A MULTIDIMENSIONAL EVALUATION OF TIMBER AS A STRUCTURAL SYSTEM IN THE TURKISH CONSTRUCTION SECTOR

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ETHICAL DECLARATION

I hereby declare that I am the sole author of this thesis and have conducted my work according to academic rules and ethical behaviour at every stage, from the planning of the thesis to its defence. I confirm that I have cited all ideas, information and findings that are not specific to my study, as required by the code of ethical behaviour, and that all statements not cited are my own.

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ABSTRACT

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This thesis presents a multidimensional evaluation of timber as a structural system in the Turkish construction sector. It explores the potential advantages and disadvantages of timber compared to traditional systems such as reinforced concrete. The study begins with an overview of the historical use of wood in Turkish architecture and its re-emergence as a viable modern construction material. Central to the research is the Regulations for the Design, Calculation, and Construction of Wooden Buildings, published in the Official Gazette on March 24, 2024, which sets out technical and safety standards related to fire resistance, earthquake performance, and load-bearing systems. The thesis also examines global examples of high-rise timber buildings, highlighting recent engineering innovations that have enabled their realization. As a comparative case study, a timber residential project in Kahramanmaraş with a concrete core was selected. This project is evaluated alongside a timber-steel hybrid structure and a reinforced concrete structure, all designed with identical form and function. For the comparative analysis, static calculations were conducted using the original ground survey reports from the Kahramanmaraş site. The study compares these systems in

terms of construction cost, speed, and environmental impact. Findings show that hybrid timber structures offer benefits such as lower carbon emissions, faster construction, and greater energy efficiency, contributing to environmental sustainability without compromising structural performance despite their higher initial cost. The thesis concludes that timber can play a vital role in advancing sustainable construction in Turkey, provided there is adequate regulatory support and encouragement from the industry.

Keywords: Hybrid Timber Structural Systems, Regulations of Wooden Buildings, Sustainable Architecture, Environmental Impact, Reinforced Concrete Comparison, High-Rise Timber Buildings

ÖZET

TÜRK İNŞAAT SEKTÖRÜNDE TAŞIYICI SİSTEM OLARAK AHŞAP KULLANIMININ FARKLI AÇILARDAN DEĞERLENDİRİLMESİ

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Bu tez, Türkiye inşaat sektöründe ahşabın taşıyıcı sistem olarak çok boyutlu bir değerlendirmesini sunmaktadır. Ahşabın, betonarme gibi geleneksel sistemlerle karşılaştırıldığında sahip olduğu potansiyel avantajlar ve dezavantajlar incelenmiştir. Çalışma, Türk mimarisinde ahşabın tarihsel kullanımına ve modern bir yapı malzemesi olarak yeniden önem kazanmasına dair bir genel bakışla başlamaktadır. Araştırmanın merkezinde, 24 Mart 2024 tarihinde Resmî Gazete'de yayımlanan Ahşap Yapıların Tasarımı, Hesaplanması ve Yapımı Hakkında Yönetmelik yer almakta olup, yangın dayanımı, deprem performansı ve taşıyıcı sistemlerle ilgili teknik ve güvenlik standartlarını ortaya koymaktadır. Tez ayrıca, dünyadaki yüksek katlı ahşap yapılar örneklerini inceleyerek, bu yapıların gerçekleştirilmesini mümkün kılan mühendislik yeniliklerini vurgulamaktadır. Karşılaştırmalı bir vaka çalışması olarak, betonarme çekirdeğe sahip Kahramanmaraş'taki bir ahşap konut projesi seçilmiştir. Bu proje, aynı form ve işlevle tasarlanmış ahşap-çelik hibrit yapı ve betonarme yapı ile birlikte değerlendirilmiştir. Karşılaştırmalı analiz için, Kahramanmaraş'taki yapıya ait orijinal zemin etüt raporları kullanılarak statik hesaplamalar yapılmıştır. Çalışmada bu

sistemler inşaat maliyeti, inşaat hızı ve çevresel etkiler açısından karşılaştırılmıştır. Bulgular, hibrit ahşap yapıların daha düşük karbon emisyonu, daha hızlı inşaat süresi ve daha yüksek enerji verimliliği gibi avantajlar sunduğunu; yapısal performanstan ödün vermeden çevresel sürdürülebilirliğe katkı sağladığını göstermektedir. Ancak, ilk yapım maliyetlerinin daha yüksek olduğu da belirtilmiştir. Tez, yeterli yasal düzenlemeler ve sektör teşvikleri sağlandığında ahşabın Türkiye'de sürdürülebilir inşaatın gelişiminde önemli bir rol oynayabileceği sonucuna varmaktadır.

Anahtar Kelimeler: Hibrit Ahşap Taşıyıcı Sistemler, Ahşap Yapı Yönetmelikleri, Sürdürülebilir Mimarlık, Çevresel Etki, Betonarme Karşılaştırması, Yüksek Katlı Ahşap Yapılar

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CHAPTER 1: INTRODUCTION

1.1. Aim of the Study

Throughout history, wood has served as a fundamental construction material, influencing architecture and the building industry. Wood was used in traditional Turkish architecture, especially in civil and religious buildings. However, in the modern era, particularly with the Industrial Revolution and the development of reinforced concrete construction techniques, wooden buildings were primarily replaced by concrete and steel structures. Nevertheless, with sustainability and environmental impacts in mind in recent years, wooden buildings have regained popularity.

The construction industry has shown increasing interest in using eco-friendly materials and energy efficiency. In this context, natural and renewable materials such as wood have emerged. Wood's carbon-reducing properties and production processes, which require less energy than concrete and steel, make it an attractive option for environmentally friendly construction systems. Furthermore, technological advancements in fire resistance, earthquake performance, and sustainable materials have made wood more reliable and economical when combined with modern construction techniques.

This thesis aims to analyse the current use of wooden structures in the Turkish construction sector and evaluate the advantages and disadvantages of wood compared to other structural systems. The Regulations for the Design, Calculation, and Construction of Wooden Buildings, published in the Official Gazette on March 24, 2024, represents a significant step toward promoting wooden buildings. The thesis examines how these regulations will contribute to the sector. The research particularly focuses on hybrid construction systems that integrate wood with reinforced concrete and steel, examining their feasibility in terms of economic efficiency, construction time, and environmental impact. A comparative analysis of the costs, construction speed, and environmental impacts of hybrid wooden and reinforced concrete systems were conducted in the Housing Building Project designed for Andırın District, Kahramanmaraş.

Additionally, this study discusses the roles of organisations like the National Timber Association in raising awareness about wooden buildings and promoting sectoral development in Turkey. International examples of high-rise wooden buildings are examined, and the feasibility of applying these projects in Turkey is discussed. The study explores whether wooden buildings can serve as an alternative in the Turkish construction sector while highlighting the future potential of this material in terms of sustainability, construction speed and technological advancements.

1.2. Research Question

The key questions to answer throughout the thesis are:

1) How widespread are wooden structures in the Turkish construction sector, and why are they used to this extent?

2) How do hybrid wooden structures compare to reinforced concrete structures in terms of cost, construction speed, and environmental impact?

3) How is the use of wooden structures being promoted in Turkey through the National Timber Association and the Regulations for the Design, Calculation, and Construction of Wooden Buildings?

1.3. Methodology

This study involves a literature review, an examination of regulations, analyses of national/international projects and a comparative analysis of a structurally hybrid wooden structure and a reinforced concrete structure.

