugla	2005	5.1	Çökertme
1941	6	Denizova	2005	5.1	Çökertme
1941	5.2	Torbalı	2009	5	Samos
1941	5.3	Kavaklıdere			
1941	6.5	Zeytin Village, Aydın			

The highest earthquakes in the surrounding area were seen in Fethiye, Muğla, which is approximately 600 km far from the ancient cities, in 155 AD and Sisam, İzmir,

which is approximately 600 km far from the ancient cities, in 177 AD (magnitude 7.3) (BDTİM 2017) (Table 2).

1.1.1.2. Earthquakes in Pamphylia Region

Pamphylia region is under high earthquake threat due to high ground acceleration (AFAD 2018). In 100 km proximity of the surrounding area, 125 earthquakes are recorded from 1900 until now. In the surroundings, between 4 and 5 in magnitude, there are 105 earthquakes. Between 5 and 6, there are 19 earthquakes and between 6 and 7, there is one earthquake. In ancient periods, earthquakes higher than 7 were recorded for approximately 500 km away from the area, in Cyprus and Rhodes directions (BDTİM 2017) (Table 3).

The Pamphylia plain was affected and damaged by earthquakes originating from Rhodes and Crete (Erel and Adatepe 2007, 242). The highest earthquakes in the surrounding area were seen in Rhodes and Cyprus, which are approximately 300 and 400 km far from the ancient cities, in 222 BC and Mediterranean Sea in 1408 (magnitude 7 or higher in Richter scale).

1.1.1.3. Earthquakes in Cilicia Region

Cilicia Region is under low earthquake threat due to low ground acceleration (AFAD 2018). In 100 km proximity of the surrounding area, 17 earthquakes have been recorded from 1900 until now. Distribution of these earthquakes: In surrounding of the area, between 4 and 5 in magnitude, there are 12 earthquakes. Between 5 and 6, there are 5 earthquakes. In ancient periods, earthquakes between 6 and 7 approximately 350 km away from the area were recorded. Only one earthquake higher than 7 in Cilicia Region was recorded and this was in 1268. There were lots of earthquakes higher than 6 magnitudes in Antiokheis (Antakya) which is about 300 km far from the ancient towers. The area was shaken and damaged by earthquakes on the Death Sea fault, Cyprus, Cilicia, Eastern Anatolian fault and Syria. The highest earthquake in the area was seen in 1268 (magnitude 7 or higher) (BDTİM, 2017) (Table 4).

Table 3. Previous earthquakes at the surroundings of Pamphylia (Source: BDTİM 2017)

YEAR	MAGNITUDE (Richter scale)	LOCATION
BC 222	7 or higher	Rhodes, Cyprus-(Tsunami)
BC 185	6-6.9	Rhodes, Cyprus
142	6-6.9	Rhodes, Myra (Demre)
226(227)	6-6.9	Rhodes, Crete, Sw Anatolian
303	4-4.9	Rhodes
336	6-6.9	Rhodes
21.07.365	6-6.9	Crete, Cyprus Tsunami
08 08 1304	10	Rdodes, Crete, Cyprus
30.12.1408	7 or higher	Mediterranean Tsunami
1914-10-03	6.9	Burdur
1924-09-10	5	Değirmenli
1925-12-18	5.1	Kestel
1927-06-05	5.5	Antalya Bay, Mediterranean
1930-09-11	5.9	Yeşilbağ, Değirmenözü
1937-05-29	5	Antalya Golf, Mediterranean
1939-01-02	5.3	Antalya Golf, Mediterranean
1941-01-20	6.5	Crete
1953-09-10	6.3	Crete
1961-09-15	6	Crete
1965-03-26	5.2	Antalya coast
1969-03-04	5.2	Bilginler
1971-02-22	5.1	Yelten
09-05-1966	5	Aşağıoba
1977-06-01	5.9	Antalya Golf, Mediterranean
1979-05-28	5.3	Antalya Golf, Mediterranean
1981-04-26	5.2	Antalya Golf, Mediterranean
11-03-1991	5.1	Nebiler
2013-12-08	5	Antalya Golf, Mediterranean
2013	6	Antalya Golf, Mediterranean
2014-09-04	5.3	Antalya Golf, Mediterranean

Table 4. Previous earthquakes at the surrounding of Cilicia Region (Source: BDTİM 2017)

YEAR	MAGNITUDE (Richter scale)	LOCATION	YEAR	MAGNITUDE (Richter scale)	LOCATION
148 BC	6-6.9	Antiokheia	972	5-5.9	Antiokheia
69 BC	6-6.9	Antiokheia	1053	6-6.9	Antiokheia
37 BC	6-6.9	Antiokheia	1072	6-6.9	Antiokheia
37	6-6.9	Antiokheia	1098	5-5.9	Halep, Antiokheia
79	5-5.9	Antiokheia	1109	6-6.9	Mümbiç, Antiokheia
115	6-6.9	Antiokheia	1114	6-6.9	Ceyhan, Antiokheia
117	5-5.9	Antiokheia	1190	6-6.9	Antiokheia and surrounfings
220	6-6.9	Antiokheia	1212	5-5.9	Antiokheia
272	6-6.9	Antiokheia	1268	App.7 (viki)	Kilikya (Çukurova)
290	6-6.9	Ceyhan, Tarsus, İçel	1514	5-5.9	İçel, Adana, Maraş
341	6-6.9	Antiokheia	1822	6-6.9	Antakya, İskenderun, Kilis
345	5-5.9	Antiokheia	1854	5-5.9	Antiokheia, Samandağ
365	6-6.9	Crete, Cyprus Tsunami	1855	5-5.9	Ceyhan, Adana
387	5-5.9	Antiokheia	1872	5-5.9	Antakya, Halep
458	6-6.9	Antiokheia	1873	5-5.9	Antiokheia, Samandağ
506	6-6.9	Antiokheia, Samandağ	1896	5-5.9	Adana, Mersin
518	6-6.9	Antiokheia	26.06.1896	5-5.9	Marmaris,Muğla, Adana
526	6-6.9	Antiokheia, Samandağ	20.3.1945	6	Ceyhan-Misis(ADANA)
527	5-5.9	Antiokheia	22.10.1952	5.6	Ceyhan – Misis(ADANA)
529	6-6.9	Antiokheia	1947-12-09	5.6	Akdeniz, Erdemli coast
534	6-6.9	İçel	2015-07-29	5.2	Akdeniz, Mersin Sarımsaklı coast
557	5-5.9	Antiokheia	1921-10-05	5.5	Akdeniz, Mersin bay
581	5-5.9	Antiokheia	1926-03-17	5.5	Camilimanda
587	6-6.9	Antiokheia			
639	5-5.9	Antiokheia			
835	5-5.9	Antiokheia			
867	6-6.9	Antiokheia			

1.2. Dry stone masonry

In archaic period, dry masonry walls were constructed out of polygonal stones with angular and rounded sides. Lesbian blocks had rounded sides, while polygonal blocks had rectilinear sides (Figure 4, 1-2-3). Polygonal stones perfectly fit into each

other, creating almost a monolithic wall with good cohesion (Yavuz 2001, 365). Thus, integrity of the wall was provided with the help of the form of the stone blocks. Since application of these techniques were considerably difficult and time-consuming, trapezoidal and ashlar blocks were preferred in later periods. While trapezoidal blocks (Figure 4, 4) with parallel top and bottom sides, but curved lateral sides had been used in the 4th and 5th centuries BC, ashlar masonry composed of square-cut rectangular stone blocks had been common in Hellenistic period (Figure 4, 5-8) (Orlandos 1968, 128-138; Nossov 2012, 26-29). Greeks laid courses of stone blocks and joints of blocks were organized by interchanging the direction of the blocks. This masonry technique was described by Vitruvius Pollione in ‘‘De Architectura’’ (first century B.C.). All courses of *isodomum* technique were of equal height. If continuous horizontal joints are created, but rows varied in height; then it was called as *pseudisodomum.* Typical examples of such masonry were named as *opus quadratum* composed of overlapping squared stones by the Romans (Vitrivius 1914, 52; Giuffre` 1991, 61-91).

Walls laid using trapezoidal or rectangular masonry were made stronger with tying elements such as headers and stretchers or clamps and dowels. These tying mechanisms were developed as a precaution to provide the integrity of the wall (Orlandos 1968, 128-138; Nossov 2012, 26-29).

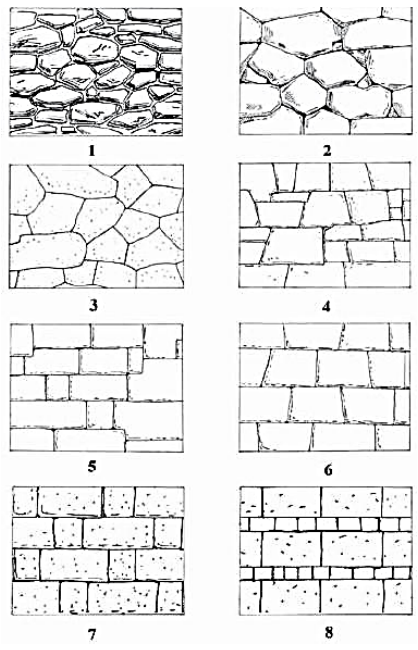


Figure 4. Types of dry masonry construction techniques (Source: Nossov 2012, 29)

1.2.1. Precautions for sustainability of structural strength in dry masonry walls

Integration of dry masonry wall blocks is achieved by either external structural element such as clamps and dowels or with appropriate organization of the blocks themselves: provision of headers and stretchers.

1.2.1.1. Organization of blocks

The structural sustainability of dry masonry walls is mainly based on organization of blocks with appropriate staggering. Blocks should be organized regularly and joint between blocks at upper and lower course should not overlap with each other. However, depending on dimension and types of the stone blocks available in the construction site, different techniques were used to integrate the stone blocks (Giuffre` 1991, 61-91).

1.2.1.1.1. Staggering

Arrangement of stone blocks with regular dimensions and patterns may provide the best layout for structural integrity of dry masonry constructions. Staggering of blocks, which is the ratio between horizontal distance between joints and height of the related course, is critical for organization of stone blocks. High staggering ratio (s/h: maximum distance between joints/height of the course) improves the in-plane behavior of the wall (Ceradini 1992; D'ayala, and Speranza 2003, 480) (Figure 5). Arrangement of blocks is also related with the form of the blocks (ratio between block length and height bl/bh). In preliminary studies, the variation in either staggering ratio (s/h) (D'Ayala and Speranza 2003) or ratio between block length and height (bl/bh) is examined (Giuffre, Pagnoni and, Tocci 1994). In these studies, joints are accepted as positioned in the middle of the upper and lower blocks, so the two ratios (s/h and bl/bh) are always proportional to each other.

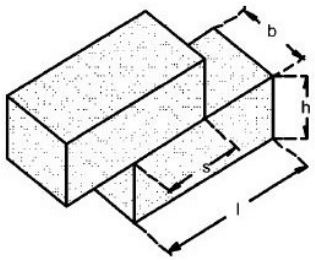


Figure 5. Critical dimensions in organization of blocks (Source: D'ayala, and Speranza 2003, 481)

1.2.1.1.2. Header and stretchers

The headers, laid perpendicularly to the course wall, strengthen the wall, keep the wall leaves together and ensure the monolithic behavior of the two leaves (Vitrivius 1914, 52; Ceradini 1992; Karlsson 1992, 86; Saner 1995, 350; Yavuz 2001, 365).

The ashlar dry masonry walls with alternating header and stretchers can be varied according to their thickness and bonding type. As the thickness of the wall increases, void between the parallel stretcher shells is created. For thicker walls, the wall is composed of three shells; two parallel stretchers and void between them. The void might be kept empty or filled in with rubble stone (Figure 8), (Adam 2005, 109-110, Orlandos 1968, 148).

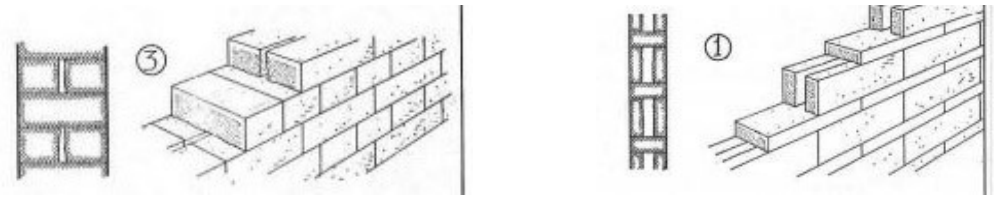


Figure 6. Ashlar masonry without void and with void between the outer leaves (Source: Orlandos 1968, 143, 148)

Alternating header and stretcher usage are observed in both isodomic and pseudoisodomic masonry (Figure 7, Figure 8).

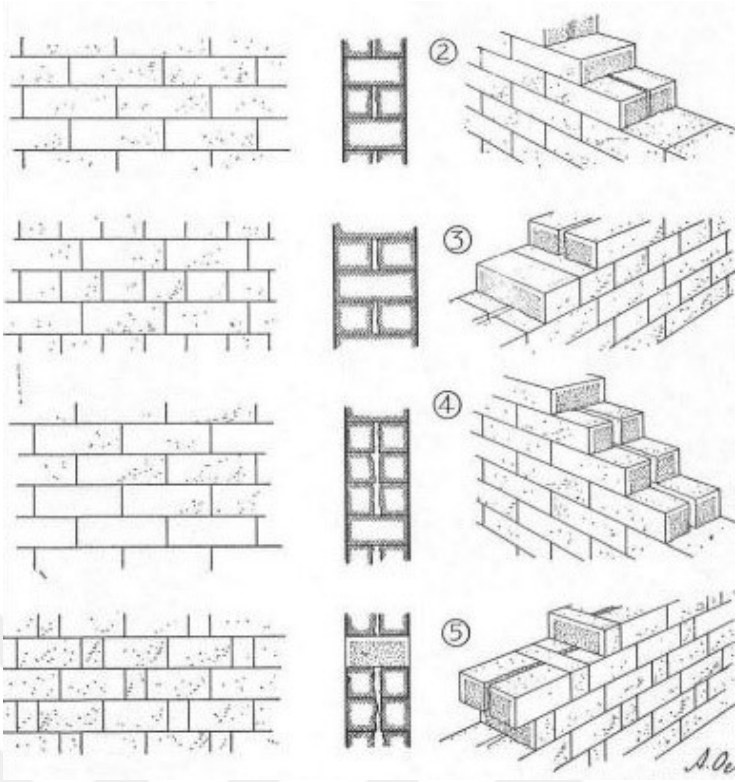


Figure 7. Alternating header and stretches usage in isodomic ashlar dry masonry (Source: Orlandos 1968, 143)

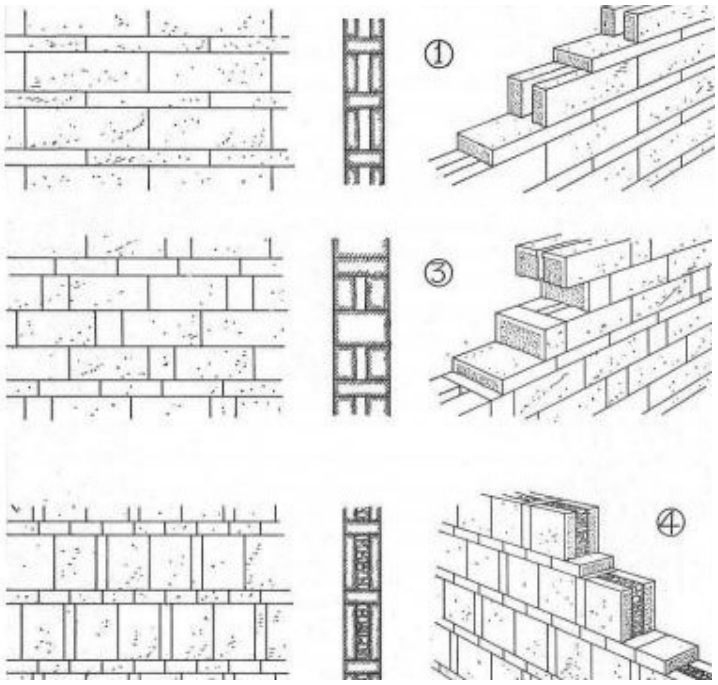


Figure 8. Alternating header and stretches usage in pseudoisodomic ashlar dry masonry (Source: Orlandos 1968, 148)

1.2.1.2. External structural elements (clamps and dowels)

Iron clamps and dowels were generally used to fasten together the blocks of stone in ashlar dry masonry construction. An iron clamp that fit into channels carved into the ends of the stone blocks stitched blocks together horizontally. Similarly, iron dowels were used to fasten the drums of columns or blocks vertically, preventing them from sliding under shear. Clamps and dowels were used against probable stone movements due to foundation settlement or earthquakes (Mark 1993, 77).

1.3. Structural vulnerability of masonry structures

Vulnerability is defined as *estimation of the level of loss associated with particular hazard* (Stovel 1998, 7). The physical vulnerability indicates the susceptibility to the hazard due the physical characteristics of the cultural heritage or weaknesses. Vulnerability is also related with value of the cultural heritage (UNESCO et all. 2010, 8). Vulnerability assessment is critical for disaster risk preparedness or assessment since disaster risk is a product of hazard and vulnerability. While a hazard is phenomenon such as earthquake, which can cause disruption or damage to cultural heritage, vulnerability is related to cultural heritage's weaknesses against a hazard due to its specific characteristics (UNESCO et al. 2010, 8).

The first step for disaster preparedness is understanding the existing risk well. Detailed information on the physical characteristics of the structure, weaknesses and strengths of characteristics should be determined. The Manual for Risk Preparedness for the Cultural Heritage prepared by Herb Stovel (2004) on behalf of the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Council on Monuments and Sites (ICOMOS), the World Heritage Centre (WHC) emphasizes that vulnerability assessment is a component of risk assessment. There are basic steps to define vulnerability of a cultural heritage (UNESCO and World Heritage Committee 2004, 16):

1. Characteristics of the cultural heritage should be identified. It will be useful to distinguish between different physical elements.

2. Vulnerability of each characteristic should be assessed for threat. This involves identifying the sub-qualities of characteristics and behavior of sub-qualities so that the possible impacts of the threat on those characteristics can be assessed.

Structural vulnerability of dry masonry structures against lateral loading is still a current research topic. There is lack of knowledge on structural behavior of dry masonry due to its peculiar techniques used in the past centuries. Structural vulnerability of masonry structures against seismic forces requires a detailed survey of the buildings and characterization of the morphology of the masonry walls and mechanical characteristics of the masonry (European Parliament 2007, 7).

Earthquake protection strategies should focus on preparation and response, since earthquakes cannot be predicted or prevented. Therefore, precautions should be determined to reduce risk at the source and improve earthquake resistance (World UNESCO and World Heritage Convention 2004, 28). For this, preliminary analysis listed in the below should be carried out.

- Analysis of past earthquakes
- Analysis of vulnerability of the building, detailed analysis of structural and morphological characteristics and probable failure mechanisms (UNESCO and World Heritage Convention 2004, 28)

Detailed vulnerability analysis should include data about geometry, the characteristics of masonry texture (single or multiple leaf walls, connection, between the leaves, joints empty or filled with mortar, physical, chemical and mechanical characteristics of the components (mortar, brick, stone), the characteristics of masonry as a composite material, deterioration with age (Bindai Valuzzi and Ceradini 2006, 347).

Determination of vulnerability of historic masonry towers in terms of behavior and failure mechanisms is critical for achievement of their seismic risk reduction (Quiroz 1977, 30). Seismic vulnerability aspects of towers are related to:

- Morphologic characteristics:
    - Plan and facade organization depending on position and dimension of openings effect the vulnerability of towers.
    - Height/Length Ratio (Slenderness): Since the towers are vertical structures, slenderness is important sub-quality effecting seismic performance.

- Characteristics of masonry with material properties: Wall profile, organization and dimension of stone blocks and types of stone blocks are significant for structural vulnerability.
- Boundary conditions: Presence of adjacent buildings are important for vulnerability against seismic forces.

1.3.1.1. Failure mechanisms of masonry structures under lateral loading related to their characteristics

Although the structural typology of masonry buildings varies in different regions, their damage resulting from lateral forces can be generalized. These damages as determined through analysis of the earthquake damage patterns (Tomazevic 2000, 31) are as in the below:

- Cracks at the corners and at wall intersections
- Cracks between walls and floors
- Diagonal in-plane cracks in walls
- Out-of-plane collapse of walls
- Partial disintegration of collapse of structural walls
- Partial or complete collapse of the building

According to Giuffrè's (1993) definition, damages can be interpreted on the basis of two fundamental collapse mechanisms. The first mechanism, the out-of-plane failure mode or "First Damage Mode", occurs due to the seismic actions perpendicular to the out-of-plane wall. This causes the overturning of the whole wall panel or collapse a significant portion of it. This behavior represents the highest vulnerability when connections between orthogonal walls are particularly poor. It was prevented by interlocking of intersecting walls by using ties in the past (Magenes, and Penna 2011, 4). The second mechanism, the in-plane failure mode or second damage mode (Giuffrè 1993), occurs due to the forces parallel to the wall (Carocci and Baggio 1993; Carocci 2001, 154). Diagonal cracks are observed related to the shear forces. Shear failure usually effects the upper parts of masonry buildings, where compressive stresses are low, and the response acceleration is high (Tomazevic 2000, 150).

Failures are observed at in-plane and out-of-plane walls of four-sided structures depending on direction of seismic action. At the walls which are perpendicular to lateral

force, out-of-plane bending are observed, and vertical cracks occur at the corners and in the middle of the walls. Shear stress causes diagonal cracks in the walls parallel to lateral force (Tomazevic 2000, 31) (Figure 9).

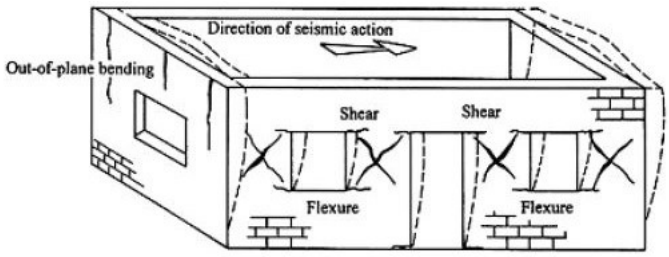


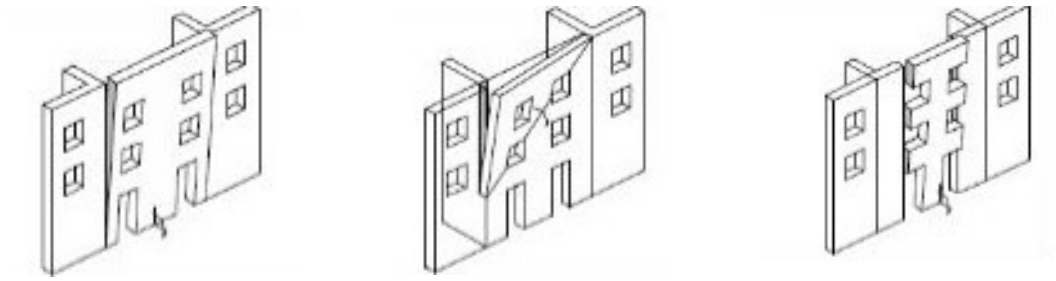
Figure 9. Damage patterns depending on seismic motion direction (Source: Tomazevic 2000, 31)

The occurrence of different failure mechanisms is based on lateral loading and characteristics of the building such as morphology, the masonry characteristics (arrangement of stone blocks and joints between them, in-plane and cross-section masonry pattern), boundary conditions and characteristics of materials (blocks and interfaces) (Binda, Saisi, and Tiraboschi 2000, 202; Restrepo-Velez, Magenes, and Griffith 2014) as mentioned previous part (1.3). The analysis of failure patterns can clearly identify the weak and good points of different structural systems (Tomazevic 2000, 31).

Depending on characteristics of structures, failure mechanisms vary as out-of-plane, in-plane, hybrid and body. Out of plane failures depend on the quality and strength of the connections with the other elements of the structure, party walls, internal load-bearing partitions, floors, and roof structures (Mechanism A, D, E). For symmetrical corner connections, without proper constraint at one corner and both corners, the wall collapses as Mechanism A and D, respectively (Figure 10) (D'ayala, and Speranza 2003, 480; Ceradini 1992).

If the structure is not strengthened, the only restraint against overturning is the friction of the contact surface, and this gives rise to different types of failures (D'ayala, and Speranza 2003, 498). However, if the structural vulnerability has been controlled by means of ties, simple overturning is prevented, while mechanisms relying on arch effect

develop (Mechanism F, G). Mechanism G occurs, when wall span is rather long: trapezoidal central portion of the wall is affected (Shi et al. 2016, 39) (Figure 11).



Mechanism A
Overturning of out-of-plane wall

Mechanism D
Partial overturning of out-of-plane wall

Mechanism E
Vertical strip overturning

Figure 10. Out-of-plane failure mechanisms determined by numerical analysis (Source: D'ayala, and Speranza 2003, 495)

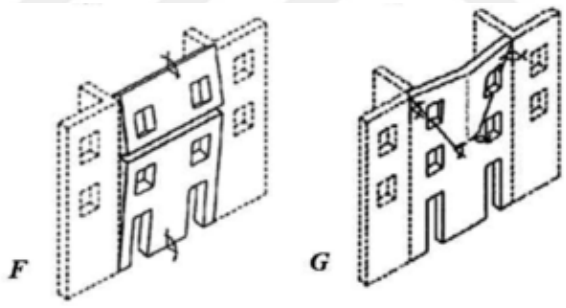


Figure 11. Arch effect (Source: D'ayala, and Speranza 2003, 499)

In-plane behavior of masonry walls change in accordance with arrangement of stone blocks (Figure 5). In a wall with small sized stone blocks and small staggering ratio, collapse of triangular portion of side walls with in-plane shear cracking is observed. If the staggering ratio and length of stone blocks increase, collapse of trapezoidal portion of side walls is observed (Figure 12) (Giuffre 2010, 50-52). In higher staggering ratios, total body failure of the whole wall is seen.

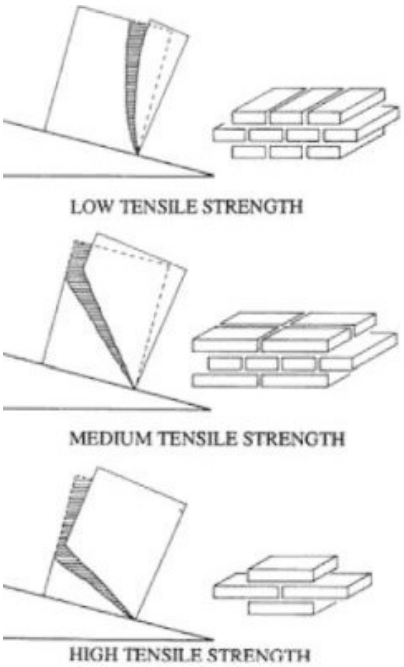


Figure 12. Variation in in-plane failure mechanisms in relation with stone block organization (Source: Giuffre 2010, 50-52)

If organization of corners are strong, shear stress causes diagonal cracks at in-plane walls. this is followed by collapse of triangular portions of in-plane walls together with the out-of-plane wall. These mechanisms (Mechanism B1 and B2) results from in-plane behavior. Due to the direction of lateral force and position of openings, corner failure may occur (mechanism C) (Figure 13). Hybrid mechanism is composed of failures both at in-plane and out-of-plane walls (Mechanism B_2+A).

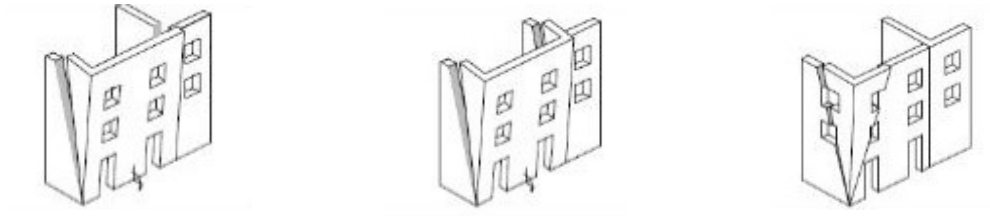


Figure 13. Failure mechanisms determined by numerical analysis (Source: D'ayala, and Speranza 2003, 495)

When resistance of walls and their connections are good enough against lateral loading, body behavior takes place because of slenderness (height/length) of the towers. Header blocks perpendicular to the face of the wall connecting various leaves together supports body behavior (Giuffre` 1991, 61-91). Studies and experimental tests have demonstrated clearly the function of the header stones in ensuring the monolithic behavior of the two shells of the wall and in improving its out-of-plane resistance (D'ayala, and Speranza 2003, 480; Ceradini 1992).

This behavior may vary as bending (a), bending-shear (b), rocking parallel to base (c) and rocking together with foundation (d) (Figure 14), (Preciado, Sperbeck, and Ramirez-Gaytan 2016, 52). Bending starts with horizontal cracks at the facade followed by in-plane cracking of the body. Bending behavior can be combined with vertical splitting or diagonal cracking (Figure 14e) (Milani, Shehu, and Valente 2018, 213-214).

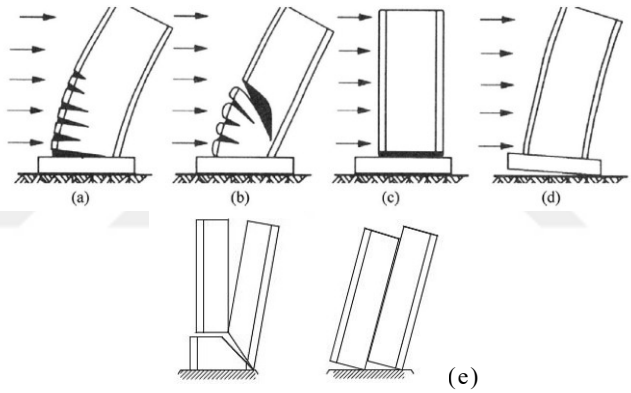


Figure 14. Body behavior of towers (Source: Preciado, Sperbeck, and Ramirez-Gaytan 2016, 52; Milani, Shehu, and Valente 2018, 213-214)

1.4. Literature Review

Possible causes of structural vulnerability of dry masonry walls have been tested with various methods in preliminary studies. First, methods used in literature are introduced. Since it is recognized that each preliminary study focused on relatively limited sub-qualities of characteristics, evaluation methods in presence of multi-characteristics affecting each other is also researched considering statistical tools adapted to different disciplines.

1.4.1. Studies on structural resistance and behavior of dry masonry

Numerous studies have been carried out to determine sub-qualities related to morphological and structural characteristics and material usage, which affect the vulnerability of dry masonry structures. Sub-qualities of morphological characteristics vary as proportional relationship between wall length and height (slenderness) and the presence, area and position of openings. Wall thickness, number and connection of shells, organization, dimensions and connection of stone blocks, staggering of blocks and vertical loads such as roof, floor are sub-qualities effecting resistance of structural characteristics.

Most of the studies in literature examine only a single quality or two qualities by analyzing in-plane or out-of-plane behavior of a wall or a wall with two side walls (Giuffre 1996; Vaculik et al. 2004; De Felice 2011; Jimenez 2011; Foti, Vacca, and Facchini 2018). There are many studies focusing on sub-qualities related to arrangement of blocks: size of stone blocks, staggering ratio and usage of header stones. De Felice (2011) studied stone size and number of headers; Foti, Vacca, and Facchini (2018) studied masonry pattern and Giuffre (1996) studied usage of header stones between shells. Organization of blocks were also examined in relation with material characteristics (Giuffre, Pagnoni, and Tocci 1994; Vaculik, 2012; Godio, Stefanou, and Sab (2017). Regardless of characteristics of masonry and morphology are studied by Vaculik et al. (2004) and Jimenez (2011) in terms of opening organizations with boundary conditions and slenderness with reinforcement, respectively.

If the studies that investigate more than two sub-qualities related to characteristics are mentioned, Giuffre, Pagnoni, and Tocci 1994 studied organization of blocks, vertical loading and horizontal connection along the top portion of a wall with its self-weight and without side walls. Shi, D'ayala, and Prateek (2008) and Shi (2016) studied the effect of proportional relationship between length and height (slenderness), friction coefficient and corner connections on lateral capacity of dry masonry. Vaculik (2012) investigated effect of dimension of walls (height and length), openings, vertical loads, arrangement and friction coefficient of the stone blocks on out-of-plane strength of a masonry wall. Restrepo-Velez, Magenes, and Griffith (2014) studied six different sub-qualities related different characteristics: effects of different wall lengths, position of openings, connection of stone blocks, vertical loads, height and story number of buildings. Bui et al. (2017) studied the same configurations with Restrepo-Velez, Magenes, and Griffith (2014) to

test the validity of the used method. However, in these studies, there are no configurations with combinations of sub-qualities to examine the effect of these sub-qualities to each other and which quality is more effective in which combinations.

Among the methods preferred for understanding of structural vulnerability of the configurations comprehending multi-characteristics, the quasi-static analysis stands forward. The quasi-static analysis is based on equilibrium and strength methods (Jimenez 2011; DeJong 2009). In quasi-static tilt analysis carried out by taking into account the equilibrium conditions, the structures are tilted by degrees with a tilt table, the failure mechanisms of the structures are observed, and the collapse angles are determined. At the collapse position, the horizontal component of the gravitational acceleration of the tilt table defines the level of collapse (DeJong 2009). Tilt analysis can be carried out by physical models in the laboratory environment (Giuffre, Pagnoni, and Tocci 1994; Vaculik et al. 2004; Shi, D'ayala, and Prateek 2008; Jimenez 2011; Restrepo-Velez, Magenes, and Griffith 2014), while simulation of 3D models can also be carried out in computer environment with different approaches (Azevado, and Sincraian 2000; De Felice 2005; Da Costa 2012). The validity of analysis in computer environment is done with the experimental results (Giuffre, Pagnoni, and Tocci 1994; De Felice and, Giannini 2001; Vaculik 2012; Bui et al. 2017; Foti, Vacca, and Facchini 2018).

Despite the high reliability of the experimental analysis in the laboratory environment, experiments are time-consuming and necessitate high-budget, extra human power is required. In cases where a large number of analysis are required, need of human force and working time increase. Simulation of 3D models carried out in computer environment validated by experimental methods presents a quick and practical idea about the lateral load resistance of dry masonry (Bui et al. 2017). The video game industry has been using and developing advanced rigid-body simulation tools over the past decades. They may contribute to traditional engineering tools in terms of speed, ease of use and flexibility (De Jong, Wormnes, and Tiso 2014)

1.4.2. Studies on statistical evaluation

Since review of literature on structural behavior of dry masonry presented that the relation between the sub-qualities that affect vulnerability has not been considered so far, an appropriate technique for this evaluation has been searched. Multiple regression

analysis is a statistical technique that analyzes the relationship between two or more independent variables and estimates the value of the dependent variables. In multiple regression, the objective is to build a model that relates a dependent variable to more than one independent variable. Regression analysis is used in different research areas such as economy (Angleche, Manole, and Anghel 2015; Duran and Lopes 2015; Duran 2017; Uysal, and Aydemir 2016) medicine (Pervaiz, et al. 2017; Önder, and Batıgün 2016; Başgelmez, and Yıldız 2017), educational sciences (Ünal, Tarhan, and Köksal 2017; Yavuz et al. 2017), agriculture (Kelechi 2012) and engineering (Kanıt, and Baykan 2004). In these studies, variables vary between five and sixteen. Coefficient of variables with a linear relationship with dependent variable are determined.

In regression analysis, the important point is the evaluation of coefficient values. The coefficient values of variables in the regression analysis cannot be compared with each other, when the units of the variables are different from each other. In order to compare the variables with each other, an impact analysis was performed using the standard deviation value and coefficients of each parameter. In this way, the effect of the variables could be compared with each other (Ünal et al. 2017; Yavuz et al. 2017; Ertekin, and Özmen 2017).

1.5. Problem definition and aim

Masters in the antiquity revealed the ways of constructing dry masonry towers that were resistant to the earthquake in accordance with the characteristics of their sites. Earthquake behavior of towers had been tried to be improved by appropriate building geometry and construction techniques. The relation between the original characteristics and behavior of the structures should be deciphered before the intervention decisions are determined. Since building geometry and construction technique are important factors in structural behavior, different building types and different construction techniques should be studied one by one. In this study, tower building type constructed in dry masonry technique is focused on. Dry masonry towers in ancient Caria, Pamphylia and Cilicia, which have different ground accelerations, are examined. So, possible variations stemming from the site's earthquake potential are questioned. The aim is to identify the structural behavior of dry masonry towers under lateral loading so that decision making phase regarding their restoration projects can be supported. Emphasis is made on collapse

angles and failure mechanisms of the towers to present a preliminary assessment framework. This allows to put forward an idea for basic behavior of the towers. Internalization of behavior of towers will help the architect specialized in restoration to restitute the partially demolished towers through the analysis of their failures and damages. Within this frame, the relationship between the structural characteristics and behavior of six dry masonry towers under lateral loading in ancient Caria, Pamphylia and Cilicia on the Aegean and Mediterranean coasts are examined. Parameters that play role in structural vulnerability of ancient dry masonry towers are determined.

Characteristics that affect structural vulnerability of dry masonry construction systems have been searched in numerous studies. Proportional relationships between height and length, opening number, position and area, arrangement and dimension of stone blocks, density and friction coefficient of materials, and vertical loads were determined as significant sub-qualities of characteristics affecting structural vulnerability of dry masonry depending on direction of seismic action in literature. However, data to be tested were not gathered from real dry masonry buildings; they were completely fictional. Also, impact of these sub-qualities on each other has not been studied in an integrated way.

1.6. Methodology and tools

The way followed includes combination of the quasi-static analysis and tools of the statistical discipline with conventional methods of the discipline of architectural conservation. The work was realized in four phases: documentation of characteristics of case study towers, impact analysis of these characteristics, examination of results and discussion (Figure 16).

Documentation phase is composed of selection of the case studies and determination of characteristics of case studies. While selecting case studies, building type is evaluated as a factor that should be kept constant in the analysis. Since different building types have different forms and sizes, comparison may not be carried out on equal terms among them. Watch towers constructed out of dry masonry have similar forms and sizes; so, comparison of minor variations become possible for evaluating their impact on structural strength. Thus, individual towers or towers that are part of a city wall constructed in the southern and western coasts of Turkey in ancient periods are

researched. The towers that have sustained their integrity and authenticity or whose reliable information is available are chosen as case studies. These are the six dry masonry Hellenistic towers in Caria, Pamphylia and Cilicia. Their structural and morphological characteristics are documented by traditional documentation techniques and material usage of case study towers are investigated with laboratory analysis.

Documentation is composed of series of phases. Laser meter, steel tape, range rod and ladder were used. At towers on inclined topography, wall thicknesses of the upper stories were reached from the exterior by standing on the bedrock. Wall thickness of upper portions of towers at plane areas were measured from the inside with the help of a ladder and a steel tape. Some towers are filled with earth; this made easy to reach the upper portions of the walls (Figure 15). Dimension of stone blocks and position of joints were measured with a steel tape at the lower parts, but photos parallel to facades were taken without tilting the camera in horizon direction. Then, these photos were rectified by Zoner Photo Studio X and used to draw the arrangement of stone blocks at the upper parts. Data coming from rectifications were combined with measured data at Autodesk 2018 by overlapping the reference points.

Figure 15. Measurement of wall thicknesses at floor levels

Data about structural and morphologic characteristics, material usage and ground topography of the towers are classified:

- Wall profile types in terms of organization of leaves and blocks are documented.
- Ratios between wall thickness, length and height, and opening types in terms of position, area and number are documented.
- Types of materials used in the stone blocks are determined.
- Ground topographies are documented.

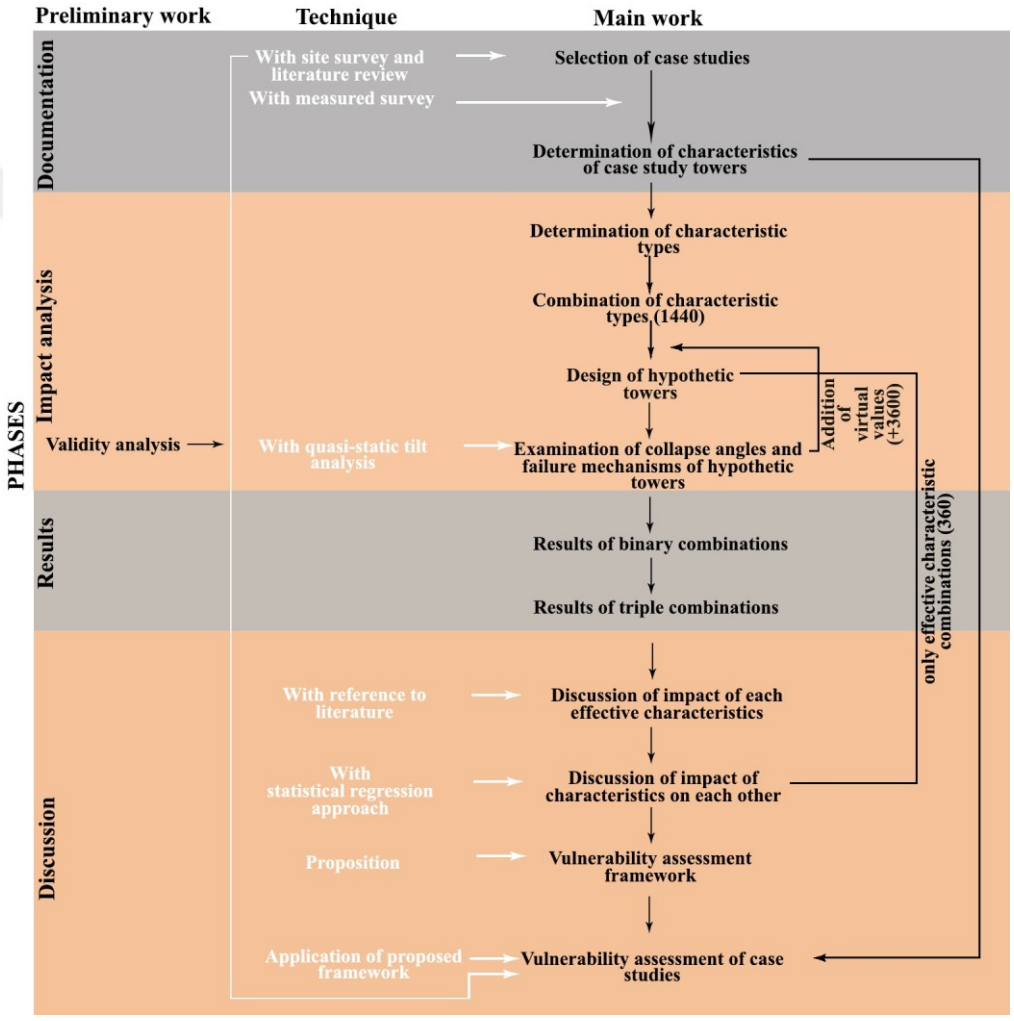


Figure 16. Phases of the methodology

Impact analysis phase consists of determination and combination of characteristics types of real towers, design of hypothetic towers and analysis of collapse angles and failure mechanisms of hypothetic towers. With combination of characteristics, hypothetic towers are designed and modelled. Tilt analysis of hypothetic towers is carried

out to determine impact of characteristics on collapse angle and behavior. Hypothetical towers are modeled as individual rigid blocks brought together without any connecting element in SketchUp 2013. This was preferred because the real towers are composed of rigid blocks that are not connected to each other. In order to determine the seismic behavior of the hypothetical towers, MS Physics 0.9.9 software is used for the quasi-static tilt analysis simulation based on the equilibrium state. MS Physics software provides rigid block, group, and component densities based on connection states, and physical simulation. In MSPhysics, an object can be modelled with a specific shape, specific state, density, contact and magnet characteristics. Gravity, update timestep, and solver model values can be adjusted (Extension Warehouse 2017). In the simulations, friction coefficient is taken into consideration, but elasticity coefficient is ignored based on studies in literature (D'Ayala and Speranza 2003). The update time step is taken as 1/120 since smaller update time step provides more accurate simulation results and prevents collisions from deteriorating. Since the towers are composed of many moving blocks, the iterative value is taken as 16 (Synytsia 2016). The elements of floors and roofs, and relation of the tower with the city walls are not taken into consideration, since majority of the towers have limited information for these characteristics. Authentic construction technique and building geometry that have preserved their integrity to a great extend are focused on. Similarly, structural failures stemming from previous lateral loading, settlement, vandalism, weathering, etc. are not included in the modeling process. The case study towers are modelled with their original geometry and constructional characteristics excluding their roofs, floors and juxtaposing city wall.

Constant horizontal acceleration was applied to each virtual model by tilting the ground plane of the model. The amount of tilt was increased one degree by one degree, until total collapse occurred (Figure 17). Critical angles of crack, partial and total collapses were determined.

In tilt analysis, base of each tower is quasi-statically tilted until collapse occurs. The horizontal component of the ground acceleration at the level of collapse may be interpreted as a value corresponding to the peak ground acceleration. The horizontal acceleration (λ) equals the horizontal component of the gravitational acceleration: $\lambda = m_g \times \sin \Theta$ (DeJong 2009) (Figure 18). While this equivalent static loading does not represent the effects of dynamics as presented through seismic loading, it makes possible to measure the lateral load bearing capacity of the structure until it collapses.

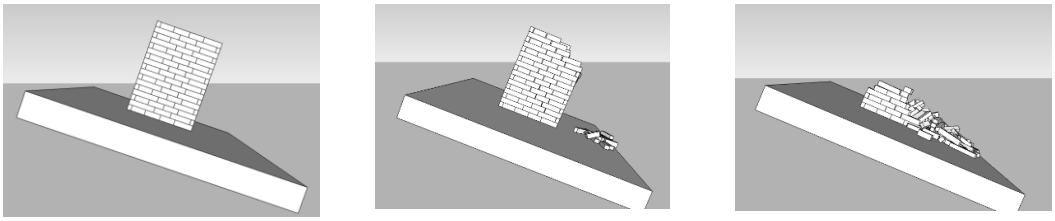


Figure 17. Tilt analysis in MS Physics

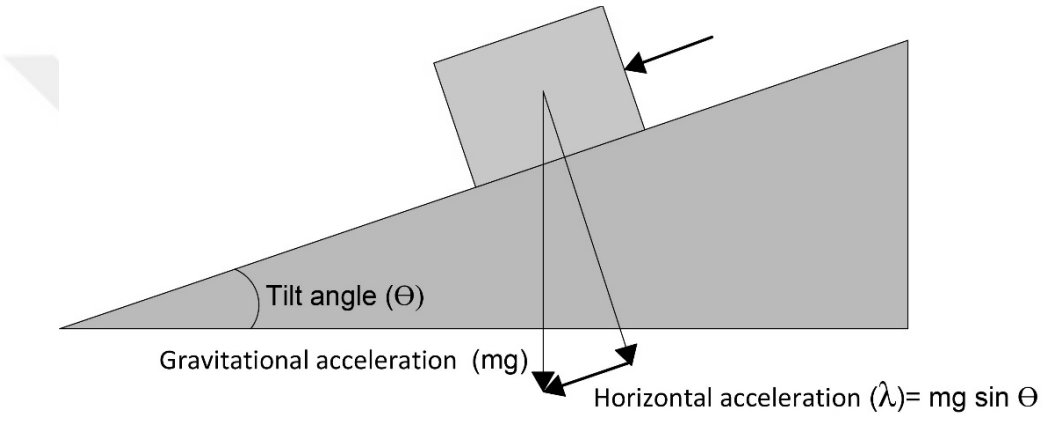


Figure 18. Horizontal acceleration (λ) as a component of gravitational acceleration.

Each designed tower is tilted in two directions considering variation in the position of openings: openings at in-plane and out-of-plane walls. The highest collapse angle is always taken into consideration for the evaluation.

Analysis results are examined in terms of collapse angles and failure mechanisms. In-plane and out of plane behavior of walls are evaluated with regard to definitions developed by Giuffre (1993), and D'Ayala and Speranza (2003). Total tower failure mechanisms are identified with the help of the studies of Bazan and Meli (2003), and Milanu, Shehu and Valente (2018). All failure mechanisms in their sequence of happening are described with reference to literature. Additional definitions are proposed, if necessary (Table 5).

Abundant collapse angle and failure mechanism results, gained by tilt analysis, necessitate a stepped evaluation, thus grouping of characteristic types as binary and triple combinations is made. First, 10 binary combinations listed in the below are examined.

- wall profile- opening type
- wall profile-h/l
- wall profile-material usage
- wall profile-ground topography
- opening type-h/l
- opening type-material usage
- opening type-ground topography
- h/l-material usage
- h/l-ground topography
- material-ground topography

Table 5. Codes of failure mechanisms

Failure mechanism codes in previous studies	**Proposed failure mechanism codes**
A	B_{2T}
sG	B_2 +A
B_1	B_1 +A
B_2	B_1 +A+G
	B_{1+2T}
	B_{2T+VS}
	B_{2T+DT}

While interpreting a specific binary combination, all other characteristic types are kept constant. The constants are taken as average or ideal values documented in the real towers. These constants are listed in the below:

- Wall profile 1
- Ratio between wall height and length: 2
- Material: Limestone
- Ground topography: on inclined ground
- Opening type: opening 1

In order to evaluate the impact of characteristics that present variation in a very narrow range, namely, slenderness (h/l ratio) and material usage; the real limits are

broadened. Examination of binary combinations makes possible to filter effective characteristics. These characteristics are further examined in triple combinations.

Then, impact of characteristics is discussed with reference to literature review. Since studies on behavior of four sided dry masonry structures are limited (Jimenez 2011, Restrepo-Velez, Magenes, and Griffith 2014); studies on a dry masonry wall portion (Giuffre, Pagnoni and, Tocci 1994; Giuffre 1996; De Felice and, Giannini 2001), and dry masonry walls with one or two side walls (D'Ayala, and Speranza 2003; Restrepo-Velez, Magenes, and Griffith 2014; Shi, D'ayala, and Prateek 2008; Bui et al. 2017) are also taken into consideration. Sub-qualities that shape each characteristic is effective on structural behavior of towers are clarified. While investigating impact of a sub-quality, the best performance intervals of the other characteristics are taken into consideration.

Furthermore, it has been tested whether the sub-qualities are a parameter affecting the resistance of the structure and if there is a parameter, impact value of a sub-quality is determined with statistical evaluation. By using the data set gathered from tilt analysis of hypothetic towers, multiple regression analysis is carried out with the help of the Eviews software. The sub-qualities are identified as variables (X); collapse angle is identified as dependent variable (Y) for statistical evaluation.

Multiple regression analysis helps predicting the value of the dependent variable Y for given values of independent variables X_1, X_2, …, X_k. In general, the multiple regression equation of Y on X_1, X_2, …, X_k is given by:

$Y = \text{constant} + b_1 X_1 + b_2 X_2 + \ldots\ldots\ldots\ldots\ldots\ldots + b_k X_k$ (Eviews 2017).

b_1, b_2, b_3, …, b_k are called regression coefficients. Y is the dependent variable. Thus, if $b_1 = 2.5$, then Y will increase by 2.5 units, when X_1 is increased by 1 unit.

With regression analysis, the coefficients and probability of the variables and probability and acceptance of regression model are determined. If the probability of coefficients and the model is close to zero, it means that the results are significant, and variables are accepted as parameters affecting regression model (Eviews 2017). Coefficient of determination (R-squared) shows the proportion in which the independent variable is explained through the variables. R-squared always lies between 0 and 1. The statistic will equal one, if the regression fits perfectly, and zero, if it fits no better than the simple mean of the dependent variable (Eviews 2017).

Each parameter unit increases or decreases the strength of the unit's structure by 1 unit. For example, if the coefficient of the stone depth is 0.032; this means that when the stone depth increases by 1 cm, the degree of collapse angle increases by 0.032 degrees.

However, if the parameters have different unit types, comparison of parameters cannot be carried out. In order to compare the parameters with each other, an impact analysis is performed using the standard deviation value and coefficients of each parameter with the formula in the below:

Impact value = Coefficient of independent v. x Standard Deviation (Independent v.)
/Standard Deviation (Dependent v.)

With the help of the impact values (Appendix C), dominancy of parameters can be compared with each other (Ünal et al. 2017; Yavuz et al. 2017; Ertekin, and Özeren 2017). At last, vulnerability framework is proposed with the help of the impact values of parameters gained by statistical evaluation and failure mechanisms related to the parameters. The framework is based on data coming from only analysis of hypothetic towers, but not on data of previous studies. So, it is specific to dry masonry towers only.

Vulnerability is assessed in incremental steps with the help of the impact values of parameters; ranking vulnerability at levels such as very high, high, medium, low, considerably low and critical. Vulnerability rankings are determined for openings at in-plane position, since always the worst case is considered. Types of failures as body, in-plane, hybrid and out-of-plane are evaluated separately for positioning of openings at in-plane and out-of-plane walls. At the end, the framework is applied on case study towers.

1.7. Content of the study

This study is composed of five chapters; introduction, documentation, impact analysis, discussion and conclusion.

In the first chapter, dry masonry construction techniques and their behaviors under lateral loading are introduced. Then, structural analysis methods used in investigating the failure mechanisms of dry masonry structures and statistical analysis methods used for the assessment of abundant data regarding various disciplines are presented with reference to literature review.

In the second chapter, case studies are identified with reference to measured survey, visual analysis and literature review. Their structural characteristics are described in in detail.

In the third chapter, classification is made to define the types of each characteristic documented in the previous chapter. These possible types are combined with each other;

in turn, hypothetic towers are designed. Hypothetic towers are analyzed with quasi-tilting method, which is validated with experimental results in laboratory and literature. In turn, maximum collapse angles and related failure mechanisms are obtained for all possibilities. Results regarding various combinations are grouped. First, the results regarding towers in which two characteristics present variation and the rest are kept constant are evaluated. These are named as binary combinations. It is seen wall profile is the most effective characteristic in determining the collapse angle and failure mechanisms. In addition, opening type and h/l ratio are effective in specific situations. So, these three characteristics should be evaluated together: Triple combinations are evaluated in terms of collapse angles and failure mechanisms.

In the fourth chapter, impact of effective characteristics on structural resistance and behavior of towers are discussed with reference to literature review. The parameters that shape the effective characteristics and their relative effect on overall structural strength of a tower are evaluated statistically. Impact values of parameters are determined. Then, vulnerability assessment framework for towers is proposed by using all discussed data. At last, this framework is applied to the case study towers (Figure 16).

In conclusion, all outputs regarding the structural strength and weakness of dry masonry towers are summarized.

1.8. Terminology

Characteristic: A distinguishing structural and morphologic quality of a tower; e.g. wall profile, material usage, etc.

Effective characteristic: Characteristics effective in structural resistance of a tower; e.g. wall profile, opening organization.

Ineffective characteristic: Characteristics ineffective in structural resistance of a tower; e.g. ground topography.

Characteristic type: A specific characteristic of towers possessing definite qualities; e.g. wall profile type 1, opening type 14, etc.

Sub-quality: Qualities affecting dominancy of characteristics on resistance and behavior; e.g. staggering ratio and stone depth are sub-qualities of wall profile, opening area and number are sub-qualities of opening organization, etc.

Variable: Distinguishing sub-qualities of characteristics for use in statistical approach; e.g. staggering ratio, etc.

Dependent variable: A variable that depends on other variables; collapse angle.

Independent variable: A variable that is not changed by the other variables; e.g. staggering ratio, etc.

Parameter: Significant variables (sub-qualities) according to results of statistical approach; e.g. staggering ratio, etc.

Hypothetic tower: A tower designed with combination of possible characteristic types; e.g. wall profile 1, opening organization 14, H/L ratio 2, ground topography flat and limestone usage.

Update timestep: "Timestep" is the time interval for which simulation will progress during next "step".

Iterative Value: A procedure that involves repetition of steps (iteration) to achieve the desired outcome.

Resistance: Structural strength against lateral loading.

Failure mechanism: The physical process in which structural resistance ability is lost as a result of excessive lateral loading.

Collapse angle: The highest angle of resistance of a tower against lateral loading just before collapse occurs.

Vulnerability: Capability of or susceptibility to lateral loading.

Risk: The potential negative impact of lateral loading.

CHAPTER 2

CHARACTERISTICS OF CASE STUDY TOWERS

The six case study towers in Caria, Pamphylia and Cilicia regions are introduced within their geographical and historical contexts.

2.1. Towers in Caria

First; Latmos and Alinda towers are identified; then, the earthquake history of the region is summarized.

2.1.1. Latmos Tower

Latmos Tower is located in Herakleia on Mount Latmus, which is the current Beşparmak Mountains, Kapıkırı, on the eastern shore of Lake Bafa. The Mount Latmus is located 150 km at the south of Izmir, halfway between the cities of Söke and Milas. Its northern part belongs to Aydın, while its southern part belongs to Muğla. In the antiquity, this region formed the north-western part of Caria. Caria in the southwest of Asia Minor was bordered by Ionia in its north-west, Lydia at its north, Phrygia and Pisidia at its east (Figure 19), (Peschlow-Bindokat 2014, 16).

It is not known when the city of Latmos was exactly established, however, literary and epigraphical sources demonstrated that the city was built at the 6th century BC. According to prehistoric rock paintings and settlements, the earliest evidence of human life belonged to Hittite Empire in the 2nd millennium BC. In the time of colonization, around the transition from 2nd to the 1st millennium BC, the Ionians, who had immigrated to Asia Minor, removed the Carians from the coast areas to the Carian hinterlands. However, with the help of the rock wilderness of the Latmos, the city was not affected by colonization and the area had always belonged to Carians. Until the end of the 5th century BC, Latmos was a settlement without fortifications. In that period the city was part of the Delian-Attic Leage, as its neighbours Myus and Priene were. Probably in the first quarter of the 4th century BC, the city was enclosed with a wall. In its layout, the fortification

wall of Latmos is a typical great circuit wall. The fortifications consisted of a wall ring with fourteen towers and three forts (McNicoll 1997, 77-79; Peschlow-Bindokat 2014, 98-104).

In the beginning of the 3rd century BC, Pleistarchheia, Macedonian Commander, controlled the large parts of Caria and made the Herakleai capital of its empire. Part of the Carians founded a new settlement on the southwest slope of the mountain in 300 BC. In that period, the city was named as Pleistarchheia, later, it was called as Herakleia. At Herakleia, the city walls are still partly preserved up to their total height, whereas the walls of Latmos were entirely pulled down when the town was abandoned (Peschlow-Bindokat 2014, 116) (Figure 20).

Figure 19. Ancient Caria (Source: Kiepert 1903)

The city had its greatest power during the Hellenistic period, with its harbor and transshipment position. In contrast to the organically grown old Carian settlement of Latmos, Herakleia had regular city plan recognized as a typical Greek-Hellenistic City (Peschlow-Bindokat 2014, 117-118). However, in the Roman Period the city lost its

earlier importance. In the 1st century BC, the Bafa Lake formed with land movements, and the direct relation of city and sea was lost. Marine trade completely ended. The settlement was abandoned. In the 1st century AD, the Christian Missioners had settled in the city. A number of monasteries were constructed in the area (T.C. Muğla Valiliği and Muğla Hizmet Vakfı 2019).

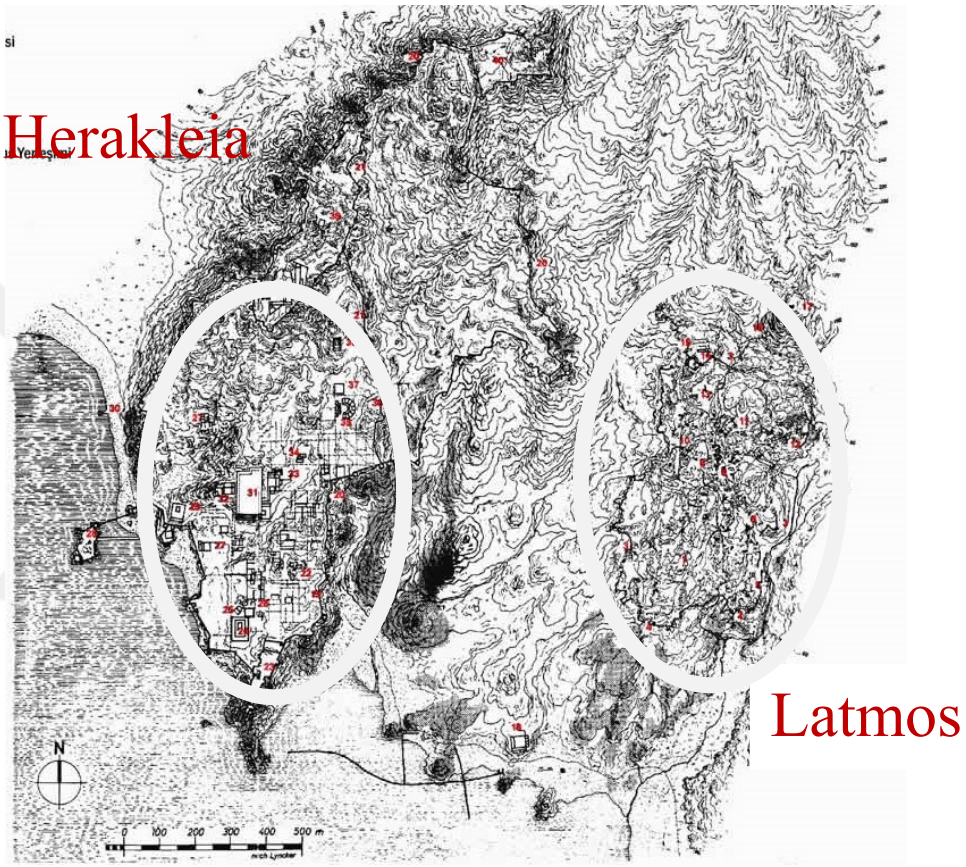


Figure 20. Location of Latmos and Herakleia (Source: Peschlow-Bindokat 2014, 100-101 from Lyncker 1912)

Herakleia ancient city was surrounded by fortification walls supported with towers irregularly. The case study tower at the upper citadel is still standing up to the level of its roof. Nearly squared planned (6.15x6.9 m) tower is constructed as an isodomic masonry structure with header and stretcher blocks (*Emplecton*). The tower is approximately 42 square meters. Since the two storied tower is located on a hill skirt, the height of facades present differences depending on their positions. The highest facade facing the Lake Bafa is approximately 1069 cm, while the shortest facade facing the

mountain is approximately 925 cm. The tower (Table 6) is connected with city walls from the southern and northern facades. There are two entrances at the northern and southern facades. At the lower storey, arrow slits for shooting are provided as seen in southern and western facades. At the upper storey, symmetrical openings (90x150 cm) are positioned on the western and northern facades. There are asymmetrical two openings (75x160, 143x210 cm) on the southern facade. The larger opening is adjacent to the corner. On the eastern facade, there is an asymmetrical opening (95x265 cm) in the middle (Figure 21).

Figure 21. Latmos Tower; northern and western facades

Characteristics of the masonry system is examined from units to wall. Two types of units are observed: header stones are longitudinal units, while stretchers are transverse units. Dimension of header stones are 30, 33, 50, 65x50x120 cm, while stretchers are about 100-150x50x50 cm. The masonry walls are composed of two outer leaves and a gap between them. The leaves are connected with header stones that do not touch each other and distributed evenly. Position of joints between blocks is described with staggering ratio (ratio between minimum length between joints and course height). Staggering ratio is between 0.6 and 0.1. Shorter lengths of header stones cause decrease in staggering ratio.

Wall thickness of the walls show differences in accordance with the story system. At the lower story, wall thickness is about 115-120 cm, while at the upper story, it is about 90 cm. After approximately 500 cm from the ground, wall thickness decreases.

Distribution of headers are similar in each facade. Area of headers are approximately 4-7 % at the corners and 8-10 % at the middle. Headers are observed at the intersection of corners. Two neighboring walls, western and northern wall have asymmetric corners, while the other neighboring walls have symmetric corners.

Beam holes (25x25 cm) for wooden floors are observed approximately 550 cm from the ground level. Wooden floor was probably composed of eight beams with 60 cm intervals. First and last beams are located on the thicker ground floor wall. Stone blocks on the very top were provided to carry the pitched roof.

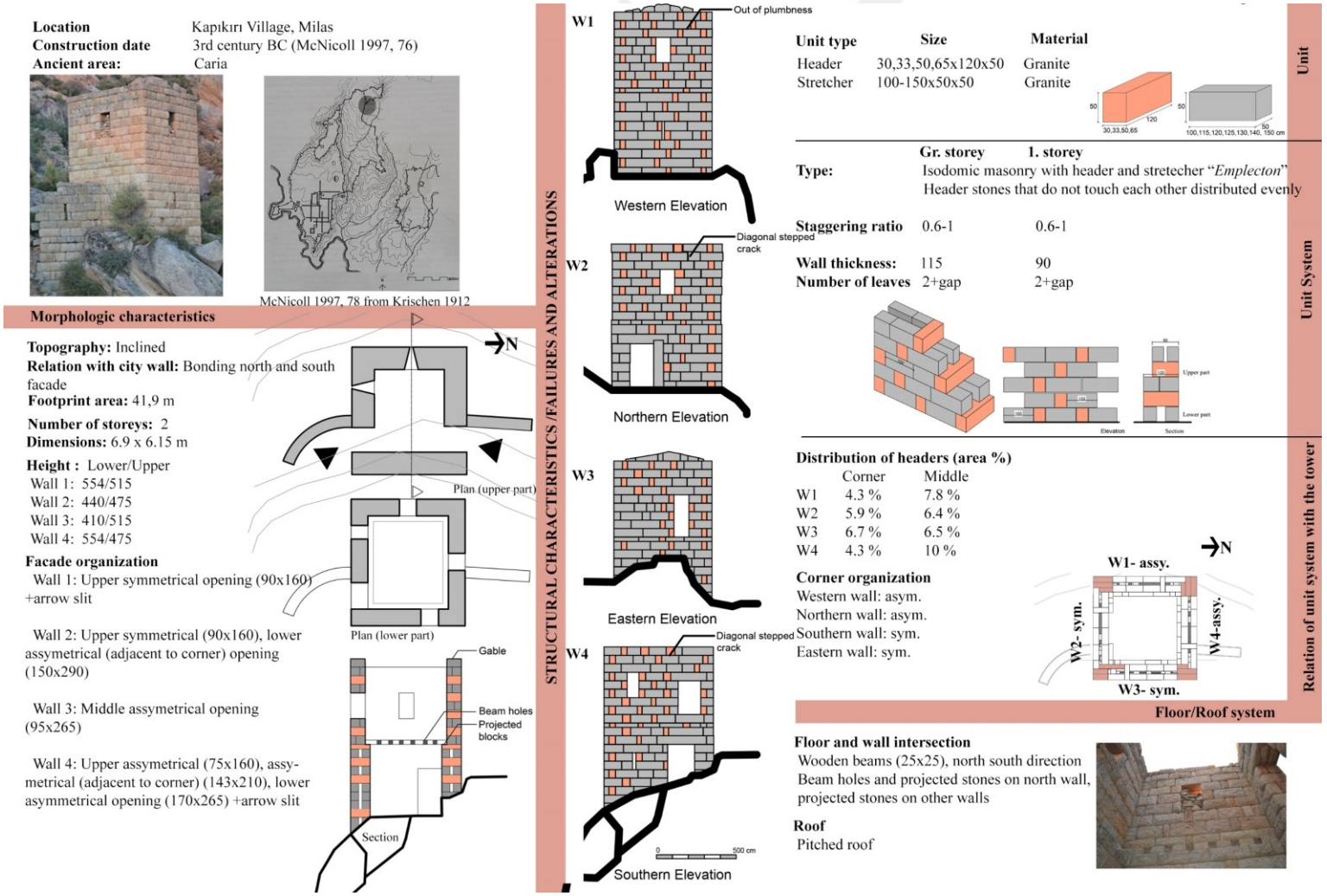
The tower has sustained its original morphologic and structural characteristic, except the timber floor and the roof. The dry masonry walls have almost no structural failure, they have just minor problems such as diagonal stepped cracks and slight out of plumpness of the wall (Table 6).

2.1.2. Alinda Tower

Alinda is an ancient inland city in Caria, Asia Minor (Anatolia). It is situated on a hilltop near Demircideresi, Karpuzlu, Aydın in western Turkey and overlooks the plain of Karpuzlu. The remains of ancient Alinda extend over the eastern slope of a mountain ridge that rises from the edge of Karpuzlu plain. In the antiquity, the fortified town was responsible of the protection of the main route passing by Alabanda (Çine) and connecting Tralleis (modern Aydın) at the north and Physkos (modern Marmaris) at the south (McNicoll 1997, 26; Konecny and Ruggendorfer 2014, 709).

According to the tribute lists of the Delian League, Alinda was a party to the treaty from the year of its foundation in 478/7 BC, together with 40 other communities in the Ionian-Karian region (McNicoll 1997, 26). An honorary inscription giving information about Hellenistic Period of Alinda was found in Karakol, a village in the eastern part of the Karpuzlu plain. The inscription is dedicated to Dionytas and Apollas, rulers of Olympichos, who controlled Caria between 240 and 220 BC (Laumonier 1934, 291–298; Konecny and Ruggendorfer 2014, 711).

Table 6. Characteristics of Latmos Tower



After removal of Princess Ada from Halicarnassus by Pixodarus in 341 BC, she came to Alinda. She remained in Alinda until the arrival of Alexander in 334 BC. Alexander recognized her as the satrap of Caria, then, the city was rapidly Hellenized. Probably fortifications were constructed before 341 BC. The length of the walls that enclose the settlement was 400 m whose of 2000 m are still extant and visible. It has a total of nineteen towers. Several towers are still standing up till their upper stories (McNicoll 1997, 26) (Figure 22).

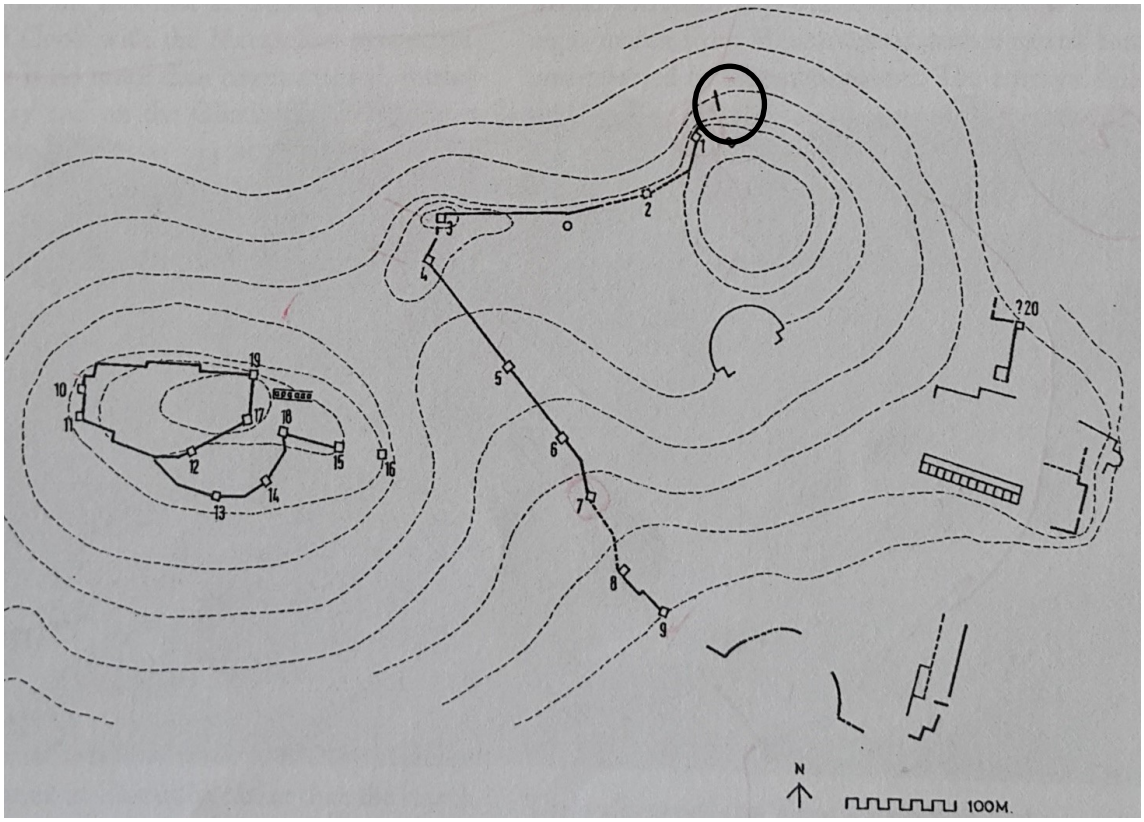


Figure 22. Alinda ancient city and the location of the case study tower (Source: McNicoll 1997, 27)

The case study tower was located at the east of the city. The tower, located on inclined topography, has three stories. The upper floor is approximately 6.25 m., while ground storey's height show differences depending on inclined topography. Therefore, the mezzanine floor's position varies between 3.10-7.80 m from the ground. The total height of facades shows differences depending on their positions. The highest facade facing the plain is approximately 1405 cm, while the shortest facade facing backyard is approximately 935 cm. The tower is connected with city wall from the southwest and

northeast facades. The floor coverage is approximately 47 m^2. There are two entrances at the southwestern and southeastern facades. The southwestern entrance opens to the exterior of the city. Except southeastern facade, small sized openings (100x100 cm) are positioned asymmetrically and symmetrically. On the southeastern facade, one symmetrical large (172x330 cm) and two symmetrical small sized (100x100 cm) openings are positioned. The large opening was probably the entrance of the upper floor. The upper floor may be accessed via wall walks that continue as timber floor projection (McNicoll 1997, 28-30). Position of timber beams can be observed from the facade.

The tower is constructed as isodomic masonry (*emplecton*) composed of headers and stretchers. Headers are about 30, 33, 50, 65x50x120 cm in dimension, while stretchers are 100-150x50x50 cm in dimension. The length of only one stretcher on the southwestern wall reaches 590 cm. Usage of such a long stone is rare for dry masonry tower technology. Staggering ratio is between 0.75 and 2.

The masonry walls are composed of two outer leaves and a gap between leaves. The leaves are connected with header stones that do not touch each other and are distributed evenly. Area of headers in each wall are approximately 1.6-3 % at the corners and 6-8 % in the middle. However, on the southwestern facade, headers are just positioned in the middle (4 %).

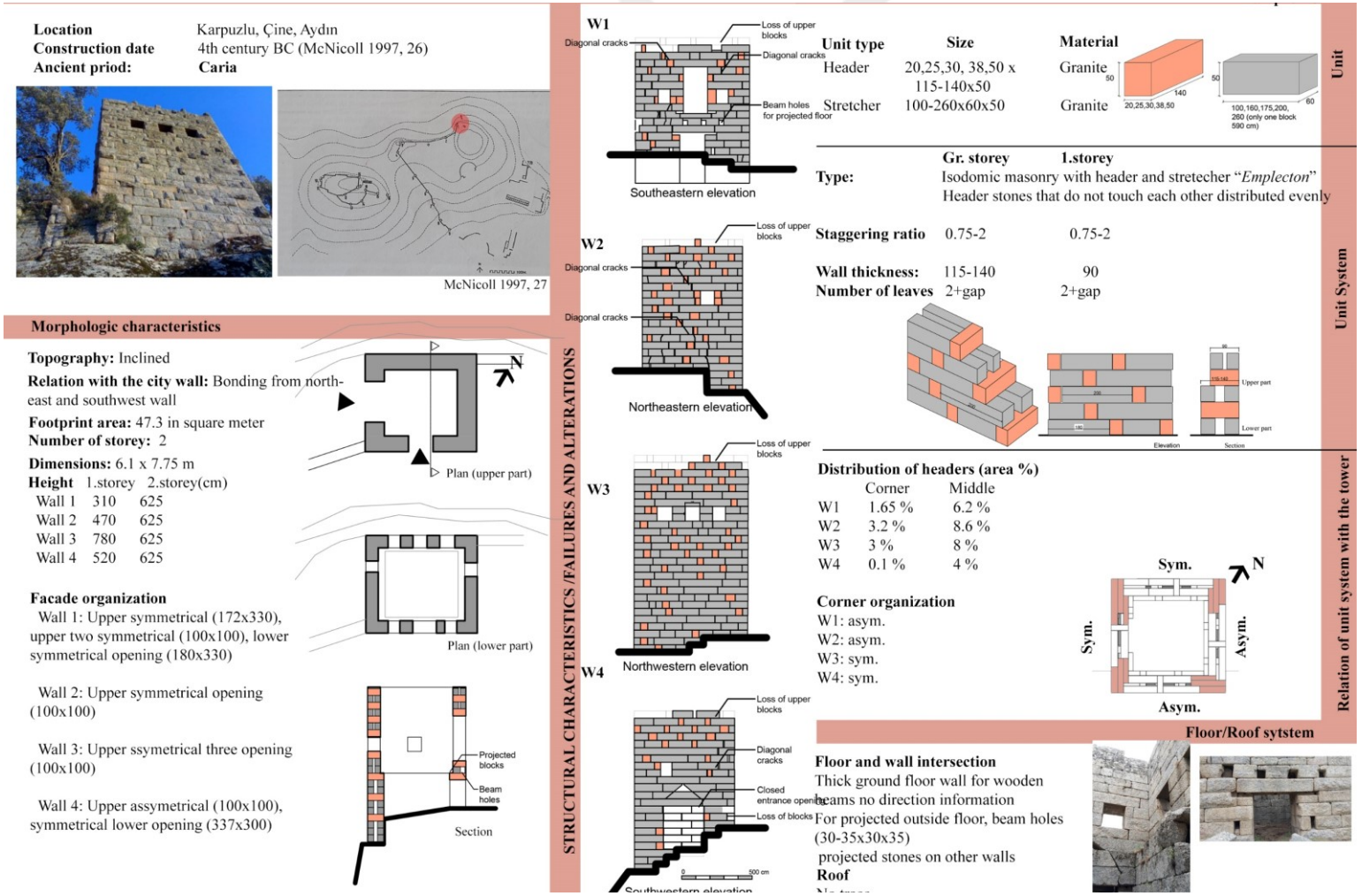
Wall thicknesses present differences in accordance with their stories. At the ground story, wall thicknesses are about 115-140 cm, while at the upper one, wall thicknesses may decrease to 90 cm.

Headers are observed at the corners. The two neighboring walls, southeastern and northeastern walls have asymmetric corners, while the other neighboring walls have symmetric corners.

Wooden floor beams were probably positioned on thicker ground floor wall, while there are no traces about the direction of the beams. However, beams' holes (app. 30x30 cm) are observed on the southeastern facade for to support the projection reaching the upper floor.

The tower has sustained its original morphologic and structural characteristics, except its timber floors and roof. Diagonal stepped cracks are observed above and below the openings. The diagonal cracks are seen at the lower part of the southeastern facade. Separation of upper blocks is observed due to the loss of the timber roof (Table 7).

Table 7. Characteristics of Alinda Tower



2.2. Towers in Pamphylia

Sillyon and Perge Towers in Pamphylia region are identified.

2.2.1. Sillyon Tower

Sillyon Tower is located in Sillyon Ancient City (1 BC, 1 AD), Pamphylia, southern Anatolia. It is on a 210 m high butte 28 km at the northeast of Antalya (Bryce 2009, 653).

Side, Aspendos, Sillyon, Perge, Magydos, Olbia and Phasalis were the seven cities that emerged in Pamphylia in the Archaic period (before 700 BC) (Figure 23). Two other cities were established in the Hellenistic Period: Attaleia, Korakesion. The first seven can be classified as four coastal (Side, Phasalis, Magydos and Olbia) and three inland (Sillyon, Perge and Aspendos) cities (Figure 24). The three inland cities were founded at the quarter century BC, after Phasalis (Grainger 1939, 4).

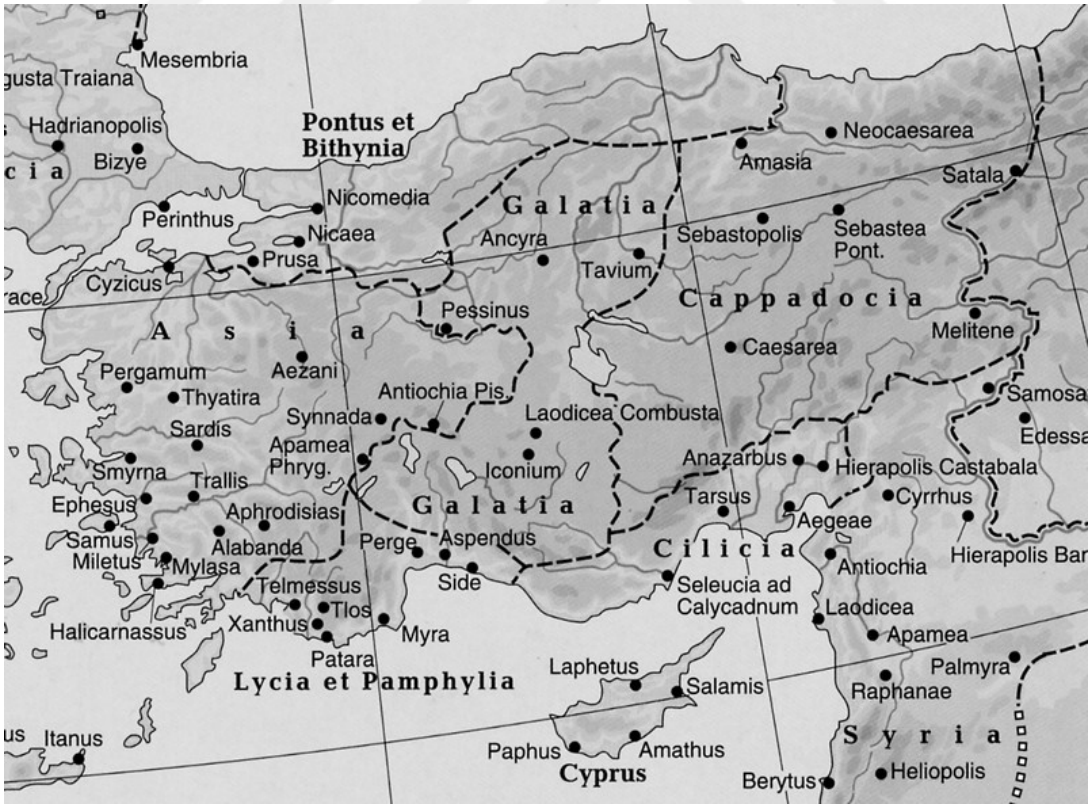


Figure 23. Location of Pamphylia Region (Source: Brandt and Kolb 2005)

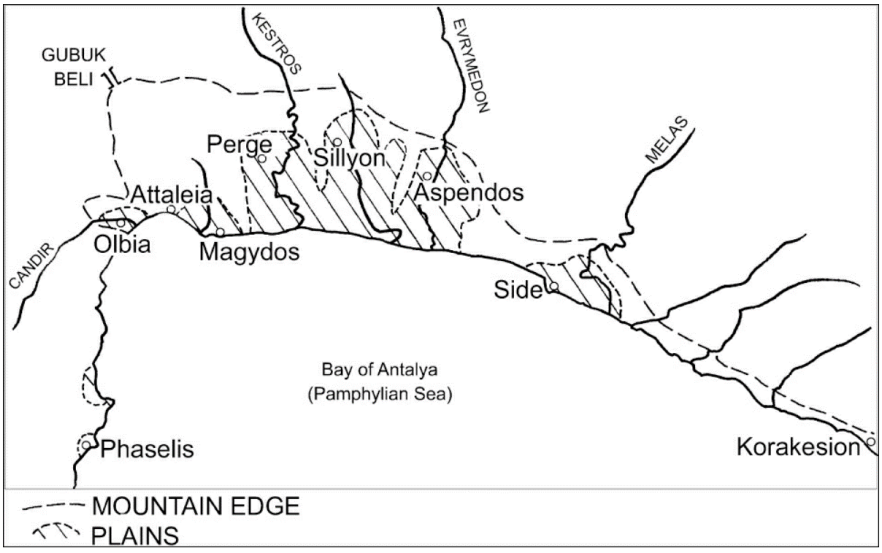


Figure 24. Cities of Pamphylia (Source: Grainger 1939, 4)

Sillyum is located near Asar Köy, 12 km at the north-east of Perge (Strabon 1991; McNicoll 1997, 136). It was one of the settlements in southern Anatolia whose foundation was associated with the legendary Mopsus, who was the founder of several Pamphylian towns (Bryce 2009, 522-523).

The recorded history of the city is limited. The city is mentioned for the first time in the Periplus of Pseudo-Scylax, an ancient Greek periplus describing the sea route around the Mediterranean and Black Sea (fourth century BCE) (McNicoll 1997, 136). After that time Alexander the Great' army came to the place, however, it failed to take the city due to the Barbarians and foreign mercenaries (Arrian 1884, 72). Sillyum and Termessus in Pisidia are famous as the only cities in the southern Asia Minor which managed to stand out against the Macedonian forces. According to Arrian, Alexander found a Persian garrison during his occupation of Sillyon in 334 BC (1884). That is direct written evidence for Persian involvement in Pamphylia (Grainger 1939, 3). The city was reconstructed under the Seleucids. In later times, when most of western Asia Minor was under Kingdom of Pergamon, Sillyon remained as a free city by a decision of the Roman Senate (Gernot 2003, 439–443).

Sillyon is comprised of two parts; the upper sill and the lower ground. Most of the ruins are found in the sill. Lower ground was developed later. Over the years, the settlement expanded to the southeast, partly due to the need of its inhabitants to be close to their farms in the plain. During the Imperial period, the area was strengthened with a new fortification (McNicoll 1997, 137; Sielhorst 2011, 31-46). A two-storied defensive

tower with six windows has survived intact (McNicoll 1997, 139). Sillyon's remains include city walls, a city gate, a temple, a theater, an odeum, simple rectangular tombs and domestic architecture. In Sillyon, city walls were composed of a number of towers such as gate towers and bastion towers (Özer and Taşkıran 2012, 204). However, most of the towers were demolished. The case study tower has sustained its authenticity and integrity (Figure 26). It is located at a less inclined topography at the west of the city.

The nearly squared planned (6.8x5.75 m) tower was constructed as an isodomic masonry structure at its ground floor and pseudoisodomic masonry at its upper floors. The tower is approximately 3.9 square meters. It has two stories in addition to the ground floor. The height of the tower is approximately 10.25 m (Figure 26).

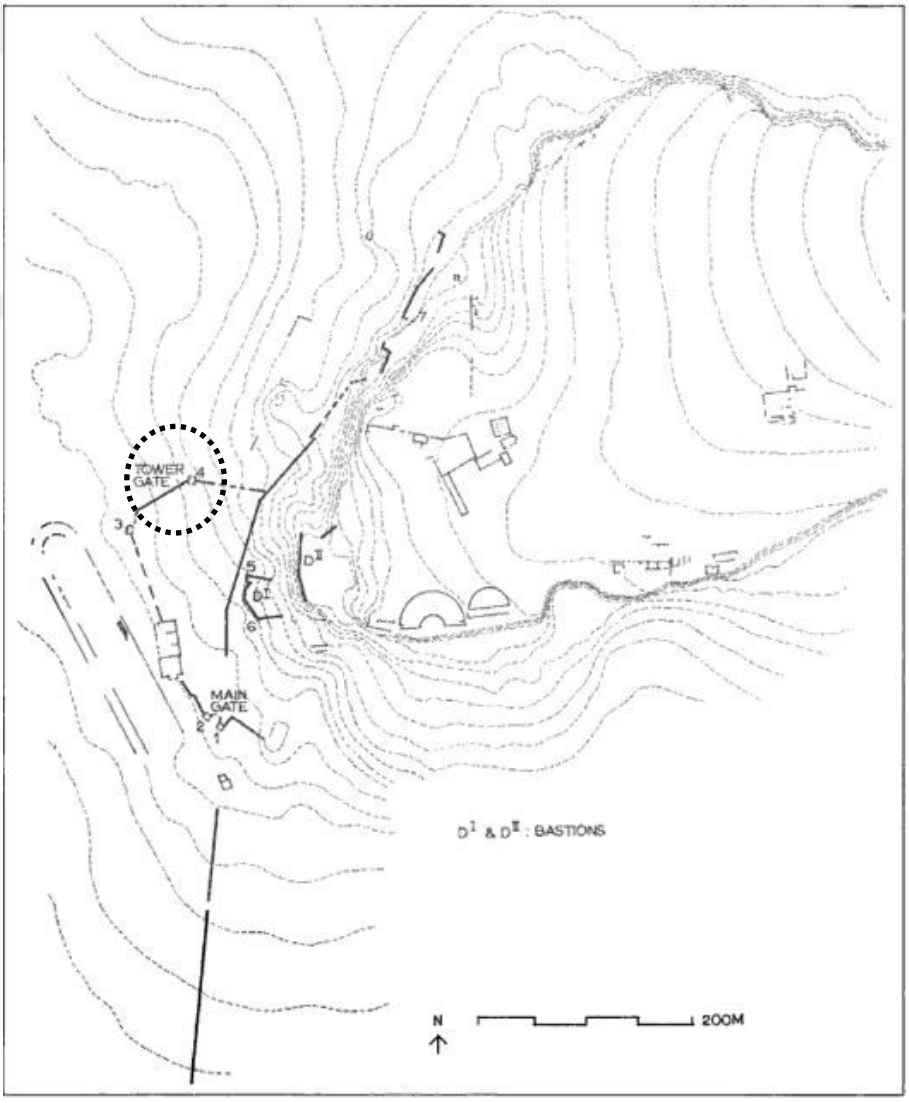


Figure 25. Location of Sillyon Tower (Source: McNicoll 1997, 138)

Figure 26. Sillyon Tower, northern and western facade

The city wall is perpendicular to the tower's east and west facades. There are two entrances at the north and south facades. The wall walks of the city wall continue throughout the tower. The tower's ground floor is a gate with a flat arched entrance at the north facade and a semicircular arched entrance at the south facade. On each facade, at the last story, there is a symmetrical opening (50x75 cm), while in the middle story, dimension and location of the openings present differences. On the southern and northern facades, small sized symmetrical openings (50x75) are positioned, while on the eastern (105x217 cm) and western facades (105x300 cm), size of the openings are relatively larger, and openings' positions are asymmetrical. The opening on the western facade is adjacent to the corner.

The masonry system is examined from unit to building whole. Ground story is composed of rectangular blocks that have uniform dimensions (100-120x50x75 cm), at the upper stories except the mentioned rectangular blocks, shorter adjacent row stone blocks: about 100-120, 175x25-30x75 cm are located at each two rows. Ground story is isodomic masonry, while upper two stories are constructed as pseudoisodomic masonry. Squat blocks are located in each sequential course. Approximately 25-30 % of each wall are composed of squat stone blocks. Depending on the organization of blocks, staggering ratio at the lower (0.6-1) and upper-parts (1.5-2) present differences. With the help of the squat blocks, the staggering ratio at the upper part is approximately 1.75. The thickness

of the walls is equal to the depth of the stone blocks (75 cm), thus wall profile is composed of one leaf (Table 8).

When corner organizations of walls are examined, two neighboring walls, south and west wall have asymmetric corners, while the other neighboring walls (north and east) have symmetric corners.

The lost wooden floor system was probably composed of beams (app. 15-20x15x20 cm). Beam holes of each story are observed at the inner walls. According to beam holes, the direction of beams is from east and west, along the long side.

The tower has sustained its original morphologic and structural characteristic, except wooden floors. There is no trace of gabling at the roof. The most problematic structural failure is vertical cracks observed in all of the facades. Also, diagonal stepped cracks are observed at the top and bottom portions of the upper and middle openings.

2.2.2. Perge Tower

The tower is located in Perge ancient city, two kilometers at the north of Aksu Village, Antalya. Perge, which was one of the inland cities of Pamphylia, on the south west of Sillyon and west of the Aksu Çay (Cestrus). According to Strabon, Perge was established by colonists from Argos (Pekman 1989, 5-6). Also, the name of "Perge" and "Kestros" were recorded in an inscription found around Boğazköy and dated to 13th BC. In addition to this document, archaeological remains date to the late Chalcolithic and early Bronze age (Pekman 1989, 5-6; Abbasoğlu 2007, 21-22).

In the 7th century BC, Greek colonies and local people settled (Abbasoğlu 2001, 1). Perge became a Hellenistic city in the 4th century BC. The city developed from the hillskirts of the acropolis towards the plain area (Abbasoğlu 2001, 1). The city walls were probably constructed in 4th century BC in Hellenistic Period. In 333 BC, the city was conquered by Alexander the Great without any resistance (Arrian 1884, 26; Pekman 1973, 18-19). In 100 BC, the city became a part of Cilicia. In the 2nd AD, the city lived its most brilliant period (Abbasoğlu 2000, 44).

The city is composed of three parts: the Acropolis at the north; the Lower City, which was surrounded by early Hellenistic Fortifications; and the Southern Extension, a part of which was also fortified with a wall in a later period (Akarca1987, 81) (Figure 27).

Table 8. Characteristics of Sillyon Tower

Location Serik, Antalya
Construction date Late 2nd century BC (Nossov 2009, 25)
Ancient area Pamphylia

(McNicoll 1997, 138)

Morphologic characteristics

Topography: Less inclined
Relation with the city wall: east-west wall
Footprint area: 39 in square meter
Number of storeys: 3
Dimensions: 6.8x5.75 m

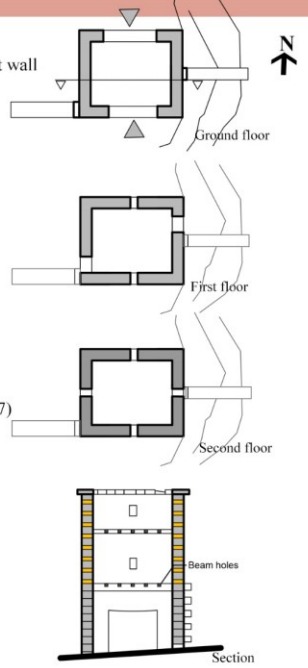
Height
1. storey 4.55 m
2. storey 3 m
3. storey 2.8 m

Facade organization
Wall 1: Upper symmetrical (50x75), middle symmetrical (50x75), lower symmetrical opening (335x310)

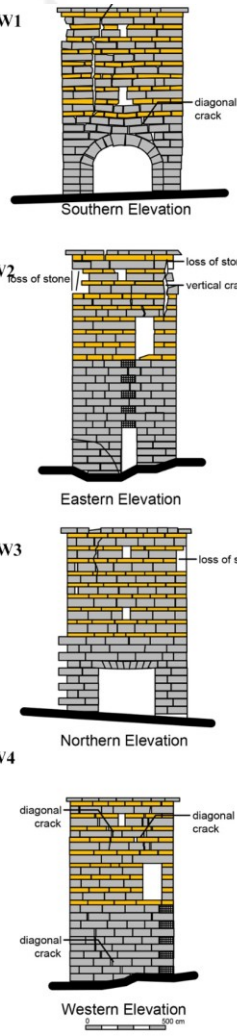
Wall 2: Upper symmetrical (50x75), middle asyymetrical opening (105x217)

Wall 3: Upper ssymetrical (50x75), middle symmetrical (50x75), lower symmeetrical opening (320x290)

Wall 4: Upper assymetrical (50x75), middle asymmetrical (adjacent to corner) opening (105x300)

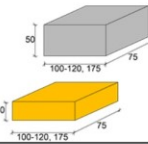


STRUCTURAL CHARACTERISTICS /FAILURES AND ALTERATIONS



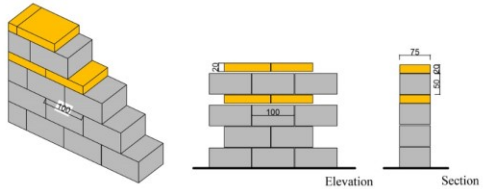
Unit

Unit type	Size	Material
Rectangular1 (row stone)	10-120, 175 x25-30x75	Limestone
Rectangular2	100-120, 175x50x75	Limestone



Unit System

Type:	Gr. storey Isodomic	1. storey Pseudoisodomic	2. storey
Staggering ratio	0.6-1	1.5-2	1.5-2
Wall thickness:	75	75	75
Number of leaves	1	1	1

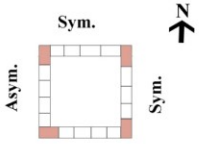


Relation of unit system with the tower

Distribution of row stones (area %)

	Corner
W1	26 %
W2	24 %
W3	27 %
W4	29 %

Corner organization
W1: asym.
W2: sym.
W3: sym.
W4: asym.



Floor/Roof sytstem

Floor and wall intersection
Beam holes (15-20x15-20)
Direction: north-south

Roof
No trace

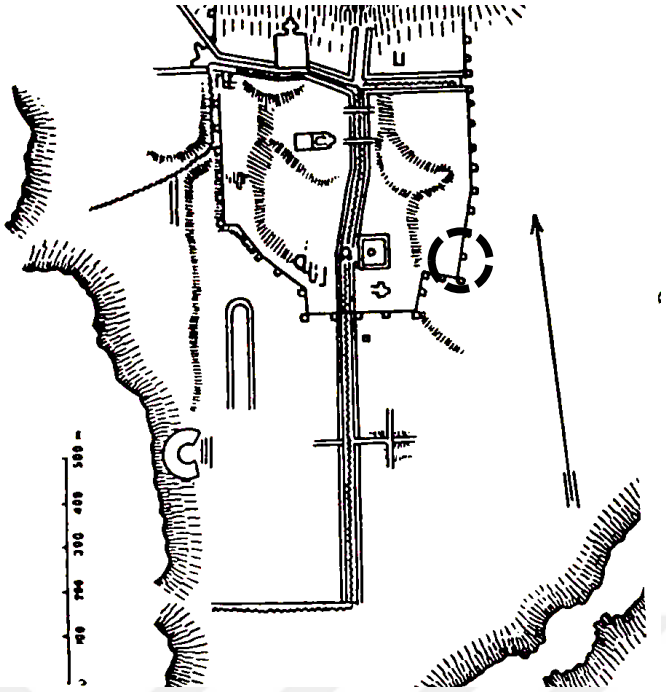


Figure 27. Perge ancient city and location of the case study tower (Source: Akarca 1998, 81)

The Acropolis was established at the northern portion of the hill and was served by an ancient road leading to the Attalia direction. Spreading over the valley beneath the hill, the Lower City is laid out in a grid-iron pattern (Akarca 1987, 81). The borders of the lower city are marked with the remains of a Hellenistic Fortification and the city itself identified a residential area and a number of social constructions, including a bath, palestra, agora and a well-developed water system with a Nymphaeum and channels. The third part of city is a later-period southern extension to the lower city and is composed of two parts: part one was fortified with a later period addition to the old fortifications, while part two was not fortified. The additional fortifications enclose the Basilica, the Southern Bath and the Agora inside the city, while important structures like the stadium and the theatre are placed outside.

The Hellenistic towers of Perge project out of the city walls (McNicoll 2014, 128). The case study tower is one of the towers bonded to the older wall at the east of the city. The wall walks run behind it. However, all of the towers were demolished or had lost their integrity. Old photographs give data about the integrity of the towers (Figure 28). The case study tower, located on a plane ground, has three storeys with the ground storey.

Square planned tower, constructed as an isodomic masonry, is approximately 46 square meters. The height of the tower is approximately 13.7 m.

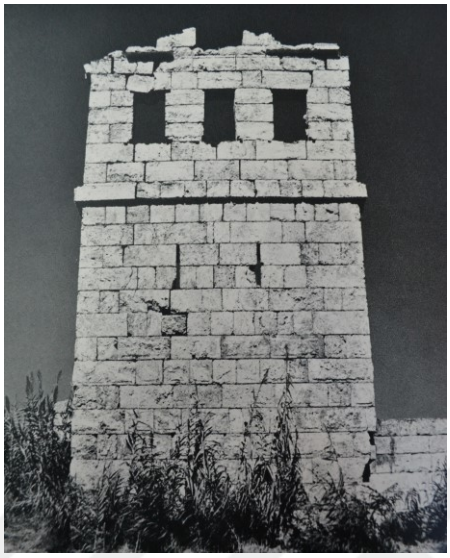


Figure 28. Old photograph of Perge Tower (Source: Martin 1967, 33)

The city wall is bonded to the tower from its north and south. The entrance is located at the inner side of the city walls on the western facade. At the middle stories, there are slits facing the north and south directions and two slits facing the east of the city. At upper story, there are three symmetrical openings (90x150 cm).

Ground and first stories' walls are constructed with stretchers (100-120x50x60 cm) and header blocks (60x50x120 cm), however, upper walls are composed of just stone blocks: 100-120x50x60 cm in dimension. Ground and first story walls are constructed with adjacent header stones lying along the wall depth in each sequential course, while header blocks are not used at the top floor. Depending on the usage of header stones, staggering ratio changed at the upper and lower stories. Staggering ratio at the upper story is between 0.6 and 1, while ratio is 0.3 at the lower two stories. Approximately 25% of each wall is composed of header stones at two lower stories.

The thickness of the walls at the lower two stories are equal to the depth of the header blocks: 120 cm. Lower stories are composed of two outer leaves without a gap. Upper wall is composed of one leaf: 60 cm.

When walls are examined in terms of corner intersections, all walls have mirror symmetrical corner organization due to their masonry technique.

The lost wooden beams of the floors were located at the thicker lower walls from north to south direction, however, traces are insufficient for determining the dimension of the beams.

Except its eastern wall, all the other walls were demolished. Upper parts of the north and south walls were separated in form of diagonal steps. Upper part of the western facade had totally collapsed (Table 9).

2.3. Towers in Cilicia

Gömeç and Sarayın Tower located in Cilicia Region are identified.

2.3.1. Gömeç Tower

The case study watchtower is located in the district of Erdemli in Mersin province, about three kilometres at the north of Kızkalesi and 20 kilometres at the southwest of Erdemli. There are a number of towers in the area. The older tower of Gücük is about 200 m away from the case study. Sarayın Tower is two kilometres southeast, and Akkum Tower is three kilometers southwest of the Gömeç Tower (Durugönül 1998, 12) (Figure 29, Figure 30).

The tower is located in Rough Cilicia. There is limited information on Rough Cilicia in the 10th and 20th century BC. According to remains, Rough Cilicia might have been located in the borders of Tarhundaşşa Kingdom or Hittite Empire. In 10th century BC, this area had been probably within the boundaries of Assyria. The area was named as “Hilakku” (Zoroğlu 1994, 440). In 612 BC, Assyrian administration was terminated (Sevin 1984, 286). Colonies were established in the area (Mansel 1970, 169). Then, the region “Pirundu” until the border of Gazipaşa at the west was taken under the rule of Babylon (Zoroğlu 1994), 440. After that, the area was taken under the rule of Persians (547-400 BC), Macedonian Empire (333 BC) and Seleucids. Towards the end of the 2th century BC, piracy and slave trade were prevalent. In this period, the watchtowers were constructed in the area for security. Romans fought against pirates, then in 67 BC, Romans took the control of the area over (Koşay 1968, 298). During the period of Seleucids and Roman Empire, the watchtowers had been probably constructed in the area for security.

Table 9. Characteristics of Perge Tower

Location Aksu, Antalya
Construction date 3rd century BC (Arrian 1884, 26)
Ancient priod: Pamphylia

(Martin 1967, 33)

(Akarca 1998, 81)

Morphologic characteristics

Topography: Plane

Relation with the city wall: north-south

Footprint area: 46.2 in square meter

Number of storeys: 3

Dimensions: 6.8 x 6.8 m

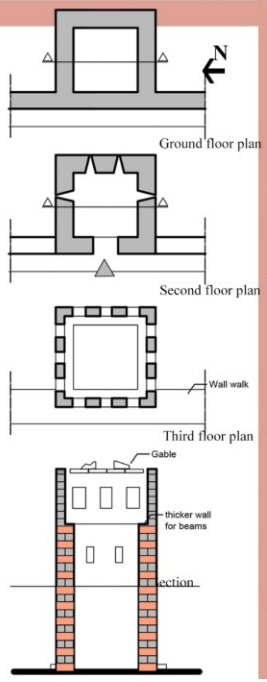
Height
1. storey 5.8 m
2. storey 4.2 m
3. storey 3.7 m

Facade organization
Wall 1: Upper symmetrical three opening (90x150) + two symetterical slits

Wall 2: Upper symmetrical three opening (90x150) +one symmetrical slit

Wall 3: Upper symmetrical three opening (90x150)+one symmetrical slit

Wall 4: Upper symmetrical three opening (90x150), lower symmetrical opening (..)



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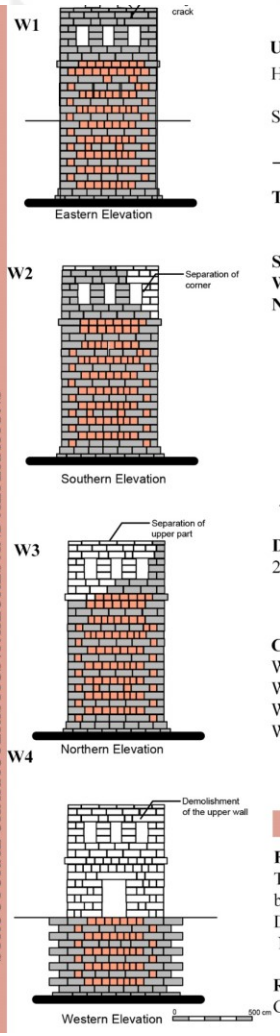
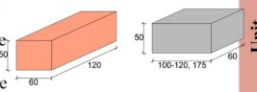


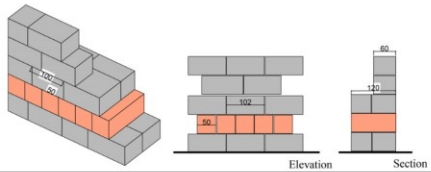
Unit System

Unit

Unit type	Size	Material
Header	60x50x120	Limestone
Stretcher	100-120x50x60	Limestone



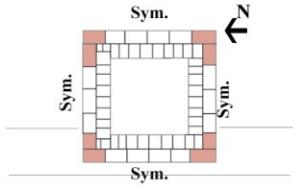
	Gr. storey	1. storey	2. storey
Type	Isodomic masonry with header and stretcher (Adjacent header stones in ecah row at lower two level)		Isodomic
Staggering ratio	0.3	0.3	0.6-1
Wall thickness:	120	120	60
Number of leaves	2	2	1



Relation of unit system with the tower

Distribution of headers (area %)
25 % header stones at lower two levels in each wall (in area)

Corner organization
W1: sym.
W2: sym.
W3: sym.
W4: sym.



Floor/Roof sytstem

Floor and wall intersection
Thick first floor wall for wooden beams
Direction: north-south
No size trace

Roof
Gable, pitched roof

Figure 29. Location of towers (Source: YandexMaps 2018)

In Rough Cilicia, particularly in the area between the river Kalykadnos (modern Göksu) and the Lamos (modern Limonlu), there are many Late Hellenistic and Roman towers. Some of these were free-standing, some were parts of fortresses. There are five free-standing towers in the isodomic style (Akkum, Boyan, Gömeç, Sarayın and Yalama). They were probably built between the end of Seleucid rule in 133 BC, the defeat of the pirates by Pompey in 65 BC (Durugönül 1998, 94-96; Kaplan 2014, 72).

The studied tower was located on the ancient Roman road from Korykos to Olba-Diocasearea. It is known that it was built for guarding pirate activities along the coast of Korykos. It also knows that these towers were also used for storing grain (Mitford-Andrews 1980, 1247). The squared planned (4.75x4.75 m) tower is constructed isodomic masonry. The tower is approximately 22.6 square meters. It has four storeys with ground storey. Beam holes in each storey are observed at the inner walls. The height of the tower is approximately 10.86 meters. City wall remains have not been observed around the tower. There is an asymmetrical entrance (100x180 cm), and small (100x100 cm) openings in the middle and upper storeys of the western facade. However, the openings in the middle were closed by cut stone blocks. There are small sized openings (100x100 cm), which have been closed later, at the upper stories of the northern and southern facades (Figure 31).

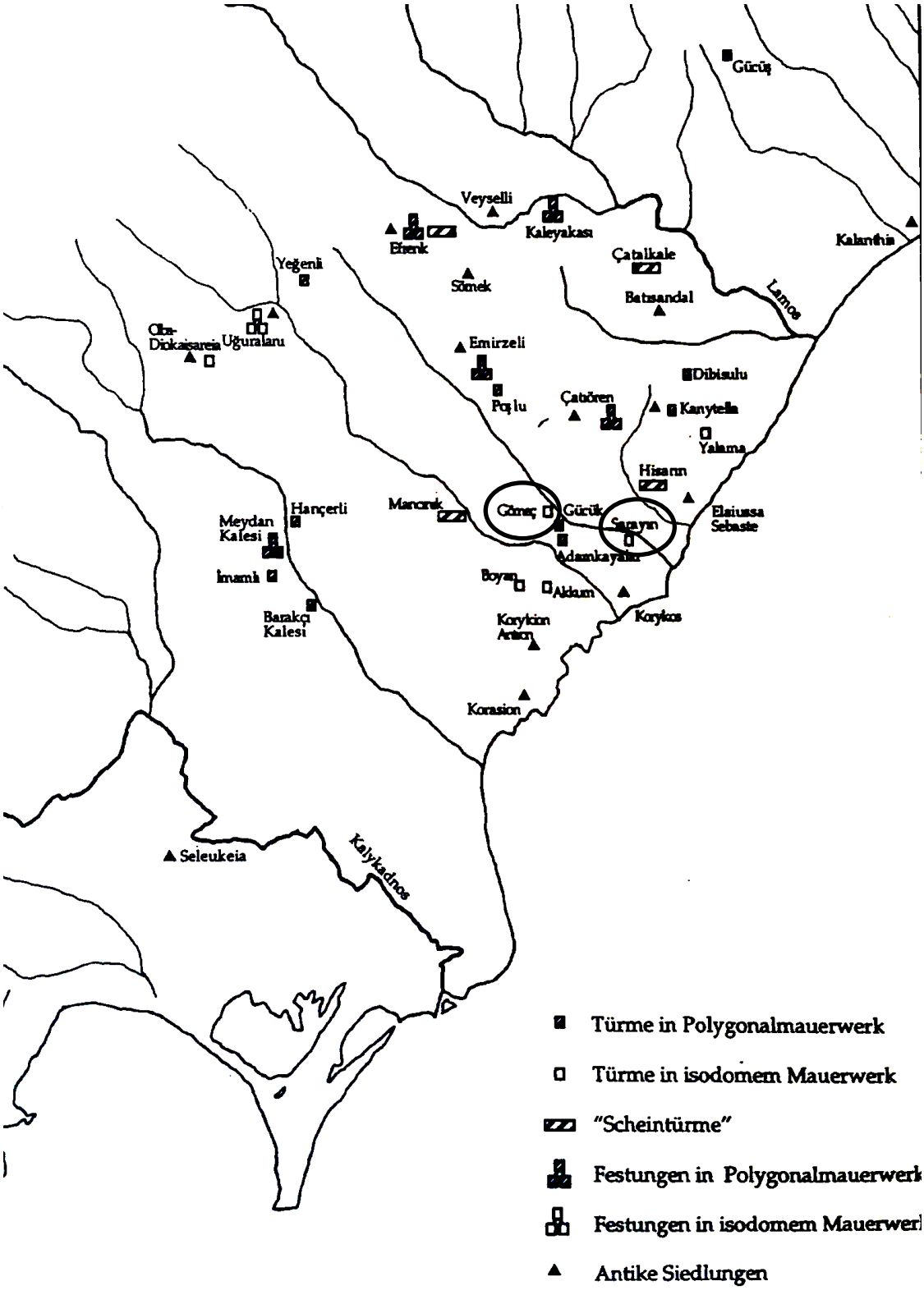


Figure 30. Location of towers in Cilicia (Source: Durugönül 1998, 12)

Figure 31. Gömeç Tower, western facade

The masonry system is examined from unit to all building. The masonry system is composed of rectangular blocks (75-100x50x60 cm) and trapezoidal blocks (35-100x50x60 cm). Trapezoidal blocks are distributed randomly between the rectangular blocks. Staggering ratio changes between 0.2 and 0.6. Upper and lower courses' joints are overlapped randomly. Joints are not always at the same line due to high stone blocks. The thickness of the wall is equal to depth of the stone blocks (60 cm), thus wall profile is composed of a single leaf.

The number of trapezoidal joints is between 2 and 8 at the western, eastern and southern walls, while 20 joints are observed at the northern wall.

When corner organizations of walls are examined, two neighboring walls, north and west walls have asymmetric corners; while the other neighboring walls (south and east) have symmetric corners.

Floor system of the tower is examined with the help of the beam holes (15-20x15-20 cm). The direction of the beams changes in each story level; beams are located from east to west direction at the first and third stories, while beams are located from north to south direction at the second story. According to finishing blocks of the tower, the roof seems to be designed as a terrace.

The tower has sustained its integrity except timber floors and roof. However, some openings have been filled in with cut and rubble stones, and joints were filled with mortar in some places. The main structural problem is erosion of sides of rectangular blocks and this causes formation of wide joints between the blocks (Table 10).

2.3.2. Sarayın Tower

The tower is located in the Erdemli district of Mersin, Turkey about three kilometers northeast of Kızkalesi, two kilometers west of Ayaş. It is located at the east of the road, which leads to the north on the outskirts of Kızkalesi, the ancient Korykos along the eastern side of the valley Şeytan Deresi. The tower is located about two kilometers northwest of Gömeç tower. Sarayın is one of the watchtowers that had been constructed against pirates in Seleucid and Roman periods between 133 BC and 65 BC (Durugönül 1998, 54-78).

The approximately squared planned (5.9x5.8 m) tower is constructed as isodomic masonry. It is approximately 34 square meters. It has four stories including the ground story. Projected stone blocks are observed at the inner walls at each story level. The height of the tower is approximately 10.86 meters. No city wall remains are observed around the tower. There is an asymmetrical entrance adjacent to corner (150x200 cm), a small asymmetrical opening (100x100 cm) in the middle, and a small symmetrical opening at the upper story of the western facade. There are small sized (100x100 cm) symmetrical openings, which are filled in, on other facade walls.

The masonry system is composed of rectangular blocks (65-100x50x 25,30,35,60 cm). Staggering ratio changes between 0.5 and 0.8. Upper and lower course joints overlap randomly in some places. The wall thickness of the ground floor is 75 cm, while the thickness of upper floors is 60 cm. Each opposite wall (north-south) have asymmetrical corners, while the other two walls have symmetrical corner organizations.

Table 10. Characteristics of Gömeç Tower

Location Gömeç, Erdemli, Mersin
Construction date 133 BC-65 BC (Durugönül 1998, 54-78)
Ancient area Cilicia

(YandexMaps 2018)

Morphologic characteristics

Topography: Plane
Relation with the city wall: -
Footpint area: 22.6 in square meter
Number of storeys: 4
Dimensions: 4.75x4.75 m

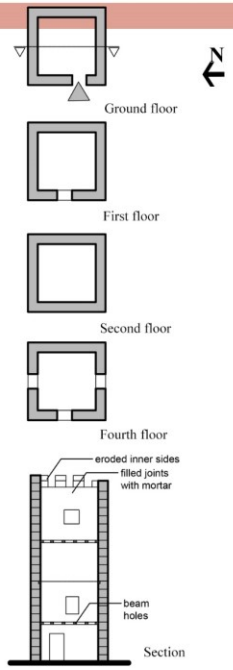
Height
1. storey 2.39 m
2. storey 2.68 m
3. storey 2.19 m
4. storey 3.56 m

Facade organization
Wall 1: Upper symmetrical (100x100), closed middle symmetrical (100x100), lower asymmetrical opening (100x180)

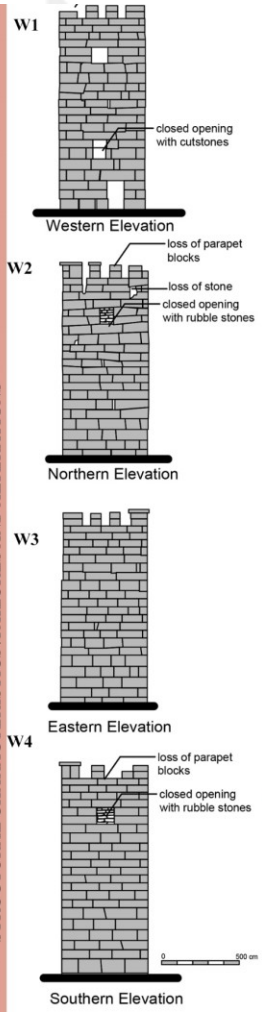
Wall 2: Closed upper symmetrical opening (100x100)

Wall 3: ---

Wall 4: Closed upper assymetrical (100x100)

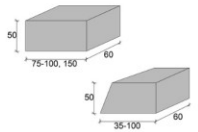


STRUCTURAL CHARACTERISTICS /FAILURES AND ALTERATIONS



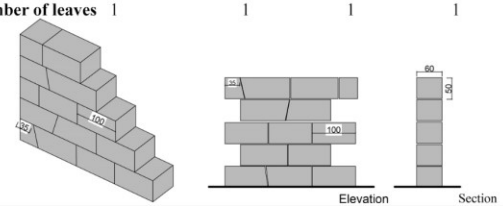
Unit

Unit type	Size	Material
Rectangular	75-100x50x60	Limestone
Trapezoidal	35-100x50x60	Limestone



Unit System

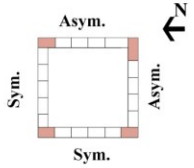
	Gr. storey	1. storey	3. storey	4. storey
Type:	Isodomic masonry Trapezoidal blocks are distributed irregularly			
Staggering ratio	0.2-0.6	0.2-0.6	0.2-0.6	0.2-0.6
	(upper and lower joints are sometimes overlapped)			
Wall thickness:	60	60	60	60
Number of leaves	1	1	1	1



Relation of unit system with the tower

Number of trapeziodal joints (number)
W1 8
W2 20
W3 2
W4 4

Corner organization
W1: sym.
W2: sym.
W3: asym.
W4: asym.



Floor/Roof sytstem

Floor and wall intersection
Beam holes (15-20x15-20)
Direction: At the first and third floor, east-west
At the second floor, north-south

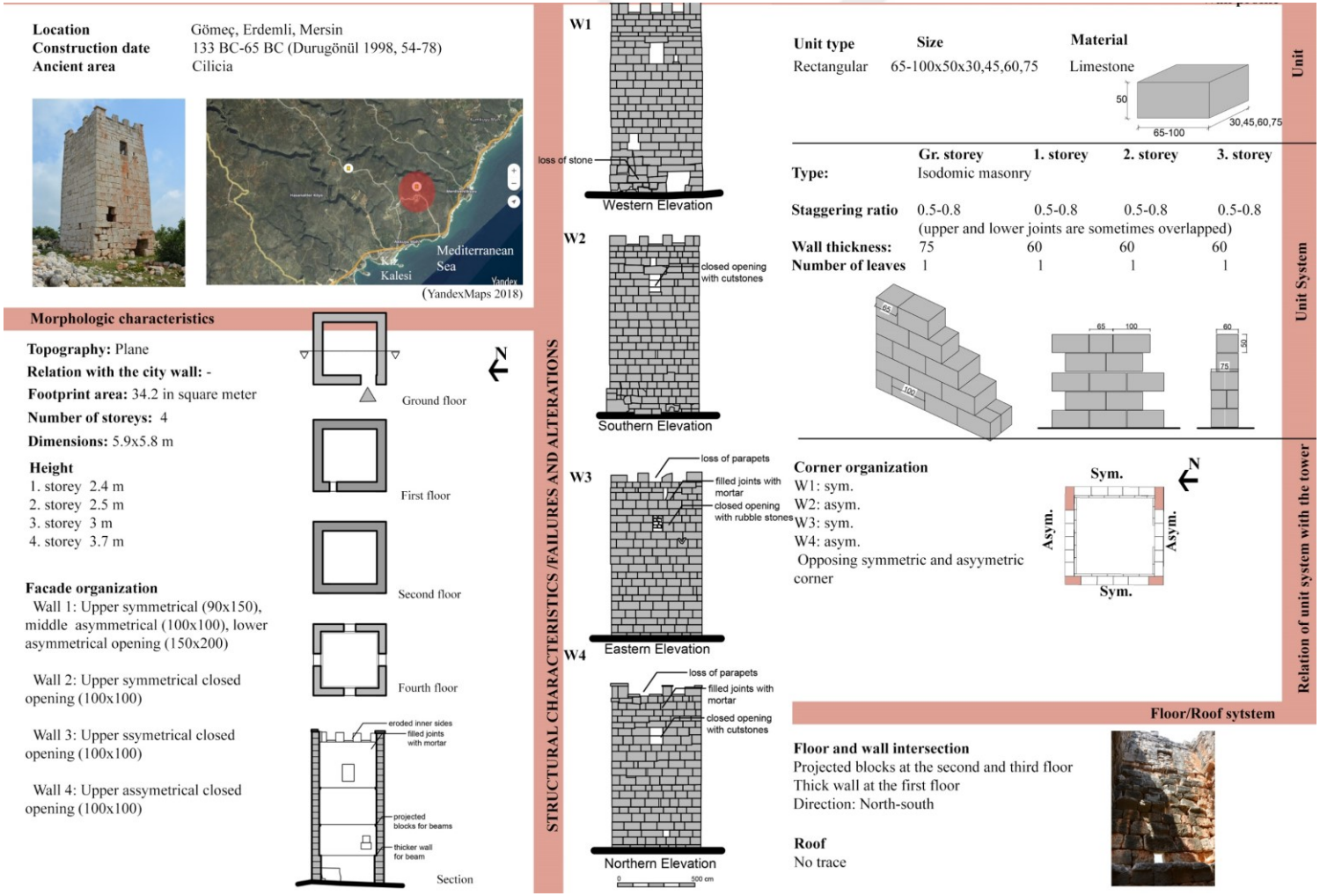
Roof
No trace

Floor system can be examined with the help of the projected stone blocks at each story. Projected story levels from north to south direction are observed at the second and third floors. At the first floor, beams are positioned on the thicker ground floor wall. There are no traces regarding dimensions and number of wooden beams. According to finishing blocks of the tower, the roof seems to be designed without roof (Table 11).

The tower has sustained its integrity except its timber floors. However, some openings are filled with cut and rubble stones, and inner joints were filled with mortar in some places. The main structural problem is erosion of sides of rectangular blocks and this causes formation of wide joints between the blocks (Figure 32).

Figure 32. Sarayın Tower

Table 11. Characteristics of Sarayın Tower



CHAPTER 3

IMPACT ANALYSIS OF CHARACTERISTICS

To analyze impact of characteristics of dry masonry ancient towers on their structural resistance and behavior, a hypothetical process is designed. First, types of structural, morphologic and material characteristics of towers are identified based on data gathered through documentation. Then, hypothetic towers are designed by combining these characteristics' types with each other to analyze how they affect the resistance of the structure in different combinations. After analysis of hypothetic towers, results of simulation are examined by grouping types.

3.1. Design of Hypothetic Towers

Design phase is composed of two parts; determination of characteristics' types and combination of these types.

3.1.1. Determination of characteristic types

Structural characteristics of towers vary in accordance with wall profiles composed of different dimensions, forms and organizations of blocks. Towers with stone blocks out of granite or limestone are possible. Dimension, number and position of an opening; proportional relationship between height and length of a tower, and flat or inclined ground topography are the possibilities of morphologic characteristics. Thus, all these possibilities are considered in the design hypothetic towers.

3.1.1.1. Wall profile types

Wall profiles show differences in terms of wall thickness, number of leaves, connection of leaves and corners, organization, size and form of stone blocks (Figure 33). 6 wall profiles are determined.

• Wall profile 1 represents the wall profile of Gömeç Tower. It has a single-leaf with a thickness of 60 cm. Trapezoidal blocks are placed irregularly between rectangular blocks. The length of the stone blocks varies between 36 and 150 cm, but stone blocks with a length of 75 cm are predominant. On each facade, there are one or two stone blocks approximately 150 cm long. The height of the blocks is 50 cm and the thickness is about 60 cm. Corner organizations are composed of two symmetric and two asymmetrical connections. The staggering ratio of stone blocks (s / h) is generally small; it ranges between 0.2 and 0.6. Stone blocks where the joints overlap, and the staggering ratio is zero are also seen.

• Wall profile 2 represents the wall profile of Sarayın Tower. The wall varies in number of leaves and thickness after 3 meters. The wall thickness is 75 cm at lower elevations and 60 cm at upper elevations. The lower part is double-leafed, and the upper part is single-leafed. There is no connection element between the walls. The length of the stone blocks varies between 65 and 100 cm. The height of the blocks varies between 35 and 60 cm. The staggering ratio (s / h) of the stone blocks varies between 0.5 and 0.8.

• Wall profile 3 represents the wall profile of Perge Tower. The number of leaves, wall thickness and block organization change after 7 meters from the bottom. Wall thickness is 120 cm at lower levels and 60 cm at upper levels. In the lower part, double-leafed and two adjacent rows of header stones are arranged. The upper part is single leaf and there is no header stone. The length of the stone blocks varies between 100-120 cm and the length of the header stones used at the bottom is 60 cm. The height of the blocks is 50 cm and their thicknesses are 60 cm. The staggering ratio (s / h) of the stone blocks is about 0.3 at the ground and first stories due to the usage of header stones adjacent to each other and between 0.6 and 1 at the second story.

• Wall profile 4; represents the wall profile of the Sillyon Tower. The wall profile is a single-leafed masonry system with a wall thickness of 75 cm. The organization of stone blocks changes after about 5-6 m. The lower levels are made of stone blocks with a height of 50 cm, while the upper elevations consist of a row of cut stone blocks of 25-30 cm in height. The length of the stone blocks varies between 100-120 cm. While the staggering ratio (s / h) varies between 1.5 and 2 at the first and second stories, the staggering ratio at the ground story is between 0.6 and 1.

• Wall profiles 5 and 6 have 115-130 cm and 90 cm thicknesses in their lower and upper parts, respectively. On facades because of slope; wall thickness changes after 3.5 and 6.5 meters from the ground story in wall profile 5, and after 3.5 and 4.5 m from the

ground story in wall profile 6. The wall profiles consist of a gap between the outer leaves. The leaves are connected with header stones that do not touch each other. The difference between the two wall profiles is the length of the stone blocks. In the wall profile 6, the length of the stone blocks is between 100 and 260 cm, and in the wall profile 5, the length of the stone blocks is between 100 and 150 cm. Depending on the location of the joints; the staggering ratio of the wall profile 5 varies between 0.6 and 1, whereas the staggering ratio of profile 6 ranges between 0.75 and 2.

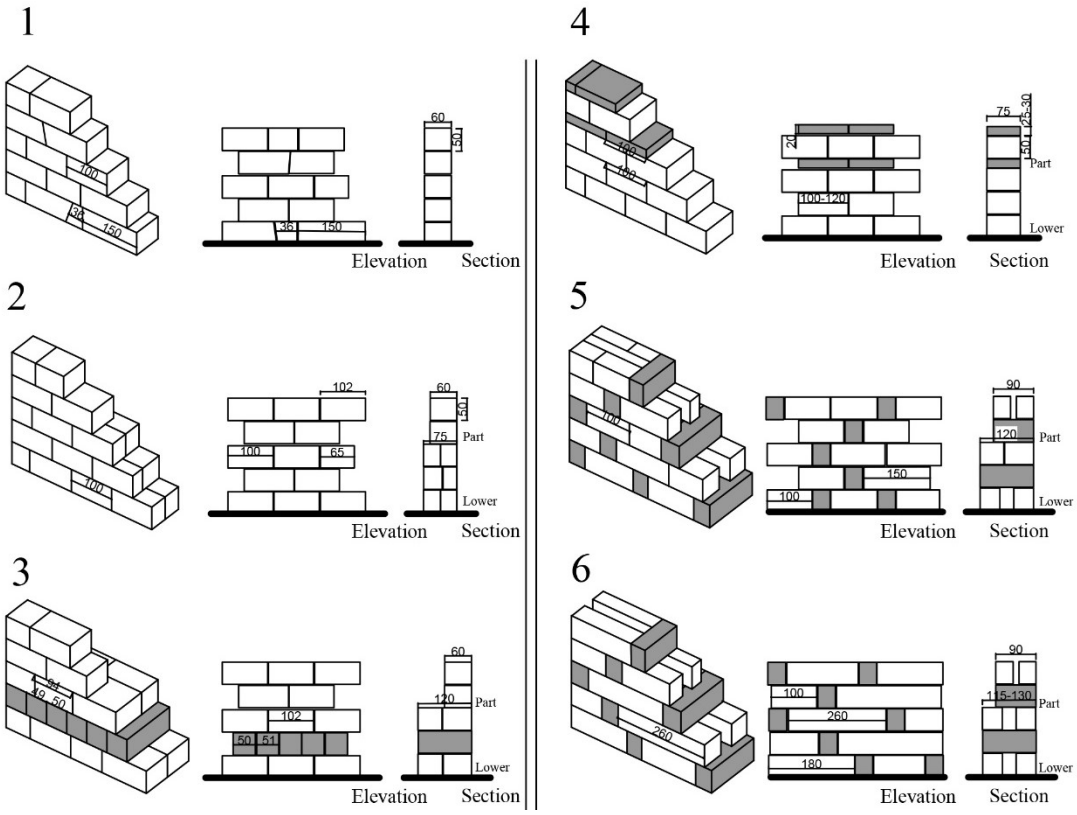


Figure 33. Wall profile types

3.1.1.2. Proportional relationships

The dimensions of documented towers are listed in the below (Table 12). All towers have different wall thicknesses changing between 60 and 115 cm. Wall thicknesses present variation depending on story level. Number of stories change between 2 and 4, heights of the towers vary between 1086 and 1405 cm. Length of the walls vary between 475 and 775 cm.

Table 12. Proportional relationship

	Floor Level	Alinda Tower	Latmos Tower	Sillyon Tower	Perge Tower	Sarayın Tower	Gömeç Tower
Thickness (cm)	**Gr.**	115-140	115	75	120	75	60
	1st	90	90	75	120	60	60
	2nd	-	-	75	60	60	60
	3rd	-	-	-	-	60	60
Height (cm)	**Gr.**	310-780	410-554	455	580	240	239
	1st	625	475-515	300	420	250	268
	2nd	-	-	280	370	300	219
	3rd	-	-	-	-	370	356
	Total	935-1405	915-1069	1035	1370	1160	1086
Length (cm)		610, 775	690, 615	685, 575	680, 680	590, 580	475, 475
H/L(Slenderness)		1.3-2.3	1.3-1.7	1.6-1.8	2	2	2.29
T/H	**Gr.**	0.37-0.14	0.28-0.2	0.16	0.2	0.3	0.25
	1st	0.14	0.19-0.17	0.25	0.28	0.24	0.22
	2nd		-	0.26	0.16	0.2	0.27
	3rd		-	-	-	0.16	0.16
	Ave.	0.26	0.225	0.22	0.21	0.23	0.22
T/L		0.12-0.18	0.11-0.15	0.11-0.13	0.08-0.18	0.1-0.13	0.12

Although each tower has different wall thicknesses, the ratio between thickness and height (0.21-0.26) and thickness and length (0.1-0.18) are approximately the same. These are evaluated as ideal values found with trial and error. The ratio between height and length, however, change between 1.6 and 2.3. Since some towers are positioned at inclined ground, walls situated on bedrock are low; thus, the h/l ratio is small (1.3). This ratio is calculated only from bedrock side facade.

Studies in literature demonstrate that the ratio between height and length (slenderness) is critical for structural behavior of towers (Shi, D'Ayala, and Jain 2008; Romaro 2011; Casolo et al. 2013). The effect of t/l and t/h ratios are generally studied in a wall without side walls (De Felice, and Giannini 2001). If the towers are studied in terms of t/h and t/l, height and length values become very different to achieve the same t/h or t/l ratios with different wall thicknesses, because wall thicknesses vary between 60-155 cm. Therefore, effect of proportional relationship on behavior of towers is studied by focusing on h/l ratio. The effect of wall thickness is tested under the heading of wall profile (Section 3.1.1.1). Towers with four different h/l ratios (1.6, 1.8, 2 and 2.3) are designed. While designing towers that have these ratios, height and length values are kept in the range of the real values of the towers ($1000 \leq h \leq 1405$, $475 \leq l \leq 775$). Extra-long or high towers are not designed.

3.1.1.3. Opening organization types

Opening types vary depending on their position, size and number. Position of the openings are categorized as top, middle or ground, and symmetrical, asymmetrical or asymmetrical adjacent to corner. Size of openings vary as small sized (50x75, 100x100), medium sized (75x160, 90x160) and large sized (95x270, 95x270, 100x230 and 180x300 cm). There are a number of possible combinations; thus, 15 opening types are determined. The top openings (op. 1, 2, 3, 8 and 11) are analyzed by considering two options with or without ground opening (Figure 34). A tower without an opening is not taken into consideration, since it is not possible as revealed in the documented examples. An opening type is positioned at only one wall of the tower; other three walls are designed with symmetrical small sized opening that has ideal position and minimum area (op. 1).

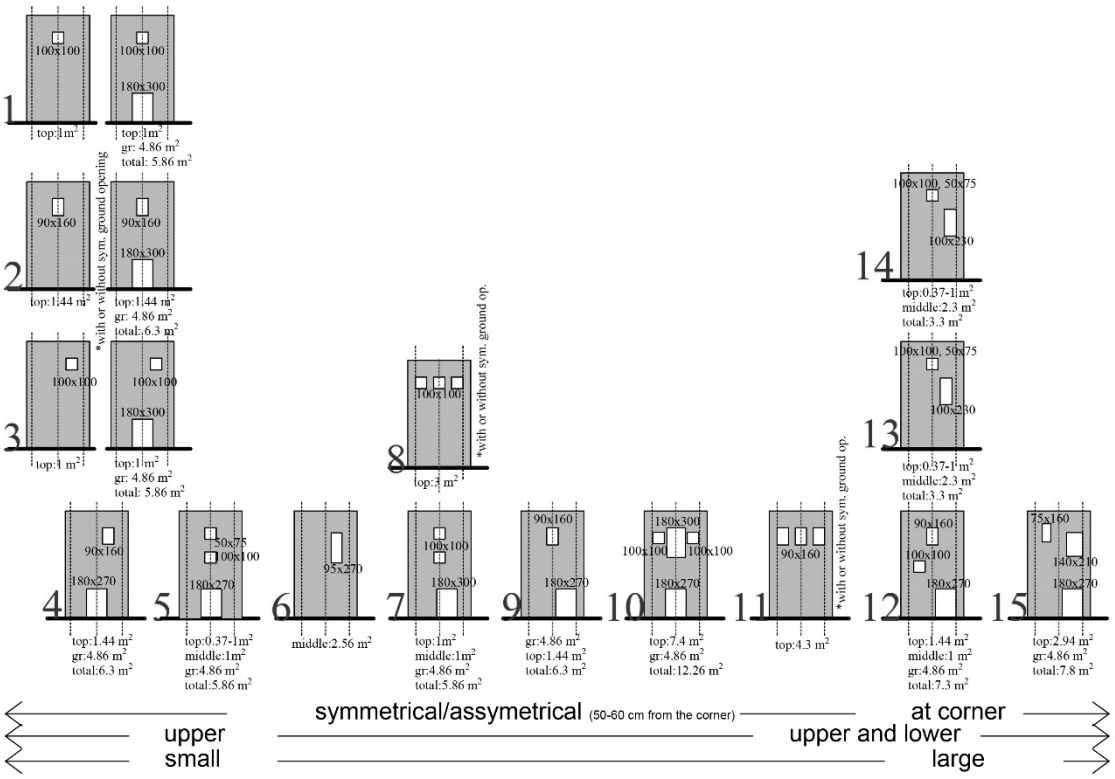


Figure 34. Opening types

3.1.1.4. Material usage

Based on laboratory analysis, two types of stone are determined; granite and limestone (Appendix A). General properties of these materials are listed in the below (Byerlee 1978; Zhu 2012; Arpaz 2015) (Table 13).

Table 13. Properties of stone materials

Granite: **Density:** 2600-2900 kg/m^3 **Friction coefficients of granite on granite:** 0.6-0.7 (Fanning 1892, 396) Modulus of elasticity: 10-70 GPa Porosity: 0.5-1.5 %	**Limestone:** **Density:** 1900-2600 kg/m^3 **Friction coefficients of limestone on limestone:** 0.6- 0.7 (Colas et al. 2016) Modulus of elasticity: 15-55 GPa Porosity: 5-30 %

In the studies about behavior of dry masonry in literature, the modulus of elasticity of the materials is neglected, because the displacements due to elastic deformation are

negligible due to joint sliding and the tilting-tests are static. Density (weight) and coefficient of friction values are taken into consideration (De Felice, and Giannini 2001; Restrepo-Vélez, Magenes, and Grifftih 2014; Bui et. al 2017). The behavior of dry-stone masonry is mostly related to the frictional resistance of the joints (Naik and, Menon 1990, 541). Friction coefficient of rock stone in masonry change between 0.6 and 0.7 (Concrete Institute 1909, 144), so there is not a considerable difference between coefficients of rocks. Also, finishing techniques of stone masonry as chisel pointing change the friction coefficient of the stones. For example, friction coefficient of pointed dressed granite on granite is 0.7, while friction of fine cut granite on granite is 0.58 (Fanning 1892, 396). Density of materials change depending on hardness or softness of the material (Colas et. al 2016). In this study, the general values of fine cut stones in masonry from literature are taken into consideration to compare effectiveness of density and friction (Table 14).

Table 14. Determined properties of materials from literature

Material type	*Friction (μ)*	*Determined General Density Value*
Limestone	0.72 (Colas et al. 2016)	2560 (ASTM C568 2016)
Granite	0.6 (Jay 1908, 224)	2750 (Zhu 2012)

3.1.1.5. Ground topography

The towers are either positioned on plane or inclined topography.

3.1.2. Combination of characteristic types

Since characteristic types could be refined after reaching significant results clarifying behavior and resistance of towers, combination of characteristic types are composed of a series of phases. First; configurations are designed based on real towers' data. However, results of some configurations composed of h/l ratio and material usage are similar, therefore, to prove the advantage of these historic preferences, the real limits are broadened for h/l ratio and material usage. After interpretation of results,

configurations composed of effective characteristic types are used for the assessment by eliminating ineffective ones.

1. Configurations based on real towers

While designing hypothetic towers, six wall profile type, four ratios between wall height and length, 15 opening, two material and two ground topography types are combined with each other. All possible towers are defined. Each of these towers is a permutation. If number of each characteristic type is multiplied by each other, 1440 tower combinations are created. While designing hypothetic towers, impact of an opening type is analyzed at only one wall of the tower; other three walls are designed with symmetrical small sized opening that has ideal position and minimum area (op. 1). The impact of opening type is taken into consideration depending on its in-plane and out-of-plane position.

Number of hypothetic towers (based on real towers) =

Wall profile type x h/l x opening type x material type x ground topography type=

6 x 4 x 15 x 2 x 2=1440

2. Configurations beyond real towers with virtual values

According to analysis of hypothetic towers based on real towers, results of configurations composed of h/l ratio and material usage were almost similar, therefore, to prove the advantage of these historic preferences, the real limits are broadened for h/l ratio and material usage. Therefore, the following characteristic types are added to configurations:

•The real ratio between wall height and length varies between 1.6 and 2.3. To determine the effect of h/l, these values are taken between 1 and 2.5 (by adding h/l ratios 1, 1.3 and 2.5).

• Density and friction of limestone and granite are similar (Table 6). Limestone has higher friction without regard to finishing of stone and lower density in comparison to granite, this difference does give an opinion about reverse relation of friction and density. To be able to evaluate the rationality of this reverse relationship, different rock materials with different density and friction coefficient are tried to be tested, however with reference to literature, it is seen that density values of rocks change between 2000 and 2900 kg/m^3(Carmicheal, and Clein 2019), friction coefficient of dry stone on dry stone is determined between 0.6 and 0.7 (Concrete Institute 1909, 144; Jay 1908, 224). There is no strong dependence of friction on rock type (Byerlee 1978, 618), surface finishing techniques as rough or fine pointing change friction coefficients (Fanning 1892,

396) (Table 15). Although comparison with another rock type does not probably help to evaluate the effect of friction and density, a sandstone type which has similar friction with limestone and slightly lower density in comparison to limestone is analyzed as a virtual rock stone material. Comparison with lower friction and density values is required for evaluation, however the values of rock materials are similar. Nevertheless, brick is also used as virtual material with lower density and similar friction with granite, however there are not materials to be used in towers with smaller friction coefficient lower than 0.6.

Table 15. Properties of materials

	Material type	*Friction (μ)*	*Determined General Density Value*	*Interval Density (kg/m³)*
Real	Limestone	0.7 (Colas et al. 2016)	2560 (ASTM C568 2016)	1900-2600 (Carmicheal and, Clein 2019)
	Granite	0.6 (Jay 1908, 224)	2750 (Zhu 2012)	2600-2900 (Arpaz 2015)
Virtual	Sandstone	0.7 (Rutter and, Glover 2012; Colas et al. 2016)	2000 (Zhu 2012; ASTM C616 2016)	2000-2600 (Carmicheal and, Clein 2019)
	Red Brick	0.6 (Funning 1896, 396; Jay 1908, 224)	1800 (Givoni 1998)	1500-1800 (Givoni 1998)

Additional configurations (3 h/l ratio and 2 material type) increase number of hypothetic towers up to 5040.

Number of hypothetic towers (with additional configurations) (See Appendix E)

=Wall profile type x h/l x opening type x material type x ground condition type=

6x7x15x4x2=5040

At the results part, all hypothetic towers are examined, effective types are determined between the configurations.

3.2. Validation of Analysis Method

Preliminary analyses have been carried out to test the validity of the MsPhysics software to be used for simulation of behavior of hypothetic towers against lateral

loading. Simulation based on quasi-static tilt analysis is validated based on the experimental results both in literature (Restrepo-Vélez, Magenes, and Griffith 2014, 1-28) and at laboratory.

3.2.1. Comparison with experimental results of Restrepo-Vélez, Magenes, and Griffith (2014)

Restrepo-Vélez, Magenes, and Griffith (2014) studied the behavior of dry masonry walls under lateral force with an experimental study. Walls constructed in a laboratory environment were tilted by placing on a wooden table; collapsing angles and mechanisms of different configurations were found. Based on the wall sizes and properties of materials produced by Restrepo-Vélez, Magenes, and Griffith (2014), 3D models were created in Sketch-up software, and the failure mechanisms were investigated by tilting these models with a virtual table in MsPhysics. The results of the simulation were compared with the experimental results (Restrepo-Vélez, Magenes, and Griffith 2014, 1-28). The damage mechanisms of real and virtual models were similar (Figure 35) and the collapse angles had the same curve graphically. However, the simulation results were about 3 degrees lower than the results of experimental method (Table 16).

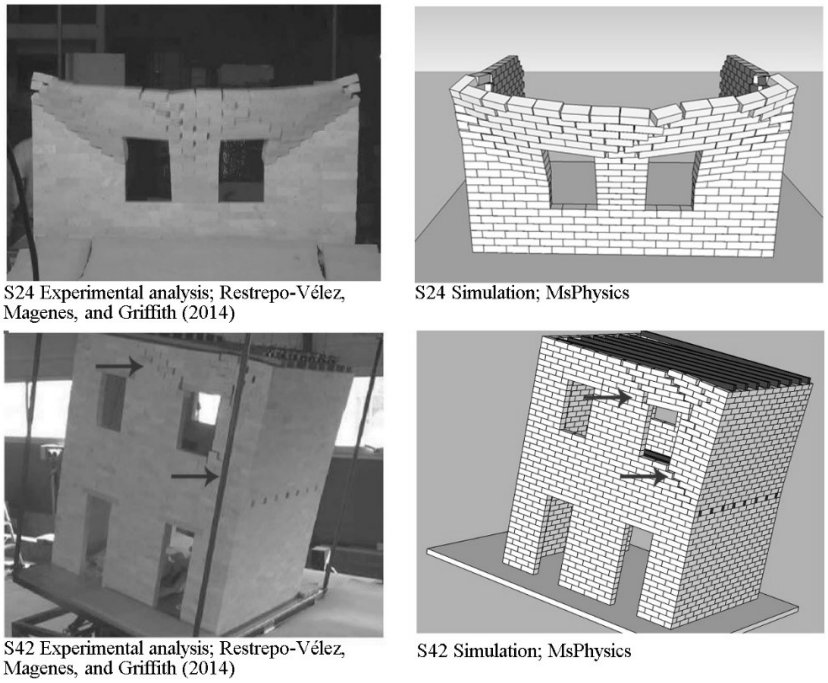


Figure 35. Failure mechanisms observed in experiments and simulations

Table 16. Comparison of experiments and simulations

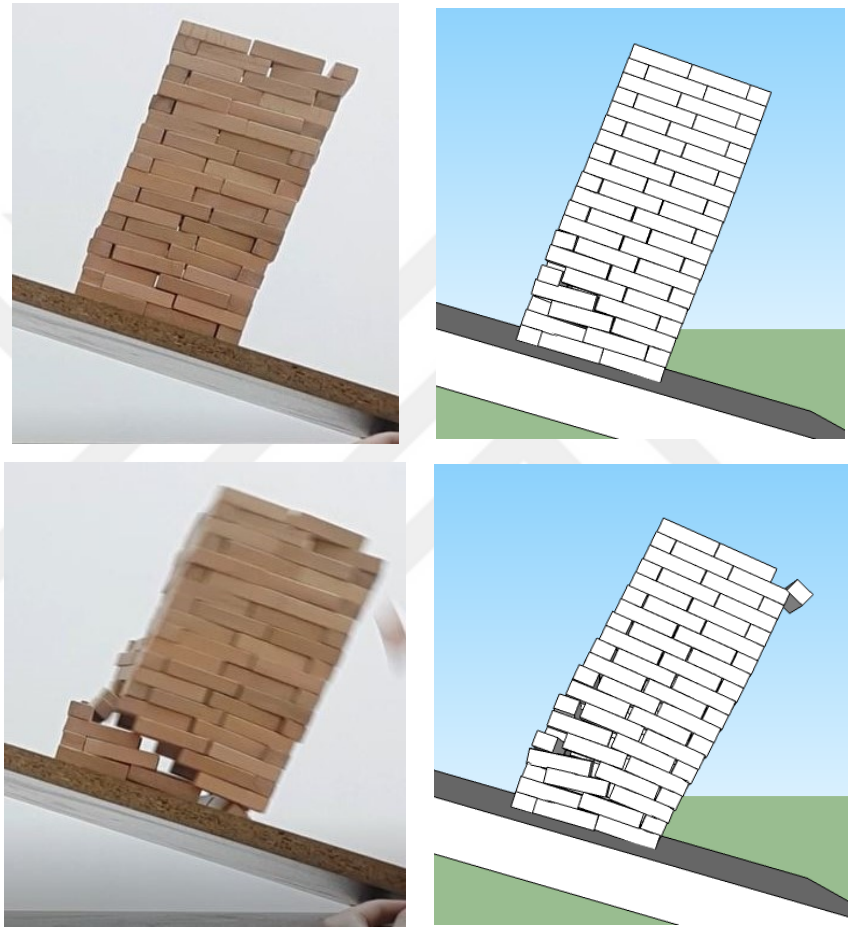
Configurations Restrepo-Vélez, Magenes, and Griffith (2014)	**Results of experimental analysis** Restrepo-Vélez, Magenes, and Griffith (2014)		**Results of simulation**	
	Collapse angle	**Lateral acceleration**	**Collapse angle**	**Lateral acceleration**
S1	15	0.254 g	12	0.207 g
S4	9	0.161 g	8	0.139 g
S5	20	0.349 g	16	0.275 g
S6	12	0.208 g	9	0.15 g
S7	17	0.291 g	14	0.241 g
S8	21	0.362 g	18	0.309 g
S10	12	0.213 g	10	0.17 g
S11	5.5	0.097 g	6	0.104 g
S12	7	0.129 g	7	0.121 g
S13	10	0.181 g	9	0.15 g
S14	14.5	0.251 g	14	0.24 g
S15	11.5	0.199 g	11	0.19 g
S16	8	0.139 g	7	0.12 g
S23	8.5	0.144 g	6	0.10 g
S24	9.1	0.156 g	7	0.12 g
S42	13.7	0.236 g	12	0.207 g

3.2.2. Comparison with experimental results

By using wooden blocks (6.6 x 2.1 x 1.5 cm), a tower composed of 20 rows was modelled at the laboratory. A tilting table was formed with wooden platforms connected to each other with a hinge and an angle meter was placed between the platforms. The upper platform was elevated from one side, the tilting angle at the moment of collapse was recorded with the angle meter. Coefficient of static friction of wooden blocks to be required in simulation is equal to the tangent of the critical angle of failure. Angle failure of a wooden block was found approximately 50 degrees. Therefore, the friction coefficient of a wooden block was accepted as 1.19 in simulations.

Table 17. Comparison of experiment and simulation results

	Collapse angle (degrees)	
	Experimental	Simulation
20 rows	21	18
15 rows	25	23



20 rows experimental results 20 rows simulation results

Figure 36. Comparison of experiments and simulations

The damage mechanisms of real and virtual models were similar (Figure 36) and the collapse angles were 3 degrees lower than the results of experimental method (Table 17). Thus, MsPhysics software is evaluated as sufficient and practical for understanding relationship of characteristics under lateral load. MsPhysics is selected to be used to determine the behavior of hypothetic towers under increasing lateral loads.

3.3. Evaluation of results of analysis

Results of analysis are evaluated in terms of collapse angle and failure mechanisms. In-plane and out-of-plane behavior of walls or behavior of the tower are evaluated with regard to definitions developed by Giuffre (1993); D'ayala and Speranza (2003); Preciado et. al (2016); Milanu, Shehu and Valente (2018). Also, combined failure mechanisms are determined. To examine results, characteristic types are grouped as binary and triple combinations. Analysis of towers including opening organization is done in two steps, the position of openings at in-plane wall and out-of-plane wall are examined separately to determine the effect of opening depending on direction of lateral loading. Effects of openings on out-of-plane behavior are analyzed both at the facade on tilting direction and opposite direction. The smalles collapse angle is taken into consideration.

After examining binary combinations, according to impact of characteristics, triple combination composed of effective characteristics is also examined.

3.3.1. Results of binary combinations

Analysis results of hypothetic towers with binary combinations of characteristic types are presented in terms of collapse angle and failure mechanisms against lateral loading.

3.3.1.1. Collapse angles

Impact of characteristics on collapse angles are examined.

3.3.1.1.1. Wall profile and opening type relation

Relationship of wall profile and opening type is evaluated, when other characteristics are kept constant. Effect of different opening types on wall behavior and collapse angle are examined depending on lateral load direction. Openings are analyzed depending on their in-plane and out-of-plane positions separately (Table 18). Since the

opening type 1 has the same opening organization at each facade, one collapse angle is written in the table.

Table 18. Collapse angles of towers with openings at in-plane and out-of-plane walls

			Wall profiles					
			W.1	W.2	W.3	W.4	W.5	W.6
Opening types	Op. 1		11	12	13.5	17	14	18
	Op. 2, 3, 4	i	11	12	13.5	17	14	18
		o	11	12	13.5	17	14	18
	Op. 5	i	11	12	13.5	17	14	18
		o	11	12	13.5	17	14	18
	Op. 6	i	11	12	13.5	17	14	18
		o	11	12	13.5	17	14	18
	Op. 7, 8	i	11	12	13.5	17	14	18
		o	11	12	13.5	17	14	18
	Op. 9	i	10	11	13	17	13	18
		o	11	12	13.5	17	14	18
	Op. 10	i	8	10	12	14	12	17
		o	9	12	13.5	17	14	18
	Op.11	i	9	11	12	16	13	18
		o	10	12	13.5	17	14	18
	Op. 12, 13	i	10	10	13.5	17	14	18
		o	11	12	13.5	17	14	18
	Op. 14, 15	i	9	11	12	16	13	18
		o	10	12	13.5	17	14	18

According to results, when openings at in-plane position, the collapse angle is approximately up to 3 degrees smaller than openings at out-of-plane position. This difference is seen generally with opening types 9-15. The resistance of the wall profile types against lateral loading is evaluated as 6, 4, 5, 3, 2 and 1 from the durable to the non-durable.

If the resistance of towers that have different opening types are compared with each other; towers that have opening types 1-9 whose overall area is between 1 and 3 m^2 at the top and in the middle and which are not adjacent to corner; collapse at the highest angles. Openings 12 (7.3 m^2) and 13 (3.3 m^2) composed of asymmetrical middle and symmetrical top openings follow openings 1-9. Openings 10, 11 and 14, 15 that are composed of large sized or adjacent to corner middle and top openings, cause collapse at

the lowest angles. Opening 10 (12.26 m^2) is composed of symmetric two small openings (100x100 cm) and a wide opening between them (180x300 cm) at the top stories. Opening 11 (14.4 m^2) consists of three symmetrical openings at the top level (each 90x160 cm) giving way to a large opening area in total. The opening 14 (3.3 m^2) is composed of a small sized symmetrical top (100x100 cm) and a middle medium sized opening adjacent to corner (100x230 cm). The opening 15 (7.8 m^2) is composed of three asymmetrical openings; whose of two are adjacent to the same corner, and with large total opening area (75x160, 140x210 and 180x300 cm from top to bottom).

Collapse angle curves of the wall profiles with different openings are generally similar, however, negative effect of problematic openings (10, 11, 14 and 15) on collapse angle are high at wall profile 1 that has lowest resistance. Negative effect of openings on collapse angle are low at wall profile 6 that has highest resistance against lateral loading. Only opening 10 in wall profile 6 decreases collapse angle 1 degree compared to other opening types of the same wall profile. However, most of the openings 10, 11, 14 and 15 decrease collapse angles between 1 and 3 degrees in other wall profiles in comparison to wall profile 6, while only openings between 1 and 9 do not effect collapse angles of wall profile 1-5. Effect of opening types on collapse angle changes depending on resistance and compositions of wall profile (Figure 37).

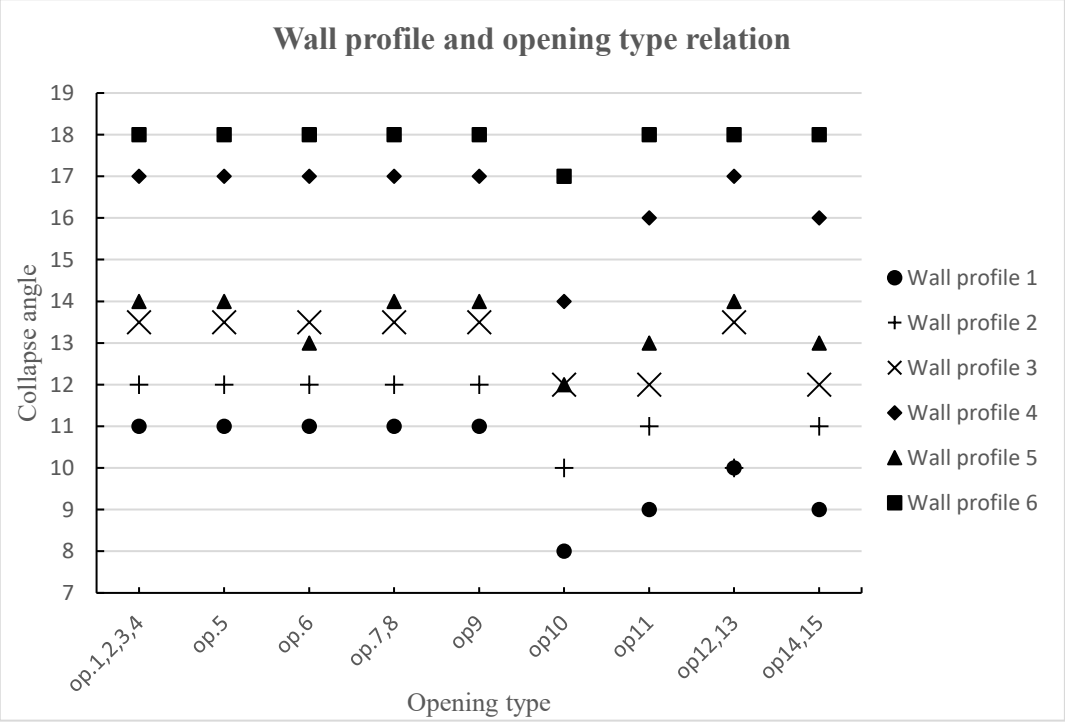


Figure 37. Opening types at in-plane position and wall profile relation

3.3.1.1.2. Wall profile and ratio between height and length relation

Relationship of wall profile and h/l ratio is evaluated, when other characteristics are kept constant. The resistance of the wall profile types against lateral loading is evaluated as 6, 4, 5, 3, 2 and 1 from the durable to the non-durable as mentioned in section 4.1.1. In this part, virtual h/l values in addition to real values, 1, 1.3 and 2.5, are used to determine h/l effect on wall profile (Figure 38).

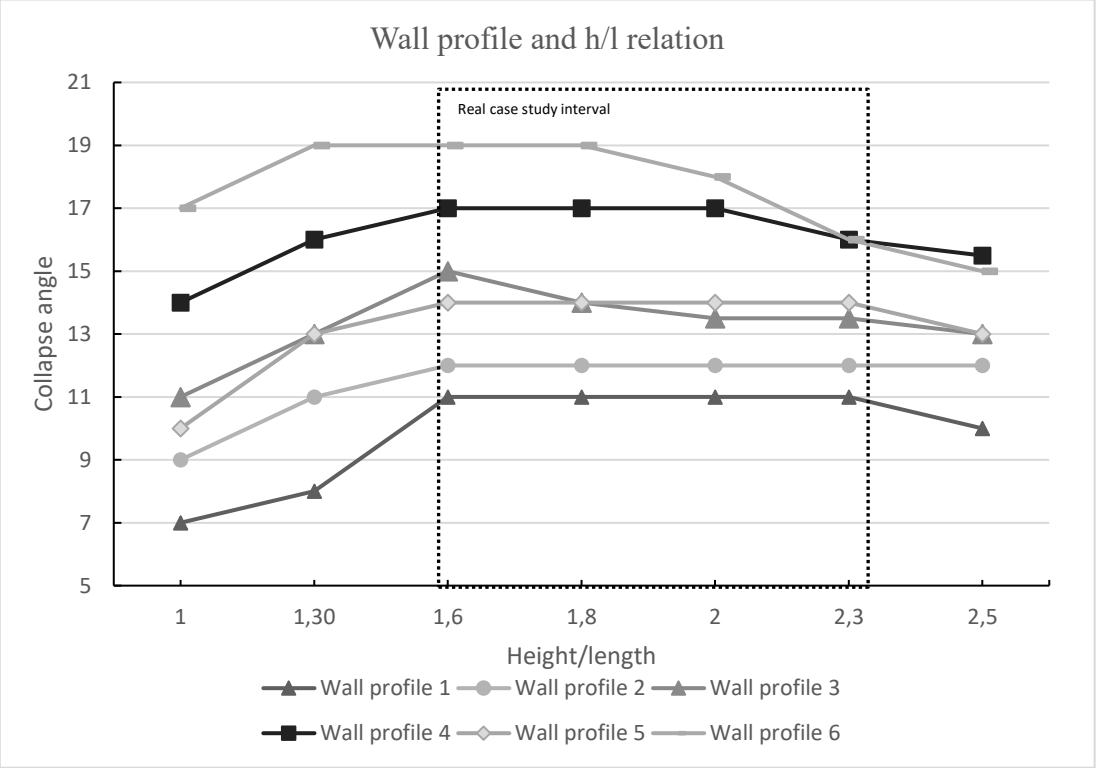


Figure 38. Wall profile and h/l relation

The collapse angles of towers whose h/l ratios are between 1.6 and 2 are mostly constant and have the highest values. The highest interval of each wall profile show differences between 1.6 and 2.3. For wall profile 6, the highest interval is between 1.6 and 1.8, while for wall profile 4 the highest interval is between 1.6 and 2. For wall profiles 1,2 and 5, the interval is the same (1.6 and 2.3), however wall profile 3 has the highest point (1.6). When the ratio decreases and increases from this interval, this causes decrease in collapse angle. This shows that these intervals are ideal for structural resistance of towers (Figure 38).

3.3.1.1.3. Wall profile and ground topography relation

Relationship of wall profile and ground topography is evaluated, when other characteristics are kept constant. The towers are located on plane or inclined topography. The towers on inclined ground are tilted both in the direction of the inclination and its reverse. When the towers are tilted from the highest wall towards the lowest one, the collapse angle increases 1 degree in each wall profile, excluding wall profile 6 providing 3 degrees advantage. However, wall profile 1 is not affected by the advantage of inclination. At the reverse direction, the collapse angle is equivalent to the tower located on plane area (Figure 39).

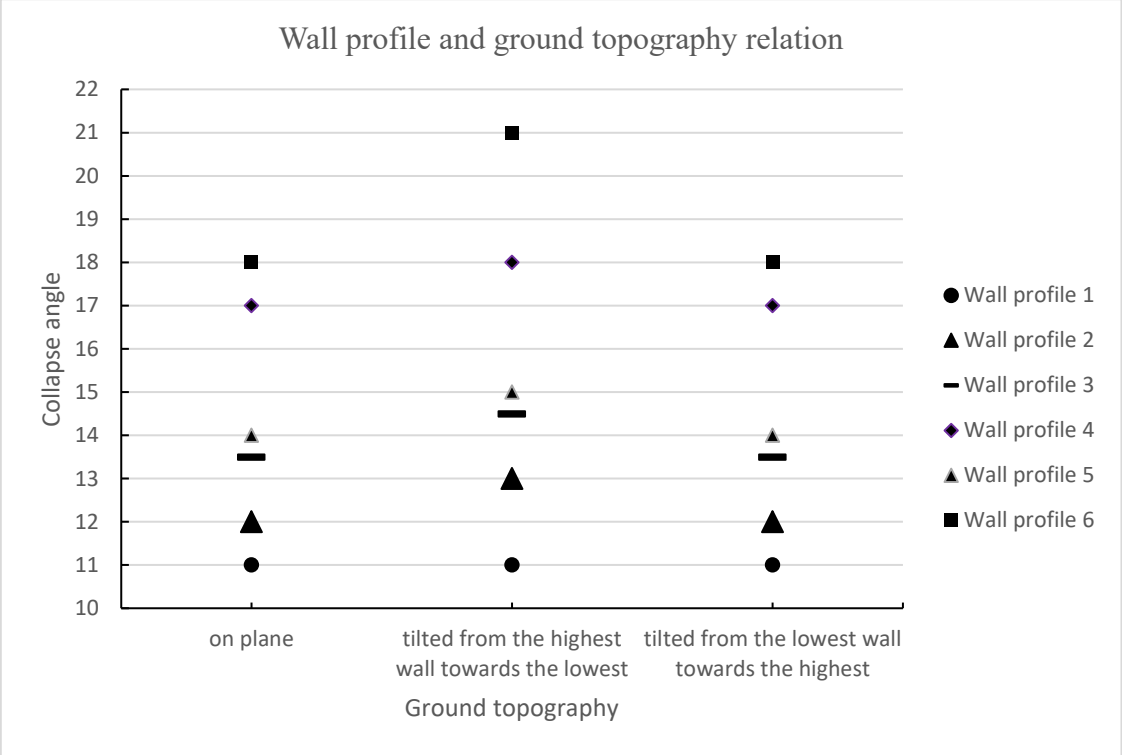


Figure 39. Ground topography and collapse relation of different wall profiles

3.3.1.1.4. Wall profile and material usage relation

Relationship of wall profile and material is evaluated, when other features are kept constant. Considering the studies on dry masonry, it was decided to neglect the modulus of elasticity, since the tilting-test is static. Density (or weight) and coefficient of friction

values are taken into consideration (De Felice and, Giannini 2001; Restrepo-Vélez, Magenes, and Grifftih 2014; Bui et. al 2017). Limestone has higher friction and lower density in comparison to granite, this difference does give an opinion about reverse relation of friction and density (Table 19).

Table 19. Properties of materials

	Material type	*Friction (μ)*	*Determined General Density Value (kg/m³)*
Real	Limestone	0.7 (Colas et al. 2016)	2560 (ASTM C568 2016)
	Granite	0.6 (Jay 1908, 224)	2750 (Zhu 2012)
Virtual	Sandstone	0.7 (Rutter and, Glover 2012; Colas et al. 2016)	2000 (Zhu 2012; ASTM C616 2016)
	Red Brick	0.6 (Funning 1896, 396; Jay 1908, 224)	1800 (Givoni 1998)

To be able to evaluate the rationality of this reverse relationship, sandstone which has similar friction with limestone and slightly lower density in comparison to limestone is analyzed. It is recorded that collapse angles of limestone and sandstone is similar; this shows that slight decrease in density (560 kg/m^3) does not affect the collapse angle. Then, brick, which has similar friction with granite and much lower density value in comparison to the other three materials (950 kg/m^3), is tested. Brick usage causes decrease in collapse angle. So, it is considered the lower the density, the lower the collapse angle. Limestone, granite and sandstone are all stones with an average density between 2000 and 2750 their collapse angles are considerably similar (Figure 40). Effectiveness of friction coefficient is not examined, since there is no material used in towers with friction coefficient lower than 0.6.

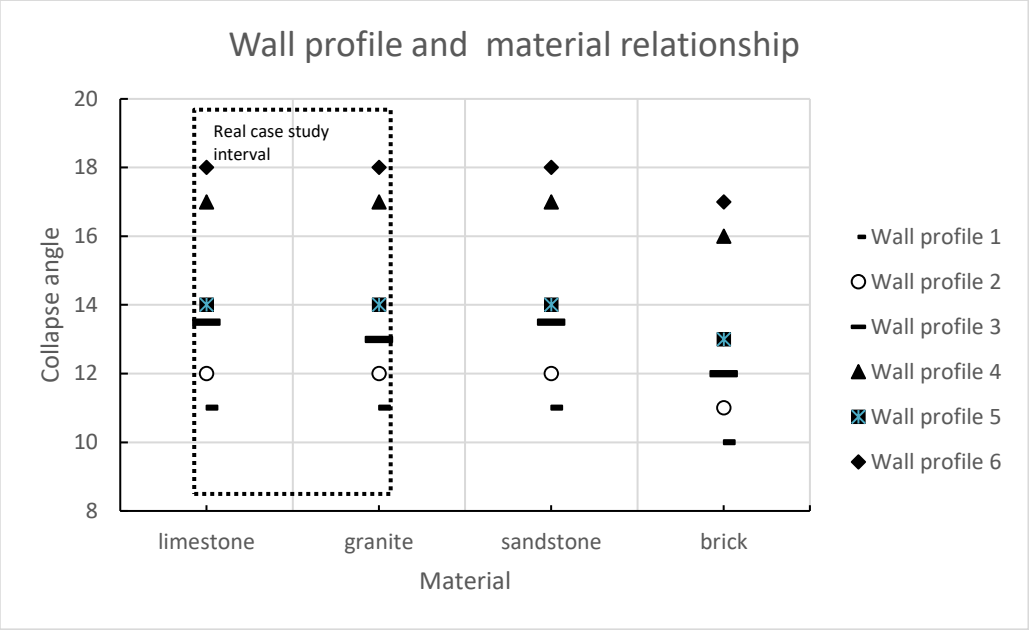


Figure 40. Material and collapse angle relation in different wall profiles

3.3.1.1.5. Opening type and h/l relation

Relationship of opening type and h/l is evaluated, when other characteristics are kept constant. Effect of different opening types on collapse angle with different h/l ratios are examined depending on lateral load direction. Openings are analyzed at in-plane and out-of-plane positions separately (Table 20). According to results, when openings at in-plane position, the collapse angle is approximately up to 3 degrees smaller than openings at out-of-plane position. Since the lowest collapse angle is taken into consideration, the collapse angles when openings at in-plane position is examined.

Table 20. Collapse angles in different opening types and h/l ratios of wall profile 1

		H/L													
		1		1.3		1.6		1.8		2		2.3		2.5	
	Openings	i	o	i	o	i	o	i	o	i	o	i	o	i	o
w. profile 1	op 1	7		8		11		11		11		11		1	
	op 2-8	7	7	8	8	11	11	11	11	11	11	11	11	10	11
	op 9, 12, 13	7	7	8	8	10	11	10	11	10	11	10	11	9	10
	op 10	7	7	8	8	9	11	9	10	8	9	8	10	8	10
	op 11	7	7	8	8	10	11	10	11	9	10	8	10	8	11
	op 14, 15	7	7	8	8	11	11	11	11	9	10	9	10	9	10

Collapse angle curves of the opening types in different ratios are similar; each opening type has an interval of better resistance. Decrease and increase from this interval cause decrease in collapse angle. For constant wall profile type (1), the collapse angles of towers have the highest values between 1.6 and 2.3, which is the real interval (Figure 41). As mentioned in the previous sections, opening 10 causes collapse at the lowest angle in each ratio. Negative effect of small sized openings not adjacent to corner (op. 1-8) are minimum. 1.6 and 1.8 h/l ratios provide the best performance for the poor openings (10, 11, 14, 15). In-plane walls show lower resistance.

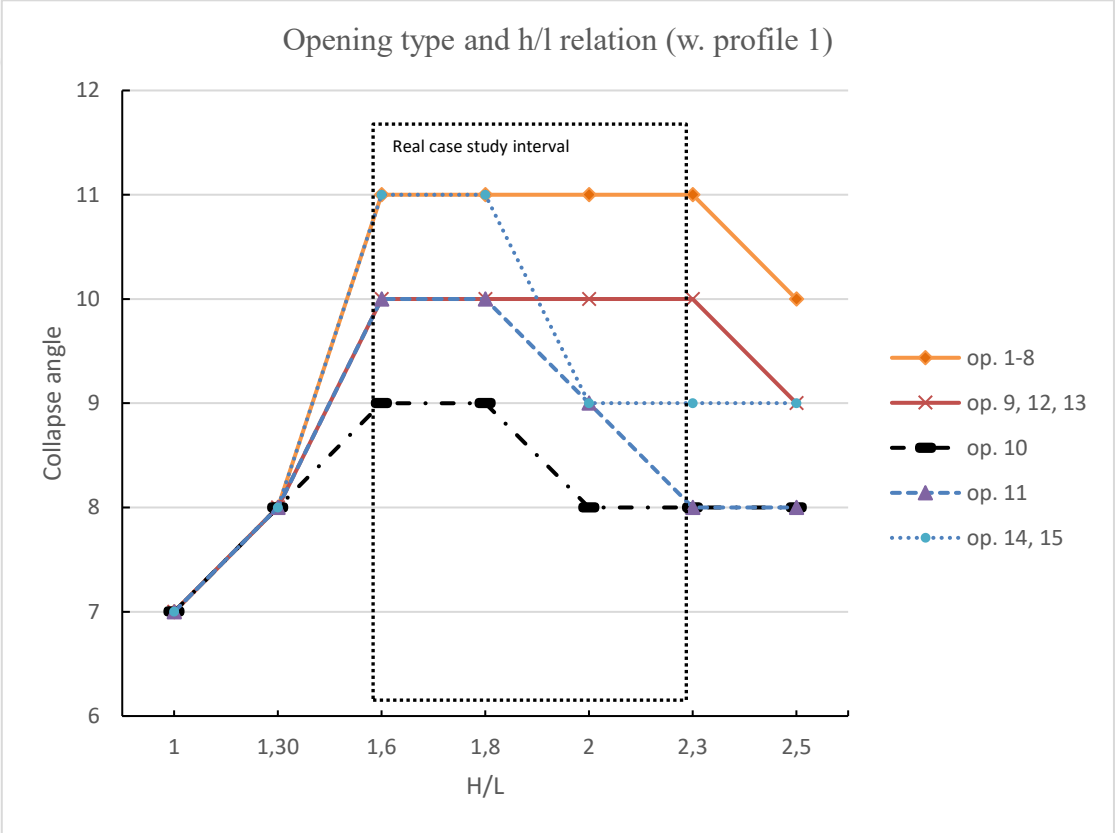


Figure 41. Relation of opening type and h/l, in-plane

3.3.1.1.6. Opening type and ground topography relation

Relationship of opening type and ground topography is evaluated, when other characteristics are kept constant. Effect of different opening types on collapse angle in different ratios are examined depending on lateral load direction. Openings are analyzed

at in-plane and out-of-plane walls separately (Table 21). As determined in the previous sections, when the tower is tilted from the highest wall towards the lowest, the collapse angle increases. For constant wall profile 1 that has the lowest resistance against lateral load, tilting from the highest wall does not change the collapse angle at the towers that have small sized openings (opening 1-8). However, tilting from the highest provides advantage for the towers that have large and asymmetrical openings (op. 9-15) (Figure 42).

Table 21. Collapse angles of different opening types and ground topography for wall profile 1

Ground topography			Low-high	High-low	On plain
Opening types	Op. 1	i	11	11	11
		o			
	Op. 2,3,4	i	11	11	11
		o	11	11	11
	Op.5	i	11	11	11
		o	11	11	11
	Op. 6	i	11	11	11
		o	11	11	11
	Op. 7, 8	i	11	11	11
		o	11	11	11
	Op. 9, 12, 13	i	10	11	10
		o	11	12	11
	Op. 10	i	8	9	8
		o	9	10	9
	Op. 11, 14, 15	i	9	10	9
		o	10	12	10

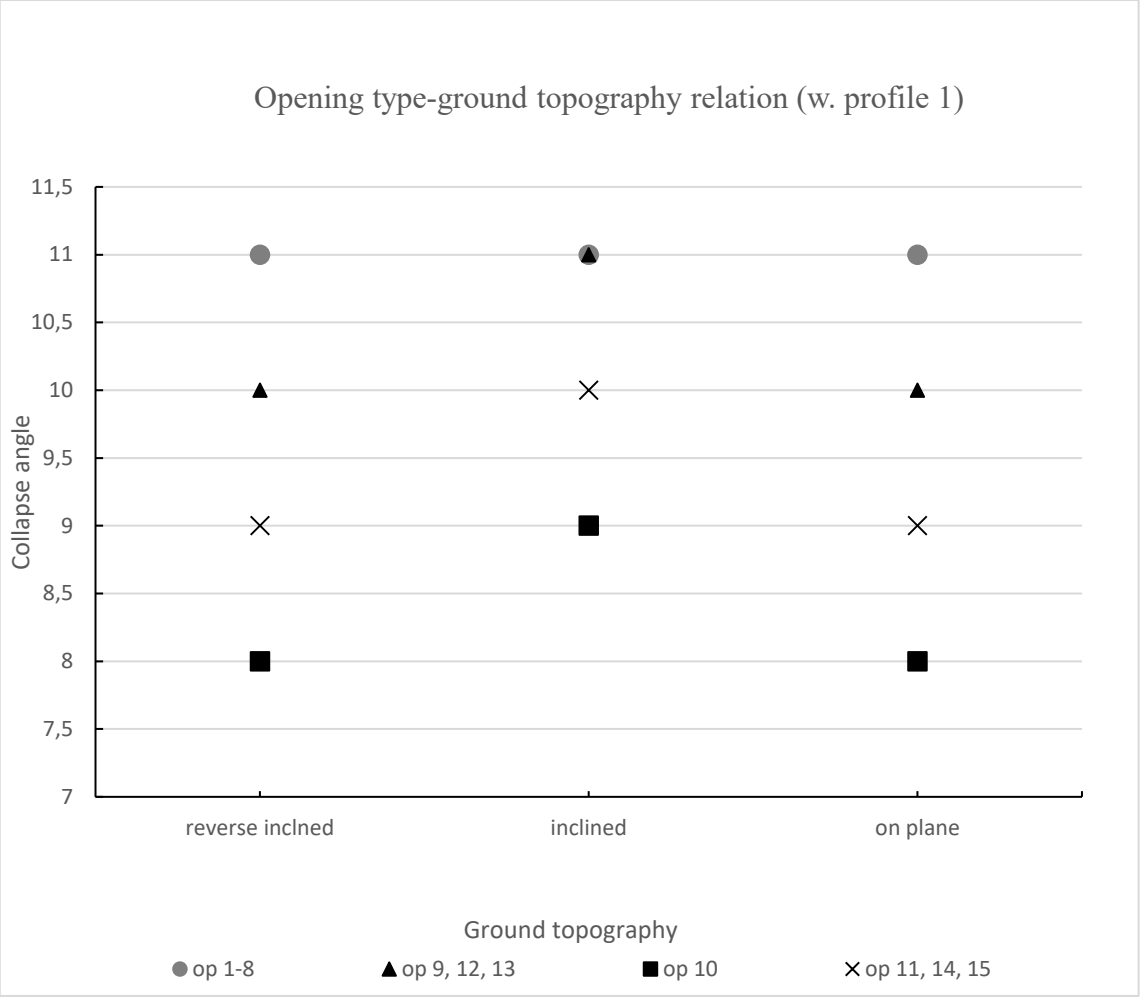


Figure 42. Opening type and ground topography relation at wall profile 1

3.3.1.1.7. Opening type and material usage relation

Relationship of opening type and material usage is evaluated, when other characteristics are kept constant. Effect of different opening types on wall behavior and collapse angle in different ratios are examined depending on lateral load direction. Openings are analyzed at in-plane and out-of-plane walls separately (Table 22).

Brick decreases collapse angle in comparison to rocks as mentioned in 4.1.4. At constant wall profile 1, brick becomes ineffective for the towers with large sized and asymmetrical openings since these openings themselves have major negative impact on structural resistance (opening 9-11, 14, 15, and 12, 13) (Figure 43). Only in opening 12 and 13, sandstone and brick have a minor negative effect at in plane positions.

Table 22. Collapse angles of towers with different openings and materials

Opening types			Materials			
			Limestone	Granite	Sandstone	Brick
	Op. 1	i	11	11	11	10
		o				
	Op. 2, 3, 4	i	11	11	11	10
		o	11	11	11	10
	Op. 5	i	11	11	11	10
		o	11	11	11	10
	Op. 6	i	11	11	11	10
		o	11	11	11	10
	Op. 7, 8	i	11	11	11	10
		o	11	11	11	10
	Op. 9	i	10	10	10	10
		o	11	11	11	10
	Op. 10	i	8	8	8	8
		o	9	9	9	9
	Op. 11	i	9	9	9	9
		o	10	10	10	10
	Op. 12, 13	i	10	10	9	9
		o	11	10	10	10
	Op. 14, 15	i	9	9	9	9
		o	10	10	10	10

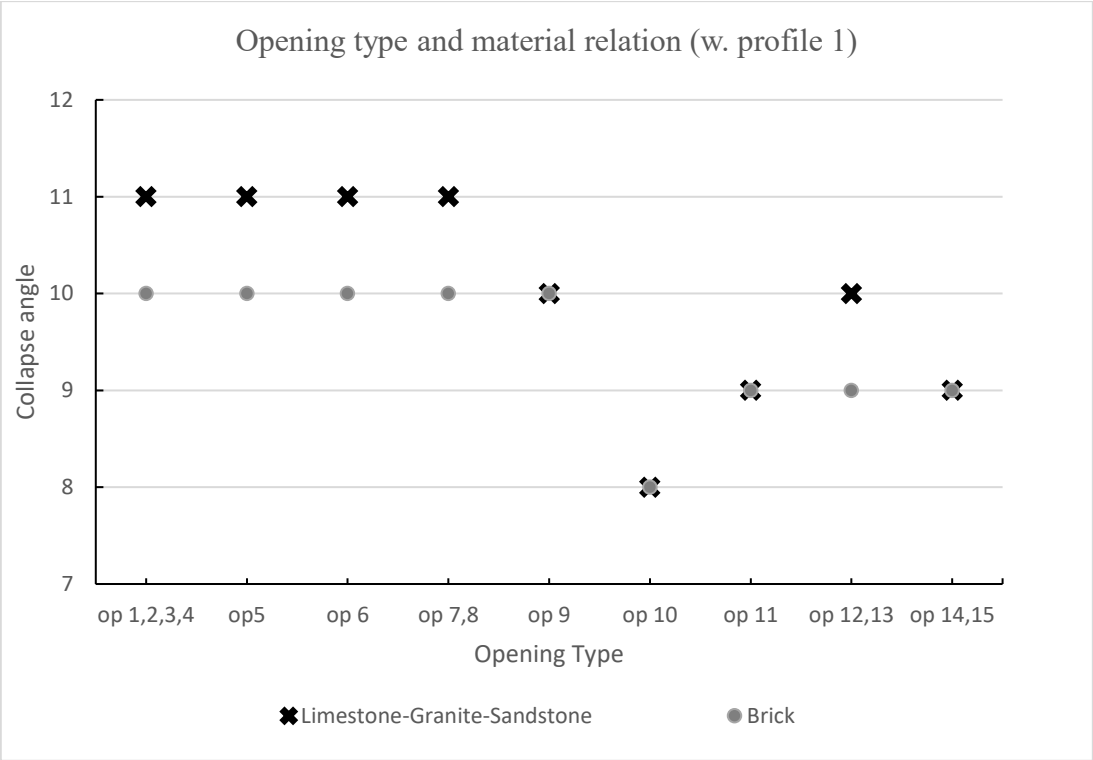


Figure 43. Openings at in-plane position and collapse angle relation in different materials at wall profile 1

3.3.1.1.8. Ratio between height and length, and material usage relation

Relationship of ratio between height and length and material usage is evaluated, when other characteristics are kept constant. As mentioned in the previous sections, the effect of usage of different stone types is similar. In different ratios, brick material decreases resistance against lateral loading considerably. Collapse angle of towers constructed with brick material is 1 degree lower than natural stones in all ratios. (Figure 44).

3.3.1.1.9. Ratio between height and length, and ground topography relation

Relationship of ratio between height and length, and ground topography is evaluated, when other characteristics are kept constant. As determined in the previous

sections, when the tower is tilted from the highest wall towards the lowest, the collapse angle increases. However, when bedrock and proportion relationship is evaluated, advantage of tilting from the highest wall is only seen in virtual ratios (h/l: 1, 1.3). The positive effect of the slope in the low towers is seen directly (Figure 45).

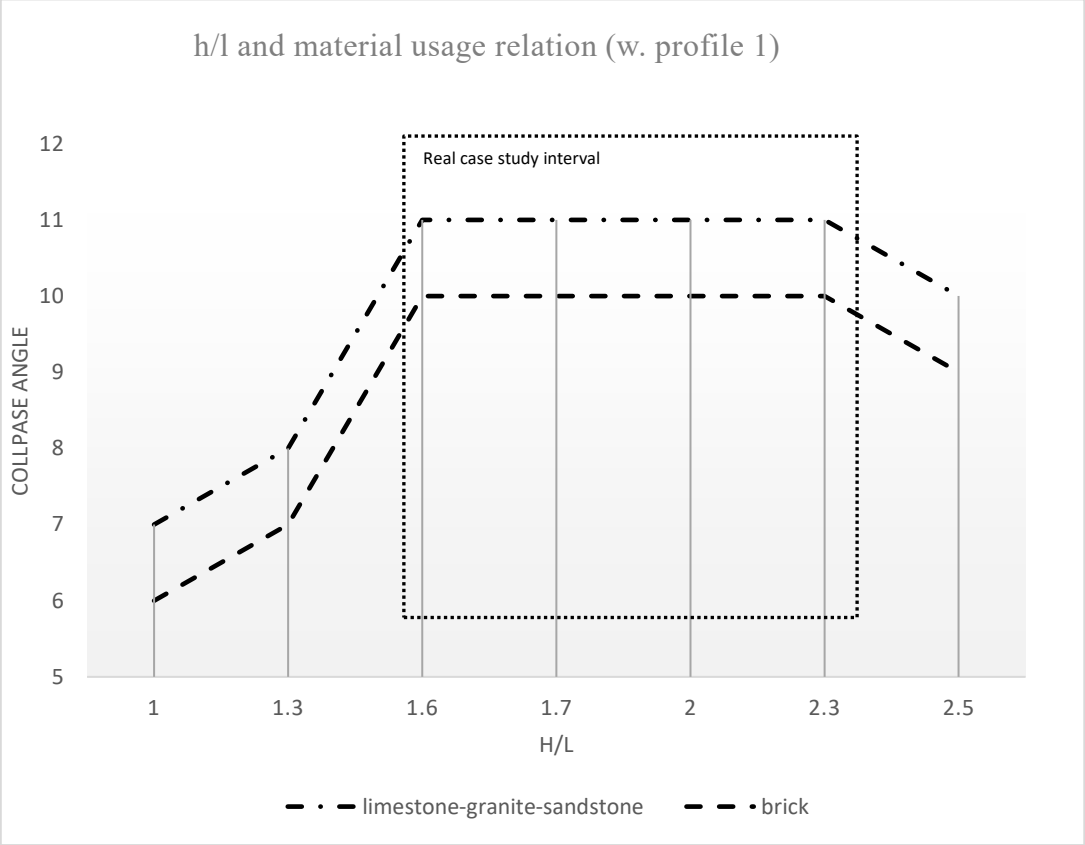


Figure 44. H/l and material usage relation at wall profile 1

3.3.1.1.10. Ground topography and material usage relation

Relationship of ground topography and material usage is evaluated, when other characteristics are kept constant. Towers constructed with natural stones collapse at higher angles and they are not affected by ground topography differences, while towers constructed with brick have low resistance. So, ground topography provides an advantage for towers out of vulnerable material (Figure 46).

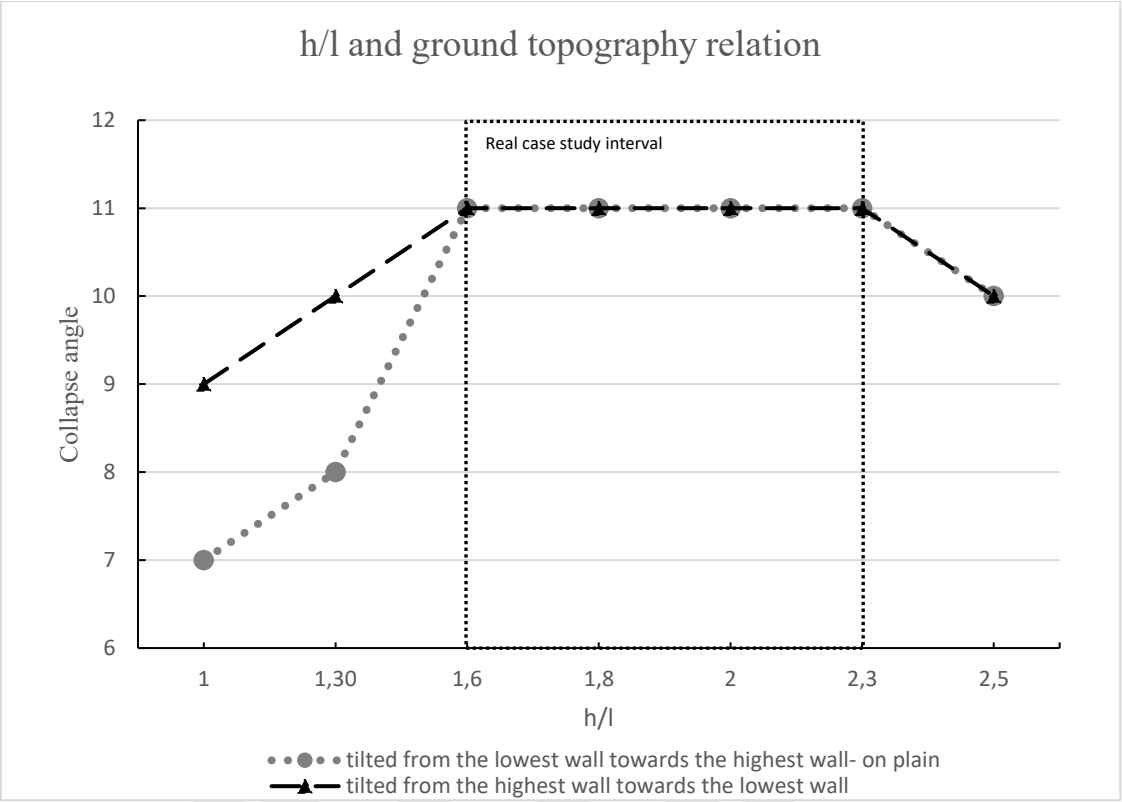


Figure 45. Ground topography and collapse relation in different h/l ratios wall profile 1

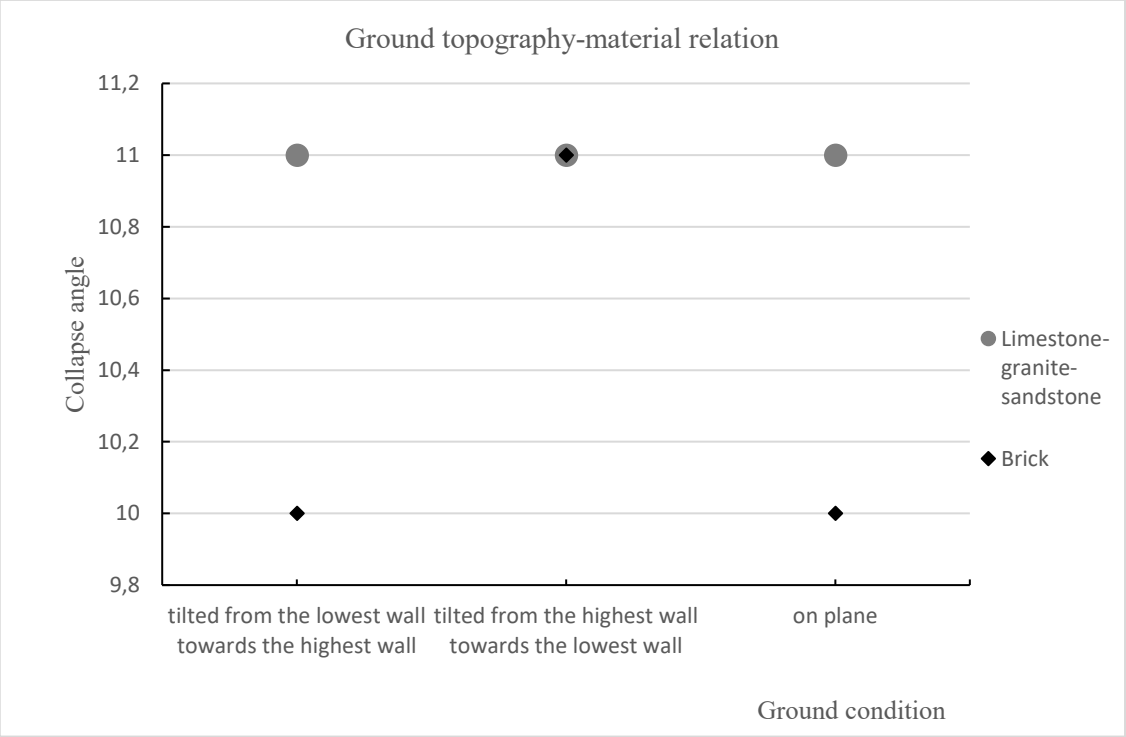


Figure 46. Ground topography in different materials at wall profile 1

3.3.1.2. Failure mechanisms

There are four types of failure mechanisms determined in the analysis: out-of-plane, in-plane, hybrid and total body failures (Table 23) (Giuffre 1993; D'ayala and Speranza 2003; Preciado et. al 2016; Milanu, Shehu and Valente 2018). Total body failure can be combined with in-plane or out-of-plane wall failures. These mechanisms are listed in the below:

Out-of-plane failure mechanisms:

- Mechanism A: overturning of the facade wall due to the vertical cracking at the corner connections
- Mechanism G: detachment of facade walls due to the diagonal cracking downwards from the corners of the facade

In-plane failure mechanisms:

- Mechanism B_1: collapse of one side wall with the facade wall due to the diagonal in-plane cracking
- Mechanism B_2: collapse of two side walls with the facade wall due to the diagonal in-plane cracking

Hybrid failure mechanisms:

- Mechanism B_2 +A: collapse of two side walls with facade wall due to diagonal in-plane cracking, followed by overturning of the facade wall due to the vertical cracking at the corner connections
- Mechanism B_2+G: collapse of two side walls with facade wall due to diagonal in-plane cracking, followed by detachment of facade wall due to the diagonal cracking downwards from the corners of the facade.
- Mechanism B_1 +A: collapse of one side wall with facade wall due to diagonal in-plane cracking, followed by overturning of the facade wall due to the vertical cracking at the corner connections.
- Mechanism B_1 +A+G: collapse of one side wall with facade wall due to diagonal in-plane cracking, followed by overturning of the facade wall due to the vertical cracking at the corner connections and also, at the same time, diagonal cracking upwards from the corners resulting in detachment of the facade wall.

Total body failures:

- Mechanism B_{2T}: diagonal in-plane cracking at the body of the tower by shear stresses, followed by horizontal cracking of the rear facade resulting in total overturning of the tower due to bending.
- Mechanism B_{2T+VS}: diagonal in-plane cracking at the body of the tower by shear stresses and horizontal cracking of the rear facade, followed by vertical in-plane cracking of side walls resulting in total overturning combined with vertical splitting.

Total body failures combined with in-plane and out-of-plane wall failures:

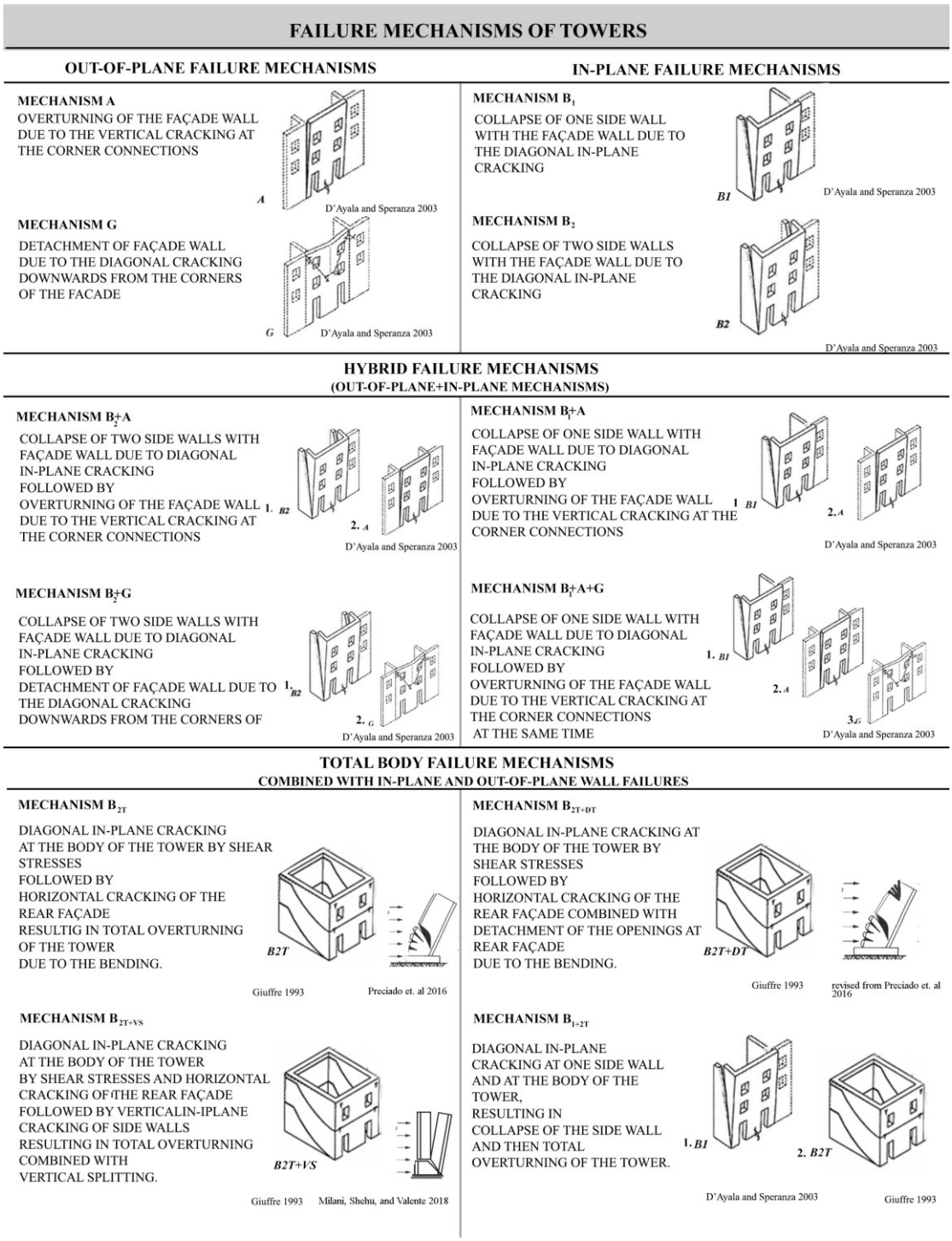
- Mechanism B_{2T+DT}: diagonal in-plane cracking at the body of the tower by shear stresses, followed by horizontal cracking of the rear facade combined with detachment of the openings at rear facade due to the bending.
- Mechanism B_{1+2T}: diagonal in-plane cracking at one side wall and at the body of the tower, resulting in collapse of the side wall and then total overturning of the tower.