The selected project is in Andırın, Kahramanmaraş, a three-floored wooden structure. To make a comparative analysis, a reinforced concrete structure of the same form and floor height and a wooden building with a steel core were designed, and the construction was evaluated in terms of speed, cost and environmental effect.

1.4.Limitations of the Study

As a case study, a timber–reinforced concrete hybrid residential building located in the Andırın district of Kahramanmaraş was selected. Additionally, a timber–steel hybrid

structure and a reinforced concrete structure with the same form and function were designed. Evaluations were carried out from three different perspectives: rough construction costs, construction speed, and CO_2 emission values in terms of environmental impact. Construction speeds and construction costs were determined based on the 2025 (January–July) unit price analyses and construction duration assessments published by the Republic of Türkiye Ministry of Environment, Urbanization and Climate Change.

Although the calculations in this study were carried out meticulously and in accordance with relevant regulations, the fact that timber-steel hybrid systems are not yet widely implemented in Turkey has limited the evaluation of technical details to a small number of existing examples. As a result, certain assumptions made in detailing may lead to partial variations in the outcomes depending on the engineering approach and the specific design decisions. Moreover, the experience and expertise of the engineer involved in the design and implementation of hybrid systems can have a direct impact on the results obtained.

Within the scope of the study, analyses were conducted in terms of carbon emissions (CO_2), and the environmental impacts of the structures were evaluated accordingly. However, the maintenance processes and long-term performance of the buildings were not analyzed. Therefore, maintenance costs and their potential impact on sustainability over time are considered beyond the scope of this thesis.

In addition, although the carbon emissions resulting from the production of steel structural elements were taken into account, the recyclability of steel was not considered in this study. This omission may constitute a limiting factor in the evaluation of the environmental impact of steel structural systems.

1.5. Literature Review

Wood is among the earliest materials employed for structural purposes across various regions worldwide. In Turkey, timber-framed buildings were also prevalent until the 1960s. Following this period, the use of timber buildings declined significantly, with reinforced concrete and masonry structures becoming the preferred choice. However, the earthquakes in Kocaeli and Düzce in 1999 brought renewed attention to traditional

construction methods. While reinforced concrete buildings suffered extensive damage, the traditional structures demonstrated better resilience during these events (Doğangün et al., 2006).

According to Vatan (2022), wood remains unmatched by modern materials as a natural and renewable resource. In line with the goals set in the Sendai Framework for Disaster Risk Reduction (2015-2030), incorporating wood into construction practices is crucial for promoting sustainability. Wood aids in the life cycle management and reuse of buildings and reduces the sector's carbon footprint.

Forestry intensely protects human homes and the environment. The health of our planet depends on the responsible management of forests. For a sustainable future, it is crucial that wood's environmental impact remains lower than that of other building materials, ensuring its continued use in the construction industry. Wood as a primary construction material will help fuel widespread economic growth and provide broader ecological protection. (Vatan, 2022)

Due to several factors, the popularity of wood construction has resurged in recent years. One of the main reasons for this is that wood-based materials, bonding, and sustainable resources are combined to produce less deterioration material than traditional methods such as steel and concrete. This makes wood a more environmentally friendly choice in the construction industry.

Timber is also utilized as a prefabricated structural element, crafted in a separate location and transported to the construction site for swift assembly. This efficient construction process saves time, and wood's high strength/weight ratio enables the construction of especially earthquake-resistant systems. Timber structures tend to have a lower overall mass, which helps reduce the forces exerted on buildings during seismic events, improving their safety and resilience (Izzi et al., 2018). Engineered wood products, such as glued-laminated timber (glulam) beams and cross-laminated timber (CLT) panels, are made by bonding wood with adhesives or connecting it using metal fasteners to create major structural components. These components, such as beams, columns, walls, panels and roofs, are widely used in construction projects. Additionally, engineered wood offers a viable alternative to conventional structural

materials like steel and concrete, and its global use has grown in recent years. (Sotayo et al., 2020).

United Nations estimates predict a 25% rise in the global population over the next thirty years, with numbers expected to grow from 7.7 billion in 2020 to 9.7 billion by 2050. According to Vatan (2022), sustainable approaches to construction, urban planning and city development are needed due to the increasing demand for building construction in the housing sector. Social, economic and environmental factors need to be balanced to achieve sustainability. Key elements of this balance include the selection of construction materials, the adoption of efficient technologies, the quality of art, transportation logistics, and profit and time management. (Vatan, 2022)

Another factor in sustainable development and urban planning is the escalating climate change crisis, which poses risks for the future of humanity. The rising global temperatures in the 21st century and increased exposure to extreme heat are expected to endanger human life. It is becoming clear that long-term climate predictions have often underestimated the speed at which these changes occur, with particular events happening much sooner than anticipated. One of the primary drivers of climate change is rapid urbanisation and population growth, although some studies suggest that the direct impact of urbanisation on climate change is relatively minor. Nonetheless, urban expansion remains a contributing factor to our environmental challenges. (Zhang, 2020).

In Turkey, promoting sustainability requires advancements in construction techniques, the development of innovative building materials, and the use of architectural and structural planning tools (Somer, 2008). Although the indicators for achieving these objectives are universally applicable, the methods of application and assessment can differ. Each region has its unique characteristics, which influence how these indicators are put into practice.

Implementing a sustainable construction strategy requires enhancing building methods, creating innovative materials and technologies, and optimizing architectural and structural planning processes (Somer, 2008). The indicators used to achieve these goals are primarily universal. This shows that general strategies for sustainable

solutions are also globally applicable. However, since each region has its dynamics, the application and evaluation of these indicators depend on local conditions.

In Turkey, economic difficulties and difficulties in developing new technologies and innovative approaches pose significant obstacles. However, taking advantage of Turkey's traditional wooden construction techniques and integrating them into today is important for modern sustainable development in the region. (Vatan, 2022)

CHAPTER 2: THE HISTORY AND DEVELOPMENT OF WOODEN STRUCTURES IN DIFFERENT COUNTRIES

Wood, being a natural material and easily accessible, has been used since ancient times for a wide range of purposes, from shelter to tools and military applications. The most common area of its use has been the construction sector. Its strength, easy availability, and ability to be used without requiring special processing made wood stand out from its alternatives in ancient times.

With the beginning of modernism and the technological advancements of industrialisation, various building materials have emerged, which caused wood to lose popularity. The reasons for this include the inability to achieve sufficient section sizes as a load-bearing system, its weaker strength compared to reinforced concrete and steel structures and its lack of durability.

Today, producing laminated wood and other engineered wood products has made wood a viable alternative. During this process, wood began to be used as a primary load-bearing system, although it was initially used as a facade cladding material for multi-story buildings. A key factor driving the growing focus on wooden buildings is the aim to reduce the negative impacts of global warming. Nowadays, in addition to economic and safety factors, producing environmentally conscious and nature-respecting buildings is of great importance. Concrete and steel structures are considered alternatives due to their high carbon footprint and contribution to adverse environmental conditions. In Turkey, the construction of buildings higher than two stories is not permitted, and while European Eurocode 5 standards are used in the design stages of wood, the "Design, Calculation, and Construction Principles of Wooden Buildings" was published in the Official Gazette on March 24, 2024, and will come into force in 2025. Developing such regulations, publications, institutions, and research centres is essential. The regulatory framework and widespread knowledge network used in designing reinforced concrete and steel structures must be spread and nationalised within the wood construction sector. The "Design, Calculation, and Construction Principles of Wooden Buildings" regulation addresses advanced calculation methods and provides a foundation for designing wooden structures.