3.3.1.2.1. Mechanisms in different wall profile and opening type combinations

Failure mechanisms of wall profile and opening type combinations are based on primarily wall profile type; and secondarily dimensions and position of openings at a facade. Mechanisms related to wall profile and opening type are evaluated, when other characteristics are kept constant. Openings are evaluated by taking into consideration their in-plane and out-of-plane positions separately. Impact of an opening type is analyzed at one wall of the tower; other three walls are designed with symmetrical small sized opening that has ideal position and minimum area (op. 1).

First, behavior of towers with different wall profiles consisting of a symmetrical small sized opening (opening type 1) with or without ground opening that has minimum top opening area (1 m^2) and ideal position, are investigated for determination of typical failure mechanism types of the wall profiles. The in-plane and out-of-plane behavior of towers with opening type 1 are not investigated separately, since all facades have opening type 1.

Table 23. Failure mechanism of towers determined in the analysis



Respective phases of failure mechanisms are presented for each wall profile type in Figure 47. Diagonal in-plane cracking at two side walls result in collapse of two side walls together with facade wall. This failure is followed by out-of-plane overturning of facade wall due to vertical cracking at the corner connection of wall profile 1, 2 and 3

(Mechanism B_2+A). However, diagonal in-plane cracking at two side walls results in collapse of two side walls together with facade wall at wall profile 4 (Mechanism B_2). At wall profiles 1, 2 and 3, blocks positioned at lower parts of the side walls slide, while sliding is not observed at the wall profile 4. At wall profiles 1, 2 and 3, side walls collapse with acute angles, demolishing high portions. The height of the demolishing portion is short due to the relatively larger angle of the cracks at wall profile 4. In-plane diagonal cracks causing collapse of side walls is related to shear stresses at the top openings of wall profiles 2, 3 and 4. Diagonal in-plane cracking of wall profile 1 is directly related to the wall profile organization, independent from opening.

Mechanisms of wall profile 5 and 6 is considerably different from wall profile 1, 2, 3 and 4, since towers constructed with wall profile 5 and 6 present total body behavior; overturning of the tower, in place of wall behavior (mechanism B_{2T}). This body behavior comes from in-plane shear, thus it is similar with mechanism B_2, however a triangular wall portion collapses at mechanism B_2, while trapezoidal shaped body of the tower is overturning at $B_{2total.}$ At wall profile 5, diagonal cracking at the towers body by shear stress is followed by vertical in-plane cracking of the body. At last, total overturning is combined with vertical splitting (mechanism B_{2T+VS}). The tower constructed with wall profile 6, which collapses at the highest angle, presents only total overturning at 18 degrees due to the horizontal cracking of the body followed by in-plane cracks caused by shear stress (Mechanism B_{2T} (Figure 47).

Up to 18° collapse angle, wall profile 6 does not present any in-plane and out-of-plane failure at side or facade walls. At 18° degrees, it presents total body behavior. Also, although wall profile 5 does not collapse at higher angles (14°), it also shows total body behavior. This shows that total body behavior is related to wall profile, since wall profile 4 collapses at higher angle (17 °), however it collapses due to the wall behavior. Total behavior does not directly correspond to high resistance against lateral loading.

Other opening types are analyzed depending on their in-plane and out-of-plane positions separately. All collapse phases are examined, and failure mechanism is represented with one phase. Openings types are grouped according to their effectiveness on behavior of wall profile types as effective and less effective ones. Less effective openings are (Figure 34) medium sized symmetrical top opening with or without symmetrical ground opening (op. 2; 1.4 m^2) and asymmetrical small sized opening (op. 3; 1 m^2) with or without symmetrical ground opening and medium sized asymmetrical top opening with symmetrical ground opening (op. 4; 1.4 m^2 top op. area), symmetrical

ground and symmetrical top and middle small sized openings (op. 5; 2 m^2 top and middle op. area), asymmetrical middle medium sized opening (op. 6; 2.56 m^2), asymmetrical ground opening and symmetrical top and middle small sized openings (op. 7; 2 m^2 top and middle op. area), ground opening adjacent to corner and symmetrical small sized top opening (op. 9; 1.4 m^2 top op. area), ground opening adjacent to corner, asymmetrical small sized middle and symmetrical medium sized top opening (op. 12; 2.44 m^2 top op. area) and asymmetrical middle large sized and small top sized opening (op. 13; 3.3 m^2).

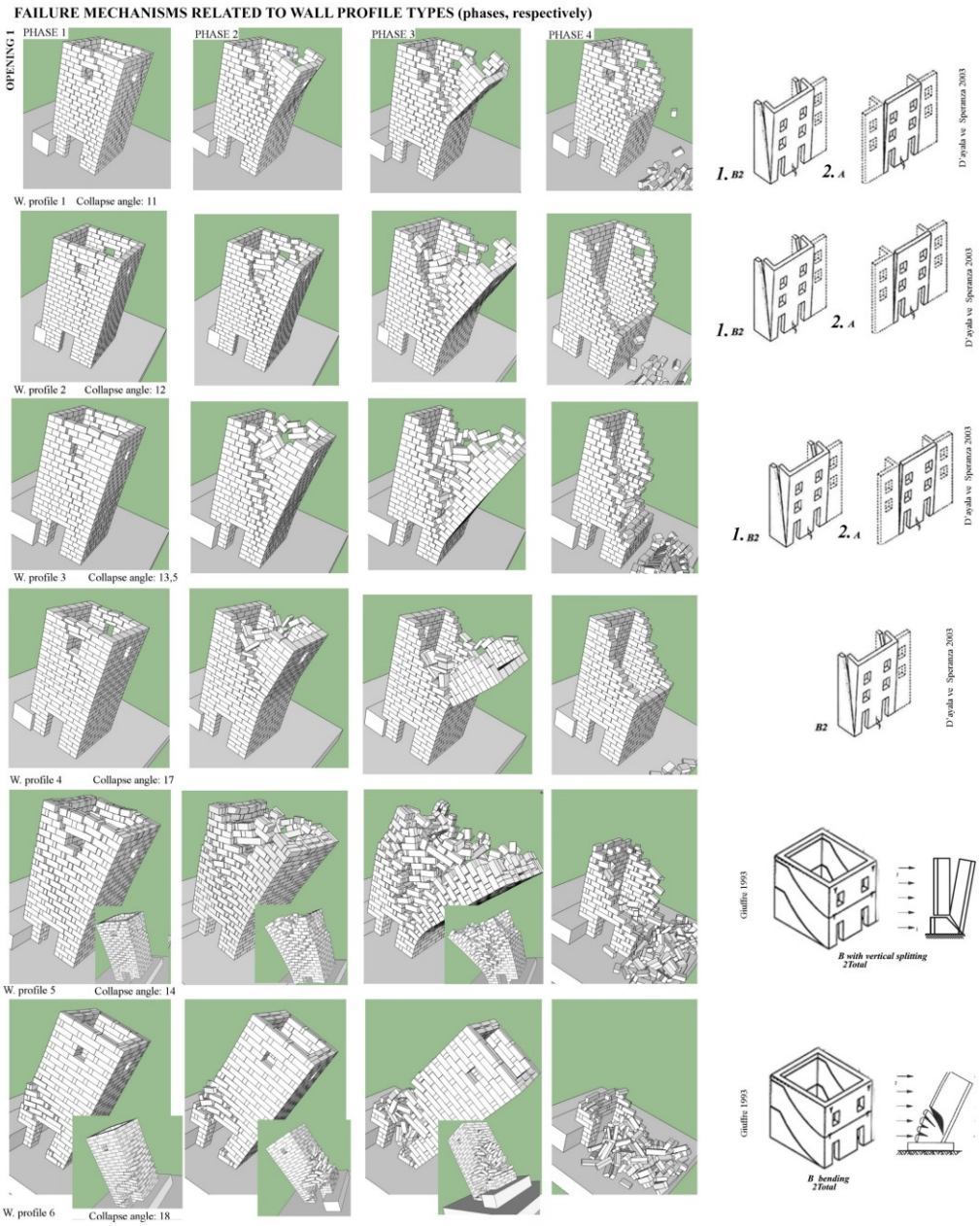


Figure 47. Failure mechanisms of different wall profiles with opening type 1

These openings at in-plane position generally do not change the mechanisms of the wall profiles with opening 1, while openings at out-of-plane position cause detachment of out-of-plane wall due to the diagonal cracks downwards from the corners almost in all wall profiles (Mechanism G). Effective openings are symmetrical small sized three top openings with or without ground opening (op. 8; 3 m^2 top op. area), symmetrical large sized top opening with two small sized top opening and ground opening (op. 10; 7.4 m^2 top op. area), symmetrical medium sized three top openings with or without ground opening (op. 11; 4.3 m^2 op. area), middle medium sized opening adjacent to corner and small top sized opening (op. 14; 3.3 m^2) and medium sized top opening adjacent to corner, asymmetrical small sized top opening with ground opening adjacent to corner (op. 15; 2.9 m^2). These openings at in-plane position causes different mechanisms depending on wall profiles. Opening 8, 11 and 15 at in-plane position can cause collapse of one side in-plane wall (mechanism B_1), while opening 10 cause fasten collapse of two side walls due to in-plane shear stress at the openings (mechanism B2) in all profile types regardless of their resistance. The only difference between opening 14 (3.3 m^2) and opening 13 is adjacent position of the middle opening, opening 14 can cause diagonal cracking as wedge shape while collapsing of two side walls due to the in-plane cracking (mechanisms B_2) depending on wall profile type.

First, less effective opening types (2-7, 9, 12, 13) are presented for each wall profile. Then, effective ones are examined in detail.

At the wall profile 1, less effective opening types at in-plane position present almost the same mechanism with opening 1 (mechanism B_2+A). Diagonal in-plane cracking is not related to the openings 2-7, 9, collapse occurs due to the characteristics of the wall profile independent from openings, however openings 6, 12 and 13 composed of asymmetrical top openings cause diagonal in-plane cracking at openings (Figure 48).

Openings at out-of-plane position cause detachment of facade wall due to the diagonal cracks downwards from the corner with sliding of top blocks of side walls (mechanism G) (Figure 48). There is not any impact of asymmetrical ground openings (9) on form of collapsing portion.

At wall profiles 2, symmetrical top openings (2, 5, 7 and 9) at in-plane position cause diagonal in-plane cracking at the openings and mechanism of wall profile with opening 1 sustains (mechanism B_2+A); diagonal in-plane cracking at two side walls resulting in collapse of two side walls with facade wall and this failure is followed by out-

of-plane overturning of the facade wall due to vertical cracking at the corner connections. However, asymmetrical openings (3, 4, 6, 12 and 13) cause directly collapse of two side walls without vertical cracking at the corners (mechanism B2). Depending on position and size of openings at in-plane position, angle of crack and form of collapsed portion change.

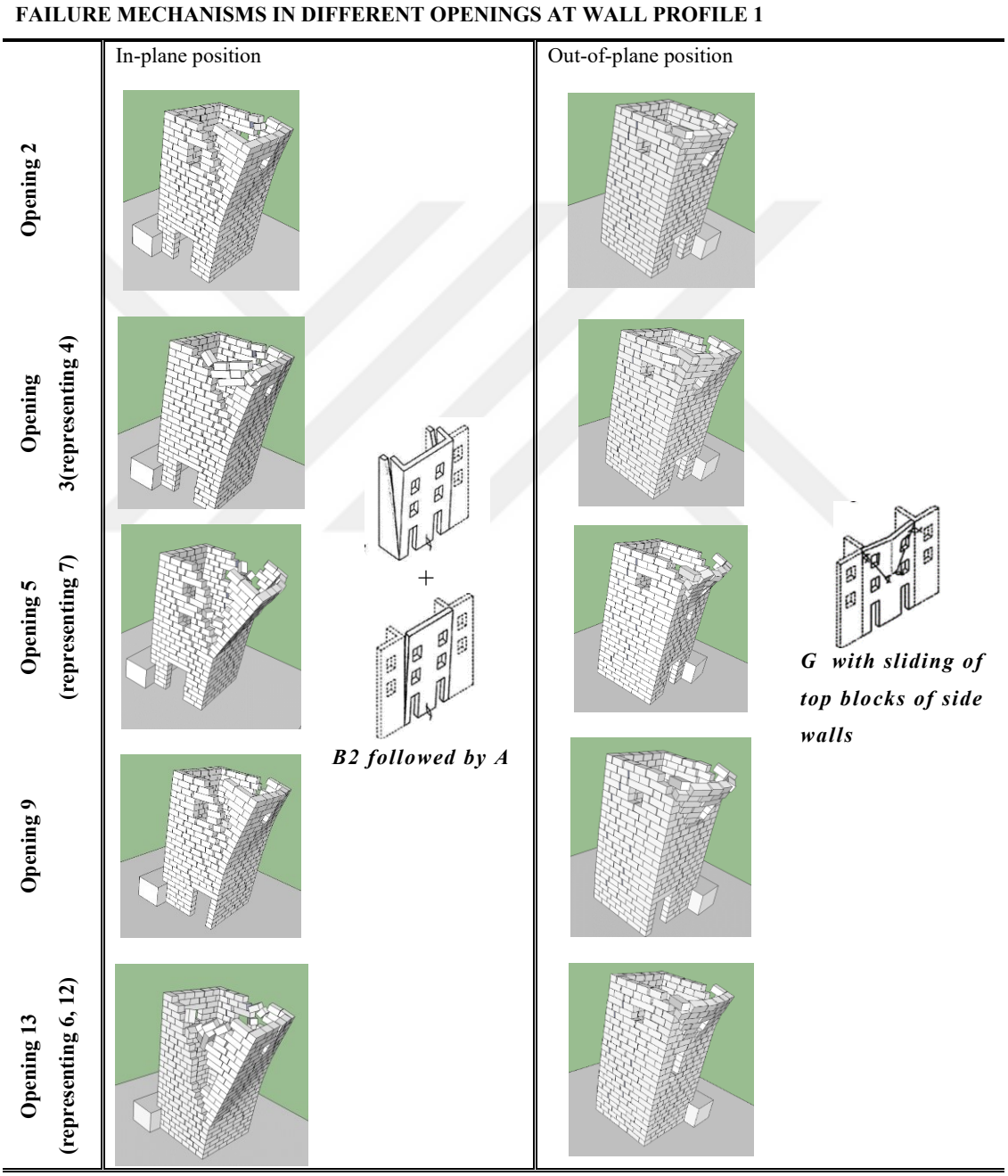


Figure 48. Similar failure mechanisms of different opening types at wall profile 1

For example, a middle and top opening (op. 5, 7 and 12) and middle medium sized openings (op. 6 and 13) cause increase in height of the collapsed portion due to the cracking at their top and bottom (Figure 49). There is not any impact of asymmetrical ground openings (9) on form of collapsing portion, its mechanism is similar with opening 2. All openings at out-of-plane position cause diagonal cracking downward from the corners resulting in detachment of facade wall with sliding of top blocks of side walls (mechanism G).

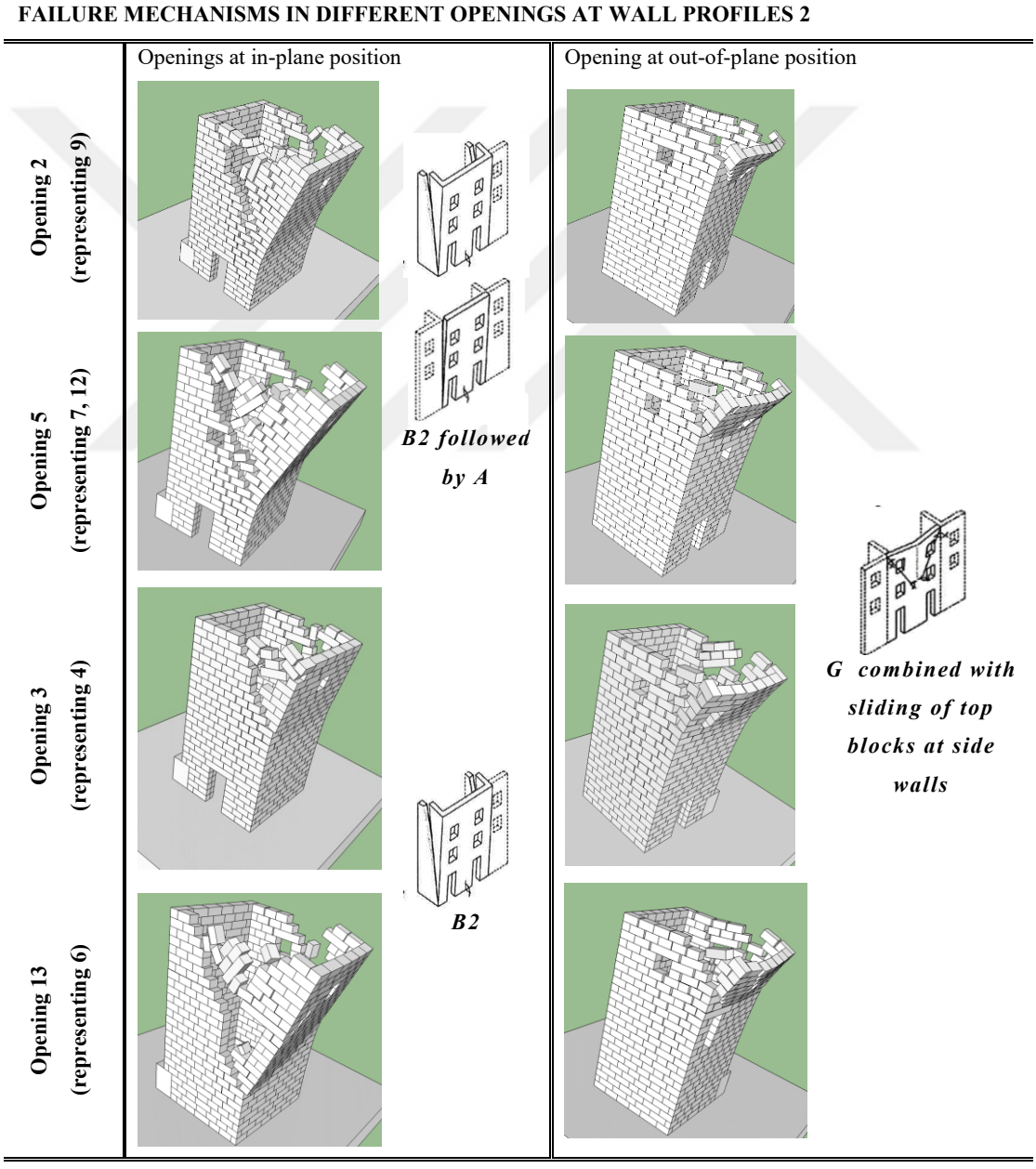


Figure 49. Similar impact of openings 2-7, 9, 12, 13 at wall profiles 2

At wall profiles 3, less effective opening types at in-plane position presents the same mechanism with opening 1 as wall profile 1 and 2 (mechanism B_2+A). Depending on position and size of openings at in-plane position, angle of crack and form of collapsed portions change. For example, a middle and a top opening or medium sized asymmetrical openings (op. 5-7, 12-13) cause cracks at their top and bottom, height of the collapsed portion increases. Openings at out-of-plane position cause only collapse of two sized walls due to the in-plane cracks (mechanism B_2). (Figure 50). There is not any impact of asymmetrical ground openings (9) on the form of collapsed portion, its mechanism is similar with opening 2.

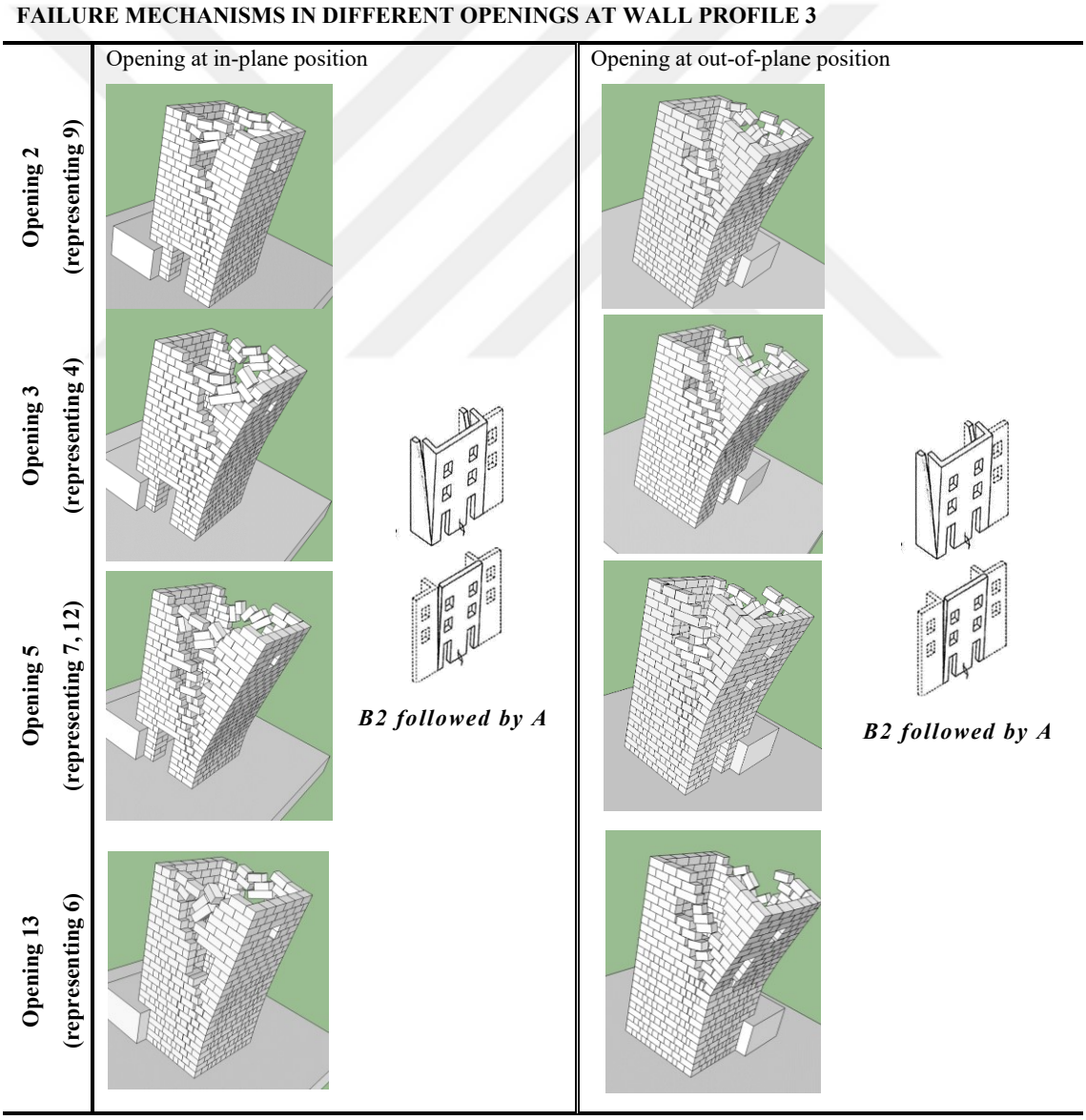


Figure 50. Similar impact of openings 2-7, 9, 12, 13 at wall profiles 3

At wall profiles 4, less effective opening types at in-plane position present the same mechanism with opening 1 (mechanism B_2). Depending on position and size of openings at in-plane position, angle of crack and form of collapsing portion change. For example, a middle and a top opening or medium sized asymmetrical openings (op. 5-7, 12-13) cause cracks at their top and bottom, height of the collapsed portion increases. Openings at out-of-plane position cause collapse of two side walls due to the in-plane cracking (mechanism B_2), also vertical cracks can be observed at the corner connections (Figure 51). With the help of the characteristic of wall profile, the openings do not cause detachment.

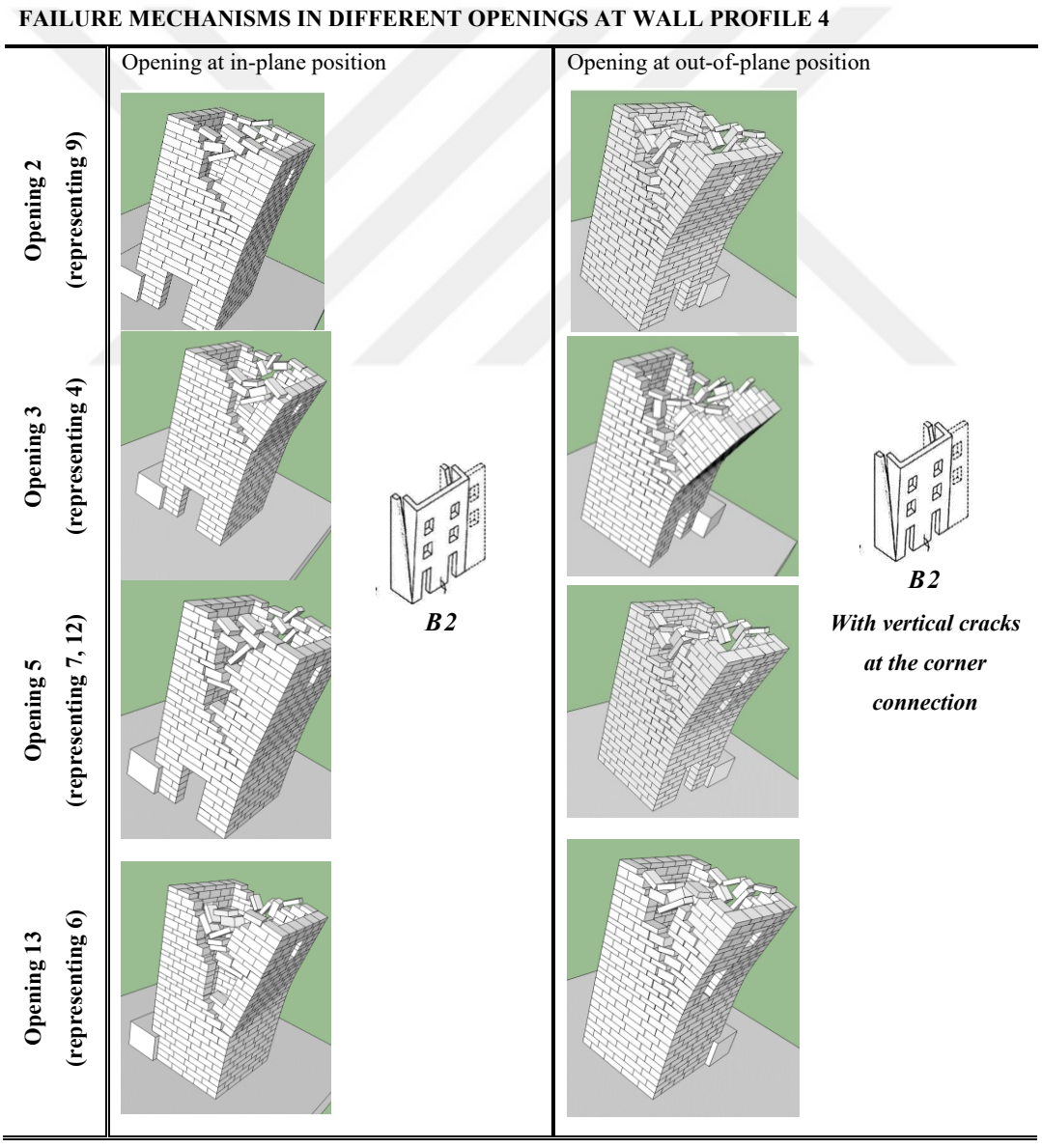


Figure 51. Similar impact of openings 2-7, 9, 12, 13 at wall profiles 4

At wall profile 5, openings at in-plane position, except asymmetrical small or medium sized (op. 3 and 4), sustain failure mechanism of opening 1; diagonal cracking at the tower's body by shear stress and horizontal cracking at the rear facade is followed by vertical in-plane cracking of the tower body and total overturning is combined with vertical splitting (mechanism B_{2T+VS}). However, asymmetrical small or medium sized top openings (openings 3 and 4) do not cause vertical splitting due to their position and the tower present only total overturning due to bending (Figure 52).

Openings at out-of-plane position also cause total overturning with detachment of rear facade due to the bending (mechanism B_{2T+DT}). For openings 3 and 4, total overturning is combined with vertical splitting (Figure 52).

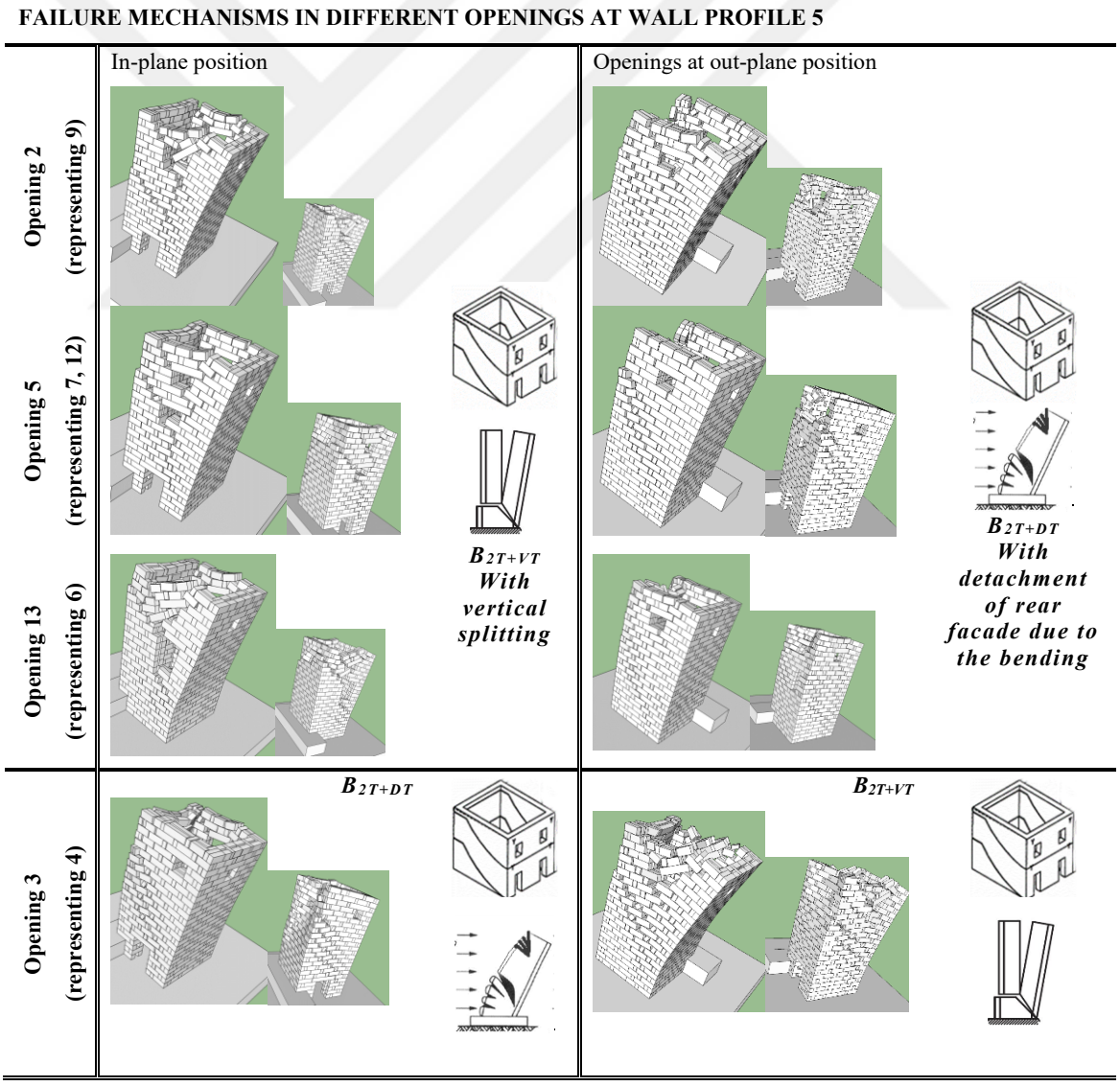


Figure 52. Similar impact of openings 2-7, 9, 12, 13 at wall profiles 5

At wall profile 6, both openings at in-plane and out-of-plane position present the same mechanism with opening 1, the tower presents total overturning due to bending at higher collapse angles (18°). However, opening 13 at in-plane cause vertical cracking at the body of the tower, the towers present total overturning combined with vertical splitting (mechanism B_{2T+VS}) (Figure 53).

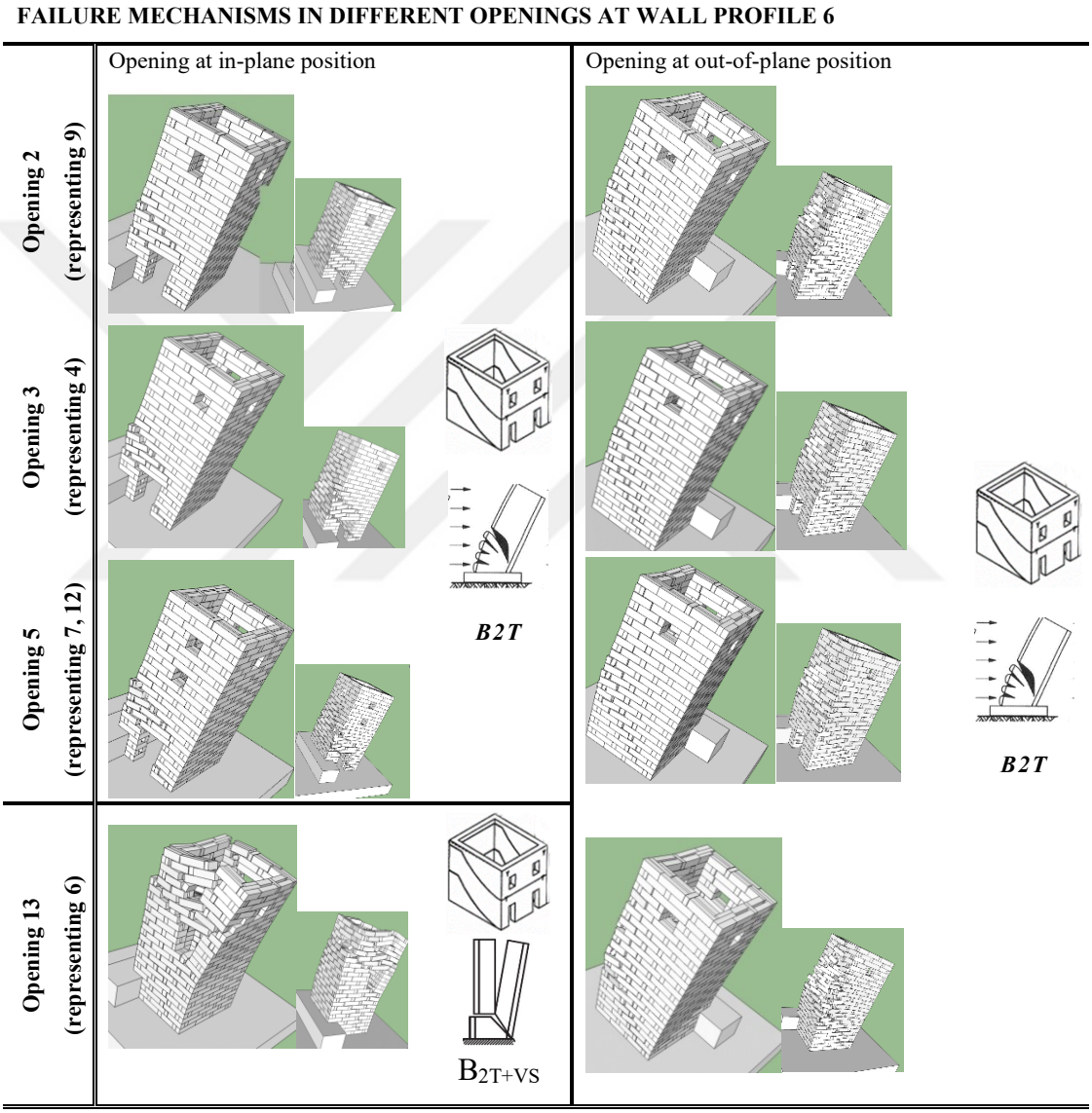


Figure 53. Impact of openings 2-7, 9, 12, 13 at wall profiles

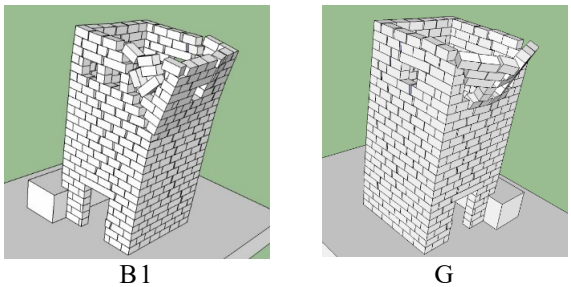
Openings (2-7, 9, 12 and 13) at in-plane and out of plane positions generally present similar mechanisms with respect to wall profiles. However, effective openings 8, 10, 11, 14 and 15 can cause change in these mechanisms depending on characteristics of

wall profiles. Opening 8 (3 m^2 top op. area), opening 10 (7.4 m^2 top op. area) with large sized top opening (180x300) and small sized two top openings (100x100 cm), opening 11 (14.4 m^2) with three top openings each (90x160 cm), opening 15 (2.9 m^2 top op. area) with medium sized top opening (140x210 cm) adjacent to corner and asymmetrical top opening (75x160 cm) affect behavior of wall profiles prominently.

First, impact on symmetrical small or medium sized three top openings with or without ground opening is examined (op. 8 and 11). Opening 8 and 11 at in-plane position cause collapse of two side walls due to the diagonal in-plane cracking (Mechanism B_2) at wall profile 2, 3 and 4, while collapse of one side wall occur at wall profile 1 and 5 due to the in-plane cracking at the opening (mechanism B_1). Also, at wall profile 6, in-plane diagonal cracking at the openings and at the tower's body due to the in-plane shear stress result in collapse of the side wall followed by total overturning (mechanism B_{1+2T}).

Opening 8 and 11 positioned at out-of-plane wall cause detachment of the facade wall due to the diagonal cracks downwards from the corners (mechanism G) at wall profile 1 and 2. However, at wall profile 3 and 5 mechanism G is combined with some other mechanisms. At wall profile 3, collapse of two side walls with facade wall due to the in-plane diagonal cracking is followed by detachment of facade wall due to diagonal cracks downwards from the corners at the openings (mechanism B_2+G). At wall profile 5, total overturning of the tower due to the in-plane body cracking and horizontal cracking at the rear facade is combined with detachment of rear facade due to the bending (mechanism B_{2T+DT}). Wall profile 4 and 6 sustain their typical mechanisms in spite of the effective openings (Figure 54, Figure 55).

Effect of opening 8 (3 m^2) which has three top openings, on failure mechanisms is similar with opening 11, although its effect on collapse angle is less in comparison to wall profile 11 as seen in heading 3.3.1.1.1 (Figure 54).



B1 G

Figure 54. Openings 8 and 11 at in plane (left) and out of plane (right) positions

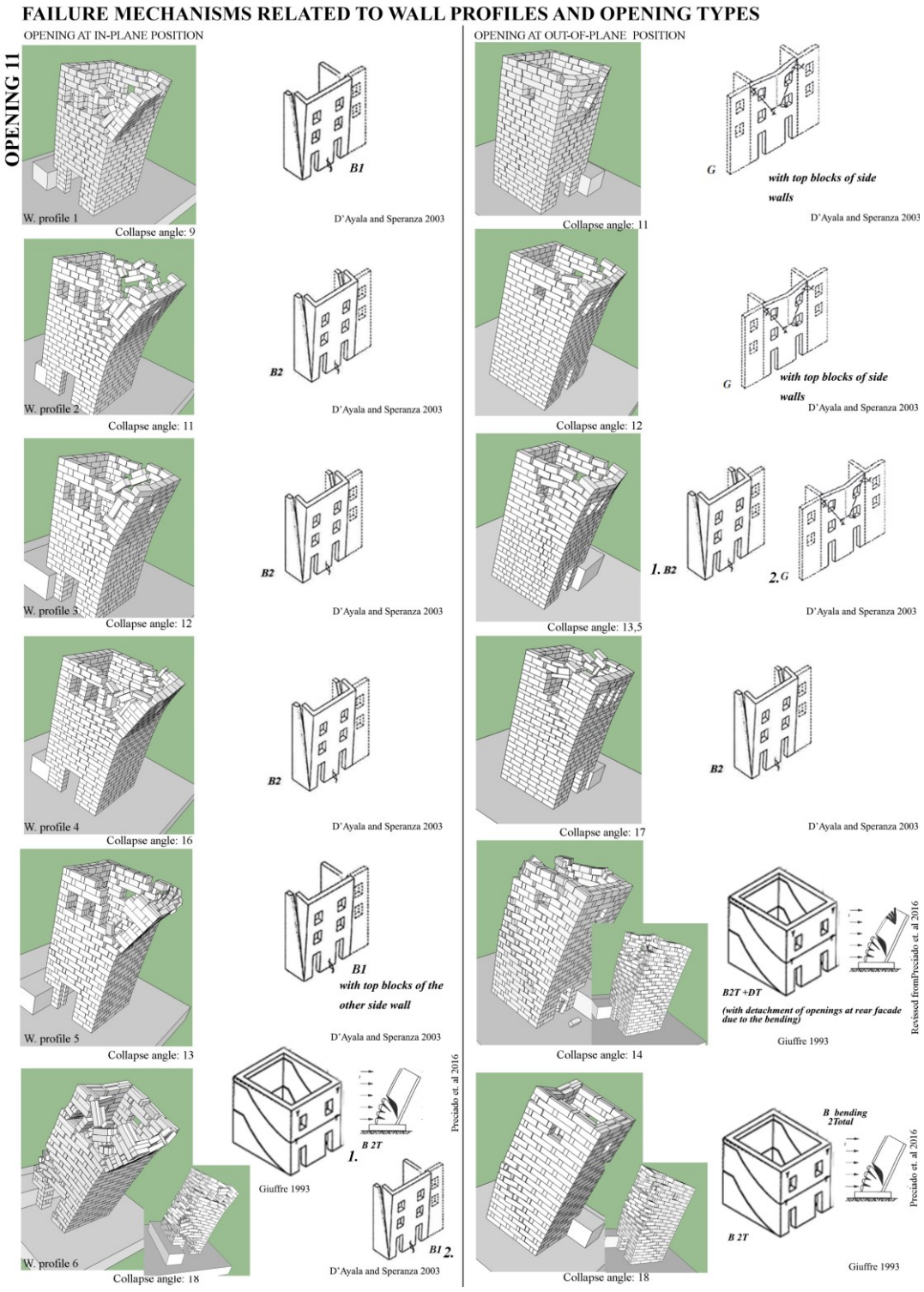


Figure 55. Effect of opening 11 on behavior of towers

Opening 10 (Figure 35), which has a large overall upper opening area, (7.4 m^2 top openings, 4.86 m^2 ground opening) at in-plane position, causes collapse of two side walls due to the diagonal in-plane cracking at the openings in all profile types (Mechanism B_2). Wall profile 1, 2 and 3 (mechanism B_2+A) and wall profile 4 (mechanism B_2) sustains

their typical failure mechanisms, however openings decrease collapse angles considerably and increase the area of the collapse portions in comparison to less effective openings (2-7, 9). Wall profile 5 and 6 do not present total body behavior due to the effect of opening, they present only mechanism B_2 by shear stresses at openings, also rear wedge facade portion collapse due to the opening close to the corner and rear facade (Figure 56).

Opening 10 at out-of-plane position sustains the typical failure mechanisms of wall profiles 1 (mechanism G), 2 (mechanism G), 3 (mechanism G), and 5 (Mechanism B_{2T+DT}) but collapse at lower collapse angles in comparison to less effective openings (mechanism G). It causes occurrence of collapse of two side wall due to the in-plane diagonal cracking followed by detachment of the facade due to the diagonal cracks downwards from the corner (mechanism B_2+G) at wall profile 4. However, opening at out-of-plane position do not cause any failure mechanism at wall profile 6, wall profile sustains typical mechanism; total overturning (Figure 56).

Middle large sized opening adjacent to corner with small sized top opening at in-plane position (op. 14; 3.3 m^2) causes mainly collapse of two side walls due to the diagonal in-plane cracking. However, this mechanism is followed by diagonal cracking of collapsed orthogonal walls as wedge portions at wall profile 2, 3, 5 and 6. Sequence of cracking as a wedge portion comes from other failure mechanism, since it is not the main effect of the failure. Wall profile 1 and 4 sustain their failure mechanisms without diagonal cracking of orthogonal walls (mechanism B_2 +A and B_2, respectively).

Wall profiles sustain their typical failure mechanisms when opening at out-of-plane position, however, collapse angle of towers decrease in comparison to ineffective openings (Figure 57).

Opening 15 (2.9 m^2 top op. area) that has top medium sized opening adjacent to corner with asymmetrical top small sized opening at in-plane position causes collapse of the side wall related to opening adjacent to corner (mechanism B_1) at wall profile 1, 4 and 5 prominently. However, collapse of two side walls occurs at wall profile 2 and 3 (mechanism B_2). Wall profile 6 sustain its typical failure mechanisms (mechanism B_{2T}).

When openings are at out-of-plane position, detachment of facade wall occur due to diagonal cracking downwards from the corners. At wall profiles 5 and 6, total overturning is combined with detachment of openings at rear facade due to the bending (Figure 58).

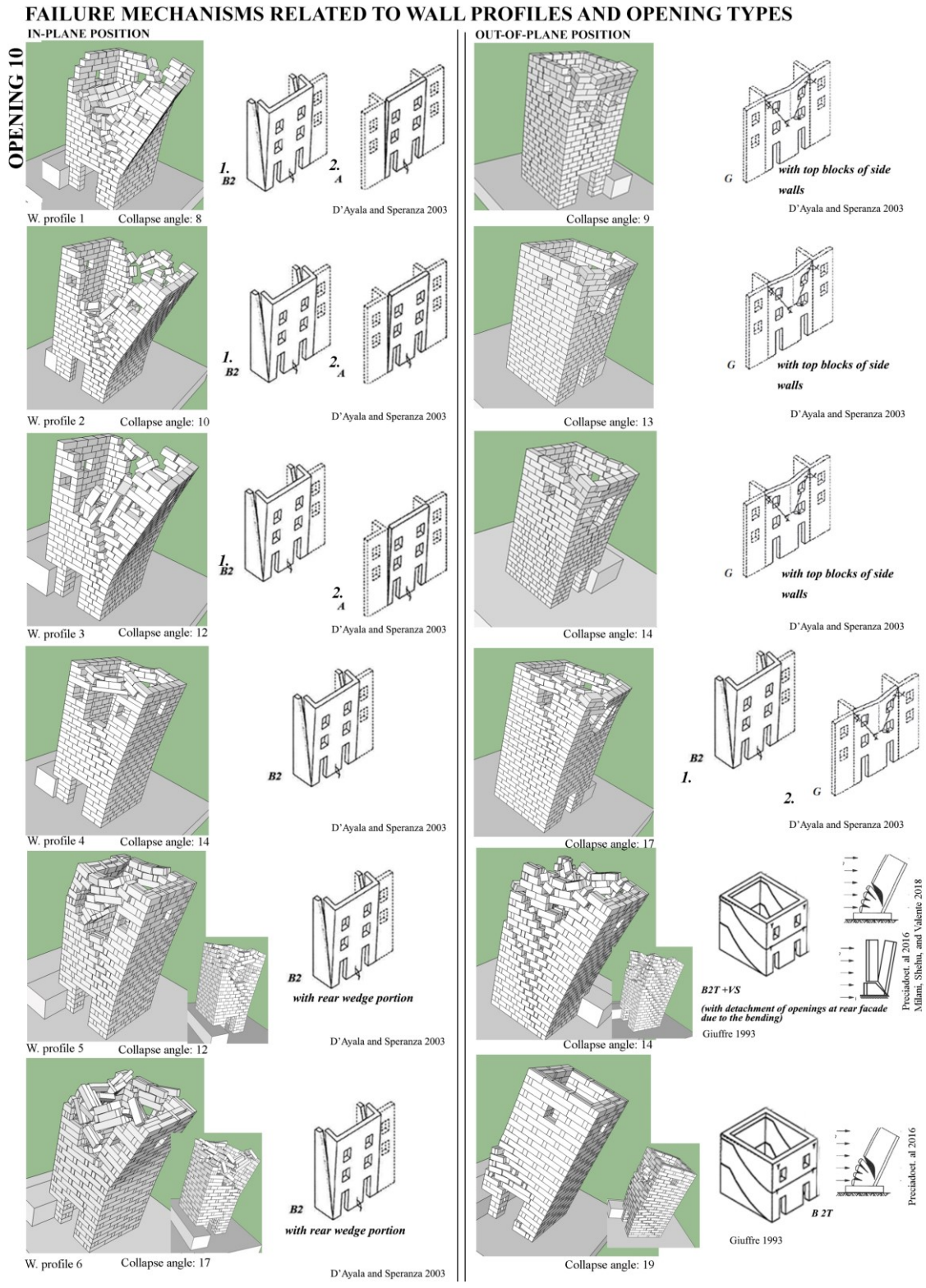


Figure 56. Effect of opening 10 on behavior of towers

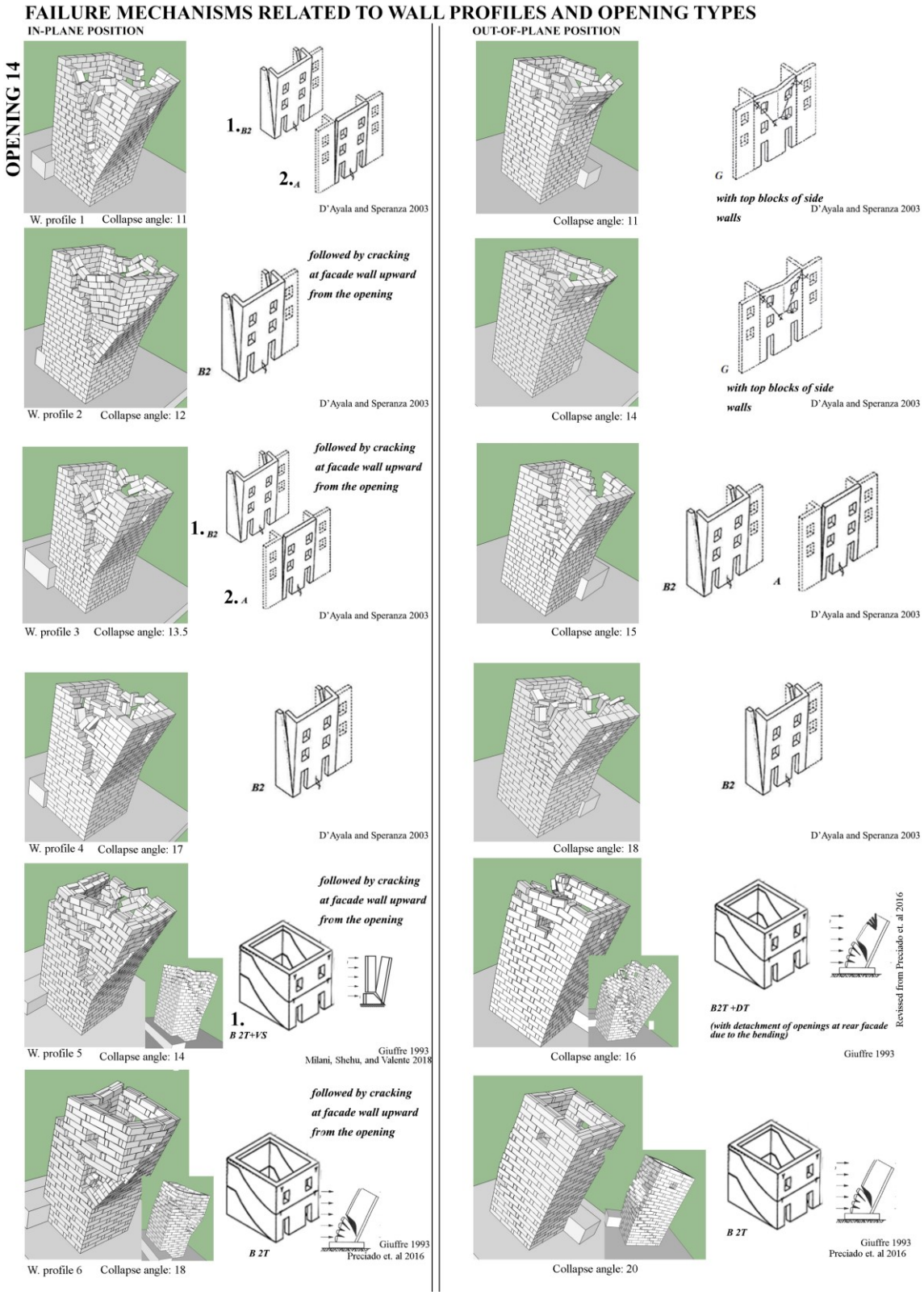


Figure 57. Failure mechanism of wall profiles with opening 14

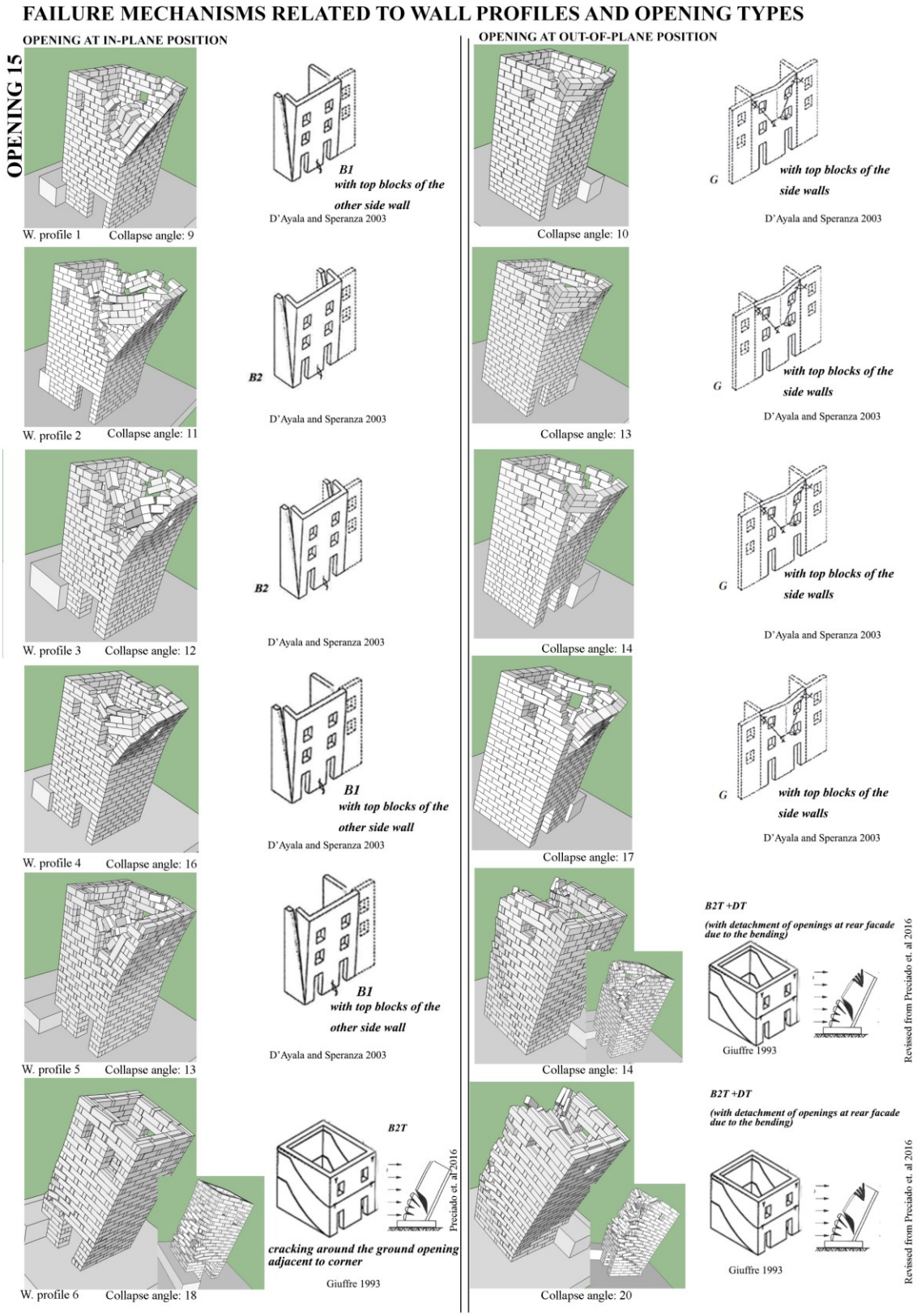


Figure 58. Effect of opening 15 on behavior of towers

3.3.1.2.2. Mechanisms in different wall profile and h/l combinations

Failure mechanisms of wall profile and h/l ratio combinations are based on primarily wall profile type and secondarily h/l ratios. Mechanisms related to wall profile and h/l combinations is evaluated, when other characteristics are kept constant. Wall profiles generally sustain their typical failure mechanisms for h/l ratios between 1.6 and 2.3 (Figure 47, Figure 59). Only wall profile 5 does not sustain its typical mechanism in 1.6 and 2.3 h/l ratios. Wall profile 5 in 1.6 h/l ratio presents collapse of two side walls due to the diagonal in-plane crackings (mechanism B_2), however wall profile 5 present total overturning with vertical splitting in other ratios (mechanism B_{2T} with vertical splitting presented in Figure 47 in detail). In 2.3 ratio, vertical splitting is not observed, the tower is overturning due to the bending (mechanism B_{2T}) (Figure 59).

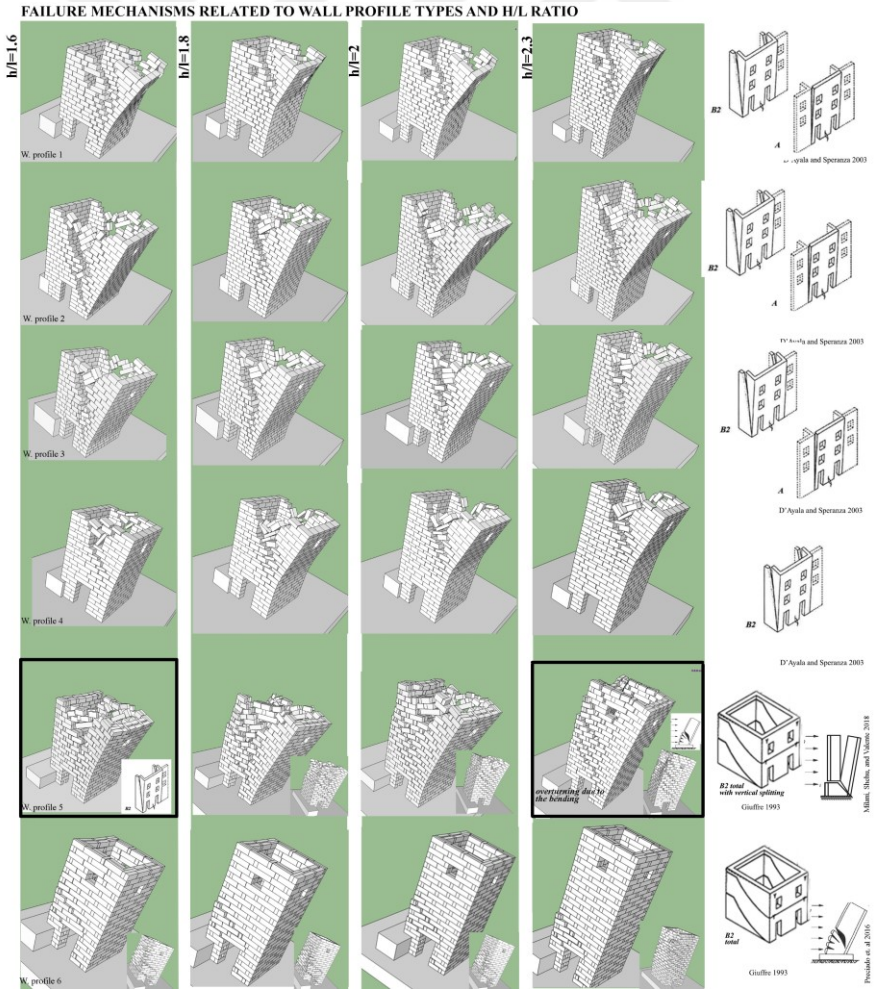


Figure 59. Effect of wall profiles on behavior in different h/l ratio

If the ratio is 1.3 or smaller than 1.3, mechanisms change due to the small h/l ratio. h/l ratio smaller than 1.3 causes generally overturning of facade wall due to the vertical cracks at the corners. At wall profile 2 and 3, overturning of only the facade wall occurs due to the vertical cracks at side walls and sliding of top blocks (mechanism A) (Figure 60). However, at wall profile 1, detachment of out-of-plane facade wall due to the diagonal cracks at the upper corners of side walls is observed (mechanism G).

At wall profile 4, collapse of two side walls is followed by vertical cracking at the corner connection (mechanism B_2+A). At wall profile 5, in place of overturning, collapse of two side walls due to in-plane cracking occurs as 1.6 h/l ratio. Wall profile 6 sustains its typical behavior, however due to the bending, detachment of the rear facade is also observed (mechanism B_{2+DT}) (6).

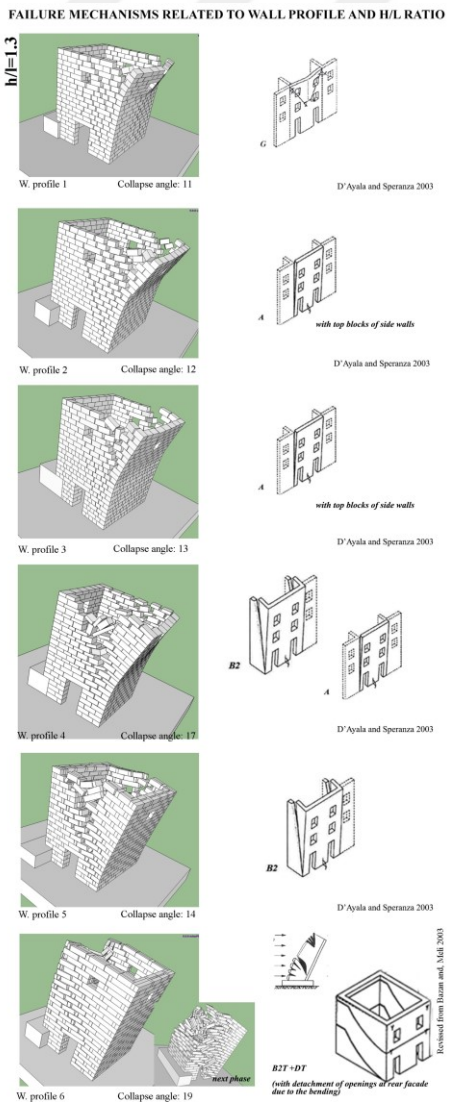


Figure 60. Failure mechanisms of wall profiles at 1.3 h/l

3.3.1.2.3. Mechanisms in different wall profile and ground topography combinations

Possible ground topographies do not change the failure mechanisms of wall profile types (Figure 61).

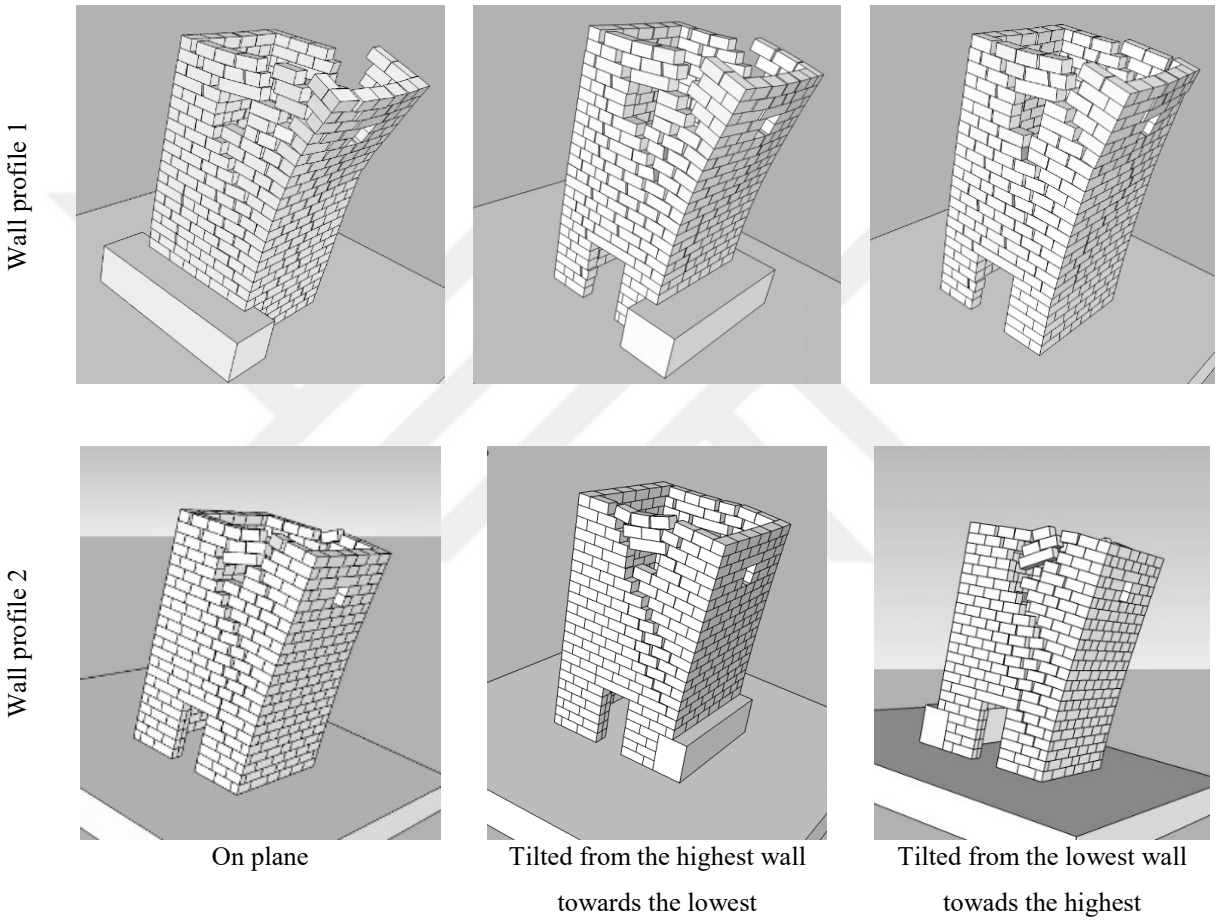
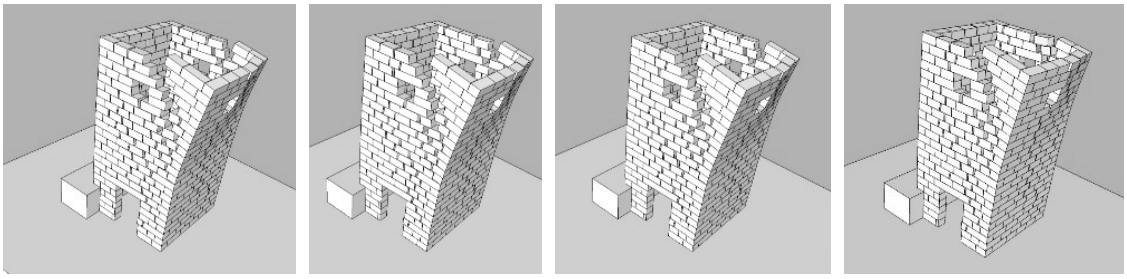


Figure 61. Failure mechanism at different ground topographies

3.3.1.2.4. Mechanisms in different wall profile and material usage combinations

Different material usage does not affect failure mechanism of wall profile (Figure 62).



Limestone Granite Sandstone Brick

Figure 62. Failure mechanisms in walls out of various materials mirror

3.3.1.2.5. Mechanisms in different opening type and h/l combinations

Failure mechanism of opening type and h/l combinations are based on primarily opening type and secondarily h/l ratios. Mechanisms related to wall profile and opening type is evaluated, when other characteristics are kept constant.

In section 3.3.1.2.1, impact of openings is analyzed. Effect of small, medium sized top openings or middle openings not adjacent to corner (2-7, 9, 12, 13) is almost similar. Ratios smaller than 1.3 cause decrease in collapse angle by sustaining mechanisms of openings at out-of-plane position (mechanism G), however, small h/l ratio changes failure mechanisms when openings at in-plane position. h/l ratio with less effective openings 2-7, 9, 12, 13 causes detachment of facade wall due to the diagonal cracks downwards from the corners of the wall profile 1 (Mechanism G) (Figure 63).

Effective openings in terms of failure mechanisms are opening 10 (7.4 m^2) with large sized top opening (180x300 cm) and small sized two top openings (100x100 cm), opening 8 (3 m^2) with three top openings, opening 8 (3 m^2) and 11 (4.3 m^2) with three top openings (90x160 cm) and opening 14 (3.3 m^2) and 15 (2.94 m^2 top op. area) with middle and top openings adjacent to corner as mentioned in the section 3.3.1.2.1.

H/L ratio smaller than 1.3 generally causes detachment of out-of-plane wall (mechanism G), however, openings 8, 10, 11, 14 and 15 become more effective in determination of mechanisms for all h/l ratios including ratios smaller than 1.3. Opening 10 at in-plane position of wall profile 1 causes collapse of two side walls due to the in-plane cracking followed by overturning of the facade due to vertical cracking at the

connection of corner (mechanism B_2+A) in all h/l ratios from 1.3 to 2.3. However, at ratios between 1.6 and 2.3, rear wedge portion of the tower collapse with side walls.

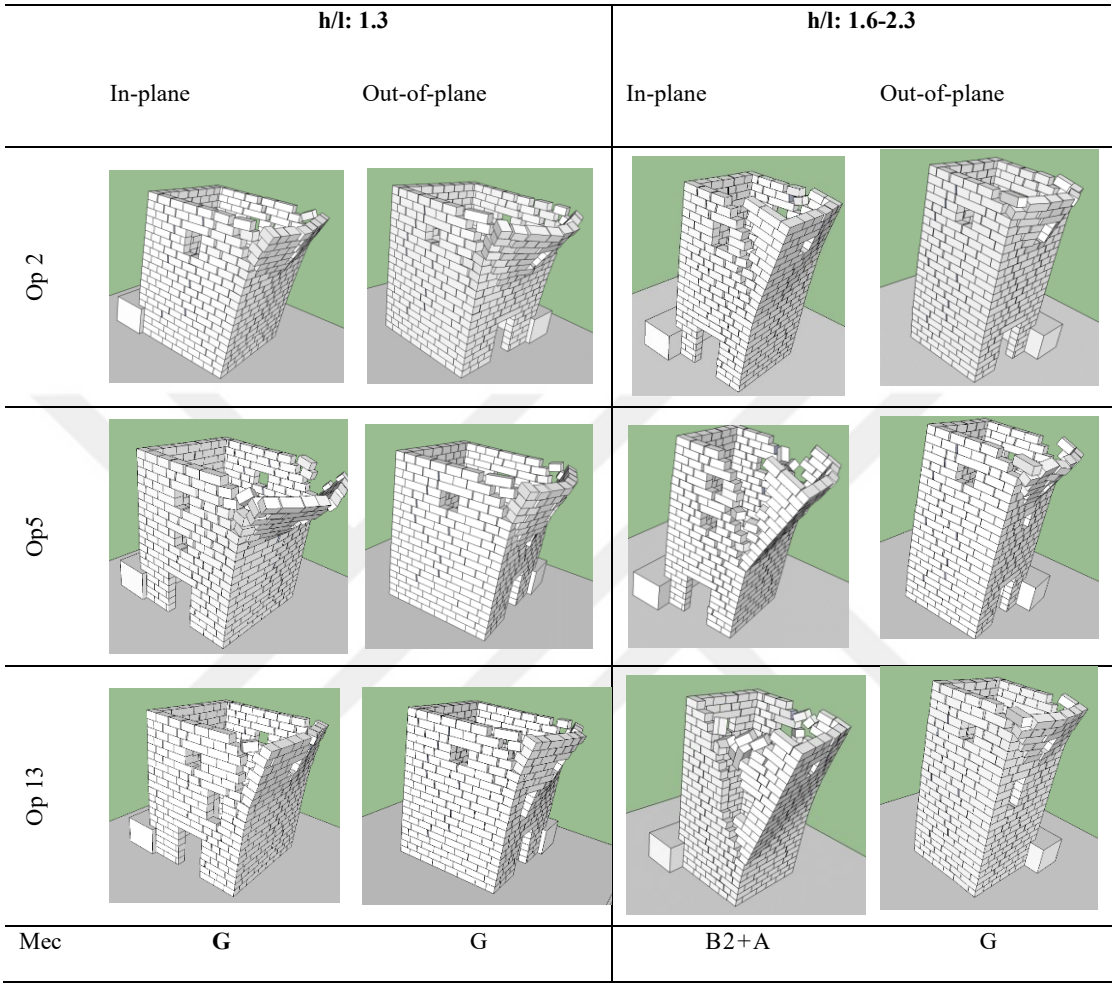


Figure 63. Effect of h/l ratio with different opening types

The opening fastens occurrence of failure, the tower collapses at lower collapse angles at ratios smaller than 1.3 and higher than 2 (Figure 64). When opening 10 is at out-of-plane position at ratios between 1.6 and 2.3, wall profile sustain its typical mechanism; detachment of out-of-plane walls with sliding of top blocks of side walls (mechanism G), (Figure 64).

Small and medium sized three top openings (op. 8 and 11) at in-plane position of wall profile 1 cause collapse of one side wall due to in-plane cracking at opening (mechanism B1) between 1.6 and 2.3 h/l ratios, at 1.3 h/l ratio, as well as collapse of the one side, overturning of the facade wall due to the vertical cracks at the corner connection

followed by detachment of the facade due to diagonal cracking downwards from the corner occurs due to the effect of small h/l (mechanism B1+A+G). Openings at out-of-plane position sustain typical mechanism: detachment of facade wall with diagonal cracks downward from the corners (mechanism G) is seen at all ratios (Figure 65, Figure 66).

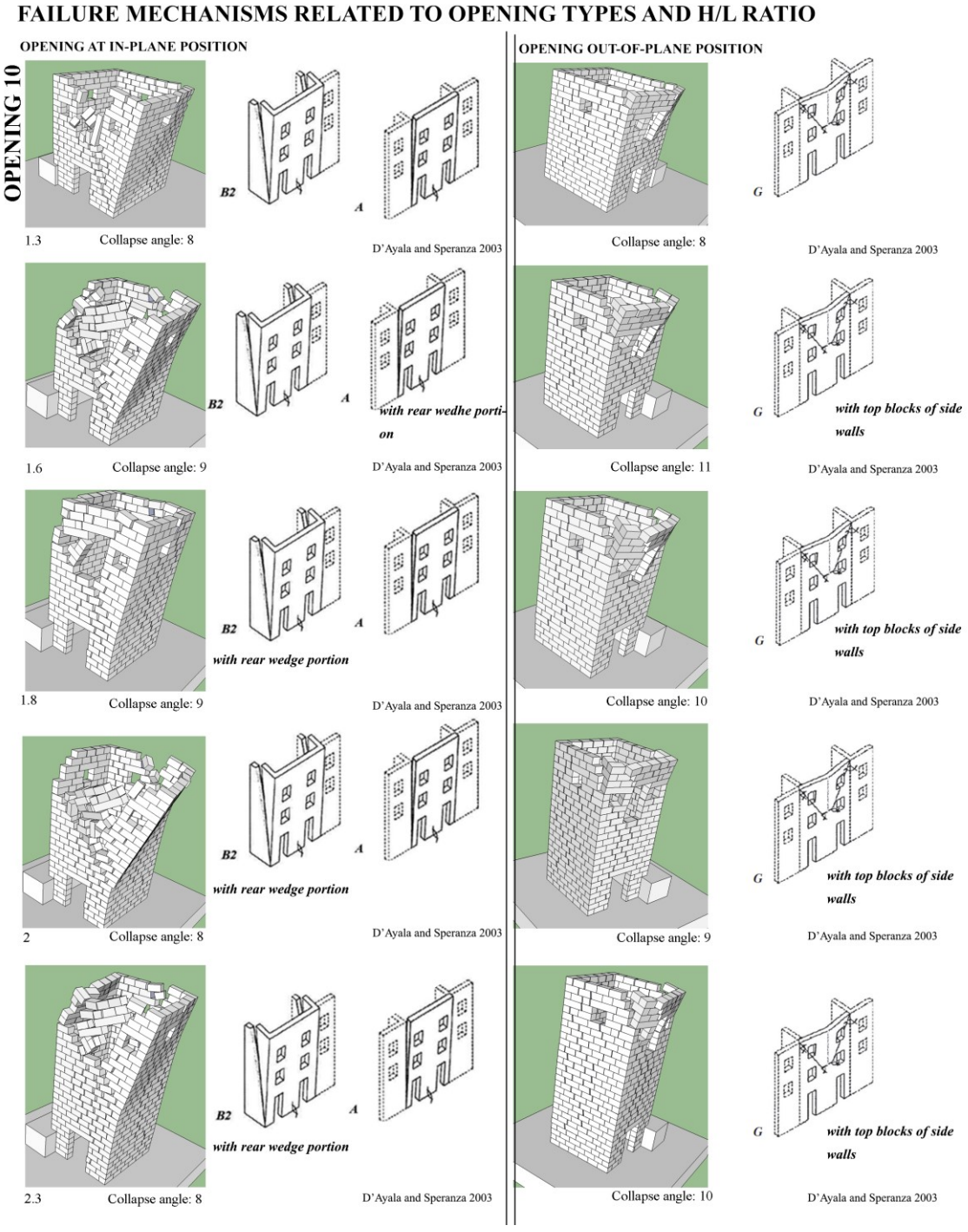


Figure 64. Failure mechanisms in different h/l ratios with opening 10 (in wall profile 1)

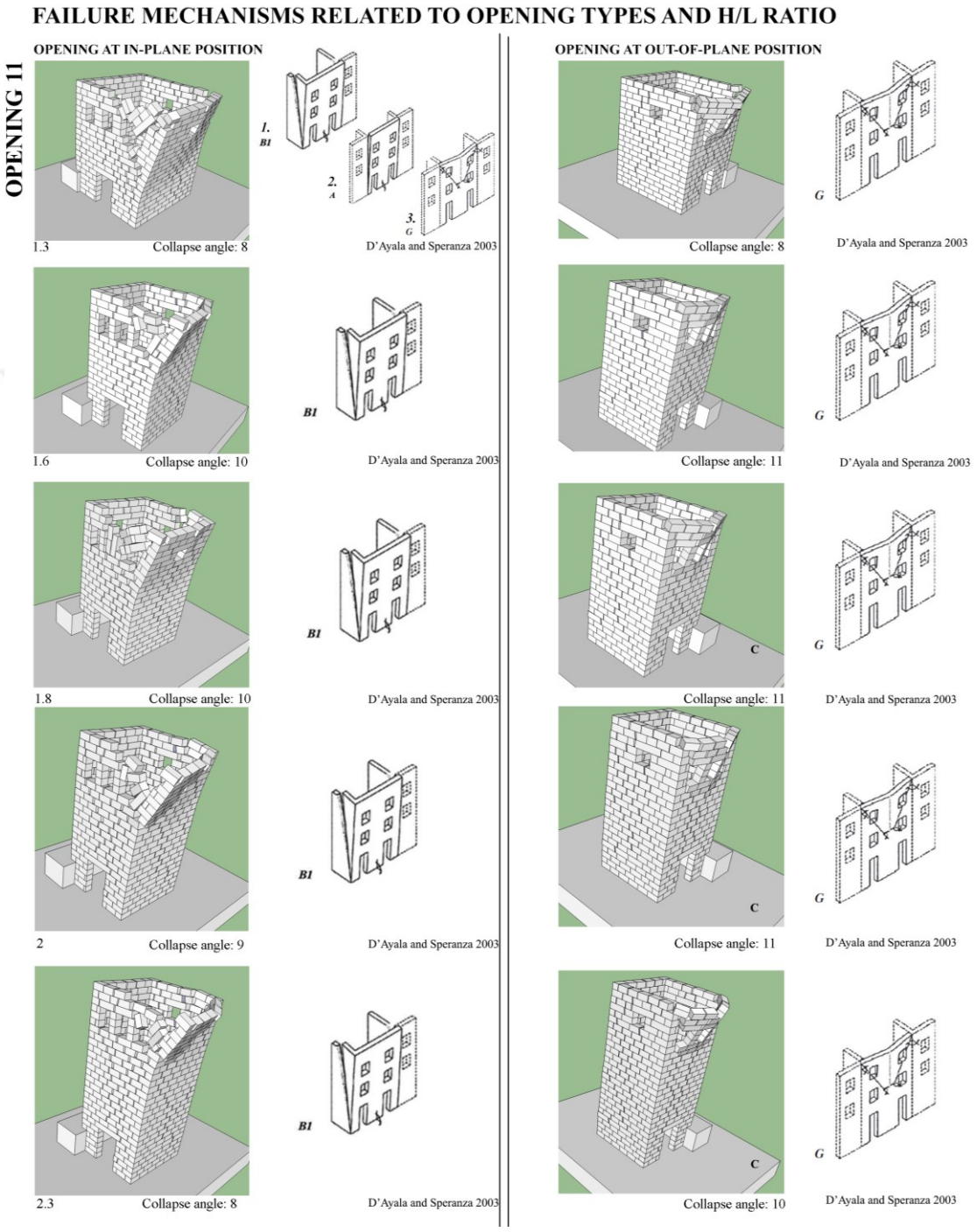


Figure 65. Failure mechanisms in different h/l ratios with opening 11 in wall profile 1

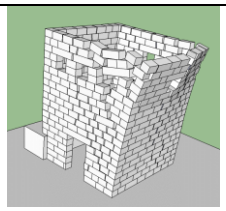
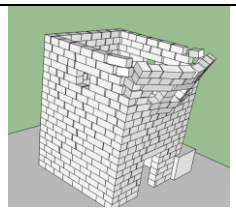
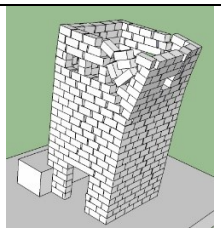
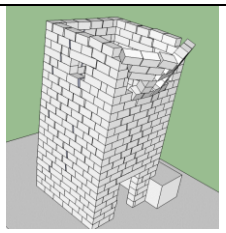
	h/l: 1.3		h/l: 1.6-2.3	
	Opening at in-plane position	Opening at out-of-plane position	Opening at in-plane position	Opening at out-of-plane position
Op 8				
Mec.	B1+A+**G**	G	B1+A	G

Figure 66. Opening 8 with various h/l ratios

Opening 14 at in-plane position causes collapse of two side walls due to the in-plane cracking followed by overturning of the facade due to the vertical cracking at the corner connections at ratios between 1.8 and 2.3. However, this mechanism is followed by cracking upwards from the corner of the facade wall as a wedge shape at ratios between 1 and 1.6, however cracking does not cause corner failure, it is observed while collapsing side wall with facade wall (Figure 67).

Opening 14 at out-of-plane position sustain typical mechanism G; detachment of the facade wall with sliding of top blocks of side walls (Figure 67).

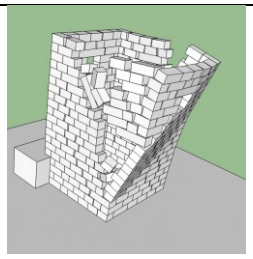
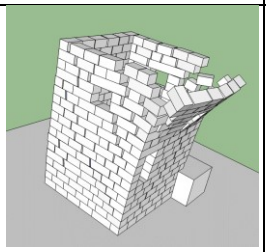
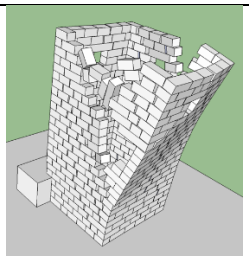
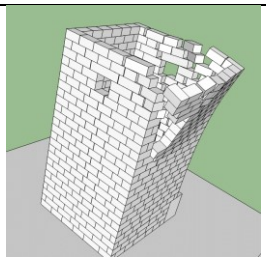
	h/l: 1-1.6		h/l: 1.8-2.3	
	In-plane	Out-of-plane	In-plane	Out-of-plane
Op 14				
Mec.	B2+A Followed by diagonal cracking upwards from the corner of the facade wall; as wedge shape	G with sliding of top blocks of side walls	B2+A	G with sliding of top blocks of side walls

Figure 67. Failure mechanisms in different h/l ratios with opening 14 in wall profile 1

Medium sized asymmetrical top opening (op. 15) at in-plane position of wall profile 1 causes collapse of the side wall due to diagonal in-plane cracking (mechanism B_1) in all h/l ratios from 1.6 to 2.3, however collapse of the side wall is followed by overturning of the facade wall due to the vertical cracking at the connections at ratios smaller than 1.3.

Openings at out-of-plane position sustains typical mechanism of the wall profile; detachment of out of plane walls (mechanism G) in h/l ratios between 1.3 and 2.5. However, at ratios between 1.6 and 2.3, sliding of the top blocks at side walls is observed. (Figure 68).

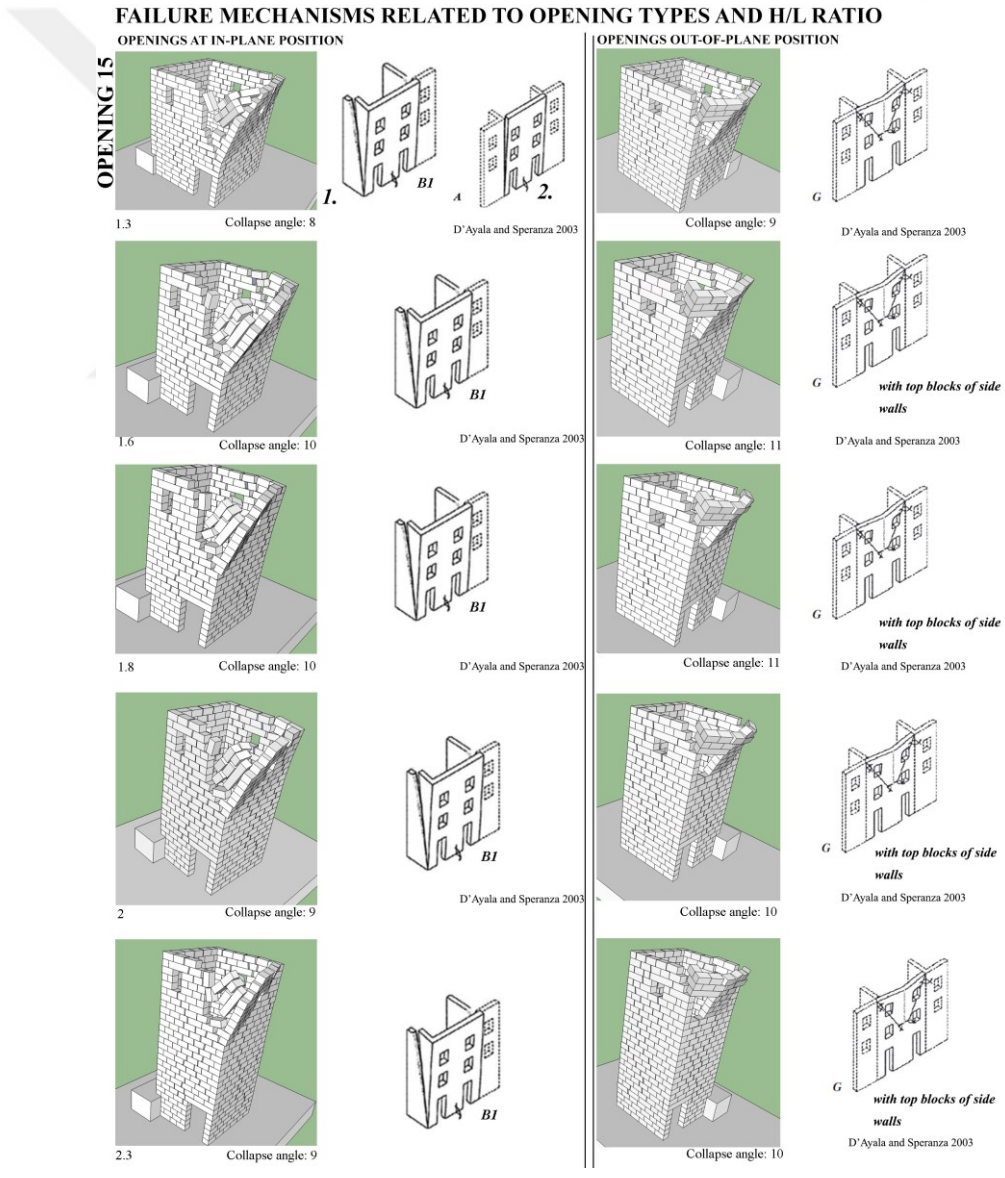


Figure 68. Failure mechanisms in different h/l ratios with opening 15 in wall profile 1

3.3.1.2.6. Mechanisms in different opening type and ground topography combinations

Variation in ground topography does not change specific failure mechanisms of wall profiles with all opening types at in-plane (Figure 69) and out-of-plane positions (Figure 70).

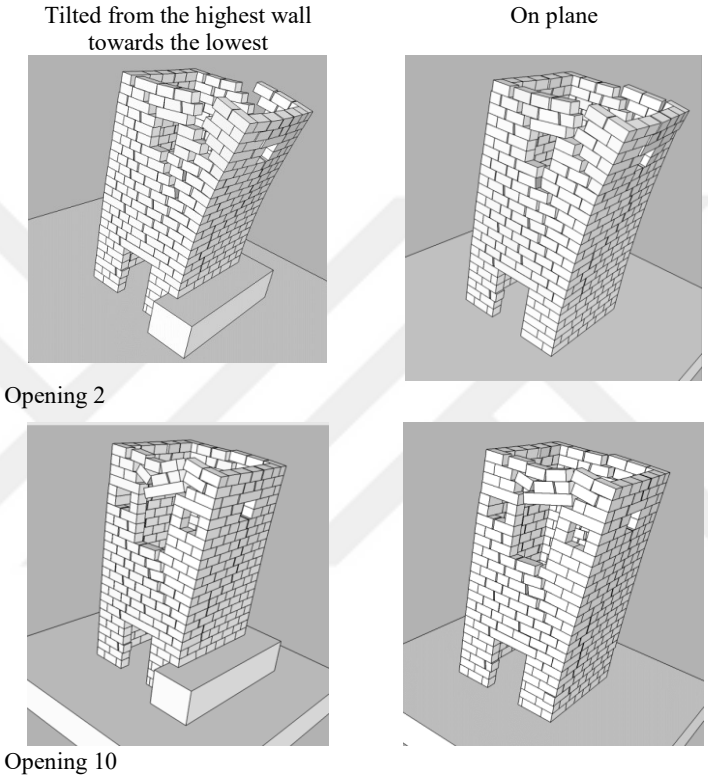


Figure 69. Failure mechanisms of towers at different ground topographies and openings at in-plane position of wall profile 1

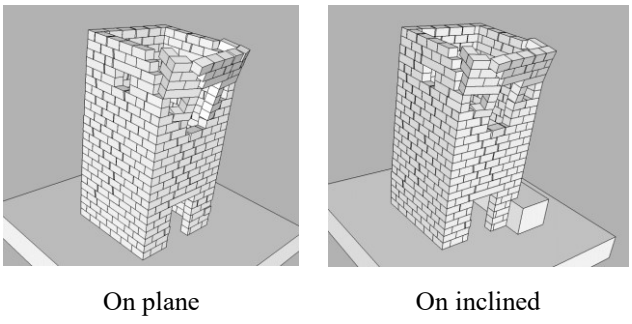


Figure 70. Opening 10 at out-of-plane position of wall profile 1

3.3.1.2.7. Mechanisms in different opening type and material usage combinations

Opening effect on behavior does not change in different material usage (Figure 68).

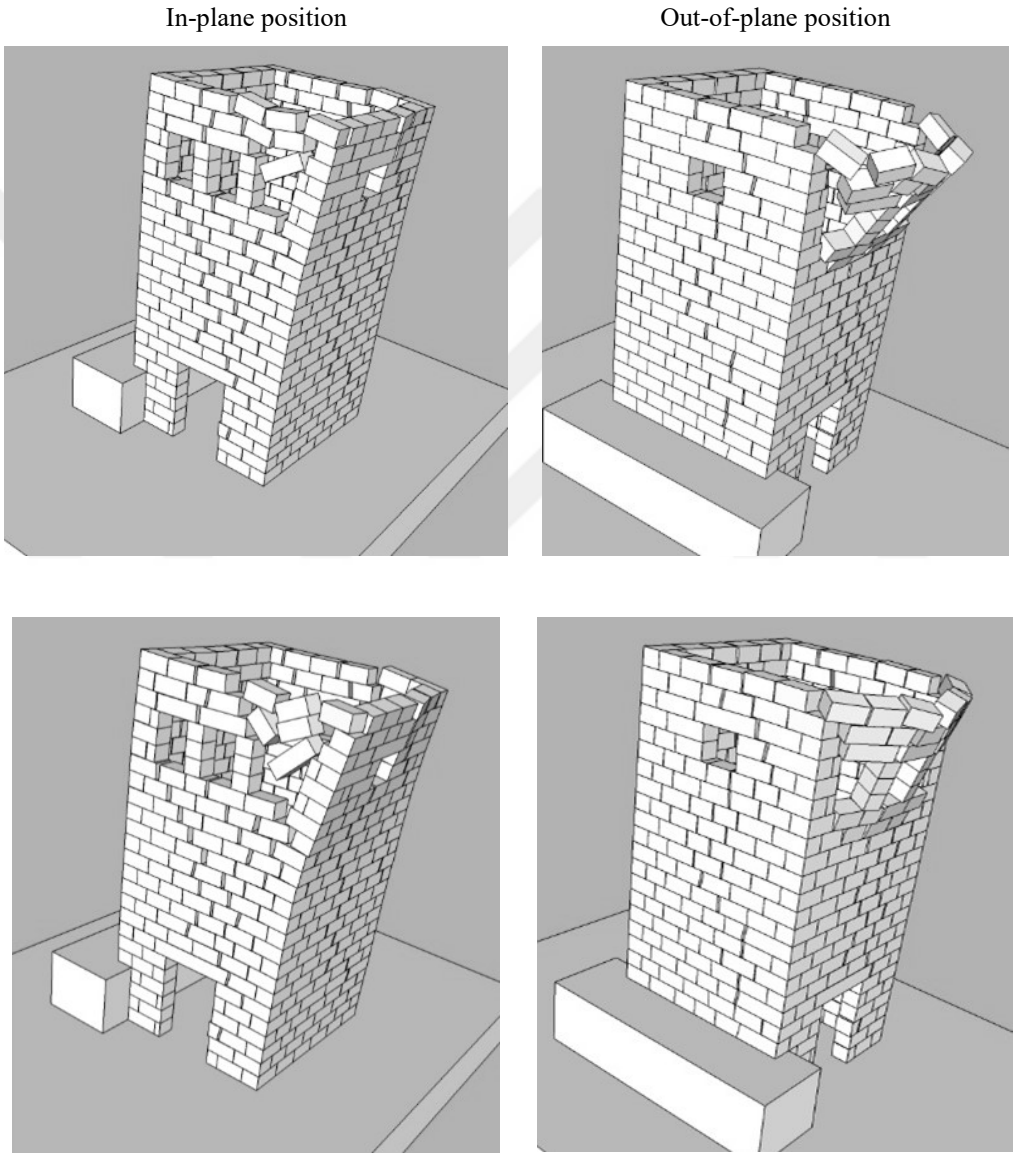


Figure 71. Usage of different materials and behavior of wall profile 1

3.3.1.2.8. Mechanisms in different h/l ratio and material usage combinations

Variation in material usage does not affect failure mechanisms in different h/l ratios (Figure 72).

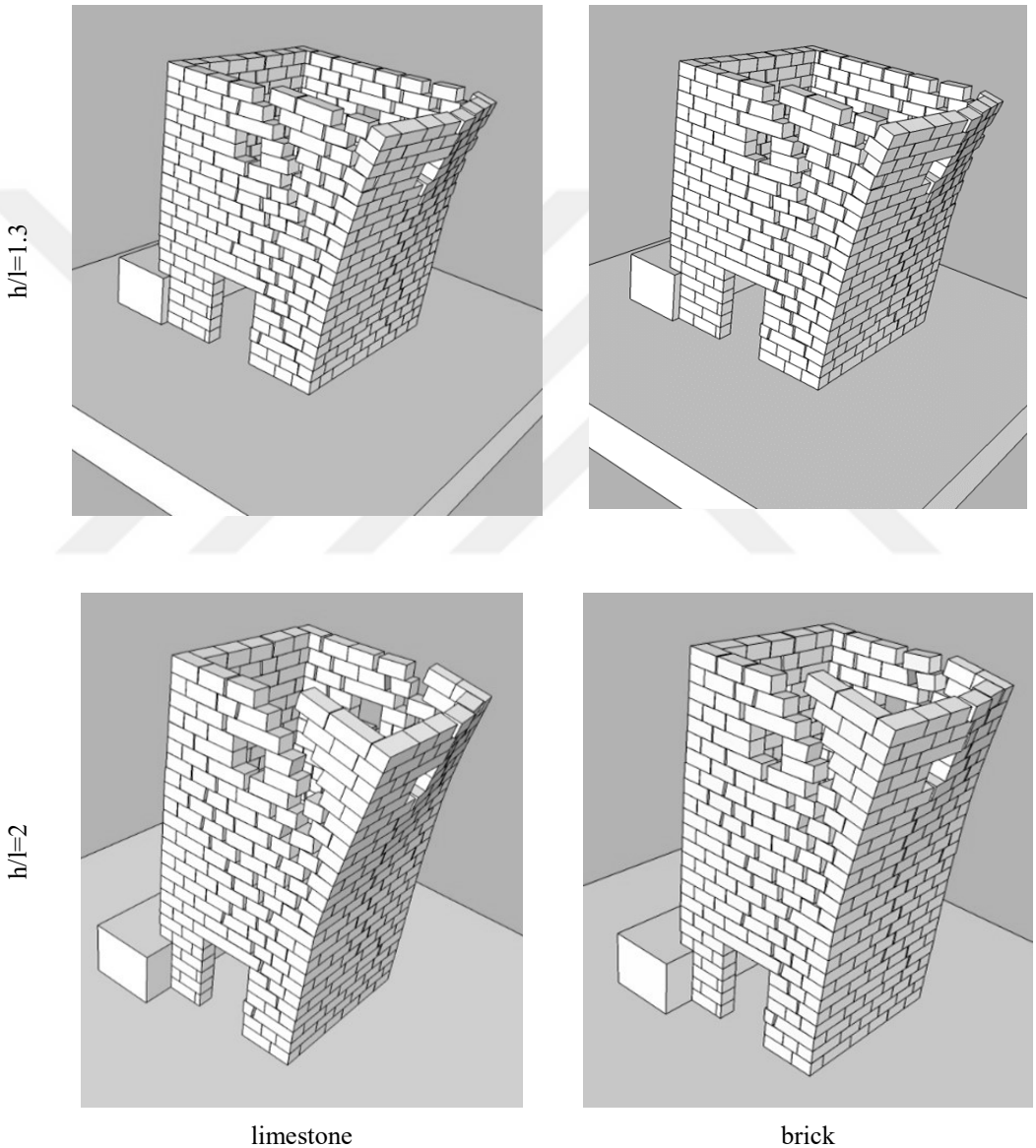


Figure 72. Failure mechanisms (mechanism A+B2) in different material and h/l ratios at wall profile 1

3.3.1.2.9. Mechanisms in different h/l ratio and ground topography combinations

As mentioned, previous sections, different h/l ratios effect failure mechanisms, however, ground topography does not change the impact of h/l ratios on the tower resistance. Lower parts of the walls slide except the inclination direction.

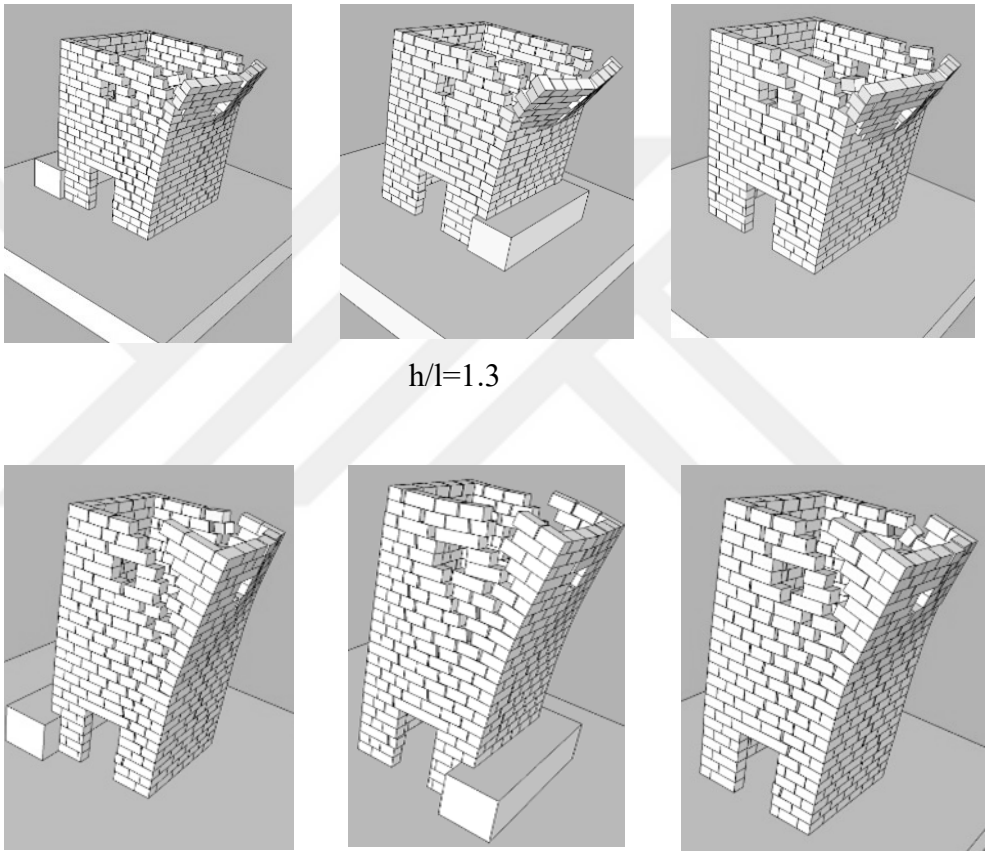


Figure 73. Failure mechanisms (mechanism B_2+A) in different h/l ratio and ground topography at wall profile

3.3.1.2.10. Mechanisms in different material usage and ground topography combinations

Variation in ground topography and material usage does not affect failure mechanisms (Figure 74).

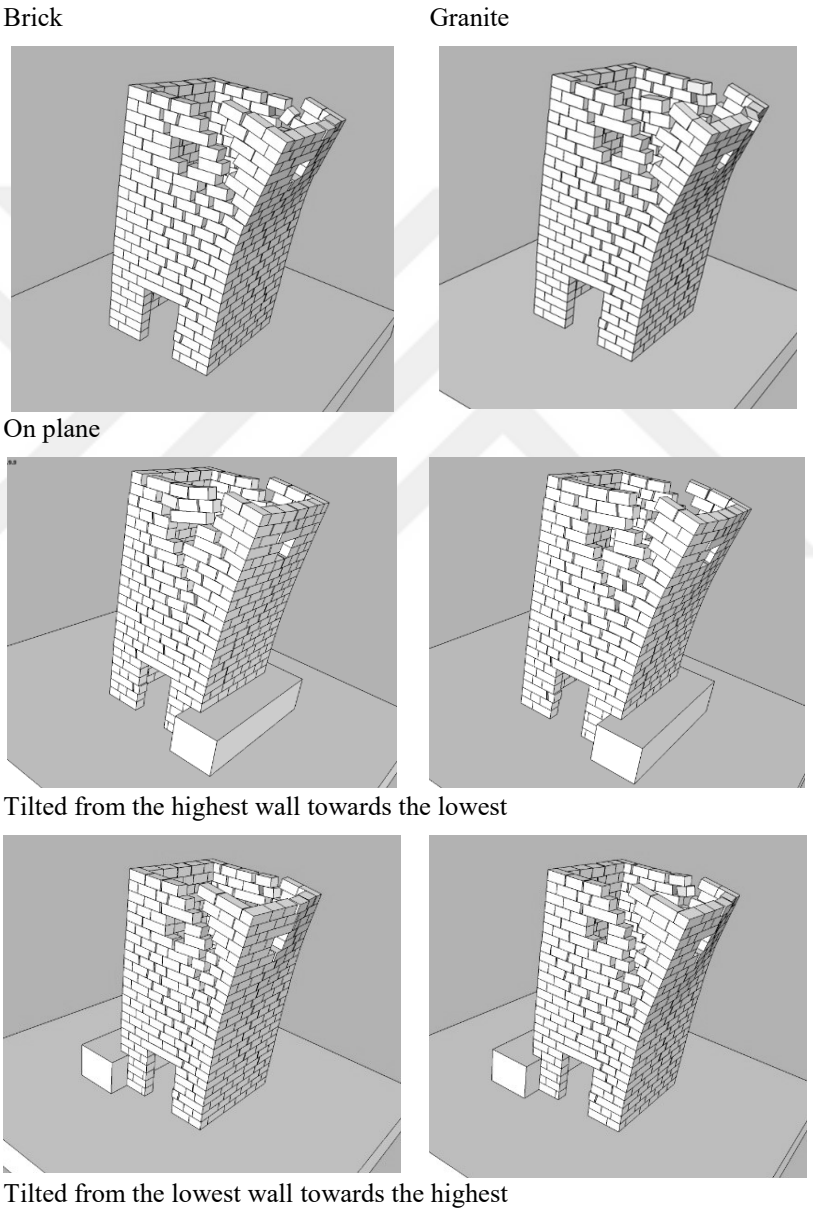


Figure 74. Failure mechanism of towers out of different material on different ground topographies

3.3.2. Results of triple combination

Results of binary combinations show that wall profile is the most effective characteristic in determining the collapse angle and failure mechanisms. Collapse angle differs at most 4 degrees for the variation of the other characteristics, while it differs up to 12 degrees for the variation in wall profiles. At the same time, each wall profile presents typical mechanism specific to the profile. As evaluated in the binary combinations; opening type and h/l ratio become effective in specific situations in terms of collapse angle and failure mechanisms depending on wall profile type, for example, opening 15 does not change typical failure mechanism and collapse angle of the wall profile 6, but it changes mechanisms in different wall profiles. Openings and h/l ratio can change collapse angle up to 4 degrees depending on what they combine with. Therefore, wall profile, opening types and h/l ratio should be evaluated together to determine their effectiveness. However, binary combinations composed of material or ground topography present that their impact on collapse angle of the towers is minimal (1-degree difference) compared to other types. They do not affect failure mechanisms, so determination of effectiveness of them is not required in triple combinations.

3.3.2.1. Collapse angles

Collapse angle results of triple combinations are evaluated by taking into consideration best and worst collapse angle performance by focusing each characteristic separately; wall profile, opening organization and h/l ratio.

Collapse angle curves of the opening types in different ratios of each wall profile are similar; each wall profile has an interval of better resistance. This interval shows differences depending on wall profile and opening types (Table 24).

When wall profiles are compared with each other in different ratios and with different opening types, wall profile 6 (Table 24; illustrated with red frame) collapses at the highest angles (19 degrees), while wall profile 1 collapses at the lowest angles (Table 24; illustrated with grey frame).

At the table, best and worst h/l ratios for each wall profile is illustrated with orange and beige color, respectively. The worst h/l ratios for wall profiles are ratios smaller than 1.3 and higher than 2.3 h/l ratios (the lowest 2 degrees of each wall is accepted as the

worst). However, wall profile 1 is mostly only affected by h/l ratios smaller than 1.3. Effectiveness of h/l ratios at other wall profiles changes depending on opening organizations. Opening 10 is mostly cause the lowest collapse angle at ratios smaller than 1.3 and higher than 2.3. Wall profile 4 has the lowest collapse angles with opening 10 at ratios smaller than 1.6 and higher than 2. For wall profile 1, 2 and 3, regardless of the opening types, h/l ratio smaller than 1.3 cause the lowest collapse angle. Wall profile 5 is also mainly affected by small h/l ratios with most of the openings (op. 6, 9-11, 14 and 15). However, wall profile 6 is affected by h/l ratios higher than 2.3 with all types of openings.

Common ratio for each wall profile that show the best resistance is 1.6. However, ratio intervals of each wall profile present differences. For wall profile 1, 2, 3, 4 and 5, the collapse angles of towers are higher for h/l ratios between 1.6 and 1.8. For wall profile 6, h/l interval for the best resistance is larger than other (between 1.3 and 1.8). When openings are at out-of-plane position at the best h/l interval of wall profiles; all wall profiles present their best performance with slight decrease stemming from the weakness of the opening type (Table 24; illustrated with grey color). Also, wall profile 2, 4 and 5 present best performances except the best h/l intervals (at 2 h/l ratio).

Effect of openings at in-plane and out-of-plane positions in different ratios of each wall profile are examined in the below. In general, when opening is at out of plane positions, the tower provides better resistance. The worst opening types at each wall profile and h/l ratio is illustrated with red bold letter. The common worst opening type that decreases angle of collapse at a maximal amount at all wall profile types and ratios is opening 10 (Table 24; illustrated with red letters). Also, as well as opening 10, openings 11 and 14, 15 decrease the collapse angles at a maximal amount depending on wall profile and h/l ratios. Wall profile 1 is affected by openings at ratios higher than 1.6, wall profile 2 is affected by openings at ratios higher than 1.3, wall profile 6 is affected at ratios between 1 and 2, while effect of opening 10 at wall profiles 4 and 5 is seen at all ratios, effect of other openings is not distributed at all ratios. Wall profile 3 is affected by openings at alla ratios.

As a result, towers designed with wall profile 1 and opening 10 at ratios higher than 2 and lower than 1.3 collapse at the smallest angle, while towers designed with wall profile 6 and with openings 1-9, 12-14, between 1.6 and 1.8 ratios collapse at the highest collapse angle.

Table 24. Collapse angles in different opening types and h/l ratios of wall profiles

		H/L													
		1		1.3		1.6		1.8		2		2.3		2.5	
	Openings	i	o	i	o	i	o	i	o	i	o	i	o	i	o
w. profile 1	op 1	7		8		11		11		11		11		10	
	op 2-8	7	7	8	8	11	11	11	11	11	11	11	11	10	11
	op 9, 12-13	7	7	8	8	10	11	10	11	10	11	10	11	9	10
	op 10	6	7	8	8	**9**	11	**9**	**10**	**8**	**9**	**8**	**10**	**8**	**10**
	op 11	7	7	8	8	**9**	11	**9**	11	**9**	11	**8**	**10**	**8**	11
	op 14, 15	7	7	8	8	**9**	11	**9**	11	**9**	11	**9**	**10**	**8**	**10**
w. profile 2	op 1	9		11		12		12		12		12		12	
	op 2-8	9	9	11	11	12	12	12	12	12	12	12	12	12	12
	op 9	9	9	11	11	12	12	12	12	11	12	11	12	11	11
	op 10	9	9	**10**	11	**11**	12	**11**	12	**10**	12	**10**	12	**9**	**11**
	op 11	9	9	**10**	11	**11**	12	**11**	12	**10**	12	11	12	10	**12**
	op 12-13	9	9	11	11	12	12	12	12	11	12	**10**	12	**9**	11
	op 14, 15	9	9	11	11	**11**	12	**11**	12	**11**	12	**9**	**11**	**8**	**10**
w. profile 3	op 1	11		13		14		14		13.5		13.5		13	
	op 2-8, 12-13	11	11	13	13	14	14	14	14	13.5	13.5	13.5	13.5	13	13
	op 9	11	11	13	13	14	14	14	14	13	13.5	13.5	13.5	13	13
	op 10	**10**	11	**12**	13	**12**	14	**12**	14	**12**	13.5	**12**	13.5	**11**	13
	op 11	**10**	11	**12**	13	**12**	14	**12**	14	**12**	13.5	**12**	13.5	**11**	13
	op 14, 15	**10**	11	**12**	13	**12**	14	**12**	14	**12**	13.5	**12**	13.5	**11**	13
w. profile 4	op 1	14		16		17		17		17		16		15	
	op 2-9, 12-13	14	14	16	16	17	17	17	17	17	17	16	16	15	15
	op 10	**12**	14	**13**	16	**15**	17	**15**	17	**14**	17	**13**	**15**	**12**	**14**
	op 11	**13**	14	15	16	17	17	17	17	16	17	16	16	**13**	15
	op 14, 15	**13**	14	15	16	17	17	17	17	16	17	15	16	**13**	15
w. profile 5	op 1	12		13		15		15		14		14		13	
	op 2-5, 8, 12-13	12	12	13	13	15	15	15	15	14	14	14	14	13	13
	op 6, 9	11	12	12	13	14	15	14	15	13	14	13	14	12	13
	op 10	**10**	**11**	**11**	**12**	**12**	15	**12**	15	**12**	14	**12**	**13**	**11**	**12**
	op 11	**10**	**11**	**11**	**12**	13	15	13	15	13	14	**12**	14	12	13
	op 14, 15	**10**	**11**	**11**	**12**	13	15	13	15	13	14	**12**	14	12	13
w. profile 6	op 1	17		19		19		19		18		16		15	
	op 2-9, 12-13	17	17	19	19	19	19	19	19	18	18	16	16	15	15
	op 10	**15**	**16**	**18**	19	**18**	19	**18**	19	**17**	18	16	16	15	15
	op 11	16	17	**18**	19	**18**	19	19	19	18	18	16	16	15	15
	op 14, 15	16	17	**18**	19	19	19	**18**	19	18	18	16	16	15	15

***Red rectangular frame:** the wall profile type demonstrating the best performance under lateral loading.
***Grey rectangular frame:** the wall profile type demonstrating the worst performance under lateral loading.
***Orange color:** best h/l performance intervals of each wall profile type.
***Beige color:** worst h/l performance intervals of each wall profile type.
***Red bold letter:** opening types causing the worst resistance.

3.3.2.2. Failure mechanisms

There are typical failure mechanisms depending on primarily characteristics of wall profiles, secondarily opening organizations and h/l ratios. Effect of opening types 8, 10, 11, 14 and 15, and h/l ratio higher than 1.8 or smaller than 1.3 on mechanisms are determined by results of binary combinations, however, it is seen that effectiveness of characteristics change depending on wall profile types. Therefore, results of three effective characteristics are further examined to decipher the dominant one (Table 25, Figure 75, Figure 76, Figure 77).

The best and worst performance intervals in terms of collapse angles is overlapped with failure mechanism distribution. The relationship between resistance and failure mechanism of wall profile types is discussed.

First, failure mechanisms of wall profiles with less effective openings and at h/l ratios providing best performance is compared with each other. Wall profile 6 that has the highest collapse angle does not present any in-plane or out-of-plane failure at side or facade walls, it presents total body behavior (mechanism B_{2T}) (Table 25; illustrated with purple color), however the weakest wall profile 1 presents especially out-of-plane behavior; mechanism A (Table 25; illustrated with pink color) as well as in-plane mechanisms. The other weakest wall profiles 2 and 3 also present typically out-of-plane mechanism A, with in-plane mechanisms. Wall profile 4 demonstrating the second highest performance does not present out-of-plane mechanism, but it presents only in-plane mechanism (mechanism B_2). However, although wall profile 5 collapses at lower angles in comparison to wall profile 4, it presents total behavior. This can stem from sub-qualities of characteristics of walls profiles. As a result, wall profiles that have lower resistance, lower than 14° collapse angle, present generally out-of-plane failure mechanism, however, wall profiles collapsing at angles higher than 15° present in-plane or total behavior.

The wall profiles with openings at out-of-plane position proves also this situation. Detachment of facade wall with diagonal cracks downwards from the corners (mechanism G) is seen, when there are openings at out of plane position. The weaker the wall profile, the widespread the out-of-plane mechanism; G. The stronger wall profiles present better performance. Profile 4 generally presents in-plane failure mechanism (mechanism B_2), and wall profile 6 presents total behavior (mechanism B_{2T}). However, wall profile 5 presents total overturning combined with detachment of rear facade (mechanism B_{2T+DT}).

Relation of collapse angles and failure mechanisms can be seen at h/l ratios presenting worst and best performance. Total and in-plane failures are replaced with out-of-plane failures at h/l ratios smaller than 1.3. At h/l ratios smaller than 1.3, the stronger wall profiles 4 and 5 start to present wall behavior in place of hybrid or total body behavior in the borders of ineffective openings (illustrated with blue letters) (mechanism B_2+A or G). Also, even if the strongest wall profile 6 sustains its total body behavior, detachment of rear facade is added to the mechanism (mechanism B_{2T+DT}) at h/l ratios smaller than 1.3 (Table 25; illustrated with blue letters). Although h/l ratios higher than 2 decreases collapse angle, typical behavior of towers is sustained (Table 25; illustrated with purple letters). The strongest wall profile sustains its total overturning mechanism and bends due to its slenderness.

At h/l intervals presenting the best performance in terms of collapse angle, the typical mechanisms are sustained in the towers with less effective openings. However, effective openings change the mechanisms even at the best h/l intervals (illustrated with bold black colors at orange columns). Weakest collapse angles (indicated with bold black letters) are seen in openings 10, 11, 14 and 15. There is not necessarily a change in the failure mechanism type because of the opening 10 in these thresholds, since both opening 10 causes mechanism B_2, collapse of two side walls with in-plane diagonal cracks, and B_2 is the most widespread failure observed in the lowest collapse angles of all wall profiles. Effect of opening 10 can be seen also at wall profiles (5 and 6), due to the effect of opening 10, only mechanism B_2 occurs in place of total overturning.

Mechanism B_1 is directly related to the opening types at in-plane position: it is mostly seen in openings 8 and 11, 14 and 15. Change of failure with the effect of openings at the best and worst h/l intervals is indicated with bold black colors.

When openings are located at out-of-plane position, there is not necessarily a change in the failure mechanisms of weaker wall profiles. However, effects of openings at out-of-plane position can be seen at wall profiles 5 and 6 that have typical total behavior. Openings cause either only mechanism G at wall profile 5 or combination of detachment of rear facade wall with overturning due to the bending at wall profile 6 (mechanism B_{2T+DT}) (indicated with bold green letters).

Table 25. Failure mechanisms in different opening types, h/l ratios and wall profiles

		1-1.3		1.6		1.8		2		2.3-2.5	
	Opening	i	o	i	o	i	o	i	o	i	o
w. profile 1	1	G		B_2+A		B_2+ A		B_2+A		B_2+A	
	2-7	G	G	B_2+A	G	B_2+A	G	B_2+ A	G ST	B_2+A	G
	9, 12, 13	G	G	B_2+A	G	B_2+A	G	B_2+A	G ST	B_2+A	G
	10	**B_2**+A	G	**B_2**+A	G	**B_2**+A	G	B_2+A	G ST	B_2+A	G
	8, 11	**B_1**+A+G	G	**B_1**	G	**B_1**	G	B_1	G ST	B_1	G
	14	B_2+A	G	**B_2**+A	G	**B_2**+A	G	B_2+ A	G	B_2+A	G
	15	**B_1**+A	G	**B_1**	G	**B_1**	G	B_1	G	B_1	G
w. profile 2	1	A		B2+A		B2+A		B2+A		B2+A	
	2-9	A	G	B_2+A	G	B_2+A	G	B2+A	G	B_2+A	G
	3-7,12, 13	B_2+A	G	B_2	G	B_2	G	B_2	G	B_2+A	G
	10	B2+A	G	B_2+A	G	B_2+A	G	B_2+A	G	B_2+A	G
	8, 11	B2+A	G	**B_2**	G	**B_2**	G	**B_2**	G	**B_2**	G
	14	B2+A	G	**B_2**	G	**B_2**	G	**B_2**	G	**B_2**	G
	15	**B_1**	G	**B_2**	G	**B_2**	G	**B_2**	G	**B_2**	G
w. profile 3	1	A		B_2+A		B_2+A		B_2+A		B_2+A	
	2-7	A	G	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A
	9, 12, 13	A	G	B_2+A	B_2+G	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A
	10	**B_2**	G	**B_2**	B_2+G	**B_2**	B_2+G	**B_2**	B_2+G	**B_2**	B_2+A
	8, 11	B_2+A	G	B2+A	G	B_2+A	G	B_2+A	G	B_2	G
	14	B_2+A	B_2+A	B2+A	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A	B_2+A
	15	**B_1**	G	**B_1**	G	**B_2**	G	**B_2**	G	**B_2**	G
w. profile 4	1	B_2+A		B_2		B_2		B_2		B_2	
	2-8	B_2+A	B_2+A	B_2	B_2	B_2	B_2	B_2	B_2	B_2	B_2
	9, 12, 13	B_2+A	B_2+A	B_2	B_2	B_2	B_2	B_2	B_2	B_2	B_2
	10	B_2	B_2+G	B_2	B_2+G	B2	B_2+G	B_2	B_2+G	B_2	B_2+G
	8, 11	**B_1**	B_2	B_2	B_2	B_2	B_2	B_2	B_2	B_2	B_2
	14	B_2	B_2	B_2	B_2	B_2	B_2	B_2	B_2	B_2	B_2
	15	**B_1**	B_2	B_2	B_2	B_2	B_2	**B_1**	B_2	**B_1**	B_2
w. profile 5	1	B_2		B_2		B_{2T+VT}		B_{2T+VT}		B_{2T}	
	2, 5-7, 9, 12,13	B_2	G	B_{2T+VT}	B_{2T+DT}	B_{2T+VT}	B_{2T+DT}	B_{2T+VT}	B_{2T+DT}	B_{2T+VT}	B_{2T+DT}
	3,4	B_2	G	B_{2T+DT}	B_{2T+VT}	B_{2T+DT}	B_{2T+VT}	B_{2T+DT}	B_{2T+VT}	B_{2T+DT}	B_{2T+DT}
	10	**B_2**	G	**B_2**	B_2+G	B_2	B_2+G	**B_2**	B_{2T+DT}	**B_2**	B_{2T+DT}
	8, 11	**B_1**	G	**B_1**	G	**B_1**	G	**B_1**	B_{2T+DT}	**B_1**	B_{2T+DT}
	14	**B_2**	G	**B_2**	G	B_{2T+VT}	B_{2T+DT}	B_{2T+VT}	B_{2T+DT}	B_{2T+VT}	B_{2T+DT}
	15	**B_1**	G	**B_1**	G	**B_1**	G	**B_1**	B_{2T+DT}	**B_1**	B_{2T+DT}
w. profile 6	1	B_{2T+DT}		B_{2T}		B_{2T}		B_{2T}		B_{2T}	
	2-7, 9, 12	B_{2T+DT}	B_{2T+DT}	B_{2T}	B_{2T}	B_{2T}	B_{2T}	B_{2T}	B_{2T}	B_{2T}	B_{2T}
	13	B_{2T+DT}	B_{2T+DT}	B_{2T}	B_{2T+DT}	B_{2T}	B_{2T+DT}	B_{2T}	B_{2T}	B_{2T}	B_{2T}
	10	**B_2**	B_{2T+DT}	**B_2**	B_{2T+DT}	**B_2**	B_{2T+DT}	**B_2**	B_{2T+DT}	B_{2T}	B_{2T}
	8, 11	**B_1**+G	B_{2T+DT}	**B_1**+G	B_{2T+DT}	**B_1**+G	B_{2T+DT}	**B_1**+2T	B_{2T}	B_{2T}	B_{2T}
	14	**B_2**+G	B_{2T+DT}	**B_2**+G	B_{2T+DT}	B_{2T}	B_{2T}	B_{2T}	B_{2T}	B_{2T}	B_{2T}
	15	**B_1**	B_{2T+DT}	**B_1**	B_{2T+DT}	**B_1**	B_{2T+DT}	B_{2T}	B_{2T+DT}	B_{2T}	B_{2T}

*Table 25 contains the legend of Table 24. **Letters** also represent the change of failures. **Purple:** total body behavior; **Pink:** out-of-plane behavior due to the wall profiles. **Blue:** out-of-plane behavior due to h/l ratios smaller than 1.3. **Bold Black:** change of failure with effects of openings. **Green:** effect of openings at out-of-plane position.

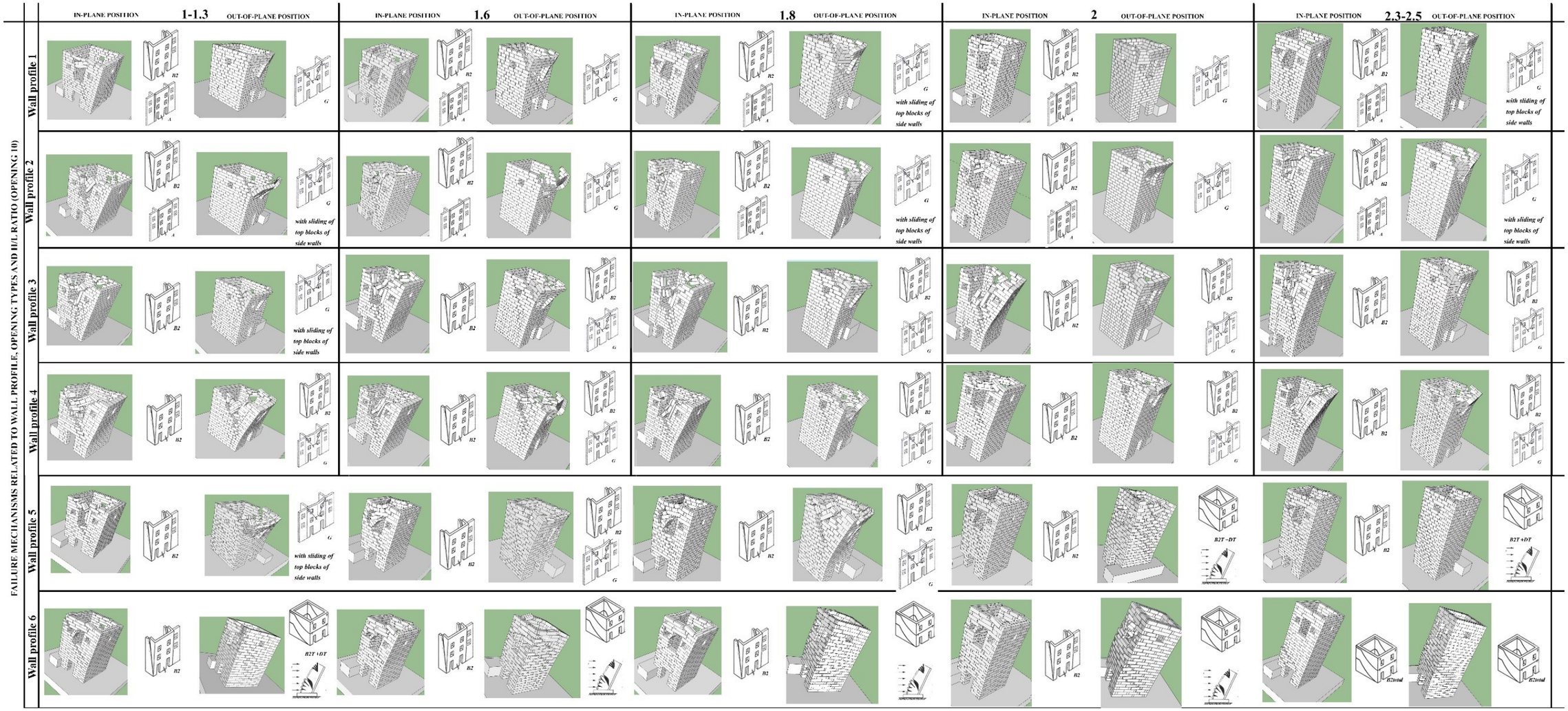


Figure 75. Failure mechanisms related to wall profile, opening type and h/l ratio (op. 10)

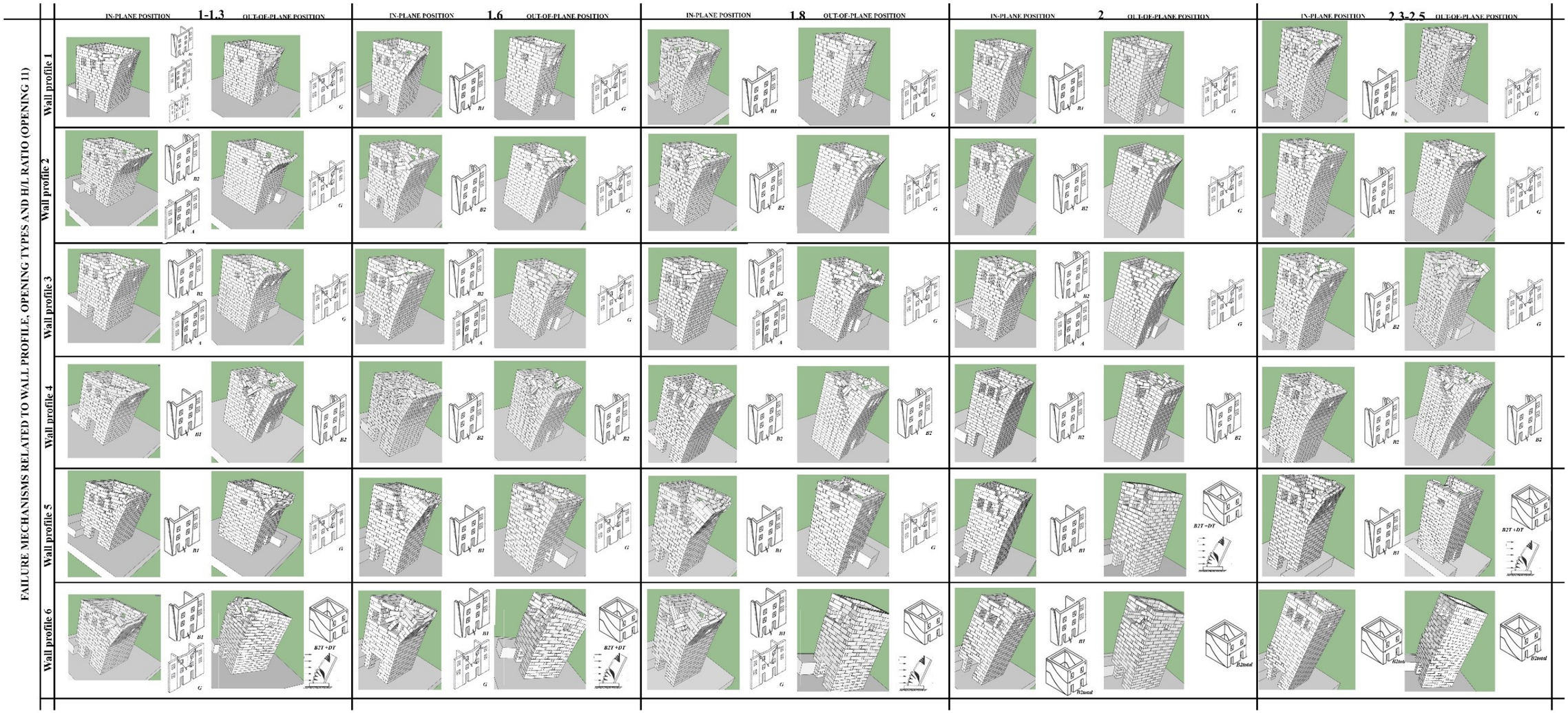


Figure 76. Failure mechanisms related to wall profile, opening type and h/l ratio (op. 11)

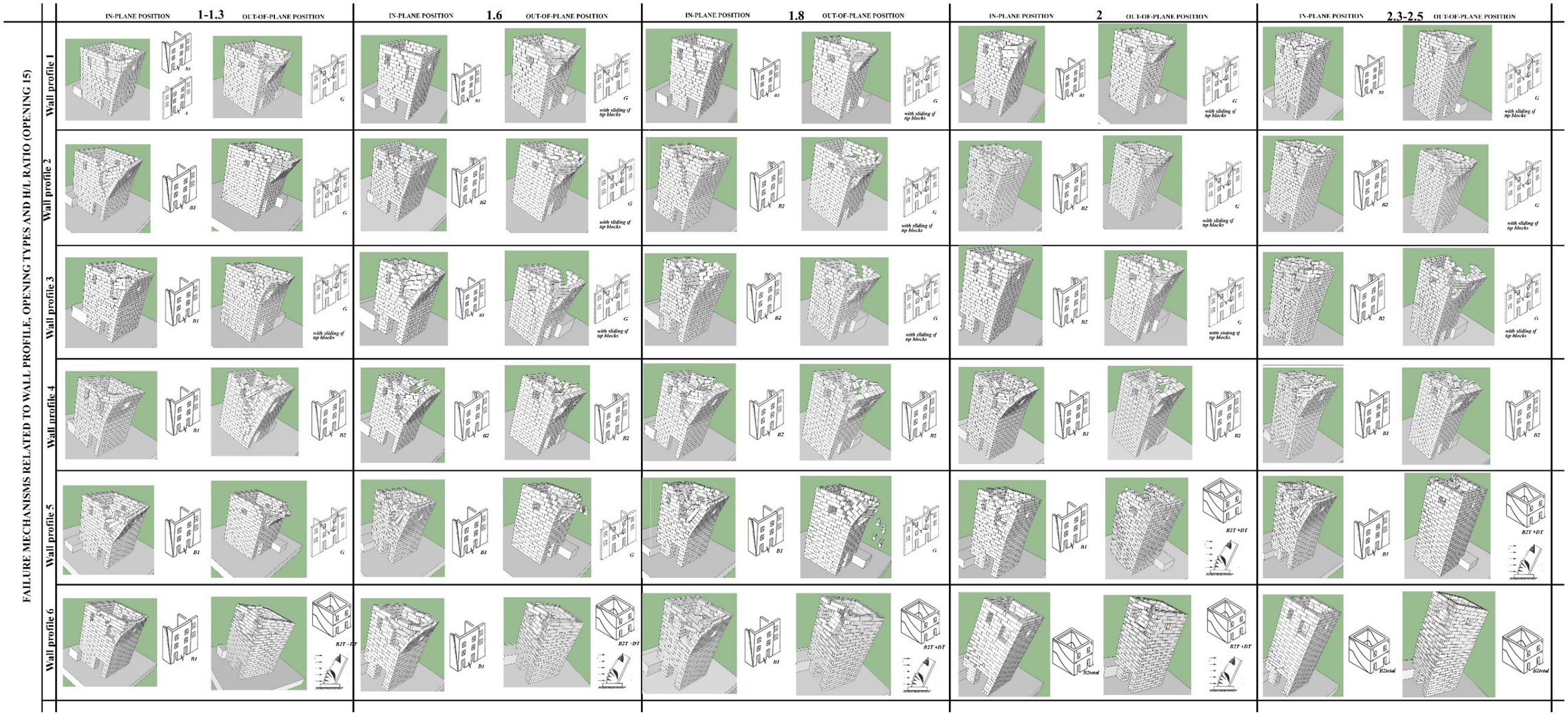


Figure 77. Failure mechanisms related to wall profile, opening type and h/l ratio (op. 15)

CHAPTER 4

DISCUSSION OF IMPACT OF CHARACTERISTICS

In this chapter, impact of effective characteristics on structural resistance and behavior of towers are discussed with reference to literature review. The structures examined in previous studies are not mostly four-sided, they are generally a wall portion with one or two side walls. So, one to one correspondence of results of the study with results in literature is not possible. The sub-qualities that shape the effective characteristics are determined. Furthermore, it has been tested whether the sub-qualities are a parameter affecting the resistance of the structure and if there is a parameter, impact value of a sub-quality is determined with statistical evaluation. Nevertheless, the sub-qualities and their relative impact on overall structural strength of a tower are evaluated statistically to enrich the discussion. Finally, a framework for vulnerability assessment of the towers is proposed.

4.1. Impact of each effective characteristic

The results of analysis demonstrate variation in performance of towers in relation with sub-qualities in wall profiles, opening organizations and proportional relations. So, these are the three effective characteristics.

4.1.1. The wall profile

Analysis of wall profile types have revealed that the organization of blocks and the wall section are effective on the structural resistance and behavior of a profile. Sub-qualities of a wall profile related to organization of blocks are staggering ratio (s/h), and the ratio between block length and height bl/bh. In literature, either staggering ratio (D'Ayala and Speranza 2003) or ratio between block length and height (Giuffre, Pagnoni and, Tocci 1994) is examined, since joints are accepted as positioned in the middle of the upper and lower blocks. So, the two ratios (s/h and bl/bh) are always proportional to each other: it is not necessary to analyze these sub-qualities separately. However, at real dry

masonry towers, the joints are not always positioned in the middle of the blocks, therefore, these two sub-qualities should be taken into consideration separately. The performance of a wall section is related with its stone depth, number of leaves and header usage. If the wall is one leafed, as seen in the upper portions of the towers, the stone depth is a sub-quality. If the wall section is composed of double leaves, usage of header is taken as a sub-quality as well.

Impact of these five sub-qualities; namely, staggering ratio, ratio between block length and height, number of leaves, upper stone depth, and usage of headers; on towers presenting average collapse angles and failure mechanisms are discussed in the below (Table 26). According to average collapse angles, horizontal acceleration is calculated: λ = mg x sin (collapse angle). While investigating effect of a sub-quality, the best performance intervals of other characteristics is taken into consideration; h/l ratios between 1.6 and 2; asymmetrical or symmetrical one or two openings whose area is up to 3 m^2.

Table 26. Average performance of sub-qualities regarding each wall profile

	Organization of blocks		**Wall section**			**Typical failure mechanism**		**Ave. resistance**	
	Ave. s/h	Ave. Block l/h	Number of leaves	Upper stone depth	Usage of headers	Op. at in-plane	Op. at out-of-plane	Ave. collapse angle	λ
Wp. 1	0.4	1.5	1	60	-	B2+ A	G	9.3	0.16g
Wp. 2	0.65	2	1	60	-	B2+ A	G	10.9	0.19g
Wp. 3	0.8	2	1	60	Lower: 25 %	B2+ A	B2+ G	12.7	0.22g
Wp. 4	1.7	3	1	75	-	B2	B2	15.8	0.27g
Wp. 5	0.8	2.4	2	50	Upper 11 %	B2T+VS B2T+DT/	B2T+DT	13	0.22g
Wp. 6	1.8	4	2	50	Upper 11 %	B2T	B2T+DT	17.9	0.3g

1. Staggering ratio

Average staggering ratios of wall profiles vary between 0.4 and 1.8. According to average resistance results, staggering ratio is dominant on determination of resistance.

Wall profiles 1, 2, 3 and 4 are composed of a single leaf, while wall profiles 5 and 6 are out of double leaves with header stones. However, regarding the wall sections, the resistance of wall profiles increases proportional to staggering ratios from 0.4 to 1.8 (Figure 78).

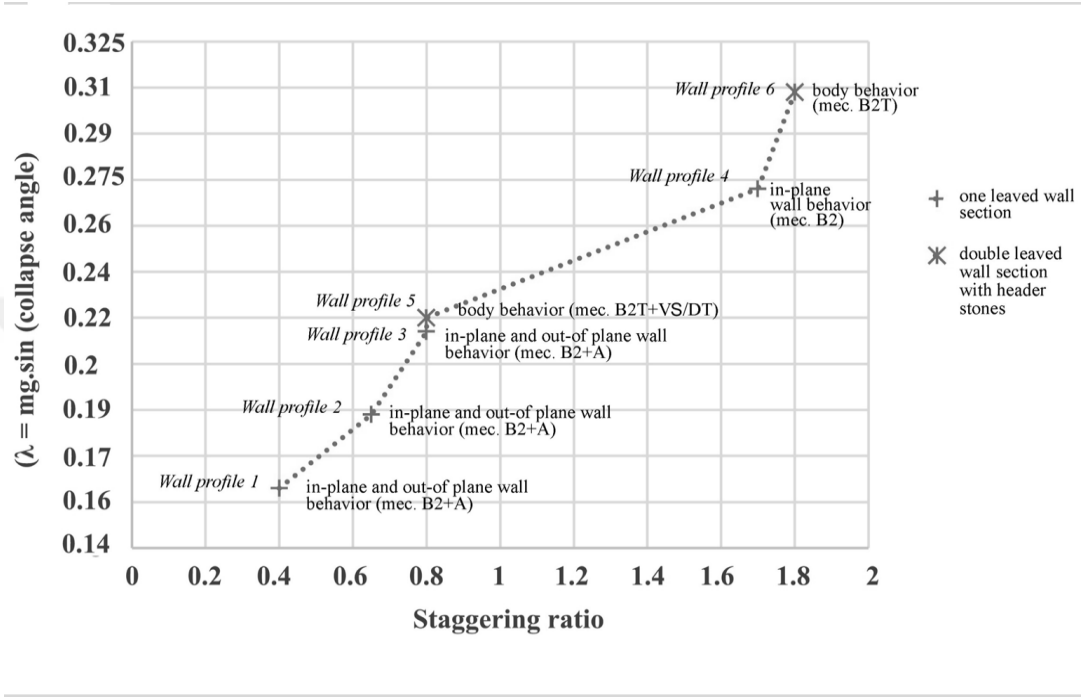


Figure 78. Impact of staggering ratio on structural resistance

The wall profiles that have the highest staggering ratios are wall profiles 4 (s/h=1.7) and 6 (s/h=1.8). They have the highest structural resistance in dependent from differentiation in their wall sections. While usage of long blocks up to 200 cm increases staggering ratio of wall profile 6, usage of short blocks (height=25-30 cm) in every two rows increases average staggering ratios of the wall profile 4. In the analytical study of D'Ayala and Speranza (2003, 488), the advantage of high staggering ratio is also proved. The staggering ratio from 0 to 1.8 increases resistance (λ) at h/l ratios between 1.25 and 2.5; similar with the results of the case study towers (Figure 79).

High staggering ratio increases resistance; however, the behavior of wall profiles is not only related with staggering ratios. Wall profile 6 that is composed of double leaves presents body behavior, while wall profile 4 that is composed of a single leaf presents in-plane behavior (Figure 78)

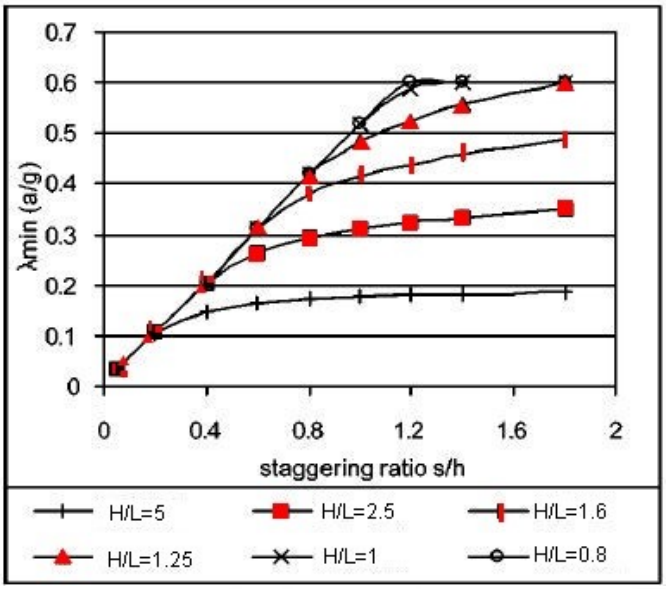


Figure 79. Impact of staggering ratio on structural resistance (Source: revised from D'Ayala and Speranza 2003, 488)

In the studies of Jimenez (2011, 86), Restrepo-Velez, Magenes, and Griffith (2014, 10, 26) and Shi, D'ayala, and Prateek (2008, 5-6), the walls composed of a single leaf with staggering ratios between 1 and 1.5 present in-plane failure mechanism similar with wall profile 4 (Figure 80). Thus, an appropriate double leafed organization gives way to total body behavior, in turn, structural resistance increases.

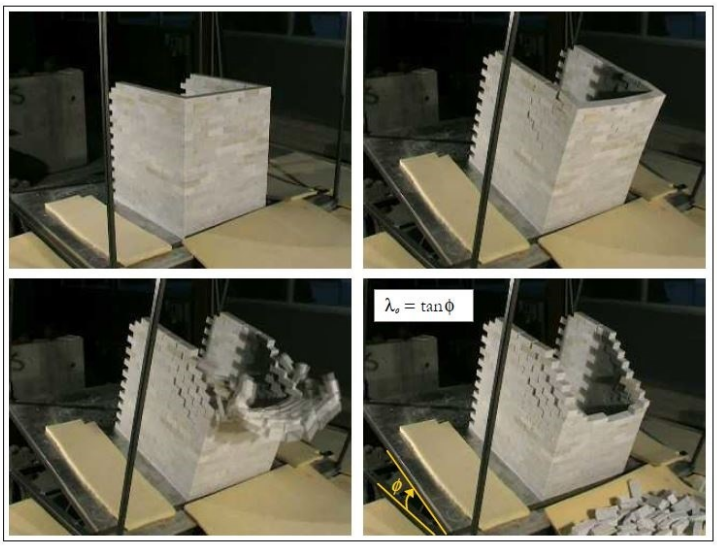


Figure 80. Collapse of side wall due to in-plane cracking (Source: Vaculik 2012, 234 from Restrepo-Velez and Magenes 2009)

When the staggering ratio is smaller than 1, if the wall profiles are not composed of double leaves with header stones, the out-of-plane failure (overturning of the facade due to vertical cracks at the corners) is seen. Staggering ratios are between 0.4 and 0.8 in the wall profiles 1, 2 and 3, since joints are positioned close to each other or they overlap. Small staggering ratio weakens the corner connections and make the tower corners unstable against the lateral load. Overturning of the out-of-plane facade wall occurs since the staggering ratio of the blocks at the corners are small ($0.4 \leq s/h \leq 0.8$). In the studies of Restrepo-Velez, Magenes, and Griffith (2014, 6) and Shi, D'ayala, and Prateek (2008, 5-6), overturning of the facade wall is observed as well due to the small staggering ratio (0.7) (Figure 81). Increase in staggering ratio supports behavior as revealed in in-plane wall or body behaviors. Small staggering ratios cause decrease in resistance of out-of-plane walls. High staggering ratio strengthen corner connection, since it provides full interlocking of corners to the side walls and gives way to in-plane behavior.

Figure 81. Overturning of the facade with vertical cracks at the corners due to the low staggering ratio (0.7) (Source: Restrepo-Velez, Magenes, and Griffith 2014, 6)

In the study of Shi, D'ayala, and Prateek (2008, 5), different corner configurations with staggering ratios 0.2, 1 and 1.5 are used to simulate different damage mechanisms. Small staggering ratio (0.2) causes overturning due to the vertical cracks at the corners, while strong connection causes entire collapse of the out-of-plane wall together with the top three courses of the side walls (Figure 82).

(a) Mechanism A (b) Mechanism D (c) Mechanism B1

s/h: 0.2 **s/h: 1** **s/h: 1.5**

Figure 82. Variation in staggering ratios of the corners (Source: Shi, D'ayala, and Prateek 2008, 5)

When the collapsed portions of the towers composed of a single leaf with staggering ratios from 0.4 and 1.7 are compared, larger triangular portions are lost at small staggering ratios (s/h≤0.8) in comparison to high (1.7) ones. In the analytical study of D'Ayala and Speranza (2003: 494-497), the number of stories collapsing is less at high staggering ratio (B_2, s/h=1.2) in comparison to low staggering ratio (B_2, s/h=0.3) during the detachment of the triangular portion (mechanism B_2).

When failures of wall profiles composed of double leaves with headers are compared with each other, it is seen that double leafed walls with high staggering (1.8) provides total body behavior at highest collapse angles, however, small staggering (0.8) cause vertical splitting as well as total body behavior.

2. Ratio between stone block length and height (bl/bh)

When the joints are positioned in the middle of the upper and lower blocks, the ratio between stone length and height is directly proportional to the staggering ratio. For example, in the study of Shi, D'Ayala and Join (2008, 5-6), by using smaller bricks, staggering ratios becomes smaller. Decreasing both sub-qualities causes decrease in resistance and out-of-plane failure mechanisms due to the poor corner connections. However, in this study, joints of stone blocks are not always positioned in the middle. Therefore, the average ratios of staggering and stone block dimensions are not proportional to each other. So, bl/bh is examined separately.

The results present that high block ratios increase structural resistance of towers. Wall profile 6 has similar staggering ratios with wall profile 4, but wall profile 6 (bl/bh=4) has higher bl/bh ratio in comparison to wall profile 4 (bl/bh=3). The wall profile 6 has higher structural resistance (Figure 78, Table 26).

The study of De Felice and Giannini (2001, 270) demonstrates the decreasing level of seismic resistance in parallel with the decreasing ratio between block height and length and also increasing height of the blocks decrease the quality of the masonry fabric with the same stone length (Figure 83).

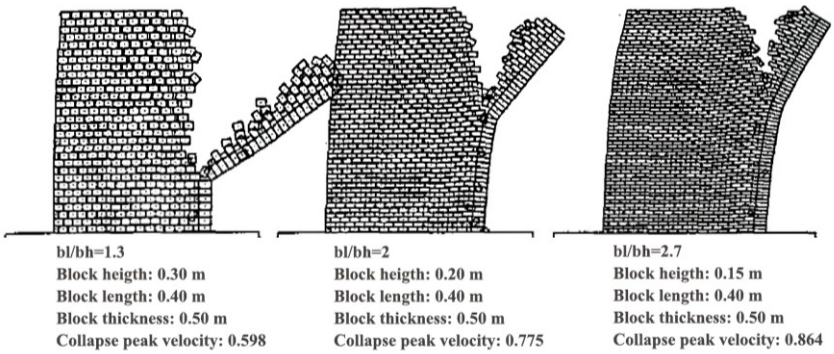


Figure 83. Impact of block ratio on failure mechanisms and resistance (Source: De Felice and Giannini 2001, 270)

In the study of Giuffre, Pagnoni and, Tocci (1994, 267-271) decrease in length of bricks in masonry walls leads to lower out-of-plane seismic capacity (Figure 81). This explains why the out-of-plane capacity of wall profile 6 with high bl/bh ratio is high (4) (Figure 84).

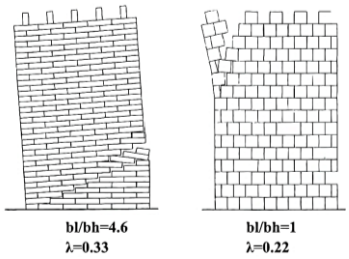


Figure 84. Impact of brick height on failure mechanisms and resistance (Source: Giuffre, Pagnoni and, Tocci 1994, 268)

Increase in structural strength proportional to stone length was presented in previous studies. This study proves that analysis of only stone length or only staggering ratio for dry masonry towers can be deceptive in terms of structural resistance. Wall profiles 3 and 5 have same staggering ratios, but they have different ratios between stone length and height, so they have different resistance. Similarly, wall profiles 2 and 3 have same stone ratios, but different staggering ratios, and they present different structural resistance.

3. Stone depth

In single leafed wall profiles whose wall thickness is equal to the depth of the stone blocks, stone depth directly effects the behavior of wall. In literature, advantage of depth of the blocks are generally studied on wall portions. In the study of Shi, D'ayala, and Prateek (2008), increase in brick depth in masonry walls leads to higher out-of-plane seismic capacity.

Wall profile 4 has longer stone depth (75 cm) in comparison to wall profile 1, 2 and 3 (60 cm). Wall profiles 1, 2 and 3 present out-of-plane failure (G or DT) when there are openings at out-of-plane position, however wall profile 4 does not present any out-of-plane failure, even if there are openings at out-of-plane position (Table 26).

4. Usage of headers

The systematic header stone distribution, namely, providing a distance between each header stone so that they do not neighbor each other, and placing fewer header stones at the sides compared to the central area (3% at the edges and 8% at the center); increase the monolithic behavior of the two leaves and improve out-plane resistance. The tower presents a total overturning by starting with diagonal body cracking and horizontal cracking at out-of-plane wall.

The wall profiles that have highest resistance are wall profiles 6 and 4 due to their high staggering ratios. While profile 4 with a single leaf presents in-plane failure mechanism, doubled leafed wall profile 6 connected with headers presents total body failure. The headers support monolithic behavior (Figure 78).

When wall profile 5 (double leafed) and 3 (single leafed) that have smaller staggering ratios (0.8) are compared with each other, wall profile 3 presents out-of-plane failure, but wall profile 5 presents body behavior.

In literature, effect of header stones connecting wall leaves on resistance against lateral force is generally studied with a wall portion without side walls (Ceradini 1992; D'ayala, and Speranza 2003, 480; Gençer et al. 2017, 84; Gençer, Hamamcıoğlu Turan, and Aktaş 2019). In the study of Giuffre (1996, 117), Ceradini (1992) and De Felice (2011, 479), the number of header blocks at wall section influence the strength capacity. The interlocking between the external leaves of masonry is crucial to provide an out-of-plane seismic capacity (Figure 85).

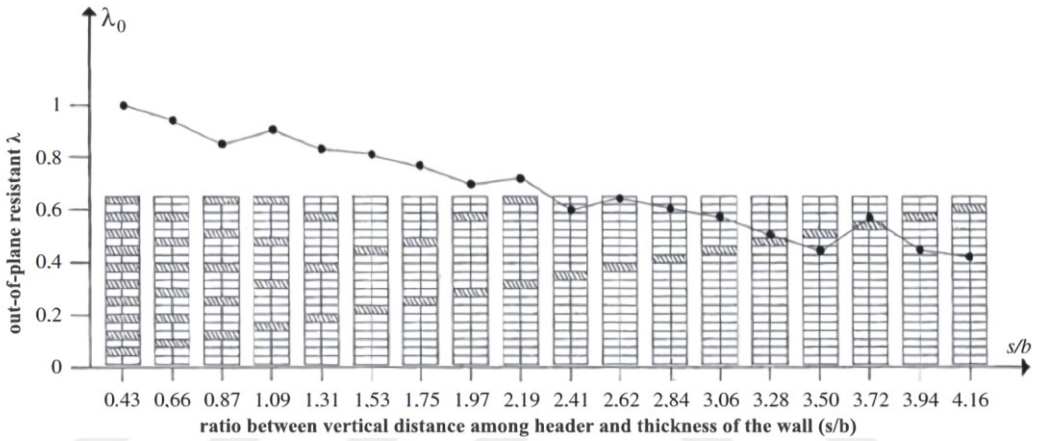


Figure 85. Decrease in out-of-plane resistant with decreasing number of headers (Source: revised by De Felice 2011, 479 and Giuffre 1996, 117)

Wall profiles 5 and 6 are composed of header stones connecting the two outer leaves. They present total body behavior. However, the resistance of wall profile 5 is lower than wall profile 6 due to its low staggering ratio. Low staggering ratio causes vertical splitting in addition to total body behavior. This proves that header usage provides more advantage in behavior compared to that in resistance. If the header usage is supported with high staggering ratio and high bl/bh ratio, the resistance increases, and the tower presents total body behavior (Figure 78). The usage of header stones with appropriate block dimensions and organizations is critical in terms of resistance and behavior.

Wall profile 3 that have header stones used only in the lower part of the towers cannot provide contribution to the resistance of the structure. Also, the header stones adjacent to each other in two rows reduce the strength of the towers considerably because

they cause decrease in staggering ratio. Wall profile 3 proves that headers may cause decrease in structural resistance, if they are used inappropriately.

The effect of header stones on behavior resembles towers that have horizontal reinforcement through a single square ring beam (with black paste glue at the top) at the top of the dry masonry models (Jimenez 2011, 84). As the reinforcement integrates the structure to act as a whole, the first crack appears at a great acceleration, no single block falls off the top, before global overturning which takes place at slightly higher acceleration as well (Figure 86). This shows that advantage of header stones is similar with horizontal reinforcement of the towers.

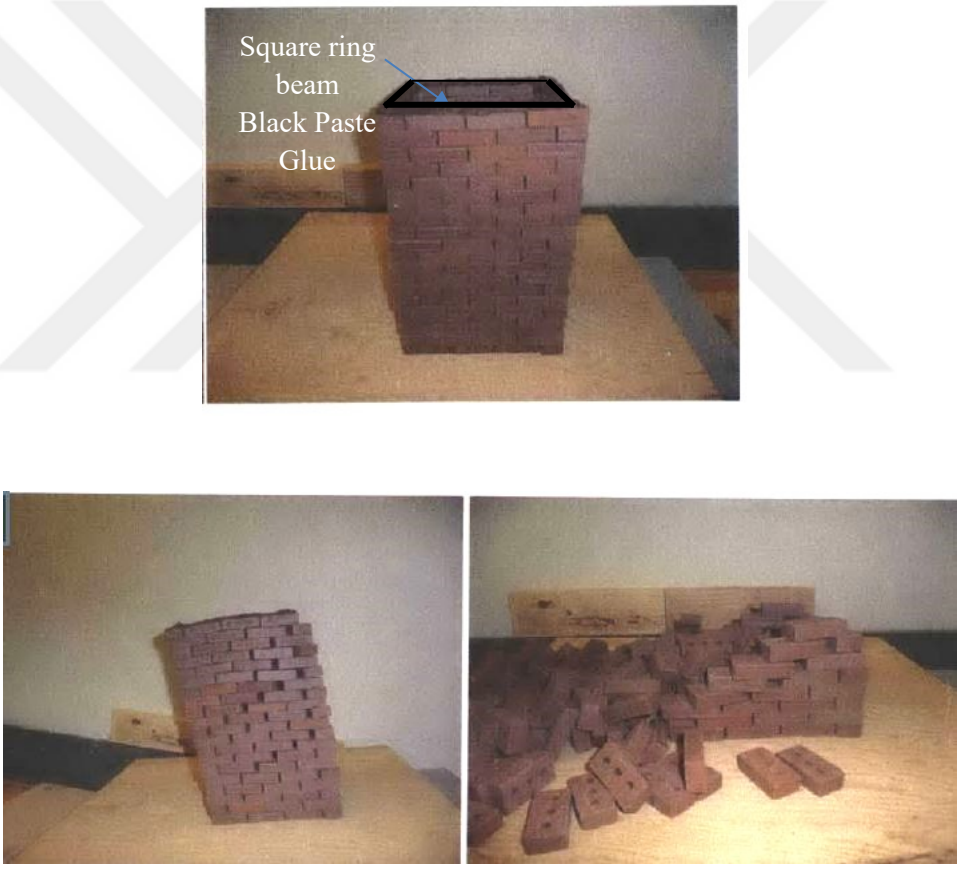


Figure 86. Behavior of horizontally reinforced tower (Source: Jimenez 2011, 117-118)

4.1.2. The opening organization

The openings affect the structural resistance and behavior in accordance with their sub-qualities such as area, number, and position. It is seen that increasing the number of

openings and their area and positioning them considering an even distribution within the facade composition and decreasing their distance to the corners reduce the resistance (Gençer et al. 2017, 84; Gençer, Hamamcıoğlu-Turan and, Aktaş 2019 in press; Table 27)).

Table 27. Average performance of sub-qualities regarding opening types

	Distribution	**Distance to corner (cm)**	**Area (upper) (m^2)**	**Number (upper)**	**Common mechanism**		**Ave. decrease in c. angle / λ**
					In-plane	Out-of-plane	
Op.1	Sym.	200-250	1	1	Typical mechanism of wall pr.	Typical mechanism of wall pr.	-
Op. 2, 5, 7, 9	Sym.	200-250	1.4-2	1 or 2	Typical mechanism of wall pr.	Typical mechanism of wall pr.	-
Op. 3, 4, 6	Asym.	50-60	1-2.5	1	Typical mechanism of wall pr.	Typical mechanism of wall pr.	-
Op. 8	Sym.	20-30	3	3	Typical mechanism of wall pr.	Typical mechanism of wall pr.	0.19 / 0.003g
Op. 12, 13	Asym.	50	1-1.5	2	Typical mechanism of wall pr.	Typical mechanism of wall pr.	0.21/ 0.003g
Op. 10	Sym.	20-30	7.4 (a large 5 m^2)	3	B2	G	1.02/ 0.02g
Op. 11	Sym.	20-30	3	3	B1	G	0.62/ 0.01g
Op. 14	Adj.	0	1	2	B2	G	0.69/ 0.01g
Op. 15	Adj.	0	2.95	2	B1	G	0.69/ 0.01g

Relation of three sub-qualities are discussed for towers with average collapse angles and failure mechanisms. Upper openings affect structural resistance more in comparison to lower openings. If a facade is composed of lower and upper openings, primarily the upper opening is taken into consideration. Although the lower openings are

adjacent to corner, they are not primary factors determining structural resistance and behavior (Figure 87).

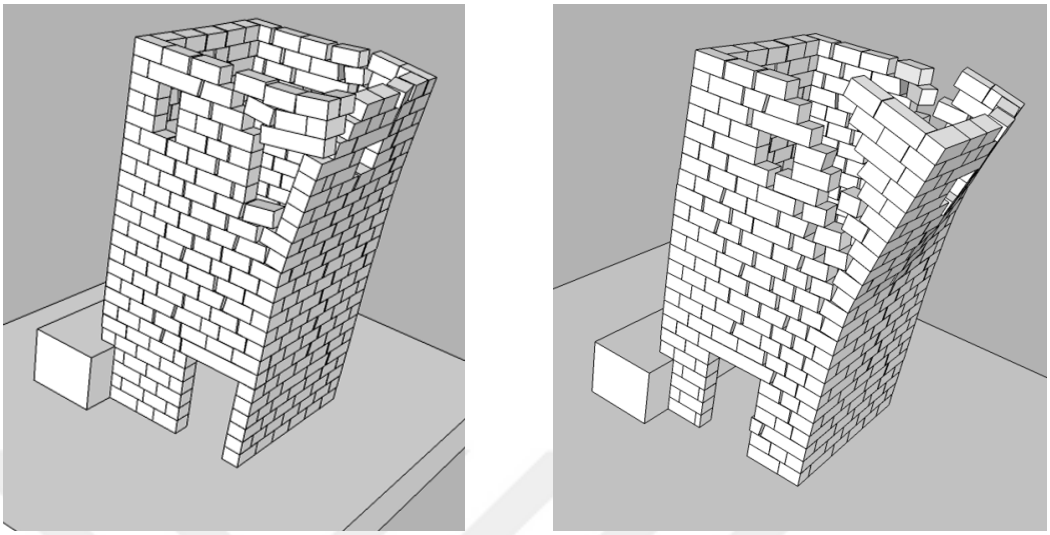
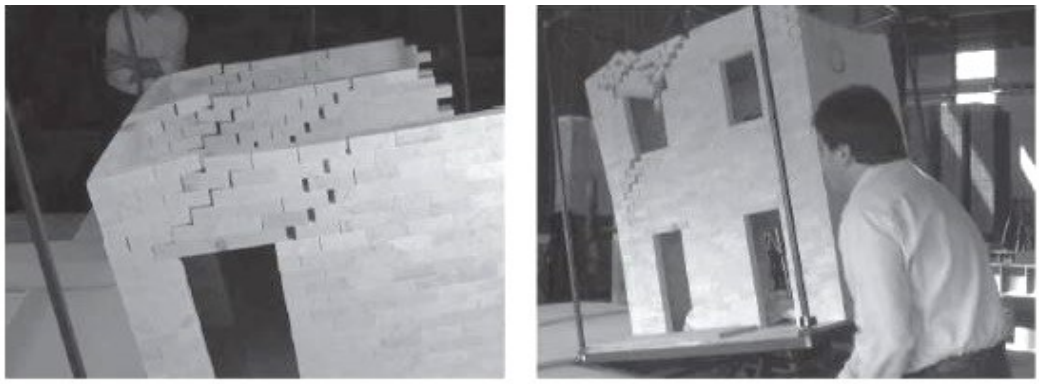


Figure 87. Impact of lower openings

One or two symmetrical or asymmetrical openings up to 3 m^2 at in-plane position or out-of-plane position that do not reduce the resistance significantly are determined as ineffective. However, their effect on behavior change depending on the properties of wall profiles.

Ineffective openings at in-plane position generally cause collapse of side walls due to in-plane shear cracking at wall profiles that are single leafed. In the study of Preciado, Sperbeck and, Gaytan (2006, 53) and Felice and Giannini (2001, 270) the in-plane failure mechanism is observed due to the cracks above and below the openings.

In the study of Restrepo-Velez, Magenes, and Griffith (2014, 10), openings at in-plane position cause diagonal cracks above the openings followed by collapse of side walls. Overturning occurs relatively faster in comparison to a wall without openings. The model, named as S42, with similar sub-qualities with the case study towers, shows similar behavior with case study towers that have similar staggering ratios (0.8) (Figure 88). However, openings cannot cause in-plane failure at wall profiles that have staggering ratio smaller than 0.4, since the tower presents out-of-plane behavior due to the poor corner connection caused by small staggering at small collapse angles before the effect of openings are seen.



(a) Test S22 (b) Test S42

Figure 88. Collapse mechanism caused by openings at in-plane wall (Source: Restrepo-Velez, Magenes, and Griffith 2014, 10)

Ineffective openings at out-of-plane position generally present detachment of the out-of-plane facade of the walls; regardless of openings position. This is proved by the studies of Restrepo-Velez, Magenes, and Griffith (2014, 9, 20) and Vaculik et al. (2004, 4-5), (Figure 89, Figure 90). These studies demonstrate cracking patterns stemming from different opening types at out-of-plane position. Diagonal cracks at the lower and upper parts cause detachment of the wall (Figure 89, Figure 90). In the cases of this study, however, the double-leafed and one-leafed wall profiles that have high staggering ratios ($\geq$1.7) are not affected by one or two openings up to 3 m^2. Even though ineffective openings at out-of-plane position change the behavior of towers, they do not affect resistance of tower. Small sized openings less than 3 m^2 do not affect resistance of towers both at in-plane and out-of-plane position.

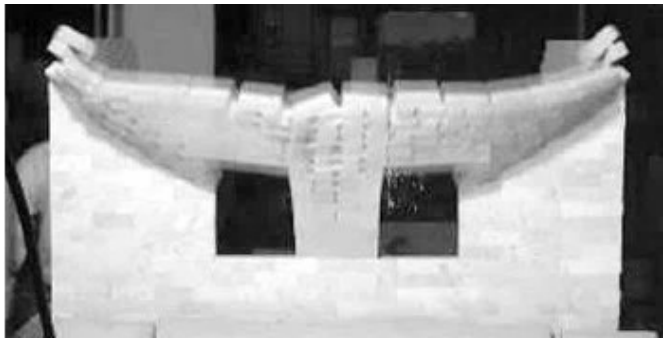
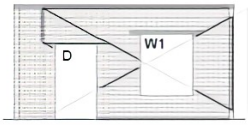
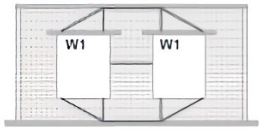
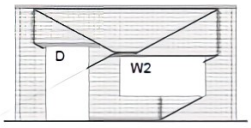


Figure 89. Failure mechanism with openings (Source: Restrepo-Velez, Magenes, and Griffith 2014, 9

Wall Id.	Wall Dimensions		Observed Collapse Mechanism
	Length (mm)	Height (mm)	
1A	2128	960	
2A 2B	1668 1668	960 960	
3A 3B 3C	2358 2358 2358	1170 1170 960	
4A 4B 4C	2473 2358 2358	1170 1170 960	
5A 5B 5C	2013 2013 2013	1170 1170 960	
6A 6B 6C	2358 2358 2358	1170 1170 960	

D: 460x780 cm
W1: 575x660 cm
W2: 920x420

Figure 90. Failure mechanism depending on opening types (Source: Vaculik et al. 2004, 4)

Effective opening types in terms of resistance and behavior are composed of more than 2 openings or larger than 5 m^2 or closed to corner (max. 30 cm). If openings are closed to corner or if they are more than two in number at in-plane position, they cause in-plane cracking of the only one side wall at which the opening is positioned. However, openings at out-of-plane position cause detachment of out-of-plane wall. Single leafed wall profiles that have both high staggering ratios and high stone depth are not affected by openings close to corner: they present in-plane failure with the help of out-of-plane resistance.

While a large sized upper opening, that has an area more than 5 m^2, at in-plane position causes collapse of side walls due to in-plane shear cracking, large sized opening at out-of-plane position (more than 5 m^2) causes out-of-plane failures regardless of wall profile characteristics.

4.1.3. The proportional relations

Studies in literature demonstrate that for the high buildings as towers, the ratio between height and length (slenderness) is a critical sub-quality in terms of behavior of the building (Shi, D'Ayala, and Prateek 2008; Romaro 2011; Casolo et al. 2013). However, effect of ratio between wall thickness and height (t/h) and wall thickness and length (t/l) on behavior are generally studied in a wall without side walls (De Felice and Giannini 2001). Also, due to the different wall thicknesses of towers changing from 60 cm to 115 cm, examining of t/l and t/h are not logical (see the related sections in Chapter 3).

H/L relation

When ratio between height and length is lower than 1.3 or higher than 2, long or high facades are being considered. High and long walls cause decrease in resistance against lateral loading. While higher h/l ratio does not affect the behavior, detachment of out-of-plane wall with diagonal cracks is seen due to the arch effect at h/l ratios smaller than 1.3 regardless of wall profile type (Figure 91).

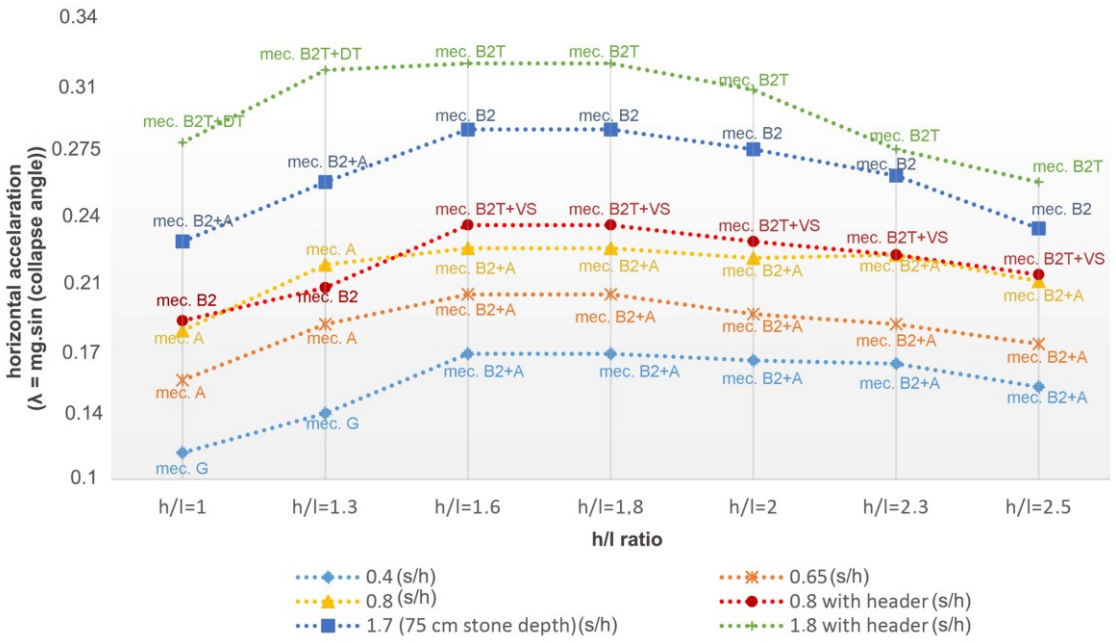


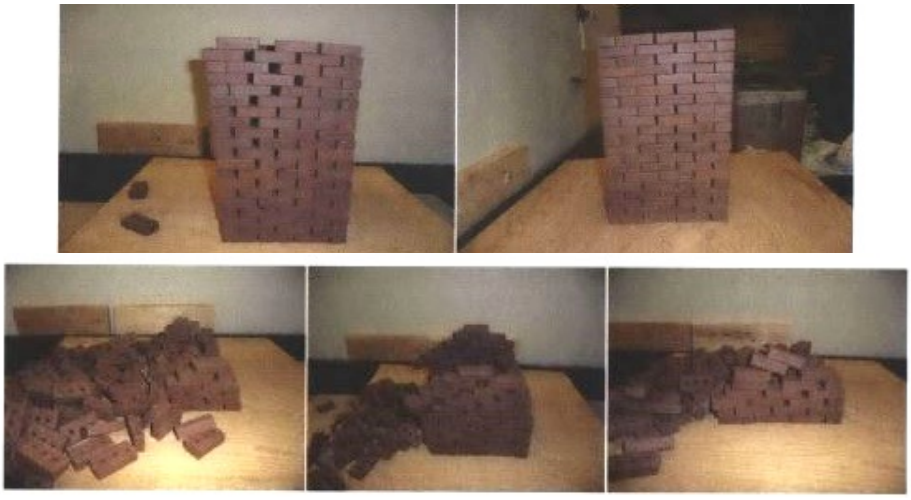
Figure 91. Resistance and behavior of wall profiles in different h/l ratios

In the study of Jimenez (2011, 77), while a square box with 0.4 h/l ratio presents out-of-plane failure; detachment of facade walls due to the arch effect, a square tower with 1.6 h/l ratio presents in-plane behavior. Failures are observed at smaller accelerations at the square box (λ: 0.131 g). Although towers in the study of Jimenez (2011, 77) have different stone block organization in comparison to real case study towers, small h/l ratios generally cause out-of-plane failure (Figure 92).

In the study of Shi, D'ayala, and Prateek (2008, 5), Restrepo-Velez, Magenes, and Griffith (2014, 7) and Bui et al. (2017, 284-287) with decreasing h/l, the arching behavior is more pronounced (Figure 93).

Effect of h/l ratio on resistance of dry masonry structures present variation with regard to staggering ratio. In the study of D'Ayala and Speranza (2003, 501), the increase of the staggering ratio produces an improvement of seismic performance only for h/l ratios higher than 1. For example, the positive effect of high staggering ratio (≥1.7) on behavior is not seen at wall profiles 4 and 6 at h/l ratios smaller than 1.3. The towers present out-of-plane failure due to the arch effect; typical failure and resistance of towers is not achieved.

Out-of-plane failure due to the arch effect at square box (h/l: 0.4), horizontal acceleration (λ): 0.131 g



In-plane behavior at square tower (h/l:1.6), horizontal acceleration (λ): 0.211 g

Figure 92. Behavior of square box and tower (Source: Jimenez 2011, 77, 83)

(d) Mechanism B2 (e) Mechanism G
h/l:1 **h/l:0.7**

Figure 93. Decreasing h/l ratio and behavior (from left to right) (Source: Shi, D'ayala, and Prateek 2008, 5)

4.2. Impact of characteristics on each other

Impact of effective characteristics on each other is discussed with the help of the statistical evaluation, namely, regression analysis, regarding the collapse angle results of hypothetic towers (see Appendix D). The effective characteristics are wall profile, opening organization and proportional relations. The sub-qualities of effective characteristics are staggering ratio, ratio between block length and height, stone depth, distribution of upper headers, upper opening area, number and position, and ratio between height and length. By using data about sub-qualities, regression analysis is carried out. These sub-qualities are called as independent variable effecting structural behavior and resistance. The collapse angle is directly related with these sub-qualities; so, it is the dependent variable in the statistical evaluation (Table 28).

Table 28. Variables of regression

Dependent variable	**Independent variables**	
Collapse angle	Wall profile	• **Staggering ratio** • **Ratio between block length and height** • **Stone depth** • **Distribution of upper headers**
	Opening	• **Upper opening area** • **Upper opening number** • **Upper opening position**
	Proportional relationship	• **Ratio between height and length**

Linear relationship between dependent variable and independent variables are determined before regression analysis. The relation between height and length proportion and collapse angle within the limits of the real towers shows linearity (Appendix B). With regression analysis, the coefficients and probability of the variables affecting the structural resistance and probability and acceptance of regression model have been determined (Table 29).

When the probability of variables is less than 5%, regression analysis is significant. The validity of the regression model is also emphasized by the test F value (probability); statistically superior value; by the fact that the value of the test sample (F - statistic) is zero. This means that all variables jointly can influence collapse angle. This indicates a strong evidence of parameters (Table 29).

Table 29. Statistical analysis results

Dependent Variable: COLLAPSE ANGLE
Method: Least Squares
Date: 02/23/19 Time: 18:34
Sample(adjusted): 1 360
Included observations: 360 after adjusting endpoints

Variable	**Coefficient**	Std. Error	t-Statistic	**Probability**
Block Length/Height ***	**0.774170***	0.253346	3.055781	**0.0024**
Height/Length***	**-1.873832***	0.132541	-14.13770	**0.0000**
Opening Area***	**-0.193814***	0.025186	-7.695450	**0.0000**
Opening Number***	**-0.171216***	0.078331	-2.185799	**0.0295**
Opening Position***	**-0.103385***	0.037915	-2.726727	**0.0067**
Staggering Ratio***	**2.263709***	0.464579	4.872603	**0.0000**
Stone Depth***	**0.131621***	0.031136	4.227269	**0.0000**
Upper Header Usage***	**0.372812***	0.066929	5.570241	**0.0000**
Constant***	**5.067544***	1.885607	2.687487	**0.0075**
R-squared	**0.945878**	Mean dependent var		13.89583
Adjusted R-squared	**0.944644**	S.D. dependent var		2.764097
S.E. of regression	0.650332	Akaike info criterion		2.002014
Sum squared resid	148.4489	Schwarz criterion		2.099166
Log likelihood	-351.3624	F-statistic		766.7899
Durbin-Watson stat	1.384484	**Probability(F-statistic)**		**0.000000**

*** represents statistical significance between 1-5%, ** at 5-10%, * higher than 10% level.

Both R-squared (R2) and Adjusted R-squared (adjusted R2) show the proportion in which the collapse angle is explained through the parameters. R-squared value is about 95%. 95 % indicates that the model explains most of the variability of the response data. Henseler et al. (2009) identifies acceptance level of R2 values as 75%, 50%, and 25%:

substantial, moderate and weak, respectively. This shows that the regression model is substantial. The regression result shows that all the coefficients are statistically very significant.

Based on the values of R-squared and F-statistic tests and residuals (see Appendix B; Figure B-2), it can be stated that the model which describes the parameters effecting structural resistance of dry masonry towers can be used to make reliable proposals for the structural vulnerability of dry masonry towers against lateral load. Coefficient of parameters that effect structural resistance negatively and positively are determined. However, the parameters cannot be compared because they have different coefficient units. In order to compare the parameters with each other, an impact values of parameters with same unit are calculated by using the standard deviation value and coefficients of each parameter. In this way, the impact of the parameters can be compared with each other. While discussing these parameters, intervals of parameters should be taken into consideration (Table 30).

Table 30. Impact values and intervals of parameters

Analysis interval	Definition	Numeric value	Impact Value
0.4-1.8	**Staggering ratio (s/h)**	1.8	4.4
0.5-0.75 m	**Stone depth**	0.75 m	3
1.5-4	**Block length/height (bl/h)**	4	2
0-11 %	**Distribution of upper headers**	11%	0.06
1-3	**Upper opening number**	3	-0.4
0-3 m	**Upper opening position**	0	-0.4
1-5 m^2	**An upper opening area**	5	-1.5
1.6-2.3	**Proportional relationship between height and length (h/l)**	2.3	-1.8

The impact value represents the highest numerical value of interval of each parameter. When impact of parameters is listed from their positive impact to negative impact, the parameters providing considerably positive impact on resistance are about wall profile; staggering ratio, stone depth and ratio between block length and height while the parameters decreasing resistance highly are about morphology; h/l ratio and opening

area (Table 31). Numerical intervals of parameters are determined according to results of analysis and properties of hypothetic towers. The table illustrates the increase in resistance from orange color to beige color (Table 31). Missing parts of interval of staggering ratio (colored with grey color) are completed with the help of the literature review at section 4 (D'Ayala and Speranza 2003, 488).

Impact of parameters are determined according to their intervals. With the help of the table, the dominancy of parameters according to their intervals is discussed when they are combined (Table 31).

The parameter presenting highest positive impact is staggering ratio higher than 1.7. Wall profile parameters have three times higher positive impact values than the opening organization and proportional relationship parameters. This demonstrates that when highest staggering ratio is combined with any other parameter, it is not affected, unless all other parameters of morphologic characteristics are taken with their negative aspects.

Table 31. Intervals and impact of parameters

		Negative impact						**Positive impact**
Impact Coefficient		**-1.8**	**-0.4**	**0**	**0.4**	**2**	**3**	**4.4**
Wall profile	Stag. ratio			0.4≤sh<0.6	0.6<sh≤0.8	0.8≤sh<1.2	1.2≤sh≤1.6	≥1.7
	Stone depth (cm)			≤ 50 (double leafed)	≤ 60 (one leafed)		≥75 (one leafed)	
	Bl/h			≤ 1.5	1.5<blh≤3	3<blh≤4		
	Header			11 %				
Pr.	H/L	>2, 1.3≤	1.8≤hl≤2	1.6≤hl≤1.8				
Opening	Area (m^2)	≥5	3<area<5	1≤area≤3				
	Position		Adj./ max 30 cm to corner	Asy - Sym				
	Number		3	1 or 2				

*The data coming from the real tower are colored black, the data supported by literature about staggering ratio are proposed by grey.

Stone depth longer than 75 cm and block ratio higher than 3 provides also positive impact. The wall profile parameters that cause the lowest resistance are staggering ratio

smaller than 0.4, stone depth shorter than 60 cm, block ratio smaller than 1.5. Header usage decreases resistance when it is combined with parameters that have lowest impact, however it increases resistance when it is combined with parameters that have higher impact values.

The morphologic parameters causing highest decrease in resistance are an opening size larger than 5 m^2 and h/l ratio higher than 2. These parameters cause decrease in resistant when they are combined with wall profile parameters, except for highest impact value as staggering ratio higher than 1.7 and stone depth higher than 75 cm. If the worst h/l ratio and opening configuration are combined with parameters that have highest impact, they can decrease resistance.

Morphologic parameters that have minimum negative impact value; h/l ratio between 1.8 and 2, openings larger than 3 m^2, more than 2 in number or close to corner (max 30 cm) cause decrease in resistance, when they are combined with parameters of wall profiles that have impact value of 0.4 and 0.

Symmetric opening with an area between 1 and 3 m^2, and h/l ratio between 1.6 and 1.8 do not decrease resistance with all other positive wall profile parameters (Table 31).

The parameters effecting resistance can cause different behavior, therefore, relationship of behavior and parameters' interval is discussed separately (Table 32). The behavior of towers changes from out-of-plane to body behavior depending on parameters. Dominant parameters as header usage, low (≤ 0.8) and high staggering ratio (≥ 1.7), stone depth, large sized openings (≥ 5 m^2), openings close to corner (max. 30 cm), and more than two in number are discussed.

High staggering (≥ 1.7) and high block ratio (≥ 3) increase out-of-plane behavior and provides in-plane or body behavior. Usage of headers at double leafed walls are not effective on better lateral resistance of towers, however it is a dominant parameter for better structural behavior. Stone depth longer than 75 cm prevents out-of-plane behavior and sustains in-plane behavior. Staggering ratio smaller than 0.8 causes out-of-plane failure due to weakness of corners.

The h/l ratio interval between 1.6 and 2 is appropriate for best performance of towers. When this ratio is beyond the limits of real towers, lower than 1.3, this causes arch effect and out-of-plane behavior.

Openings adjacent to corner and close to corner up to 30 cm cause in-plane failure of the side walls. Openings larger than 5 m^2 cause in-plane failure of two side walls. These

behaviors are common, when the openings are at in-plane position. The opening at out-of-plane position generally cause the out-of-plane failure or detachment of out-of-plane wall together with bending. Dominancy of parameters on behavior are listed in the below.

- Header usage combined with high staggering (≥1.7) and high block ratio (≥3) increase out-of-plane behavior and provides body behavior.
- If header usage with high staggering (≥1.7) and high block ratio (≥3) is combined with large sized opening, opening close to corner and more than 2 openings, this causes in-plane behavior at ratios 1.6 and 2.
- If header usage with high staggering (≥1.7) and high block ratio (≥3) are combined with openings at out-of-plane position except with large sized opening, opening close to corner and more than 2 openings, this causes out-of-plane failure together with body failure at ratios between 1.3 and 1.8
- If header usage with low staggering (0.4<sh≤0.8) and low block ratio (≤1.5) is combined with large sized opening, opening close to corner and more than 2 openings, this causes in-plane behavior at all ratios.
- If header usage is combined with low staggering (0.4≤sh<0.8) and low block ratio (≤1.5), this causes in-plane behavior together with body behavior.
- If header usage with low staggering (0.4<sh≤0.8) and low block ratio (≤1.5) is combined with openings at out-of-plane position except with large sized opening, opening close to corner and more than 2 openings; this causes out-of-plane failure together with body failure at ratios between 2 and 2.3.
- If header usage with low staggering (0.4≤sh<0.8) and low block ratio (≤1.5) is combined with large sized opening, opening close to corner and more than 2 openings at out-of-plane position; this causes out-of-plane failure at ratios between 1.3 and 1.8.
- Staggering ratio higher than 1.7, block ratio higher than 3 and stone depth longer than 75 cm provide in-plane behavior for one leafed wall section regardless of opening and h/l.
- Staggering ratio between 0.4 and 0.8, block ratio smaller than 2 and stone depth lower than 60 cm cause hybrid behavior composed of in-plane and out-of-plane failure for one leafed wall.
- When h/l ratio is beyond 1.3, this causes arch effect and out-of-plane behavior at one leafed wall regardless of opening and h/l.

Table 32. Intervals of parameters and their impact on behavior (dominant parameter shown with grey hatch)

Failure	Wall profile				Proportional	Opening					
	Double l. header	Bl/bh	Stone depth	Staggering ratio	h/l	number		position		area	
						Out	In	Out	In	Out	In
Out-of-plane	-	≤1.5	any	≤0.8	**≤1.3**	-	any	-	any	-	any
	8-11%	≤1.5		≤0.8	1.3≤h/l≤1.8	3	-	Adj	-	≥5	-
In+ out of plane	-	≤1.5	≤ 60	≤0.8	any	any	-	any	-	any	-
Body+ out-of-plane	8-11%	≥3	-	≥1.7	1.3≤h/l≤1.8	1-2	-	Sym-asym	-	≤3	-
	8-11%	≤1.5	-	≤0.8	2≤h/l≤2.3	1-2	-	Sym-asym	-	≤3	-
In-plane	-	≥3	≥75	≥1.7	any		any	-	any	-	any
	8-11%	≤1.5	-	≤0.8	any		3	-	Adj	-	≥5
	8-11%	≥3	-	≥1.7	1.6≤h/l≤2		3	-	Adj	-	≥5
Body+ in-plane	8-11%	≤1.5	-	≤0.8	any		1-2	-	Sym-asym	-	≤3
Body	8-11%	≥3	-	≥1.7	Any		1-2	-	Sym-asym	-	≤3

4.3. Vulnerability Assessment Framework

Impact of intervals of parameters and their dominance are determined according to each other in terms of resistance and behavior in section 4.2 (Table 31 and Table 32). With determination of dominancy, vulnerability framework for dry masonry towers is proposed. While proposing vulnerability, the data gathered from hypothetic towers are used only. Since the literature data are related to behavior of dry masonry walls and it is not specific to dry masonry towers, it was not used for vulnerability framework.

Vulnerability should be assessed in incremental steps with the help of the impact values of parameters; ranking vulnerability at levels such as high, medium, low, considerably low and critical (Table 31). Vulnerability rankings are determined for openings at in-plane position, since the worst case is always considered. When the openings are at out-of-plane position, the vulnerability rankings are similar with in-plane position, however the vulnerability decreases when an opening is larger than 5 m^2, close to corner and more than two in number at out-of-plane position in comparison to in-plane position. Nevertheless, failures are determined according to both in-plane and out-of-plane position of openings.

Considerably low vulnerability corresponds to the towers that are constructed within the following limits:

- Staggering ratio higher than 1.7 with stone ratio higher than 3 for double leafed wall profiles with header stones, for all opening types except larger than 5 m^2, for h/l ratio higher than 2 or smaller than 1.3.
- Staggering ratio higher than 1.7 with stone ratio between 1.5 and 3, stone depth higher than 75 cm for one leafed wall profiles, for all opening types except larger than 5 m^2 and all h/l ratios except higher than 2 or smaller than 1.3.

Low vulnerability corresponds to the towers that are constructed within the following limits:

- Staggering ratio higher than 1.7, stone ratio higher than 3 for double leafed wall profiles with header stones, for an opening larger than 5 m^2, and h/l ratio higher than 2 or smaller than 1.3.
- Staggering ratio higher than 1.7 with stone ratio between 1.5 and 3, stone depth higher than 75 cm for one leafed wall profiles, for opening types larger than 5 m^2 and h/l ratios between 1.6 and 2.

- Staggering ratio higher than 1.7 with stone ratio between 1.5 and 3, stone depth higher than 75 cm for one leafed wall profiles, for all opening types except larger than 5 m^2 and all h/l ratios higher than 2 or smaller than 1.3.

Medium vulnerability corresponds to the towers that are constructed within the following limits:

- Staggering ratio higher than 1.7 with stone ratio between 1.5 and 3, stone depth higher than 75 cm for one leafed wall profiles with opening types larger than 5 m^2, and h/l ratios higher than 2 or smaller than 1.3.
- Staggering ratio between 0.6 and 0.8, stone ratio smaller than 1.5, stone depth shorter than 60 cm for one or double leafed wall profiles, for all opening types except larger than 5 m^2, more than 2 in number, and maximum 30 cm in distance to corner, all h/l ratios except higher than 1.8 or smaller than 1.3.

High vulnerability corresponds to the towers that are constructed within the following limits:

- Staggering ratio between 0.6 and 0.8, stone ratio smaller than 1.5, stone depth shorter than 60 cm for one or double leafed wall profiles with opening types larger than 5 m^2, more than 2 in number, and maximum 30 cm in distance to corner and with h/l ratios between 1.6 and 1.8.
- Staggering ratio between 0.6 and 0.8, stone ratio smaller than 1.5, stone depth shorter than 60 cm for one or double leafed wall profiles with all opening types except larger than 5 m^2, more than 2 in number, and maximum 30 cm in distance to corner and with h/l ratios higher than 1.8 or smaller than 1.3.
- Staggering ratio smaller than 0.4, stone ratio smaller than 1.5, stone depth shorter than 60 cm for one leafed wall profiles with all opening types except larger than 5 m^2, more than 2 in number, and maximum 30 cm in distance to corner at h/l ratios 1.6 and 2.

Considerably high vulnerability corresponds to the towers that are constructed within the following limits:

- Staggering ratio between 0.6 and 0.8, stone ratio smaller than 1.5, stone depth shorter than 60 cm for one or double leafed wall profiles with opening types larger than 5 m^2, more than 2 in number, and maximum 30 cm in distance to corner at h/l ratios higher than 1.8 or smaller than 1.3.

- Staggering ratio smaller than 0.4, stone ratio smaller than 1.5, stone depth shorter than 60 cm for one leafed wall profiles with all types larger than 5 m^2, more than 2 in number, and maximum 30 cm in distance to corner and with h/l ratios between 1.8 and 2.
- Staggering ratio smaller than 0.4, stone ratio smaller than 1.5, stone depth shorter than 60 cm for one leafed wall profiles with all opening types except larger than 5 m^2, more than 2 in number, and maximum 30 cm in distance to corner and with h/l ratios higher than 2 or smaller than 1.3.

Critical vulnerability corresponds to the towers that are constructed within the following limits:

- Staggering ratio smaller than 0.4, stone ratio smaller than 1.5, stone depth shorter than 60 cm for one leafed wall profiles with all opening types larger than 5 m^2, more than 2 in number, and closed maximum 30 cm in distance to corner at h/l ratios higher than 2 or smaller than 1.3.

Types of failures observed in a tower are related with predominance of parameters with respect to each other, and they should be evaluated separately for positioning of openings at in-plane and out-of-plane walls.

Only body failure:

- Double leafed wall sections with headers (11 %) and staggering ratio higher than 1.7, ratio between length and height of stone blocks higher than 3 combined with either opening at in plane position between 1 and 3 m^2 in area or at most two asymmetric or symmetric openings and any h/l ratio.

Body failure with in-plane failure (vertical splitting):

- Double leafed wall sections with headers and staggering ratios smaller than 0.8 and ratio between length and height of stone blocks smaller than 2 with openings at in plane position between 1 and 3 m^2 in area or at most two asymmetric or symmetric openings at in-plane position and any h/l ratio.

In-plane failure:

- Double leafed wall sections with headers and staggering ratio higher than 1.7, ratio between length and height of stone blocks higher than 3 with opening at in-plane position larger than 5 m^2 in area or at least three openings at in-plane

position or openings closed to corner at most 30 cm at in-plane position and h/l ratio between 1.6 and 2.

- Double leafed wall sections with headers and staggering ratios smaller than 0.8 and ratio between length and height of stone blocks smaller than 2 with openings at in-plane position larger than 5 m^2 in area or at least three openings at in-plane position or openings closed to corner at most 30 cm at in-plane position and any h/l ratio.
- One leafed wall section and staggering ratio higher than 1.7, ratio between length and height of stone blocks higher than 3 and stone depth longer than 75 cm combined with any opening type at in-plane position and all h/l ratios except smaller than 1.3

Body and out-of-plane behavior:

- Double leafed wall profiles with staggering ratios smaller than 0.8 and ratio between length and height of stone blocks smaller than 2 and any openings positioned at out-of-plane position at any h/l ratios.
- Double leafed wall sections with headers and staggering ratio higher than 1.7, ratio between length and height of stone blocks higher than 3 with an opening area larger than 5 m^2 or at least three openings or openings closed to corner at most 30 cm at out-of-plane position and h/l ratio between 1.6 and 2.

In-plane and out-of-plane failure (overturning due to vertical cracks):

- One leafed wall section and staggering ratios smaller than 0.8, ratio between length and height of stone blocks smaller than 2 and stone depth shorter than 60 cm combined with any opening type at in-plane position and h/l ratio.
- One leafed wall section and staggering ratio higher than 1.7, ratio between length and height of stone blocks higher than 3 and stone depth longer than 75 cm combined with any opening type at in-plane position at h/l ratios smaller than 1.3.

Out-of-plane failure (detachment):

- One leafed wall section with staggering ratio smaller than 0.8, ratio between length and height of stone block smaller than 2 and any stone depth and opening organizations at h/l ratio smaller than 1.3.
- One leafed wall section with any staggering ratio, stone depth and ratio between length and height of stone block with any opening organization at out-of-plane position at any ratio.

Relation of parameters with vulnerability rankings and failure mechanisms is proposed as matrices (Table 33). This framework is specific to the characteristics of the studied dry masonry towers only. It is not a general output for all other dry masonry buildings. It can be calibrated for other dry masonry towers that have different characteristics.

Since vulnerability is a component of risk assessment, results of this framework can be used as a coefficient of risk assessment against lateral loading (UNESCO et al. 2010, 8). If this framework is combined with data on frequency and intensity of previous earthquakes, risk assessment of towers can be carried out. The framework may evolve into a risk assessment against lateral loading with further work in the future.

4.3.1. Vulnerability assessment of case studies

First, earthquake risk in the environs of the case studies in terms of frequency and severity are presented by examining earthquake history (see Chapter 2). The vulnerability framework is applied to the case studies. Probable and existing failures of case studies are compared with the results of the framework. At last, a preliminary risk assessment against lateral loading is carried out.

4.3.1.1. Towers in Caria

Alinda and Latmos Towers in Caria are approximately 70 km in distance to each other. This region is under high earthquake threat due to extremely high ground acceleration (AFAD 2018). In 100 km proximity of the case studies, 180-190 earthquakes have been recorded from 1900 until present. In environs of Latmos, 141 earthquakes have taken place between 4 and 5 in magnitude. Between 5 and 6, there are 34 and between 6 and 7, there are 8 earthquakes. In the environs of Alinda, between 4 and 5 in magnitude, there are 146 earthquakes. Between 5 and 6, there are 36 earthquakes; and between 6 and 7, there are 7 earthquakes. For ancient periods, there are no recorded earthquakes higher than magnitude 6 in approximately 100 km proximity of the area. Earthquakes higher than 7 magnitudes is approximately 600 km far from the area in ancient period (BDTİM 2017).