Unlike steel and reinforced concrete, wood, by its nature, is a living, breathable material. Although it is difficult to standardise and mould, industrial wood products have made predicting and controlling specific characteristic properties possible. Wood is heterogeneous and anisotropic, which can exhibit different behaviours in different directions. Based on the behaviours it exhibits; its applications and forms vary. Examining the history of wood and analysing examples of its structural uses in both Turkey and the world will contribute to understanding the place and importance of wood today. Therefore, the history of wood and the place of wooden structures in Turkey and the world are discussed in this section.

2.1. Historical Development of Wooden Structures

Recent excavations in eastern Germany have uncovered four wooden water wells dating back approximately 7,000 years, making them the oldest known wooden constructions in Europe (Daily Mail, 2013). These wells, built by some of the first farming communities, demonstrate surprisingly advanced carpentry techniques. The wells consist of oak timbers joined using complex mortise and tenon joints, indicating that early Neolithic societies possessed both knowledge and tools to manipulate wood with precision.

The discovery of these wells challenges the assumption that early farmers lacked sophisticated building skills. Instead, it reveals that woodworking techniques were highly developed, allowing for the creation of durable and functional structures. The excellent preservation of the oak timbers, attributed to waterlogged conditions, has enabled archaeologists to study the craftsmanship in detail (Daily Mail, 2013). This findings provides valuable information on the evolution of wooden construction techniques in prehistoric Europe.

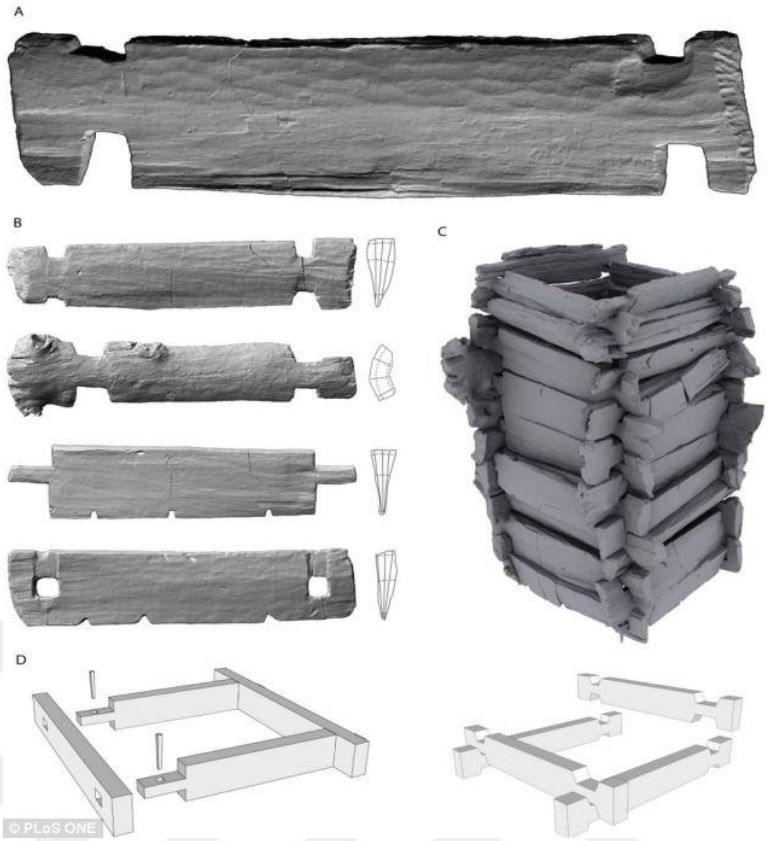


Figure 1. German Water Wells (Source: Daily Mail, 2013)



Figure 2. An example of charred oak timber in ancient times (Source: Daily Mail, 2013)

When examining the development of wood in the history of construction, factors such as the need for large spans, fire hazards, the requirement for long-lasting structures, and the load-bearing capacity of joints stand out. The use of wood became significant before the 19th century due to the need for large spans in bridges. However, wood's fire vulnerability hindered the development of wooden structures. As a result, wood was primarily used in residential buildings alongside materials like stone and adobe.

After the Industrial Revolution, wood lost its popularity due to demands for long-lasting structures, and reinforced concrete and steel began to dominate. Additionally, the load-bearing capacity issues of wooden structures, the insufficient cross-sections for use as primary load-bearing systems, and the limitations on using moment connections led to an increase in the use of steel connections in the early period.

In the early history of wooden structures, simple felled trees were used in bridge construction. Especially in tropical regions of Asia, primitive suspension bridges were made using roots, leaves, and branches. It has been documented those civilizations such as the Persians, Babylonians, Romans, Ancient Greeks, and Chinese constructed wooden bridges in ancient times. One of the oldest bridges is the one built by the Babylonians over the Euphrates River, which is 10 meters wide and 180 meters long. Another important example is the Amphipolis Bridge in Ancient Greece, built in 422 BCE, which spanned 275 meters. The Caesar Bridge (Rome), built by Julius Caesar in 10 days for crossing into Germany, was constructed using wooden beams and supports, with wedges used to join them (Ritter, 1990).

The Hongqiao (Rainbow) Bridge, a wooden bridge built in China between 960-1127 AD, is located over the Yellow River (Figure 3-4). It is said to be capable of carrying 20 livestock, various market stalls, and 500 people. The bridge is 9 meters wide, spanning 16 meters, and stands 4.9 meters above the water level. It consists of 21 wooden arch frames, each approximately 40 cm thick. The arches are supported by frames of three or four linear elements. Secondary beams and wedge-pin joints are placed between them to resist horizontal loads (Ritter, 1990).

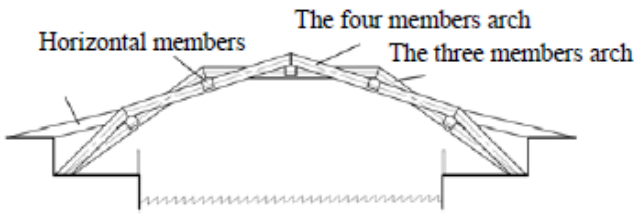


Figure 3. The elevation section of Hongqiao (Source: Chen, 2012)

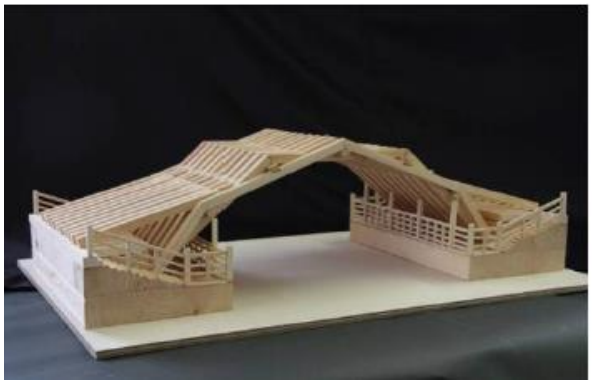


Figure 4. The study model of Hongqiao (Source: Chen, 2012)

Before the Middle Ages, the construction method known as the "Pagoda," which originated in China and spread to nearby communities, is an important example of structural design. Despite being subjected to destructive seismic loads multiple times, many Pagodas are still in service today. Another example is a Pagoda in Japan, which stands 32.55 meters tall. It has maintained its structural integrity for over a thousand years (Figure 5). Despite having endured many earthquakes over the years, the ability of the structure to remain intact is due to the construction techniques employed during its building phase. There is no direct connection between the floors of the building. The structure is formed using piles by anchoring a central load-bearing element to the ground. There is no load transfer between the floors. Nevertheless, the integrity of the structure is maintained (Nakahara et al., 2000).