Table 33.Vulnerability framework

	≤1.3 (beyond the limits of case studies)				1.6≤h/l≤1.8				1.8<h/l≤2				h/l>2			
	Op. number 1 or 2, asy/sym, 1 ≤Area ≤3 m²	**An opening area ≥5 m²**	**Op. number more than 3, 1 ≤Area ≤3 m²**	**Op. closed to corner (max 30 cm), 1 ≤Area ≤3 m²**	**Op. number 1 or 2, asy/sym, 1 ≤Area ≤3 m²**	**An opening area ≥5 m²**	**Op. number more than 3, 1 ≤Area ≤3 m²**	**Op. closed to corner (max 30 cm), 1 ≤Area ≤3 m²**	**Op. number 1 or 2, asy/sym, 1 ≤Area ≤3 m²**	**An opening area ≥5 m²**	**Op. number more than 3, 1 ≤Area ≤3 m²**	**Op. closed to corner (max 30 cm), 1 ≤Area ≤3 m²**	**Op. number 1 or 2, asy/sym, 1 ≤Area ≤3 m²**	**An opening area ≥5 m²**	**Op. number more than 3, 1 ≤Area ≤3 m²**	**Op. closed to corner (max 30 cm), 1 ≤Area ≤3 m²**
s/h ≥1.7 1.5<bl/h≤3 stone depth ≥75	**Vul. Ranking**: Low **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: In+out-of-plane (overturning)	**Vul. Ranking**: Medium **Proposed failure:** Op. at in-plane: In+out-of-plane Op. at out-of-plane: In-plane	**Vul. Ranking**: Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking**: Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In+out-of-plane	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In+out-of-plane	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Medium **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In+out-of-plane	**Vul. Ranking:** Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane	**Vul. Ranking:** Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In-plane
0.6<s/h≤0.8 bl/h ≤2 stone depth≤60	**Vul. Ranking**: Considerably high **Proposed failure:** Op. at in-plane: Out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking**: Considerably high **Proposed failure:** Op. at in-plane: In+out-of-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking**: Considerably high **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking**: Considerably high **Proposed failure:** Op. at in-plane: In+out-of-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Medium **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Medium **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)
s/h≤0.4 bl/h ≤1.5 stone depth≤60	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: Out-of-plane (detachment) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Critical **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Critical **Proposed failure:** Op. at in-plane: In+out-of-plane (detachment) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Critical **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Critical **Proposed failure:** Op. at in-plane: In+out-of-plane (overturning) Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Critical **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Critical **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)
s/h ≥1.7 3< bl/h ≤4 header 11%	**Vul. Ranking**: Considerably Low **Proposed failure:** Op. at in-plane: Body+out-of-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking**: Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking**: Considerably Low **Proposed failure:** Op. at in-plane: In+out-of-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking**: Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body	**Vul. Ranking:** Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably Low **Proposed failure:** Op. at in-plane: Body Op. at out-of-plane: Body
0.6<s/h≤0.8 bl/h ≤2 header 11%	**Vul. Ranking**: Considerably high **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking**: Considerably high **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking**: Considerably high **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking**: Considerably high **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane(detachment)	**Vul. Ranking:** Medium **Proposed failure:** Op. at in-plane: Body+in-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** Medium **Proposed failure:** Op. at in-plane: Body+in-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: In+out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Out-of-plane (detachment)	**Vul. Ranking:** High **Proposed failure:** Op. at in-plane: Body+in-plane Op. at out-of-plane: Body+in-plane	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Body+out-of-plane (detachment)	**Vul. Ranking:** Considerably High **Proposed failure:** Op. at in-plane: In-plane Op. at out-of-plane: Body+out-of-plane (detachment)

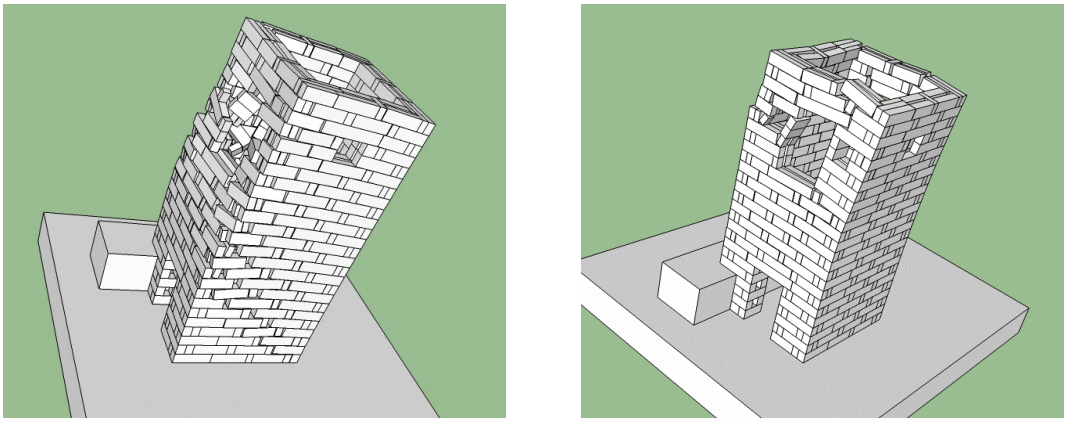
*the white part represents the h/l ratio beyond the limits of case studies

4.3.1.1.1. Vulnerability of Alinda Tower

Alinda Tower has low vulnerability with the help of the characteristics of its wall profile, although weakness of h/l ratio and opening organization increase vulnerability. It has high staggering ratio (higher than 1.8) and ratio between block length and height is higher than 4. Since walls are composed of leaves, stone depth is also small (45-50 cm), however these leaves are connected with header stones. Although the tower has the weakest opening organization (one large sized, 5 m^2) and the northwestern facade has a high h/l ratio (2.3), wall profile characteristics provide advantage against weakness of the other morphologic characteristics (Figure 95). Control of vulnerability of the large sized openings and high facade should be achieved with appropriate measures of intervention.

- **Possible Failures**

Header usage supported with high staggering ratio and high block ratio becomes significant for behavior. The headers provide integrity of the walls and staggering, and block ratio increase corner connections. The tower may show body behavior in case of lateral loading; total overturning beginning with in-plane diagonal body cracking and horizontal cracking at the out-of-plane facade. However, depending on direction of lateral loading, when the large sized opening is at in-plane position, collapse of the two side walls may be observed (Figure 94).



Total body failure; Large sized opening at out-of-plane position

In-plane failure; Large sized opening at in-plane position

Figure 94. Possible failures of tower

- **Present failures**

Diagonal stepped cracking is observed above and below the openings at the southwestern, southeastern and northeastern facades. The failure presents similarities with simulation results for the southeastern facade at out-of-plane position.

The diagonal cracks are seen at the lower part of the southeastern and southwestern facade. The failure presents similarities with simulation results for the southeastern facade at in-plane position (Figure 95).

Figure 95. Existing failures of Alinda Tower; northern (left) and southern (right) facades

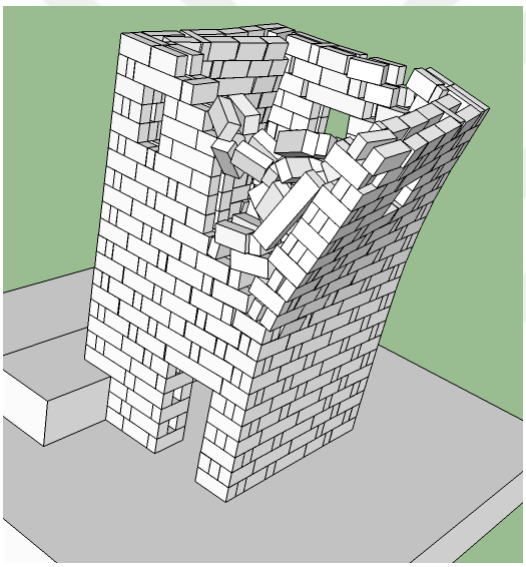
4.3.1.1.2. Vulnerability of Latmos Tower

Latmos tower has high vulnerability due to the weakness of wall profile and opening organization. Although walls are composed of leaves connected with headers, small staggering ratio (0.8) and medium ratio between stone lengths and height (2.4) increase vulnerability. Asymmetrical opening adjacent to corner also increase

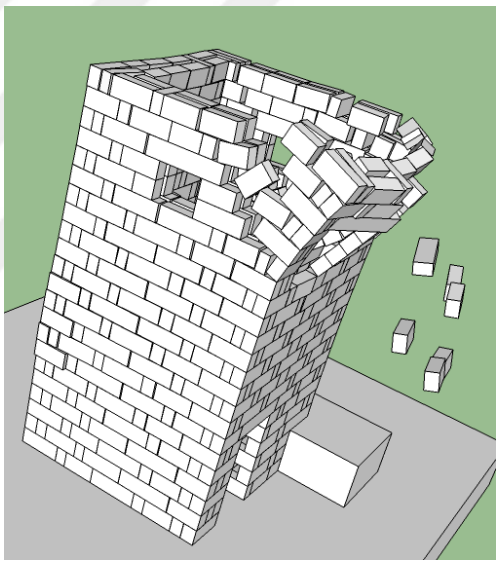
vulnerability. H/l ratio (1.7) is ideal for vulnerability (Figure 97). Control of the weakness stemming from the original wall profile should be achieved with appropriate measures of intervention.

- **Possible Failures**

When the opening adjacent to corner is at in-plane position, in-plane failure may be observed due to the small staggering and block ratio, while when openings at out-of-plane position, detachment of the out-of-plane wall can occur. In spite of usage of header stones, body behavior is not seen due to the weakness of arrangement and dimension of blocks (Figure 96).



Opening adjacent to corner at in-plane position;
In-plane failure



Opening adjacent to corner at out-of-plane position;
Out-of-plane failure with top blocks of the side walls

Figure 96. Possible failures of the tower

- **Present Failures**

Today, the tower conserves its integrity, however, there are diagonal cracks at upper parts of walls at the northern facade. These failures may present similarities with simulation results for lateral loading from the direction of the bedrock (eastern facade) (Figure 97).

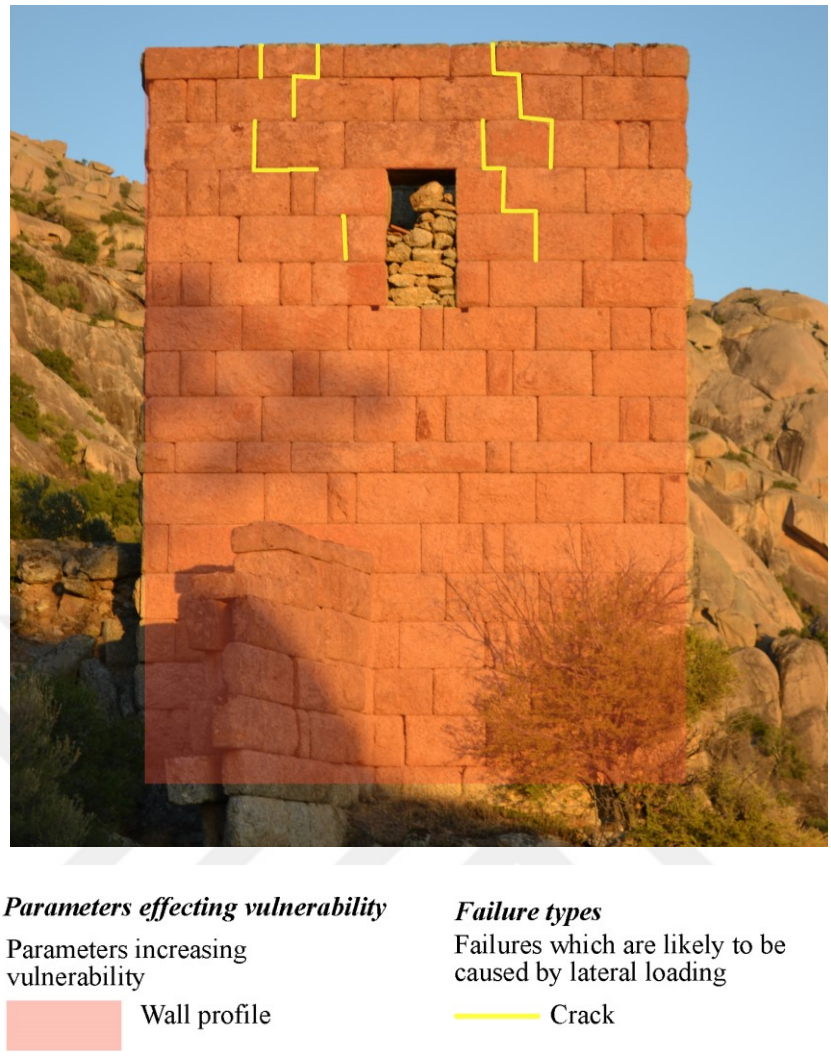


Figure 97. Existing failures of Latmos Tower; northern facade

4.3.1.2. Towers in Cilicia

Gömeç and Sarayın Towers in Cilicia Region are approximately 2 km away from each other. This region is under low earthquake threat due to low ground acceleration (AFAD 2018). In 100 km proximity of the surrounding area, 17 earthquakes have been recorded from 1900 until now: between 4 and 5 in magnitude, there are 12 earthquakes recorded. Between 5 and 6, there are 5 earthquakes. In ancient periods, recorded earthquakes are between 6 and 7, approximately 350 km away from the area. There is one recorded earthquake higher than 7 in Cilicia Region in 1268 (BDTİM 2017).

4.3.1.2.1. Vulnerability of Gömeç Tower

Gömeç Tower has considerably high vulnerability due to its wall profile characteristics and h/l ratio, although it has symmetrical small sized openings. It has small staggering ratio (0.4), small ratio between stone length and height (1.5) and narrow stone depth (60 cm), and also h/l ratio is 2.3 (Figure 99). Control of the weakness stemming from the original wall profile and high h/l ratio should be achieved with appropriate measures of intervention.

- **Possible failures**

Since the openings are ineffective, the behavior is directly related to the wall profile characteristics. Since the corner connections are weak due to their small staggering ratio and short blocks, the tower may present basically hybrid behavior; collapse of side in-plane walls followed by overturning of the out-of-plane wall with vertical cracks at the corners regardless of lateral load direction (Figure 98).

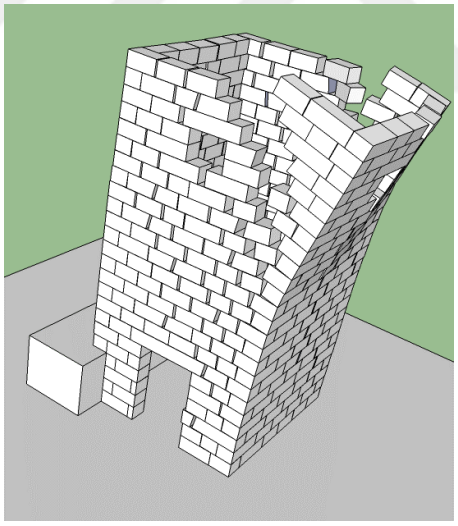


Figure 98. Probable failure mechanisms under lateral loading from the direction of southern facade

- **Present failures**

The joints of upper parts and upper openings of tower are filled with mortar and stone blocks. This may be a latter intervention after a possible failure. Therefore, any sign of structural failure cannot be traced at present (Figure 98).

Figure 99. Present situation of Gömeç Tower; northern facade

4.3.1.2.2. Vulnerability of Sarayın Tower

Sarayın Tower has medium vulnerability. It has small staggering ratio (0.6-0.8), medium ratio between stone length and height (2) and short stone depth (60 cm). Symmetrical small sized openings and h/l ratio (2) do not affect vulnerability (Figure 101). Control of the weakness stemming from the original wall profile should be achieved with appropriate measures of intervention.

- **Possible Failures**

Since the corner connections are weak due to their small staggering ratio and medium block ratio, the tower may present in-plane and out-of-plane behavior together, in-plane diagonal cracking followed by overturning of the facade due to the vertical cracks at the corners (Figure 100).

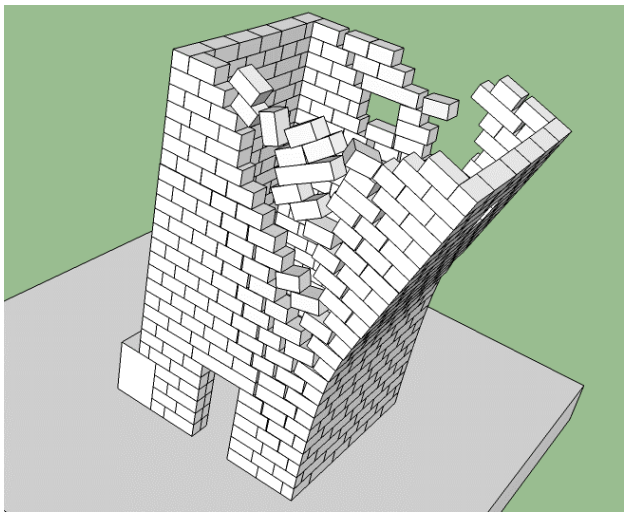


Figure 100. Probable failure mechanisms under lateral loading from the direction of eastern facade (right)

- **Present Failures**

Present situation of the tower does not give information on its structural problems, joints of upper parts and upper openings of tower are filled with mortar and stone blocks (Figure 101). Upper parts are thought to be constructed later, since the dimension of blocks are smaller at the upper parts. This may be a latter intervention after a possible failure.

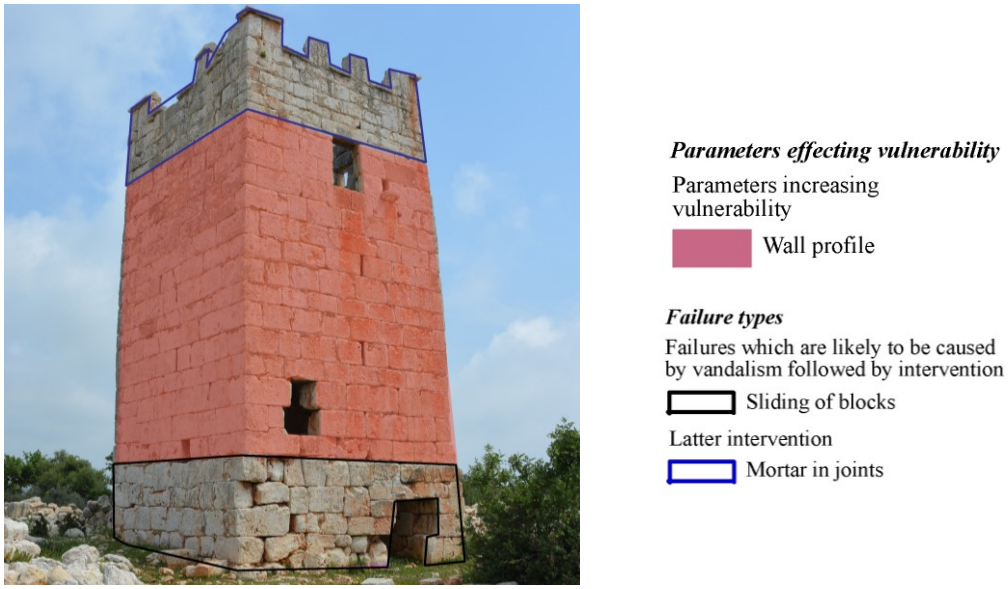


Figure 101. Present situation of Sarayın Tower

4.3.1.3. Towers in Pamphylia

Perge and Sillyon Towers in Pamphylia Region are approximately 18 km away from each other. This region is under high earthquake threat due to high ground acceleration (AFAD 2018). In 100 km proximity of the surrounding area, 125 earthquakes are recorded from 1900 until today. In the surroundings of Latmos, between 4 and 5 in magnitude, there are 105 earthquakes. Between 5 and 6, there are 19 earthquakes and between 6 and 7, there is one earthquake (BDTİM 2017).

4.3.1.3.1. Vulnerability of Perge Tower

Perge Tower has high vulnerability due to both its wall profile and opening characteristics. At lower level, staggering ratio decreases to 0.3, while it changes between 0.6 and 1 at the upper level. Ratio between stone length and height is medium (2), however, depth of stones is 60 cm. As well as weaknesses of wall profile, the tower is composed of upper medium sized (90x160 cm) symmetrical three openings at each facade. H/L ratio does not affect vulnerability (h/l: 2) (Figure 103). Control of the weakness stemming from the original wall profile and opening characteristics should be achieved with appropriate measures of intervention.

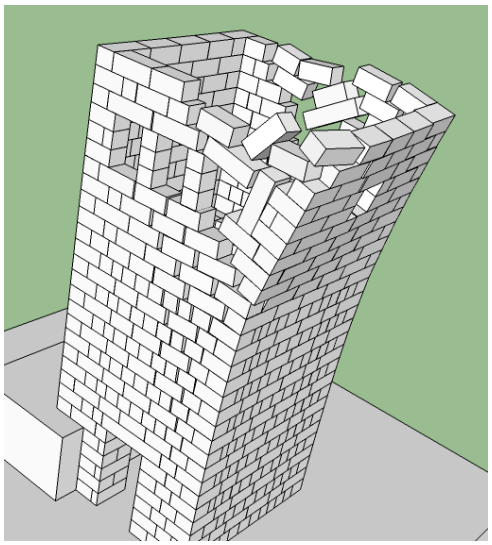


Figure 102. Probable failure mechanisms under lateral loading from the direction of eastern facade

- **Possible failures**

Since three openings are located at each facade, it not necessary to discuss the in-plane or out-of-plane position of openings separately. Possible failure in case of lateral loading may be hybrid failure mechanism; and collapse of two side walls due to the in-plane cracking followed by overturning of the facade wall due to the vertical cracks at the corners caused by small staggering ratio (Figure 102).

- **Present failures**

Today, western facade wall of the tower is not present, and the related side walls were demolished partially as well. This demolishment might be caused by hybrid failure mechanism similar with the simulation results. The lateral loading might be perpendicular to western facade (Figure 103).

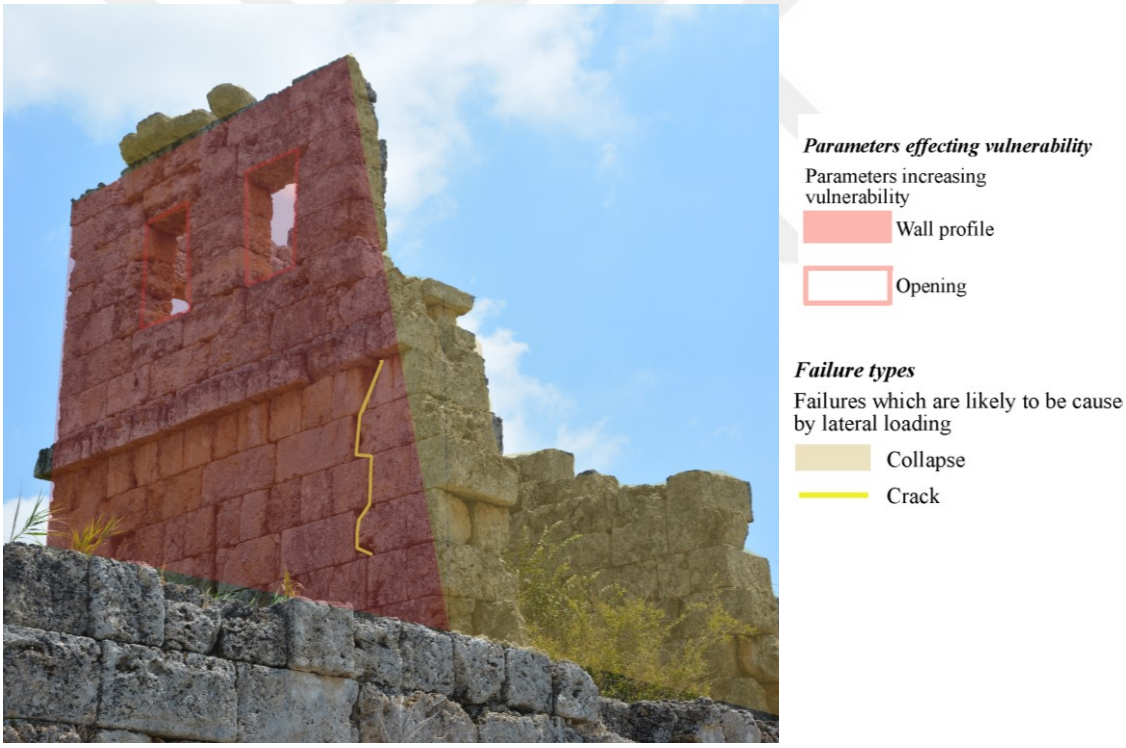


Figure 103. Present situation of Perge Tower

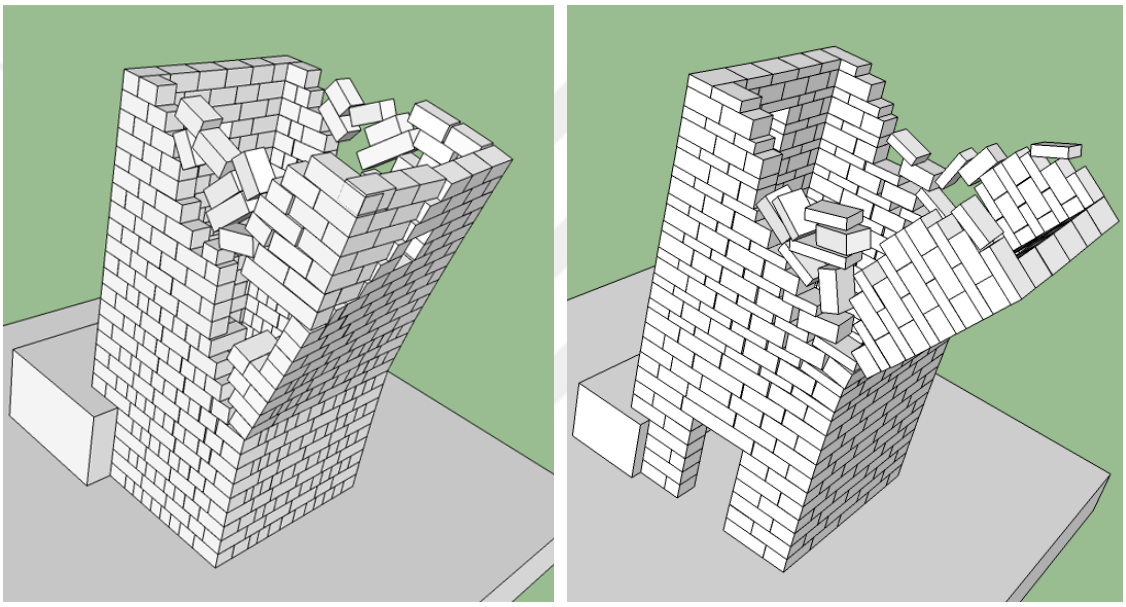
4.3.1.3.2. Vulnerability of Sillyon Tower

Sillyon tower has considerably low vulnerability with the help of the characteristics of wall profile and ideal h/l ratio (h/l between 1.6 and 1.8). It has high

staggering ratio (average 1.7) and high block length and height ratio (3) with the help of the blocks in 25 cm in height, in each row at the upper parts. One leafed wall has also longer stone depth (75 cm). The opening adjacent to corner (105x300 cm) at western facade increases vulnerability (Figure 105). Control of the weakness stemming from the original corner opening should be achieved with appropriate measures of intervention.

- **Probable failures**

The tower presents probable in-plane behavior regardless of the opening type and position of the opening type with the help of the high staggering ratio (Figure 104).



Adjacent opening at in-plane position (lateral lading from the southern facade)

Adjacent opening at out-of-plane position (lateral lading from the eastern facade)

Figure 104. Probable failure mechanisms under lateral loading from the direction of eastern facade

- **Present failures**

Today, at upper parts, diagonal cracks are observed, but the main problem of the tower is vertical cracks due to settlement. Therefore, since the reasons of probable and present failures are different, they do not correlate (Figure 105). Nevertheless, it may be stated that the tower has not faced with a severe lateral loading yet.

Figure 105. Present situation of Sillyon Tower; northern and westerns facades

Consequently, according to risk assessment of case study towers, it is seen that the towers located at low earthquake threat could have been constructed by taking into consideration precautions against earthquake. However, towers are at high earthquake threat could have been reinforced with high staggering ratio, long stone depth, long stone blocks or header usage regardless of the fact that some of these characteristics have little effect on structural improvement. Precautions preferred in the construction of ancient towers prove that there could be awareness of earthquake risk status of their sites.

CHAPTER 5

CONCLUSION

This study proves that there was consciousness of precautions necessary for structural resistance of dry masonry under earthquake risk in ancient periods. However, this knowledge was not always benefitted from, as a consequence of probable local limitations in relation with budget, time, building material or masters. The study clarifies the parameters that are effective on structural resistance of ancient dry masonry towers under lateral loading. The authentic qualities of these parameters should be sustained in conservation work.

The parameters effecting structural resistance are listed in the order of high impact to low as staggering ratio, stone depth, ratio between block length and height, proportional relationship between height and length, opening area, number and position and even distribution of header stones. These results show that primary parameters effecting structural resistance are about organization of blocks, while parameters of building morphology such as height-length relations and opening areas are secondary parameters. It was revealed that parameters should always be considered in relation with each other.

- In order to minimize the damage of the structure, regular organization of stone blocks ($s/h \geq 1.7$) should be supported with appropriate block ratio ($bl/h \geq 3$). If only the stones are organized properly, but the ratio between stone length and height is small, the resistance of the tower decreases.
- The advantage of usage of header stones has been observed when they are at appropriate position and used together with other blocks of appropriate dimensions ($bl/h \geq 3$) and organizations ($s/h \geq 1.7$)
- Header stones used only in the lower parts of the towers cannot provide contribution to the resistance of the structure.
- Header stones adjacent to each other in two rows reduce the strength of the towers considerably because they cause decrease in staggering ratio.
- The openings affect the structural resistance and behavior in accordance with their sub-qualities such as area, number, and position. It is seen that increasing their number and area, positioning them considering an uneven distribution within the

facade composition, and decreasing their distance to the corners reduce the resistance. However, the double-leafed and one-leafed wall profiles that have high staggering ratios (≥1.7) are not affected by one or two openings up to 3 m^2.

- Upper openings affect structural resistance highly in comparison to lower openings. Even if the lower openings are adjacent to a corner, they are not a primary factor determining structural resistance and behavior.
- Small sized openings (100x100 cm) less than 3 in number do not affect resistance of towers at in-plane and out-of-plane positions. However, they change the behavior of towers at out-of-plane position.
- Single leafed wall profiles that have both high staggering ratios and high stone depths are not affected by openings close to corner at out-of-plane position: they present in-plane failures.
- In certain cases, the priority of impact of the parameters can change: opening organization and proportional relationship can become the dominant parameters in specific combinations. Large sized openings (5 m^2) become always dominant in any height to length ratio. Small height to length ratio (1.3) becomes dominant from small or medium sized two openings.

A standardization in ancient construction techniques is determined for proportional relationship between wall height and length, and material usage regarding dry masonry towers. Although wall thicknesses are different, ratio between height and length (1.6-2) are preferred between certain values. These values provide maximum structural vulnerability for towers. For material usage, it has been observed that the rocks used in the construction of the towers; namely, granite and limestone; have similar density (between 2560-2750 kg/m^3) and coefficient of friction values (between 6-7.2), and they are inversely proportional with each other for each material. Small changes in values are not effective in structural behavior and durability of towers.

Consequently, with interpretation of results, a framework composed of vulnerability rankings and possible failure mechanisms was proposed for assessment of the dry masonry towers. This framework allows to put forward an idea for basic behavior of the towers. In turn, vulnerability is evaluated, possible failures are foreseen, and preventive measures may be developed. If this framework is combined with data about frequency and intensity of previous earthquakes, risk assessment can be done.

Application of the framework on case study towers demonstrated that towers under high earthquake threat were designed with strong parameters as high staggering ratio, long stone depth or high block ratio, while there is no precaution against lateral loading in the towers under minimum earthquake risk.

For future work; preventative measures that can be implemented to improve the earthquake resistance of dry masonry towers based on vulnerability framework results can be determined. A framework including intervention decisions for each level of vulnerability and possible failure mechanisms can be proposed. Internalization of structural behavior of dry masonry towers makes possible to propose restitution schemes by observing structural characteristics and failures.

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APPENDIX A

STONE CHARACTERIZATION

Experimental studies are carried out with the six stone samples collected from the towers. During sampling, stones were collected by hand from the exterior sides of towers without harming their authenticity.

For the characterization of stone used in towers, mineralogical and chemical compositions are determined. For determination of mineralogical compositions of the stones, stone samples taken from the case study towers were investigated with X-ray Diffraction (XRD) analysis performed by using a Philips X-Pert Pro X-ray Diffractometer. Chemical compositions of the samples were determined by Philips XL 30S-FEG Scanning Electron Microscope (SEM) equipped with X-Ray Energy Dispersive System (EDS).

- Chemical Compositions of Stones

  Major chemical compositions of stones were determined by SEM-EDS analysis.

Table A.1. Chemical composition of stone blocks of towers

Sample from	**CaO %**	**SiO_2 %**	**Al_2O_3 %**	**MgO %**	**Na_2O %**	**K_2O %**	**FeO %**
Gömeç Tower	97.96	1.29	0.75	-	-	-	-
Sarayın Tower	96.89	2.24	0.87	-	-	-	-
Perge Tower	97.56	1.35	0.57	0.52	-	-	-
Sillyon Tower	96.65	1.78	0.62	0.95	-	-	-
Alinda Tower	4.38	63.38	16.77	2.34	3.41	3.91	5.04
Latmos Tower	1.21	62.95	22.03	-	4.65	7.90	1.27

SEM/EDS analyses of the stone samples from Gömeç, Sarayın, Sillyon and Perge Towers show that stones were composed primarily of calcium oxide (CaO). The minor elements were silica (SiO_2) and aluminum oxide (Al_2O_3). The samples contain 97 % calcium oxide (CaO). Limestone contains higher than 56 % calcium oxide. Major chemical compositions of stones were similar to the compositions of limestone (Weeks 194, 27; Nath and, Dutta 2010, 121) (Table A-1).

SEM/EDS analyses of the stone samples from Alinda and Gömeç Towers show that stones were composed primarily of silica (SiO_2) and aluminum oxide (Al_2O_3). The minor elements were aluminum oxide (Al_2O_3), magnesium oxide (MgO), sodium oxide (Na_2O), potassium oxide (K_2O) and iron oxide (FeO). The samples contain 63 % silica (SiO_2) and 16-20 % aluminum oxide (Al_2O_3). Major chemical compositions of stones were similar to the compositions of granite (Weeks 194, 19) (Table A-1).

- Mineralogical Compositions of Stones

Mineralogical characteristics of stones of towers were determined by XRD analysis.

XRD analyzes of stone samples from Perge, Sillyon, Gömeç and Sarayın Towers show that the stones are dominated by the minerals of calcite. Limestone is composed of mainly calcite (Karayazılı 2013, 71-72) similar to stones from Perge, Sillyon, Gömeç and Sarayın Towers (Figure A-1).

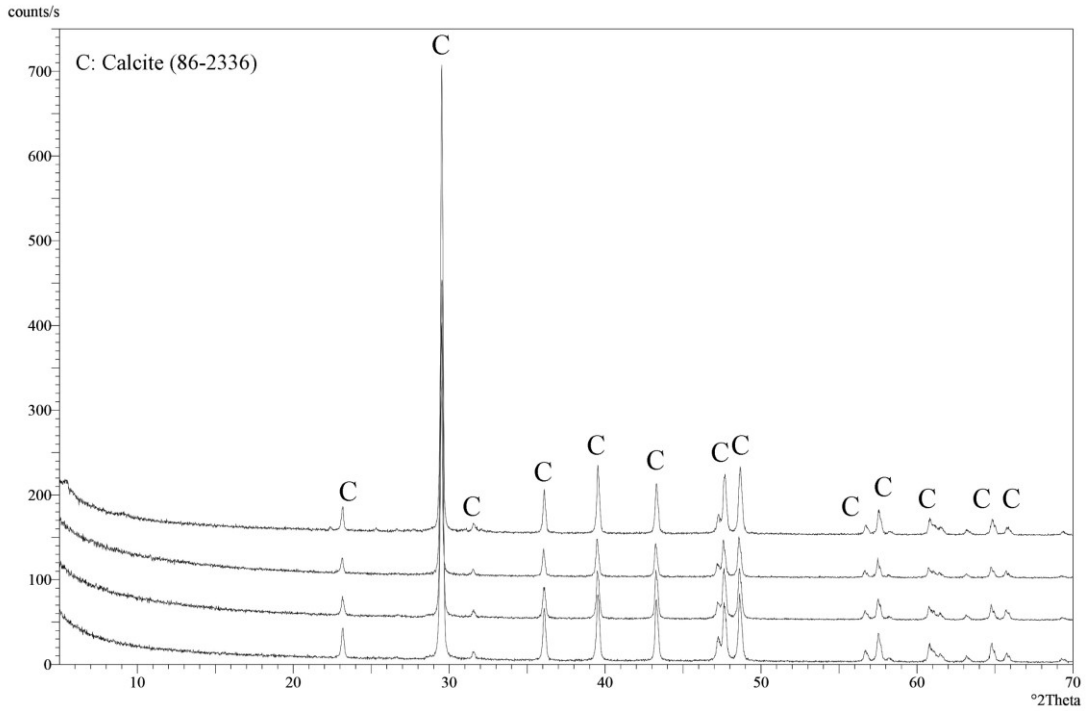

Figure A.1. XRD pattern of stones from Sillyon, Perge, Sarayın and Gömeç Towers (from bottom to the top)

XRD analyzes of stone samples from Alinda and Latmos Towers show that the stones are dominated by the minerals of muscovite, quarts, albite and orthoclase. Granite is composed of mainly quartz, muscovite, and albite (Park et al. 2014, 246) similar to stones from Alinda and Latmos Towers, (Figure A-2).

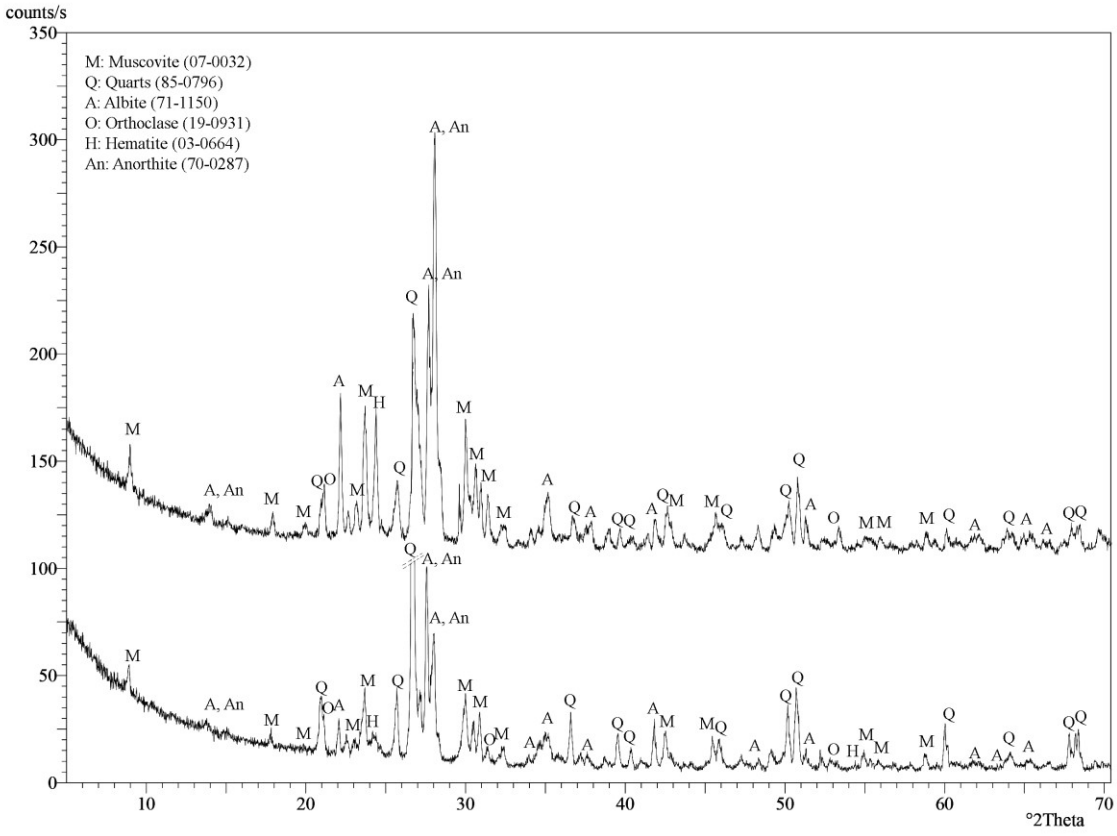

Figure A.2. XRD pattern of stones from Alinda (below) and Latmos (above) Towers

APPENDIX B

STATISTICAL EVALUATION

Linearity of variables: Linear relationship between dependent variable and independent variables are determined before regression (Figure B-1).

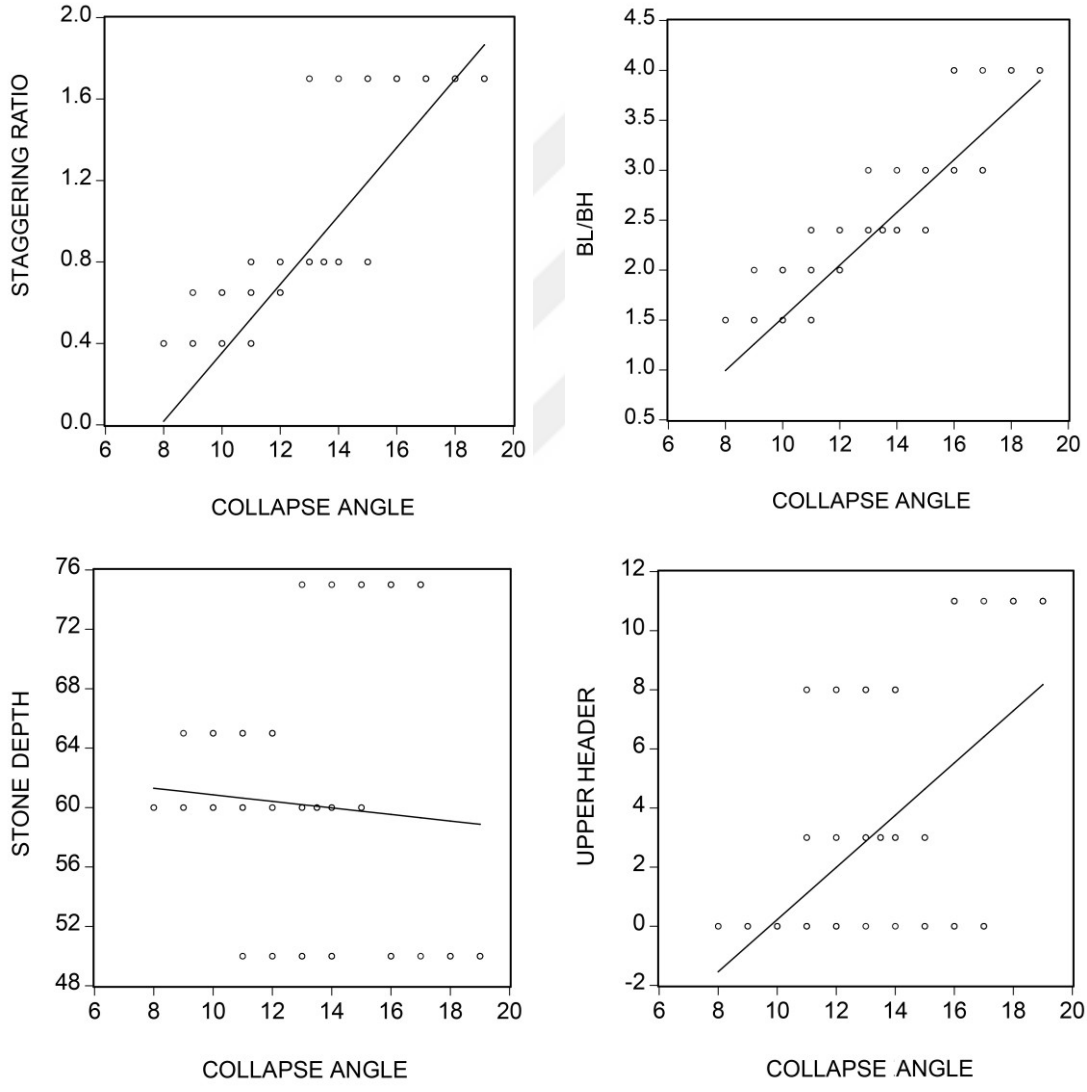

Figure B.1. Relationship of dependent and independent variables (staggering ratio and stone depth, stone ratio (bl/bh) and upper header)

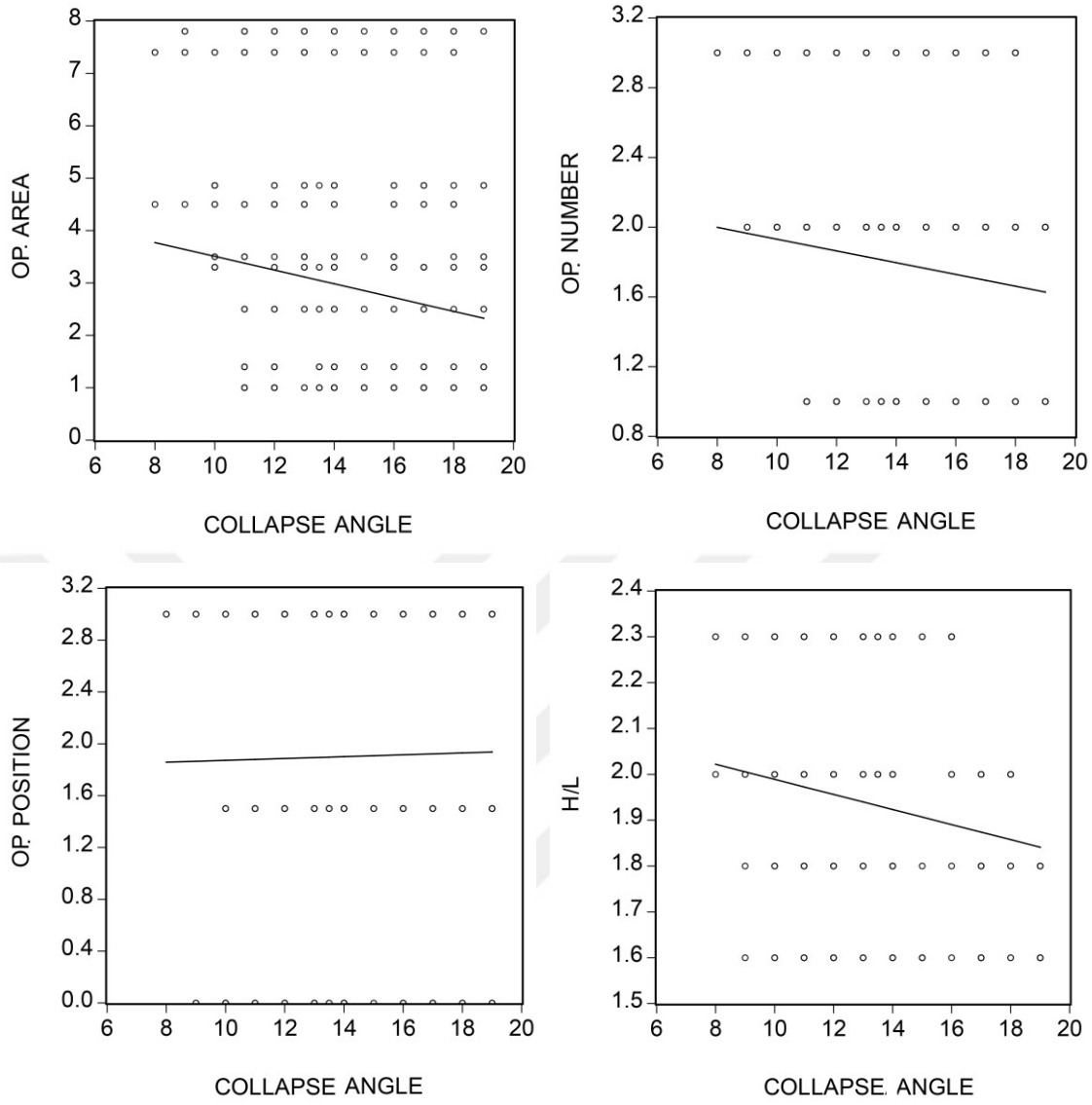

Figure B.2. Relationship of dependent and independent variables (op. area, op. position, op. number and h/l ratio)

The residual plots: After regression analysis, before examining the statistical measures for goodness-of-fit, the residual plots are checked. When looking at residual (Residual = Observed value - Fitted value) plots, if the points fall randomly around the line, then the model is not biased and correct on average. In the graph below, they are randomly scattered around zero for the entire range of fitted values (Figure B-2) (Minitab Blog 2012).

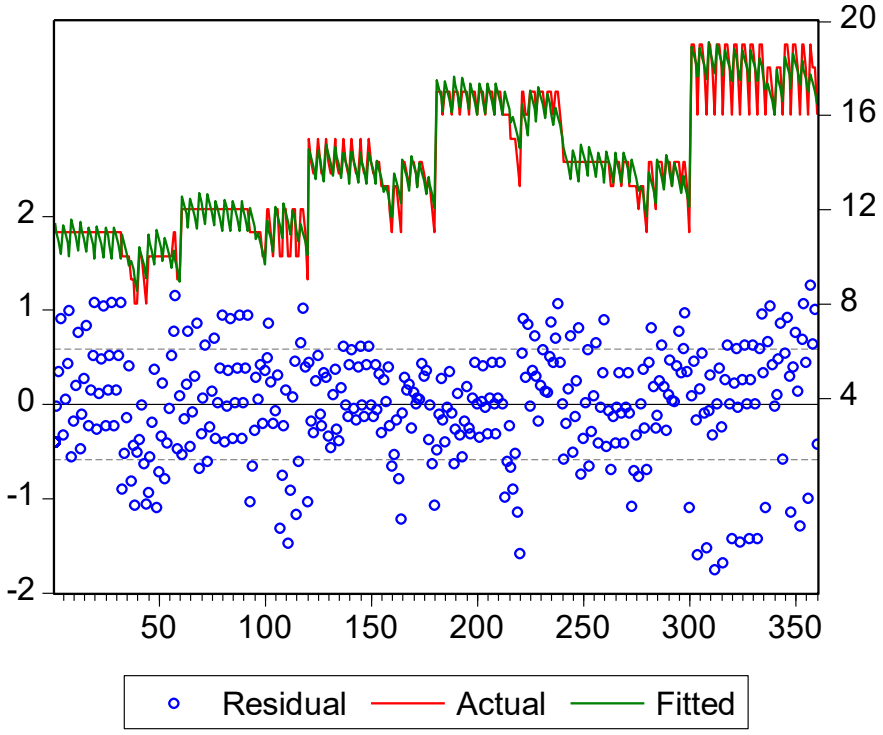

Figure B.3. Residuals

APPENDIX C

CALCULATION OF IMPACT VALUES OF PARAMETERS

In order to compare the parameters with each other, an impact analysis is performed using the standard deviation value and coefficients of each parameter with the formula in the below (Table C-1):

Impact value = Coefficient of independent v. x Standard Deviation (Independent v.)
/Standard Deviation (Dependent v.)

Standard deviation of dependent variable (collapse angle) =2.76

Table C.1. Calculation of impact values of coefficients

Independent variables	**coefficients**	**SD (indep.)**	**SD (dep.)**	**Impact value**	**x10**
Staggering ratio	2.3	0.531265	2.76	0.442064498	4.4
Stone depth	0.1	8.672307	2.76	0.313748298	3.1
bl/bh	0.8	0.825027	2.76	0.238783691	2.4
Upper header	0.4	0.043522	2.76	0.006298164	0.1
Op. number	-0.17	0.654106	2.76	-0.040229444	-0.4
Op. position	-0.1	1.159195	2.76	-0.041937559	-0.4
Op. area	-0.19	2.222842	2.76	-0.15279489	-1.5
h/l	-1.9	0.258962	2.76	-0.178006657	-1.8

APPENDIX D

DATA SET FOR REGRESSION

Table D.1. Data set for regression

w. p. type	op. type	collapse angle	h/l	staggering ratio	bl/bh	stone depth	upper header	op. number	op. position	op. area
wallp1	op. 1-4	11	1.6	0.4	1.5	60	0	1	3	1
		11	1.8	0.4	1.5	60	0	1	3	1
		11	2	0.4	1.5	60	0	1	3	1
		11	2.3	0.4	1.5	60	0	1	3	1
	op. 2	11	1.6	0.4	1.5	60	0	1	3	1.4
		11	1.8	0.4	1.5	60	0	1	3	1.4
		11	2	0.4	1.5	60	0	1	3	1.4
		11	2.3	0.4	1.5	60	0	1	3	1.4
	op. 3	11	1.6	0.4	1.5	60	0	1	1.5	1
		11	1.8	0.4	1.5	60	0	1	1.5	1
		11	2	0.4	1.5	60	0	1	1.5	1
		11	2.3	0.4	1.5	60	0	1	1.5	1
	op. 4	11	1.6	0.4	1.5	60	0	1	1.5	1.4
		11	1.8	0.4	1.5	60	0	1	1.5	1.4
		11	2	0.4	1.5	60	0	1	1.5	1.4
		11	2.3	0.4	1.5	60	0	1	1.5	1.4
	op. 5	11	1.6	0.4	1.5	60	0	2	3	1
		11	1.8	0.4	1.5	60	0	2	3	1
		11	2	0.4	1.5	60	0	2	3	1
		11	2.3	0.4	1.5	60	0	2	3	1
	op. 6	11	1.6	0.4	1.5	60	0	1	1.5	2.5
		11	1.8	0.4	1.5	60	0	1	1.5	2.5
		11	2	0.4	1.5	60	0	1	1.5	2.5
		11	2.3	0.4	1.5	60	0	1	1.5	2.5
	op. 7-8	11	1.6	0.4	1.5	60	0	2	3	1
		11	1.8	0.4	1.5	60	0	2	3	1
		11	2	0.4	1.5	60	0	2	3	1
		11	2.3	0.4	1.5	60	0	2	3	1
	op. 8	11	1.6	0.4	1.5	60	0	2	3	1
		11	1.8	0.4	1.5	60	0	2	3	1
		11	2	0.4	1.5	60	0	2	3	1
		11	2.3	0.4	1.5	60	0	2	3	1
	op. 9	10	1.6	0.4	1.5	60	0	2	1.5	3.5
		10	1.8	0.4	1.5	60	0	2	1.5	3.5
		10	2	0.4	1.5	60	0	2	1.5	3.5

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Table D.1. (cont.)

		10	2.3	0.4	1.5	60	0	2	1.5	3.5
	op. 10	9	1.6	0.4	1.5	60	0	3	3	7.4
		9	1.8	0.4	1.5	60	0	3	3	7.4
		8	2	0.4	1.5	60	0	3	3	7.4
		8	2.3	0.4	1.5	60	0	3	3	7.4
	op. 11	10	1.6	0.4	1.5	60	0	3	3	4.5
		10	1.8	0.4	1.5	60	0	3	3	4.5
		9	2	0.4	1.5	60	0	3	3	4.5
		8	2.3	0.4	1.5	60	0	3	3	4.5
	op. 12	10	1.6	0.4	1.5	60	0	2	1.5	3.3
		10	1.8	0.4	1.5	60	0	2	1.5	3.3
		10	2	0.4	1.5	60	0	2	1.5	3.3
		10	2.3	0.4	1.5	60	0	2	1.5	3.3
	op. 13	10	1.6	0.4	1.5	60	0	2	0	3.3
		10	1.8	0.4	1.5	60	0	2	0	3.3
		10	2	0.4	1.5	60	0	2	0	3.3
		10	2.3	0.4	1.5	60	0	2	0	3.3
	op. 14	10	1.6	0.4	1.5	60	0	2	0	4.86
		10	1.8	0.4	1.5	60	0	2	0	4.86
		10	2	0.4	1.5	60	0	2	0	4.86
		10	2.3	0.4	1.5	60	0	2	0	4.86
	op. 15	11	1.6	0.4	1.5	60	0	2	0	7.8
		11	1.8	0.4	1.5	60	0	2	0	7.8
		9	2	0.4	1.5	60	0	2	0	7.8
		9	2.3	0.4	1.5	60	0	2	0	7.8
wallp2	op. 1-4	12	1.6	0.65	2	65	0	1	3	1
		12	1.8	0.65	2	65	0	1	3	1
		12	2	0.65	2	65	0	1	3	1
		12	2.3	0.65	2	65	0	1	3	1
	op. 2	12	1.6	0.65	2	65	0	1	3	1.4
		12	1.8	0.65	2	65	0	1	3	1.4
		12	2	0.65	2	65	0	1	3	1.4
		12	2.3	0.65	2	65	0	1	3	1.4
	op. 3	12	1.6	0.65	2	65	0	1	1.5	1
		12	1.8	0.65	2	65	0	1	1.5	1
		12	2	0.65	2	65	0	1	1.5	1
		12	2.3	0.65	2	65	0	1	1.5	1
	op. 4	12	1.6	0.65	2	65	0	1	1.5	1.4
		12	1.8	0.65	2	65	0	1	1.5	1.4
		12	2	0.65	2	65	0	1	1.5	1.4
		12	2.3	0.65	2	65	0	1	1.5	1.4
	op. 5	12	1.6	0.65	2	65	0	2	3	1
		12	1.8	0.65	2	65	0	2	3	1

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Table D.1. (cont.)

		12	2	0.65	2	65	0	2	3	1
		12	2.3	0.65	2	65	0	2	3	1
	op. 6	12	1.6	0.65	2	65	0	1	1.5	2.5
		12	1.8	0.65	2	65	0	1	1.5	2.5
		12	2	0.65	2	65	0	1	1.5	2.5
		12	2.3	0.65	2	65	0	1	1.5	2.5
	op. 7-8	12	1.6	0.65	2	65	0	2	3	1
		12	1.8	0.65	2	65	0	2	3	1
		12	2	0.65	2	65	0	2	3	1
		12	2.3	0.65	2	65	0	2	3	1
	op. 8	12	1.6	0.65	2	65	0	2	3	1
		12	1.8	0.65	2	65	0	2	3	1
		12	2	0.65	2	65	0	2	3	1
		12	2.3	0.65	2	65	0	2	3	1
	op. 9	11	1.6	0.65	2	65	0	2	1.5	3.5
		11	1.8	0.65	2	65	0	2	1.5	3.5
		11	2	0.65	2	65	0	2	1.5	3.5
		11	2.3	0.65	2	65	0	2	1.5	3.5
	op. 10	11	1.6	0.65	2	65	0	3	3	7.4
		11	1.8	0.65	2	65	0	3	3	7.4
		10	2	0.65	2	65	0	3	3	7.4
		10	2.3	0.65	2	65	0	3	3	7.4
	op. 11	12	1.6	0.65	2	65	0	3	3	4.5
		12	1.8	0.65	2	65	0	3	3	4.5
		11	2	0.65	2	65	0	3	3	4.5
		10	2.3	0.65	2	65	0	3	3	4.5
	op. 12	12	1.6	0.65	2	65	0	2	1.5	3.3
		12	1.8	0.65	2	65	0	2	1.5	3.3
		10	2	0.65	2	65	0	2	1.5	3.3
		10	2.3	0.65	2	65	0	2	1.5	3.3
	op. 13	12	1.6	0.65	2	65	0	2	0	3.3
		12	1.8	0.65	2	65	0	2	0	3.3
		10	2	0.65	2	65	0	2	0	3.3
		10	2.3	0.65	2	65	0	2	0	3.3
	op. 14	12	1.6	0.65	2	65	0	2	0	4.86
		12	1.8	0.65	2	65	0	2	0	4.86
		10	2	0.65	2	65	0	2	0	4.86
		10	2.3	0.65	2	65	0	2	0	4.86
	op. 15	12	1.6	0.65	2	65	0	2	0	7.8
		12	1.8	0.65	2	65	0	2	0	7.8
		11	2	0.65	2	65	0	2	0	7.8
		9	2.3	0.65	2	65	0	2	0	7.8
wallp3	op. 1-4	15	1.6	0.8	2.4	60	3%	1	3	1

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Table D.1. (cont.)

		14	1.8	0.8	2.4	60	3%	1	3	1
		13.5	2	0.8	2.4	60	3%	1	3	1
		13.5	2.3	0.8	2.4	60	3%	1	3	1
	op. 2	15	1.6	0.8	2.4	60	3%	1	3	1.4
		14	1.8	0.8	2.4	60	3%	1	3	1.4
		13.5	2	0.8	2.4	60	3%	1	3	1.4
		13.5	2.3	0.8	2.4	60	3%	1	3	1.4
	op. 3	15	1.6	0.8	2.4	60	3%	1	1.5	1
		14	1.8	0.8	2.4	60	3%	1	1.5	1
		13.5	2	0.8	2.4	60	3%	1	1.5	1
		13.5	2.3	0.8	2.4	60	3%	1	1.5	1
	op. 4	15	1.6	0.8	2.4	60	3%	1	1.5	1.4
		14	1.8	0.8	2.4	60	3%	1	1.5	1.4
		13.5	2	0.8	2.4	60	3%	1	1.5	1.4
		13.5	2.3	0.8	2.4	60	3%	1	1.5	1.4
	op. 5	15	1.6	0.8	2.4	60	3%	2	3	1
		14	1.8	0.8	2.4	60	3%	2	3	1
		13.5	2	0.8	2.4	60	3%	2	3	1
		13.5	2.3	0.8	2.4	60	3%	2	3	1
	op. 6	15	1.6	0.8	2.4	60	3%	1	1.5	2.5
		14	1.8	0.8	2.4	60	3%	1	1.5	2.5
		13.5	2	0.8	2.4	60	3%	1	1.5	2.5
		13.5	2.3	0.8	2.4	60	3%	1	1.5	2.5
	op. 7-8	15	1.6	0.8	2.4	60	3%	2	3	1
		14	1.8	0.8	2.4	60	3%	2	3	1
		13.5	2	0.8	2.4	60	3%	2	3	1
		13.5	2.3	0.8	2.4	60	3%	2	3	1
	op. 8	15	1.6	0.8	2.4	60	3%	2	3	1
		14	1.8	0.8	2.4	60	3%	2	3	1
		13.5	2	0.8	2.4	60	3%	2	3	1
		13.5	2.3	0.8	2.4	60	3%	2	3	1
	op. 9	14	1.6	0.8	2.4	60	3%	2	1.5	3.5
		14	1.8	0.8	2.4	60	3%	2	1.5	3.5
		13	2	0.8	2.4	60	3%	2	1.5	3.5
		13	2.3	0.8	2.4	60	3%	2	1.5	3.5
	op. 10	13	1.6	0.8	2.4	60	3%	3	3	7.4
		13	1.8	0.8	2.4	60	3%	3	3	7.4
		12	2	0.8	2.4	60	3%	3	3	7.4
		11	2.3	0.8	2.4	60	3%	3	3	7.4
	op. 11	13	1.6	0.8	2.4	60	3%	3	3	4.5
		13	1.8	0.8	2.4	60	3%	3	3	4.5
		12	2	0.8	2.4	60	3%	3	3	4.5
		11	2.3	0.8	2.4	60	3%	3	3	4.5

(cont. on next page)

Table D.1. (cont.)

	op. 12	14	1.6	0.8	2.4	60	3%	2	1.5	3.3
		14	1.8	0.8	2.4	60	3%	2	1.5	3.3
		13.5	2	0.8	2.4	60	3%	2	1.5	3.3
		13	2.3	0.8	2.4	60	3%	2	1.5	3.3
	op. 13	14	1.6	0.8	2.4	60	3%	2	0	3.3
		14	1.8	0.8	2.4	60	3%	2	0	3.3
		13.5	2	0.8	2.4	60	3%	2	0	3.3
		13	2.3	0.8	2.4	60	3%	2	0	3.3
	op. 14	14	1.6	0.8	2.4	60	3%	2	0	4.86
		14	1.8	0.8	2.4	60	3%	2	0	4.86
		13.5	2	0.8	2.4	60	3%	2	0	4.86
		13	2.3	0.8	2.4	60	3%	2	0	4.86
	op. 15	13	1.6	0.8	2.4	60	3%	2	0	7.8
		13	1.8	0.8	2.4	60	3%	2	0	7.8
		12	2	0.8	2.4	60	3%	2	0	7.8
		11	2.3	0.8	2.4	60	3%	2	0	7.8
wallp4	op. 1-4	17	1.6	1.7	3	75	0	1	3	1
		17	1.8	1.7	3	75	0	1	3	1
		17	2	1.7	3	75	0	1	3	1
		16	2.3	1.7	3	75	0	1	3	1
	op. 2	17	1.6	1.7	3	75	0	1	3	1.4
		17	1.8	1.7	3	75	0	1	3	1.4
		17	2	1.7	3	75	0	1	3	1.4
		16	2.3	1.7	3	75	0	1	3	1.4
	op. 3	17	1.6	1.7	3	75	0	1	1.5	1
		17	1.8	1.7	3	75	0	1	1.5	1
		17	2	1.7	3	75	0	1	1.5	1
		16	2.3	1.7	3	75	0	1	1.5	1
	op. 4	17	1.6	1.7	3	75	0	1	1.5	1.4
		17	1.8	1.7	3	75	0	1	1.5	1.4
		17	2	1.7	3	75	0	1	1.5	1.4
		16	2.3	1.7	3	75	0	1	1.5	1.4
	op. 5	17	1.6	1.7	3	75	0	2	3	1
		17	1.8	1.7	3	75	0	2	3	1
		17	2	1.7	3	75	0	2	3	1
		16	2.3	1.7	3	75	0	2	3	1
	op. 6	17	1.6	1.7	3	75	0	1	1.5	2.5
		17	1.8	1.7	3	75	0	1	1.5	2.5
		17	2	1.7	3	75	0	1	1.5	2.5
		16	2.3	1.7	3	75	0	1	1.5	2.5
	op. 7-8	17	1.6	1.7	3	75	0	2	3	1
		17	1.8	1.7	3	75	0	2	3	1
		17	2	1.7	3	75	0	2	3	1

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Table D.1. (cont.)

		16	2.3	1.7	3	75	0	2	3	1
	op. 8	17	1.6	1.7	3	75	0	2	3	1
		17	1.8	1.7	3	75	0	2	3	1
		17	2	1.7	3	75	0	2	3	1
		16	2.3	1.7	3	75	0	2	3	1
	op. 9	16	1.6	1.7	3	75	0	2	1.5	3.5
		16	1.8	1.7	3	75	0	2	1.5	3.5
		16	2	1.7	3	75	0	2	1.5	3.5
		15	2.3	1.7	3	75	0	2	1.5	3.5
	op. 10	15	1.6	1.7	3	75	0	3	3	7.4
		15	1.8	1.7	3	75	0	3	3	7.4
		14	2	1.7	3	75	0	3	3	7.4
		13	2.3	1.7	3	75	0	3	3	7.4
	op. 11	17	1.6	1.7	3	75	0	3	3	4.5
		17	1.8	1.7	3	75	0	3	3	4.5
		16	2	1.7	3	75	0	3	3	4.5
		16	2.3	1.7	3	75	0	3	3	4.5
	op. 12	17	1.6	1.7	3	75	0	2	1.5	3.3
		17	1.8	1.7	3	75	0	2	1.5	3.3
		17	2	1.7	3	75	0	2	1.5	3.3
		16	2.3	1.7	3	75	0	2	1.5	3.3
	op. 13	17	1.6	1.7	3	75	0	2	0	3.3
		17	1.8	1.7	3	75	0	2	0	3.3
		17	2	1.7	3	75	0	2	0	3.3
		16	2.3	1.7	3	75	0	2	0	3.3
	op. 14	17	1.6	1.7	3	75	0	2	0	4.86
		17	1.8	1.7	3	75	0	2	0	4.86
		17	2	1.7	3	75	0	2	0	4.86
		16	2.3	1.7	3	75	0	2	0	4.86
	op. 15	17	1.6	1.7	3	75	0	2	0	7.8
		17	1.8	1.7	3	75	0	2	0	7.8
		16	2	1.7	3	75	0	2	0	7.8
		15	2.3	1.7	3	75	0	2	0	7.8
wallp5	op. 1-4	14	1.6	0.8	2.4	50	8%	1	3	1
		14	1.8	0.8	2.4	50	8%	1	3	1
		14	2	0.8	2.4	50	8%	1	3	1
		14	2.3	0.8	2.4	50	8%	1	3	1
	op. 2	14	1.6	0.8	2.4	50	8%	1	3	1.4
		14	1.8	0.8	2.4	50	8%	1	3	1.4
		14	2	0.8	2.4	50	8%	1	3	1.4
		14	2.3	0.8	2.4	50	8%	1	3	1.4
	op. 3	14	1.6	0.8	2.4	50	8%	1	1.5	1
		14	1.8	0.8	2.4	50	8%	1	1.5	1

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Table D.1. (cont.)

		14	2	0.8	2.4	50	8%	1	1.5	1
		14	2.3	0.8	2.4	50	8%	1	1.5	1
	op. 4	14	1.6	0.8	2.4	50	8%	1	1.5	1.4
		14	1.8	0.8	2.4	50	8%	1	1.5	1.4
		14	2	0.8	2.4	50	8%	1	1.5	1.4
		14	2.3	0.8	2.4	50	8%	1	1.5	1.4
	op. 5	14	1.6	0.8	2.4	50	8%	2	3	1
		14	1.8	0.8	2.4	50	8%	2	3	1
		14	2	0.8	2.4	50	8%	2	3	1
		14	2.3	0.8	2.4	50	8%	2	3	1
	op. 6	14	1.6	0.8	2.4	50	8%	1	1.5	2.5
		14	1.8	0.8	2.4	50	8%	1	1.5	2.5
		13	2	0.8	2.4	50	8%	1	1.5	2.5
		13	2.3	0.8	2.4	50	8%	1	1.5	2.5
	op. 7-8	14	1.6	0.8	2.4	50	8%	2	3	1
		14	1.8	0.8	2.4	50	8%	2	3	1
		14	2	0.8	2.4	50	8%	2	3	1
		13	2.3	0.8	2.4	50	8%	2	3	1
	op. 8	14	1.6	0.8	2.4	50	8%	2	3	1
		14	1.8	0.8	2.4	50	8%	2	3	1
		14	2	0.8	2.4	50	8%	2	3	1
		13	2.3	0.8	2.4	50	8%	2	3	1
	op. 9	13	1.6	0.8	2.4	50	8%	2	1.5	3.5
		13	1.8	0.8	2.4	50	8%	2	1.5	3.5
		13	2	0.8	2.4	50	8%	2	1.5	3.5
		12	2.3	0.8	2.4	50	8%	2	1.5	3.5
	op. 10	13	1.6	0.8	2.4	50	8%	3	3	7.4
		13	1.8	0.8	2.4	50	8%	3	3	7.4
		12	2	0.8	2.4	50	8%	3	3	7.4
		11	2.3	0.8	2.4	50	8%	3	3	7.4
	op. 11	14	1.6	0.8	2.4	50	8%	3	3	4.5
		14	1.8	0.8	2.4	50	8%	3	3	4.5
		13	2	0.8	2.4	50	8%	3	3	4.5
		12	2.3	0.8	2.4	50	8%	3	3	4.5
	op. 12	14	1.6	0.8	2.4	50	8%	2	1.5	3.3
		14	1.8	0.8	2.4	50	8%	2	1.5	3.3
		14	2	0.8	2.4	50	8%	2	1.5	3.3
		13	2.3	0.8	2.4	50	8%	2	1.5	3.3
	op. 13	14	1.6	0.8	2.4	50	8%	2	0	3.3
		14	1.8	0.8	2.4	50	8%	2	0	3.3
		14	2	0.8	2.4	50	8%	2	0	3.3
		13	2.3	0.8	2.4	50	8%	2	0	3.3
	op. 14	14	1.6	0.8	2.4	50	8%	2	0	4.86

(cont. on next page)

Table D.1. (cont.)

		14	1.8	0.8	2.4	50	8%	2	0	4.86
		14	2	0.8	2.4	50	8%	2	0	4.86
		13	2.3	0.8	2.4	50	8%	2	0	4.86
	op. 15	14	1.6	0.8	2.4	50	8%	2	0	7.8
		14	1.8	0.8	2.4	50	8%	2	0	7.8
		13	2	0.8	2.4	50	8%	2	0	7.8
		11	2.3	0.8	2.4	50	8%	2	0	7.8
wallp6	op. 1-4	19	1.6	1.7	4	50	11%	1	3	1
		19	1.8	1.7	4	50	11%	1	3	1
		18	2	1.7	4	50	11%	1	3	1
		16	2.3	1.7	4	50	11%	1	3	1
	op. 2	19	1.6	1.7	4	50	11%	1	3	1.4
		19	1.8	1.7	4	50	11%	1	3	1.4
		18	2	1.7	4	50	11%	1	3	1.4
		16	2.3	1.7	4	50	11%	1	3	1.4
	op. 3	19	1.6	1.7	4	50	11%	1	1.5	1
		19	1.8	1.7	4	50	11%	1	1.5	1
		18	2	1.7	4	50	11%	1	1.5	1
		16	2.3	1.7	4	50	11%	1	1.5	1
	op. 4	19	1.6	1.7	4	50	11%	1	1.5	1.4
		19	1.8	1.7	4	50	11%	1	1.5	1.4
		18	2	1.7	4	50	11%	1	1.5	1.4
		16	2.3	1.7	4	50	11%	1	1.5	1.4
	op. 5	19	1.6	1.7	4	50	11%	2	3	1
		19	1.8	1.7	4	50	11%	2	3	1
		18	2	1.7	4	50	11%	2	3	1
		16	2.3	1.7	4	50	11%	2	3	1
	op. 6	19	1.6	1.7	4	50	11%	1	1.5	2.5
		19	1.8	1.7	4	50	11%	1	1.5	2.5
		18	2	1.7	4	50	11%	1	1.5	2.5
		16	2.3	1.7	4	50	11%	1	1.5	2.5
	op. 7-8	19	1.6	1.7	4	50	11%	2	3	1
		19	1.8	1.7	4	50	11%	2	3	1
		18	2	1.7	4	50	11%	2	3	1
		16	2.3	1.7	4	50	11%	2	3	1
	op. 8	19	1.6	1.7	4	50	11%	2	3	1
		19	1.8	1.7	4	50	11%	2	3	1
		18	2	1.7	4	50	11%	2	3	1
		16	2.3	1.7	4	50	11%	2	3	1
	op. 9	19	1.6	1.7	4	50	11%	2	1.5	3.5
		19	1.8	1.7	4	50	11%	2	1.5	3.5
		18	2	1.7	4	50	11%	2	1.5	3.5
		16	2.3	1.7	4	50	11%	2	1.5	3.5

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Table D.1. (cont.)

	op. 10	18	1.6	1.7	4	50	11%	3	3	7.4
		18	1.8	1.7	4	50	11%	3	3	7.4
		17	2	1.7	4	50	11%	3	3	7.4
		16	2.3	1.7	4	50	11%	3	3	7.4
	op. 11	18	1.6	1.7	4	50	11%	3	3	4.5
		18	1.8	1.7	4	50	11%	3	3	4.5
		18	2	1.7	4	50	11%	3	3	4.5
		16	2.3	1.7	4	50	11%	3	3	4.5
	op. 12	19	1.6	1.7	4	50	11%	2	1.5	3.3
		19	1.8	1.7	4	50	11%	2	1.5	3.3
		18	2	1.7	4	50	11%	2	1.5	3.3
		16	2.3	1.7	4	50	11%	2	1.5	3.3
	op. 13	19	1.6	1.7	4	50	11%	2	0	3.3
		19	1.8	1.7	4	50	11%	2	0	3.3
		18	2	1.7	4	50	11%	2	0	3.3
		16	2.3	1.7	4	50	11%	2	0	3.3
	op. 14	19	1.6	1.7	4	50	11%	2	0	4.86
		19	1.8	1.7	4	50	11%	2	0	4.86
		18	2	1.7	4	50	11%	2	0	4.86
		16	2.3	1.7	4	50	11%	2	0	4.86
	op. 15	19	1.6	1.7	4	50	11%	2	0	7.8
		18	1.8	1.7	4	50	11%	2	0	7.8
		18	2	1.7	4	50	11%	2	0	7.8
		16	2.3	1.7	4	50	11%	2	0	7.8

APPENDIX E

DATA SET OF HYPOTHETICAL TOWERS

First; configurations are designed based on real towers' data. However, results of some configurations composed of h/l ratio and material usage are similar, therefore, to prove the advantage of these historic preferences, the real limits are broadened for h/l ratio and material usage. After interpretation of results, configurations composed of effective characteristic types are used for the assessment by eliminating ineffective ones.

Configurations based on real towers

While designing hypothetic towers, six wall profile type, four ratios between wall height and length, 15 opening, two material and two ground topography types are combined with each other. All possible towers are defined. Each of these towers is a permutation. If number of each characteristic type is multiplied by each other, 1440 tower combinations are created.

The impact of opening type is taken into consideration depending on its in-plane and out-of-plane position.

Number of hypothetic towers (based on real towers) = 6 x 4 x 15 x 2 x 2=1440

Configurations beyond real towers with virtual values

Additional configurations (3 h/l ratio and 2 material type) increase number of hypothetic towers up to 5040.

Number of hypothetic towers (with additional configurations) = 6x7x15x4x2 =5040

The presentation of the data set is as follows. Combinations that have topography differences are given in opposing columns. "Plane" represents both the tilting results of the towers positioned on plane topography and tilting results of the towers on inclined topography to the reverse direction of bedrock. Hypothetical towers based on real towers are illustrated with a symbol (*).

Table E.1. Data set of hypothetical towers

Tower	Col. angle	W. P. type	Op. Type	H/L	Mat. type	Gr. Topog.	Tower	Col. angle	W. P. type	Op. Type	H/L	Mat. type	Gr. Topog.
T. 1	7	1	1	1	Granite	Plane[1]	**T. 421**	7	1	1	1	Granite	Inclined
T. 2	7	1	2	1	Granite	Plane	**T. 422**	7	1	2	1	Granite	Inclined
T. 3	7	1	3	1	Granite	Plane	**T. 423**	7	1	3	1	Granite	Inclined
T. 4	7	1	4	1	Granite	Plane	**T. 424**	7	1	4	1	Granite	Inclined
T. 5	7	1	5	1	Granite	Plane	**T. 425**	7	1	5	1	Granite	Inclined
T. 6	7	1	6	1	Granite	Plane	**T. 426**	7	1	6	1	Granite	Inclined
T. 7	7	1	7	1	Granite	Plane	**T. 427**	7	1	7	1	Granite	Inclined
T. 8	7	1	8	1	Granite	Plane	**T. 428**	7	1	8	1	Granite	Inclined
T. 9	7	1	9	1	Granite	Plane	**T. 429**	7	1	9	1	Granite	Inclined
T. 10	6	1	10	1	Granite	Plane	**T. 430**	6	1	10	1	Granite	Inclined
T. 11	7	1	11	1	Granite	Plane	**T. 431**	7	1	11	1	Granite	Inclined
T. 12	7	1	12	1	Granite	Plane	**T. 432**	7	1	12	1	Granite	Inclined
T. 13	7	1	13	1	Granite	Plane	**T. 433**	7	1	13	1	Granite	Inclined
T. 14	7	1	14	1	Granite	Plane	**T. 434**	7	1	14	1	Granite	Inclined
T. 15	7	1	15	1	Granite	Plane	**T. 435**	7	1	15	1	Granite	Inclined
T. 16	8	1	1	1.3	Granite	Plane	**T. 436**	8	1	1	1.3	Granite	Inclined
T. 17	8	1	2	1.3	Granite	Plane	**T. 437**	8	1	2	1.3	Granite	Inclined
T. 18	8	1	3	1.3	Granite	Plane	**T. 438**	8	1	3	1.3	Granite	Inclined
T. 19	8	1	4	1.3	Granite	Plane	**T. 439**	8	1	4	1.3	Granite	Inclined
T. 20	8	1	5	1.3	Granite	Plane	**T. 440**	8	1	5	1.3	Granite	Inclined
T. 21	8	1	6	1.3	Granite	Plane	**T. 441**	8	1	6	1.3	Granite	Inclined
T. 22	8	1	7	1.3	Granite	Plane	**T. 442**	8	1	7	1.3	Granite	Inclined
T. 23	8	1	8	1.3	Granite	Plane	**T. 443**	8	1	8	1.3	Granite	Inclined
T. 24	8	1	9	1.3	Granite	Plane	**T. 444**	8	1	9	1.3	Granite	Inclined
T. 25	8	1	10	1.3	Granite	Plane	**T. 445**	8	1	10	1.3	Granite	Inclined
T. 26	8	1	11	1.3	Granite	Plane	**T. 446**	8	1	11	1.3	Granite	Inclined
T. 27	8	1	12	1.3	Granite	Plane	**T. 447**	8	1	12	1.3	Granite	Inclined
T. 28	8	1	13	1.3	Granite	Plane	**T. 448**	8	1	13	1.3	Granite	Inclined
T. 29	8	1	14	1.3	Granite	Plane	**T. 449**	8	1	14	1.3	Granite	Inclined
T. 30	8	1	15	1.3	Granite	Plane	**T. 450**	8	1	15	1.3	Granite	Inclined
***T. 31**[2]	11	1	1	1.6	Granite	Plane	***T. 451**	11	1	1	1.6	Granite	Inclined
***T. 32**	11	1	2	1.6	Granite	Plane	***T. 452**	11	1	2	1.6	Granite	Inclined

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Table E.1. (cont.)

***T. 33**	11	1	3	1.6	Granite	Plane	***T. 453**	11	1	3	1.6	Granite	Inclined
***T. 34**	11	1	4	1.6	Granite	Plane	***T. 454**	11	1	4	1.6	Granite	Inclined
***T. 35**	11	1	5	1.6	Granite	Plane	***T. 455**	11	1	5	1.6	Granite	Inclined
***T. 36**	11	1	6	1.6	Granite	Plane	***T. 456**	11	1	6	1.6	Granite	Inclined
***T. 37**	11	1	7	1.6	Granite	Plane	***T. 457**	11	1	7	1.6	Granite	Inclined
***T. 38**	11	1	8	1.6	Granite	Plane	***T. 458**	11	1	8	1.6	Granite	Inclined
***T. 39**	10	1	9	1.6	Granite	Plane	***T. 459**	10	1	9	1.6	Granite	Inclined
***T. 40**	9	1	10	1.6	Granite	Plane	***T. 460**	9	1	10	1.6	Granite	Inclined
***T. 41**	10	1	11	1.6	Granite	Plane	***T. 461**	10	1	11	1.6	Granite	Inclined
***T. 42**	10	1	12	1.6	Granite	Plane	***T. 462**	10	1	12	1.6	Granite	Inclined
***T. 43**	10	1	13	1.6	Granite	Plane	***T. 463**	10	1	13	1.6	Granite	Inclined
***T. 44**	10	1	14	1.6	Granite	Plane	***T. 464**	10	1	14	1.6	Granite	Inclined
***T. 45**	11	1	15	1.6	Granite	Plane	***T. 465**	11	1	15	1.6	Granite	Inclined
***T. 46**	11	1	1	1.8	Granite	Plane	***T. 466**	11	1	1	1.8	Granite	Inclined
***T. 47**	11	1	2	1.8	Granite	Plane	***T. 467**	11	1	2	1.8	Granite	Inclined
***T. 48**	11	1	3	1.8	Granite	Plane	***T. 468**	11	1	3	1.8	Granite	Inclined
***T. 49**	11	1	4	1.8	Granite	Plane	***T. 469**	11	1	4	1.8	Granite	Inclined
***T. 50**	11	1	5	1.8	Granite	Plane	***T. 470**	11	1	5	1.8	Granite	Inclined
***T. 51**	11	1	6	1.8	Granite	Plane	***T. 471**	11	1	6	1.8	Granite	Inclined
***T. 52**	11	1	7	1.8	Granite	Plane	***T. 472**	11	1	7	1.8	Granite	Inclined
***T. 53**	11	1	8	1.8	Granite	Plane	***T. 473**	11	1	8	1.8	Granite	Inclined
***T. 54**	10	1	9	1.8	Granite	Plane	***T. 474**	10	1	9	1.8	Granite	Inclined
***T. 55**	9	1	10	1.8	Granite	Plane	***T. 475**	9	1	10	1.8	Granite	Inclined
***T. 56**	10	1	11	1.8	Granite	Plane	***T. 476**	10	1	11	1.8	Granite	Inclined
***T. 57**	10	1	12	1.8	Granite	Plane	***T. 477**	10	1	12	1.8	Granite	Inclined
***T. 58**	10	1	13	1.8	Granite	Plane	***T. 478**	10	1	13	1.8	Granite	Inclined
***T. 59**	10	1	14	1.8	Granite	Plane	***T. 479**	10	1	14	1.8	Granite	Inclined
***T. 60**	11	1	15	1.8	Granite	Plane	***T. 480**	11	1	15	1.8	Granite	Inclined
***T. 61**	11	1	1	2	Granite	Plane	***T. 481**	11	1	1	2	Granite	Inclined
***T. 62**	11	1	2	2	Granite	Plane	***T. 482**	11	1	2	2	Granite	Inclined
***T. 63**	11	1	3	2	Granite	Plane	***T. 483**	11	1	3	2	Granite	Inclined
***T. 64**	11	1	4	2	Granite	Plane	***T. 484**	11	1	4	2	Granite	Inclined
***T. 65**	11	1	5	2	Granite	Plane	***T. 485**	11	1	5	2	Granite	Inclined

(cont. on next page)

Table E.1. (cont.)

***T. 66**	11	1	6	2	Granite	Plane	***T. 486**	11	1	6	2	Granite	Inclined
***T. 67**	11	1	7	2	Granite	Plane	***T. 487**	11	1	7	2	Granite	Inclined
***T. 68**	11	1	8	2	Granite	Plane	***T. 488**	11	1	8	2	Granite	Inclined
***T. 69**	10	1	9	2	Granite	Plane	***T. 489**	10	1	9	2	Granite	Inclined
***T. 70**	8	1	10	2	Granite	Plane	***T. 490**	8	1	10	2	Granite	Inclined
***T. 71**	9	1	11	2	Granite	Plane	***T. 491**	9	1	11	2	Granite	Inclined
***T. 72**	10	1	12	2	Granite	Plane	***T. 492**	10	1	12	2	Granite	Inclined
***T. 73**	10	1	13	2	Granite	Plane	***T. 493**	10	1	13	2	Granite	Inclined
***T. 74**	10	1	14	2	Granite	Plane	***T. 494**	10	1	14	2	Granite	Inclined
***T. 75**	9	1	15	2	Granite	Plane	***T. 495**	9	1	15	2	Granite	Inclined
***T. 76**	11	1	1	2.3	Granite	Plane	***T. 496**	11	1	1	2.3	Granite	Inclined
***T. 77**	11	1	2	2.3	Granite	Plane	***T. 497**	11	1	2	2.3	Granite	Inclined
***T. 78**	11	1	3	2.3	Granite	Plane	***T. 498**	11	1	3	2.3	Granite	Inclined
***T. 79**	11	1	4	2.3	Granite	Plane	***T. 499**	11	1	4	2.3	Granite	Inclined
***T. 80**	11	1	5	2.3	Granite	Plane	***T. 500**	11	1	5	2.3	Granite	Inclined
***T. 81**	11	1	6	2.3	Granite	Plane	***T. 501**	11	1	6	2.3	Granite	Inclined
***T. 82**	11	1	7	2.3	Granite	Plane	***T. 502**	11	1	7	2.3	Granite	Inclined
***T. 83**	11	1	8	2.3	Granite	Plane	***T. 503**	11	1	8	2.3	Granite	Inclined
***T. 84**	10	1	9	2.3	Granite	Plane	***T. 504**	10	1	9	2.3	Granite	Inclined
***T. 85**	8	1	10	2.3	Granite	Plane	***T. 505**	8	1	10	2.3	Granite	Inclined
***T. 86**	8	1	11	2.3	Granite	Plane	***T. 506**	8	1	11	2.3	Granite	Inclined
***T. 87**	10	1	12	2.3	Granite	Plane	***T. 507**	10	1	12	2.3	Granite	Inclined
***T. 88**	10	1	13	2.3	Granite	Plane	***T. 508**	10	1	13	2.3	Granite	Inclined
***T. 89**	10	1	14	2.3	Granite	Plane	***T. 509**	10	1	14	2.3	Granite	Inclined
***T. 90**	9	1	15	2.3	Granite	Plane	***T. 510**	9	1	15	2.3	Granite	Inclined
T. 91	10	1	1	2.5	Granite	Plane	**T. 511**	10	1	1	2.5	Granite	Inclined
T. 92	10	1	2	2.5	Granite	Plane	**T. 512**	10	1	2	2.5	Granite	Inclined
T. 93	10	1	3	2.5	Granite	Plane	**T. 513**	10	1	3	2.5	Granite	Inclined
T. 94	10	1	4	2.5	Granite	Plane	**T. 514**	10	1	4	2.5	Granite	Inclined
T. 95	10	1	5	2.5	Granite	Plane	**T. 515**	10	1	5	2.5	Granite	Inclined
T. 96	10	1	6	2.5	Granite	Plane	**T. 516**	10	1	6	2.5	Granite	Inclined
T. 97	10	1	7	2.5	Granite	Plane	**T. 517**	10	1	7	2.5	Granite	Inclined
T. 98	10	1	8	2.5	Granite	Plane	**T. 518**	10	1	8	2.5	Granite	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 99	9	1	9	2.5	Granite	Plane	**T. 519**	9	1	9	2.5	Granite	Inclined
T. 100	8	1	10	2.5	Granite	Plane	**T. 520**	8	1	10	2.5	Granite	Inclined
T. 101	8	1	11	2.5	Granite	Plane	**T. 521**	8	1	11	2.5	Granite	Inclined
T. 102	9	1	12	2.5	Granite	Plane	**T. 522**	9	1	12	2.5	Granite	Inclined
T. 103	9	1	13	2.5	Granite	Plane	**T. 523**	9	1	13	2.5	Granite	Inclined
T. 104	8	1	14	2.5	Granite	Plane	**T. 524**	8	1	14	2.5	Granite	Inclined
T. 105	8	1	15	2.5	Granite	Plane	**T. 525**	8	1	15	2.5	Granite	Inclined
T. 106	7	1	1	1	Limestone	Plane	**T. 526**	7	1	1	1	Limestone	Inclined
T. 107	7	1	2	1	Limestone	Plane	**T. 527**	7	1	2	1	Limestone	Inclined
T. 108	7	1	3	1	Limestone	Plane	**T. 528**	7	1	3	1	Limestone	Inclined
T. 109	7	1	4	1	Limestone	Plane	**T. 529**	7	1	4	1	Limestone	Inclined
T. 110	7	1	5	1	Limestone	Plane	**T. 530**	7	1	5	1	Limestone	Inclined
T. 111	7	1	6	1	Limestone	Plane	**T. 531**	7	1	6	1	Limestone	Inclined
T. 112	7	1	7	1	Limestone	Plane	**T. 532**	7	1	7	1	Limestone	Inclined
T. 113	7	1	8	1	Limestone	Plane	**T. 533**	7	1	8	1	Limestone	Inclined
T. 114	7	1	9	1	Limestone	Plane	**T. 534**	7	1	9	1	Limestone	Inclined
T. 115	6	1	10	1	Limestone	Plane	**T. 535**	6	1	10	1	Limestone	Inclined
T. 116	7	1	11	1	Limestone	Plane	**T. 536**	7	1	11	1	Limestone	Inclined
T. 117	7	1	12	1	Limestone	Plane	**T. 537**	7	1	12	1	Limestone	Inclined
T. 118	7	1	13	1	Limestone	Plane	**T. 538**	7	1	13	1	Limestone	Inclined
T. 119	7	1	14	1	Limestone	Plane	**T. 539**	7	1	14	1	Limestone	Inclined
T. 120	7	1	15	1	Limestone	Plane	**T. 540**	7	1	15	1	Limestone	Inclined
T. 121	8	1	1	1.3	Limestone	Plane	**T. 541**	8	1	1	1.3	Limestone	Inclined
T. 122	8	1	2	1.3	Limestone	Plane	**T. 542**	8	1	2	1.3	Limestone	Inclined
T. 123	8	1	3	1.3	Limestone	Plane	**T. 543**	8	1	3	1.3	Limestone	Inclined
T. 124	8	1	4	1.3	Limestone	Plane	**T. 544**	8	1	4	1.3	Limestone	Inclined
T. 125	8	1	5	1.3	Limestone	Plane	**T. 545**	8	1	5	1.3	Limestone	Inclined
T. 126	8	1	6	1.3	Limestone	Plane	**T. 546**	8	1	6	1.3	Limestone	Inclined
T. 127	8	1	7	1.3	Limestone	Plane	**T. 547**	8	1	7	1.3	Limestone	Inclined
T. 128	8	1	8	1.3	Limestone	Plane	**T. 548**	8	1	8	1.3	Limestone	Inclined
T. 129	8	1	9	1.3	Limestone	Plane	**T. 549**	8	1	9	1.3	Limestone	Inclined
T. 130	8	1	10	1.3	Limestone	Plane	**T. 550**	8	1	10	1.3	Limestone	Inclined
T. 131	8	1	11	1.3	Limestone	Plane	**T. 551**	8	1	11	1.3	Limestone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 132	8	1	12	1.3	Limestone	Plane	**T. 552**	8	1	12	1.3	Limestone	Inclined
T. 133	8	1	13	1.3	Limestone	Plane	**T. 553**	8	1	13	1.3	Limestone	Inclined
T. 134	8	1	14	1.3	Limestone	Plane	**T. 554**	8	1	14	1.3	Limestone	Inclined
T. 135	8	1	15	1.3	Limestone	Plane	**T. 555**	8	1	15	1.3	Limestone	Inclined
***T. 136**	11	1	1	1.6	Limestone	Plane	**T. 556**	11	1	1	1.6	Limestone	Inclined
***T. 137**	11	1	2	1.6	Limestone	Plane	**T. 557**	11	1	2	1.6	Limestone	Inclined
***T. 138**	11	1	3	1.6	Limestone	Plane	**T. 558**	11	1	3	1.6	Limestone	Inclined
***T. 139**	11	1	4	1.6	Limestone	Plane	**T. 559**	11	1	4	1.6	Limestone	Inclined
***T. 140**	11	1	5	1.6	Limestone	Plane	**T. 560**	11	1	5	1.6	Limestone	Inclined
***T. 141**	11	1	6	1.6	Limestone	Plane	**T. 561**	11	1	6	1.6	Limestone	Inclined
***T. 142**	11	1	7	1.6	Limestone	Plane	**T. 562**	11	1	7	1.6	Limestone	Inclined
***T. 143**	11	1	8	1.6	Limestone	Plane	**T. 563**	11	1	8	1.6	Limestone	Inclined
***T. 144**	10	1	9	1.6	Limestone	Plane	**T. 564**	10	1	9	1.6	Limestone	Inclined
***T. 145**	9	1	10	1.6	Limestone	Plane	**T. 565**	9	1	10	1.6	Limestone	Inclined
***T. 146**	10	1	11	1.6	Limestone	Plane	**T. 566**	10	1	11	1.6	Limestone	Inclined
***T. 147**	10	1	12	1.6	Limestone	Plane	**T. 567**	10	1	12	1.6	Limestone	Inclined
***T. 148**	10	1	13	1.6	Limestone	Plane	**T. 568**	10	1	13	1.6	Limestone	Inclined
***T. 149**	10	1	14	1.6	Limestone	Plane	**T. 569**	10	1	14	1.6	Limestone	Inclined
***T. 150**	11	1	15	1.6	Limestone	Plane	**T. 570**	11	1	15	1.6	Limestone	Inclined
***T. 151**	11	1	1	1.8	Limestone	Plane	**T. 571**	11	1	1	1.8	Limestone	Inclined
***T. 152**	11	1	2	1.8	Limestone	Plane	**T. 572**	11	1	2	1.8	Limestone	Inclined
***T. 153**	11	1	3	1.8	Limestone	Plane	**T. 573**	11	1	3	1.8	Limestone	Inclined
***T. 154**	11	1	4	1.8	Limestone	Plane	**T. 574**	11	1	4	1.8	Limestone	Inclined
***T. 155**	11	1	5	1.8	Limestone	Plane	**T. 575**	11	1	5	1.8	Limestone	Inclined
***T. 156**	11	1	6	1.8	Limestone	Plane	**T. 576**	11	1	6	1.8	Limestone	Inclined
***T. 157**	11	1	7	1.8	Limestone	Plane	**T. 577**	11	1	7	1.8	Limestone	Inclined
***T. 158**	11	1	8	1.8	Limestone	Plane	**T. 578**	11	1	8	1.8	Limestone	Inclined
***T. 159**	10	1	9	1.8	Limestone	Plane	**T. 579**	10	1	9	1.8	Limestone	Inclined
***T. 160**	9	1	10	1.8	Limestone	Plane	**T. 580**	9	1	10	1.8	Limestone	Inclined
***T. 161**	10	1	11	1.8	Limestone	Plane	**T. 581**	10	1	11	1.8	Limestone	Inclined
***T. 162**	10	1	12	1.8	Limestone	Plane	**T. 582**	10	1	12	1.8	Limestone	Inclined
***T. 163**	10	1	13	1.8	Limestone	Plane	**T. 583**	10	1	13	1.8	Limestone	Inclined
***T. 164**	10	1	14	1.8	Limestone	Plane	**T. 584**	10	1	14	1.8	Limestone	Inclined

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Table E.1. (cont.)