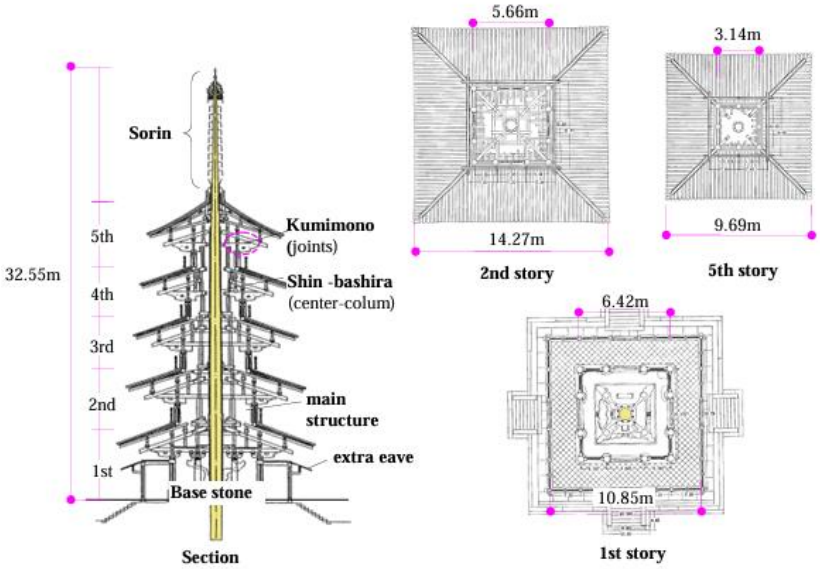


Figure 5. The structural system of ‘Pagoda’ (Source: Nakahara. et al. 2000)

In the 6th century, Japan used woodworking techniques influenced by Chinese craftsmanship. Master builders and great artisans became highly respected in Japanese society. A strong frame construction method was developed during the Asuka and Nara periods. The building method included a sturdy roof held up by pillars. They were connected to notched beams and created a frame that could bear heavy loads. These structures sat on base blocks, which allowed them to absorb and flex during earthquakes. It made them very resilient. The frame's solid pillars could handle heavy weight and provide earthquake resistance by enabling the building to move without breaking. (Krötsch and Müller, 2018)

Stefan Krötsch and Lutz Müller also explained the Pagada in their article; the five-story pagoda at Kōfuku-ji Temple in Nara, Japan's capital, was built in 725. It stood over 50 meters tall. Another example is the main hall of Tōdai-ji Temple, also in Nara, which was completed in 745. This massive wooden structure, considered the largest of its kind globally, has dimensions of 57.01 meters in width, 50.48 meters in depth, and 48.74 meters in height (Krötsch and Müller, 2018).

In the 9th century, the Tō-ji Temple in Kyoto featured a five-story, 57-meter-high pagoda, the tallest building in Japan at that time. These showcase Japan's skill in creating strong and flexible wooden buildings. (Krötsch and Müller, 2018)



Figure 6. Hōryū-ji Temple, found in 607 (Source: Wikipedia, 2024)

Hōryū-ji Temple is a major Buddhist temple in Nara Prefecture, Japan, considered one of the oldest wooden structures in the world. The temple was founded in 607 by Prince Shōtoku and rebuilt after being destroyed by fire in 670. The reconstructed structures include a five-story pagoda, main hall (Kondō), central gate (Chūmon), and surrounding corridor. Dating from the 7th century, these structures are among the oldest wooden structures in Japan. Hōryū-ji played an important role in the early history of Buddhism in Japan and is a symbol of Prince Shōtoku's efforts to spread Buddhism. The temple complex served as both a religious center and an educational institution. Inscribed on the UNESCO World Heritage List in 1993, Hōryū-ji is an important part of Japan's cultural and historical heritage (Coaldrake, W. H. 1982).

By the approaching 18th century, construction techniques had expanded significantly. In France, wooden bridges could span distances ranging from 20 to 45 meters. The Schaffhausen Bridge, built in 1758 over the Rhine River, was notable for spanning two openings of 52 and 58 meters (Figure 7). The Wittingen Bridge in Germany stands out for its single-span capability of 120 meters. In pre-18th century America, short-span wooden bridges were standard, but by the mid-18th century, larger spans began to be constructed. The bridge built in 1761 over the York River was 80 meters long and 7 meters wide. The movement of boats on the river significantly impacted the bridge design (Ritter, 1990).

By the late 18th century, the Piscataqua Bridge gained significant attention. The bridge, approximately 720 meters long and 12 meters wide, was constructed with a supporting system of three wooden arches arranged in a lattice structure. Built by engineer Timothy Palmer, this bridge was covered with a roof to protect it from harsh weather conditions and was known as "The Great Arch," making it the largest wooden bridge of its time (Ritter, 1990).

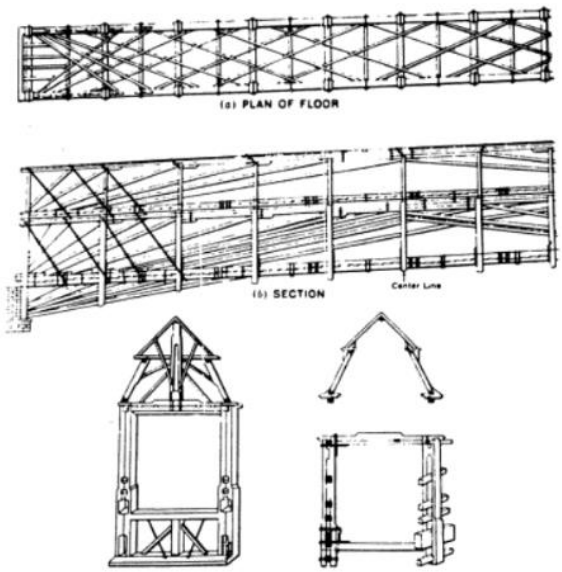


Figure 7. The Schaffhausen Bridge, built in 1758 across the Rhine River in Switzerland. (Source: The American Society of Civil Engineers; 1976)

In the 1830s, the "Balloon Frame" wooden construction technique was introduced in Chicago, North America. Workshops were established to produce plywood on an economic scale for use in this system. The production of plywood, and later other wooden panels, allowed small wooden pieces to be utilized in construction, contributing to the economy (Öztank, 2004).

With the Industrial Revolution, wood materials became more functional in the construction industry, leading to improvements in mass production, clean craftsmanship, variability in cross-sections, and flexibility in joint connections. New manufacturing processes and chemical and physical interventions on wood's organic structure enhanced its durability and physical properties. The first chipboard was produced in 1908 in Austria under the name Heraklith, the first fiberboard was produced in 1915 in America, and the first particleboard was produced in 1941 by the Torfit-Werke company. After World War II, due to challenges in the steel industry and the development of plastic-based adhesives, solid wood structural elements became increasingly utilized, often impregnated and treated for added durability (Öztank, 2004).

In the early 1900s, multi-story wooden buildings incorporated brick and beams into their structural design. While brick and stone were used for the exterior walls, the interior structure consisted of wooden posts and beams. Many tall wooden buildings that have maintained their structural integrity from the past to the present can still be found today. Figure 8 shows the Kelly Douglas Building in Vancouver, Canada, constructed in 1905 and restored in 1988. The building was built using a wooden frame system with a height of 30 meters (Aydın, 2019).

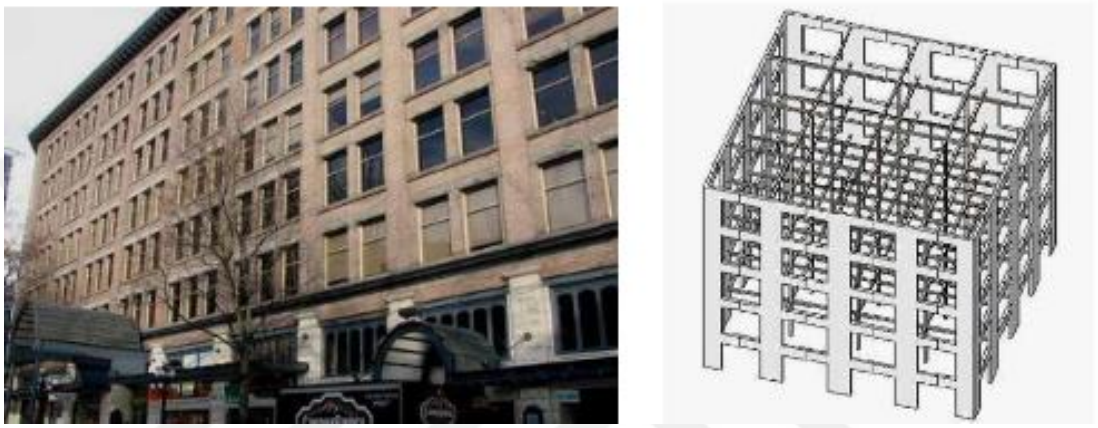


Figure 8. Kelly Douglas Building (Source: Aydın, 2019)

During World War II, the discovery of artificial resin adhesives resistant to various climatic conditions and moisture improved wooden construction technology. This new material, which is more durable in terms of static and strength properties, has allowed the use of wood as a structural element. Additionally, the ability to produce wood in various cross-sections and lengths increased the diversity of wood construction designs (Duman and Ökten, 1988).

NAS Tillamook's wooden hangars are an important example of the extensive use of the period. Tillamook, located in Oregon, USA, is home to the world's largest free-standing, extensive tree structure. Covering approximately seven acres, the structure is 1,072 feet long, 296 feet tall, and 15 stories high. Built in 1943 by the US Navy, NAS Tillamook's Hangar B structure was designed to house blimps for submarine patrol and convoy escort. (Oregon Encyclopedia, 2024)

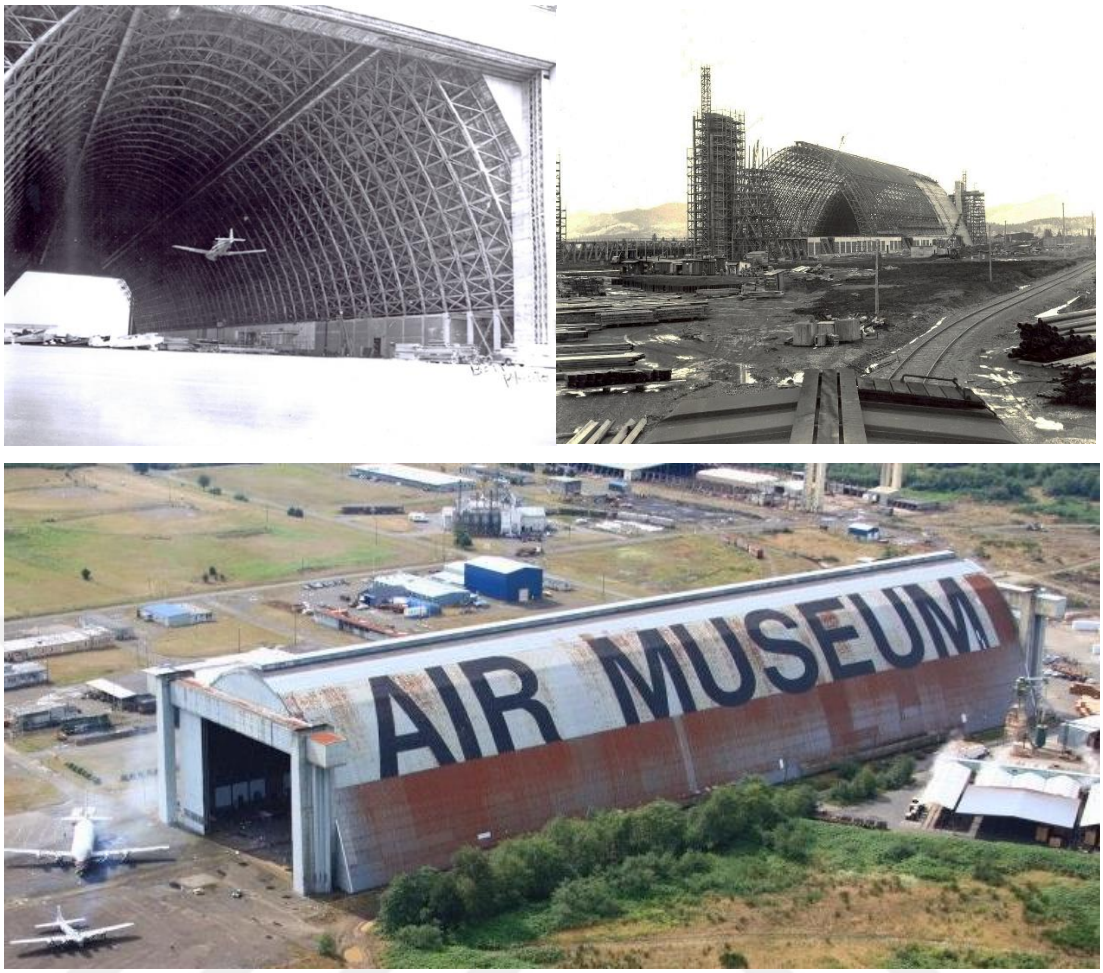


Figure 9. Naval Air Station Tillamook/ Tillamook Air Museum (Source: Oregon Encyclopedia, 2024)

Hangar A, completed the same year, was destroyed in an explosion in 1992. Records can be kept that both hangars could hold a total of eight K-class blimps. Over two million pieces of lumber, most of which came from Oregon, were used in the construction of the structure. Wood was even used for gutters and drainpipes to conserve metal. In addition, each piece of lumber was made durable and used for the product.

At the beginning of the 20th century, the use of wood as a structural system in construction began to increase. Before and during World War I, steel, a valuable material for weapons, was withdrawn from the construction field, leading to the widespread use of wood in various functional structures. Research was conducted into the mechanical and physical properties of wood, and various studies were carried out

on connection details, aiming to increase the material's resistance to external factors (Çalışkan, Meriç and Yüncüler, 2019).

Studies on how wood responds to various external factors such as moisture, heat, cold, fire, snow, and earthquakes led to discussions on its potential as an alternative material, even in highly competitive structures.

Bozkurt states that wood, as a natural material, can easily reintegrate into the environment. In terms of density, it is a strong material despite its low density compared to other building materials. Wood becomes a long-lasting and sustainable material when designed to be compatible with climate conditions and other materials. Due to these favourable properties, they are important in traditional Turkish architecture. Even without protective or chemical products, wood materials used in traditional Turkish architecture can still maintain their durability today. For the continued existence of wooden structures, it is crucial to use the right materials, protect them from moisture, and ensure sufficient cross-sections when used as load-bearing elements (Bozkurt, 2011).