***T. 165**	11	1	15	1.8	Limestone	Plane	**T. 585**	11	1	15	1.8	Limestone	Inclined
***T. 166**	11	1	1	2	Limestone	Plane	**T. 586**	11	1	1	2	Limestone	Inclined
***T. 167**	11	1	2	2	Limestone	Plane	**T. 587**	11	1	2	2	Limestone	Inclined
***T. 168**	11	1	3	2	Limestone	Plane	**T. 588**	11	1	3	2	Limestone	Inclined
***T. 169**	11	1	4	2	Limestone	Plane	**T. 589**	11	1	4	2	Limestone	Inclined
***T. 170**	11	1	5	2	Limestone	Plane	**T. 590**	11	1	5	2	Limestone	Inclined
***T. 171**	11	1	6	2	Limestone	Plane	**T. 591**	11	1	6	2	Limestone	Inclined
***T. 172**	11	1	7	2	Limestone	Plane	**T. 592**	11	1	7	2	Limestone	Inclined
***T. 173**	11	1	8	2	Limestone	Plane	**T. 593**	11	1	8	2	Limestone	Inclined
***T. 174**	10	1	9	2	Limestone	Plane	**T. 594**	10	1	9	2	Limestone	Inclined
***T. 175**	8	1	10	2	Limestone	Plane	**T. 595**	8	1	10	2	Limestone	Inclined
***T. 176**	9	1	11	2	Limestone	Plane	**T. 596**	9	1	11	2	Limestone	Inclined
***T. 177**	10	1	12	2	Limestone	Plane	**T. 597**	10	1	12	2	Limestone	Inclined
***T. 178**	10	1	13	2	Limestone	Plane	**T. 598**	10	1	13	2	Limestone	Inclined
***T. 179**	10	1	14	2	Limestone	Plane	**T. 599**	10	1	14	2	Limestone	Inclined
***T. 180**	9	1	15	2	Limestone	Plane	**T. 600**	9	1	15	2	Limestone	Inclined
***T. 181**	11	1	1	2.3	Limestone	Plane	**T. 601**	11	1	1	2.3	Limestone	Inclined
***T. 182**	11	1	2	2.3	Limestone	Plane	**T. 602**	11	1	2	2.3	Limestone	Inclined
***T. 183**	11	1	3	2.3	Limestone	Plane	**T. 603**	11	1	3	2.3	Limestone	Inclined
***T. 184**	11	1	4	2.3	Limestone	Plane	**T. 604**	11	1	4	2.3	Limestone	Inclined
***T. 185**	11	1	5	2.3	Limestone	Plane	**T. 605**	11	1	5	2.3	Limestone	Inclined
***T. 186**	11	1	6	2.3	Limestone	Plane	**T. 606**	11	1	6	2.3	Limestone	Inclined
***T. 187**	11	1	7	2.3	Limestone	Plane	**T. 607**	11	1	7	2.3	Limestone	Inclined
***T. 188**	11	1	8	2.3	Limestone	Plane	**T. 608**	11	1	8	2.3	Limestone	Inclined
***T. 189**	10	1	9	2.3	Limestone	Plane	**T. 609**	10	1	9	2.3	Limestone	Inclined
***T. 190**	8	1	10	2.3	Limestone	Plane	**T. 610**	8	1	10	2.3	Limestone	Inclined
***T. 191**	8	1	11	2.3	Limestone	Plane	**T. 611**	8	1	11	2.3	Limestone	Inclined
***T. 192**	10	1	12	2.3	Limestone	Plane	**T. 612**	10	1	12	2.3	Limestone	Inclined
***T. 193**	10	1	13	2.3	Limestone	Plane	**T. 613**	10	1	13	2.3	Limestone	Inclined
***T. 194**	10	1	14	2.3	Limestone	Plane	**T. 614**	10	1	14	2.3	Limestone	Inclined
***T. 195**	9	1	15	2.3	Limestone	Plane	**T. 615**	9	1	15	2.3	Limestone	Inclined
T. 196	10	1	1	2.5	Limestone	Plane	**T. 616**	10	1	1	2.5	Limestone	Inclined
T. 197	10	1	2	2.5	Limestone	Plane	**T. 617**	10	1	2	2.5	Limestone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 198	10	1	3	2.5	Limestone	Plane	**T. 618**	10	1	3	2.5	Limestone	Inclined
T. 199	10	1	4	2.5	Limestone	Plane	**T. 619**	10	1	4	2.5	Limestone	Inclined
T. 200	10	1	5	2.5	Limestone	Plane	**T. 620**	10	1	5	2.5	Limestone	Inclined
T. 201	10	1	6	2.5	Limestone	Plane	**T. 621**	10	1	6	2.5	Limestone	Inclined
T. 202	10	1	7	2.5	Limestone	Plane	**T. 622**	10	1	7	2.5	Limestone	Inclined
T. 203	10	1	8	2.5	Limestone	Plane	**T. 623**	10	1	8	2.5	Limestone	Inclined
T. 204	9	1	9	2.5	Limestone	Plane	**T. 624**	9	1	9	2.5	Limestone	Inclined
T. 205	8	1	10	2.5	Limestone	Plane	**T. 625**	8	1	10	2.5	Limestone	Inclined
T. 206	8	1	11	2.5	Limestone	Plane	**T. 626**	8	1	11	2.5	Limestone	Inclined
T. 207	9	1	12	2.5	Limestone	Plane	**T. 627**	9	1	12	2.5	Limestone	Inclined
T. 208	9	1	13	2.5	Limestone	Plane	**T. 628**	9	1	13	2.5	Limestone	Inclined
T. 209	8	1	14	2.5	Limestone	Plane	**T. 629**	8	1	14	2.5	Limestone	Inclined
T. 210	8	1	15	2.5	Limestone	Plane	**T. 630**	8	1	15	2.5	Limestone	Inclined
T. 211	7	1	1	1	Sandstone	Plane	**T. 631**	7	1	1	1	Sandstone	Inclined
T. 212	7	1	2	1	Sandstone	Plane	**T. 632**	7	1	2	1	Sandstone	Inclined
T. 213	7	1	3	1	Sandstone	Plane	**T. 633**	7	1	3	1	Sandstone	Inclined
T. 214	7	1	4	1	Sandstone	Plane	**T. 634**	7	1	4	1	Sandstone	Inclined
T. 215	7	1	5	1	Sandstone	Plane	**T. 635**	7	1	5	1	Sandstone	Inclined
T. 216	7	1	6	1	Sandstone	Plane	**T. 636**	7	1	6	1	Sandstone	Inclined
T. 217	7	1	7	1	Sandstone	Plane	**T. 637**	7	1	7	1	Sandstone	Inclined
T. 218	7	1	8	1	Sandstone	Plane	**T. 638**	7	1	8	1	Sandstone	Inclined
T. 219	7	1	9	1	Sandstone	Plane	**T. 639**	7	1	9	1	Sandstone	Inclined
T. 220	6	1	10	1	Sandstone	Plane	**T. 640**	6	1	10	1	Sandstone	Inclined
T. 221	7	1	11	1	Sandstone	Plane	**T. 641**	7	1	11	1	Sandstone	Inclined
T. 222	7	1	12	1	Sandstone	Plane	**T. 642**	7	1	12	1	Sandstone	Inclined
T. 223	7	1	13	1	Sandstone	Plane	**T. 643**	7	1	13	1	Sandstone	Inclined
T. 224	7	1	14	1	Sandstone	Plane	**T. 644**	7	1	14	1	Sandstone	Inclined
T. 225	7	1	15	1	Sandstone	Plane	**T. 645**	7	1	15	1	Sandstone	Inclined
T. 226	8	1	1	1.3	Sandstone	Plane	**T. 646**	8	1	1	1.3	Sandstone	Inclined
T. 227	8	1	2	1.3	Sandstone	Plane	**T. 647**	8	1	2	1.3	Sandstone	Inclined
T. 228	8	1	3	1.3	Sandstone	Plane	**T. 648**	8	1	3	1.3	Sandstone	Inclined
T. 229	8	1	4	1.3	Sandstone	Plane	**T. 649**	8	1	4	1.3	Sandstone	Inclined
T. 230	8	1	5	1.3	Sandstone	Plane	**T. 650**	8	1	5	1.3	Sandstone	Inclined

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Table E.1. (cont.)

T. 231	8	1	6	1.3	Sandstone	Plane	**T. 651**	8	1	6	1.3	Sandstone	Inclined
T. 232	8	1	7	1.3	Sandstone	Plane	**T. 652**	8	1	7	1.3	Sandstone	Inclined
T. 233	8	1	8	1.3	Sandstone	Plane	**T. 653**	8	1	8	1.3	Sandstone	Inclined
T. 234	8	1	9	1.3	Sandstone	Plane	**T. 654**	8	1	9	1.3	Sandstone	Inclined
T. 235	8	1	10	1.3	Sandstone	Plane	**T. 655**	8	1	10	1.3	Sandstone	Inclined
T. 236	8	1	11	1.3	Sandstone	Plane	**T. 656**	8	1	11	1.3	Sandstone	Inclined
T. 237	8	1	12	1.3	Sandstone	Plane	**T. 657**	8	1	12	1.3	Sandstone	Inclined
T. 238	8	1	13	1.3	Sandstone	Plane	**T. 658**	8	1	13	1.3	Sandstone	Inclined
T. 239	8	1	14	1.3	Sandstone	Plane	**T. 659**	8	1	14	1.3	Sandstone	Inclined
T. 240	8	1	15	1.3	Sandstone	Plane	**T. 660**	8	1	15	1.3	Sandstone	Inclined
T. 241	11	1	1	1.6	Sandstone	Plane	**T. 661**	11	1	1	1.6	Sandstone	Inclined
T. 242	11	1	2	1.6	Sandstone	Plane	**T. 662**	11	1	2	1.6	Sandstone	Inclined
T. 243	11	1	3	1.6	Sandstone	Plane	**T. 663**	11	1	3	1.6	Sandstone	Inclined
T. 244	11	1	4	1.6	Sandstone	Plane	**T. 664**	11	1	4	1.6	Sandstone	Inclined
T. 245	11	1	5	1.6	Sandstone	Plane	**T. 665**	11	1	5	1.6	Sandstone	Inclined
T. 246	11	1	6	1.6	Sandstone	Plane	**T. 666**	11	1	6	1.6	Sandstone	Inclined
T. 247	11	1	7	1.6	Sandstone	Plane	**T. 667**	11	1	7	1.6	Sandstone	Inclined
T. 248	11	1	8	1.6	Sandstone	Plane	**T. 668**	11	1	8	1.6	Sandstone	Inclined
T. 249	10	1	9	1.6	Sandstone	Plane	**T. 669**	10	1	9	1.6	Sandstone	Inclined
T. 250	9	1	10	1.6	Sandstone	Plane	**T. 670**	9	1	10	1.6	Sandstone	Inclined
T. 251	10	1	11	1.6	Sandstone	Plane	**T. 671**	10	1	11	1.6	Sandstone	Inclined
T. 252	10	1	12	1.6	Sandstone	Plane	**T. 672**	10	1	12	1.6	Sandstone	Inclined
T. 253	10	1	13	1.6	Sandstone	Plane	**T. 673**	10	1	13	1.6	Sandstone	Inclined
T. 254	10	1	14	1.6	Sandstone	Plane	**T. 674**	10	1	14	1.6	Sandstone	Inclined
T. 255	11	1	15	1.6	Sandstone	Plane	**T. 675**	11	1	15	1.6	Sandstone	Inclined
T. 256	11	1	1	1.8	Sandstone	Plane	**T. 676**	11	1	1	1.8	Sandstone	Inclined
T. 257	11	1	2	1.8	Sandstone	Plane	**T. 677**	11	1	2	1.8	Sandstone	Inclined
T. 258	11	1	3	1.8	Sandstone	Plane	**T. 678**	11	1	3	1.8	Sandstone	Inclined
T. 259	11	1	4	1.8	Sandstone	Plane	**T. 679**	11	1	4	1.8	Sandstone	Inclined
T. 260	11	1	5	1.8	Sandstone	Plane	**T. 680**	11	1	5	1.8	Sandstone	Inclined
T. 261	11	1	6	1.8	Sandstone	Plane	**T. 681**	11	1	6	1.8	Sandstone	Inclined
T. 262	11	1	7	1.8	Sandstone	Plane	**T. 682**	11	1	7	1.8	Sandstone	Inclined
T. 263	11	1	8	1.8	Sandstone	Plane	**T. 683**	11	1	8	1.8	Sandstone	Inclined

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Table E.1. (cont.)

T. 264	10	1	9	1.8	Sandstone	Plane	**T. 684**	10	1	9	1.8	Sandstone	Inclined
T. 265	9	1	10	1.8	Sandstone	Plane	**T. 685**	9	1	10	1.8	Sandstone	Inclined
T. 266	10	1	11	1.8	Sandstone	Plane	**T. 686**	10	1	11	1.8	Sandstone	Inclined
T. 267	10	1	12	1.8	Sandstone	Plane	**T. 687**	10	1	12	1.8	Sandstone	Inclined
T. 268	10	1	13	1.8	Sandstone	Plane	**T. 688**	10	1	13	1.8	Sandstone	Inclined
T. 269	10	1	14	1.8	Sandstone	Plane	**T. 689**	10	1	14	1.8	Sandstone	Inclined
T. 270	11	1	15	1.8	Sandstone	Plane	**T. 690**	11	1	15	1.8	Sandstone	Inclined
T. 271	11	1	1	2	Sandstone	Plane	**T. 691**	11	1	1	2	Sandstone	Inclined
T. 272	11	1	2	2	Sandstone	Plane	**T. 692**	11	1	2	2	Sandstone	Inclined
T. 273	11	1	3	2	Sandstone	Plane	**T. 693**	11	1	3	2	Sandstone	Inclined
T. 274	11	1	4	2	Sandstone	Plane	**T. 694**	11	1	4	2	Sandstone	Inclined
T. 275	11	1	5	2	Sandstone	Plane	**T. 695**	11	1	5	2	Sandstone	Inclined
T. 276	11	1	6	2	Sandstone	Plane	**T. 696**	11	1	6	2	Sandstone	Inclined
T. 277	11	1	7	2	Sandstone	Plane	**T. 697**	11	1	7	2	Sandstone	Inclined
T. 278	11	1	8	2	Sandstone	Plane	**T. 698**	11	1	8	2	Sandstone	Inclined
T. 279	10	1	9	2	Sandstone	Plane	**T. 699**	10	1	9	2	Sandstone	Inclined
T. 280	8	1	10	2	Sandstone	Plane	**T. 700**	8	1	10	2	Sandstone	Inclined
T. 281	9	1	11	2	Sandstone	Plane	**T. 701**	9	1	11	2	Sandstone	Inclined
T. 282	10	1	12	2	Sandstone	Plane	**T. 702**	10	1	12	2	Sandstone	Inclined
T. 283	10	1	13	2	Sandstone	Plane	**T. 703**	10	1	13	2	Sandstone	Inclined
T. 284	10	1	14	2	Sandstone	Plane	**T. 704**	10	1	14	2	Sandstone	Inclined
T. 285	9	1	15	2	Sandstone	Plane	**T. 705**	9	1	15	2	Sandstone	Inclined
T. 286	11	1	1	2.3	Sandstone	Plane	**T. 706**	11	1	1	2.3	Sandstone	Inclined
T. 287	11	1	2	2.3	Sandstone	Plane	**T. 707**	11	1	2	2.3	Sandstone	Inclined
T. 288	11	1	3	2.3	Sandstone	Plane	**T. 708**	11	1	3	2.3	Sandstone	Inclined
T. 289	11	1	4	2.3	Sandstone	Plane	**T. 709**	11	1	4	2.3	Sandstone	Inclined
T. 290	11	1	5	2.3	Sandstone	Plane	**T. 710**	11	1	5	2.3	Sandstone	Inclined
T. 291	11	1	6	2.3	Sandstone	Plane	**T. 711**	11	1	6	2.3	Sandstone	Inclined
T. 292	11	1	7	2.3	Sandstone	Plane	**T. 712**	11	1	7	2.3	Sandstone	Inclined
T. 293	11	1	8	2.3	Sandstone	Plane	**T. 713**	11	1	8	2.3	Sandstone	Inclined
T. 294	10	1	9	2.3	Sandstone	Plane	**T. 714**	10	1	9	2.3	Sandstone	Inclined
T. 295	8	1	10	2.3	Sandstone	Plane	**T. 715**	8	1	10	2.3	Sandstone	Inclined
T. 296	8	1	11	2.3	Sandstone	Plane	**T. 716**	8	1	11	2.3	Sandstone	Inclined

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Table E.1. (cont.)

T. 297	10	1	12	2.3	Sandstone	Plane	**T. 717**	10	1	12	2.3	Sandstone	Inclined
T. 298	10	1	13	2.3	Sandstone	Plane	**T. 718**	10	1	13	2.3	Sandstone	Inclined
T. 299	10	1	14	2.3	Sandstone	Plane	**T. 719**	10	1	14	2.3	Sandstone	Inclined
T. 300	9	1	15	2.3	Sandstone	Plane	**T. 720**	9	1	15	2.3	Sandstone	Inclined
T. 301	10	1	1	2.5	Sandstone	Plane	**T. 721**	10	1	1	2.5	Sandstone	Inclined
T. 302	10	1	2	2.5	Sandstone	Plane	**T. 722**	10	1	2	2.5	Sandstone	Inclined
T. 303	10	1	3	2.5	Sandstone	Plane	**T. 723**	10	1	3	2.5	Sandstone	Inclined
T. 304	10	1	4	2.5	Sandstone	Plane	**T. 724**	10	1	4	2.5	Sandstone	Inclined
T. 305	10	1	5	2.5	Sandstone	Plane	**T. 725**	10	1	5	2.5	Sandstone	Inclined
T. 306	10	1	6	2.5	Sandstone	Plane	**T. 726**	10	1	6	2.5	Sandstone	Inclined
T. 307	10	1	7	2.5	Sandstone	Plane	**T. 727**	10	1	7	2.5	Sandstone	Inclined
T. 308	10	1	8	2.5	Sandstone	Plane	**T. 728**	10	1	8	2.5	Sandstone	Inclined
T. 309	9	1	9	2.5	Sandstone	Plane	**T. 729**	9	1	9	2.5	Sandstone	Inclined
T. 310	8	1	10	2.5	Sandstone	Plane	**T. 730**	8	1	10	2.5	Sandstone	Inclined
T. 311	8	1	11	2.5	Sandstone	Plane	**T. 731**	8	1	11	2.5	Sandstone	Inclined
T. 312	9	1	12	2.5	Sandstone	Plane	**T. 732**	9	1	12	2.5	Sandstone	Inclined
T. 313	9	1	13	2.5	Sandstone	Plane	**T. 733**	9	1	13	2.5	Sandstone	Inclined
T. 314	8	1	14	2.5	Sandstone	Plane	**T. 734**	8	1	14	2.5	Sandstone	Inclined
T. 315	8	1	15	2.5	Sandstone	Plane	**T. 735**	8	1	15	2.5	Sandstone	Inclined
T. 316	6	1	1	1	Brick	Plane	**T. 736**	7	1	1	1	Brick	Inclined
T. 317	6	1	2	1	Brick	Plane	**T. 737**	7	1	2	1	Brick	Inclined
T. 318	6	1	3	1	Brick	Plane	**T. 738**	7	1	3	1	Brick	Inclined
T. 319	6	1	4	1	Brick	Plane	**T. 739**	7	1	4	1	Brick	Inclined
T. 320	6	1	5	1	Brick	Plane	**T. 740**	7	1	5	1	Brick	Inclined
T. 321	6	1	6	1	Brick	Plane	**T. 741**	7	1	6	1	Brick	Inclined
T. 322	6	1	7	1	Brick	Plane	**T. 742**	7	1	7	1	Brick	Inclined
T. 323	6	1	8	1	Brick	Plane	**T. 743**	7	1	8	1	Brick	Inclined
T. 324	6	1	9	1	Brick	Plane	**T. 744**	7	1	9	1	Brick	Inclined
T. 325	6	1	10	1	Brick	Plane	**T. 745**	7	1	10	1	Brick	Inclined
T. 326	6	1	11	1	Brick	Plane	**T. 746**	7	1	11	1	Brick	Inclined
T. 327	6	1	12	1	Brick	Plane	**T. 747**	7	1	12	1	Brick	Inclined
T. 328	6	1	13	1	Brick	Plane	**T. 748**	7	1	13	1	Brick	Inclined
T. 329	6	1	14	1	Brick	Plane	**T. 749**	7	1	14	1	Brick	Inclined

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Table E.1. (cont.)

T. 330	6	1	15	1	Brick	Plane	**T. 750**	7	1	15	1	Brick	Inclined
T. 331	7	1	1	1.3	Brick	Plane	**T. 751**	8	1	1	1.3	Brick	Inclined
T. 332	7	1	2	1.3	Brick	Plane	**T. 752**	8	1	2	1.3	Brick	Inclined
T. 333	7	1	3	1.3	Brick	Plane	**T. 753**	8	1	3	1.3	Brick	Inclined
T. 334	7	1	4	1.3	Brick	Plane	**T. 754**	8	1	4	1.3	Brick	Inclined
T. 335	7	1	5	1.3	Brick	Plane	**T. 755**	8	1	5	1.3	Brick	Inclined
T. 336	7	1	6	1.3	Brick	Plane	**T. 756**	8	1	6	1.3	Brick	Inclined
T. 337	7	1	7	1.3	Brick	Plane	**T. 757**	8	1	7	1.3	Brick	Inclined
T. 338	7	1	8	1.3	Brick	Plane	**T. 758**	8	1	8	1.3	Brick	Inclined
T. 339	7	1	9	1.3	Brick	Plane	**T. 759**	8	1	9	1.3	Brick	Inclined
T. 340	7	1	10	1.3	Brick	Plane	**T. 760**	8	1	10	1.3	Brick	Inclined
T. 341	7	1	11	1.3	Brick	Plane	**T. 761**	8	1	11	1.3	Brick	Inclined
T. 342	7	1	12	1.3	Brick	Plane	**T. 762**	8	1	12	1.3	Brick	Inclined
T. 343	7	1	13	1.3	Brick	Plane	**T. 763**	8	1	13	1.3	Brick	Inclined
T. 344	7	1	14	1.3	Brick	Plane	**T. 764**	8	1	14	1.3	Brick	Inclined
T. 345	7	1	15	1.3	Brick	Plane	**T. 765**	8	1	15	1.3	Brick	Inclined
T. 346	10	1	1	1.6	Brick	Plane	**T. 766**	11	1	1	1.6	Brick	Inclined
T. 347	10	1	2	1.6	Brick	Plane	**T. 767**	11	1	2	1.6	Brick	Inclined
T. 348	10	1	3	1.6	Brick	Plane	**T. 768**	11	1	3	1.6	Brick	Inclined
T. 349	10	1	4	1.6	Brick	Plane	**T. 769**	11	1	4	1.6	Brick	Inclined
T. 350	10	1	5	1.6	Brick	Plane	**T. 770**	11	1	5	1.6	Brick	Inclined
T. 351	10	1	6	1.6	Brick	Plane	**T. 771**	11	1	6	1.6	Brick	Inclined
T. 352	10	1	7	1.6	Brick	Plane	**T. 772**	11	1	7	1.6	Brick	Inclined
T. 353	10	1	8	1.6	Brick	Plane	**T. 773**	11	1	8	1.6	Brick	Inclined
T. 354	10	1	9	1.6	Brick	Plane	**T. 774**	11	1	9	1.6	Brick	Inclined
T. 355	8	1	10	1.6	Brick	Plane	**T. 775**	9	1	10	1.6	Brick	Inclined
T. 356	9	1	11	1.6	Brick	Plane	**T. 776**	10	1	11	1.6	Brick	Inclined
T. 357	9	1	12	1.6	Brick	Plane	**T. 777**	10	1	12	1.6	Brick	Inclined
T. 358	9	1	13	1.6	Brick	Plane	**T. 778**	10	1	13	1.6	Brick	Inclined
T. 359	9	1	14	1.6	Brick	Plane	**T. 779**	10	1	14	1.6	Brick	Inclined
T. 360	9	1	15	1.6	Brick	Plane	**T. 780**	10	1	15	1.6	Brick	Inclined
T. 361	10	1	1	1.8	Brick	Plane	**T. 781**	11	1	1	1.8	Brick	Inclined
T. 362	10	1	2	1.8	Brick	Plane	**T. 782**	11	1	2	1.8	Brick	Inclined

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Table E.1. (cont.)

T. 363	10	1	3	1.8	Brick	Plane	**T. 783**	11	1	3	1.8	Brick	Inclined
T. 364	10	1	4	1.8	Brick	Plane	**T. 784**	11	1	4	1.8	Brick	Inclined
T. 365	10	1	5	1.8	Brick	Plane	**T. 785**	11	1	5	1.8	Brick	Inclined
T. 366	10	1	6	1.8	Brick	Plane	**T. 786**	11	1	6	1.8	Brick	Inclined
T. 367	10	1	7	1.8	Brick	Plane	**T. 787**	11	1	7	1.8	Brick	Inclined
T. 368	10	1	8	1.8	Brick	Plane	**T. 788**	11	1	8	1.8	Brick	Inclined
T. 369	10	1	9	1.8	Brick	Plane	**T. 789**	11	1	9	1.8	Brick	Inclined
T. 370	8	1	10	1.8	Brick	Plane	**T. 790**	9	1	10	1.8	Brick	Inclined
T. 371	9	1	11	1.8	Brick	Plane	**T. 791**	10	1	11	1.8	Brick	Inclined
T. 372	9	1	12	1.8	Brick	Plane	**T. 792**	10	1	12	1.8	Brick	Inclined
T. 373	9	1	13	1.8	Brick	Plane	**T. 793**	10	1	13	1.8	Brick	Inclined
T. 374	9	1	14	1.8	Brick	Plane	**T. 794**	10	1	14	1.8	Brick	Inclined
T. 375	9	1	15	1.8	Brick	Plane	**T. 795**	10	1	15	1.8	Brick	Inclined
T. 376	10	1	1	2	Brick	Plane	**T. 796**	11	1	1	2	Brick	Inclined
T. 377	10	1	2	2	Brick	Plane	**T. 797**	11	1	2	2	Brick	Inclined
T. 378	10	1	3	2	Brick	Plane	**T. 798**	11	1	3	2	Brick	Inclined
T. 379	10	1	4	2	Brick	Plane	**T. 799**	11	1	4	2	Brick	Inclined
T. 380	10	1	5	2	Brick	Plane	**T. 800**	11	1	5	2	Brick	Inclined
T. 381	10	1	6	2	Brick	Plane	**T. 801**	11	1	6	2	Brick	Inclined
T. 382	10	1	7	2	Brick	Plane	**T. 802**	11	1	7	2	Brick	Inclined
T. 383	10	1	8	2	Brick	Plane	**T. 803**	11	1	8	2	Brick	Inclined
T. 384	10	1	9	2	Brick	Plane	**T. 804**	11	1	9	2	Brick	Inclined
T. 385	8	1	10	2	Brick	Plane	**T. 805**	9	1	10	2	Brick	Inclined
T. 386	9	1	11	2	Brick	Plane	**T. 806**	10	1	11	2	Brick	Inclined
T. 387	9	1	12	2	Brick	Plane	**T. 807**	10	1	12	2	Brick	Inclined
T. 388	9	1	13	2	Brick	Plane	**T. 808**	10	1	13	2	Brick	Inclined
T. 389	9	1	14	2	Brick	Plane	**T. 809**	10	1	14	2	Brick	Inclined
T. 390	9	1	15	2	Brick	Plane	**T. 810**	10	1	15	2	Brick	Inclined
T. 391	10	1	1	2.3	Brick	Plane	**T. 811**	11	1	1	2.3	Brick	Inclined
T. 392	10	1	2	2.3	Brick	Plane	**T. 812**	11	1	2	2.3	Brick	Inclined
T. 393	10	1	3	2.3	Brick	Plane	**T. 813**	11	1	3	2.3	Brick	Inclined
T. 394	10	1	4	2.3	Brick	Plane	**T. 814**	11	1	4	2.3	Brick	Inclined
T. 395	10	1	5	2.3	Brick	Plane	**T. 815**	11	1	5	2.3	Brick	Inclined

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Table E.1. (cont.)

T. 396	10	1	6	2.3	Brick	Plane	**T. 816**	11	1	6	2.3	Brick	Inclined
T. 397	10	1	7	2.3	Brick	Plane	**T. 817**	11	1	7	2.3	Brick	Inclined
T. 398	10	1	8	2.3	Brick	Plane	**T. 818**	11	1	8	2.3	Brick	Inclined
T. 399	10	1	9	2.3	Brick	Plane	**T. 819**	11	1	9	2.3	Brick	Inclined
T. 400	8	1	10	2.3	Brick	Plane	**T. 820**	9	1	10	2.3	Brick	Inclined
T. 401	9	1	11	2.3	Brick	Plane	**T. 821**	10	1	11	2.3	Brick	Inclined
T. 402	9	1	12	2.3	Brick	Plane	**T. 822**	10	1	12	2.3	Brick	Inclined
T. 403	9	1	13	2.3	Brick	Plane	**T. 823**	10	1	13	2.3	Brick	Inclined
T. 404	9	1	14	2.3	Brick	Plane	**T. 824**	10	1	14	2.3	Brick	Inclined
T. 405	9	1	15	2.3	Brick	Plane	**T. 825**	10	1	15	2.3	Brick	Inclined
T. 406	9	1	1	2.5	Brick	Plane	**T. 826**	10	1	1	2.5	Brick	Inclined
T. 407	9	1	2	2.5	Brick	Plane	**T. 827**	10	1	2	2.5	Brick	Inclined
T. 408	9	1	3	2.5	Brick	Plane	**T. 828**	10	1	3	2.5	Brick	Inclined
T. 409	9	1	4	2.5	Brick	Plane	**T. 829**	10	1	4	2.5	Brick	Inclined
T. 410	9	1	5	2.5	Brick	Plane	**T. 830**	10	1	5	2.5	Brick	Inclined
T. 411	9	1	6	2.5	Brick	Plane	**T. 831**	10	1	6	2.5	Brick	Inclined
T. 412	9	1	7	2.5	Brick	Plane	**T. 832**	10	1	7	2.5	Brick	Inclined
T. 413	9	1	8	2.5	Brick	Plane	**T. 833**	10	1	8	2.5	Brick	Inclined
T. 414	9	1	9	2.5	Brick	Plane	**T. 834**	10	1	9	2.5	Brick	Inclined
T. 415	7	1	10	2.5	Brick	Plane	**T. 835**	8	1	10	2.5	Brick	Inclined
T. 416	8	1	11	2.5	Brick	Plane	**T. 836**	9	1	11	2.5	Brick	Inclined
T. 417	9	1	12	2.5	Brick	Plane	**T. 837**	10	1	12	2.5	Brick	Inclined
T. 418	10	1	13	2.5	Brick	Plane	**T. 838**	11	1	13	2.5	Brick	Inclined
T. 419	8	1	14	2.5	Brick	Plane	**T. 839**	9	1	14	2.5	Brick	Inclined
T. 420	8	1	15	2.5	Brick	Plane	**T. 840**	9	1	15	2.5	Brick	Inclined
T. 841	9	2	1	1	Granite	Plane	**T. 1261**	10	2	1	1	Granite	Inclined
T. 842	9	2	2	1	Granite	Plane	**T. 1262**	10	2	2	1	Granite	Inclined
T. 843	9	2	3	1	Granite	Plane	**T. 1263**	10	2	3	1	Granite	Inclined
T. 844	9	2	4	1	Granite	Plane	**T. 1264**	10	2	4	1	Granite	Inclined
T. 845	9	2	5	1	Granite	Plane	**T. 1265**	10	2	5	1	Granite	Inclined
T. 846	9	2	6	1	Granite	Plane	**T. 1266**	10	2	6	1	Granite	Inclined
T. 847	9	2	7	1	Granite	Plane	**T. 1267**	10	2	7	1	Granite	Inclined
T. 848	9	2	8	1	Granite	Plane	**T. 1268**	10	2	8	1	Granite	Inclined

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Table E.1. (cont.)

T. 849	9	2	9	1	Granite	Plane	**T. 1269**	10	2	9	1	Granite	Inclined
T. 850	9	2	10	1	Granite	Plane	**T. 1270**	10	2	10	1	Granite	Inclined
T. 851	9	2	11	1	Granite	Plane	**T. 1271**	10	2	11	1	Granite	Inclined
T. 852	9	2	12	1	Granite	Plane	**T. 1272**	10	2	12	1	Granite	Inclined
T. 853	9	2	13	1	Granite	Plane	**T. 1273**	10	2	13	1	Granite	Inclined
T. 854	9	2	14	1	Granite	Plane	**T. 1274**	10	2	14	1	Granite	Inclined
T. 855	9	2	15	1	Granite	Plane	**T. 1275**	10	2	15	1	Granite	Inclined
T. 856	11	2	1	1.3	Granite	Plane	**T. 1276**	12	2	1	1.3	Granite	Inclined
T. 857	11	2	2	1.3	Granite	Plane	**T. 1277**	12	2	2	1.3	Granite	Inclined
T. 858	11	2	3	1.3	Granite	Plane	**T. 1278**	12	2	3	1.3	Granite	Inclined
T. 859	11	2	4	1.3	Granite	Plane	**T. 1279**	12	2	4	1.3	Granite	Inclined
T. 860	11	2	5	1.3	Granite	Plane	**T. 1280**	12	2	5	1.3	Granite	Inclined
T. 861	11	2	6	1.3	Granite	Plane	**T. 1281**	12	2	6	1.3	Granite	Inclined
T. 862	11	2	7	1.3	Granite	Plane	**T. 1282**	12	2	7	1.3	Granite	Inclined
T. 863	11	2	8	1.3	Granite	Plane	**T. 1283**	12	2	8	1.3	Granite	Inclined
T. 864	11	2	9	1.3	Granite	Plane	**T. 1284**	12	2	9	1.3	Granite	Inclined
T. 865	10	2	10	1.3	Granite	Plane	**T. 1285**	11	2	10	1.3	Granite	Inclined
T. 866	10	2	11	1.3	Granite	Plane	**T. 1286**	11	2	11	1.3	Granite	Inclined
T. 867	11	2	12	1.3	Granite	Plane	**T. 1287**	12	2	12	1.3	Granite	Inclined
T. 868	11	2	13	1.3	Granite	Plane	**T. 1288**	12	2	13	1.3	Granite	Inclined
T. 869	11	2	14	1.3	Granite	Plane	**T. 1289**	12	2	14	1.3	Granite	Inclined
T. 870	11	2	15	1.3	Granite	Plane	**T. 1290**	12	2	15	1.3	Granite	Inclined
***T. 871**	12	2	1	1.6	Granite	Plane	***T. 1291**	13	2	1	1.6	Granite	Inclined
***T. 872**	12	2	2	1.6	Granite	Plane	***T. 1292**	13	2	2	1.6	Granite	Inclined
***T. 873**	12	2	3	1.6	Granite	Plane	***T. 1293**	13	2	3	1.6	Granite	Inclined
***T. 874**	12	2	4	1.6	Granite	Plane	***T. 1294**	13	2	4	1.6	Granite	Inclined
***T. 875**	12	2	5	1.6	Granite	Plane	***T. 1295**	13	2	5	1.6	Granite	Inclined
***T. 876**	12	2	6	1.6	Granite	Plane	***T. 1296**	13	2	6	1.6	Granite	Inclined
***T. 877**	12	2	7	1.6	Granite	Plane	***T. 1297**	13	2	7	1.6	Granite	Inclined
***T. 878**	12	2	8	1.6	Granite	Plane	***T. 1298**	13	2	8	1.6	Granite	Inclined
***T. 879**	12	2	9	1.6	Granite	Plane	***T. 1299**	13	2	9	1.6	Granite	Inclined
***T. 880**	11	2	10	1.6	Granite	Plane	***T. 1300**	12	2	10	1.6	Granite	Inclined
***T. 881**	11	2	11	1.6	Granite	Plane	***T. 1301**	12	2	11	1.6	Granite	Inclined

(cont. on next page)

Table E.1. (cont.)

***T. 882**	12	2	12	1.6	Granite	Plane	***T. 1302**	13	2	12	1.6	Granite	Inclined
***T. 883**	12	2	13	1.6	Granite	Plane	***T. 1303**	13	2	13	1.6	Granite	Inclined
***T. 884**	11	2	14	1.6	Granite	Plane	***T. 1304**	12	2	14	1.6	Granite	Inclined
***T. 885**	11	2	15	1.6	Granite	Plane	***T. 1305**	12	2	15	1.6	Granite	Inclined
***T. 886**	12	2	1	1.8	Granite	Plane	***T. 1306**	13	2	1	1.8	Granite	Inclined
***T. 887**	12	2	2	1.8	Granite	Plane	***T. 1307**	13	2	2	1.8	Granite	Inclined
***T. 888**	12	2	3	1.8	Granite	Plane	***T. 1308**	13	2	3	1.8	Granite	Inclined
***T. 889**	12	2	4	1.8	Granite	Plane	***T. 1309**	13	2	4	1.8	Granite	Inclined
***T. 890**	12	2	5	1.8	Granite	Plane	***T. 1310**	13	2	5	1.8	Granite	Inclined
***T. 891**	12	2	6	1.8	Granite	Plane	***T. 1311**	13	2	6	1.8	Granite	Inclined
***T. 892**	12	2	7	1.8	Granite	Plane	***T. 1312**	13	2	7	1.8	Granite	Inclined
***T. 893**	12	2	8	1.8	Granite	Plane	***T. 1313**	13	2	8	1.8	Granite	Inclined
***T. 894**	12	2	9	1.8	Granite	Plane	***T. 1314**	13	2	9	1.8	Granite	Inclined
***T. 895**	11	2	10	1.8	Granite	Plane	***T. 1315**	12	2	10	1.8	Granite	Inclined
***T. 896**	11	2	11	1.8	Granite	Plane	***T. 1316**	12	2	11	1.8	Granite	Inclined
***T. 897**	12	2	12	1.8	Granite	Plane	***T. 1317**	13	2	12	1.8	Granite	Inclined
***T. 898**	12	2	13	1.8	Granite	Plane	***T. 1318**	13	2	13	1.8	Granite	Inclined
***T. 899**	11	2	14	1.8	Granite	Plane	***T. 1319**	12	2	14	1.8	Granite	Inclined
***T. 900**	11	2	15	1.8	Granite	Plane	***T. 1320**	12	2	15	1.8	Granite	Inclined
***T. 901**	11	2	1	2	Granite	Plane	***T. 1321**	12	2	1	2	Granite	Inclined
***T. 902**	12	2	2	2	Granite	Plane	***T. 1322**	13	2	2	2	Granite	Inclined
***T. 903**	12	2	3	2	Granite	Plane	***T. 1323**	13	2	3	2	Granite	Inclined
***T. 904**	12	2	4	2	Granite	Plane	***T. 1324**	13	2	4	2	Granite	Inclined
***T. 905**	12	2	5	2	Granite	Plane	***T. 1325**	13	2	5	2	Granite	Inclined
***T. 906**	12	2	6	2	Granite	Plane	***T. 1326**	13	2	6	2	Granite	Inclined
***T. 907**	12	2	7	2	Granite	Plane	***T. 1327**	13	2	7	2	Granite	Inclined
***T. 908**	12	2	8	2	Granite	Plane	***T. 1328**	13	2	8	2	Granite	Inclined
***T. 909**	11	2	9	2	Granite	Plane	***T. 1329**	12	2	9	2	Granite	Inclined
***T. 910**	10	2	10	2	Granite	Plane	***T. 1330**	11	2	10	2	Granite	Inclined
***T. 911**	10	2	11	2	Granite	Plane	***T. 1331**	11	2	11	2	Granite	Inclined
***T. 912**	11	2	12	2	Granite	Plane	***T. 1332**	12	2	12	2	Granite	Inclined
***T. 913**	11	2	13	2	Granite	Plane	***T. 1333**	12	2	13	2	Granite	Inclined
***T. 914**	10	2	14	2	Granite	Plane	***T. 1334**	11	2	14	2	Granite	Inclined

(cont. on next page)

Table E.1. (cont.)

***T. 915**	10	2	15	2	Granite	Plane	***T. 1335**	11	2	15	2	Granite	Inclined
***T. 916**	12	2	1	2.3	Granite	Plane	***T. 1336**	13	2	1	2.3	Granite	Inclined
***T. 917**	12	2	2	2.3	Granite	Plane	***T. 1337**	13	2	2	2.3	Granite	Inclined
***T. 918**	12	2	3	2.3	Granite	Plane	***T. 1338**	13	2	3	2.3	Granite	Inclined
***T. 919**	12	2	4	2.3	Granite	Plane	***T. 1339**	13	2	4	2.3	Granite	Inclined
***T. 920**	12	2	5	2.3	Granite	Plane	***T. 1340**	13	2	5	2.3	Granite	Inclined
***T. 921**	12	2	6	2.3	Granite	Plane	***T. 1341**	13	2	6	2.3	Granite	Inclined
***T. 922**	12	2	7	2.3	Granite	Plane	***T. 1342**	13	2	7	2.3	Granite	Inclined
***T. 923**	12	2	8	2.3	Granite	Plane	***T. 1343**	13	2	8	2.3	Granite	Inclined
***T. 924**	11	2	9	2.3	Granite	Plane	***T. 1344**	12	2	9	2.3	Granite	Inclined
***T. 925**	10	2	10	2.3	Granite	Plane	***T. 1345**	11	2	10	2.3	Granite	Inclined
***T. 926**	11	2	11	2.3	Granite	Plane	***T. 1346**	12	2	11	2.3	Granite	Inclined
***T. 927**	10	2	12	2.3	Granite	Plane	***T. 1347**	11	2	12	2.3	Granite	Inclined
***T. 928**	10	2	13	2.3	Granite	Plane	***T. 1348**	11	2	13	2.3	Granite	Inclined
***T. 929**	9	2	14	2.3	Granite	Plane	***T. 1349**	10	2	14	2.3	Granite	Inclined
***T. 930**	9	2	15	2.3	Granite	Plane	***T. 1350**	10	2	15	2.3	Granite	Inclined
T. 931	12	2	1	2.5	Granite	Plane	**T. 1351**	13	2	1	2.5	Granite	Inclined
T. 932	12	2	2	2.5	Granite	Plane	**T. 1352**	13	2	2	2.5	Granite	Inclined
T. 933	12	2	3	2.5	Granite	Plane	**T. 1353**	13	2	3	2.5	Granite	Inclined
T. 934	12	2	4	2.5	Granite	Plane	**T. 1354**	13	2	4	2.5	Granite	Inclined
T. 935	12	2	5	2.5	Granite	Plane	**T. 1355**	13	2	5	2.5	Granite	Inclined
T. 936	12	2	6	2.5	Granite	Plane	**T. 1356**	13	2	6	2.5	Granite	Inclined
T. 937	12	2	7	2.5	Granite	Plane	**T. 1357**	13	2	7	2.5	Granite	Inclined
T. 938	12	2	8	2.5	Granite	Plane	**T. 1358**	13	2	8	2.5	Granite	Inclined
T. 939	11	2	9	2.5	Granite	Plane	**T. 1359**	12	2	9	2.5	Granite	Inclined
T. 940	9	2	10	2.5	Granite	Plane	**T. 1360**	10	2	10	2.5	Granite	Inclined
T. 941	10	2	11	2.5	Granite	Plane	**T. 1361**	11	2	11	2.5	Granite	Inclined
T. 942	9	2	12	2.5	Granite	Plane	**T. 1362**	10	2	12	2.5	Granite	Inclined
T. 943	9	2	13	2.5	Granite	Plane	**T. 1363**	10	2	13	2.5	Granite	Inclined
T. 944	8	2	14	2.5	Granite	Plane	**T. 1364**	9	2	14	2.5	Granite	Inclined
T. 945	8	2	15	2.5	Granite	Plane	**T. 1365**	9	2	15	2.5	Granite	Inclined
T. 946	9	2	1	1	Limestone	Plane	**T. 1366**	10	2	1	1	Limestone	Inclined
T. 947	9	2	2	1	Limestone	Plane	**T. 1367**	10	2	2	1	Limestone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 948	9	2	3	1	Limestone	Plane	**T. 1368**	10	2	3	1	Limestone	Inclined
T. 949	9	2	4	1	Limestone	Plane	**T. 1369**	10	2	4	1	Limestone	Inclined
T. 950	9	2	5	1	Limestone	Plane	**T. 1370**	10	2	5	1	Limestone	Inclined
T. 951	9	2	6	1	Limestone	Plane	**T. 1371**	10	2	6	1	Limestone	Inclined
T. 952	9	2	7	1	Limestone	Plane	**T. 1372**	10	2	7	1	Limestone	Inclined
T. 953	9	2	8	1	Limestone	Plane	**T. 1373**	10	2	8	1	Limestone	Inclined
T. 954	9	2	9	1	Limestone	Plane	**T. 1374**	10	2	9	1	Limestone	Inclined
T. 955	9	2	10	1	Limestone	Plane	**T. 1375**	10	2	10	1	Limestone	Inclined
T. 956	9	2	11	1	Limestone	Plane	**T. 1376**	10	2	11	1	Limestone	Inclined
T. 957	9	2	12	1	Limestone	Plane	**T. 1377**	10	2	12	1	Limestone	Inclined
T. 958	9	2	13	1	Limestone	Plane	**T. 1378**	10	2	13	1	Limestone	Inclined
T. 959	9	2	14	1	Limestone	Plane	**T. 1379**	10	2	14	1	Limestone	Inclined
T. 960	9	2	15	1	Limestone	Plane	**T. 1380**	10	2	15	1	Limestone	Inclined
T. 961	11	2	1	1.3	Limestone	Plane	**T. 1381**	12	2	1	1.3	Limestone	Inclined
T. 962	11	2	2	1.3	Limestone	Plane	**T. 1382**	12	2	2	1.3	Limestone	Inclined
T. 963	11	2	3	1.3	Limestone	Plane	**T. 1383**	12	2	3	1.3	Limestone	Inclined
T. 964	11	2	4	1.3	Limestone	Plane	**T. 1384**	12	2	4	1.3	Limestone	Inclined
T. 965	11	2	5	1.3	Limestone	Plane	**T. 1385**	12	2	5	1.3	Limestone	Inclined
T. 966	11	2	6	1.3	Limestone	Plane	**T. 1386**	12	2	6	1.3	Limestone	Inclined
T. 967	11	2	7	1.3	Limestone	Plane	**T. 1387**	12	2	7	1.3	Limestone	Inclined
T. 968	11	2	8	1.3	Limestone	Plane	**T. 1388**	12	2	8	1.3	Limestone	Inclined
T. 969	11	2	9	1.3	Limestone	Plane	**T. 1389**	12	2	9	1.3	Limestone	Inclined
T. 970	10	2	10	1.3	Limestone	Plane	**T. 1390**	11	2	10	1.3	Limestone	Inclined
T. 971	10	2	11	1.3	Limestone	Plane	**T. 1391**	11	2	11	1.3	Limestone	Inclined
T. 972	11	2	12	1.3	Limestone	Plane	**T. 1392**	12	2	12	1.3	Limestone	Inclined
T. 973	11	2	13	1.3	Limestone	Plane	**T. 1393**	12	2	13	1.3	Limestone	Inclined
T. 974	11	2	14	1.3	Limestone	Plane	**T. 1394**	12	2	14	1.3	Limestone	Inclined
T. 975	11	2	15	1.3	Limestone	Plane	**T. 1395**	12	2	15	1.3	Limestone	Inclined
***T. 976**	12	2	1	1.6	Limestone	Plane	***T. 1396**	13	2	1	1.6	Limestone	Inclined
***T. 977**	12	2	2	1.6	Limestone	Plane	***T. 1397**	13	2	2	1.6	Limestone	Inclined
***T. 978**	12	2	3	1.6	Limestone	Plane	***T. 1398**	13	2	3	1.6	Limestone	Inclined
***T. 979**	12	2	4	1.6	Limestone	Plane	***T. 1399**	13	2	4	1.6	Limestone	Inclined
***T. 980**	12	2	5	1.6	Limestone	Plane	***T. 1400**	13	2	5	1.6	Limestone	Inclined

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Table E.1. (cont.)

***T. 981**	12	2	6	1.6	Limestone	Plane	***T. 1401**	13	2	6	1.6	Limestone	Inclined
***T. 982**	12	2	7	1.6	Limestone	Plane	***T. 1402**	13	2	7	1.6	Limestone	Inclined
***T. 983**	12	2	8	1.6	Limestone	Plane	***T. 1403**	13	2	8	1.6	Limestone	Inclined
***T. 984**	12	2	9	1.6	Limestone	Plane	***T. 1404**	13	2	9	1.6	Limestone	Inclined
***T. 985**	11	2	10	1.6	Limestone	Plane	***T. 1405**	12	2	10	1.6	Limestone	Inclined
***T. 986**	11	2	11	1.6	Limestone	Plane	***T. 1406**	12	2	11	1.6	Limestone	Inclined
***T. 987**	12	2	12	1.6	Limestone	Plane	***T. 1407**	13	2	12	1.6	Limestone	Inclined
***T. 988**	12	2	13	1.6	Limestone	Plane	***T. 1408**	13	2	13	1.6	Limestone	Inclined
***T. 989**	11	2	14	1.6	Limestone	Plane	***T. 1409**	12	2	14	1.6	Limestone	Inclined
***T. 990**	11	2	15	1.6	Limestone	Plane	***T. 1410**	12	2	15	1.6	Limestone	Inclined
***T. 991**	12	2	1	1.8	Limestone	Plane	***T. 1411**	13	2	1	1.8	Limestone	Inclined
***T. 992**	12	2	2	1.8	Limestone	Plane	***T. 1412**	13	2	2	1.8	Limestone	Inclined
***T. 993**	12	2	3	1.8	Limestone	Plane	***T. 1413**	13	2	3	1.8	Limestone	Inclined
***T. 994**	12	2	4	1.8	Limestone	Plane	***T. 1414**	13	2	4	1.8	Limestone	Inclined
***T. 995**	12	2	5	1.8	Limestone	Plane	***T. 1415**	13	2	5	1.8	Limestone	Inclined
***T. 996**	12	2	6	1.8	Limestone	Plane	***T. 1416**	13	2	6	1.8	Limestone	Inclined
***T. 997**	12	2	7	1.8	Limestone	Plane	***T. 1417**	13	2	7	1.8	Limestone	Inclined
***T. 998**	12	2	8	1.8	Limestone	Plane	***T. 1418**	13	2	8	1.8	Limestone	Inclined
***T. 999**	12	2	9	1.8	Limestone	Plane	***T. 1419**	13	2	9	1.8	Limestone	Inclined
***T. 1000**	11	2	10	1.8	Limestone	Plane	***T. 1420**	12	2	10	1.8	Limestone	Inclined
***T. 1001**	11	2	11	1.8	Limestone	Plane	***T. 1421**	12	2	11	1.8	Limestone	Inclined
***T. 1002**	12	2	12	1.8	Limestone	Plane	***T. 1422**	13	2	12	1.8	Limestone	Inclined
***T. 1003**	12	2	13	1.8	Limestone	Plane	***T. 1423**	13	2	13	1.8	Limestone	Inclined
***T. 1004**	11	2	14	1.8	Limestone	Plane	***T. 1424**	12	2	14	1.8	Limestone	Inclined
***T. 1005**	11	2	15	1.8	Limestone	Plane	***T. 1425**	12	2	15	1.8	Limestone	Inclined
***T. 1006**	11	2	1	2	Limestone	Plane	***T. 1426**	12	2	1	2	Limestone	Inclined
***T. 1007**	12	2	2	2	Limestone	Plane	***T. 1427**	13	2	2	2	Limestone	Inclined
***T. 1008**	12	2	3	2	Limestone	Plane	***T. 1428**	13	2	3	2	Limestone	Inclined
***T. 1009**	12	2	4	2	Limestone	Plane	***T. 1429**	13	2	4	2	Limestone	Inclined
***T. 1010**	12	2	5	2	Limestone	Plane	***T. 1430**	13	2	5	2	Limestone	Inclined
***T. 1011**	12	2	6	2	Limestone	Plane	***T. 1431**	13	2	6	2	Limestone	Inclined
***T. 1012**	12	2	7	2	Limestone	Plane	***T. 1432**	13	2	7	2	Limestone	Inclined
***T. 1013**	12	2	8	2	Limestone	Plane	***T. 1433**	13	2	8	2	Limestone	Inclined

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Table E.1. (cont.)

***T. 1014**	11	2	9	2	Limestone	Plane	***T. 1434**	12	2	9	2	Limestone	Inclined
***T. 1015**	10	2	10	2	Limestone	Plane	***T. 1435**	11	2	10	2	Limestone	Inclined
***T. 1016**	10	2	11	2	Limestone	Plane	***T. 1436**	11	2	11	2	Limestone	Inclined
***T. 1017**	11	2	12	2	Limestone	Plane	***T. 1437**	12	2	12	2	Limestone	Inclined
***T. 1018**	11	2	13	2	Limestone	Plane	***T. 1438**	12	2	13	2	Limestone	Inclined
***T. 1019**	10	2	14	2	Limestone	Plane	***T. 1439**	11	2	14	2	Limestone	Inclined
***T. 1020**	10	2	15	2	Limestone	Plane	***T. 1440**	11	2	15	2	Limestone	Inclined
***T. 1021**	12	2	1	2.3	Limestone	Plane	***T. 1441**	13	2	1	2.3	Limestone	Inclined
***T. 1022**	12	2	2	2.3	Limestone	Plane	***T. 1442**	13	2	2	2.3	Limestone	Inclined
***T. 1023**	12	2	3	2.3	Limestone	Plane	***T. 1443**	13	2	3	2.3	Limestone	Inclined
***T. 1024**	12	2	4	2.3	Limestone	Plane	***T. 1444**	13	2	4	2.3	Limestone	Inclined
***T. 1025**	12	2	5	2.3	Limestone	Plane	***T. 1445**	13	2	5	2.3	Limestone	Inclined
***T. 1026**	12	2	6	2.3	Limestone	Plane	***T. 1446**	13	2	6	2.3	Limestone	Inclined
***T. 1027**	12	2	7	2.3	Limestone	Plane	***T. 1447**	13	2	7	2.3	Limestone	Inclined
***T. 1028**	12	2	8	2.3	Limestone	Plane	***T. 1448**	13	2	8	2.3	Limestone	Inclined
***T. 1029**	11	2	9	2.3	Limestone	Plane	***T. 1449**	12	2	9	2.3	Limestone	Inclined
***T. 1030**	10	2	10	2.3	Limestone	Plane	***T. 1450**	11	2	10	2.3	Limestone	Inclined
***T. 1031**	11	2	11	2.3	Limestone	Plane	***T. 1451**	12	2	11	2.3	Limestone	Inclined
***T. 1032**	10	2	12	2.3	Limestone	Plane	***T. 1452**	11	2	12	2.3	Limestone	Inclined
***T. 1033**	10	2	13	2.3	Limestone	Plane	***T. 1453**	11	2	13	2.3	Limestone	Inclined
***T. 1034**	9	2	14	2.3	Limestone	Plane	***T. 1454**	10	2	14	2.3	Limestone	Inclined
***T. 1035**	9	2	15	2.3	Limestone	Plane	***T. 1455**	10	2	15	2.3	Limestone	Inclined
T. 1036	12	2	1	2.5	Limestone	Plane	**T. 1456**	13	2	1	2.5	Limestone	Inclined
T. 1037	12	2	2	2.5	Limestone	Plane	**T. 1457**	13	2	2	2.5	Limestone	Inclined
T. 1038	12	2	3	2.5	Limestone	Plane	**T. 1458**	13	2	3	2.5	Limestone	Inclined
T. 1039	12	2	4	2.5	Limestone	Plane	**T. 1459**	13	2	4	2.5	Limestone	Inclined
T. 1040	12	2	5	2.5	Limestone	Plane	**T. 1460**	13	2	5	2.5	Limestone	Inclined
T. 1041	12	2	6	2.5	Limestone	Plane	**T. 1461**	13	2	6	2.5	Limestone	Inclined
T. 1042	12	2	7	2.5	Limestone	Plane	**T. 1462**	13	2	7	2.5	Limestone	Inclined
T. 1043	12	2	8	2.5	Limestone	Plane	**T. 1463**	13	2	8	2.5	Limestone	Inclined
T. 1044	11	2	9	2.5	Limestone	Plane	**T. 1464**	12	2	9	2.5	Limestone	Inclined
T. 1045	9	2	10	2.5	Limestone	Plane	**T. 1465**	10	2	10	2.5	Limestone	Inclined
T. 1046	10	2	11	2.5	Limestone	Plane	**T. 1466**	11	2	11	2.5	Limestone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 1047	9	2	12	2.5	Limestone	Plane	**T. 1467**	10	2	12	2.5	Limestone	Inclined
T. 1048	9	2	13	2.5	Limestone	Plane	**T. 1468**	10	2	13	2.5	Limestone	Inclined
T. 1049	8	2	14	2.5	Limestone	Plane	**T. 1469**	9	2	14	2.5	Limestone	Inclined
T. 1050	8	2	15	2.5	Limestone	Plane	**T. 1470**	9	2	15	2.5	Limestone	Inclined
T. 1051	9	2	1	1	Sandstone	Plane	**T. 1471**	10	2	1	1	Sandstone	Inclined
T. 1052	9	2	2	1	Sandstone	Plane	**T. 1472**	10	2	2	1	Sandstone	Inclined
T. 1053	9	2	3	1	Sandstone	Plane	**T. 1473**	10	2	3	1	Sandstone	Inclined
T. 1054	9	2	4	1	Sandstone	Plane	**T. 1474**	10	2	4	1	Sandstone	Inclined
T. 1055	9	2	5	1	Sandstone	Plane	**T. 1475**	10	2	5	1	Sandstone	Inclined
T. 1056	9	2	6	1	Sandstone	Plane	**T. 1476**	10	2	6	1	Sandstone	Inclined
T. 1057	9	2	7	1	Sandstone	Plane	**T. 1477**	10	2	7	1	Sandstone	Inclined
T. 1058	9	2	8	1	Sandstone	Plane	**T. 1478**	10	2	8	1	Sandstone	Inclined
T. 1059	9	2	9	1	Sandstone	Plane	**T. 1479**	10	2	9	1	Sandstone	Inclined
T. 1060	9	2	10	1	Sandstone	Plane	**T. 1480**	10	2	10	1	Sandstone	Inclined
T. 1061	9	2	11	1	Sandstone	Plane	**T. 1481**	10	2	11	1	Sandstone	Inclined
T. 1062	9	2	12	1	Sandstone	Plane	**T. 1482**	10	2	12	1	Sandstone	Inclined
T. 1063	9	2	13	1	Sandstone	Plane	**T. 1483**	10	2	13	1	Sandstone	Inclined
T. 1064	9	2	14	1	Sandstone	Plane	**T. 1484**	10	2	14	1	Sandstone	Inclined
T. 1065	9	2	15	1	Sandstone	Plane	**T. 1485**	10	2	15	1	Sandstone	Inclined
T. 1066	11	2	1	1.3	Sandstone	Plane	**T. 1486**	12	2	1	1.3	Sandstone	Inclined
T. 1067	11	2	2	1.3	Sandstone	Plane	**T. 1487**	12	2	2	1.3	Sandstone	Inclined
T. 1068	11	2	3	1.3	Sandstone	Plane	**T. 1488**	12	2	3	1.3	Sandstone	Inclined
T. 1069	11	2	4	1.3	Sandstone	Plane	**T. 1489**	12	2	4	1.3	Sandstone	Inclined
T. 1070	11	2	5	1.3	Sandstone	Plane	**T. 1490**	12	2	5	1.3	Sandstone	Inclined
T. 1071	11	2	6	1.3	Sandstone	Plane	**T. 1491**	12	2	6	1.3	Sandstone	Inclined
T. 1072	11	2	7	1.3	Sandstone	Plane	**T. 1492**	12	2	7	1.3	Sandstone	Inclined
T. 1073	11	2	8	1.3	Sandstone	Plane	**T. 1493**	12	2	8	1.3	Sandstone	Inclined
T. 1074	11	2	9	1.3	Sandstone	Plane	**T. 1494**	12	2	9	1.3	Sandstone	Inclined
T. 1075	10	2	10	1.3	Sandstone	Plane	**T. 1495**	11	2	10	1.3	Sandstone	Inclined
T. 1076	10	2	11	1.3	Sandstone	Plane	**T. 1496**	11	2	11	1.3	Sandstone	Inclined
T. 1077	11	2	12	1.3	Sandstone	Plane	**T. 1497**	12	2	12	1.3	Sandstone	Inclined
T. 1078	11	2	13	1.3	Sandstone	Plane	**T. 1498**	12	2	13	1.3	Sandstone	Inclined
T. 1079	11	2	14	1.3	Sandstone	Plane	**T. 1499**	12	2	14	1.3	Sandstone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 1080	11	2	15	1.3	Sandstone	Plane	**T. 1500**	12	2	15	1.3	Sandstone	Inclined
T. 1081	12	2	1	1.6	Sandstone	Plane	**T. 1501**	13	2	1	1.6	Sandstone	Inclined
T. 1082	12	2	2	1.6	Sandstone	Plane	**T. 1502**	13	2	2	1.6	Sandstone	Inclined
T. 1083	12	2	3	1.6	Sandstone	Plane	**T. 1503**	13	2	3	1.6	Sandstone	Inclined
T. 1084	12	2	4	1.6	Sandstone	Plane	**T. 1504**	13	2	4	1.6	Sandstone	Inclined
T. 1085	12	2	5	1.6	Sandstone	Plane	**T. 1505**	13	2	5	1.6	Sandstone	Inclined
T. 1086	12	2	6	1.6	Sandstone	Plane	**T. 1506**	13	2	6	1.6	Sandstone	Inclined
T. 1087	12	2	7	1.6	Sandstone	Plane	**T. 1507**	13	2	7	1.6	Sandstone	Inclined
T. 1088	12	2	8	1.6	Sandstone	Plane	**T. 1508**	13	2	8	1.6	Sandstone	Inclined
T. 1089	12	2	9	1.6	Sandstone	Plane	**T. 1509**	13	2	9	1.6	Sandstone	Inclined
T. 1090	11	2	10	1.6	Sandstone	Plane	**T. 1510**	12	2	10	1.6	Sandstone	Inclined
T. 1091	11	2	11	1.6	Sandstone	Plane	**T. 1511**	12	2	11	1.6	Sandstone	Inclined
T. 1092	12	2	12	1.6	Sandstone	Plane	**T. 1512**	13	2	12	1.6	Sandstone	Inclined
T. 1093	12	2	13	1.6	Sandstone	Plane	**T. 1513**	13	2	13	1.6	Sandstone	Inclined
T. 1094	11	2	14	1.6	Sandstone	Plane	**T. 1514**	12	2	14	1.6	Sandstone	Inclined
T. 1095	11	2	15	1.6	Sandstone	Plane	**T. 1515**	12	2	15	1.6	Sandstone	Inclined
T. 1096	12	2	1	1.8	Sandstone	Plane	**T. 1516**	13	2	1	1.8	Sandstone	Inclined
T. 1097	12	2	2	1.8	Sandstone	Plane	**T. 1517**	13	2	2	1.8	Sandstone	Inclined
T. 1098	12	2	3	1.8	Sandstone	Plane	**T. 1518**	13	2	3	1.8	Sandstone	Inclined
T. 1099	12	2	4	1.8	Sandstone	Plane	**T. 1519**	13	2	4	1.8	Sandstone	Inclined
T. 1100	12	2	5	1.8	Sandstone	Plane	**T. 1520**	13	2	5	1.8	Sandstone	Inclined
T. 1101	12	2	6	1.8	Sandstone	Plane	**T. 1521**	13	2	6	1.8	Sandstone	Inclined
T. 1102	12	2	7	1.8	Sandstone	Plane	**T. 1522**	13	2	7	1.8	Sandstone	Inclined
T. 1103	12	2	8	1.8	Sandstone	Plane	**T. 1523**	13	2	8	1.8	Sandstone	Inclined
T. 1104	12	2	9	1.8	Sandstone	Plane	**T. 1524**	13	2	9	1.8	Sandstone	Inclined
T. 1105	11	2	10	1.8	Sandstone	Plane	**T. 1525**	12	2	10	1.8	Sandstone	Inclined
T. 1106	11	2	11	1.8	Sandstone	Plane	**T. 1526**	12	2	11	1.8	Sandstone	Inclined
T. 1107	12	2	12	1.8	Sandstone	Plane	**T. 1527**	13	2	12	1.8	Sandstone	Inclined
T. 1108	12	2	13	1.8	Sandstone	Plane	**T. 1528**	13	2	13	1.8	Sandstone	Inclined
T. 1109	11	2	14	1.8	Sandstone	Plane	**T. 1529**	12	2	14	1.8	Sandstone	Inclined
T. 1110	11	2	15	1.8	Sandstone	Plane	**T. 1530**	12	2	15	1.8	Sandstone	Inclined
T. 1111	11	2	1	2	Sandstone	Plane	**T. 1531**	12	2	1	2	Sandstone	Inclined
T. 1112	12	2	2	2	Sandstone	Plane	**T. 1532**	13	2	2	2	Sandstone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 1113	12	2	3	2	Sandstone	Plane	**T. 1533**	13	2	3	2	Sandstone	Inclined
T. 1114	12	2	4	2	Sandstone	Plane	**T. 1534**	13	2	4	2	Sandstone	Inclined
T. 1115	12	2	5	2	Sandstone	Plane	**T. 1535**	13	2	5	2	Sandstone	Inclined
T. 1116	12	2	6	2	Sandstone	Plane	**T. 1536**	13	2	6	2	Sandstone	Inclined
T. 1117	12	2	7	2	Sandstone	Plane	**T. 1537**	13	2	7	2	Sandstone	Inclined
T. 1118	12	2	8	2	Sandstone	Plane	**T. 1538**	13	2	8	2	Sandstone	Inclined
T. 1119	11	2	9	2	Sandstone	Plane	**T. 1539**	12	2	9	2	Sandstone	Inclined
T. 1120	10	2	10	2	Sandstone	Plane	**T. 1540**	11	2	10	2	Sandstone	Inclined
T. 1121	10	2	11	2	Sandstone	Plane	**T. 1541**	11	2	11	2	Sandstone	Inclined
T. 1122	11	2	12	2	Sandstone	Plane	**T. 1542**	12	2	12	2	Sandstone	Inclined
T. 1123	11	2	13	2	Sandstone	Plane	**T. 1543**	12	2	13	2	Sandstone	Inclined
T. 1124	10	2	14	2	Sandstone	Plane	**T. 1544**	11	2	14	2	Sandstone	Inclined
T. 1125	10	2	15	2	Sandstone	Plane	**T. 1545**	11	2	15	2	Sandstone	Inclined
T. 1126	12	2	1	2.3	Sandstone	Plane	**T. 1546**	13	2	1	2.3	Sandstone	Inclined
T. 1127	12	2	2	2.3	Sandstone	Plane	**T. 1547**	13	2	2	2.3	Sandstone	Inclined
T. 1128	12	2	3	2.3	Sandstone	Plane	**T. 1548**	13	2	3	2.3	Sandstone	Inclined
T. 1129	12	2	4	2.3	Sandstone	Plane	**T. 1549**	13	2	4	2.3	Sandstone	Inclined
T. 1130	12	2	5	2.3	Sandstone	Plane	**T. 1550**	13	2	5	2.3	Sandstone	Inclined
T. 1131	12	2	6	2.3	Sandstone	Plane	**T. 1551**	13	2	6	2.3	Sandstone	Inclined
T. 1132	12	2	7	2.3	Sandstone	Plane	**T. 1552**	13	2	7	2.3	Sandstone	Inclined
T. 1133	12	2	8	2.3	Sandstone	Plane	**T. 1553**	13	2	8	2.3	Sandstone	Inclined
T. 1134	11	2	9	2.3	Sandstone	Plane	**T. 1554**	12	2	9	2.3	Sandstone	Inclined
T. 1135	10	2	10	2.3	Sandstone	Plane	**T. 1555**	11	2	10	2.3	Sandstone	Inclined
T. 1136	11	2	11	2.3	Sandstone	Plane	**T. 1556**	12	2	11	2.3	Sandstone	Inclined
T. 1137	10	2	12	2.3	Sandstone	Plane	**T. 1557**	11	2	12	2.3	Sandstone	Inclined
T. 1138	10	2	13	2.3	Sandstone	Plane	**T. 1558**	11	2	13	2.3	Sandstone	Inclined
T. 1139	9	2	14	2.3	Sandstone	Plane	**T. 1559**	10	2	14	2.3	Sandstone	Inclined
T. 1140	9	2	15	2.3	Sandstone	Plane	**T. 1560**	10	2	15	2.3	Sandstone	Inclined
T. 1141	12	2	1	2.5	Sandstone	Plane	**T. 1561**	13	2	1	2.5	Sandstone	Inclined
T. 1142	12	2	2	2.5	Sandstone	Plane	**T. 1562**	13	2	2	2.5	Sandstone	Inclined
T. 1143	12	2	3	2.5	Sandstone	Plane	**T. 1563**	13	2	3	2.5	Sandstone	Inclined
T. 1144	12	2	4	2.5	Sandstone	Plane	**T. 1564**	13	2	4	2.5	Sandstone	Inclined
T. 1145	12	2	5	2.5	Sandstone	Plane	**T. 1565**	13	2	5	2.5	Sandstone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 1146	12	2	6	2.5	Sandstone	Plane	**T. 1566**	13	2	6	2.5	Sandstone	Inclined
T. 1147	12	2	7	2.5	Sandstone	Plane	**T. 1567**	13	2	7	2.5	Sandstone	Inclined
T. 1148	12	2	8	2.5	Sandstone	Plane	**T. 1568**	13	2	8	2.5	Sandstone	Inclined
T. 1149	11	2	9	2.5	Sandstone	Plane	**T. 1569**	12	2	9	2.5	Sandstone	Inclined
T. 1150	9	2	10	2.5	Sandstone	Plane	**T. 1570**	10	2	10	2.5	Sandstone	Inclined
T. 1151	10	2	11	2.5	Sandstone	Plane	**T. 1571**	11	2	11	2.5	Sandstone	Inclined
T. 1152	9	2	12	2.5	Sandstone	Plane	**T. 1572**	10	2	12	2.5	Sandstone	Inclined
T. 1153	9	2	13	2.5	Sandstone	Plane	**T. 1573**	10	2	13	2.5	Sandstone	Inclined
T. 1154	8	2	14	2.5	Sandstone	Plane	**T. 1574**	9	2	14	2.5	Sandstone	Inclined
T. 1155	8	2	15	2.5	Sandstone	Plane	**T. 1575**	9	2	15	2.5	Sandstone	Inclined
T. 1156	8	2	1	1	Brick	Plane	**T. 1576**	9	2	1	1	Brick	Inclined
T. 1157	8	2	2	1	Brick	Plane	**T. 1577**	9	2	2	1	Brick	Inclined
T. 1158	8	2	3	1	Brick	Plane	**T. 1578**	9	2	3	1	Brick	Inclined
T. 1159	8	2	4	1	Brick	Plane	**T. 1579**	9	2	4	1	Brick	Inclined
T. 1160	8	2	5	1	Brick	Plane	**T. 1580**	9	2	5	1	Brick	Inclined
T. 1161	8	2	6	1	Brick	Plane	**T. 1581**	9	2	6	1	Brick	Inclined
T. 1162	8	2	7	1	Brick	Plane	**T. 1582**	9	2	7	1	Brick	Inclined
T. 1163	8	2	8	1	Brick	Plane	**T. 1583**	9	2	8	1	Brick	Inclined
T. 1164	8	2	9	1	Brick	Plane	**T. 1584**	9	2	9	1	Brick	Inclined
T. 1165	8	2	10	1	Brick	Plane	**T. 1585**	9	2	10	1	Brick	Inclined
T. 1166	8	2	11	1	Brick	Plane	**T. 1586**	9	2	11	1	Brick	Inclined
T. 1167	8	2	12	1	Brick	Plane	**T. 1587**	9	2	12	1	Brick	Inclined
T. 1168	8	2	13	1	Brick	Plane	**T. 1588**	9	2	13	1	Brick	Inclined
T. 1169	8	2	14	1	Brick	Plane	**T. 1589**	9	2	14	1	Brick	Inclined
T. 1170	8	2	15	1	Brick	Plane	**T. 1590**	9	2	15	1	Brick	Inclined
T. 1171	10	2	1	1.3	Brick	Plane	**T. 1591**	11	2	1	1.3	Brick	Inclined
T. 1172	10	2	2	1.3	Brick	Plane	**T. 1592**	11	2	2	1.3	Brick	Inclined
T. 1173	10	2	3	1.3	Brick	Plane	**T. 1593**	11	2	3	1.3	Brick	Inclined
T. 1174	10	2	4	1.3	Brick	Plane	**T. 1594**	11	2	4	1.3	Brick	Inclined
T. 1175	10	2	5	1.3	Brick	Plane	**T. 1595**	11	2	5	1.3	Brick	Inclined
T. 1176	10	2	6	1.3	Brick	Plane	**T. 1596**	11	2	6	1.3	Brick	Inclined
T. 1177	10	2	7	1.3	Brick	Plane	**T. 1597**	11	2	7	1.3	Brick	Inclined
T. 1178	10	2	8	1.3	Brick	Plane	**T. 1598**	11	2	8	1.3	Brick	Inclined

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Table E.1. (cont.)

T. 1179	10	2	9	1.3	Brick	Plane	**T. 1599**	11	2	9	1.3	Brick	Inclined
T. 1180	9	2	10	1.3	Brick	Plane	**T. 1600**	10	2	10	1.3	Brick	Inclined
T. 1181	9	2	11	1.3	Brick	Plane	**T. 1601**	10	2	11	1.3	Brick	Inclined
T. 1182	10	2	12	1.3	Brick	Plane	**T. 1602**	11	2	12	1.3	Brick	Inclined
T. 1183	10	2	13	1.3	Brick	Plane	**T. 1603**	11	2	13	1.3	Brick	Inclined
T. 1184	10	2	14	1.3	Brick	Plane	**T. 1604**	11	2	14	1.3	Brick	Inclined
T. 1185	10	2	15	1.3	Brick	Plane	**T. 1605**	11	2	15	1.3	Brick	Inclined
T. 1186	11	2	1	1.6	Brick	Plane	**T. 1606**	12	2	1	1.6	Brick	Inclined
T. 1187	11	2	2	1.6	Brick	Plane	**T. 1607**	12	2	2	1.6	Brick	Inclined
T. 1188	11	2	3	1.6	Brick	Plane	**T. 1608**	12	2	3	1.6	Brick	Inclined
T. 1189	11	2	4	1.6	Brick	Plane	**T. 1609**	12	2	4	1.6	Brick	Inclined
T. 1190	11	2	5	1.6	Brick	Plane	**T. 1610**	12	2	5	1.6	Brick	Inclined
T. 1191	11	2	6	1.6	Brick	Plane	**T. 1611**	12	2	6	1.6	Brick	Inclined
T. 1192	11	2	7	1.6	Brick	Plane	**T. 1612**	12	2	7	1.6	Brick	Inclined
T. 1193	11	2	8	1.6	Brick	Plane	**T. 1613**	12	2	8	1.6	Brick	Inclined
T. 1194	11	2	9	1.6	Brick	Plane	**T. 1614**	12	2	9	1.6	Brick	Inclined
T. 1195	10	2	10	1.6	Brick	Plane	**T. 1615**	11	2	10	1.6	Brick	Inclined
T. 1196	10	2	11	1.6	Brick	Plane	**T. 1616**	11	2	11	1.6	Brick	Inclined
T. 1197	11	2	12	1.6	Brick	Plane	**T. 1617**	12	2	12	1.6	Brick	Inclined
T. 1198	11	2	13	1.6	Brick	Plane	**T. 1618**	12	2	13	1.6	Brick	Inclined
T. 1199	10	2	14	1.6	Brick	Plane	**T. 1619**	11	2	14	1.6	Brick	Inclined
T. 1200	10	2	15	1.6	Brick	Plane	**T. 1620**	11	2	15	1.6	Brick	Inclined
T. 1201	11	2	1	1.8	Brick	Plane	**T. 1621**	12	2	1	1.8	Brick	Inclined
T. 1202	11	2	2	1.8	Brick	Plane	**T. 1622**	12	2	2	1.8	Brick	Inclined
T. 1203	11	2	3	1.8	Brick	Plane	**T. 1623**	12	2	3	1.8	Brick	Inclined
T. 1204	11	2	4	1.8	Brick	Plane	**T. 1624**	12	2	4	1.8	Brick	Inclined
T. 1205	11	2	5	1.8	Brick	Plane	**T. 1625**	12	2	5	1.8	Brick	Inclined
T. 1206	11	2	6	1.8	Brick	Plane	**T. 1626**	12	2	6	1.8	Brick	Inclined
T. 1207	11	2	7	1.8	Brick	Plane	**T. 1627**	12	2	7	1.8	Brick	Inclined
T. 1208	11	2	8	1.8	Brick	Plane	**T. 1628**	12	2	8	1.8	Brick	Inclined
T. 1209	11	2	9	1.8	Brick	Plane	**T. 1629**	12	2	9	1.8	Brick	Inclined
T. 1210	10	2	10	1.8	Brick	Plane	**T. 1630**	11	2	10	1.8	Brick	Inclined
T. 1211	10	2	11	1.8	Brick	Plane	**T. 1631**	11	2	11	1.8	Brick	Inclined

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Table E.1. (cont.)

T. 1212	11	2	12	1.8	Brick	Plane	**T. 1632**	12	2	12	1.8	Brick	Inclined
T. 1213	11	2	13	1.8	Brick	Plane	**T. 1633**	12	2	13	1.8	Brick	Inclined
T. 1214	10	2	14	1.8	Brick	Plane	**T. 1634**	11	2	14	1.8	Brick	Inclined
T. 1215	10	2	15	1.8	Brick	Plane	**T. 1635**	11	2	15	1.8	Brick	Inclined
T. 1216	10	2	1	2	Brick	Plane	**T. 1636**	11	2	1	2	Brick	Inclined
T. 1217	11	2	2	2	Brick	Plane	**T. 1637**	12	2	2	2	Brick	Inclined
T. 1218	11	2	3	2	Brick	Plane	**T. 1638**	12	2	3	2	Brick	Inclined
T. 1219	11	2	4	2	Brick	Plane	**T. 1639**	12	2	4	2	Brick	Inclined
T. 1220	11	2	5	2	Brick	Plane	**T. 1640**	12	2	5	2	Brick	Inclined
T. 1221	11	2	6	2	Brick	Plane	**T. 1641**	12	2	6	2	Brick	Inclined
T. 1222	11	2	7	2	Brick	Plane	**T. 1642**	12	2	7	2	Brick	Inclined
T. 1223	11	2	8	2	Brick	Plane	**T. 1643**	12	2	8	2	Brick	Inclined
T. 1224	10	2	9	2	Brick	Plane	**T. 1644**	11	2	9	2	Brick	Inclined
T. 1225	9	2	10	2	Brick	Plane	**T. 1645**	10	2	10	2	Brick	Inclined
T. 1226	9	2	11	2	Brick	Plane	**T. 1646**	10	2	11	2	Brick	Inclined
T. 1227	10	2	12	2	Brick	Plane	**T. 1647**	11	2	12	2	Brick	Inclined
T. 1228	10	2	13	2	Brick	Plane	**T. 1648**	11	2	13	2	Brick	Inclined
T. 1229	9	2	14	2	Brick	Plane	**T. 1649**	10	2	14	2	Brick	Inclined
T. 1230	9	2	15	2	Brick	Plane	**T. 1650**	10	2	15	2	Brick	Inclined
T. 1231	11	2	1	2.3	Brick	Plane	**T. 1651**	12	2	1	2.3	Brick	Inclined
T. 1232	11	2	2	2.3	Brick	Plane	**T. 1652**	12	2	2	2.3	Brick	Inclined
T. 1233	11	2	3	2.3	Brick	Plane	**T. 1653**	12	2	3	2.3	Brick	Inclined
T. 1234	11	2	4	2.3	Brick	Plane	**T. 1654**	12	2	4	2.3	Brick	Inclined
T. 1235	11	2	5	2.3	Brick	Plane	**T. 1655**	12	2	5	2.3	Brick	Inclined
T. 1236	11	2	6	2.3	Brick	Plane	**T. 1656**	12	2	6	2.3	Brick	Inclined
T. 1237	11	2	7	2.3	Brick	Plane	**T. 1657**	12	2	7	2.3	Brick	Inclined
T. 1238	11	2	8	2.3	Brick	Plane	**T. 1658**	12	2	8	2.3	Brick	Inclined
T. 1239	10	2	9	2.3	Brick	Plane	**T. 1659**	11	2	9	2.3	Brick	Inclined
T. 1240	9	2	10	2.3	Brick	Plane	**T. 1660**	10	2	10	2.3	Brick	Inclined
T. 1241	10	2	11	2.3	Brick	Plane	**T. 1661**	11	2	11	2.3	Brick	Inclined
T. 1242	9	2	12	2.3	Brick	Plane	**T. 1662**	10	2	12	2.3	Brick	Inclined
T. 1243	9	2	13	2.3	Brick	Plane	**T. 1663**	10	2	13	2.3	Brick	Inclined
T. 1244	8	2	14	2.3	Brick	Plane	**T. 1664**	9	2	14	2.3	Brick	Inclined

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Table E.1. (cont.)

T. 1245	8	2	15	2.3	Brick	Plane	**T. 1665**	9	2	15	2.3	Brick	Inclined
T. 1246	11	2	1	2.5	Brick	Plane	**T. 1666**	12	2	1	2.5	Brick	Inclined
T. 1247	11	2	2	2.5	Brick	Plane	**T. 1667**	12	2	2	2.5	Brick	Inclined
T. 1248	11	2	3	2.5	Brick	Plane	**T. 1668**	12	2	3	2.5	Brick	Inclined
T. 1249	11	2	4	2.5	Brick	Plane	**T. 1669**	12	2	4	2.5	Brick	Inclined
T. 1250	11	2	5	2.5	Brick	Plane	**T. 1670**	12	2	5	2.5	Brick	Inclined
T. 1251	11	2	6	2.5	Brick	Plane	**T. 1671**	12	2	6	2.5	Brick	Inclined
T. 1252	11	2	7	2.5	Brick	Plane	**T. 1672**	12	2	7	2.5	Brick	Inclined
T. 1253	11	2	8	2.5	Brick	Plane	**T. 1673**	12	2	8	2.5	Brick	Inclined
T. 1254	10	2	9	2.5	Brick	Plane	**T. 1674**	11	2	9	2.5	Brick	Inclined
T. 1255	8	2	10	2.5	Brick	Plane	**T. 1675**	9	2	10	2.5	Brick	Inclined
T. 1256	9	2	11	2.5	Brick	Plane	**T. 1676**	10	2	11	2.5	Brick	Inclined
T. 1257	8	2	12	2.5	Brick	Plane	**T. 1677**	9	2	12	2.5	Brick	Inclined
T. 1258	8	2	13	2.5	Brick	Plane	**T. 1678**	9	2	13	2.5	Brick	Inclined
T. 1259	7	2	14	2.5	Brick	Plane	**T. 1679**	8	2	14	2.5	Brick	Inclined
T. 1260	7	2	15	2.5	Brick	Plane	**T. 1680**	8	2	15	2.5	Brick	Inclined
T. 1681	11	3	1	1	Granite	Plane	**T. 2101**	12	3	1	1	Granite	Inclined
T. 1682	11	3	2	1	Granite	Plane	**T. 2102**	12	3	2	1	Granite	Inclined
T. 1683	11	3	3	1	Granite	Plane	**T. 2103**	12	3	3	1	Granite	Inclined
T. 1684	11	3	4	1	Granite	Plane	**T. 2104**	12	3	4	1	Granite	Inclined
T. 1685	11	3	5	1	Granite	Plane	**T. 2105**	12	3	5	1	Granite	Inclined
T. 1686	11	3	6	1	Granite	Plane	**T. 2106**	12	3	6	1	Granite	Inclined
T. 1687	11	3	7	1	Granite	Plane	**T. 2107**	12	3	7	1	Granite	Inclined
T. 1688	11	3	8	1	Granite	Plane	**T. 2108**	12	3	8	1	Granite	Inclined
T. 1689	11	3	9	1	Granite	Plane	**T. 2109**	12	3	9	1	Granite	Inclined
T. 1690	10	3	10	1	Granite	Plane	**T. 2110**	11	3	10	1	Granite	Inclined
T. 1691	10	3	11	1	Granite	Plane	**T. 2111**	11	3	11	1	Granite	Inclined
T. 1692	11	3	12	1	Granite	Plane	**T. 2112**	12	3	12	1	Granite	Inclined
T. 1693	11	3	13	1	Granite	Plane	**T. 2113**	12	3	13	1	Granite	Inclined
T. 1694	10	3	14	1	Granite	Plane	**T. 2114**	11	3	14	1	Granite	Inclined
T. 1695	10	3	15	1	Granite	Plane	**T. 2115**	11	3	15	1	Granite	Inclined
T. 1696	13	3	1	1.3	Granite	Plane	**T. 2116**	14	3	1	1.3	Granite	Inclined
T. 1697	13	3	2	1.3	Granite	Plane	**T. 2117**	14	3	2	1.3	Granite	Inclined

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Table E.1. (cont.)

T. 1698	13	3	3	1.3	Granite	Plane	**T. 2118**	14	3	3	1.3	Granite	Inclined
T. 1699	13	3	4	1.3	Granite	Plane	**T. 2119**	14	3	4	1.3	Granite	Inclined
T. 1700	13	3	5	1.3	Granite	Plane	**T. 2120**	14	3	5	1.3	Granite	Inclined
T. 1701	13	3	6	1.3	Granite	Plane	**T. 2121**	14	3	6	1.3	Granite	Inclined
T. 1702	13	3	7	1.3	Granite	Plane	**T. 2122**	14	3	7	1.3	Granite	Inclined
T. 1703	13	3	8	1.3	Granite	Plane	**T. 2123**	14	3	8	1.3	Granite	Inclined
T. 1704	13	3	9	1.3	Granite	Plane	**T. 2124**	14	3	9	1.3	Granite	Inclined
T. 1705	12	3	10	1.3	Granite	Plane	**T. 2125**	13	3	10	1.3	Granite	Inclined
T. 1706	12	3	11	1.3	Granite	Plane	**T. 2126**	13	3	11	1.3	Granite	Inclined
T. 1707	13	3	12	1.3	Granite	Plane	**T. 2127**	14	3	12	1.3	Granite	Inclined
T. 1708	13	3	13	1.3	Granite	Plane	**T. 2128**	14	3	13	1.3	Granite	Inclined
T. 1709	12	3	14	1.3	Granite	Plane	**T. 2129**	13	3	14	1.3	Granite	Inclined
T. 1710	12	3	15	1.3	Granite	Plane	**T. 2130**	13	3	15	1.3	Granite	Inclined
***T. 1711**	14	3	1	1.6	Granite	Plane	***T. 2131**	15	3	1	1.6	Granite	Inclined
***T. 1712**	14	3	2	1.6	Granite	Plane	***T. 2132**	15	3	2	1.6	Granite	Inclined
***T. 1713**	14	3	3	1.6	Granite	Plane	***T. 2133**	15	3	3	1.6	Granite	Inclined
***T. 1714**	14	3	4	1.6	Granite	Plane	***T. 2134**	15	3	4	1.6	Granite	Inclined
***T. 1715**	14	3	5	1.6	Granite	Plane	***T. 2135**	15	3	5	1.6	Granite	Inclined
***T. 1716**	14	3	6	1.6	Granite	Plane	***T. 2136**	15	3	6	1.6	Granite	Inclined
***T. 1717**	14	3	7	1.6	Granite	Plane	***T. 2137**	15	3	7	1.6	Granite	Inclined
***T. 1718**	14	3	8	1.6	Granite	Plane	***T. 2138**	15	3	8	1.6	Granite	Inclined
***T. 1719**	14	3	9	1.6	Granite	Plane	***T. 2139**	15	3	9	1.6	Granite	Inclined
***T. 1720**	12	3	10	1.6	Granite	Plane	***T. 2140**	13	3	10	1.6	Granite	Inclined
***T. 1721**	12	3	11	1.6	Granite	Plane	***T. 2141**	13	3	11	1.6	Granite	Inclined
***T. 1722**	14	3	12	1.6	Granite	Plane	***T. 2142**	15	3	12	1.6	Granite	Inclined
***T. 1723**	14	3	13	1.6	Granite	Plane	***T. 2143**	15	3	13	1.6	Granite	Inclined
***T. 1724**	12	3	14	1.6	Granite	Plane	***T. 2144**	13	3	14	1.6	Granite	Inclined
***T. 1725**	12	3	15	1.6	Granite	Plane	***T. 2145**	13	3	15	1.6	Granite	Inclined
***T. 1726**	14	3	1	1.8	Granite	Plane	***T. 2146**	15	3	1	1.8	Granite	Inclined
***T. 1727**	14	3	2	1.8	Granite	Plane	***T. 2147**	15	3	2	1.8	Granite	Inclined
***T. 1728**	14	3	3	1.8	Granite	Plane	***T. 2148**	15	3	3	1.8	Granite	Inclined
***T. 1729**	14	3	4	1.8	Granite	Plane	***T. 2149**	15	3	4	1.8	Granite	Inclined
***T. 1730**	14	3	5	1.8	Granite	Plane	***T. 2150**	15	3	5	1.8	Granite	Inclined

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Table E.1. (cont.)

***T. 1731**	14	3	6	1.8	Granite	Plane	***T. 2151**	15	3	6	1.8	Granite	Inclined
***T. 1732**	14	3	7	1.8	Granite	Plane	***T. 2152**	15	3	7	1.8	Granite	Inclined
***T. 1733**	14	3	8	1.8	Granite	Plane	***T. 2153**	15	3	8	1.8	Granite	Inclined
***T. 1734**	14	3	9	1.8	Granite	Plane	***T. 2154**	15	3	9	1.8	Granite	Inclined
***T. 1735**	12	3	10	1.8	Granite	Plane	***T. 2155**	13	3	10	1.8	Granite	Inclined
***T. 1736**	12	3	11	1.8	Granite	Plane	***T. 2156**	13	3	11	1.8	Granite	Inclined
***T. 1737**	14	3	12	1.8	Granite	Plane	***T. 2157**	15	3	12	1.8	Granite	Inclined
***T. 1738**	14	3	13	1.8	Granite	Plane	***T. 2158**	15	3	13	1.8	Granite	Inclined
***T. 1739**	12	3	14	1.8	Granite	Plane	***T. 2159**	13	3	14	1.8	Granite	Inclined
***T. 1740**	12	3	15	1.8	Granite	Plane	***T. 2160**	13	3	15	1.8	Granite	Inclined
***T. 1741**	13,5	3	1	2	Granite	Plane	***T. 2161**	15	3	1	2	Granite	Inclined
***T. 1742**	13,5	3	2	2	Granite	Plane	***T. 2162**	15	3	2	2	Granite	Inclined
***T. 1743**	13,5	3	3	2	Granite	Plane	***T. 2163**	15	3	3	2	Granite	Inclined
***T. 1744**	13,5	3	4	2	Granite	Plane	***T. 2164**	15	3	4	2	Granite	Inclined
***T. 1745**	13,5	3	5	2	Granite	Plane	***T. 2165**	15	3	5	2	Granite	Inclined
***T. 1746**	13,5	3	6	2	Granite	Plane	***T. 2166**	15	3	6	2	Granite	Inclined
***T. 1747**	13,5	3	7	2	Granite	Plane	***T. 2167**	15	3	7	2	Granite	Inclined
***T. 1748**	13,5	3	8	2	Granite	Plane	***T. 2168**	15	3	8	2	Granite	Inclined
***T. 1749**	13	3	9	2	Granite	Plane	***T. 2169**	14	3	9	2	Granite	Inclined
***T. 1750**	12	3	10	2	Granite	Plane	***T. 2170**	13	3	10	2	Granite	Inclined
***T. 1751**	12	3	11	2	Granite	Plane	***T. 2171**	13	3	11	2	Granite	Inclined
***T. 1752**	13,5	3	12	2	Granite	Plane	***T. 2172**	15	3	12	2	Granite	Inclined
***T. 1753**	13,5	3	13	2	Granite	Plane	***T. 2173**	15	3	13	2	Granite	Inclined
***T. 1754**	12	3	14	2	Granite	Plane	***T. 2174**	13	3	14	2	Granite	Inclined
***T. 1755**	12	3	15	2	Granite	Plane	***T. 2175**	13	3	15	2	Granite	Inclined
***T. 1756**	13,5	3	1	2.3	Granite	Plane	***T. 2176**	15	3	1	2.3	Granite	Inclined
***T. 1757**	13,5	3	2	2.3	Granite	Plane	***T. 2177**	15	3	2	2.3	Granite	Inclined
***T. 1758**	13,5	3	3	2.3	Granite	Plane	***T. 2178**	15	3	3	2.3	Granite	Inclined
***T. 1759**	13,5	3	4	2.3	Granite	Plane	***T. 2179**	15	3	4	2.3	Granite	Inclined
***T. 1760**	13,5	3	5	2.3	Granite	Plane	***T. 2180**	15	3	5	2.3	Granite	Inclined
***T. 1761**	13,5	3	6	2.3	Granite	Plane	***T. 2181**	15	3	6	2.3	Granite	Inclined
***T. 1762**	13,5	3	7	2.3	Granite	Plane	***T. 2182**	15	3	7	2.3	Granite	Inclined
***T. 1763**	13,5	3	8	2.3	Granite	Plane	***T. 2183**	15	3	8	2.3	Granite	Inclined

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Table E.1. (cont.)

***T. 1764**	13,5	3	9	2.3	Granite	Plane	***T. 2184**	15	3	9	2.3	Granite	Inclined
***T. 1765**	12	3	10	2.3	Granite	Plane	***T. 2185**	13	3	10	2.3	Granite	Inclined
***T. 1766**	12	3	11	2.3	Granite	Plane	***T. 2186**	13	3	11	2.3	Granite	Inclined
***T. 1767**	13,5	3	12	2.3	Granite	Plane	***T. 2187**	15	3	12	2.3	Granite	Inclined
***T. 1768**	13,5	3	13	2.3	Granite	Plane	***T. 2188**	15	3	13	2.3	Granite	Inclined
***T. 1769**	12	3	14	2.3	Granite	Plane	***T. 2189**	13	3	14	2.3	Granite	Inclined
***T. 1770**	12	3	15	2.3	Granite	Plane	***T. 2190**	13	3	15	2.3	Granite	Inclined
T. 1771	13	3	1	2.5	Granite	Plane	**T. 2191**	14	3	1	2.5	Granite	Inclined
T. 1772	13	3	2	2.5	Granite	Plane	**T. 2192**	14	3	2	2.5	Granite	Inclined
T. 1773	13	3	3	2.5	Granite	Plane	**T. 2193**	14	3	3	2.5	Granite	Inclined
T. 1774	13	3	4	2.5	Granite	Plane	**T. 2194**	14	3	4	2.5	Granite	Inclined
T. 1775	13	3	5	2.5	Granite	Plane	**T. 2195**	14	3	5	2.5	Granite	Inclined
T. 1776	13	3	6	2.5	Granite	Plane	**T. 2196**	14	3	6	2.5	Granite	Inclined
T. 1777	13	3	7	2.5	Granite	Plane	**T. 2197**	14	3	7	2.5	Granite	Inclined
T. 1778	13	3	8	2.5	Granite	Plane	**T. 2198**	14	3	8	2.5	Granite	Inclined
T. 1779	13	3	9	2.5	Granite	Plane	**T. 2199**	14	3	9	2.5	Granite	Inclined
T. 1780	11	3	10	2.5	Granite	Plane	**T. 2200**	12	3	10	2.5	Granite	Inclined
T. 1781	11	3	11	2.5	Granite	Plane	**T. 2201**	12	3	11	2.5	Granite	Inclined
T. 1782	13	3	12	2.5	Granite	Plane	**T. 2202**	14	3	12	2.5	Granite	Inclined
T. 1783	13	3	13	2.5	Granite	Plane	**T. 2203**	14	3	13	2.5	Granite	Inclined
T. 1784	11	3	14	2.5	Granite	Plane	**T. 2204**	12	3	14	2.5	Granite	Inclined
T. 1785	11	3	15	2.5	Granite	Plane	**T. 2205**	12	3	15	2.5	Granite	Inclined
T. 1786	11	3	1	1	Limestone	Plane	**T. 2206**	12	3	1	1	Limestone	Inclined
T. 1787	11	3	2	1	Limestone	Plane	**T. 2207**	12	3	2	1	Limestone	Inclined
T. 1788	11	3	3	1	Limestone	Plane	**T. 2208**	12	3	3	1	Limestone	Inclined
T. 1789	11	3	4	1	Limestone	Plane	**T. 2209**	12	3	4	1	Limestone	Inclined
T. 1790	11	3	5	1	Limestone	Plane	**T. 2210**	12	3	5	1	Limestone	Inclined
T. 1791	11	3	6	1	Limestone	Plane	**T. 2211**	12	3	6	1	Limestone	Inclined
T. 1792	11	3	7	1	Limestone	Plane	**T. 2212**	12	3	7	1	Limestone	Inclined
T. 1793	11	3	8	1	Limestone	Plane	**T. 2213**	12	3	8	1	Limestone	Inclined
T. 1794	11	3	9	1	Limestone	Plane	**T. 2214**	12	3	9	1	Limestone	Inclined
T. 1795	10	3	10	1	Limestone	Plane	**T. 2215**	11	3	10	1	Limestone	Inclined
T. 1796	10	3	11	1	Limestone	Plane	**T. 2216**	11	3	11	1	Limestone	Inclined

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Table E.1. (cont.)