2.2. Examples of Timber Structures in Turkey

Turkey includes important examples for the use of structural wood. Some of them are listed below.

2.2.1. The Büyükada Greek Orphanage

The Büyükada Greek Orphanage (Prinkipo Palace) is known as the largest wooden building in Europe and the second-largest multi-story wooden structure globally (Wikipedia, 2025). Designed by French architect Alexandre Vallaury between 1898 and 1899 as a hotel and casino, the building remained unused due to Sultan Abdulhamid II's disapproval of its intended function. In 1902, it was purchased by Eleni Zarifi, the wife of banker Yorgo Zarifi, and in 1903, it was opened as an orphanage. Featuring a timber frame structural system, the building measures 100 meters in length, 32 meters in width, and 24 meters in height and covers an approximate footprint of 11,000 m² (Kızılelma and Akar, 2022). The plan is symmetrical, with a central entrance hall leading to wings oriented along an east-west axis. The building features concert halls, dining areas, and spacious rooms; the exterior

is clad with horizontal timber boards, while the interior boasts plastered walls, mosaic flooring, and wooden ceilings. During World War I, the building suffered significant damage due to its use by the military and as a shelter for Russian refugees. (Kızılelma and Akar, 2022)



Figure 10. Prinkipo Greek Orphanage in Büyükada (Source: Onedio, 2025)

Closed during the Cyprus crisis of the 1960s and returned to the Greek Patriarchate in 2010 by a decision of the European Court of Human Rights, the structure remained functionless for 58 years and suffered considerable structural damage. In 2021, digital documentation and survey studies conducted by BİMTAŞ, a subsidiary of the Istanbul Metropolitan Municipality, revealed that 50% of the roof had collapsed, the third and fourth-floor slabs were severely damaged, and approximately 60% of the timber beams had lost their structural capacity. It was recommended that the preserved parts be restored and severely damaged sections be reconstructed in line with the building's original character. Additionally, the structure is proposed to be re-functionalized in accordance with the island's needs, incorporating flexible and mixed-use spaces adaptable to seasonal changes. (Kızılelma and Akar, 2022)

2.2.2. Eşrefoğlu Mosque, Konya, Turkey

Eşrefoğlu Mosque, (1402) located in the Beyşehir district of Konya, is a historical structure that stands out because of its proximity to Lake Beyşehir. Although there are

no examples of wooden architecture before the 17th century, information about the quality of wooden construction workmanship in the Middle Ages can be obtained from other wooden structures such as the Eşrefoğlu Mosque (Kuban, 2013). This mosque is considered one of the unique examples of tree-columned mosque architecture found in cities like Samarkand and Bukhara in the Turkistan region, and it has been adapted to Anatolia. The mosque's structural system consists of over forty wooden columns. According to legend, these columns were kept in the lake for six months before construction to increase their durability. In winter, the snow that accumulated on the mosque's roof was directed to a stone pool in the inner courtyard through an opening in the centre of the roof, helping to maintain the building's humidity balance and prevent the wooden elements from drying and cracking. However, this system lost its function in 1965 when the roof was covered with glass. The mosque is adorned with a mihrab, decorated with a 6-meter-high tile mosaic, a walnut wood pulpit with a roof and intricate carvings, ceiling decorations painted with natural dyes, and a monumental portal showcasing masterful Seljuk-era stone and wood craftsmanship. For these reasons, the mosque became one of the five medieval Anatolian wooden hypostyle mosques added to the UNESCO World Heritage List in 2023. (Kulturportalı, 2025)



Figure 11. Eşrefoğlu Mosque, Konya (Source: Kulturportali, 2025)

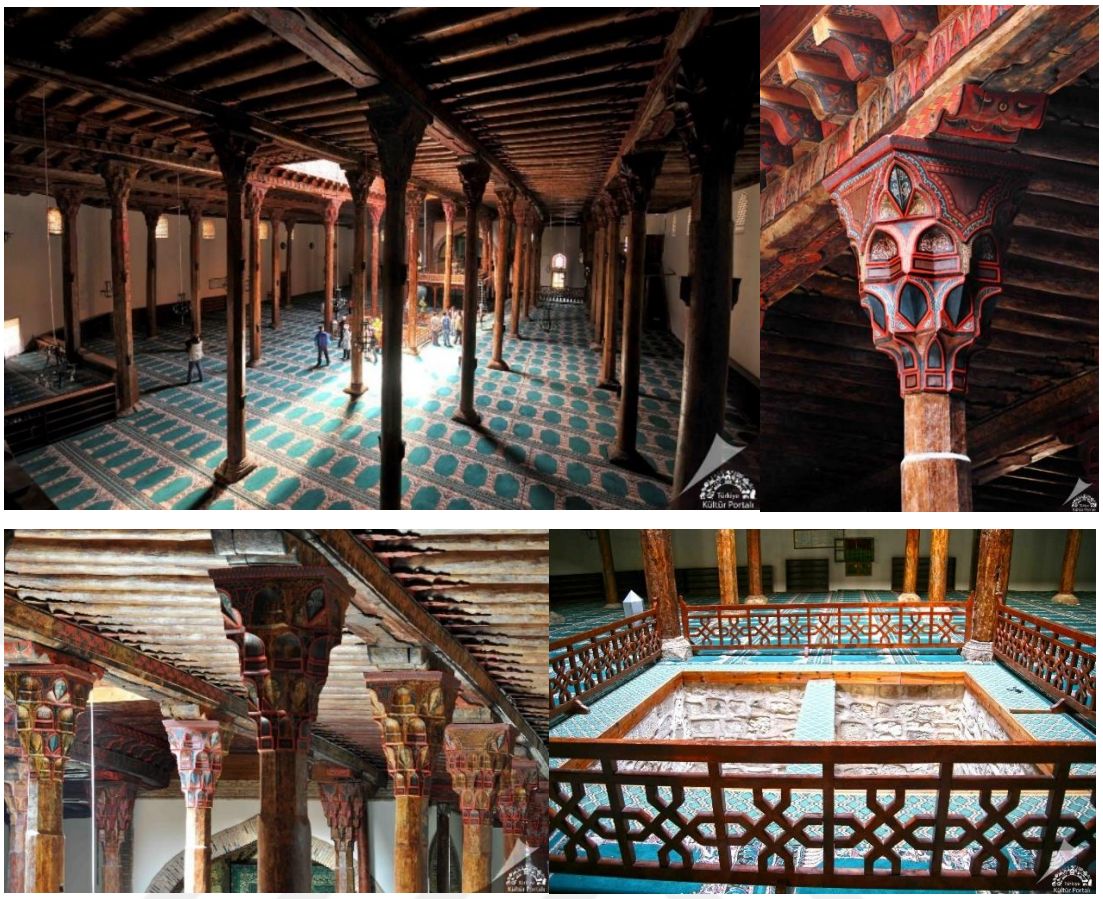


Figure 12. Eşrefoğlu Mosque, Konya (Source: Kulturportali, 2025)

2.2.3. Mahmut Bey Mosque, Kastamonu, Turkey



Figure 13. Mahmut Bey Mosque, Kastamonu (Source: Kulturportali, 2025)

Mahmut Bey Mosque was built in 1366 during the Candaroğulları Emirate period in Kasaba village, Kastamonu. This structure, one of the significant wooden-ceilinged mosques in Anatolia, has exterior walls made of rubble stone, while its interior is entirely constructed from wood. The wooden roof of the mosque was built using the

joint technique, without the use of metal or nails, and all the wooden surfaces inside are decorated with traditional calligraphy work. These decorations feature a variety of colours and plant and geometric motifs. One of the most notable features of the mosque is the wooden entrance door, carved by Nakkaş Mahmutoğlu Abdullah. This rare example is preserved in the Kastamonu Ethnography Museum. Mahmut Bey Mosque is one of the five medieval Anatolian wooden hypostyle mosques inscribed on the UNESCO World Heritage List in 2023. (Kulturportalı, 2025)

2.2.4. Göğceli Mosque, Samsun, Turkey



Figure 14. Göğceli Mosque, Samsun, (Source: Trthaber, 2025)

Göğceli Mosque is in the Göğceli Cemetery in the Çay District and was built using the timber framing technique. Tests conducted by researchers from abroad revealed that the mosque was constructed in 1206, with the arcade in front added or renovated in 1335. The structure was built with continuous wooden panels extending along the walls, featuring special joints at the corners, and was constructed without using nails. Only forged iron nails were used to connect the column heads to the beams and add extensions to the arcade section rafters. (Ministry of Culture and Tourism, 2025)

The mosque was built with wood sourced from trees like black ash, European ash, and chestnut. The thick wooden planks used in the walls measure around 15-18 cm in thickness, 50-70 cm in width, and range from 12 to 20 meters in length (Ministry of Culture and Tourism, 2025). The mosque's portability is facilitated by logs placed on large stones, raising the base about 60-70 cm from the ground. The space beneath the structure allows air circulation, preventing moisture buildup and decay. The ceiling decorations inside the mosque have faded and deteriorated over time. The roof has a slight slope on the northern side, with a three-shoulder gable design, and is covered

with Turkish tiles. The mosque underwent an extensive restoration in 2007. (Ministry of Culture and Tourism, 2025)

2.2.5. Atabey Gazi Mosque (Kırkdirekli Mosque), Afyon, Turkey



Figure 15. Atabey Gazi Mosque (Kırkdirekli Mosque), Afyon (Source: İstenci, 2025)

Atabey Gazi Mosque, built in 1273, underwent restorations in 1800 and 1871. Constructed with cut and rubble stone, the mosque features a wooden ceiling supported by forty wooden columns, which has earned it the nickname "Forty Columns Mosque" among locals. The entrance door is made of stone. According to legend, Hüsamettin Çoban Bey, a prominent Seljuk commander with a tribe of 200,000 tents, ordered the construction of a mosque near the castle's foothills after conquering Kastamonu. He performed the first Friday prayer there and ascended the pulpit with a sword as a symbol of the conquest. Later, his grandson, Muzafereddin Yavlak Arslan, demolished the original mosque and replaced it with the present-day Atabey Mosque. However, the tradition of the sword on the pulpit, initiated by Hüsamettin Çoban Bey, has continued to this day, with the imam still wearing a sword when delivering the Friday sermon. (İstenci, 2025)

2.3. Use of Wood in Traditional Turkish Architecture

Wood has been the primary material used to meet basic shelter needs since ancient times. Its history predates that of concrete and steel. Wood is a durable and sustainable option when applied with the proper techniques, as it is derived from nature and can be reused. Properly designing the cross-sections of load-bearing wooden elements,

protecting them from adverse weather conditions like moisture and mould, and ensuring their durability through thoughtful design are crucial (Bozkurt, 2011).

Turkish architecture has a legacy of wooden construction dating back to the Ottoman era. Wood has been used as a traditional building material for many years, especially in residences, mosques, palaces, and inns. Due to its light and flexible structure, wood is preferred in earthquake-prone regions. Wooden houses in Safranbolu and mansions in Istanbul can be given as examples of wood's aesthetic and functional aspects.

In Turkish architecture, wood is used structurally in exterior facades, interior layouts, and furniture. During the Ottoman period, it attracted attention with its wooden craftsmanship, intricate carvings and rich decorations.

Turgut Cansever's statement, "In Turkish architecture, the relationship between nature and humanity has always been significant. It is an architectural approach where harmony with nature, placing humanity within nature, and prioritising proportion, balance, and aesthetics in the design are emphasised," explains why wooden buildings have such a long-standing history in Turkish architecture. Wood, as a material, bridges the gap between nature and humanity, making it an integral part of Turkish architectural heritage.

Wood has become a preferred material in Anatolia's house construction due to its durability and ease of processing. In traditional Anatolian houses, wood has given a different identity to the architectural texture due to local building traditions and geographical conditions. The widespread use of this construction technique is due to its adaptability to various floor plans. According to Sedat Hakkı Eldem, wooden structures are favoured because they offer more expansive, more spacious, well-ventilated homes, shorter construction times, and resistance to earthquakes. In addition, Eldem notes that features like projections, recesses, and large eaves can be easily applied, and air circulation is ensured in the walls, preventing moisture formation (Bozdoğan, Özkan, and Yenal, 1987).

Ahunbay's research indicates that timber frame construction became an integral part of traditional Turkish architecture in the seventeenth century and continued to be

widely used in the following years (Ahunbay, 2000). In both cities and towns, it is possible to find houses with one or more stories.

Traditional timber-framed houses typically feature a masonry basement with upper floors constructed using wooden frames and roofs. The basement walls, which function as both foundations and moisture barriers, range from 80 to 150 cm in thickness. These load-bearing walls extend up to the ground floor level. Stones used in their construction are usually sourced from nearby quarries or collected from streambeds and are left unplastered (Öztank, 2010).

According to the research by Öztank, while the basement and ground floors are built with masonry, the upper floors are constructed with a timber-framed system. Timber framing for the upper floors included studs spaced 30–90 cm apart, framed with 15x15 cm posts, and reinforced with diagonal and horizontal bracing elements. The components used in the timber-framed construction system are diagonal and X shaped braces. They are typically angled at 30° to 40° to reinforce corner posts. (Figure 16)



Figure 16: The building on Şeyh Şabanı Veli Street in Kastamonu (Source: Kıran, 2023)

The frame was filled with stone, rubble, daub and bricks (either fired or unfired). These braces' upper ends and joints are positioned just above the corner post's centre. They extend down to the base after making contact with the stud near the window. Nails hold the bracing and other timber frame components in place. The design often does not need tenon or other complex joinery techniques, but notches on the bottom ridge plates facilitate brace connections.

Traditional wooden structures, generally considered typical housing systems, are prevalent in rural areas. In these regions where spaces such as warehouses are located, materials such as stone are widely used in the basements of houses. However, as seen in figure 17, wooden walls are preferred in construction on the upper floors. These wooden walls provide structural support. It also contributes to the aesthetic and functional qualities of buildings suitable for local environmental conditions.