T. 1797	11	3	12	1	Limestone	Plane	**T. 2217**	12	3	12	1	Limestone	Inclined
T. 1798	11	3	13	1	Limestone	Plane	**T. 2218**	12	3	13	1	Limestone	Inclined
T. 1799	10	3	14	1	Limestone	Plane	**T. 2219**	11	3	14	1	Limestone	Inclined
T. 1800	10	3	15	1	Limestone	Plane	**T. 2220**	11	3	15	1	Limestone	Inclined
T. 1801	13	3	1	1.3	Limestone	Plane	**T. 2221**	14	3	1	1.3	Limestone	Inclined
T. 1802	13	3	2	1.3	Limestone	Plane	**T. 2222**	14	3	2	1.3	Limestone	Inclined
T. 1803	13	3	3	1.3	Limestone	Plane	**T. 2223**	14	3	3	1.3	Limestone	Inclined
T. 1804	13	3	4	1.3	Limestone	Plane	**T. 2224**	14	3	4	1.3	Limestone	Inclined
T. 1805	13	3	5	1.3	Limestone	Plane	**T. 2225**	14	3	5	1.3	Limestone	Inclined
T. 1806	13	3	6	1.3	Limestone	Plane	**T. 2226**	14	3	6	1.3	Limestone	Inclined
T. 1807	13	3	7	1.3	Limestone	Plane	**T. 2227**	14	3	7	1.3	Limestone	Inclined
T. 1808	13	3	8	1.3	Limestone	Plane	**T. 2228**	14	3	8	1.3	Limestone	Inclined
T. 1809	13	3	9	1.3	Limestone	Plane	**T. 2229**	14	3	9	1.3	Limestone	Inclined
T. 1810	12	3	10	1.3	Limestone	Plane	**T. 2230**	13	3	10	1.3	Limestone	Inclined
T. 1811	12	3	11	1.3	Limestone	Plane	**T. 2231**	13	3	11	1.3	Limestone	Inclined
T. 1812	13	3	12	1.3	Limestone	Plane	**T. 2232**	14	3	12	1.3	Limestone	Inclined
T. 1813	13	3	13	1.3	Limestone	Plane	**T. 2233**	14	3	13	1.3	Limestone	Inclined
T. 1814	12	3	14	1.3	Limestone	Plane	**T. 2234**	13	3	14	1.3	Limestone	Inclined
T. 1815	12	3	15	1.3	Limestone	Plane	**T. 2235**	13	3	15	1.3	Limestone	Inclined
***T. 1816**	14	3	1	1.6	Limestone	Plane	***T. 2236**	15	3	1	1.6	Limestone	Inclined
***T. 1817**	14	3	2	1.6	Limestone	Plane	***T. 2237**	15	3	2	1.6	Limestone	Inclined
***T. 1818**	14	3	3	1.6	Limestone	Plane	***T. 2238**	15	3	3	1.6	Limestone	Inclined
***T. 1819**	14	3	4	1.6	Limestone	Plane	***T. 2239**	15	3	4	1.6	Limestone	Inclined
***T. 1820**	14	3	5	1.6	Limestone	Plane	***T. 2240**	15	3	5	1.6	Limestone	Inclined
***T. 1821**	14	3	6	1.6	Limestone	Plane	***T. 2241**	15	3	6	1.6	Limestone	Inclined
***T. 1822**	14	3	7	1.6	Limestone	Plane	***T. 2242**	15	3	7	1.6	Limestone	Inclined
***T. 1823**	14	3	8	1.6	Limestone	Plane	***T. 2243**	15	3	8	1.6	Limestone	Inclined
***T. 1824**	14	3	9	1.6	Limestone	Plane	***T. 2244**	15	3	9	1.6	Limestone	Inclined
***T. 1825**	12	3	10	1.6	Limestone	Plane	***T. 2245**	13	3	10	1.6	Limestone	Inclined
***T. 1826**	12	3	11	1.6	Limestone	Plane	***T. 2246**	13	3	11	1.6	Limestone	Inclined
***T. 1827**	14	3	12	1.6	Limestone	Plane	***T. 2247**	15	3	12	1.6	Limestone	Inclined
***T. 1828**	14	3	13	1.6	Limestone	Plane	***T. 2248**	15	3	13	1.6	Limestone	Inclined
***T. 1829**	12	3	14	1.6	Limestone	Plane	***T. 2249**	13	3	14	1.6	Limestone	Inclined

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Table E.1. (cont.)

***T. 1830**	12	3	15	1.6	Limestone	Plane	***T. 2250**	13	3	15	1.6	Limestone	Inclined
***T. 1831**	14	3	1	1.8	Limestone	Plane	***T. 2251**	15	3	1	1.8	Limestone	Inclined
***T. 1832**	14	3	2	1.8	Limestone	Plane	***T. 2252**	15	3	2	1.8	Limestone	Inclined
***T. 1833**	14	3	3	1.8	Limestone	Plane	***T. 2253**	15	3	3	1.8	Limestone	Inclined
***T. 1834**	14	3	4	1.8	Limestone	Plane	***T. 2254**	15	3	4	1.8	Limestone	Inclined
***T. 1835**	14	3	5	1.8	Limestone	Plane	***T. 2255**	15	3	5	1.8	Limestone	Inclined
***T. 1836**	14	3	6	1.8	Limestone	Plane	***T. 2256**	15	3	6	1.8	Limestone	Inclined
***T. 1837**	14	3	7	1.8	Limestone	Plane	***T. 2257**	15	3	7	1.8	Limestone	Inclined
***T. 1838**	14	3	8	1.8	Limestone	Plane	***T. 2258**	15	3	8	1.8	Limestone	Inclined
***T. 1839**	14	3	9	1.8	Limestone	Plane	***T. 2259**	15	3	9	1.8	Limestone	Inclined
***T. 1840**	12	3	10	1.8	Limestone	Plane	***T. 2260**	13	3	10	1.8	Limestone	Inclined
***T. 1841**	12	3	11	1.8	Limestone	Plane	***T. 2261**	13	3	11	1.8	Limestone	Inclined
***T. 1842**	14	3	12	1.8	Limestone	Plane	***T. 2262**	15	3	12	1.8	Limestone	Inclined
***T. 1843**	14	3	13	1.8	Limestone	Plane	***T. 2263**	15	3	13	1.8	Limestone	Inclined
***T. 1844**	12	3	14	1.8	Limestone	Plane	***T. 2264**	13	3	14	1.8	Limestone	Inclined
***T. 1845**	12	3	15	1.8	Limestone	Plane	***T. 2265**	13	3	15	1.8	Limestone	Inclined
***T. 1846**	13,5	3	1	2	Limestone	Plane	***T. 2266**	15	3	1	2	Limestone	Inclined
***T. 1847**	13,5	3	2	2	Limestone	Plane	***T. 2267**	15	3	2	2	Limestone	Inclined
***T. 1848**	13,5	3	3	2	Limestone	Plane	***T. 2268**	15	3	3	2	Limestone	Inclined
***T. 1849**	13,5	3	4	2	Limestone	Plane	***T. 2269**	15	3	4	2	Limestone	Inclined
***T. 1850**	13,5	3	5	2	Limestone	Plane	***T. 2270**	15	3	5	2	Limestone	Inclined
***T. 1851**	13,5	3	6	2	Limestone	Plane	***T. 2271**	15	3	6	2	Limestone	Inclined
***T. 1852**	13,5	3	7	2	Limestone	Plane	***T. 2272**	15	3	7	2	Limestone	Inclined
***T. 1853**	13,5	3	8	2	Limestone	Plane	***T. 2273**	15	3	8	2	Limestone	Inclined
***T. 1854**	13	3	9	2	Limestone	Plane	***T. 2274**	14	3	9	2	Limestone	Inclined
***T. 1855**	12	3	10	2	Limestone	Plane	***T. 2275**	13	3	10	2	Limestone	Inclined
***T. 1856**	12	3	11	2	Limestone	Plane	***T. 2276**	13	3	11	2	Limestone	Inclined
***T. 1857**	13,5	3	12	2	Limestone	Plane	***T. 2277**	15	3	12	2	Limestone	Inclined
***T. 1858**	13,5	3	13	2	Limestone	Plane	***T. 2278**	15	3	13	2	Limestone	Inclined
***T. 1859**	12	3	14	2	Limestone	Plane	***T. 2279**	13	3	14	2	Limestone	Inclined
***T. 1860**	12	3	15	2	Limestone	Plane	***T. 2280**	13	3	15	2	Limestone	Inclined
***T. 1861**	13,5	3	1	2.3	Limestone	Plane	***T. 2281**	15	3	1	2.3	Limestone	Inclined
***T. 1862**	13,5	3	2	2.3	Limestone	Plane	***T. 2282**	15	3	2	2.3	Limestone	Inclined

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Table E.1. (cont.)

***T. 1863**	13,5	3	3	2.3	Limestone	Plane	***T. 2283**	15	3	3	2.3	Limestone	Inclined
***T. 1864**	13,5	3	4	2.3	Limestone	Plane	***T. 2284**	15	3	4	2.3	Limestone	Inclined
***T. 1865**	13,5	3	5	2.3	Limestone	Plane	***T. 2285**	15	3	5	2.3	Limestone	Inclined
***T. 1866**	13,5	3	6	2.3	Limestone	Plane	***T. 2286**	15	3	6	2.3	Limestone	Inclined
***T. 1867**	13,5	3	7	2.3	Limestone	Plane	***T. 2287**	15	3	7	2.3	Limestone	Inclined
***T. 1868**	13,5	3	8	2.3	Limestone	Plane	***T. 2288**	15	3	8	2.3	Limestone	Inclined
***T. 1869**	13,5	3	9	2.3	Limestone	Plane	***T. 2289**	15	3	9	2.3	Limestone	Inclined
***T. 1870**	12	3	10	2.3	Limestone	Plane	***T. 2290**	13	3	10	2.3	Limestone	Inclined
***T. 1871**	12	3	11	2.3	Limestone	Plane	***T. 2291**	13	3	11	2.3	Limestone	Inclined
***T. 1872**	13,5	3	12	2.3	Limestone	Plane	***T. 2292**	15	3	12	2.3	Limestone	Inclined
***T. 1873**	13,5	3	13	2.3	Limestone	Plane	***T. 2293**	15	3	13	2.3	Limestone	Inclined
***T. 1874**	12	3	14	2.3	Limestone	Plane	***T. 2294**	13	3	14	2.3	Limestone	Inclined
***T. 1875**	12	3	15	2.3	Limestone	Plane	***T. 2295**	13	3	15	2.3	Limestone	Inclined
T. 1876	13	3	1	2.5	Limestone	Plane	**T. 2296**	14	3	1	2.5	Limestone	Inclined
T. 1877	13	3	2	2.5	Limestone	Plane	**T. 2297**	14	3	2	2.5	Limestone	Inclined
T. 1878	13	3	3	2.5	Limestone	Plane	**T. 2298**	14	3	3	2.5	Limestone	Inclined
T. 1879	13	3	4	2.5	Limestone	Plane	**T. 2299**	14	3	4	2.5	Limestone	Inclined
T. 1880	13	3	5	2.5	Limestone	Plane	**T. 2300**	14	3	5	2.5	Limestone	Inclined
T. 1881	13	3	6	2.5	Limestone	Plane	**T. 2301**	14	3	6	2.5	Limestone	Inclined
T. 1882	13	3	7	2.5	Limestone	Plane	**T. 2302**	14	3	7	2.5	Limestone	Inclined
T. 1883	13	3	8	2.5	Limestone	Plane	**T. 2303**	14	3	8	2.5	Limestone	Inclined
T. 1884	13	3	9	2.5	Limestone	Plane	**T. 2304**	14	3	9	2.5	Limestone	Inclined
T. 1885	11	3	10	2.5	Limestone	Plane	**T. 2305**	12	3	10	2.5	Limestone	Inclined
T. 1886	11	3	11	2.5	Limestone	Plane	**T. 2306**	12	3	11	2.5	Limestone	Inclined
T. 1887	13	3	12	2.5	Limestone	Plane	**T. 2307**	14	3	12	2.5	Limestone	Inclined
T. 1888	13	3	13	2.5	Limestone	Plane	**T. 2308**	14	3	13	2.5	Limestone	Inclined
T. 1889	11	3	14	2.5	Limestone	Plane	**T. 2309**	12	3	14	2.5	Limestone	Inclined
T. 1890	11	3	15	2.5	Limestone	Plane	**T. 2310**	12	3	15	2.5	Limestone	Inclined
T. 1891	11	3	1	1	Sandstone	Plane	**T. 2311**	12	3	1	1	Sandstone	Inclined
T. 1892	11	3	2	1	Sandstone	Plane	**T. 2312**	12	3	2	1	Sandstone	Inclined
T. 1893	11	3	3	1	Sandstone	Plane	**T. 2313**	12	3	3	1	Sandstone	Inclined
T. 1894	11	3	4	1	Sandstone	Plane	**T. 2314**	12	3	4	1	Sandstone	Inclined
T. 1895	11	3	5	1	Sandstone	Plane	**T. 2315**	12	3	5	1	Sandstone	Inclined

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Table E.1. (cont.)

T. 1896	11	3	6	1	Sandstone	Plane	**T. 2316**	12	3	6	1	Sandstone	Inclined
T. 1897	11	3	7	1	Sandstone	Plane	**T. 2317**	12	3	7	1	Sandstone	Inclined
T. 1898	11	3	8	1	Sandstone	Plane	**T. 2318**	12	3	8	1	Sandstone	Inclined
T. 1899	11	3	9	1	Sandstone	Plane	**T. 2319**	12	3	9	1	Sandstone	Inclined
T. 1900	10	3	10	1	Sandstone	Plane	**T. 2320**	11	3	10	1	Sandstone	Inclined
T. 1901	10	3	11	1	Sandstone	Plane	**T. 2321**	11	3	11	1	Sandstone	Inclined
T. 1902	11	3	12	1	Sandstone	Plane	**T. 2322**	12	3	12	1	Sandstone	Inclined
T. 1903	11	3	13	1	Sandstone	Plane	**T. 2323**	12	3	13	1	Sandstone	Inclined
T. 1904	10	3	14	1	Sandstone	Plane	**T. 2324**	11	3	14	1	Sandstone	Inclined
T. 1905	10	3	15	1	Sandstone	Plane	**T. 2325**	11	3	15	1	Sandstone	Inclined
T. 1906	13	3	1	1.3	Sandstone	Plane	**T. 2326**	14	3	1	1.3	Sandstone	Inclined
T. 1907	13	3	2	1.3	Sandstone	Plane	**T. 2327**	14	3	2	1.3	Sandstone	Inclined
T. 1908	13	3	3	1.3	Sandstone	Plane	**T. 2328**	14	3	3	1.3	Sandstone	Inclined
T. 1909	13	3	4	1.3	Sandstone	Plane	**T. 2329**	14	3	4	1.3	Sandstone	Inclined
T. 1910	13	3	5	1.3	Sandstone	Plane	**T. 2330**	14	3	5	1.3	Sandstone	Inclined
T. 1911	13	3	6	1.3	Sandstone	Plane	**T. 2331**	14	3	6	1.3	Sandstone	Inclined
T. 1912	13	3	7	1.3	Sandstone	Plane	**T. 2332**	14	3	7	1.3	Sandstone	Inclined
T. 1913	13	3	8	1.3	Sandstone	Plane	**T. 2333**	14	3	8	1.3	Sandstone	Inclined
T. 1914	13	3	9	1.3	Sandstone	Plane	**T. 2334**	14	3	9	1.3	Sandstone	Inclined
T. 1915	12	3	10	1.3	Sandstone	Plane	**T. 2335**	13	3	10	1.3	Sandstone	Inclined
T. 1916	12	3	11	1.3	Sandstone	Plane	**T. 2336**	13	3	11	1.3	Sandstone	Inclined
T. 1917	13	3	12	1.3	Sandstone	Plane	**T. 2337**	14	3	12	1.3	Sandstone	Inclined
T. 1918	13	3	13	1.3	Sandstone	Plane	**T. 2338**	14	3	13	1.3	Sandstone	Inclined
T. 1919	12	3	14	1.3	Sandstone	Plane	**T. 2339**	13	3	14	1.3	Sandstone	Inclined
T. 1920	12	3	15	1.3	Sandstone	Plane	**T. 2340**	13	3	15	1.3	Sandstone	Inclined
T. 1921	14	3	1	1.6	Sandstone	Plane	**T. 2341**	15	3	1	1.6	Sandstone	Inclined
T. 1922	14	3	2	1.6	Sandstone	Plane	**T. 2342**	15	3	2	1.6	Sandstone	Inclined
T. 1923	14	3	3	1.6	Sandstone	Plane	**T. 2343**	15	3	3	1.6	Sandstone	Inclined
T. 1924	14	3	4	1.6	Sandstone	Plane	**T. 2344**	15	3	4	1.6	Sandstone	Inclined
T. 1925	14	3	5	1.6	Sandstone	Plane	**T. 2345**	15	3	5	1.6	Sandstone	Inclined
T. 1926	14	3	6	1.6	Sandstone	Plane	**T. 2346**	15	3	6	1.6	Sandstone	Inclined
T. 1927	14	3	7	1.6	Sandstone	Plane	**T. 2347**	15	3	7	1.6	Sandstone	Inclined
T. 1928	14	3	8	1.6	Sandstone	Plane	**T. 2348**	15	3	8	1.6	Sandstone	Inclined

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Table E.1. (cont.)

T. 1929	14	3	9	1.6	Sandstone	Plane	**T. 2349**	15	3	9	1.6	Sandstone	Inclined
T. 1930	12	3	10	1.6	Sandstone	Plane	**T. 2350**	13	3	10	1.6	Sandstone	Inclined
T. 1931	12	3	11	1.6	Sandstone	Plane	**T. 2351**	13	3	11	1.6	Sandstone	Inclined
T. 1932	14	3	12	1.6	Sandstone	Plane	**T. 2352**	15	3	12	1.6	Sandstone	Inclined
T. 1933	14	3	13	1.6	Sandstone	Plane	**T. 2353**	15	3	13	1.6	Sandstone	Inclined
T. 1934	12	3	14	1.6	Sandstone	Plane	**T. 2354**	13	3	14	1.6	Sandstone	Inclined
T. 1935	12	3	15	1.6	Sandstone	Plane	**T. 2355**	13	3	15	1.6	Sandstone	Inclined
T. 1936	14	3	1	1.8	Sandstone	Plane	**T. 2356**	15	3	1	1.8	Sandstone	Inclined
T. 1937	14	3	2	1.8	Sandstone	Plane	**T. 2357**	15	3	2	1.8	Sandstone	Inclined
T. 1938	14	3	3	1.8	Sandstone	Plane	**T. 2358**	15	3	3	1.8	Sandstone	Inclined
T. 1939	14	3	4	1.8	Sandstone	Plane	**T. 2359**	15	3	4	1.8	Sandstone	Inclined
T. 1940	14	3	5	1.8	Sandstone	Plane	**T. 2360**	15	3	5	1.8	Sandstone	Inclined
T. 1941	14	3	6	1.8	Sandstone	Plane	**T. 2361**	15	3	6	1.8	Sandstone	Inclined
T. 1942	14	3	7	1.8	Sandstone	Plane	**T. 2362**	15	3	7	1.8	Sandstone	Inclined
T. 1943	14	3	8	1.8	Sandstone	Plane	**T. 2363**	15	3	8	1.8	Sandstone	Inclined
T. 1944	14	3	9	1.8	Sandstone	Plane	**T. 2364**	15	3	9	1.8	Sandstone	Inclined
T. 1945	12	3	10	1.8	Sandstone	Plane	**T. 2365**	13	3	10	1.8	Sandstone	Inclined
T. 1946	12	3	11	1.8	Sandstone	Plane	**T. 2366**	13	3	11	1.8	Sandstone	Inclined
T. 1947	14	3	12	1.8	Sandstone	Plane	**T. 2367**	15	3	12	1.8	Sandstone	Inclined
T. 1948	14	3	13	1.8	Sandstone	Plane	**T. 2368**	15	3	13	1.8	Sandstone	Inclined
T. 1949	12	3	14	1.8	Sandstone	Plane	**T. 2369**	13	3	14	1.8	Sandstone	Inclined
T. 1950	12	3	15	1.8	Sandstone	Plane	**T. 2370**	13	3	15	1.8	Sandstone	Inclined
T. 1951	13,5	3	1	2	Sandstone	Plane	**T. 2371**	15	3	1	2	Sandstone	Inclined
T. 1952	13,5	3	2	2	Sandstone	Plane	**T. 2372**	15	3	2	2	Sandstone	Inclined
T. 1953	13,5	3	3	2	Sandstone	Plane	**T. 2373**	15	3	3	2	Sandstone	Inclined
T. 1954	13,5	3	4	2	Sandstone	Plane	**T. 2374**	15	3	4	2	Sandstone	Inclined
T. 1955	13,5	3	5	2	Sandstone	Plane	**T. 2375**	15	3	5	2	Sandstone	Inclined
T. 1956	13,5	3	6	2	Sandstone	Plane	**T. 2376**	15	3	6	2	Sandstone	Inclined
T. 1957	13,5	3	7	2	Sandstone	Plane	**T. 2377**	15	3	7	2	Sandstone	Inclined
T. 1958	13,5	3	8	2	Sandstone	Plane	**T. 2378**	15	3	8	2	Sandstone	Inclined
T. 1959	13	3	9	2	Sandstone	Plane	**T. 2379**	14	3	9	2	Sandstone	Inclined
T. 1960	12	3	10	2	Sandstone	Plane	**T. 2380**	13	3	10	2	Sandstone	Inclined
T. 1961	12	3	11	2	Sandstone	Plane	**T. 2381**	13	3	11	2	Sandstone	Inclined

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Table E.1. (cont.)

T. 1962	13,5	3	12	2	Sandstone	Plane	**T. 2382**	15	3	12	2	Sandstone	Inclined
T. 1963	13,5	3	13	2	Sandstone	Plane	**T. 2383**	15	3	13	2	Sandstone	Inclined
T. 1964	12	3	14	2	Sandstone	Plane	**T. 2384**	13	3	14	2	Sandstone	Inclined
T. 1965	12	3	15	2	Sandstone	Plane	**T. 2385**	13	3	15	2	Sandstone	Inclined
T. 1966	13,5	3	1	2.3	Sandstone	Plane	**T. 2386**	15	3	1	2.3	Sandstone	Inclined
T. 1967	13,5	3	2	2.3	Sandstone	Plane	**T. 2387**	15	3	2	2.3	Sandstone	Inclined
T. 1968	13,5	3	3	2.3	Sandstone	Plane	**T. 2388**	15	3	3	2.3	Sandstone	Inclined
T. 1969	13,5	3	4	2.3	Sandstone	Plane	**T. 2389**	15	3	4	2.3	Sandstone	Inclined
T. 1970	13,5	3	5	2.3	Sandstone	Plane	**T. 2390**	15	3	5	2.3	Sandstone	Inclined
T. 1971	13,5	3	6	2.3	Sandstone	Plane	**T. 2391**	15	3	6	2.3	Sandstone	Inclined
T. 1972	13,5	3	7	2.3	Sandstone	Plane	**T. 2392**	15	3	7	2.3	Sandstone	Inclined
T. 1973	13,5	3	8	2.3	Sandstone	Plane	**T. 2393**	15	3	8	2.3	Sandstone	Inclined
T. 1974	13,5	3	9	2.3	Sandstone	Plane	**T. 2394**	15	3	9	2.3	Sandstone	Inclined
T. 1975	12	3	10	2.3	Sandstone	Plane	**T. 2395**	13	3	10	2.3	Sandstone	Inclined
T. 1976	12	3	11	2.3	Sandstone	Plane	**T. 2396**	13	3	11	2.3	Sandstone	Inclined
T. 1977	13,5	3	12	2.3	Sandstone	Plane	**T. 2397**	15	3	12	2.3	Sandstone	Inclined
T. 1978	13,5	3	13	2.3	Sandstone	Plane	**T. 2398**	15	3	13	2.3	Sandstone	Inclined
T. 1979	12	3	14	2.3	Sandstone	Plane	**T. 2399**	13	3	14	2.3	Sandstone	Inclined
T. 1980	12	3	15	2.3	Sandstone	Plane	**T. 2400**	13	3	15	2.3	Sandstone	Inclined
T. 1981	13	3	1	2.5	Sandstone	Plane	**T. 2401**	14	3	1	2.5	Sandstone	Inclined
T. 1982	13	3	2	2.5	Sandstone	Plane	**T. 2402**	14	3	2	2.5	Sandstone	Inclined
T. 1983	13	3	3	2.5	Sandstone	Plane	**T. 2403**	14	3	3	2.5	Sandstone	Inclined
T. 1984	13	3	4	2.5	Sandstone	Plane	**T. 2404**	14	3	4	2.5	Sandstone	Inclined
T. 1985	13	3	5	2.5	Sandstone	Plane	**T. 2405**	14	3	5	2.5	Sandstone	Inclined
T. 1986	13	3	6	2.5	Sandstone	Plane	**T. 2406**	14	3	6	2.5	Sandstone	Inclined
T. 1987	13	3	7	2.5	Sandstone	Plane	**T. 2407**	14	3	7	2.5	Sandstone	Inclined
T. 1988	13	3	8	2.5	Sandstone	Plane	**T. 2408**	14	3	8	2.5	Sandstone	Inclined
T. 1989	13	3	9	2.5	Sandstone	Plane	**T. 2409**	14	3	9	2.5	Sandstone	Inclined
T. 1990	11	3	10	2.5	Sandstone	Plane	**T. 2410**	12	3	10	2.5	Sandstone	Inclined
T. 1991	11	3	11	2.5	Sandstone	Plane	**T. 2411**	12	3	11	2.5	Sandstone	Inclined
T. 1992	13	3	12	2.5	Sandstone	Plane	**T. 2412**	14	3	12	2.5	Sandstone	Inclined
T. 1993	13	3	13	2.5	Sandstone	Plane	**T. 2413**	14	3	13	2.5	Sandstone	Inclined
T. 1994	11	3	14	2.5	Sandstone	Plane	**T. 2414**	12	3	14	2.5	Sandstone	Inclined

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Table E.1. (cont.)

T. 1995	11	3	15	2.5	Sandstone	Plane	**T. 2415**	12	3	15	2.5	Sandstone	Inclined
T. 1996	10	3	1	1	Brick	Plane	**T. 2416**	11	3	1	1	Brick	Inclined
T. 1997	10	3	2	1	Brick	Plane	**T. 2417**	11	3	2	1	Brick	Inclined
T. 1998	10	3	3	1	Brick	Plane	**T. 2418**	11	3	3	1	Brick	Inclined
T. 1999	10	3	4	1	Brick	Plane	**T. 2419**	11	3	4	1	Brick	Inclined
T. 2000	10	3	5	1	Brick	Plane	**T. 2420**	11	3	5	1	Brick	Inclined
T. 2001	10	3	6	1	Brick	Plane	**T. 2421**	11	3	6	1	Brick	Inclined
T. 2002	10	3	7	1	Brick	Plane	**T. 2422**	11	3	7	1	Brick	Inclined
T. 2003	10	3	8	1	Brick	Plane	**T. 2423**	11	3	8	1	Brick	Inclined
T. 2004	10	3	9	1	Brick	Plane	**T. 2424**	11	3	9	1	Brick	Inclined
T. 2005	10	3	10	1	Brick	Plane	**T. 2425**	11	3	10	1	Brick	Inclined
T. 2006	9	3	11	1	Brick	Plane	**T. 2426**	10	3	11	1	Brick	Inclined
T. 2007	9	3	12	1	Brick	Plane	**T. 2427**	10	3	12	1	Brick	Inclined
T. 2008	10	3	13	1	Brick	Plane	**T. 2428**	11	3	13	1	Brick	Inclined
T. 2009	10	3	14	1	Brick	Plane	**T. 2429**	11	3	14	1	Brick	Inclined
T. 2010	9	3	15	1	Brick	Plane	**T. 2430**	10	3	15	1	Brick	Inclined
T. 2011	9	3	1	1.3	Brick	Plane	**T. 2431**	10	3	1	1.3	Brick	Inclined
T. 2012	12	3	2	1.3	Brick	Plane	**T. 2432**	13	3	2	1.3	Brick	Inclined
T. 2013	12	3	3	1.3	Brick	Plane	**T. 2433**	13	3	3	1.3	Brick	Inclined
T. 2014	12	3	4	1.3	Brick	Plane	**T. 2434**	13	3	4	1.3	Brick	Inclined
T. 2015	12	3	5	1.3	Brick	Plane	**T. 2435**	13	3	5	1.3	Brick	Inclined
T. 2016	12	3	6	1.3	Brick	Plane	**T. 2436**	13	3	6	1.3	Brick	Inclined
T. 2017	12	3	7	1.3	Brick	Plane	**T. 2437**	13	3	7	1.3	Brick	Inclined
T. 2018	12	3	8	1.3	Brick	Plane	**T. 2438**	13	3	8	1.3	Brick	Inclined
T. 2019	12	3	9	1.3	Brick	Plane	**T. 2439**	13	3	9	1.3	Brick	Inclined
T. 2020	12	3	10	1.3	Brick	Plane	**T. 2440**	13	3	10	1.3	Brick	Inclined
T. 2021	11	3	11	1.3	Brick	Plane	**T. 2441**	12	3	11	1.3	Brick	Inclined
T. 2022	11	3	12	1.3	Brick	Plane	**T. 2442**	12	3	12	1.3	Brick	Inclined
T. 2023	12	3	13	1.3	Brick	Plane	**T. 2443**	13	3	13	1.3	Brick	Inclined
T. 2024	12	3	14	1.3	Brick	Plane	**T. 2444**	13	3	14	1.3	Brick	Inclined
T. 2025	11	3	15	1.3	Brick	Plane	**T. 2445**	12	3	15	1.3	Brick	Inclined
T. 2026	11	3	1	1.6	Brick	Plane	**T. 2446**	12	3	1	1.6	Brick	Inclined
T. 2027	13	3	2	1.6	Brick	Plane	**T. 2447**	14	3	2	1.6	Brick	Inclined

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Table E.1. (cont.)

T. 2028	13	3	3	1.6	Brick	Plane	**T. 2448**	14	3	3	1.6	Brick	Inclined
T. 2029	13	3	4	1.6	Brick	Plane	**T. 2449**	14	3	4	1.6	Brick	Inclined
T. 2030	13	3	5	1.6	Brick	Plane	**T. 2450**	14	3	5	1.6	Brick	Inclined
T. 2031	13	3	6	1.6	Brick	Plane	**T. 2451**	14	3	6	1.6	Brick	Inclined
T. 2032	13	3	7	1.6	Brick	Plane	**T. 2452**	14	3	7	1.6	Brick	Inclined
T. 2033	13	3	8	1.6	Brick	Plane	**T. 2453**	14	3	8	1.6	Brick	Inclined
T. 2034	13	3	9	1.6	Brick	Plane	**T. 2454**	14	3	9	1.6	Brick	Inclined
T. 2035	13	3	10	1.6	Brick	Plane	**T. 2455**	14	3	10	1.6	Brick	Inclined
T. 2036	11	3	11	1.6	Brick	Plane	**T. 2456**	12	3	11	1.6	Brick	Inclined
T. 2037	11	3	12	1.6	Brick	Plane	**T. 2457**	12	3	12	1.6	Brick	Inclined
T. 2038	13	3	13	1.6	Brick	Plane	**T. 2458**	14	3	13	1.6	Brick	Inclined
T. 2039	13	3	14	1.6	Brick	Plane	**T. 2459**	14	3	14	1.6	Brick	Inclined
T. 2040	11	3	15	1.6	Brick	Plane	**T. 2460**	12	3	15	1.6	Brick	Inclined
T. 2041	11	3	1	1.8	Brick	Plane	**T. 2461**	12	3	1	1.8	Brick	Inclined
T. 2042	13	3	2	1.8	Brick	Plane	**T. 2462**	14	3	2	1.8	Brick	Inclined
T. 2043	13	3	3	1.8	Brick	Plane	**T. 2463**	14	3	3	1.8	Brick	Inclined
T. 2044	13	3	4	1.8	Brick	Plane	**T. 2464**	14	3	4	1.8	Brick	Inclined
T. 2045	13	3	5	1.8	Brick	Plane	**T. 2465**	14	3	5	1.8	Brick	Inclined
T. 2046	13	3	6	1.8	Brick	Plane	**T. 2466**	14	3	6	1.8	Brick	Inclined
T. 2047	13	3	7	1.8	Brick	Plane	**T. 2467**	14	3	7	1.8	Brick	Inclined
T. 2048	13	3	8	1.8	Brick	Plane	**T. 2468**	14	3	8	1.8	Brick	Inclined
T. 2049	13	3	9	1.8	Brick	Plane	**T. 2469**	14	3	9	1.8	Brick	Inclined
T. 2050	13	3	10	1.8	Brick	Plane	**T. 2470**	14	3	10	1.8	Brick	Inclined
T. 2051	11	3	11	1.8	Brick	Plane	**T. 2471**	12	3	11	1.8	Brick	Inclined
T. 2052	11	3	12	1.8	Brick	Plane	**T. 2472**	12	3	12	1.8	Brick	Inclined
T. 2053	13	3	13	1.8	Brick	Plane	**T. 2473**	14	3	13	1.8	Brick	Inclined
T. 2054	13	3	14	1.8	Brick	Plane	**T. 2474**	14	3	14	1.8	Brick	Inclined
T. 2055	11	3	15	1.8	Brick	Plane	**T. 2475**	12	3	15	1.8	Brick	Inclined
T. 2056	11	3	1	2	Brick	Plane	**T. 2476**	12	3	1	2	Brick	Inclined
T. 2057	12,5	3	2	2	Brick	Plane	**T. 2477**	14	3	2	2	Brick	Inclined
T. 2058	12,5	3	3	2	Brick	Plane	**T. 2478**	14	3	3	2	Brick	Inclined
T. 2059	12,5	3	4	2	Brick	Plane	**T. 2479**	14	3	4	2	Brick	Inclined
T. 2060	12,5	3	5	2	Brick	Plane	**T. 2480**	14	3	5	2	Brick	Inclined

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Table E.1. (cont.)

T. 2061	12,5	3	6	2	Brick	Plane	**T. 2481**	14	3	6	2	Brick	Inclined
T. 2062	12,5	3	7	2	Brick	Plane	**T. 2482**	14	3	7	2	Brick	Inclined
T. 2063	12,5	3	8	2	Brick	Plane	**T. 2483**	14	3	8	2	Brick	Inclined
T. 2064	12,5	3	9	2	Brick	Plane	**T. 2484**	14	3	9	2	Brick	Inclined
T. 2065	12	3	10	2	Brick	Plane	**T. 2485**	13	3	10	2	Brick	Inclined
T. 2066	11	3	11	2	Brick	Plane	**T. 2486**	12	3	11	2	Brick	Inclined
T. 2067	11	3	12	2	Brick	Plane	**T. 2487**	12	3	12	2	Brick	Inclined
T. 2068	12,5	3	13	2	Brick	Plane	**T. 2488**	14	3	13	2	Brick	Inclined
T. 2069	12,5	3	14	2	Brick	Plane	**T. 2489**	14	3	14	2	Brick	Inclined
T. 2070	11	3	15	2	Brick	Plane	**T. 2490**	12	3	15	2	Brick	Inclined
T. 2071	11	3	1	2.3	Brick	Plane	**T. 2491**	12	3	1	2.3	Brick	Inclined
T. 2072	12,5	3	2	2.3	Brick	Plane	**T. 2492**	14	3	2	2.3	Brick	Inclined
T. 2073	12,5	3	3	2.3	Brick	Plane	**T. 2493**	14	3	3	2.3	Brick	Inclined
T. 2074	12,5	3	4	2.3	Brick	Plane	**T. 2494**	14	3	4	2.3	Brick	Inclined
T. 2075	12,5	3	5	2.3	Brick	Plane	**T. 2495**	14	3	5	2.3	Brick	Inclined
T. 2076	12,5	3	6	2.3	Brick	Plane	**T. 2496**	14	3	6	2.3	Brick	Inclined
T. 2077	12,5	3	7	2.3	Brick	Plane	**T. 2497**	14	3	7	2.3	Brick	Inclined
T. 2078	12,5	3	8	2.3	Brick	Plane	**T. 2498**	14	3	8	2.3	Brick	Inclined
T. 2079	12,5	3	9	2.3	Brick	Plane	**T. 2499**	14	3	9	2.3	Brick	Inclined
T. 2080	12,5	3	10	2.3	Brick	Plane	**T. 2500**	14	3	10	2.3	Brick	Inclined
T. 2081	11	3	11	2.3	Brick	Plane	**T. 2501**	12	3	11	2.3	Brick	Inclined
T. 2082	11	3	12	2.3	Brick	Plane	**T. 2502**	12	3	12	2.3	Brick	Inclined
T. 2083	12,5	3	13	2.3	Brick	Plane	**T. 2503**	14	3	13	2.3	Brick	Inclined
T. 2084	12,5	3	14	2.3	Brick	Plane	**T. 2504**	14	3	14	2.3	Brick	Inclined
T. 2085	11	3	15	2.3	Brick	Plane	**T. 2505**	12	3	15	2.3	Brick	Inclined
T. 2086	11	3	1	2.5	Brick	Plane	**T. 2506**	12	3	1	2.5	Brick	Inclined
T. 2087	12	3	2	2.5	Brick	Plane	**T. 2507**	13	3	2	2.5	Brick	Inclined
T. 2088	12	3	3	2.5	Brick	Plane	**T. 2508**	13	3	3	2.5	Brick	Inclined
T. 2089	12	3	4	2.5	Brick	Plane	**T. 2509**	13	3	4	2.5	Brick	Inclined
T. 2090	12	3	5	2.5	Brick	Plane	**T. 2510**	13	3	5	2.5	Brick	Inclined
T. 2091	12	3	6	2.5	Brick	Plane	**T. 2511**	13	3	6	2.5	Brick	Inclined
T. 2092	12	3	7	2.5	Brick	Plane	**T. 2512**	13	3	7	2.5	Brick	Inclined
T. 2093	12	3	8	2.5	Brick	Plane	**T. 2513**	13	3	8	2.5	Brick	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 2094	12	3	9	2.5	Brick	Plane	**T. 2514**	13	3	9	2.5	Brick	Inclined
T. 2095	12	3	10	2.5	Brick	Plane	**T. 2515**	13	3	10	2.5	Brick	Inclined
T. 2096	10	3	11	2.5	Brick	Plane	**T. 2516**	11	3	11	2.5	Brick	Inclined
T. 2097	10	3	12	2.5	Brick	Plane	**T. 2517**	11	3	12	2.5	Brick	Inclined
T. 2098	12	3	13	2.5	Brick	Plane	**T. 2518**	13	3	13	2.5	Brick	Inclined
T. 2099	12	3	14	2.5	Brick	Plane	**T. 2519**	13	3	14	2.5	Brick	Inclined
T. 2100	10	3	15	2.5	Brick	Plane	**T. 2520**	11	3	15	2.5	Brick	Inclined
T. 2521	14	4	1	1	Granite	Plane	**T. 2941**	15	4	1	1	Granite	Inclined
T. 2522	14	4	2	1	Granite	Plane	**T. 2942**	15	4	2	1	Granite	Inclined
T. 2523	14	4	3	1	Granite	Plane	**T. 2943**	15	4	3	1	Granite	Inclined
T. 2524	14	4	4	1	Granite	Plane	**T. 2944**	15	4	4	1	Granite	Inclined
T. 2525	14	4	5	1	Granite	Plane	**T. 2945**	15	4	5	1	Granite	Inclined
T. 2526	14	4	6	1	Granite	Plane	**T. 2946**	15	4	6	1	Granite	Inclined
T. 2527	14	4	7	1	Granite	Plane	**T. 2947**	15	4	7	1	Granite	Inclined
T. 2528	14	4	8	1	Granite	Plane	**T. 2948**	15	4	8	1	Granite	Inclined
T. 2529	14	4	9	1	Granite	Plane	**T. 2949**	15	4	9	1	Granite	Inclined
T. 2530	12	4	10	1	Granite	Plane	**T. 2950**	13	4	10	1	Granite	Inclined
T. 2531	13	4	11	1	Granite	Plane	**T. 2951**	14	4	11	1	Granite	Inclined
T. 2532	14	4	12	1	Granite	Plane	**T. 2952**	15	4	12	1	Granite	Inclined
T. 2533	14	4	13	1	Granite	Plane	**T. 2953**	15	4	13	1	Granite	Inclined
T. 2534	13	4	14	1	Granite	Plane	**T. 2954**	14	4	14	1	Granite	Inclined
T. 2535	13	4	15	1	Granite	Plane	**T. 2955**	14	4	15	1	Granite	Inclined
T. 2536	16	4	1	1.3	Granite	Plane	**T. 2956**	17	4	1	1.3	Granite	Inclined
T. 2537	16	4	2	1.3	Granite	Plane	**T. 2957**	17	4	2	1.3	Granite	Inclined
T. 2538	16	4	3	1.3	Granite	Plane	**T. 2958**	17	4	3	1.3	Granite	Inclined
T. 2539	16	4	4	1.3	Granite	Plane	**T. 2959**	17	4	4	1.3	Granite	Inclined
T. 2540	16	4	5	1.3	Granite	Plane	**T. 2960**	17	4	5	1.3	Granite	Inclined
T. 2541	16	4	6	1.3	Granite	Plane	**T. 2961**	17	4	6	1.3	Granite	Inclined
T. 2542	16	4	7	1.3	Granite	Plane	**T. 2962**	17	4	7	1.3	Granite	Inclined
T. 2543	16	4	8	1.3	Granite	Plane	**T. 2963**	17	4	8	1.3	Granite	Inclined
T. 2544	16	4	9	1.3	Granite	Plane	**T. 2964**	17	4	9	1.3	Granite	Inclined
T. 2545	13	4	10	1.3	Granite	Plane	**T. 2965**	14	4	10	1.3	Granite	Inclined
T. 2546	15	4	11	1.3	Granite	Plane	**T. 2966**	16	4	11	1.3	Granite	Inclined

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Table E.1. (cont.)

T. 2547	16	4	12	1.3	Granite	Plane	**T. 2967**	17	4	12	1.3	Granite	Inclined
T. 2548	16	4	13	1.3	Granite	Plane	**T. 2968**	17	4	13	1.3	Granite	Inclined
T. 2549	15	4	14	1.3	Granite	Plane	**T. 2969**	16	4	14	1.3	Granite	Inclined
T. 2550	15	4	15	1.3	Granite	Plane	**T. 2970**	16	4	15	1.3	Granite	Inclined
***T. 2551**	17	4	1	1.6	Granite	Plane	***T. 2971**	18	4	1	1.6	Granite	Inclined
***T. 2552**	17	4	2	1.6	Granite	Plane	***T. 2972**	18	4	2	1.6	Granite	Inclined
***T. 2553**	17	4	3	1.6	Granite	Plane	***T. 2973**	18	4	3	1.6	Granite	Inclined
***T. 2554**	17	4	4	1.6	Granite	Plane	***T. 2974**	18	4	4	1.6	Granite	Inclined
***T. 2555**	17	4	5	1.6	Granite	Plane	***T. 2975**	18	4	5	1.6	Granite	Inclined
***T. 2556**	17	4	6	1.6	Granite	Plane	***T. 2976**	18	4	6	1.6	Granite	Inclined
***T. 2557**	17	4	7	1.6	Granite	Plane	***T. 2977**	18	4	7	1.6	Granite	Inclined
***T. 2558**	17	4	8	1.6	Granite	Plane	***T. 2978**	18	4	8	1.6	Granite	Inclined
***T. 2559**	17	4	9	1.6	Granite	Plane	***T. 2979**	18	4	9	1.6	Granite	Inclined
***T. 2560**	15	4	10	1.6	Granite	Plane	***T. 2980**	16	4	10	1.6	Granite	Inclined
***T. 2561**	17	4	11	1.6	Granite	Plane	***T. 2981**	18	4	11	1.6	Granite	Inclined
***T. 2562**	17	4	12	1.6	Granite	Plane	***T. 2982**	18	4	12	1.6	Granite	Inclined
***T. 2563**	17	4	13	1.6	Granite	Plane	***T. 2983**	18	4	13	1.6	Granite	Inclined
***T. 2564**	17	4	14	1.6	Granite	Plane	***T. 2984**	18	4	14	1.6	Granite	Inclined
***T. 2565**	17	4	15	1.6	Granite	Plane	***T. 2985**	18	4	15	1.6	Granite	Inclined
***T. 2566**	17	4	1	1.8	Granite	Plane	***T. 2986**	18	4	1	1.8	Granite	Inclined
***T. 2567**	17	4	2	1.8	Granite	Plane	***T. 2987**	18	4	2	1.8	Granite	Inclined
***T. 2568**	17	4	3	1.8	Granite	Plane	***T. 2988**	18	4	3	1.8	Granite	Inclined
***T. 2569**	17	4	4	1.8	Granite	Plane	***T. 2989**	18	4	4	1.8	Granite	Inclined
***T. 2570**	17	4	5	1.8	Granite	Plane	***T. 2990**	18	4	5	1.8	Granite	Inclined
***T. 2571**	17	4	6	1.8	Granite	Plane	***T. 2991**	18	4	6	1.8	Granite	Inclined
***T. 2572**	17	4	7	1.8	Granite	Plane	***T. 2992**	18	4	7	1.8	Granite	Inclined
***T. 2573**	17	4	8	1.8	Granite	Plane	***T. 2993**	18	4	8	1.8	Granite	Inclined
***T. 2574**	17	4	9	1.8	Granite	Plane	***T. 2994**	18	4	9	1.8	Granite	Inclined
***T. 2575**	15	4	10	1.8	Granite	Plane	***T. 2995**	16	4	10	1.8	Granite	Inclined
***T. 2576**	17	4	11	1.8	Granite	Plane	***T. 2996**	18	4	11	1.8	Granite	Inclined
***T. 2577**	17	4	12	1.8	Granite	Plane	***T. 2997**	18	4	12	1.8	Granite	Inclined
***T. 2578**	17	4	13	1.8	Granite	Plane	***T. 2998**	18	4	13	1.8	Granite	Inclined
***T. 2579**	17	4	14	1.8	Granite	Plane	***T. 2999**	18	4	14	1.8	Granite	Inclined

(cont. on next page)

Table E.1. (cont.)

***T. 2580**	17	4	15	1.8	Granite	Plane	***T. 3000**	18	4	15	1.8	Granite	Inclined
***T. 2581**	17	4	1	2	Granite	Plane	***T. 3001**	18	4	1	2	Granite	Inclined
***T. 2582**	17	4	2	2	Granite	Plane	***T. 3002**	18	4	2	2	Granite	Inclined
***T. 2583**	17	4	3	2	Granite	Plane	***T. 3003**	18	4	3	2	Granite	Inclined
***T. 2584**	17	4	4	2	Granite	Plane	***T. 3004**	18	4	4	2	Granite	Inclined
***T. 2585**	17	4	5	2	Granite	Plane	***T. 3005**	18	4	5	2	Granite	Inclined
***T. 2586**	17	4	6	2	Granite	Plane	***T. 3006**	18	4	6	2	Granite	Inclined
***T. 2587**	17	4	7	2	Granite	Plane	***T. 3007**	18	4	7	2	Granite	Inclined
***T. 2588**	17	4	8	2	Granite	Plane	***T. 3008**	18	4	8	2	Granite	Inclined
***T. 2589**	17	4	9	2	Granite	Plane	***T. 3009**	18	4	9	2	Granite	Inclined
***T. 2590**	14	4	10	2	Granite	Plane	***T. 3010**	15	4	10	2	Granite	Inclined
***T. 2591**	16	4	11	2	Granite	Plane	***T. 3011**	17	4	11	2	Granite	Inclined
***T. 2592**	17	4	12	2	Granite	Plane	***T. 3012**	18	4	12	2	Granite	Inclined
***T. 2593**	17	4	13	2	Granite	Plane	***T. 3013**	18	4	13	2	Granite	Inclined
***T. 2594**	16	4	14	2	Granite	Plane	***T. 3014**	17	4	14	2	Granite	Inclined
***T. 2595**	16	4	15	2	Granite	Plane	***T. 3015**	17	4	15	2	Granite	Inclined
***T. 2596**	16	4	1	2.3	Granite	Plane	***T. 3016**	17	4	1	2.3	Granite	Inclined
***T. 2597**	16	4	2	2.3	Granite	Plane	***T. 3017**	17	4	2	2.3	Granite	Inclined
***T. 2598**	16	4	3	2.3	Granite	Plane	***T. 3018**	17	4	3	2.3	Granite	Inclined
***T. 2599**	16	4	4	2.3	Granite	Plane	***T. 3019**	17	4	4	2.3	Granite	Inclined
***T. 2600**	16	4	5	2.3	Granite	Plane	***T. 3020**	17	4	5	2.3	Granite	Inclined
***T. 2601**	16	4	6	2.3	Granite	Plane	***T. 3021**	17	4	6	2.3	Granite	Inclined
***T. 2602**	16	4	7	2.3	Granite	Plane	***T. 3022**	17	4	7	2.3	Granite	Inclined
***T. 2603**	16	4	8	2.3	Granite	Plane	***T. 3023**	17	4	8	2.3	Granite	Inclined
***T. 2604**	16	4	9	2.3	Granite	Plane	***T. 3024**	17	4	9	2.3	Granite	Inclined
***T. 2605**	13	4	10	2.3	Granite	Plane	***T. 3025**	14	4	10	2.3	Granite	Inclined
***T. 2606**	16	4	11	2.3	Granite	Plane	***T. 3026**	17	4	11	2.3	Granite	Inclined
***T. 2607**	16	4	12	2.3	Granite	Plane	***T. 3027**	17	4	12	2.3	Granite	Inclined
***T. 2608**	16	4	13	2.3	Granite	Plane	***T. 3028**	17	4	13	2.3	Granite	Inclined
***T. 2609**	15	4	14	2.3	Granite	Plane	***T. 3029**	16	4	14	2.3	Granite	Inclined
***T. 2610**	15	4	15	2.3	Granite	Plane	***T. 3030**	16	4	15	2.3	Granite	Inclined
T. 2611	15	4	1	2.5	Granite	Plane	**T. 3031**	16	4	1	2.5	Granite	Inclined
T. 2612	15	4	2	2.5	Granite	Plane	**T. 3032**	16	4	2	2.5	Granite	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 2613	15	4	3	2.5	Granite	Plane	**T. 3033**	16	4	3	2.5	Granite	Inclined
T. 2614	15	4	4	2.5	Granite	Plane	**T. 3034**	16	4	4	2.5	Granite	Inclined
T. 2615	15	4	5	2.5	Granite	Plane	**T. 3035**	16	4	5	2.5	Granite	Inclined
T. 2616	15	4	6	2.5	Granite	Plane	**T. 3036**	16	4	6	2.5	Granite	Inclined
T. 2617	15	4	7	2.5	Granite	Plane	**T. 3037**	16	4	7	2.5	Granite	Inclined
T. 2618	15	4	8	2.5	Granite	Plane	**T. 3038**	16	4	8	2.5	Granite	Inclined
T. 2619	15	4	9	2.5	Granite	Plane	**T. 3039**	16	4	9	2.5	Granite	Inclined
T. 2620	12	4	10	2.5	Granite	Plane	**T. 3040**	13	4	10	2.5	Granite	Inclined
T. 2621	13	4	11	2.5	Granite	Plane	**T. 3041**	14	4	11	2.5	Granite	Inclined
T. 2622	15	4	12	2.5	Granite	Plane	**T. 3042**	16	4	12	2.5	Granite	Inclined
T. 2623	15	4	13	2.5	Granite	Plane	**T. 3043**	16	4	13	2.5	Granite	Inclined
T. 2624	13	4	14	2.5	Granite	Plane	**T. 3044**	14	4	14	2.5	Granite	Inclined
T. 2625	13	4	15	2.5	Granite	Plane	**T. 3045**	14	4	15	2.5	Granite	Inclined
T. 2626	14	4	1	1	Limestone	Plane	**T. 3046**	15	4	1	1	Limestone	Inclined
T. 2627	14	4	2	1	Limestone	Plane	**T. 3047**	15	4	2	1	Limestone	Inclined
T. 2628	14	4	3	1	Limestone	Plane	**T. 3048**	15	4	3	1	Limestone	Inclined
T. 2629	14	4	4	1	Limestone	Plane	**T. 3049**	15	4	4	1	Limestone	Inclined
T. 2630	14	4	5	1	Limestone	Plane	**T. 3050**	15	4	5	1	Limestone	Inclined
T. 2631	14	4	6	1	Limestone	Plane	**T. 3051**	15	4	6	1	Limestone	Inclined
T. 2632	14	4	7	1	Limestone	Plane	**T. 3052**	15	4	7	1	Limestone	Inclined
T. 2633	14	4	8	1	Limestone	Plane	**T. 3053**	15	4	8	1	Limestone	Inclined
T. 2634	14	4	9	1	Limestone	Plane	**T. 3054**	15	4	9	1	Limestone	Inclined
T. 2635	12	4	10	1	Limestone	Plane	**T. 3055**	13	4	10	1	Limestone	Inclined
T. 2636	13	4	11	1	Limestone	Plane	**T. 3056**	14	4	11	1	Limestone	Inclined
T. 2637	14	4	12	1	Limestone	Plane	**T. 3057**	15	4	12	1	Limestone	Inclined
T. 2638	14	4	13	1	Limestone	Plane	**T. 3058**	15	4	13	1	Limestone	Inclined
T. 2639	13	4	14	1	Limestone	Plane	**T. 3059**	14	4	14	1	Limestone	Inclined
T. 2640	13	4	15	1	Limestone	Plane	**T. 3060**	14	4	15	1	Limestone	Inclined
T. 2641	16	4	1	1.3	Limestone	Plane	**T. 3061**	17	4	1	1.3	Limestone	Inclined
T. 2642	16	4	2	1.3	Limestone	Plane	**T. 3062**	17	4	2	1.3	Limestone	Inclined
T. 2643	16	4	3	1.3	Limestone	Plane	**T. 3063**	17	4	3	1.3	Limestone	Inclined
T. 2644	16	4	4	1.3	Limestone	Plane	**T. 3064**	17	4	4	1.3	Limestone	Inclined
T. 2645	16	4	5	1.3	Limestone	Plane	**T. 3065**	17	4	5	1.3	Limestone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 2646	16	4	6	1.3	Limestone	Plane	**T. 3066**	17	4	6	1.3	Limestone	Inclined
T. 2647	16	4	7	1.3	Limestone	Plane	**T. 3067**	17	4	7	1.3	Limestone	Inclined
T. 2648	16	4	8	1.3	Limestone	Plane	**T. 3068**	17	4	8	1.3	Limestone	Inclined
T. 2649	16	4	9	1.3	Limestone	Plane	**T. 3069**	17	4	9	1.3	Limestone	Inclined
T. 2650	13	4	10	1.3	Limestone	Plane	**T. 3070**	14	4	10	1.3	Limestone	Inclined
T. 2651	15	4	11	1.3	Limestone	Plane	**T. 3071**	16	4	11	1.3	Limestone	Inclined
T. 2652	16	4	12	1.3	Limestone	Plane	**T. 3072**	17	4	12	1.3	Limestone	Inclined
T. 2653	16	4	13	1.3	Limestone	Plane	**T. 3073**	17	4	13	1.3	Limestone	Inclined
T. 2654	15	4	14	1.3	Limestone	Plane	**T. 3074**	16	4	14	1.3	Limestone	Inclined
T. 2655	15	4	15	1.3	Limestone	Plane	**T. 3075**	16	4	15	1.3	Limestone	Inclined
***T. 2656**	17	4	1	1.6	Limestone	Plane	***T. 3076**	18	4	1	1.6	Limestone	Inclined
***T. 2657**	17	4	2	1.6	Limestone	Plane	***T. 3077**	18	4	2	1.6	Limestone	Inclined
***T. 2658**	17	4	3	1.6	Limestone	Plane	***T. 3078**	18	4	3	1.6	Limestone	Inclined
***T. 2659**	17	4	4	1.6	Limestone	Plane	***T. 3079**	18	4	4	1.6	Limestone	Inclined
***T. 2660**	17	4	5	1.6	Limestone	Plane	***T. 3080**	18	4	5	1.6	Limestone	Inclined
***T. 2661**	17	4	6	1.6	Limestone	Plane	***T. 3081**	18	4	6	1.6	Limestone	Inclined
***T. 2662**	17	4	7	1.6	Limestone	Plane	***T. 3082**	18	4	7	1.6	Limestone	Inclined
***T. 2663**	17	4	8	1.6	Limestone	Plane	***T. 3083**	18	4	8	1.6	Limestone	Inclined
***T. 2664**	17	4	9	1.6	Limestone	Plane	***T. 3084**	18	4	9	1.6	Limestone	Inclined
***T. 2665**	15	4	10	1.6	Limestone	Plane	***T. 3085**	16	4	10	1.6	Limestone	Inclined
***T. 2666**	17	4	11	1.6	Limestone	Plane	***T. 3086**	18	4	11	1.6	Limestone	Inclined
***T. 2667**	17	4	12	1.6	Limestone	Plane	***T. 3087**	18	4	12	1.6	Limestone	Inclined
***T. 2668**	17	4	13	1.6	Limestone	Plane	***T. 3088**	18	4	13	1.6	Limestone	Inclined
***T. 2669**	17	4	14	1.6	Limestone	Plane	***T. 3089**	18	4	14	1.6	Limestone	Inclined
***T. 2670**	17	4	15	1.6	Limestone	Plane	***T. 3090**	18	4	15	1.6	Limestone	Inclined
***T. 2671**	17	4	1	1.8	Limestone	Plane	***T. 3091**	18	4	1	1.8	Limestone	Inclined
***T. 2672**	17	4	2	1.8	Limestone	Plane	***T. 3092**	18	4	2	1.8	Limestone	Inclined
***T. 2673**	17	4	3	1.8	Limestone	Plane	***T. 3093**	18	4	3	1.8	Limestone	Inclined
***T. 2674**	17	4	4	1.8	Limestone	Plane	***T. 3094**	18	4	4	1.8	Limestone	Inclined
***T. 2675**	17	4	5	1.8	Limestone	Plane	***T. 3095**	18	4	5	1.8	Limestone	Inclined
***T. 2676**	17	4	6	1.8	Limestone	Plane	***T. 3096**	18	4	6	1.8	Limestone	Inclined
***T. 2677**	17	4	7	1.8	Limestone	Plane	***T. 3097**	18	4	7	1.8	Limestone	Inclined
***T. 2678**	17	4	8	1.8	Limestone	Plane	***T. 3098**	18	4	8	1.8	Limestone	Inclined

(cont. on next page)

Table E.1. (cont.)

***T. 2679**	17	4	9	1.8	Limestone	Plane	***T. 3099**	18	4	9	1.8	Limestone	Inclined
***T. 2680**	15	4	10	1.8	Limestone	Plane	***T. 3100**	16	4	10	1.8	Limestone	Inclined
***T. 2681**	17	4	11	1.8	Limestone	Plane	***T. 3101**	18	4	11	1.8	Limestone	Inclined
***T. 2682**	17	4	12	1.8	Limestone	Plane	***T. 3102**	18	4	12	1.8	Limestone	Inclined
***T. 2683**	17	4	13	1.8	Limestone	Plane	***T. 3103**	18	4	13	1.8	Limestone	Inclined
***T. 2684**	17	4	14	1.8	Limestone	Plane	***T. 3104**	18	4	14	1.8	Limestone	Inclined
***T. 2685**	17	4	15	1.8	Limestone	Plane	***T. 3105**	18	4	15	1.8	Limestone	Inclined
***T. 2686**	17	4	1	2	Limestone	Plane	***T. 3106**	18	4	1	2	Limestone	Inclined
***T. 2687**	17	4	2	2	Limestone	Plane	***T. 3107**	18	4	2	2	Limestone	Inclined
***T. 2688**	17	4	3	2	Limestone	Plane	***T. 3108**	18	4	3	2	Limestone	Inclined
***T. 2689**	17	4	4	2	Limestone	Plane	***T. 3109**	18	4	4	2	Limestone	Inclined
***T. 2690**	17	4	5	2	Limestone	Plane	***T. 3110**	18	4	5	2	Limestone	Inclined
***T. 2691**	17	4	6	2	Limestone	Plane	***T. 3111**	18	4	6	2	Limestone	Inclined
***T. 2692**	17	4	7	2	Limestone	Plane	***T. 3112**	18	4	7	2	Limestone	Inclined
***T. 2693**	17	4	8	2	Limestone	Plane	***T. 3113**	18	4	8	2	Limestone	Inclined
***T. 2694**	17	4	9	2	Limestone	Plane	***T. 3114**	18	4	9	2	Limestone	Inclined
***T. 2695**	14	4	10	2	Limestone	Plane	***T. 3115**	15	4	10	2	Limestone	Inclined
***T. 2696**	16	4	11	2	Limestone	Plane	***T. 3116**	17	4	11	2	Limestone	Inclined
***T. 2697**	17	4	12	2	Limestone	Plane	***T. 3117**	18	4	12	2	Limestone	Inclined
***T. 2698**	17	4	13	2	Limestone	Plane	***T. 3118**	18	4	13	2	Limestone	Inclined
***T. 2699**	16	4	14	2	Limestone	Plane	***T. 3119**	17	4	14	2	Limestone	Inclined
***T. 2700**	16	4	15	2	Limestone	Plane	***T. 3120**	17	4	15	2	Limestone	Inclined
***T. 2701**	16	4	1	2.3	Limestone	Plane	***T. 3121**	17	4	1	2.3	Limestone	Inclined
***T. 2702**	16	4	2	2.3	Limestone	Plane	***T. 3122**	17	4	2	2.3	Limestone	Inclined
***T. 2703**	16	4	3	2.3	Limestone	Plane	***T. 3123**	17	4	3	2.3	Limestone	Inclined
***T. 2704**	16	4	4	2.3	Limestone	Plane	***T. 3124**	17	4	4	2.3	Limestone	Inclined
***T. 2705**	16	4	5	2.3	Limestone	Plane	***T. 3125**	17	4	5	2.3	Limestone	Inclined
***T. 2706**	16	4	6	2.3	Limestone	Plane	***T. 3126**	17	4	6	2.3	Limestone	Inclined
***T. 2707**	16	4	7	2.3	Limestone	Plane	***T. 3127**	17	4	7	2.3	Limestone	Inclined
***T. 2708**	16	4	8	2.3	Limestone	Plane	***T. 3128**	17	4	8	2.3	Limestone	Inclined
***T. 2709**	16	4	9	2.3	Limestone	Plane	***T. 3129**	17	4	9	2.3	Limestone	Inclined
***T. 2710**	13	4	10	2.3	Limestone	Plane	***T. 3130**	14	4	10	2.3	Limestone	Inclined
***T. 2711**	16	4	11	2.3	Limestone	Plane	***T. 3131**	17	4	11	2.3	Limestone	Inclined

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Table E.1. (cont.)

***T. 2712**	16	4	12	2.3	Limestone	Plane	***T. 3132**	17	4	12	2.3	Limestone	Inclined
***T. 2713**	16	4	13	2.3	Limestone	Plane	***T. 3133**	17	4	13	2.3	Limestone	Inclined
***T. 2714**	15	4	14	2.3	Limestone	Plane	***T. 3134**	16	4	14	2.3	Limestone	Inclined
***T. 2715**	15	4	15	2.3	Limestone	Plane	***T. 3135**	16	4	15	2.3	Limestone	Inclined
T. 2716	15	4	1	2.5	Limestone	Plane	**T. 3136**	16	4	1	2.5	Limestone	Inclined
T. 2717	15	4	2	2.5	Limestone	Plane	**T. 3137**	16	4	2	2.5	Limestone	Inclined
T. 2718	15	4	3	2.5	Limestone	Plane	**T. 3138**	16	4	3	2.5	Limestone	Inclined
T. 2719	15	4	4	2.5	Limestone	Plane	**T. 3139**	16	4	4	2.5	Limestone	Inclined
T. 2720	15	4	5	2.5	Limestone	Plane	**T. 3140**	16	4	5	2.5	Limestone	Inclined
T. 2721	15	4	6	2.5	Limestone	Plane	**T. 3141**	16	4	6	2.5	Limestone	Inclined
T. 2722	15	4	7	2.5	Limestone	Plane	**T. 3142**	16	4	7	2.5	Limestone	Inclined
T. 2723	15	4	8	2.5	Limestone	Plane	**T. 3143**	16	4	8	2.5	Limestone	Inclined
T. 2724	15	4	9	2.5	Limestone	Plane	**T. 3144**	16	4	9	2.5	Limestone	Inclined
T. 2725	12	4	10	2.5	Limestone	Plane	**T. 3145**	13	4	10	2.5	Limestone	Inclined
T. 2726	13	4	11	2.5	Limestone	Plane	**T. 3146**	14	4	11	2.5	Limestone	Inclined
T. 2727	15	4	12	2.5	Limestone	Plane	**T. 3147**	16	4	12	2.5	Limestone	Inclined
T. 2728	15	4	13	2.5	Limestone	Plane	**T. 3148**	16	4	13	2.5	Limestone	Inclined
T. 2729	13	4	14	2.5	Limestone	Plane	**T. 3149**	14	4	14	2.5	Limestone	Inclined
T. 2730	13	4	15	2.5	Limestone	Plane	**T. 3150**	14	4	15	2.5	Limestone	Inclined
T. 2731	14	4	1	1	Sandstone	Plane	**T. 3151**	15	4	1	1	Sandstone	Inclined
T. 2732	14	4	2	1	Sandstone	Plane	**T. 3152**	15	4	2	1	Sandstone	Inclined
T. 2733	14	4	3	1	Sandstone	Plane	**T. 3153**	15	4	3	1	Sandstone	Inclined
T. 2734	14	4	4	1	Sandstone	Plane	**T. 3154**	15	4	4	1	Sandstone	Inclined
T. 2735	14	4	5	1	Sandstone	Plane	**T. 3155**	15	4	5	1	Sandstone	Inclined
T. 2736	14	4	6	1	Sandstone	Plane	**T. 3156**	15	4	6	1	Sandstone	Inclined
T. 2737	14	4	7	1	Sandstone	Plane	**T. 3157**	15	4	7	1	Sandstone	Inclined
T. 2738	14	4	8	1	Sandstone	Plane	**T. 3158**	15	4	8	1	Sandstone	Inclined
T. 2739	14	4	9	1	Sandstone	Plane	**T. 3159**	15	4	9	1	Sandstone	Inclined
T. 2740	12	4	10	1	Sandstone	Plane	**T. 3160**	13	4	10	1	Sandstone	Inclined
T. 2741	13	4	11	1	Sandstone	Plane	**T. 3161**	14	4	11	1	Sandstone	Inclined
T. 2742	14	4	12	1	Sandstone	Plane	**T. 3162**	15	4	12	1	Sandstone	Inclined
T. 2743	14	4	13	1	Sandstone	Plane	**T. 3163**	15	4	13	1	Sandstone	Inclined
T. 2744	13	4	14	1	Sandstone	Plane	**T. 3164**	14	4	14	1	Sandstone	Inclined

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Table E.1. (cont.)

T. 2745	13	4	15	1	Sandstone	Plane	**T. 3165**	14	4	15	1	Sandstone	Inclined
T. 2746	16	4	1	1.3	Sandstone	Plane	**T. 3166**	17	4	1	1.3	Sandstone	Inclined
T. 2747	16	4	2	1.3	Sandstone	Plane	**T. 3167**	17	4	2	1.3	Sandstone	Inclined
T. 2748	16	4	3	1.3	Sandstone	Plane	**T. 3168**	17	4	3	1.3	Sandstone	Inclined
T. 2749	16	4	4	1.3	Sandstone	Plane	**T. 3169**	17	4	4	1.3	Sandstone	Inclined
T. 2750	16	4	5	1.3	Sandstone	Plane	**T. 3170**	17	4	5	1.3	Sandstone	Inclined
T. 2751	16	4	6	1.3	Sandstone	Plane	**T. 3171**	17	4	6	1.3	Sandstone	Inclined
T. 2752	16	4	7	1.3	Sandstone	Plane	**T. 3172**	17	4	7	1.3	Sandstone	Inclined
T. 2753	16	4	8	1.3	Sandstone	Plane	**T. 3173**	17	4	8	1.3	Sandstone	Inclined
T. 2754	16	4	9	1.3	Sandstone	Plane	**T. 3174**	17	4	9	1.3	Sandstone	Inclined
T. 2755	13	4	10	1.3	Sandstone	Plane	**T. 3175**	14	4	10	1.3	Sandstone	Inclined
T. 2756	15	4	11	1.3	Sandstone	Plane	**T. 3176**	16	4	11	1.3	Sandstone	Inclined
T. 2757	16	4	12	1.3	Sandstone	Plane	**T. 3177**	17	4	12	1.3	Sandstone	Inclined
T. 2758	16	4	13	1.3	Sandstone	Plane	**T. 3178**	17	4	13	1.3	Sandstone	Inclined
T. 2759	15	4	14	1.3	Sandstone	Plane	**T. 3179**	16	4	14	1.3	Sandstone	Inclined
T. 2760	15	4	15	1.3	Sandstone	Plane	**T. 3180**	16	4	15	1.3	Sandstone	Inclined
T. 2761	17	4	1	1.6	Sandstone	Plane	**T. 3181**	18	4	1	1.6	Sandstone	Inclined
T. 2762	17	4	2	1.6	Sandstone	Plane	**T. 3182**	18	4	2	1.6	Sandstone	Inclined
T. 2763	17	4	3	1.6	Sandstone	Plane	**T. 3183**	18	4	3	1.6	Sandstone	Inclined
T. 2764	17	4	4	1.6	Sandstone	Plane	**T. 3184**	18	4	4	1.6	Sandstone	Inclined
T. 2765	17	4	5	1.6	Sandstone	Plane	**T. 3185**	18	4	5	1.6	Sandstone	Inclined
T. 2766	17	4	6	1.6	Sandstone	Plane	**T. 3186**	18	4	6	1.6	Sandstone	Inclined
T. 2767	17	4	7	1.6	Sandstone	Plane	**T. 3187**	18	4	7	1.6	Sandstone	Inclined
T. 2768	17	4	8	1.6	Sandstone	Plane	**T. 3188**	18	4	8	1.6	Sandstone	Inclined
T. 2769	17	4	9	1.6	Sandstone	Plane	**T. 3189**	18	4	9	1.6	Sandstone	Inclined
T. 2770	15	4	10	1.6	Sandstone	Plane	**T. 3190**	16	4	10	1.6	Sandstone	Inclined
T. 2771	17	4	11	1.6	Sandstone	Plane	**T. 3191**	18	4	11	1.6	Sandstone	Inclined
T. 2772	17	4	12	1.6	Sandstone	Plane	**T. 3192**	18	4	12	1.6	Sandstone	Inclined
T. 2773	17	4	13	1.6	Sandstone	Plane	**T. 3193**	18	4	13	1.6	Sandstone	Inclined
T. 2774	17	4	14	1.6	Sandstone	Plane	**T. 3194**	18	4	14	1.6	Sandstone	Inclined
T. 2775	17	4	15	1.6	Sandstone	Plane	**T. 3195**	18	4	15	1.6	Sandstone	Inclined
T. 2776	17	4	1	1.8	Sandstone	Plane	**T. 3196**	18	4	1	1.8	Sandstone	Inclined
T. 2777	17	4	2	1.8	Sandstone	Plane	**T. 3197**	18	4	2	1.8	Sandstone	Inclined

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Table E.1. (cont.)

T. 2778	17	4	3	1.8	Sandstone	Plane	**T. 3198**	18	4	3	1.8	Sandstone	Inclined
T. 2779	17	4	4	1.8	Sandstone	Plane	**T. 3199**	18	4	4	1.8	Sandstone	Inclined
T. 2780	17	4	5	1.8	Sandstone	Plane	**T. 3200**	18	4	5	1.8	Sandstone	Inclined
T. 2781	17	4	6	1.8	Sandstone	Plane	**T. 3201**	18	4	6	1.8	Sandstone	Inclined
T. 2782	17	4	7	1.8	Sandstone	Plane	**T. 3202**	18	4	7	1.8	Sandstone	Inclined
T. 2783	17	4	8	1.8	Sandstone	Plane	**T. 3203**	18	4	8	1.8	Sandstone	Inclined
T. 2784	17	4	9	1.8	Sandstone	Plane	**T. 3204**	18	4	9	1.8	Sandstone	Inclined
T. 2785	15	4	10	1.8	Sandstone	Plane	**T. 3205**	16	4	10	1.8	Sandstone	Inclined
T. 2786	17	4	11	1.8	Sandstone	Plane	**T. 3206**	18	4	11	1.8	Sandstone	Inclined
T. 2787	17	4	12	1.8	Sandstone	Plane	**T. 3207**	18	4	12	1.8	Sandstone	Inclined
T. 2788	17	4	13	1.8	Sandstone	Plane	**T. 3208**	18	4	13	1.8	Sandstone	Inclined
T. 2789	17	4	14	1.8	Sandstone	Plane	**T. 3209**	18	4	14	1.8	Sandstone	Inclined
T. 2790	17	4	15	1.8	Sandstone	Plane	**T. 3210**	18	4	15	1.8	Sandstone	Inclined
T. 2791	17	4	1	2	Sandstone	Plane	**T. 3211**	18	4	1	2	Sandstone	Inclined
T. 2792	17	4	2	2	Sandstone	Plane	**T. 3212**	18	4	2	2	Sandstone	Inclined
T. 2793	17	4	3	2	Sandstone	Plane	**T. 3213**	18	4	3	2	Sandstone	Inclined
T. 2794	17	4	4	2	Sandstone	Plane	**T. 3214**	18	4	4	2	Sandstone	Inclined
T. 2795	17	4	5	2	Sandstone	Plane	**T. 3215**	18	4	5	2	Sandstone	Inclined
T. 2796	17	4	6	2	Sandstone	Plane	**T. 3216**	18	4	6	2	Sandstone	Inclined
T. 2797	17	4	7	2	Sandstone	Plane	**T. 3217**	18	4	7	2	Sandstone	Inclined
T. 2798	17	4	8	2	Sandstone	Plane	**T. 3218**	18	4	8	2	Sandstone	Inclined
T. 2799	17	4	9	2	Sandstone	Plane	**T. 3219**	18	4	9	2	Sandstone	Inclined
T. 2800	14	4	10	2	Sandstone	Plane	**T. 3220**	15	4	10	2	Sandstone	Inclined
T. 2801	16	4	11	2	Sandstone	Plane	**T. 3221**	17	4	11	2	Sandstone	Inclined
T. 2802	17	4	12	2	Sandstone	Plane	**T. 3222**	18	4	12	2	Sandstone	Inclined
T. 2803	17	4	13	2	Sandstone	Plane	**T. 3223**	18	4	13	2	Sandstone	Inclined
T. 2804	16	4	14	2	Sandstone	Plane	**T. 3224**	17	4	14	2	Sandstone	Inclined
T. 2805	16	4	15	2	Sandstone	Plane	**T. 3225**	17	4	15	2	Sandstone	Inclined
T. 2806	16	4	1	2.3	Sandstone	Plane	**T. 3226**	17	4	1	2.3	Sandstone	Inclined
T. 2807	16	4	2	2.3	Sandstone	Plane	**T. 3227**	17	4	2	2.3	Sandstone	Inclined
T. 2808	16	4	3	2.3	Sandstone	Plane	**T. 3228**	17	4	3	2.3	Sandstone	Inclined
T. 2809	16	4	4	2.3	Sandstone	Plane	**T. 3229**	17	4	4	2.3	Sandstone	Inclined
T. 2810	16	4	5	2.3	Sandstone	Plane	**T. 3230**	17	4	5	2.3	Sandstone	Inclined

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Table E.1. (cont.)

T. 2811	16	4	6	2.3	Sandstone	Plane	**T. 3231**	17	4	6	2.3	Sandstone	Inclined
T. 2812	16	4	7	2.3	Sandstone	Plane	**T. 3232**	17	4	7	2.3	Sandstone	Inclined
T. 2813	16	4	8	2.3	Sandstone	Plane	**T. 3233**	17	4	8	2.3	Sandstone	Inclined
T. 2814	16	4	9	2.3	Sandstone	Plane	**T. 3234**	17	4	9	2.3	Sandstone	Inclined
T. 2815	13	4	10	2.3	Sandstone	Plane	**T. 3235**	14	4	10	2.3	Sandstone	Inclined
T. 2816	16	4	11	2.3	Sandstone	Plane	**T. 3236**	17	4	11	2.3	Sandstone	Inclined
T. 2817	16	4	12	2.3	Sandstone	Plane	**T. 3237**	17	4	12	2.3	Sandstone	Inclined
T. 2818	16	4	13	2.3	Sandstone	Plane	**T. 3238**	17	4	13	2.3	Sandstone	Inclined
T. 2819	15	4	14	2.3	Sandstone	Plane	**T. 3239**	16	4	14	2.3	Sandstone	Inclined
T. 2820	15	4	15	2.3	Sandstone	Plane	**T. 3240**	16	4	15	2.3	Sandstone	Inclined
T. 2821	15	4	1	2.5	Sandstone	Plane	**T. 3241**	16	4	1	2.5	Sandstone	Inclined
T. 2822	15	4	2	2.5	Sandstone	Plane	**T. 3242**	16	4	2	2.5	Sandstone	Inclined
T. 2823	15	4	3	2.5	Sandstone	Plane	**T. 3243**	16	4	3	2.5	Sandstone	Inclined
T. 2824	15	4	4	2.5	Sandstone	Plane	**T. 3244**	16	4	4	2.5	Sandstone	Inclined
T. 2825	15	4	5	2.5	Sandstone	Plane	**T. 3245**	16	4	5	2.5	Sandstone	Inclined
T. 2826	15	4	6	2.5	Sandstone	Plane	**T. 3246**	16	4	6	2.5	Sandstone	Inclined
T. 2827	15	4	7	2.5	Sandstone	Plane	**T. 3247**	16	4	7	2.5	Sandstone	Inclined
T. 2828	15	4	8	2.5	Sandstone	Plane	**T. 3248**	16	4	8	2.5	Sandstone	Inclined
T. 2829	15	4	9	2.5	Sandstone	Plane	**T. 3249**	16	4	9	2.5	Sandstone	Inclined
T. 2830	12	4	10	2.5	Sandstone	Plane	**T. 3250**	13	4	10	2.5	Sandstone	Inclined
T. 2831	13	4	11	2.5	Sandstone	Plane	**T. 3251**	14	4	11	2.5	Sandstone	Inclined
T. 2832	15	4	12	2.5	Sandstone	Plane	**T. 3252**	16	4	12	2.5	Sandstone	Inclined
T. 2833	15	4	13	2.5	Sandstone	Plane	**T. 3253**	16	4	13	2.5	Sandstone	Inclined
T. 2834	13	4	14	2.5	Sandstone	Plane	**T. 3254**	14	4	14	2.5	Sandstone	Inclined
T. 2835	13	4	15	2.5	Sandstone	Plane	**T. 3255**	14	4	15	2.5	Sandstone	Inclined
T. 2836	13	4	1	1	Brick	Plane	**T. 3256**	14	4	1	1	Brick	Inclined
T. 2837	13	4	2	1	Brick	Plane	**T. 3257**	14	4	2	1	Brick	Inclined
T. 2838	13	4	3	1	Brick	Plane	**T. 3258**	14	4	3	1	Brick	Inclined
T. 2839	13	4	4	1	Brick	Plane	**T. 3259**	14	4	4	1	Brick	Inclined
T. 2840	13	4	5	1	Brick	Plane	**T. 3260**	14	4	5	1	Brick	Inclined
T. 2841	13	4	6	1	Brick	Plane	**T. 3261**	14	4	6	1	Brick	Inclined
T. 2842	13	4	7	1	Brick	Plane	**T. 3262**	14	4	7	1	Brick	Inclined
T. 2843	13	4	8	1	Brick	Plane	**T. 3263**	14	4	8	1	Brick	Inclined

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Table E.1. (cont.)

T. 2844	13	4	9	1	Brick	Plane	**T. 3264**	14	4	9	1	Brick	Inclined
T. 2845	11	4	10	1	Brick	Plane	**T. 3265**	12	4	10	1	Brick	Inclined
T. 2846	12	4	11	1	Brick	Plane	**T. 3266**	13	4	11	1	Brick	Inclined
T. 2847	13	4	12	1	Brick	Plane	**T. 3267**	14	4	12	1	Brick	Inclined
T. 2848	13	4	13	1	Brick	Plane	**T. 3268**	14	4	13	1	Brick	Inclined
T. 2849	12	4	14	1	Brick	Plane	**T. 3269**	13	4	14	1	Brick	Inclined
T. 2850	12	4	15	1	Brick	Plane	**T. 3270**	13	4	15	1	Brick	Inclined
T. 2851	15	4	1	1.3	Brick	Plane	**T. 3271**	16	4	1	1.3	Brick	Inclined
T. 2852	15	4	2	1.3	Brick	Plane	**T. 3272**	16	4	2	1.3	Brick	Inclined
T. 2853	15	4	3	1.3	Brick	Plane	**T. 3273**	16	4	3	1.3	Brick	Inclined
T. 2854	15	4	4	1.3	Brick	Plane	**T. 3274**	16	4	4	1.3	Brick	Inclined
T. 2855	15	4	5	1.3	Brick	Plane	**T. 3275**	16	4	5	1.3	Brick	Inclined
T. 2856	15	4	6	1.3	Brick	Plane	**T. 3276**	16	4	6	1.3	Brick	Inclined
T. 2857	15	4	7	1.3	Brick	Plane	**T. 3277**	16	4	7	1.3	Brick	Inclined
T. 2858	15	4	8	1.3	Brick	Plane	**T. 3278**	16	4	8	1.3	Brick	Inclined
T. 2859	15	4	9	1.3	Brick	Plane	**T. 3279**	16	4	9	1.3	Brick	Inclined
T. 2860	12	4	10	1.3	Brick	Plane	**T. 3280**	13	4	10	1.3	Brick	Inclined
T. 2861	14	4	11	1.3	Brick	Plane	**T. 3281**	15	4	11	1.3	Brick	Inclined
T. 2862	15	4	12	1.3	Brick	Plane	**T. 3282**	16	4	12	1.3	Brick	Inclined
T. 2863	15	4	13	1.3	Brick	Plane	**T. 3283**	16	4	13	1.3	Brick	Inclined
T. 2864	14	4	14	1.3	Brick	Plane	**T. 3284**	15	4	14	1.3	Brick	Inclined
T. 2865	14	4	15	1.3	Brick	Plane	**T. 3285**	15	4	15	1.3	Brick	Inclined
T. 2866	16	4	1	1.6	Brick	Plane	**T. 3286**	17	4	1	1.6	Brick	Inclined
T. 2867	16	4	2	1.6	Brick	Plane	**T. 3287**	17	4	2	1.6	Brick	Inclined
T. 2868	16	4	3	1.6	Brick	Plane	**T. 3288**	17	4	3	1.6	Brick	Inclined
T. 2869	16	4	4	1.6	Brick	Plane	**T. 3289**	17	4	4	1.6	Brick	Inclined
T. 2870	16	4	5	1.6	Brick	Plane	**T. 3290**	17	4	5	1.6	Brick	Inclined
T. 2871	16	4	6	1.6	Brick	Plane	**T. 3291**	17	4	6	1.6	Brick	Inclined
T. 2872	16	4	7	1.6	Brick	Plane	**T. 3292**	17	4	7	1.6	Brick	Inclined
T. 2873	16	4	8	1.6	Brick	Plane	**T. 3293**	17	4	8	1.6	Brick	Inclined
T. 2874	16	4	9	1.6	Brick	Plane	**T. 3294**	17	4	9	1.6	Brick	Inclined
T. 2875	14	4	10	1.6	Brick	Plane	**T. 3295**	15	4	10	1.6	Brick	Inclined
T. 2876	16	4	11	1.6	Brick	Plane	**T. 3296**	17	4	11	1.6	Brick	Inclined

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Table E.1. (cont.)

T. 2877	16	4	12	1.6	Brick	Plane	**T. 3297**	17	4	12	1.6	Brick	Inclined
T. 2878	16	4	13	1.6	Brick	Plane	**T. 3298**	17	4	13	1.6	Brick	Inclined
T. 2879	16	4	14	1.6	Brick	Plane	**T. 3299**	17	4	14	1.6	Brick	Inclined
T. 2880	16	4	15	1.6	Brick	Plane	**T. 3300**	17	4	15	1.6	Brick	Inclined
T. 2881	16	4	1	1.8	Brick	Plane	**T. 3301**	17	4	1	1.8	Brick	Inclined
T. 2882	16	4	2	1.8	Brick	Plane	**T. 3302**	17	4	2	1.8	Brick	Inclined
T. 2883	16	4	3	1.8	Brick	Plane	**T. 3303**	17	4	3	1.8	Brick	Inclined
T. 2884	16	4	4	1.8	Brick	Plane	**T. 3304**	17	4	4	1.8	Brick	Inclined
T. 2885	16	4	5	1.8	Brick	Plane	**T. 3305**	17	4	5	1.8	Brick	Inclined
T. 2886	16	4	6	1.8	Brick	Plane	**T. 3306**	17	4	6	1.8	Brick	Inclined
T. 2887	16	4	7	1.8	Brick	Plane	**T. 3307**	17	4	7	1.8	Brick	Inclined
T. 2888	16	4	8	1.8	Brick	Plane	**T. 3308**	17	4	8	1.8	Brick	Inclined
T. 2889	16	4	9	1.8	Brick	Plane	**T. 3309**	17	4	9	1.8	Brick	Inclined
T. 2890	14	4	10	1.8	Brick	Plane	**T. 3310**	15	4	10	1.8	Brick	Inclined
T. 2891	16	4	11	1.8	Brick	Plane	**T. 3311**	17	4	11	1.8	Brick	Inclined
T. 2892	16	4	12	1.8	Brick	Plane	**T. 3312**	17	4	12	1.8	Brick	Inclined
T. 2893	16	4	13	1.8	Brick	Plane	**T. 3313**	17	4	13	1.8	Brick	Inclined
T. 2894	16	4	14	1.8	Brick	Plane	**T. 3314**	17	4	14	1.8	Brick	Inclined
T. 2895	16	4	15	1.8	Brick	Plane	**T. 3315**	17	4	15	1.8	Brick	Inclined
T. 2896	16	4	1	2	Brick	Plane	**T. 3316**	17	4	1	2	Brick	Inclined
T. 2897	16	4	2	2	Brick	Plane	**T. 3317**	17	4	2	2	Brick	Inclined
T. 2898	16	4	3	2	Brick	Plane	**T. 3318**	17	4	3	2	Brick	Inclined
T. 2899	16	4	4	2	Brick	Plane	**T. 3319**	17	4	4	2	Brick	Inclined
T. 2900	16	4	5	2	Brick	Plane	**T. 3320**	17	4	5	2	Brick	Inclined
T. 2901	16	4	6	2	Brick	Plane	**T. 3321**	17	4	6	2	Brick	Inclined
T. 2902	16	4	7	2	Brick	Plane	**T. 3322**	17	4	7	2	Brick	Inclined
T. 2903	16	4	8	2	Brick	Plane	**T. 3323**	17	4	8	2	Brick	Inclined
T. 2904	16	4	9	2	Brick	Plane	**T. 3324**	17	4	9	2	Brick	Inclined
T. 2905	13	4	10	2	Brick	Plane	**T. 3325**	14	4	10	2	Brick	Inclined
T. 2906	15	4	11	2	Brick	Plane	**T. 3326**	16	4	11	2	Brick	Inclined
T. 2907	16	4	12	2	Brick	Plane	**T. 3327**	17	4	12	2	Brick	Inclined
T. 2908	16	4	13	2	Brick	Plane	**T. 3328**	17	4	13	2	Brick	Inclined
T. 2909	15	4	14	2	Brick	Plane	**T. 3329**	16	4	14	2	Brick	Inclined

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Table E.1. (cont.)

T. 2910	15	4	15	2	Brick	Plane	**T. 3330**	16	4	15	2	Brick	Inclined
T. 2911	15	4	1	2.3	Brick	Plane	**T. 3331**	16	4	1	2.3	Brick	Inclined
T. 2912	15	4	2	2.3	Brick	Plane	**T. 3332**	16	4	2	2.3	Brick	Inclined
T. 2913	15	4	3	2.3	Brick	Plane	**T. 3333**	16	4	3	2.3	Brick	Inclined
T. 2914	15	4	4	2.3	Brick	Plane	**T. 3334**	16	4	4	2.3	Brick	Inclined
T. 2915	15	4	5	2.3	Brick	Plane	**T. 3335**	16	4	5	2.3	Brick	Inclined
T. 2916	15	4	6	2.3	Brick	Plane	**T. 3336**	16	4	6	2.3	Brick	Inclined
T. 2917	15	4	7	2.3	Brick	Plane	**T. 3337**	16	4	7	2.3	Brick	Inclined
T. 2918	15	4	8	2.3	Brick	Plane	**T. 3338**	16	4	8	2.3	Brick	Inclined
T. 2919	15	4	9	2.3	Brick	Plane	**T. 3339**	16	4	9	2.3	Brick	Inclined
T. 2920	12	4	10	2.3	Brick	Plane	**T. 3340**	13	4	10	2.3	Brick	Inclined
T. 2921	15	4	11	2.3	Brick	Plane	**T. 3341**	16	4	11	2.3	Brick	Inclined
T. 2922	15	4	12	2.3	Brick	Plane	**T. 3342**	16	4	12	2.3	Brick	Inclined
T. 2923	15	4	13	2.3	Brick	Plane	**T. 3343**	16	4	13	2.3	Brick	Inclined
T. 2924	14	4	14	2.3	Brick	Plane	**T. 3344**	15	4	14	2.3	Brick	Inclined
T. 2925	14	4	15	2.3	Brick	Plane	**T. 3345**	15	4	15	2.3	Brick	Inclined
T. 2926	14	4	1	2.5	Brick	Plane	**T. 3346**	15	4	1	2.5	Brick	Inclined
T. 2927	14	4	2	2.5	Brick	Plane	**T. 3347**	15	4	2	2.5	Brick	Inclined
T. 2928	14	4	3	2.5	Brick	Plane	**T. 3348**	15	4	3	2.5	Brick	Inclined
T. 2929	14	4	4	2.5	Brick	Plane	**T. 3349**	15	4	4	2.5	Brick	Inclined
T. 2930	14	4	5	2.5	Brick	Plane	**T. 3350**	15	4	5	2.5	Brick	Inclined
T. 2931	14	4	6	2.5	Brick	Plane	**T. 3351**	15	4	6	2.5	Brick	Inclined
T. 2932	14	4	7	2.5	Brick	Plane	**T. 3352**	15	4	7	2.5	Brick	Inclined
T. 2933	14	4	8	2.5	Brick	Plane	**T. 3353**	15	4	8	2.5	Brick	Inclined
T. 2934	14	4	9	2.5	Brick	Plane	**T. 3354**	15	4	9	2.5	Brick	Inclined
T. 2935	11	4	10	2.5	Brick	Plane	**T. 3355**	12	4	10	2.5	Brick	Inclined
T. 2936	12	4	11	2.5	Brick	Plane	**T. 3356**	13	4	11	2.5	Brick	Inclined
T. 2937	14	4	12	2.5	Brick	Plane	**T. 3357**	15	4	12	2.5	Brick	Inclined
T. 2938	14	4	13	2.5	Brick	Plane	**T. 3358**	15	4	13	2.5	Brick	Inclined
T. 2939	12	4	14	2.5	Brick	Plane	**T. 3359**	13	4	14	2.5	Brick	Inclined
T. 2940	12	4	15	2.5	Brick	Plane	**T. 3360**	13	4	15	2.5	Brick	Inclined
T. 3361	12	5	1	1	Granite	Plane	**T. 3781**	13	5	1	1	Granite	Inclined
T. 3362	12	5	2	1	Granite	Plane	**T. 3782**	13	5	2	1	Granite	Inclined

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Table E.1. (cont.)

T. 3363	12	5	3	1	Granite	Plane	**T. 3783**	13	5	3	1	Granite	Inclined
T. 3364	12	5	4	1	Granite	Plane	**T. 3784**	13	5	4	1	Granite	Inclined
T. 3365	12	5	5	1	Granite	Plane	**T. 3785**	13	5	5	1	Granite	Inclined
T. 3366	11	5	6	1	Granite	Plane	**T. 3786**	12	5	6	1	Granite	Inclined
T. 3367	12	5	7	1	Granite	Plane	**T. 3787**	13	5	7	1	Granite	Inclined
T. 3368	12	5	8	1	Granite	Plane	**T. 3788**	13	5	8	1	Granite	Inclined
T. 3369	11	5	9	1	Granite	Plane	**T. 3789**	12	5	9	1	Granite	Inclined
T. 3370	10	5	10	1	Granite	Plane	**T. 3790**	11	5	10	1	Granite	Inclined
T. 3371	10	5	11	1	Granite	Plane	**T. 3791**	11	5	11	1	Granite	Inclined
T. 3372	12	5	12	1	Granite	Plane	**T. 3792**	13	5	12	1	Granite	Inclined
T. 3373	12	5	13	1	Granite	Plane	**T. 3793**	13	5	13	1	Granite	Inclined
T. 3374	10	5	14	1	Granite	Plane	**T. 3794**	11	5	14	1	Granite	Inclined
T. 3375	10	5	15	1	Granite	Plane	**T. 3795**	11	5	15	1	Granite	Inclined
T. 3376	13	5	1	1.3	Granite	Plane	**T. 3796**	14	5	1	1.3	Granite	Inclined
T. 3377	13	5	2	1.3	Granite	Plane	**T. 3797**	14	5	2	1.3	Granite	Inclined
T. 3378	13	5	3	1.3	Granite	Plane	**T. 3798**	14	5	3	1.3	Granite	Inclined
T. 3379	13	5	4	1.3	Granite	Plane	**T. 3799**	14	5	4	1.3	Granite	Inclined
T. 3380	13	5	5	1.3	Granite	Plane	**T. 3800**	14	5	5	1.3	Granite	Inclined
T. 3381	12	5	6	1.3	Granite	Plane	**T. 3801**	13	5	6	1.3	Granite	Inclined
T. 3382	13	5	7	1.3	Granite	Plane	**T. 3802**	14	5	7	1.3	Granite	Inclined
T. 3383	13	5	8	1.3	Granite	Plane	**T. 3803**	14	5	8	1.3	Granite	Inclined
T. 3384	12	5	9	1.3	Granite	Plane	**T. 3804**	13	5	9	1.3	Granite	Inclined
T. 3385	11	5	10	1.3	Granite	Plane	**T. 3805**	12	5	10	1.3	Granite	Inclined
T. 3386	11	5	11	1.3	Granite	Plane	**T. 3806**	12	5	11	1.3	Granite	Inclined
T. 3387	13	5	12	1.3	Granite	Plane	**T. 3807**	14	5	12	1.3	Granite	Inclined
T. 3388	13	5	13	1.3	Granite	Plane	**T. 3808**	14	5	13	1.3	Granite	Inclined
T. 3389	11	5	14	1.3	Granite	Plane	**T. 3809**	12	5	14	1.3	Granite	Inclined
T. 3390	11	5	15	1.3	Granite	Plane	**T. 3810**	12	5	15	1.3	Granite	Inclined
***T. 3391**	15	5	1	1.6	Granite	Plane	***T. 3811**	16	5	1	1.6	Granite	Inclined
***T. 3392**	15	5	2	1.6	Granite	Plane	***T. 3812**	16	5	2	1.6	Granite	Inclined
***T. 3393**	15	5	3	1.6	Granite	Plane	***T. 3813**	16	5	3	1.6	Granite	Inclined
***T. 3394**	15	5	4	1.6	Granite	Plane	***T. 3814**	16	5	4	1.6	Granite	Inclined
***T. 3395**	15	5	5	1.6	Granite	Plane	***T. 3815**	16	5	5	1.6	Granite	Inclined

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Table E.1. (cont.)

***T. 3396**	14	5	6	1.6	Granite	Plane	***T. 3816**	15	5	6	1.6	Granite	Inclined
***T. 3397**	15	5	7	1.6	Granite	Plane	***T. 3817**	16	5	7	1.6	Granite	Inclined
***T. 3398**	15	5	8	1.6	Granite	Plane	***T. 3818**	16	5	8	1.6	Granite	Inclined
***T. 3399**	14	5	9	1.6	Granite	Plane	***T. 3819**	15	5	9	1.6	Granite	Inclined
***T. 3400**	12	5	10	1.6	Granite	Plane	***T. 3820**	13	5	10	1.6	Granite	Inclined
***T. 3401**	13	5	11	1.6	Granite	Plane	***T. 3821**	14	5	11	1.6	Granite	Inclined
***T. 3402**	15	5	12	1.6	Granite	Plane	***T. 3822**	16	5	12	1.6	Granite	Inclined
***T. 3403**	15	5	13	1.6	Granite	Plane	***T. 3823**	16	5	13	1.6	Granite	Inclined
***T. 3404**	13	5	14	1.6	Granite	Plane	***T. 3824**	14	5	14	1.6	Granite	Inclined
***T. 3405**	13	5	15	1.6	Granite	Plane	***T. 3825**	14	5	15	1.6	Granite	Inclined
***T. 3406**	15	5	1	1.8	Granite	Plane	***T. 3826**	16	5	1	1.8	Granite	Inclined
***T. 3407**	15	5	2	1.8	Granite	Plane	***T. 3827**	16	5	2	1.8	Granite	Inclined
***T. 3408**	15	5	3	1.8	Granite	Plane	***T. 3828**	16	5	3	1.8	Granite	Inclined
***T. 3409**	15	5	4	1.8	Granite	Plane	***T. 3829**	16	5	4	1.8	Granite	Inclined
***T. 3410**	15	5	5	1.8	Granite	Plane	***T. 3830**	16	5	5	1.8	Granite	Inclined
***T. 3411**	14	5	6	1.8	Granite	Plane	***T. 3831**	15	5	6	1.8	Granite	Inclined
***T. 3412**	15	5	7	1.8	Granite	Plane	***T. 3832**	16	5	7	1.8	Granite	Inclined
***T. 3413**	15	5	8	1.8	Granite	Plane	***T. 3833**	16	5	8	1.8	Granite	Inclined
***T. 3414**	14	5	9	1.8	Granite	Plane	***T. 3834**	15	5	9	1.8	Granite	Inclined
***T. 3415**	12	5	10	1.8	Granite	Plane	***T. 3835**	13	5	10	1.8	Granite	Inclined
***T. 3416**	13	5	11	1.8	Granite	Plane	***T. 3836**	14	5	11	1.8	Granite	Inclined
***T. 3417**	15	5	12	1.8	Granite	Plane	***T. 3837**	16	5	12	1.8	Granite	Inclined
***T. 3418**	15	5	13	1.8	Granite	Plane	***T. 3838**	16	5	13	1.8	Granite	Inclined
***T. 3419**	13	5	14	1.8	Granite	Plane	***T. 3839**	14	5	14	1.8	Granite	Inclined
***T. 3420**	13	5	15	1.8	Granite	Plane	***T. 3840**	14	5	15	1.8	Granite	Inclined
***T. 3421**	14	5	1	2	Granite	Plane	***T. 3841**	15	5	1	2	Granite	Inclined
***T. 3422**	14	5	2	2	Granite	Plane	***T. 3842**	15	5	2	2	Granite	Inclined
***T. 3423**	14	5	3	2	Granite	Plane	***T. 3843**	15	5	3	2	Granite	Inclined
***T. 3424**	14	5	4	2	Granite	Plane	***T. 3844**	15	5	4	2	Granite	Inclined
***T. 3425**	14	5	5	2	Granite	Plane	***T. 3845**	15	5	5	2	Granite	Inclined
***T. 3426**	13	5	6	2	Granite	Plane	***T. 3846**	14	5	6	2	Granite	Inclined
***T. 3427**	14	5	7	2	Granite	Plane	***T. 3847**	15	5	7	2	Granite	Inclined
***T. 3428**	14	5	8	2	Granite	Plane	***T. 3848**	15	5	8	2	Granite	Inclined

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Table E.1. (cont.)

***T. 3429**	13	5	9	2	Granite	Plane	***T. 3849**	14	5	9	2	Granite	Inclined
***T. 3430**	12	5	10	2	Granite	Plane	***T. 3850**	13	5	10	2	Granite	Inclined
***T. 3431**	13	5	11	2	Granite	Plane	***T. 3851**	14	5	11	2	Granite	Inclined
***T. 3432**	14	5	12	2	Granite	Plane	***T. 3852**	15	5	12	2	Granite	Inclined
***T. 3433**	14	5	13	2	Granite	Plane	***T. 3853**	15	5	13	2	Granite	Inclined
***T. 3434**	13	5	14	2	Granite	Plane	***T. 3854**	14	5	14	2	Granite	Inclined
***T. 3435**	13	5	15	2	Granite	Plane	***T. 3855**	14	5	15	2	Granite	Inclined
***T. 3436**	14	5	1	2.3	Granite	Plane	***T. 3856**	15	5	1	2.3	Granite	Inclined
***T. 3437**	14	5	2	2.3	Granite	Plane	***T. 3857**	15	5	2	2.3	Granite	Inclined
***T. 3438**	14	5	3	2.3	Granite	Plane	***T. 3858**	15	5	3	2.3	Granite	Inclined
***T. 3439**	14	5	4	2.3	Granite	Plane	***T. 3859**	15	5	4	2.3	Granite	Inclined
***T. 3440**	14	5	5	2.3	Granite	Plane	***T. 3860**	15	5	5	2.3	Granite	Inclined
***T. 3441**	13	5	6	2.3	Granite	Plane	***T. 3861**	14	5	6	2.3	Granite	Inclined
***T. 3442**	14	5	7	2.3	Granite	Plane	***T. 3862**	15	5	7	2.3	Granite	Inclined
***T. 3443**	14	5	8	2.3	Granite	Plane	***T. 3863**	15	5	8	2.3	Granite	Inclined
***T. 3444**	13	5	9	2.3	Granite	Plane	***T. 3864**	14	5	9	2.3	Granite	Inclined
***T. 3445**	12	5	10	2.3	Granite	Plane	***T. 3865**	13	5	10	2.3	Granite	Inclined
***T. 3446**	12	5	11	2.3	Granite	Plane	***T. 3866**	13	5	11	2.3	Granite	Inclined
***T. 3447**	14	5	12	2.3	Granite	Plane	***T. 3867**	15	5	12	2.3	Granite	Inclined
***T. 3448**	14	5	13	2.3	Granite	Plane	***T. 3868**	15	5	13	2.3	Granite	Inclined
***T. 3449**	12	5	14	2.3	Granite	Plane	***T. 3869**	13	5	14	2.3	Granite	Inclined
***T. 3450**	12	5	15	2.3	Granite	Plane	***T. 3870**	13	5	15	2.3	Granite	Inclined
T. 3451	13	5	1	2.5	Granite	Plane	**T. 3871**	14	5	1	2.5	Granite	Inclined
T. 3452	13	5	2	2.5	Granite	Plane	**T. 3872**	14	5	2	2.5	Granite	Inclined
T. 3453	13	5	3	2.5	Granite	Plane	**T. 3873**	14	5	3	2.5	Granite	Inclined
T. 3454	13	5	4	2.5	Granite	Plane	**T. 3874**	14	5	4	2.5	Granite	Inclined
T. 3455	13	5	5	2.5	Granite	Plane	**T. 3875**	14	5	5	2.5	Granite	Inclined
T. 3456	12	5	6	2.5	Granite	Plane	**T. 3876**	13	5	6	2.5	Granite	Inclined
T. 3457	13	5	7	2.5	Granite	Plane	**T. 3877**	14	5	7	2.5	Granite	Inclined
T. 3458	13	5	8	2.5	Granite	Plane	**T. 3878**	14	5	8	2.5	Granite	Inclined
T. 3459	12	5	9	2.5	Granite	Plane	**T. 3879**	13	5	9	2.5	Granite	Inclined
T. 3460	11	5	10	2.5	Granite	Plane	**T. 3880**	12	5	10	2.5	Granite	Inclined
T. 3461	12	5	11	2.5	Granite	Plane	**T. 3881**	13	5	11	2.5	Granite	Inclined

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Table E.1. (cont.)

T. 3462	13	5	12	2.5	Granite	Plane	**T. 3882**	14	5	12	2.5	Granite	Inclined
T. 3463	13	5	13	2.5	Granite	Plane	**T. 3883**	14	5	13	2.5	Granite	Inclined
T. 3464	12	5	14	2.5	Granite	Plane	**T. 3884**	13	5	14	2.5	Granite	Inclined
T. 3465	12	5	15	2.5	Granite	Plane	**T. 3885**	13	5	15	2.5	Granite	Inclined
T. 3466	12	5	1	1	Limestone	Plane	**T. 3886**	13	5	1	1	Limestone	Inclined
T. 3467	12	5	2	1	Limestone	Plane	**T. 3887**	13	5	2	1	Limestone	Inclined
T. 3468	12	5	3	1	Limestone	Plane	**T. 3888**	13	5	3	1	Limestone	Inclined
T. 3469	12	5	4	1	Limestone	Plane	**T. 3889**	13	5	4	1	Limestone	Inclined
T. 3470	12	5	5	1	Limestone	Plane	**T. 3890**	13	5	5	1	Limestone	Inclined
T. 3471	11	5	6	1	Limestone	Plane	**T. 3891**	12	5	6	1	Limestone	Inclined
T. 3472	12	5	7	1	Limestone	Plane	**T. 3892**	13	5	7	1	Limestone	Inclined
T. 3473	12	5	8	1	Limestone	Plane	**T. 3893**	13	5	8	1	Limestone	Inclined
T. 3474	11	5	9	1	Limestone	Plane	**T. 3894**	12	5	9	1	Limestone	Inclined
T. 3475	10	5	10	1	Limestone	Plane	**T. 3895**	11	5	10	1	Limestone	Inclined
T. 3476	10	5	11	1	Limestone	Plane	**T. 3896**	11	5	11	1	Limestone	Inclined
T. 3477	12	5	12	1	Limestone	Plane	**T. 3897**	13	5	12	1	Limestone	Inclined
T. 3478	12	5	13	1	Limestone	Plane	**T. 3898**	13	5	13	1	Limestone	Inclined
T. 3479	10	5	14	1	Limestone	Plane	**T. 3899**	11	5	14	1	Limestone	Inclined
T. 3480	10	5	15	1	Limestone	Plane	**T. 3900**	11	5	15	1	Limestone	Inclined
T. 3481	13	5	1	1.3	Limestone	Plane	**T. 3901**	14	5	1	1.3	Limestone	Inclined
T. 3482	13	5	2	1.3	Limestone	Plane	**T. 3902**	14	5	2	1.3	Limestone	Inclined
T. 3483	13	5	3	1.3	Limestone	Plane	**T. 3903**	14	5	3	1.3	Limestone	Inclined
T. 3484	13	5	4	1.3	Limestone	Plane	**T. 3904**	14	5	4	1.3	Limestone	Inclined
T. 3485	13	5	5	1.3	Limestone	Plane	**T. 3905**	14	5	5	1.3	Limestone	Inclined
T. 3486	12	5	6	1.3	Limestone	Plane	**T. 3906**	13	5	6	1.3	Limestone	Inclined
T. 3487	13	5	7	1.3	Limestone	Plane	**T. 3907**	14	5	7	1.3	Limestone	Inclined
T. 3488	13	5	8	1.3	Limestone	Plane	**T. 3908**	14	5	8	1.3	Limestone	Inclined
T. 3489	12	5	9	1.3	Limestone	Plane	**T. 3909**	13	5	9	1.3	Limestone	Inclined
T. 3490	11	5	10	1.3	Limestone	Plane	**T. 3910**	12	5	10	1.3	Limestone	Inclined
T. 3491	11	5	11	1.3	Limestone	Plane	**T. 3911**	12	5	11	1.3	Limestone	Inclined
T. 3492	13	5	12	1.3	Limestone	Plane	**T. 3912**	14	5	12	1.3	Limestone	Inclined
T. 3493	13	5	13	1.3	Limestone	Plane	**T. 3913**	14	5	13	1.3	Limestone	Inclined
T. 3494	11	5	14	1.3	Limestone	Plane	**T. 3914**	12	5	14	1.3	Limestone	Inclined

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Table E.1. (cont.)

T. 3495	11	5	15	1.3	Limestone	Plane	**T. 3915**	12	5	15	1.3	Limestone	Inclined
***T. 3496**	15	5	1	1.6	Limestone	Plane	***T. 3916**	16	5	1	1.6	Limestone	Inclined
***T. 3497**	15	5	2	1.6	Limestone	Plane	***T. 3917**	16	5	2	1.6	Limestone	Inclined
***T. 3498**	15	5	3	1.6	Limestone	Plane	***T. 3918**	16	5	3	1.6	Limestone	Inclined
***T. 3499**	15	5	4	1.6	Limestone	Plane	***T. 3919**	16	5	4	1.6	Limestone	Inclined
***T. 3500**	15	5	5	1.6	Limestone	Plane	***T. 3920**	16	5	5	1.6	Limestone	Inclined
***T. 3501**	14	5	6	1.6	Limestone	Plane	***T. 3921**	15	5	6	1.6	Limestone	Inclined
***T. 3502**	15	5	7	1.6	Limestone	Plane	***T. 3922**	16	5	7	1.6	Limestone	Inclined
***T. 3503**	15	5	8	1.6	Limestone	Plane	***T. 3923**	16	5	8	1.6	Limestone	Inclined
***T. 3504**	14	5	9	1.6	Limestone	Plane	***T. 3924**	15	5	9	1.6	Limestone	Inclined
***T. 3505**	12	5	10	1.6	Limestone	Plane	***T. 3925**	13	5	10	1.6	Limestone	Inclined
***T. 3506**	13	5	11	1.6	Limestone	Plane	***T. 3926**	14	5	11	1.6	Limestone	Inclined
***T. 3507**	15	5	12	1.6	Limestone	Plane	***T. 3927**	16	5	12	1.6	Limestone	Inclined
***T. 3508**	15	5	13	1.6	Limestone	Plane	***T. 3928**	16	5	13	1.6	Limestone	Inclined
***T. 3509**	13	5	14	1.6	Limestone	Plane	***T. 3929**	14	5	14	1.6	Limestone	Inclined
***T. 3510**	13	5	15	1.6	Limestone	Plane	***T. 3930**	14	5	15	1.6	Limestone	Inclined
***T. 3511**	15	5	1	1.8	Limestone	Plane	***T. 3931**	16	5	1	1.8	Limestone	Inclined
***T. 3512**	15	5	2	1.8	Limestone	Plane	***T. 3932**	16	5	2	1.8	Limestone	Inclined
***T. 3513**	15	5	3	1.8	Limestone	Plane	***T. 3933**	16	5	3	1.8	Limestone	Inclined
***T. 3514**	15	5	4	1.8	Limestone	Plane	***T. 3934**	16	5	4	1.8	Limestone	Inclined
***T. 3515**	15	5	5	1.8	Limestone	Plane	***T. 3935**	16	5	5	1.8	Limestone	Inclined
***T. 3516**	14	5	6	1.8	Limestone	Plane	***T. 3936**	15	5	6	1.8	Limestone	Inclined
***T. 3517**	15	5	7	1.8	Limestone	Plane	***T. 3937**	16	5	7	1.8	Limestone	Inclined
***T. 3518**	15	5	8	1.8	Limestone	Plane	***T. 3938**	16	5	8	1.8	Limestone	Inclined
***T. 3519**	14	5	9	1.8	Limestone	Plane	***T. 3939**	15	5	9	1.8	Limestone	Inclined
***T. 3520**	12	5	10	1.8	Limestone	Plane	***T. 3940**	13	5	10	1.8	Limestone	Inclined
***T. 3521**	13	5	11	1.8	Limestone	Plane	***T. 3941**	14	5	11	1.8	Limestone	Inclined
***T. 3522**	15	5	12	1.8	Limestone	Plane	***T. 3942**	16	5	12	1.8	Limestone	Inclined
***T. 3523**	15	5	13	1.8	Limestone	Plane	***T. 3943**	16	5	13	1.8	Limestone	Inclined
***T. 3524**	13	5	14	1.8	Limestone	Plane	***T. 3944**	14	5	14	1.8	Limestone	Inclined
***T. 3525**	13	5	15	1.8	Limestone	Plane	***T. 3945**	14	5	15	1.8	Limestone	Inclined
***T. 3526**	14	5	1	2	Limestone	Plane	***T. 3946**	15	5	1	2	Limestone	Inclined
***T. 3527**	14	5	2	2	Limestone	Plane	***T. 3947**	15	5	2	2	Limestone	Inclined

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Table E.1. (cont.)

***T. 3528**	14	5	3	2	Limestone	Plane	***T. 3948**	15	5	3	2	Limestone	Inclined
***T. 3529**	14	5	4	2	Limestone	Plane	***T. 3949**	15	5	4	2	Limestone	Inclined
***T. 3530**	14	5	5	2	Limestone	Plane	***T. 3950**	15	5	5	2	Limestone	Inclined
***T. 3531**	13	5	6	2	Limestone	Plane	***T. 3951**	14	5	6	2	Limestone	Inclined
***T. 3532**	14	5	7	2	Limestone	Plane	***T. 3952**	15	5	7	2	Limestone	Inclined
***T. 3533**	14	5	8	2	Limestone	Plane	***T. 3953**	15	5	8	2	Limestone	Inclined
***T. 3534**	13	5	9	2	Limestone	Plane	***T. 3954**	14	5	9	2	Limestone	Inclined
***T. 3535**	12	5	10	2	Limestone	Plane	***T. 3955**	13	5	10	2	Limestone	Inclined
***T. 3536**	13	5	11	2	Limestone	Plane	***T. 3956**	14	5	11	2	Limestone	Inclined
***T. 3537**	14	5	12	2	Limestone	Plane	***T. 3957**	15	5	12	2	Limestone	Inclined
***T. 3538**	14	5	13	2	Limestone	Plane	***T. 3958**	15	5	13	2	Limestone	Inclined
***T. 3539**	13	5	14	2	Limestone	Plane	***T. 3959**	14	5	14	2	Limestone	Inclined
***T. 3540**	13	5	15	2	Limestone	Plane	***T. 3960**	14	5	15	2	Limestone	Inclined
***T. 3541**	14	5	1	2.3	Limestone	Plane	***T. 3961**	15	5	1	2.3	Limestone	Inclined
***T. 3542**	14	5	2	2.3	Limestone	Plane	***T. 3962**	15	5	2	2.3	Limestone	Inclined
***T. 3543**	14	5	3	2.3	Limestone	Plane	***T. 3963**	15	5	3	2.3	Limestone	Inclined
***T. 3544**	14	5	4	2.3	Limestone	Plane	***T. 3964**	15	5	4	2.3	Limestone	Inclined
***T. 3545**	14	5	5	2.3	Limestone	Plane	***T. 3965**	15	5	5	2.3	Limestone	Inclined
***T. 3546**	13	5	6	2.3	Limestone	Plane	***T. 3966**	14	5	6	2.3	Limestone	Inclined
***T. 3547**	14	5	7	2.3	Limestone	Plane	***T. 3967**	15	5	7	2.3	Limestone	Inclined
***T. 3548**	14	5	8	2.3	Limestone	Plane	***T. 3968**	15	5	8	2.3	Limestone	Inclined
***T. 3549**	13	5	9	2.3	Limestone	Plane	***T. 3969**	14	5	9	2.3	Limestone	Inclined
***T. 3550**	12	5	10	2.3	Limestone	Plane	***T. 3970**	13	5	10	2.3	Limestone	Inclined
***T. 3551**	12	5	11	2.3	Limestone	Plane	***T. 3971**	13	5	11	2.3	Limestone	Inclined
***T. 3552**	14	5	12	2.3	Limestone	Plane	***T. 3972**	15	5	12	2.3	Limestone	Inclined
***T. 3553**	14	5	13	2.3	Limestone	Plane	***T. 3973**	15	5	13	2.3	Limestone	Inclined
***T. 3554**	12	5	14	2.3	Limestone	Plane	***T. 3974**	13	5	14	2.3	Limestone	Inclined
***T. 3555**	12	5	15	2.3	Limestone	Plane	***T. 3975**	13	5	15	2.3	Limestone	Inclined
T. 3556	13	5	1	2.5	Limestone	Plane	**T. 3976**	14	5	1	2.5	Limestone	Inclined
T. 3557	13	5	2	2.5	Limestone	Plane	**T. 3977**	14	5	2	2.5	Limestone	Inclined
T. 3558	13	5	3	2.5	Limestone	Plane	**T. 3978**	14	5	3	2.5	Limestone	Inclined
T. 3559	13	5	4	2.5	Limestone	Plane	**T. 3979**	14	5	4	2.5	Limestone	Inclined
T. 3560	13	5	5	2.5	Limestone	Plane	**T. 3980**	14	5	5	2.5	Limestone	Inclined

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Table E.1. (cont.)

T. 3561	12	5	6	2.5	Limestone	Plane	**T. 3981**	13	5	6	2.5	Limestone	Inclined
T. 3562	13	5	7	2.5	Limestone	Plane	**T. 3982**	14	5	7	2.5	Limestone	Inclined
T. 3563	13	5	8	2.5	Limestone	Plane	**T. 3983**	14	5	8	2.5	Limestone	Inclined
T. 3564	12	5	9	2.5	Limestone	Plane	**T. 3984**	13	5	9	2.5	Limestone	Inclined
T. 3565	11	5	10	2.5	Limestone	Plane	**T. 3985**	12	5	10	2.5	Limestone	Inclined
T. 3566	12	5	11	2.5	Limestone	Plane	**T. 3986**	13	5	11	2.5	Limestone	Inclined
T. 3567	13	5	12	2.5	Limestone	Plane	**T. 3987**	14	5	12	2.5	Limestone	Inclined
T. 3568	13	5	13	2.5	Limestone	Plane	**T. 3988**	14	5	13	2.5	Limestone	Inclined
T. 3569	12	5	14	2.5	Limestone	Plane	**T. 3989**	13	5	14	2.5	Limestone	Inclined
T. 3570	12	5	15	2.5	Limestone	Plane	**T. 3990**	13	5	15	2.5	Limestone	Inclined
T. 3571	12	5	1	1	Sandstone	Plane	**T. 3991**	13	5	1	1	Sandstone	Inclined
T. 3572	12	5	2	1	Sandstone	Plane	**T. 3992**	13	5	2	1	Sandstone	Inclined
T. 3573	12	5	3	1	Sandstone	Plane	**T. 3993**	13	5	3	1	Sandstone	Inclined
T. 3574	12	5	4	1	Sandstone	Plane	**T. 3994**	13	5	4	1	Sandstone	Inclined
T. 3575	12	5	5	1	Sandstone	Plane	**T. 3995**	13	5	5	1	Sandstone	Inclined
T. 3576	11	5	6	1	Sandstone	Plane	**T. 3996**	12	5	6	1	Sandstone	Inclined
T. 3577	12	5	7	1	Sandstone	Plane	**T. 3997**	13	5	7	1	Sandstone	Inclined
T. 3578	12	5	8	1	Sandstone	Plane	**T. 3998**	13	5	8	1	Sandstone	Inclined
T. 3579	11	5	9	1	Sandstone	Plane	**T. 3999**	12	5	9	1	Sandstone	Inclined
T. 3580	10	5	10	1	Sandstone	Plane	**T. 4000**	11	5	10	1	Sandstone	Inclined
T. 3581	10	5	11	1	Sandstone	Plane	**T. 4001**	11	5	11	1	Sandstone	Inclined
T. 3582	12	5	12	1	Sandstone	Plane	**T. 4002**	13	5	12	1	Sandstone	Inclined
T. 3583	12	5	13	1	Sandstone	Plane	**T. 4003**	13	5	13	1	Sandstone	Inclined
T. 3584	10	5	14	1	Sandstone	Plane	**T. 4004**	11	5	14	1	Sandstone	Inclined
T. 3585	10	5	15	1	Sandstone	Plane	**T. 4005**	11	5	15	1	Sandstone	Inclined
T. 3586	13	5	1	1.3	Sandstone	Plane	**T. 4006**	14	5	1	1.3	Sandstone	Inclined
T. 3587	13	5	2	1.3	Sandstone	Plane	**T. 4007**	14	5	2	1.3	Sandstone	Inclined
T. 3588	13	5	3	1.3	Sandstone	Plane	**T. 4008**	14	5	3	1.3	Sandstone	Inclined
T. 3589	13	5	4	1.3	Sandstone	Plane	**T. 4009**	14	5	4	1.3	Sandstone	Inclined
T. 3590	13	5	5	1.3	Sandstone	Plane	**T. 4010**	14	5	5	1.3	Sandstone	Inclined
T. 3591	12	5	6	1.3	Sandstone	Plane	**T. 4011**	13	5	6	1.3	Sandstone	Inclined
T. 3592	13	5	7	1.3	Sandstone	Plane	**T. 4012**	14	5	7	1.3	Sandstone	Inclined
T. 3593	13	5	8	1.3	Sandstone	Plane	**T. 4013**	14	5	8	1.3	Sandstone	Inclined

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Table E.1. (cont.)

T. 3594	12	5	9	1.3	Sandstone	Plane	**T. 4014**	13	5	9	1.3	Sandstone	Inclined
T. 3595	11	5	10	1.3	Sandstone	Plane	**T. 4015**	12	5	10	1.3	Sandstone	Inclined
T. 3596	11	5	11	1.3	Sandstone	Plane	**T. 4016**	12	5	11	1.3	Sandstone	Inclined
T. 3597	13	5	12	1.3	Sandstone	Plane	**T. 4017**	14	5	12	1.3	Sandstone	Inclined
T. 3598	13	5	13	1.3	Sandstone	Plane	**T. 4018**	14	5	13	1.3	Sandstone	Inclined
T. 3599	11	5	14	1.3	Sandstone	Plane	**T. 4019**	12	5	14	1.3	Sandstone	Inclined
T. 3600	11	5	15	1.3	Sandstone	Plane	**T. 4020**	12	5	15	1.3	Sandstone	Inclined
T. 3601	15	5	1	1.6	Sandstone	Plane	**T. 4021**	16	5	1	1.6	Sandstone	Inclined
T. 3602	15	5	2	1.6	Sandstone	Plane	**T. 4022**	16	5	2	1.6	Sandstone	Inclined
T. 3603	15	5	3	1.6	Sandstone	Plane	**T. 4023**	16	5	3	1.6	Sandstone	Inclined
T. 3604	15	5	4	1.6	Sandstone	Plane	**T. 4024**	16	5	4	1.6	Sandstone	Inclined
T. 3605	15	5	5	1.6	Sandstone	Plane	**T. 4025**	16	5	5	1.6	Sandstone	Inclined
T. 3606	14	5	6	1.6	Sandstone	Plane	**T. 4026**	15	5	6	1.6	Sandstone	Inclined
T. 3607	15	5	7	1.6	Sandstone	Plane	**T. 4027**	16	5	7	1.6	Sandstone	Inclined
T. 3608	15	5	8	1.6	Sandstone	Plane	**T. 4028**	16	5	8	1.6	Sandstone	Inclined
T. 3609	14	5	9	1.6	Sandstone	Plane	**T. 4029**	15	5	9	1.6	Sandstone	Inclined
T. 3610	12	5	10	1.6	Sandstone	Plane	**T. 4030**	13	5	10	1.6	Sandstone	Inclined
T. 3611	13	5	11	1.6	Sandstone	Plane	**T. 4031**	14	5	11	1.6	Sandstone	Inclined
T. 3612	15	5	12	1.6	Sandstone	Plane	**T. 4032**	16	5	12	1.6	Sandstone	Inclined
T. 3613	15	5	13	1.6	Sandstone	Plane	**T. 4033**	16	5	13	1.6	Sandstone	Inclined
T. 3614	13	5	14	1.6	Sandstone	Plane	**T. 4034**	14	5	14	1.6	Sandstone	Inclined
T. 3615	13	5	15	1.6	Sandstone	Plane	**T. 4035**	14	5	15	1.6	Sandstone	Inclined
T. 3616	15	5	1	1.8	Sandstone	Plane	**T. 4036**	16	5	1	1.8	Sandstone	Inclined
T. 3617	15	5	2	1.8	Sandstone	Plane	**T. 4037**	16	5	2	1.8	Sandstone	Inclined
T. 3618	15	5	3	1.8	Sandstone	Plane	**T. 4038**	16	5	3	1.8	Sandstone	Inclined
T. 3619	15	5	4	1.8	Sandstone	Plane	**T. 4039**	16	5	4	1.8	Sandstone	Inclined
T. 3620	15	5	5	1.8	Sandstone	Plane	**T. 4040**	16	5	5	1.8	Sandstone	Inclined
T. 3621	14	5	6	1.8	Sandstone	Plane	**T. 4041**	15	5	6	1.8	Sandstone	Inclined
T. 3622	15	5	7	1.8	Sandstone	Plane	**T. 4042**	16	5	7	1.8	Sandstone	Inclined
T. 3623	15	5	8	1.8	Sandstone	Plane	**T. 4043**	16	5	8	1.8	Sandstone	Inclined
T. 3624	14	5	9	1.8	Sandstone	Plane	**T. 4044**	15	5	9	1.8	Sandstone	Inclined
T. 3625	12	5	10	1.8	Sandstone	Plane	**T. 4045**	13	5	10	1.8	Sandstone	Inclined
T. 3626	13	5	11	1.8	Sandstone	Plane	**T. 4046**	14	5	11	1.8	Sandstone	Inclined

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Table E.1. (cont.)

T. 3627	15	5	12	1.8	Sandstone	Plane	**T. 4047**	16	5	12	1.8	Sandstone	Inclined
T. 3628	15	5	13	1.8	Sandstone	Plane	**T. 4048**	16	5	13	1.8	Sandstone	Inclined
T. 3629	13	5	14	1.8	Sandstone	Plane	**T. 4049**	14	5	14	1.8	Sandstone	Inclined
T. 3630	13	5	15	1.8	Sandstone	Plane	**T. 4050**	14	5	15	1.8	Sandstone	Inclined
T. 3631	14	5	1	2	Sandstone	Plane	**T. 4051**	15	5	1	2	Sandstone	Inclined
T. 3632	14	5	2	2	Sandstone	Plane	**T. 4052**	15	5	2	2	Sandstone	Inclined
T. 3633	14	5	3	2	Sandstone	Plane	**T. 4053**	15	5	3	2	Sandstone	Inclined
T. 3634	14	5	4	2	Sandstone	Plane	**T. 4054**	15	5	4	2	Sandstone	Inclined
T. 3635	14	5	5	2	Sandstone	Plane	**T. 4055**	15	5	5	2	Sandstone	Inclined
T. 3636	13	5	6	2	Sandstone	Plane	**T. 4056**	14	5	6	2	Sandstone	Inclined
T. 3637	14	5	7	2	Sandstone	Plane	**T. 4057**	15	5	7	2	Sandstone	Inclined
T. 3638	14	5	8	2	Sandstone	Plane	**T. 4058**	15	5	8	2	Sandstone	Inclined
T. 3639	13	5	9	2	Sandstone	Plane	**T. 4059**	14	5	9	2	Sandstone	Inclined
T. 3640	12	5	10	2	Sandstone	Plane	**T. 4060**	13	5	10	2	Sandstone	Inclined
T. 3641	13	5	11	2	Sandstone	Plane	**T. 4061**	14	5	11	2	Sandstone	Inclined
T. 3642	14	5	12	2	Sandstone	Plane	**T. 4062**	15	5	12	2	Sandstone	Inclined
T. 3643	14	5	13	2	Sandstone	Plane	**T. 4063**	15	5	13	2	Sandstone	Inclined
T. 3644	13	5	14	2	Sandstone	Plane	**T. 4064**	14	5	14	2	Sandstone	Inclined
T. 3645	13	5	15	2	Sandstone	Plane	**T. 4065**	14	5	15	2	Sandstone	Inclined
T. 3646	14	5	1	2.3	Sandstone	Plane	**T. 4066**	15	5	1	2.3	Sandstone	Inclined
T. 3647	14	5	2	2.3	Sandstone	Plane	**T. 4067**	15	5	2	2.3	Sandstone	Inclined
T. 3648	14	5	3	2.3	Sandstone	Plane	**T. 4068**	15	5	3	2.3	Sandstone	Inclined
T. 3649	14	5	4	2.3	Sandstone	Plane	**T. 4069**	15	5	4	2.3	Sandstone	Inclined
T. 3650	14	5	5	2.3	Sandstone	Plane	**T. 4070**	15	5	5	2.3	Sandstone	Inclined
T. 3651	13	5	6	2.3	Sandstone	Plane	**T. 4071**	14	5	6	2.3	Sandstone	Inclined
T. 3652	14	5	7	2.3	Sandstone	Plane	**T. 4072**	15	5	7	2.3	Sandstone	Inclined
T. 3653	14	5	8	2.3	Sandstone	Plane	**T. 4073**	15	5	8	2.3	Sandstone	Inclined
T. 3654	13	5	9	2.3	Sandstone	Plane	**T. 4074**	14	5	9	2.3	Sandstone	Inclined
T. 3655	12	5	10	2.3	Sandstone	Plane	**T. 4075**	13	5	10	2.3	Sandstone	Inclined
T. 3656	12	5	11	2.3	Sandstone	Plane	**T. 4076**	13	5	11	2.3	Sandstone	Inclined
T. 3657	14	5	12	2.3	Sandstone	Plane	**T. 4077**	15	5	12	2.3	Sandstone	Inclined
T. 3658	14	5	13	2.3	Sandstone	Plane	**T. 4078**	15	5	13	2.3	Sandstone	Inclined
T. 3659	12	5	14	2.3	Sandstone	Plane	**T. 4079**	13	5	14	2.3	Sandstone	Inclined

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Table E.1. (cont.)

T. 3660	12	5	15	2.3	Sandstone	Plane	**T. 4080**	13	5	15	2.3	Sandstone	Inclined
T. 3661	13	5	1	2.5	Sandstone	Plane	**T. 4081**	14	5	1	2.5	Sandstone	Inclined
T. 3662	13	5	2	2.5	Sandstone	Plane	**T. 4082**	14	5	2	2.5	Sandstone	Inclined
T. 3663	13	5	3	2.5	Sandstone	Plane	**T. 4083**	14	5	3	2.5	Sandstone	Inclined
T. 3664	13	5	4	2.5	Sandstone	Plane	**T. 4084**	14	5	4	2.5	Sandstone	Inclined
T. 3665	13	5	5	2.5	Sandstone	Plane	**T. 4085**	14	5	5	2.5	Sandstone	Inclined
T. 3666	12	5	6	2.5	Sandstone	Plane	**T. 4086**	13	5	6	2.5	Sandstone	Inclined
T. 3667	13	5	7	2.5	Sandstone	Plane	**T. 4087**	14	5	7	2.5	Sandstone	Inclined
T. 3668	13	5	8	2.5	Sandstone	Plane	**T. 4088**	14	5	8	2.5	Sandstone	Inclined
T. 3669	12	5	9	2.5	Sandstone	Plane	**T. 4089**	13	5	9	2.5	Sandstone	Inclined
T. 3670	11	5	10	2.5	Sandstone	Plane	**T. 4090**	12	5	10	2.5	Sandstone	Inclined
T. 3671	12	5	11	2.5	Sandstone	Plane	**T. 4091**	13	5	11	2.5	Sandstone	Inclined
T. 3672	13	5	12	2.5	Sandstone	Plane	**T. 4092**	14	5	12	2.5	Sandstone	Inclined
T. 3673	13	5	13	2.5	Sandstone	Plane	**T. 4093**	14	5	13	2.5	Sandstone	Inclined
T. 3674	12	5	14	2.5	Sandstone	Plane	**T. 4094**	13	5	14	2.5	Sandstone	Inclined
T. 3675	12	5	15	2.5	Sandstone	Plane	**T. 4095**	13	5	15	2.5	Sandstone	Inclined
T. 3676	11	5	1	1	Brick	Plane	**T. 4096**	12	5	1	1	Brick	Inclined
T. 3677	11	5	2	1	Brick	Plane	**T. 4097**	12	5	2	1	Brick	Inclined
T. 3678	11	5	3	1	Brick	Plane	**T. 4098**	12	5	3	1	Brick	Inclined
T. 3679	11	5	4	1	Brick	Plane	**T. 4099**	12	5	4	1	Brick	Inclined
T. 3680	11	5	5	1	Brick	Plane	**T. 4100**	12	5	5	1	Brick	Inclined
T. 3681	10	5	6	1	Brick	Plane	**T. 4101**	11	5	6	1	Brick	Inclined
T. 3682	11	5	7	1	Brick	Plane	**T. 4102**	12	5	7	1	Brick	Inclined
T. 3683	11	5	8	1	Brick	Plane	**T. 4103**	12	5	8	1	Brick	Inclined
T. 3684	10	5	9	1	Brick	Plane	**T. 4104**	11	5	9	1	Brick	Inclined
T. 3685	9	5	10	1	Brick	Plane	**T. 4105**	10	5	10	1	Brick	Inclined
T. 3686	9	5	11	1	Brick	Plane	**T. 4106**	10	5	11	1	Brick	Inclined
T. 3687	11	5	12	1	Brick	Plane	**T. 4107**	12	5	12	1	Brick	Inclined
T. 3688	11	5	13	1	Brick	Plane	**T. 4108**	12	5	13	1	Brick	Inclined
T. 3689	9	5	14	1	Brick	Plane	**T. 4109**	10	5	14	1	Brick	Inclined
T. 3690	9	5	15	1	Brick	Plane	**T. 4110**	10	5	15	1	Brick	Inclined
T. 3691	12	5	1	1.3	Brick	Plane	**T. 4111**	13	5	1	1.3	Brick	Inclined
T. 3692	12	5	2	1.3	Brick	Plane	**T. 4112**	13	5	2	1.3	Brick	Inclined

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Table E.1. (cont.)

T. 3693	12	5	3	1.3	Brick	Plane	**T. 4113**	13	5	3	1.3	Brick	Inclined
T. 3694	12	5	4	1.3	Brick	Plane	**T. 4114**	13	5	4	1.3	Brick	Inclined
T. 3695	12	5	5	1.3	Brick	Plane	**T. 4115**	13	5	5	1.3	Brick	Inclined
T. 3696	11	5	6	1.3	Brick	Plane	**T. 4116**	12	5	6	1.3	Brick	Inclined
T. 3697	12	5	7	1.3	Brick	Plane	**T. 4117**	13	5	7	1.3	Brick	Inclined
T. 3698	12	5	8	1.3	Brick	Plane	**T. 4118**	13	5	8	1.3	Brick	Inclined
T. 3699	11	5	9	1.3	Brick	Plane	**T. 4119**	12	5	9	1.3	Brick	Inclined
T. 3700	10	5	10	1.3	Brick	Plane	**T. 4120**	11	5	10	1.3	Brick	Inclined
T. 3701	10	5	11	1.3	Brick	Plane	**T. 4121**	11	5	11	1.3	Brick	Inclined
T. 3702	12	5	12	1.3	Brick	Plane	**T. 4122**	13	5	12	1.3	Brick	Inclined
T. 3703	12	5	13	1.3	Brick	Plane	**T. 4123**	13	5	13	1.3	Brick	Inclined
T. 3704	10	5	14	1.3	Brick	Plane	**T. 4124**	11	5	14	1.3	Brick	Inclined
T. 3705	10	5	15	1.3	Brick	Plane	**T. 4125**	11	5	15	1.3	Brick	Inclined
T. 3706	14	5	1	1.6	Brick	Plane	**T. 4126**	15	5	1	1.6	Brick	Inclined
T. 3707	14	5	2	1.6	Brick	Plane	**T. 4127**	15	5	2	1.6	Brick	Inclined
T. 3708	14	5	3	1.6	Brick	Plane	**T. 4128**	15	5	3	1.6	Brick	Inclined
T. 3709	14	5	4	1.6	Brick	Plane	**T. 4129**	15	5	4	1.6	Brick	Inclined
T. 3710	14	5	5	1.6	Brick	Plane	**T. 4130**	15	5	5	1.6	Brick	Inclined
T. 3711	13	5	6	1.6	Brick	Plane	**T. 4131**	14	5	6	1.6	Brick	Inclined
T. 3712	14	5	7	1.6	Brick	Plane	**T. 4132**	15	5	7	1.6	Brick	Inclined
T. 3713	14	5	8	1.6	Brick	Plane	**T. 4133**	15	5	8	1.6	Brick	Inclined
T. 3714	13	5	9	1.6	Brick	Plane	**T. 4134**	14	5	9	1.6	Brick	Inclined
T. 3715	11	5	10	1.6	Brick	Plane	**T. 4135**	12	5	10	1.6	Brick	Inclined
T. 3716	12	5	11	1.6	Brick	Plane	**T. 4136**	13	5	11	1.6	Brick	Inclined
T. 3717	14	5	12	1.6	Brick	Plane	**T. 4137**	15	5	12	1.6	Brick	Inclined
T. 3718	14	5	13	1.6	Brick	Plane	**T. 4138**	15	5	13	1.6	Brick	Inclined
T. 3719	12	5	14	1.6	Brick	Plane	**T. 4139**	13	5	14	1.6	Brick	Inclined
T. 3720	12	5	15	1.6	Brick	Plane	**T. 4140**	13	5	15	1.6	Brick	Inclined
T. 3721	14	5	1	1.8	Brick	Plane	**T. 4141**	15	5	1	1.8	Brick	Inclined
T. 3722	14	5	2	1.8	Brick	Plane	**T. 4142**	15	5	2	1.8	Brick	Inclined
T. 3723	14	5	3	1.8	Brick	Plane	**T. 4143**	15	5	3	1.8	Brick	Inclined
T. 3724	14	5	4	1.8	Brick	Plane	**T. 4144**	15	5	4	1.8	Brick	Inclined
T. 3725	14	5	5	1.8	Brick	Plane	**T. 4145**	15	5	5	1.8	Brick	Inclined

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Table E.1. (cont.)

T. 3726	13	5	6	1.8	Brick	Plane	**T. 4146**	14	5	6	1.8	Brick	Inclined
T. 3727	14	5	7	1.8	Brick	Plane	**T. 4147**	15	5	7	1.8	Brick	Inclined
T. 3728	14	5	8	1.8	Brick	Plane	**T. 4148**	15	5	8	1.8	Brick	Inclined
T. 3729	13	5	9	1.8	Brick	Plane	**T. 4149**	14	5	9	1.8	Brick	Inclined
T. 3730	11	5	10	1.8	Brick	Plane	**T. 4150**	12	5	10	1.8	Brick	Inclined
T. 3731	12	5	11	1.8	Brick	Plane	**T. 4151**	13	5	11	1.8	Brick	Inclined
T. 3732	14	5	12	1.8	Brick	Plane	**T. 4152**	15	5	12	1.8	Brick	Inclined
T. 3733	14	5	13	1.8	Brick	Plane	**T. 4153**	15	5	13	1.8	Brick	Inclined
T. 3734	12	5	14	1.8	Brick	Plane	**T. 4154**	13	5	14	1.8	Brick	Inclined
T. 3735	12	5	15	1.8	Brick	Plane	**T. 4155**	13	5	15	1.8	Brick	Inclined
T. 3736	13	5	1	2	Brick	Plane	**T. 4156**	14	5	1	2	Brick	Inclined
T. 3737	13	5	2	2	Brick	Plane	**T. 4157**	14	5	2	2	Brick	Inclined
T. 3738	13	5	3	2	Brick	Plane	**T. 4158**	14	5	3	2	Brick	Inclined
T. 3739	13	5	4	2	Brick	Plane	**T. 4159**	14	5	4	2	Brick	Inclined
T. 3740	13	5	5	2	Brick	Plane	**T. 4160**	14	5	5	2	Brick	Inclined
T. 3741	12	5	6	2	Brick	Plane	**T. 4161**	13	5	6	2	Brick	Inclined
T. 3742	13	5	7	2	Brick	Plane	**T. 4162**	14	5	7	2	Brick	Inclined
T. 3743	13	5	8	2	Brick	Plane	**T. 4163**	14	5	8	2	Brick	Inclined
T. 3744	12	5	9	2	Brick	Plane	**T. 4164**	13	5	9	2	Brick	Inclined
T. 3745	11	5	10	2	Brick	Plane	**T. 4165**	12	5	10	2	Brick	Inclined
T. 3746	12	5	11	2	Brick	Plane	**T. 4166**	13	5	11	2	Brick	Inclined
T. 3747	13	5	12	2	Brick	Plane	**T. 4167**	14	5	12	2	Brick	Inclined
T. 3748	13	5	13	2	Brick	Plane	**T. 4168**	14	5	13	2	Brick	Inclined
T. 3749	12	5	14	2	Brick	Plane	**T. 4169**	13	5	14	2	Brick	Inclined
T. 3750	12	5	15	2	Brick	Plane	**T. 4170**	13	5	15	2	Brick	Inclined
T. 3751	13	5	1	2.3	Brick	Plane	**T. 4171**	14	5	1	2.3	Brick	Inclined
T. 3752	13	5	2	2.3	Brick	Plane	**T. 4172**	14	5	2	2.3	Brick	Inclined
T. 3753	13	5	3	2.3	Brick	Plane	**T. 4173**	14	5	3	2.3	Brick	Inclined
T. 3754	13	5	4	2.3	Brick	Plane	**T. 4174**	14	5	4	2.3	Brick	Inclined
T. 3755	13	5	5	2.3	Brick	Plane	**T. 4175**	14	5	5	2.3	Brick	Inclined
T. 3756	12	5	6	2.3	Brick	Plane	**T. 4176**	13	5	6	2.3	Brick	Inclined
T. 3757	13	5	7	2.3	Brick	Plane	**T. 4177**	14	5	7	2.3	Brick	Inclined
T. 3758	13	5	8	2.3	Brick	Plane	**T. 4178**	14	5	8	2.3	Brick	Inclined

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Table E.1. (cont.)

T. 3759	12	5	9	2.3	Brick	Plane	**T. 4179**	13	5	9	2.3	Brick	Inclined
T. 3760	11	5	10	2.3	Brick	Plane	**T. 4180**	12	5	10	2.3	Brick	Inclined
T. 3761	11	5	11	2.3	Brick	Plane	**T. 4181**	12	5	11	2.3	Brick	Inclined
T. 3762	13	5	12	2.3	Brick	Plane	**T. 4182**	14	5	12	2.3	Brick	Inclined
T. 3763	13	5	13	2.3	Brick	Plane	**T. 4183**	14	5	13	2.3	Brick	Inclined
T. 3764	11	5	14	2.3	Brick	Plane	**T. 4184**	12	5	14	2.3	Brick	Inclined
T. 3765	11	5	15	2.3	Brick	Plane	**T. 4185**	12	5	15	2.3	Brick	Inclined
T. 3766	12	5	1	2.5	Brick	Plane	**T. 4186**	13	5	1	2.5	Brick	Inclined
T. 3767	12	5	2	2.5	Brick	Plane	**T. 4187**	13	5	2	2.5	Brick	Inclined
T. 3768	12	5	3	2.5	Brick	Plane	**T. 4188**	13	5	3	2.5	Brick	Inclined
T. 3769	12	5	4	2.5	Brick	Plane	**T. 4189**	13	5	4	2.5	Brick	Inclined
T. 3770	12	5	5	2.5	Brick	Plane	**T. 4190**	13	5	5	2.5	Brick	Inclined
T. 3771	11	5	6	2.5	Brick	Plane	**T. 4191**	12	5	6	2.5	Brick	Inclined
T. 3772	12	5	7	2.5	Brick	Plane	**T. 4192**	13	5	7	2.5	Brick	Inclined
T. 3773	12	5	8	2.5	Brick	Plane	**T. 4193**	13	5	8	2.5	Brick	Inclined
T. 3774	11	5	9	2.5	Brick	Plane	**T. 4194**	12	5	9	2.5	Brick	Inclined
T. 3775	10	5	10	2.5	Brick	Plane	**T. 4195**	11	5	10	2.5	Brick	Inclined
T. 3776	11	5	11	2.5	Brick	Plane	**T. 4196**	12	5	11	2.5	Brick	Inclined
T. 3777	12	5	12	2.5	Brick	Plane	**T. 4197**	13	5	12	2.5	Brick	Inclined
T. 3778	12	5	13	2.5	Brick	Plane	**T. 4198**	13	5	13	2.5	Brick	Inclined
T. 3779	11	5	14	2.5	Brick	Plane	**T. 4199**	12	5	14	2.5	Brick	Inclined
T. 3780	11	5	15	2.5	Brick	Plane	**T. 4200**	12	5	15	2.5	Brick	Inclined
T. 4201	17	6	1	1	Granite	Plane	**T. 4621**	18	6	1	1	Granite	Inclined
T. 4202	17	6	2	1	Granite	Plane	**T. 4622**	18	6	2	1	Granite	Inclined
T. 4203	17	6	3	1	Granite	Plane	**T. 4623**	18	6	3	1	Granite	Inclined
T. 4204	17	6	4	1	Granite	Plane	**T. 4624**	18	6	4	1	Granite	Inclined
T. 4205	17	6	5	1	Granite	Plane	**T. 4625**	18	6	5	1	Granite	Inclined
T. 4206	17	6	6	1	Granite	Plane	**T. 4626**	18	6	6	1	Granite	Inclined
T. 4207	17	6	7	1	Granite	Plane	**T. 4627**	18	6	7	1	Granite	Inclined
T. 4208	17	6	8	1	Granite	Plane	**T. 4628**	18	6	8	1	Granite	Inclined
T. 4209	17	6	9	1	Granite	Plane	**T. 4629**	18	6	9	1	Granite	Inclined
T. 4210	15	6	10	1	Granite	Plane	**T. 4630**	16	6	10	1	Granite	Inclined
T. 4211	16	6	11	1	Granite	Plane	**T. 4631**	17	6	11	1	Granite	Inclined

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Table E.1. (cont.)

T. 4212	17	6	12	1	Granite	Plane	**T. 4632**	18	6	12	1	Granite	Inclined
T. 4213	17	6	13	1	Granite	Plane	**T. 4633**	18	6	13	1	Granite	Inclined
T. 4214	16	6	14	1	Granite	Plane	**T. 4634**	17	6	14	1	Granite	Inclined
T. 4215	16	6	15	1	Granite	Plane	**T. 4635**	17	6	15	1	Granite	Inclined
T. 4216	19	6	1	1.3	Granite	Plane	**T. 4636**	20	6	1	1.3	Granite	Inclined
T. 4217	19	6	2	1.3	Granite	Plane	**T. 4637**	20	6	2	1.3	Granite	Inclined
T. 4218	19	6	3	1.3	Granite	Plane	**T. 4638**	20	6	3	1.3	Granite	Inclined
T. 4219	19	6	4	1.3	Granite	Plane	**T. 4639**	20	6	4	1.3	Granite	Inclined
T. 4220	19	6	5	1.3	Granite	Plane	**T. 4640**	20	6	5	1.3	Granite	Inclined
T. 4221	19	6	6	1.3	Granite	Plane	**T. 4641**	20	6	6	1.3	Granite	Inclined
T. 4222	19	6	7	1.3	Granite	Plane	**T. 4642**	20	6	7	1.3	Granite	Inclined
T. 4223	19	6	8	1.3	Granite	Plane	**T. 4643**	20	6	8	1.3	Granite	Inclined
T. 4224	19	6	9	1.3	Granite	Plane	**T. 4644**	20	6	9	1.3	Granite	Inclined
T. 4225	18	6	10	1.3	Granite	Plane	**T. 4645**	19	6	10	1.3	Granite	Inclined
T. 4226	18	6	11	1.3	Granite	Plane	**T. 4646**	19	6	11	1.3	Granite	Inclined
T. 4227	19	6	12	1.3	Granite	Plane	**T. 4647**	20	6	12	1.3	Granite	Inclined
T. 4228	19	6	13	1.3	Granite	Plane	**T. 4648**	20	6	13	1.3	Granite	Inclined
T. 4229	18	6	14	1.3	Granite	Plane	**T. 4649**	19	6	14	1.3	Granite	Inclined
T. 4230	18	6	15	1.3	Granite	Plane	**T. 4650**	19	6	15	1.3	Granite	Inclined
***T. 4231**	19	6	1	1.6	Granite	Plane	***T. 4651**	20	6	1	1.6	Granite	Inclined
***T. 4232**	19	6	2	1.6	Granite	Plane	***T. 4652**	20	6	2	1.6	Granite	Inclined
***T. 4233**	19	6	3	1.6	Granite	Plane	***T. 4653**	20	6	3	1.6	Granite	Inclined
***T. 4234**	19	6	4	1.6	Granite	Plane	***T. 4654**	20	6	4	1.6	Granite	Inclined
***T. 4235**	19	6	5	1.6	Granite	Plane	***T. 4655**	20	6	5	1.6	Granite	Inclined
***T. 4236**	19	6	6	1.6	Granite	Plane	***T. 4656**	20	6	6	1.6	Granite	Inclined
***T. 4237**	19	6	7	1.6	Granite	Plane	***T. 4657**	20	6	7	1.6	Granite	Inclined
***T. 4238**	19	6	8	1.6	Granite	Plane	***T. 4658**	20	6	8	1.6	Granite	Inclined
***T. 4239**	19	6	9	1.6	Granite	Plane	***T. 4659**	20	6	9	1.6	Granite	Inclined
***T. 4240**	18	6	10	1.6	Granite	Plane	***T. 4660**	19	6	10	1.6	Granite	Inclined
***T. 4241**	18	6	11	1.6	Granite	Plane	***T. 4661**	19	6	11	1.6	Granite	Inclined
***T. 4242**	19	6	12	1.6	Granite	Plane	***T. 4662**	20	6	12	1.6	Granite	Inclined
***T. 4243**	19	6	13	1.6	Granite	Plane	***T. 4663**	20	6	13	1.6	Granite	Inclined
***T. 4244**	19	6	14	1.6	Granite	Plane	***T. 4664**	20	6	14	1.6	Granite	Inclined

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Table E.1. (cont.

***T. 4245**	19	6	15	1.6	Granite	Plane	***T. 4665**	20	6	15	1.6	Granite	Inclined
***T. 4246**	19	6	1	1.8	Granite	Plane	***T. 4666**	20	6	1	1.8	Granite	Inclined
***T. 4247**	19	6	2	1.8	Granite	Plane	***T. 4667**	20	6	2	1.8	Granite	Inclined
***T. 4248**	19	6	3	1.8	Granite	Plane	***T. 4668**	20	6	3	1.8	Granite	Inclined
***T. 4249**	19	6	4	1.8	Granite	Plane	***T. 4669**	20	6	4	1.8	Granite	Inclined
***T. 4250**	19	6	5	1.8	Granite	Plane	***T. 4670**	20	6	5	1.8	Granite	Inclined
***T. 4251**	19	6	6	1.8	Granite	Plane	***T. 4671**	20	6	6	1.8	Granite	Inclined
***T. 4252**	19	6	7	1.8	Granite	Plane	***T. 4672**	20	6	7	1.8	Granite	Inclined
***T. 4253**	19	6	8	1.8	Granite	Plane	***T. 4673**	20	6	8	1.8	Granite	Inclined
***T. 4254**	19	6	9	1.8	Granite	Plane	***T. 4674**	20	6	9	1.8	Granite	Inclined
***T. 4255**	18	6	10	1.8	Granite	Plane	***T. 4675**	19	6	10	1.8	Granite	Inclined
***T. 4256**	19	6	11	1.8	Granite	Plane	***T. 4676**	20	6	11	1.8	Granite	Inclined
***T. 4257**	19	6	12	1.8	Granite	Plane	***T. 4677**	20	6	12	1.8	Granite	Inclined
***T. 4258**	19	6	13	1.8	Granite	Plane	***T. 4678**	20	6	13	1.8	Granite	Inclined
***T. 4259**	18	6	14	1.8	Granite	Plane	***T. 4679**	19	6	14	1.8	Granite	Inclined
***T. 4260**	18	6	15	1.8	Granite	Plane	***T. 4680**	19	6	15	1.8	Granite	Inclined
***T. 4261**	18	6	1	2	Granite	Plane	***T. 4681**	19	6	1	2	Granite	Inclined
***T. 4262**	18	6	2	2	Granite	Plane	***T. 4682**	19	6	2	2	Granite	Inclined
***T. 4263**	18	6	3	2	Granite	Plane	***T. 4683**	19	6	3	2	Granite	Inclined
***T. 4264**	18	6	4	2	Granite	Plane	***T. 4684**	19	6	4	2	Granite	Inclined
***T. 4265**	18	6	5	2	Granite	Plane	***T. 4685**	19	6	5	2	Granite	Inclined
***T. 4266**	18	6	6	2	Granite	Plane	***T. 4686**	19	6	6	2	Granite	Inclined
***T. 4267**	18	6	7	2	Granite	Plane	***T. 4687**	19	6	7	2	Granite	Inclined
***T. 4268**	18	6	8	2	Granite	Plane	***T. 4688**	19	6	8	2	Granite	Inclined
***T. 4269**	18	6	9	2	Granite	Plane	***T. 4689**	19	6	9	2	Granite	Inclined
***T. 4270**	17	6	10	2	Granite	Plane	***T. 4690**	18	6	10	2	Granite	Inclined
***T. 4271**	18	6	11	2	Granite	Plane	***T. 4691**	19	6	11	2	Granite	Inclined
***T. 4272**	18	6	12	2	Granite	Plane	***T. 4692**	19	6	12	2	Granite	Inclined
***T. 4273**	18	6	13	2	Granite	Plane	***T. 4693**	19	6	13	2	Granite	Inclined
***T. 4274**	18	6	14	2	Granite	Plane	***T. 4694**	19	6	14	2	Granite	Inclined
***T. 4275**	18	6	15	2	Granite	Plane	***T. 4695**	19	6	15	2	Granite	Inclined
***T. 4276**	16	6	1	2.3	Granite	Plane	***T. 4696**	17	6	1	2.3	Granite	Inclined
***T. 4277**	16	6	2	2.3	Granite	Plane	***T. 4697**	17	6	2	2.3	Granite	Inclined

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Table E.1. (cont.)

***T. 4278**	16	6	3	2.3	Granite	Plane	***T. 4698**	17	6	3	2.3	Granite	Inclined
***T. 4279**	16	6	4	2.3	Granite	Plane	***T. 4699**	17	6	4	2.3	Granite	Inclined
***T. 4280**	16	6	5	2.3	Granite	Plane	***T. 4700**	17	6	5	2.3	Granite	Inclined
***T. 4281**	16	6	6	2.3	Granite	Plane	***T. 4701**	17	6	6	2.3	Granite	Inclined
***T. 4282**	16	6	7	2.3	Granite	Plane	***T. 4702**	17	6	7	2.3	Granite	Inclined
***T. 4283**	16	6	8	2.3	Granite	Plane	***T. 4703**	17	6	8	2.3	Granite	Inclined
***T. 4284**	16	6	9	2.3	Granite	Plane	***T. 4704**	17	6	9	2.3	Granite	Inclined
***T. 4285**	16	6	10	2.3	Granite	Plane	***T. 4705**	17	6	10	2.3	Granite	Inclined
***T. 4286**	16	6	11	2.3	Granite	Plane	***T. 4706**	17	6	11	2.3	Granite	Inclined
***T. 4287**	16	6	12	2.3	Granite	Plane	***T. 4707**	17	6	12	2.3	Granite	Inclined
***T. 4288**	16	6	13	2.3	Granite	Plane	***T. 4708**	17	6	13	2.3	Granite	Inclined
***T. 4289**	16	6	14	2.3	Granite	Plane	***T. 4709**	17	6	14	2.3	Granite	Inclined
***T. 4290**	16	6	15	2.3	Granite	Plane	***T. 4710**	17	6	15	2.3	Granite	Inclined
T. 4291	15	6	1	2.5	Granite	Plane	**T. 4711**	16	6	1	2.5	Granite	Inclined
T. 4292	15	6	2	2.5	Granite	Plane	**T. 4712**	16	6	2	2.5	Granite	Inclined
T. 4293	15	6	3	2.5	Granite	Plane	**T. 4713**	16	6	3	2.5	Granite	Inclined
T. 4294	15	6	4	2.5	Granite	Plane	**T. 4714**	16	6	4	2.5	Granite	Inclined
T. 4295	15	6	5	2.5	Granite	Plane	**T. 4715**	16	6	5	2.5	Granite	Inclined
T. 4296	15	6	6	2.5	Granite	Plane	**T. 4716**	16	6	6	2.5	Granite	Inclined
T. 4297	15	6	7	2.5	Granite	Plane	**T. 4717**	16	6	7	2.5	Granite	Inclined
T. 4298	15	6	8	2.5	Granite	Plane	**T. 4718**	16	6	8	2.5	Granite	Inclined
T. 4299	15	6	9	2.5	Granite	Plane	**T. 4719**	16	6	9	2.5	Granite	Inclined
T. 4300	15	6	10	2.5	Granite	Plane	**T. 4720**	16	6	10	2.5	Granite	Inclined
T. 4301	15	6	11	2.5	Granite	Plane	**T. 4721**	16	6	11	2.5	Granite	Inclined
T. 4302	15	6	12	2.5	Granite	Plane	**T. 4722**	16	6	12	2.5	Granite	Inclined
T. 4303	15	6	13	2.5	Granite	Plane	**T. 4723**	16	6	13	2.5	Granite	Inclined
T. 4304	15	6	14	2.5	Granite	Plane	**T. 4724**	16	6	14	2.5	Granite	Inclined
T. 4305	15	6	15	2.5	Granite	Plane	**T. 4725**	16	6	15	2.5	Granite	Inclined
T. 4306	17	6	1	1	Limestone	Plane	**T. 4726**	18	6	1	1	Limestone	Inclined
T. 4307	17	6	2	1	Limestone	Plane	**T. 4727**	18	6	2	1	Limestone	Inclined
T. 4308	17	6	3	1	Limestone	Plane	**T. 4728**	18	6	3	1	Limestone	Inclined
T. 4309	17	6	4	1	Limestone	Plane	**T. 4729**	18	6	4	1	Limestone	Inclined
T. 4310	17	6	5	1	Limestone	Plane	**T. 4730**	18	6	5	1	Limestone	Inclined

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Table E.1. (cont.

T. 4311	17	6	6	1	Limestone	Plane	**T. 4731**	18	6	6	1	Limestone	Inclined
T. 4312	17	6	7	1	Limestone	Plane	**T. 4732**	18	6	7	1	Limestone	Inclined
T. 4313	17	6	8	1	Limestone	Plane	**T. 4733**	18	6	8	1	Limestone	Inclined
T. 4314	17	6	9	1	Limestone	Plane	**T. 4734**	18	6	9	1	Limestone	Inclined
T. 4315	15	6	10	1	Limestone	Plane	**T. 4735**	16	6	10	1	Limestone	Inclined
T. 4316	16	6	11	1	Limestone	Plane	**T. 4736**	17	6	11	1	Limestone	Inclined
T. 4317	17	6	12	1	Limestone	Plane	**T. 4737**	18	6	12	1	Limestone	Inclined
T. 4318	17	6	13	1	Limestone	Plane	**T. 4738**	18	6	13	1	Limestone	Inclined
T. 4319	16	6	14	1	Limestone	Plane	**T. 4739**	17	6	14	1	Limestone	Inclined
T. 4320	16	6	15	1	Limestone	Plane	**T. 4740**	17	6	15	1	Limestone	Inclined
T. 4321	19	6	1	1.3	Limestone	Plane	**T. 4741**	20	6	1	1.3	Limestone	Inclined
T. 4322	19	6	2	1.3	Limestone	Plane	**T. 4742**	20	6	2	1.3	Limestone	Inclined
T. 4323	19	6	3	1.3	Limestone	Plane	**T. 4743**	20	6	3	1.3	Limestone	Inclined
T. 4324	19	6	4	1.3	Limestone	Plane	**T. 4744**	20	6	4	1.3	Limestone	Inclined
T. 4325	19	6	5	1.3	Limestone	Plane	**T. 4745**	20	6	5	1.3	Limestone	Inclined
T. 4326	19	6	6	1.3	Limestone	Plane	**T. 4746**	20	6	6	1.3	Limestone	Inclined
T. 4327	19	6	7	1.3	Limestone	Plane	**T. 4747**	20	6	7	1.3	Limestone	Inclined
T. 4328	19	6	8	1.3	Limestone	Plane	**T. 4748**	20	6	8	1.3	Limestone	Inclined
T. 4329	19	6	9	1.3	Limestone	Plane	**T. 4749**	20	6	9	1.3	Limestone	Inclined
T. 4330	18	6	10	1.3	Limestone	Plane	**T. 4750**	19	6	10	1.3	Limestone	Inclined
T. 4331	18	6	11	1.3	Limestone	Plane	**T. 4751**	19	6	11	1.3	Limestone	Inclined
T. 4332	19	6	12	1.3	Limestone	Plane	**T. 4752**	20	6	12	1.3	Limestone	Inclined
T. 4333	19	6	13	1.3	Limestone	Plane	**T. 4753**	20	6	13	1.3	Limestone	Inclined
T. 4334	18	6	14	1.3	Limestone	Plane	**T. 4754**	19	6	14	1.3	Limestone	Inclined
T. 4335	18	6	15	1.3	Limestone	Plane	**T. 4755**	19	6	15	1.3	Limestone	Inclined
***T. 4336**	19	6	1	1.6	Limestone	Plane	***T. 4756**	20	6	1	1.6	Limestone	Inclined
***T. 4337**	19	6	2	1.6	Limestone	Plane	***T. 4757**	20	6	2	1.6	Limestone	Inclined
***T. 4338**	19	6	3	1.6	Limestone	Plane	***T. 4758**	20	6	3	1.6	Limestone	Inclined
***T. 4339**	19	6	4	1.6	Limestone	Plane	***T. 4759**	20	6	4	1.6	Limestone	Inclined
***T. 4340**	19	6	5	1.6	Limestone	Plane	***T. 4760**	20	6	5	1.6	Limestone	Inclined
***T. 4341**	19	6	6	1.6	Limestone	Plane	***T. 4761**	20	6	6	1.6	Limestone	Inclined
***T. 4342**	19	6	7	1.6	Limestone	Plane	***T. 4762**	20	6	7	1.6	Limestone	Inclined
***T. 4343**	19	6	8	1.6	Limestone	Plane	***T. 4763**	20	6	8	1.6	Limestone	Inclined

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Table E.1. (cont.)

***T. 4344**	19	6	9	1.6	Limestone	Plane	***T. 4764**	20	6	9	1.6	Limestone	Inclined
***T. 4345**	18	6	10	1.6	Limestone	Plane	***T. 4765**	19	6	10	1.6	Limestone	Inclined
***T. 4346**	18	6	11	1.6	Limestone	Plane	***T. 4766**	19	6	11	1.6	Limestone	Inclined
***T. 4347**	19	6	12	1.6	Limestone	Plane	***T. 4767**	20	6	12	1.6	Limestone	Inclined
***T. 4348**	19	6	13	1.6	Limestone	Plane	***T. 4768**	20	6	13	1.6	Limestone	Inclined
***T. 4349**	19	6	14	1.6	Limestone	Plane	***T. 4769**	20	6	14	1.6	Limestone	Inclined
***T. 4350**	19	6	15	1.6	Limestone	Plane	***T. 4770**	20	6	15	1.6	Limestone	Inclined
***T. 4351**	19	6	1	1.8	Limestone	Plane	***T. 4771**	20	6	1	1.8	Limestone	Inclined
***T. 4352**	19	6	2	1.8	Limestone	Plane	***T. 4772**	20	6	2	1.8	Limestone	Inclined
***T. 4353**	19	6	3	1.8	Limestone	Plane	***T. 4773**	20	6	3	1.8	Limestone	Inclined
***T. 4354**	19	6	4	1.8	Limestone	Plane	***T. 4774**	20	6	4	1.8	Limestone	Inclined
***T. 4355**	19	6	5	1.8	Limestone	Plane	***T. 4775**	20	6	5	1.8	Limestone	Inclined
***T. 4356**	19	6	6	1.8	Limestone	Plane	***T. 4776**	20	6	6	1.8	Limestone	Inclined
***T. 4357**	19	6	7	1.8	Limestone	Plane	***T. 4777**	20	6	7	1.8	Limestone	Inclined
***T. 4358**	19	6	8	1.8	Limestone	Plane	***T. 4778**	20	6	8	1.8	Limestone	Inclined
***T. 4359**	19	6	9	1.8	Limestone	Plane	***T. 4779**	20	6	9	1.8	Limestone	Inclined
***T. 4360**	18	6	10	1.8	Limestone	Plane	***T. 4780**	19	6	10	1.8	Limestone	Inclined
***T. 4361**	19	6	11	1.8	Limestone	Plane	***T. 4781**	20	6	11	1.8	Limestone	Inclined
***T. 4362**	19	6	12	1.8	Limestone	Plane	***T. 4782**	20	6	12	1.8	Limestone	Inclined
***T. 4363**	19	6	13	1.8	Limestone	Plane	***T. 4783**	20	6	13	1.8	Limestone	Inclined
***T. 4364**	18	6	14	1.8	Limestone	Plane	***T. 4784**	19	6	14	1.8	Limestone	Inclined
***T. 4365**	18	6	15	1.8	Limestone	Plane	***T. 4785**	19	6	15	1.8	Limestone	Inclined
***T. 4366**	18	6	1	2	Limestone	Plane	***T. 4786**	19	6	1	2	Limestone	Inclined
***T. 4367**	18	6	2	2	Limestone	Plane	***T. 4787**	19	6	2	2	Limestone	Inclined
***T. 4368**	18	6	3	2	Limestone	Plane	***T. 4788**	19	6	3	2	Limestone	Inclined
***T. 4369**	18	6	4	2	Limestone	Plane	***T. 4789**	19	6	4	2	Limestone	Inclined
***T. 4370**	18	6	5	2	Limestone	Plane	***T. 4790**	19	6	5	2	Limestone	Inclined
***T. 4371**	18	6	6	2	Limestone	Plane	***T. 4791**	19	6	6	2	Limestone	Inclined
***T. 4372**	18	6	7	2	Limestone	Plane	***T. 4792**	19	6	7	2	Limestone	Inclined
***T. 4373**	18	6	8	2	Limestone	Plane	***T. 4793**	19	6	8	2	Limestone	Inclined
***T. 4374**	18	6	9	2	Limestone	Plane	***T. 4794**	19	6	9	2	Limestone	Inclined
***T. 4375**	17	6	10	2	Limestone	Plane	***T. 4795**	18	6	10	2	Limestone	Inclined
***T. 4376**	18	6	11	2	Limestone	Plane	***T. 4796**	19	6	11	2	Limestone	Inclined

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Table E.1. (cont.)

***T. 4377**	18	6	12	2	Limestone	Plane	***T. 4797**	19	6	12	2	Limestone	Inclined
***T. 4378**	18	6	13	2	Limestone	Plane	***T. 4798**	19	6	13	2	Limestone	Inclined
***T. 4379**	18	6	14	2	Limestone	Plane	***T. 4799**	19	6	14	2	Limestone	Inclined
***T. 4380**	18	6	15	2	Limestone	Plane	***T. 4800**	19	6	15	2	Limestone	Inclined
***T. 4381**	16	6	1	2.3	Limestone	Plane	***T. 4801**	17	6	1	2.3	Limestone	Inclined
***T. 4382**	16	6	2	2.3	Limestone	Plane	***T. 4802**	17	6	2	2.3	Limestone	Inclined
***T. 4383**	16	6	3	2.3	Limestone	Plane	***T. 4803**	17	6	3	2.3	Limestone	Inclined
***T. 4384**	16	6	4	2.3	Limestone	Plane	***T. 4804**	17	6	4	2.3	Limestone	Inclined
***T. 4385**	16	6	5	2.3	Limestone	Plane	***T. 4805**	17	6	5	2.3	Limestone	Inclined
***T. 4386**	16	6	6	2.3	Limestone	Plane	***T. 4806**	17	6	6	2.3	Limestone	Inclined
***T. 4387**	16	6	7	2.3	Limestone	Plane	***T. 4807**	17	6	7	2.3	Limestone	Inclined
***T. 4388**	16	6	8	2.3	Limestone	Plane	***T. 4808**	17	6	8	2.3	Limestone	Inclined
***T. 4389**	16	6	9	2.3	Limestone	Plane	***T. 4809**	17	6	9	2.3	Limestone	Inclined
***T. 4390**	16	6	10	2.3	Limestone	Plane	***T. 4810**	17	6	10	2.3	Limestone	Inclined
***T. 4391**	16	6	11	2.3	Limestone	Plane	***T. 4811**	17	6	11	2.3	Limestone	Inclined
***T. 4392**	16	6	12	2.3	Limestone	Plane	***T. 4812**	17	6	12	2.3	Limestone	Inclined
***T. 4393**	16	6	13	2.3	Limestone	Plane	***T. 4813**	17	6	13	2.3	Limestone	Inclined
***T. 4394**	16	6	14	2.3	Limestone	Plane	***T. 4814**	17	6	14	2.3	Limestone	Inclined
***T. 4395**	16	6	15	2.3	Limestone	Plane	***T. 4815**	17	6	15	2.3	Limestone	Inclined
T. 4396	15	6	1	2.5	Limestone	Plane	**T. 4816**	16	6	1	2.5	Limestone	Inclined
T. 4397	15	6	2	2.5	Limestone	Plane	**T. 4817**	16	6	2	2.5	Limestone	Inclined
T. 4398	15	6	3	2.5	Limestone	Plane	**T. 4818**	16	6	3	2.5	Limestone	Inclined
T. 4399	15	6	4	2.5	Limestone	Plane	**T. 4819**	16	6	4	2.5	Limestone	Inclined
T. 4400	15	6	5	2.5	Limestone	Plane	**T. 4820**	16	6	5	2.5	Limestone	Inclined
T. 4401	15	6	6	2.5	Limestone	Plane	**T. 4821**	16	6	6	2.5	Limestone	Inclined
T. 4402	15	6	7	2.5	Limestone	Plane	**T. 4822**	16	6	7	2.5	Limestone	Inclined
T. 4403	15	6	8	2.5	Limestone	Plane	**T. 4823**	16	6	8	2.5	Limestone	Inclined
T. 4404	15	6	9	2.5	Limestone	Plane	**T. 4824**	16	6	9	2.5	Limestone	Inclined
T. 4405	15	6	10	2.5	Limestone	Plane	**T. 4825**	16	6	10	2.5	Limestone	Inclined
T. 4406	15	6	11	2.5	Limestone	Plane	**T. 4826**	16	6	11	2.5	Limestone	Inclined
T. 4407	15	6	12	2.5	Limestone	Plane	**T. 4827**	16	6	12	2.5	Limestone	Inclined
T. 4408	15	6	13	2.5	Limestone	Plane	**T. 4828**	16	6	13	2.5	Limestone	Inclined
T. 4409	15	6	14	2.5	Limestone	Plane	**T. 4829**	16	6	14	2.5	Limestone	Inclined

(cont. on next page)

Table E.1. (cont.)

T. 4410	15	6	15	2.5	Limestone	Plane	**T. 4830**	16	6	15	2.5	Limestone	Inclined
T. 4411	17	6	1	1	Sandstone	Plane	**T. 4831**	18	6	1	1	Sandstone	Inclined
T. 4412	17	6	2	1	Sandstone	Plane	**T. 4832**	18	6	2	1	Sandstone	Inclined
T. 4413	17	6	3	1	Sandstone	Plane	**T. 4833**	18	6	3	1	Sandstone	Inclined
T. 4414	17	6	4	1	Sandstone	Plane	**T. 4834**	18	6	4	1	Sandstone	Inclined
T. 4415	17	6	5	1	Sandstone	Plane	**T. 4835**	18	6	5	1	Sandstone	Inclined
T. 4416	17	6	6	1	Sandstone	Plane	**T. 4836**	18	6	6	1	Sandstone	Inclined
T. 4417	17	6	7	1	Sandstone	Plane	**T. 4837**	18	6	7	1	Sandstone	Inclined
T. 4418	17	6	8	1	Sandstone	Plane	**T. 4838**	18	6	8	1	Sandstone	Inclined
T. 4419	17	6	9	1	Sandstone	Plane	**T. 4839**	18	6	9	1	Sandstone	Inclined
T. 4420	15	6	10	1	Sandstone	Plane	**T. 4840**	16	6	10	1	Sandstone	Inclined
T. 4421	16	6	11	1	Sandstone	Plane	**T. 4841**	17	6	11	1	Sandstone	Inclined
T. 4422	17	6	12	1	Sandstone	Plane	**T. 4842**	18	6	12	1	Sandstone	Inclined
T. 4423	17	6	13	1	Sandstone	Plane	**T. 4843**	18	6	13	1	Sandstone	Inclined
T. 4424	16	6	14	1	Sandstone	Plane	**T. 4844**	17	6	14	1	Sandstone	Inclined
T. 4425	16	6	15	1	Sandstone	Plane	**T. 4845**	17	6	15	1	Sandstone	Inclined
T. 4426	19	6	1	1.3	Sandstone	Plane	**T. 4846**	20	6	1	1.3	Sandstone	Inclined
T. 4427	19	6	2	1.3	Sandstone	Plane	**T. 4847**	20	6	2	1.3	Sandstone	Inclined
T. 4428	19	6	3	1.3	Sandstone	Plane	**T. 4848**	20	6	3	1.3	Sandstone	Inclined
T. 4429	19	6	4	1.3	Sandstone	Plane	**T. 4849**	20	6	4	1.3	Sandstone	Inclined
T. 4430	19	6	5	1.3	Sandstone	Plane	**T. 4850**	20	6	5	1.3	Sandstone	Inclined
T. 4431	19	6	6	1.3	Sandstone	Plane	**T. 4851**	20	6	6	1.3	Sandstone	Inclined
T. 4432	19	6	7	1.3	Sandstone	Plane	**T. 4852**	20	6	7	1.3	Sandstone	Inclined
T. 4433	19	6	8	1.3	Sandstone	Plane	**T. 4853**	20	6	8	1.3	Sandstone	Inclined
T. 4434	19	6	9	1.3	Sandstone	Plane	**T. 4854**	20	6	9	1.3	Sandstone	Inclined
T. 4435	18	6	10	1.3	Sandstone	Plane	**T. 4855**	19	6	10	1.3	Sandstone	Inclined
T. 4436	18	6	11	1.3	Sandstone	Plane	**T. 4856**	19	6	11	1.3	Sandstone	Inclined
T. 4437	19	6	12	1.3	Sandstone	Plane	**T. 4857**	20	6	12	1.3	Sandstone	Inclined
T. 4438	19	6	13	1.3	Sandstone	Plane	**T. 4858**	20	6	13	1.3	Sandstone	Inclined
T. 4439	18	6	14	1.3	Sandstone	Plane	**T. 4859**	19	6	14	1.3	Sandstone	Inclined
T. 4440	18	6	15	1.3	Sandstone	Plane	**T. 4860**	19	6	15	1.3	Sandstone	Inclined
T. 4441	19	6	1	1.6	Sandstone	Plane	**T. 4861**	20	6	1	1.6	Sandstone	Inclined
T. 4442	19	6	2	1.6	Sandstone	Plane	**T. 4862**	20	6	2	1.6	Sandstone	Inclined

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Table E.1. (cont.)

T. 4443	19	6	3	1.6	Sandstone	Plane	**T. 4863**	20	6	3	1.6	Sandstone	Inclined
T. 4444	19	6	4	1.6	Sandstone	Plane	**T. 4864**	20	6	4	1.6	Sandstone	Inclined
T. 4445	19	6	5	1.6	Sandstone	Plane	**T. 4865**	20	6	5	1.6	Sandstone	Inclined
T. 4446	19	6	6	1.6	Sandstone	Plane	**T. 4866**	20	6	6	1.6	Sandstone	Inclined
T. 4447	19	6	7	1.6	Sandstone	Plane	**T. 4867**	20	6	7	1.6	Sandstone	Inclined
T. 4448	19	6	8	1.6	Sandstone	Plane	**T. 4868**	20	6	8	1.6	Sandstone	Inclined
T. 4449	19	6	9	1.6	Sandstone	Plane	**T. 4869**	20	6	9	1.6	Sandstone	Inclined
T. 4450	18	6	10	1.6	Sandstone	Plane	**T. 4870**	19	6	10	1.6	Sandstone	Inclined
T. 4451	18	6	11	1.6	Sandstone	Plane	**T. 4871**	19	6	11	1.6	Sandstone	Inclined
T. 4452	19	6	12	1.6	Sandstone	Plane	**T. 4872**	20	6	12	1.6	Sandstone	Inclined
T. 4453	19	6	13	1.6	Sandstone	Plane	**T. 4873**	20	6	13	1.6	Sandstone	Inclined
T. 4454	19	6	14	1.6	Sandstone	Plane	**T. 4874**	20	6	14	1.6	Sandstone	Inclined
T. 4455	19	6	15	1.6	Sandstone	Plane	**T. 4875**	20	6	15	1.6	Sandstone	Inclined
T. 4456	19	6	1	1.8	Sandstone	Plane	**T. 4876**	20	6	1	1.8	Sandstone	Inclined
T. 4457	19	6	2	1.8	Sandstone	Plane	**T. 4877**	20	6	2	1.8	Sandstone	Inclined
T. 4458	19	6	3	1.8	Sandstone	Plane	**T. 4878**	20	6	3	1.8	Sandstone	Inclined
T. 4459	19	6	4	1.8	Sandstone	Plane	**T. 4879**	20	6	4	1.8	Sandstone	Inclined
T. 4460	19	6	5	1.8	Sandstone	Plane	**T. 4880**	20	6	5	1.8	Sandstone	Inclined
T. 4461	19	6	6	1.8	Sandstone	Plane	**T. 4881**	20	6	6	1.8	Sandstone	Inclined
T. 4462	19	6	7	1.8	Sandstone	Plane	**T. 4882**	20	6	7	1.8	Sandstone	Inclined
T. 4463	19	6	8	1.8	Sandstone	Plane	**T. 4883**	20	6	8	1.8	Sandstone	Inclined
T. 4464	19	6	9	1.8	Sandstone	Plane	**T. 4884**	20	6	9	1.8	Sandstone	Inclined
T. 4465	18	6	10	1.8	Sandstone	Plane	**T. 4885**	19	6	10	1.8	Sandstone	Inclined
T. 4466	19	6	11	1.8	Sandstone	Plane	**T. 4886**	20	6	11	1.8	Sandstone	Inclined
T. 4467	19	6	12	1.8	Sandstone	Plane	**T. 4887**	20	6	12	1.8	Sandstone	Inclined
T. 4468	19	6	13	1.8	Sandstone	Plane	**T. 4888**	20	6	13	1.8	Sandstone	Inclined
T. 4469	18	6	14	1.8	Sandstone	Plane	**T. 4889**	19	6	14	1.8	Sandstone	Inclined
T. 4470	18	6	15	1.8	Sandstone	Plane	**T. 4890**	19	6	15	1.8	Sandstone	Inclined
T. 4471	18	6	1	2	Sandstone	Plane	**T. 4891**	19	6	1	2	Sandstone	Inclined
T. 4472	18	6	2	2	Sandstone	Plane	**T. 4892**	19	6	2	2	Sandstone	Inclined
T. 4473	18	6	3	2	Sandstone	Plane	**T. 4893**	19	6	3	2	Sandstone	Inclined
T. 4474	18	6	4	2	Sandstone	Plane	**T. 4894**	19	6	4	2	Sandstone	Inclined
T. 4475	18	6	5	2	Sandstone	Plane	**T. 4895**	19	6	5	2	Sandstone	Inclined

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Table E.1. (cont.)

T. 4476	18	6	6	2	Sandstone	Plane	**T. 4896**	19	6	6	2	Sandstone	Inclined
T. 4477	18	6	7	2	Sandstone	Plane	**T. 4897**	19	6	7	2	Sandstone	Inclined
T. 4478	18	6	8	2	Sandstone	Plane	**T. 4898**	19	6	8	2	Sandstone	Inclined
T. 4479	18	6	9	2	Sandstone	Plane	**T. 4899**	19	6	9	2	Sandstone	Inclined
T. 4480	17	6	10	2	Sandstone	Plane	**T. 4900**	18	6	10	2	Sandstone	Inclined
T. 4481	18	6	11	2	Sandstone	Plane	**T. 4901**	19	6	11	2	Sandstone	Inclined
T. 4482	18	6	12	2	Sandstone	Plane	**T. 4902**	19	6	12	2	Sandstone	Inclined
T. 4483	18	6	13	2	Sandstone	Plane	**T. 4903**	19	6	13	2	Sandstone	Inclined
T. 4484	18	6	14	2	Sandstone	Plane	**T. 4904**	19	6	14	2	Sandstone	Inclined
T. 4485	18	6	15	2	Sandstone	Plane	**T. 4905**	19	6	15	2	Sandstone	Inclined
T. 4486	16	6	1	2.3	Sandstone	Plane	**T. 4906**	17	6	1	2.3	Sandstone	Inclined
T. 4487	16	6	2	2.3	Sandstone	Plane	**T. 4907**	17	6	2	2.3	Sandstone	Inclined
T. 4488	16	6	3	2.3	Sandstone	Plane	**T. 4908**	17	6	3	2.3	Sandstone	Inclined
T. 4489	16	6	4	2.3	Sandstone	Plane	**T. 4909**	17	6	4	2.3	Sandstone	Inclined
T. 4490	16	6	5	2.3	Sandstone	Plane	**T. 4910**	17	6	5	2.3	Sandstone	Inclined
T. 4491	16	6	6	2.3	Sandstone	Plane	**T. 4911**	17	6	6	2.3	Sandstone	Inclined
T. 4492	16	6	7	2.3	Sandstone	Plane	**T. 4912**	17	6	7	2.3	Sandstone	Inclined
T. 4493	16	6	8	2.3	Sandstone	Plane	**T. 4913**	17	6	8	2.3	Sandstone	Inclined
T. 4494	16	6	9	2.3	Sandstone	Plane	**T. 4914**	17	6	9	2.3	Sandstone	Inclined
T. 4495	16	6	10	2.3	Sandstone	Plane	**T. 4915**	17	6	10	2.3	Sandstone	Inclined
T. 4496	16	6	11	2.3	Sandstone	Plane	**T. 4916**	17	6	11	2.3	Sandstone	Inclined
T. 4497	16	6	12	2.3	Sandstone	Plane	**T. 4917**	17	6	12	2.3	Sandstone	Inclined
T. 4498	16	6	13	2.3	Sandstone	Plane	**T. 4918**	17	6	13	2.3	Sandstone	Inclined
T. 4499	16	6	14	2.3	Sandstone	Plane	**T. 4919**	17	6	14	2.3	Sandstone	Inclined
T. 4500	16	6	15	2.3	Sandstone	Plane	**T. 4920**	17	6	15	2.3	Sandstone	Inclined
T. 4501	15	6	1	2.5	Sandstone	Plane	**T. 4921**	16	6	1	2.5	Sandstone	Inclined
T. 4502	15	6	2	2.5	Sandstone	Plane	**T. 4922**	16	6	2	2.5	Sandstone	Inclined
T. 4503	15	6	3	2.5	Sandstone	Plane	**T. 4923**	16	6	3	2.5	Sandstone	Inclined
T. 4504	15	6	4	2.5	Sandstone	Plane	**T. 4924**	16	6	4	2.5	Sandstone	Inclined
T. 4505	15	6	5	2.5	Sandstone	Plane	**T. 4925**	16	6	5	2.5	Sandstone	Inclined
T. 4506	15	6	6	2.5	Sandstone	Plane	**T. 4926**	16	6	6	2.5	Sandstone	Inclined
T. 4507	15	6	7	2.5	Sandstone	Plane	**T. 4927**	16	6	7	2.5	Sandstone	Inclined
T. 4508	15	6	8	2.5	Sandstone	Plane	**T. 4928**	16	6	8	2.5	Sandstone	Inclined

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Table E.1. (cont.

T. 4509	15	6	9	2.5	Sandstone	Plane	**T. 4929**	16	6	9	2.5	Sandstone	Inclined
T. 4510	15	6	10	2.5	Sandstone	Plane	**T. 4930**	16	6	10	2.5	Sandstone	Inclined
T. 4511	15	6	11	2.5	Sandstone	Plane	**T. 4931**	16	6	11	2.5	Sandstone	Inclined
T. 4512	15	6	12	2.5	Sandstone	Plane	**T. 4932**	16	6	12	2.5	Sandstone	Inclined
T. 4513	15	6	13	2.5	Sandstone	Plane	**T. 4933**	16	6	13	2.5	Sandstone	Inclined
T. 4514	15	6	14	2.5	Sandstone	Plane	**T. 4934**	16	6	14	2.5	Sandstone	Inclined
T. 4515	15	6	15	2.5	Sandstone	Plane	**T. 4935**	16	6	15	2.5	Sandstone	Inclined
T. 4516	16	6	1	1	Brick	Plane	**T. 4936**	17	6	1	1	Brick	Inclined
T. 4517	16	6	2	1	Brick	Plane	**T. 4937**	17	6	2	1	Brick	Inclined
T. 4518	16	6	3	1	Brick	Plane	**T. 4938**	17	6	3	1	Brick	Inclined
T. 4519	16	6	4	1	Brick	Plane	**T. 4939**	17	6	4	1	Brick	Inclined
T. 4520	16	6	5	1	Brick	Plane	**T. 4940**	17	6	5	1	Brick	Inclined
T. 4521	16	6	6	1	Brick	Plane	**T. 4941**	17	6	6	1	Brick	Inclined
T. 4522	16	6	7	1	Brick	Plane	**T. 4942**	17	6	7	1	Brick	Inclined
T. 4523	16	6	8	1	Brick	Plane	**T. 4943**	17	6	8	1	Brick	Inclined
T. 4524	16	6	9	1	Brick	Plane	**T. 4944**	17	6	9	1	Brick	Inclined
T. 4525	14	6	10	1	Brick	Plane	**T. 4945**	15	6	10	1	Brick	Inclined
T. 4526	15	6	11	1	Brick	Plane	**T. 4946**	16	6	11	1	Brick	Inclined
T. 4527	16	6	12	1	Brick	Plane	**T. 4947**	17	6	12	1	Brick	Inclined
T. 4528	16	6	13	1	Brick	Plane	**T. 4948**	17	6	13	1	Brick	Inclined
T. 4529	15	6	14	1	Brick	Plane	**T. 4949**	16	6	14	1	Brick	Inclined
T. 4530	15	6	15	1	Brick	Plane	**T. 4950**	16	6	15	1	Brick	Inclined
T. 4531	18	6	1	1.3	Brick	Plane	**T. 4951**	19	6	1	1.3	Brick	Inclined
T. 4532	18	6	2	1.3	Brick	Plane	**T. 4952**	19	6	2	1.3	Brick	Inclined
T. 4533	18	6	3	1.3	Brick	Plane	**T. 4953**	19	6	3	1.3	Brick	Inclined
T. 4534	18	6	4	1.3	Brick	Plane	**T. 4954**	19	6	4	1.3	Brick	Inclined
T. 4535	18	6	5	1.3	Brick	Plane	**T. 4955**	19	6	5	1.3	Brick	Inclined
T. 4536	18	6	6	1.3	Brick	Plane	**T. 4956**	19	6	6	1.3	Brick	Inclined
T. 4537	18	6	7	1.3	Brick	Plane	**T. 4957**	19	6	7	1.3	Brick	Inclined
T. 4538	18	6	8	1.3	Brick	Plane	**T. 4958**	19	6	8	1.3	Brick	Inclined
T. 4539	18	6	9	1.3	Brick	Plane	**T. 4959**	19	6	9	1.3	Brick	Inclined
T. 4540	17	6	10	1.3	Brick	Plane	**T. 4960**	18	6	10	1.3	Brick	Inclined
T. 4541	17	6	11	1.3	Brick	Plane	**T. 4961**	18	6	11	1.3	Brick	Inclined

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Table E.1. (cont.)

T. 4542	18	6	12	1.3	Brick	Plane	**T. 4962**	19	6	12	1.3	Brick	Inclined
T. 4543	18	6	13	1.3	Brick	Plane	**T. 4963**	19	6	13	1.3	Brick	Inclined
T. 4544	17	6	14	1.3	Brick	Plane	**T. 4964**	18	6	14	1.3	Brick	Inclined
T. 4545	17	6	15	1.3	Brick	Plane	**T. 4965**	18	6	15	1.3	Brick	Inclined
T. 4546	18	6	1	1.6	Brick	Plane	**T. 4966**	19	6	1	1.6	Brick	Inclined
T. 4547	18	6	2	1.6	Brick	Plane	**T. 4967**	19	6	2	1.6	Brick	Inclined
T. 4548	18	6	3	1.6	Brick	Plane	**T. 4968**	19	6	3	1.6	Brick	Inclined
T. 4549	18	6	4	1.6	Brick	Plane	**T. 4969**	19	6	4	1.6	Brick	Inclined
T. 4550	18	6	5	1.6	Brick	Plane	**T. 4970**	19	6	5	1.6	Brick	Inclined
T. 4551	18	6	6	1.6	Brick	Plane	**T. 4971**	19	6	6	1.6	Brick	Inclined
T. 4552	18	6	7	1.6	Brick	Plane	**T. 4972**	19	6	7	1.6	Brick	Inclined
T. 4553	18	6	8	1.6	Brick	Plane	**T. 4973**	19	6	8	1.6	Brick	Inclined
T. 4554	18	6	9	1.6	Brick	Plane	**T. 4974**	19	6	9	1.6	Brick	Inclined
T. 4555	17	6	10	1.6	Brick	Plane	**T. 4975**	18	6	10	1.6	Brick	Inclined
T. 4556	17	6	11	1.6	Brick	Plane	**T. 4976**	18	6	11	1.6	Brick	Inclined
T. 4557	18	6	12	1.6	Brick	Plane	**T. 4977**	19	6	12	1.6	Brick	Inclined
T. 4558	18	6	13	1.6	Brick	Plane	**T. 4978**	19	6	13	1.6	Brick	Inclined
T. 4559	18	6	14	1.6	Brick	Plane	**T. 4979**	19	6	14	1.6	Brick	Inclined
T. 4560	18	6	15	1.6	Brick	Plane	**T. 4980**	19	6	15	1.6	Brick	Inclined
T. 4561	18	6	1	1.8	Brick	Plane	**T. 4981**	19	6	1	1.8	Brick	Inclined
T. 4562	18	6	2	1.8	Brick	Plane	**T. 4982**	19	6	2	1.8	Brick	Inclined
T. 4563	18	6	3	1.8	Brick	Plane	**T. 4983**	19	6	3	1.8	Brick	Inclined
T. 4564	18	6	4	1.8	Brick	Plane	**T. 4984**	19	6	4	1.8	Brick	Inclined
T. 4565	18	6	5	1.8	Brick	Plane	**T. 4985**	19	6	5	1.8	Brick	Inclined
T. 4566	18	6	6	1.8	Brick	Plane	**T. 4986**	19	6	6	1.8	Brick	Inclined
T. 4567	18	6	7	1.8	Brick	Plane	**T. 4987**	19	6	7	1.8	Brick	Inclined
T. 4568	18	6	8	1.8	Brick	Plane	**T. 4988**	19	6	8	1.8	Brick	Inclined
T. 4569	18	6	9	1.8	Brick	Plane	**T. 4989**	19	6	9	1.8	Brick	Inclined
T. 4570	17	6	10	1.8	Brick	Plane	**T. 4990**	18	6	10	1.8	Brick	Inclined
T. 4571	18	6	11	1.8	Brick	Plane	**T. 4991**	19	6	11	1.8	Brick	Inclined
T. 4572	18	6	12	1.8	Brick	Plane	**T. 4992**	19	6	12	1.8	Brick	Inclined
T. 4573	18	6	13	1.8	Brick	Plane	**T. 4993**	19	6	13	1.8	Brick	Inclined
T. 4574	17	6	14	1.8	Brick	Plane	**T. 4994**	18	6	14	1.8	Brick	Inclined

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Table E.1. (cont.)

T. 4575	17	6	15	1.8	Brick	Plane	**T. 4995**	18	6	15	1.8	Brick	Inclined
T. 4576	17	6	1	2	Brick	Plane	**T. 4996**	18	6	1	2	Brick	Inclined
T. 4577	17	6	2	2	Brick	Plane	**T. 4997**	18	6	2	2	Brick	Inclined
T. 4578	17	6	3	2	Brick	Plane	**T. 4998**	18	6	3	2	Brick	Inclined
T. 4579	17	6	4	2	Brick	Plane	**T. 4999**	18	6	4	2	Brick	Inclined
T. 4580	17	6	5	2	Brick	Plane	**T. 5000**	18	6	5	2	Brick	Inclined
T. 4581	17	6	6	2	Brick	Plane	**T. 5001**	18	6	6	2	Brick	Inclined
T. 4582	17	6	7	2	Brick	Plane	**T. 5002**	18	6	7	2	Brick	Inclined
T. 4583	17	6	8	2	Brick	Plane	**T. 5003**	18	6	8	2	Brick	Inclined
T. 4584	17	6	9	2	Brick	Plane	**T. 5004**	18	6	9	2	Brick	Inclined
T. 4585	16	6	10	2	Brick	Plane	**T. 5005**	17	6	10	2	Brick	Inclined
T. 4586	17	6	11	2	Brick	Plane	**T. 5006**	18	6	11	2	Brick	Inclined
T. 4587	17	6	12	2	Brick	Plane	**T. 5007**	18	6	12	2	Brick	Inclined
T. 4588	17	6	13	2	Brick	Plane	**T. 5008**	18	6	13	2	Brick	Inclined
T. 4589	17	6	14	2	Brick	Plane	**T. 5009**	18	6	14	2	Brick	Inclined
T. 4590	17	6	15	2	Brick	Plane	**T. 5010**	18	6	15	2	Brick	Inclined
T. 4591	15	6	1	2.3	Brick	Plane	**T. 5011**	16	6	1	2.3	Brick	Inclined
T. 4592	15	6	2	2.3	Brick	Plane	**T. 5012**	16	6	2	2.3	Brick	Inclined
T. 4593	15	6	3	2.3	Brick	Plane	**T. 5013**	16	6	3	2.3	Brick	Inclined
T. 4594	15	6	4	2.3	Brick	Plane	**T. 5014**	16	6	4	2.3	Brick	Inclined
T. 4595	15	6	5	2.3	Brick	Plane	**T. 5015**	16	6	5	2.3	Brick	Inclined
T. 4596	15	6	6	2.3	Brick	Plane	**T. 5016**	16	6	6	2.3	Brick	Inclined
T. 4597	15	6	7	2.3	Brick	Plane	**T. 5017**	16	6	7	2.3	Brick	Inclined
T. 4598	15	6	8	2.3	Brick	Plane	**T. 5018**	16	6	8	2.3	Brick	Inclined
T. 4599	15	6	9	2.3	Brick	Plane	**T. 5019**	16	6	9	2.3	Brick	Inclined
T. 4600	15	6	10	2.3	Brick	Plane	**T. 5020**	16	6	10	2.3	Brick	Inclined
T. 4601	15	6	11	2.3	Brick	Plane	**T. 5021**	16	6	11	2.3	Brick	Inclined
T. 4602	15	6	12	2.3	Brick	Plane	**T. 5022**	16	6	12	2.3	Brick	Inclined
T. 4603	15	6	13	2.3	Brick	Plane	**T. 5023**	16	6	13	2.3	Brick	Inclined
T. 4604	15	6	14	2.3	Brick	Plane	**T. 5024**	16	6	14	2.3	Brick	Inclined
T. 4605	15	6	15	2.3	Brick	Plane	**T. 5025**	16	6	15	2.3	Brick	Inclined
T. 4606	14	6	1	2.5	Brick	Plane	**T. 5026**	15	6	1	2.5	Brick	Inclined
T. 4607	14	6	2	2.5	Brick	Plane	**T. 5027**	15	6	2	2.5	Brick	Inclined

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Table E.1. (cont.)

T. 4608	14	6	3	2.5	Brick	Plane	**T. 5028**	15	6	3	2.5	Brick	Inclined
T. 4609	14	6	4	2.5	Brick	Plane	**T. 5029**	15	6	4	2.5	Brick	Inclined
T. 4610	14	6	5	2.5	Brick	Plane	**T. 5030**	15	6	5	2.5	Brick	Inclined
T. 4611	14	6	6	2.5	Brick	Plane	**T. 5031**	15	6	6	2.5	Brick	Inclined
T. 4612	14	6	7	2.5	Brick	Plane	**T. 5032**	15	6	7	2.5	Brick	Inclined
T. 4613	14	6	8	2.5	Brick	Plane	**T. 5033**	15	6	8	2.5	Brick	Inclined
T. 4614	14	6	9	2.5	Brick	Plane	**T. 5034**	15	6	9	2.5	Brick	Inclined
T. 4615	14	6	10	2.5	Brick	Plane	**T. 5035**	15	6	10	2.5	Brick	Inclined
T. 4616	14	6	11	2.5	Brick	Plane	**T. 5036**	15	6	11	2.5	Brick	Inclined
T. 4617	14	6	12	2.5	Brick	Plane	**T. 5037**	15	6	12	2.5	Brick	Inclined
T. 4618	14	6	13	2.5	Brick	Plane	**T. 5038**	15	6	13	2.5	Brick	Inclined
T. 4619	14	6	14	2.5	Brick	Plane	**T. 5039**	15	6	14	2.5	Brick	Inclined
T. 4620	14	6	15	2.5	Brick	Plane	**T. 5040**	15	6	15	2.5	Brick	Inclined

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Thesis: "Structural Vulnerability of Ancient Dry Masonry Towers Under Lateral Loading"

M.Sc., İzmir Institute of Technology, Graduate School of Engineering and Sciences, Department of Architectural Restoration (2010-2013)
Thesis: "Photogrammetric Evaluation Options for Ancient Structures in Hypokremnos, Pagos, Paradiso And Nysa"

Erasmus Exchange Student, Faculty of Architecture and Civil Engineering, Bielefeld University of Applied Sciences, Germany (2011, Fall Semester)
Project: Virtualizing the Architectural Model of the Town Gumbinnen (Eastprussia)

B.Arch., Dokuz Eylül University, Department of Architecture (Graduate ranking third in the department) (2005-2009)

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