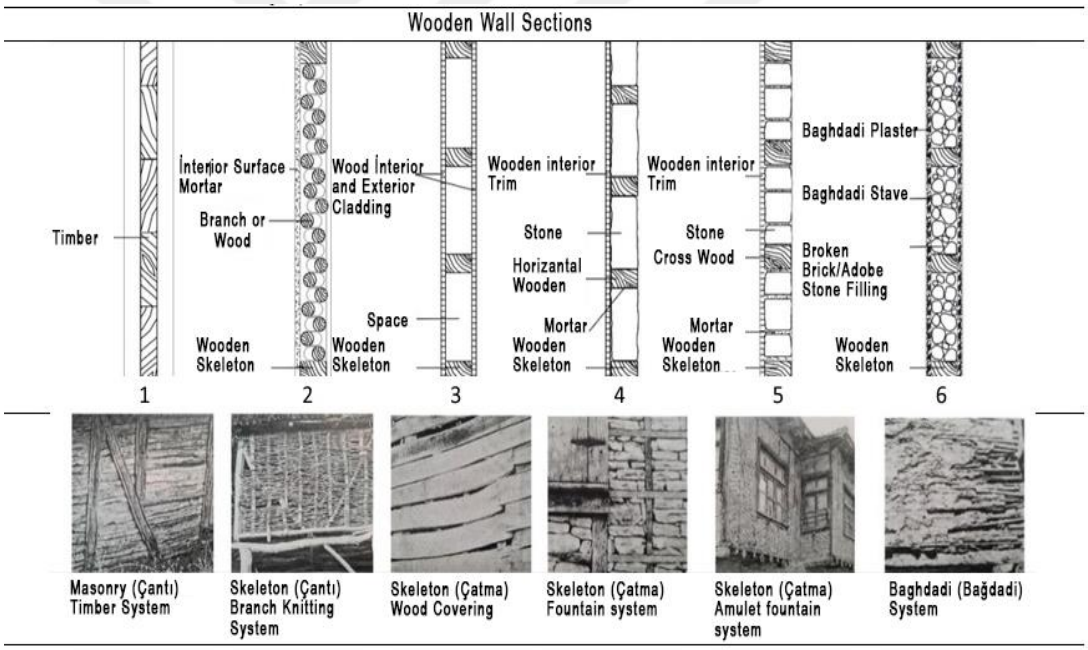


Figure 17: Sections And Examples of Traditional Wooden Wall Types in the Eastern Black Sea region (Source: Edited from Tuna, 2008)

Wall types built from wooden materials in the Eastern Black Sea region can be summarised as masonry, wattle, wooden covering, dolma, and Baghdadi. Masonry systems are formed by connecting logs and timber using interlocking methods. Branch knitting is a primitive and straightforward method. The knitting between the wooden pillars forms the wall with branch braids. In the case of a wooden cladding wall, the

inner and outer areas formed from the same studs are covered with horizontal or vertical boards. A wooden skeleton is prepared to form horizontal and vertical square eyes in the filled wall, generally made of stone, stone, brick, adobe, etc. It is filled with ingredients. There are also types in the form of amulets. On the other hand, the Baghdadi wall covers both sides of the wooden frame with spaced slats and plaster to obtain a wall surface (Tuna, 2008). (Figure 17)

According to M. Saatci, Ş. Gürsoy and Y. Turcan's research shows that traditional timber structural systems, according to structural behaviour and construction types, are divided into three general types: wood log systems, panel systems, and frame (çatkı) systems. (Figure 18)

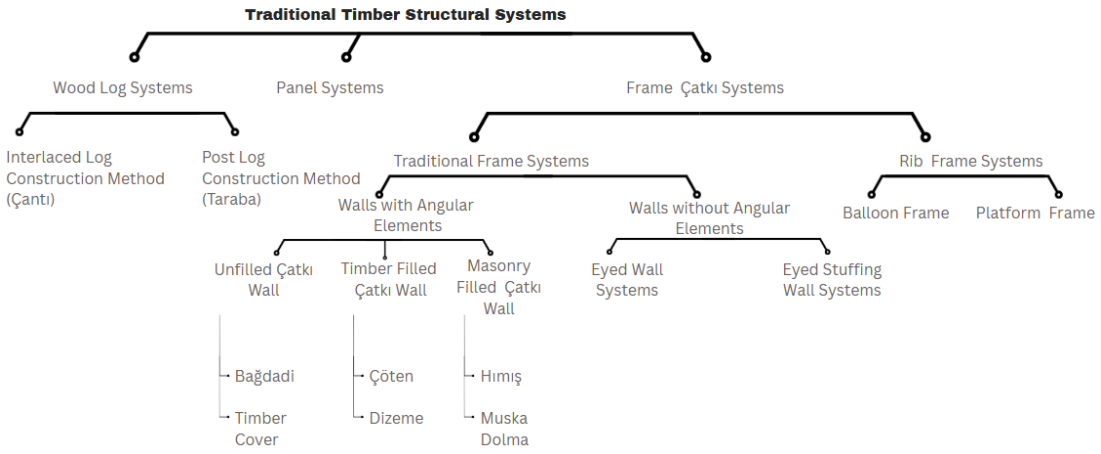


Figure 18: Wall Shapes and Structural Systems of Timber Structures (Revised from Saatci, Gürsoy, and Turcan, 2022)

2.3.1. Wood Log Systems

Wood Log Systems can be classified into interlaced log construction and post-log construction. They are used not only in Turkey but also in many countries around the world. They are predominantly utilised in regions with cold climates, such as the mountainous areas of Central Europe and Scandinavia. In the past, the role of these structures was significant for the local inhabitants. Due to structural challenges and cost constraints, constructing mid-rise multi-story timber buildings is not considered practical. (Premrov and Leskovar, 2023)

2.3.1.1. Interlaced Log Construction Method (Çantı)

Timber masonry Wall systems occur with overlapping tree trunks and logs horizontally. These walls constitute the carrier system and do not need a frame system. The timber masonry walls used in this system are both separator and bearer. This timber masonry wall is called a block timber structure or 'çantı.' These systems are usually used in two—to three-story buildings (Figure 19). These systems are constructed without any fasteners, such as glue and bolts.

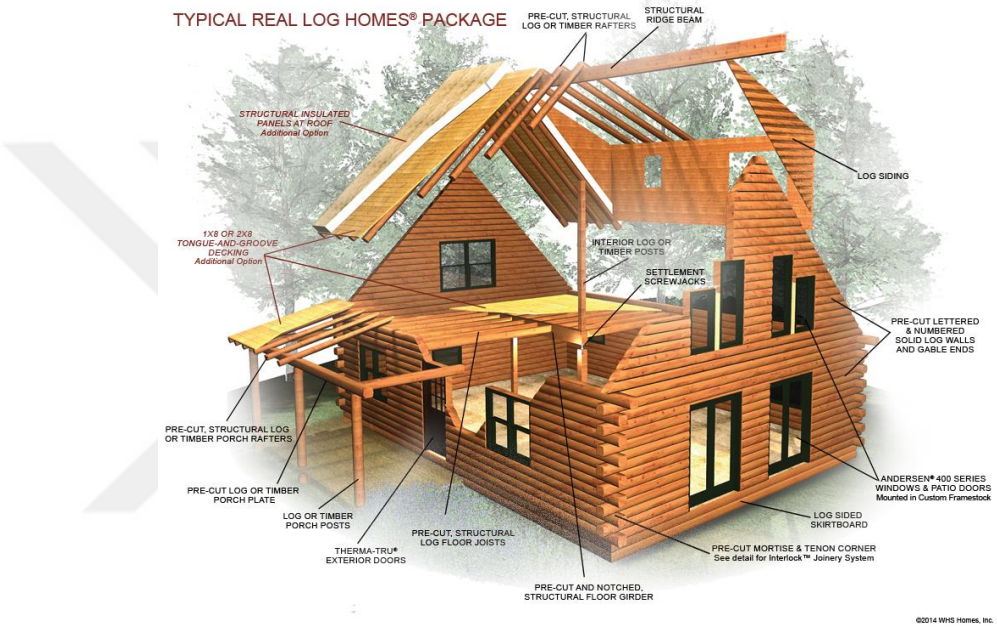


Figure 19: Log Construction Detail (Source: Gooch Real Log Homes,2024)

Therefore, increasing the number of stories is impossible due to the structure's weight. These structures are generally used for warehouses, cellars, and other purposes and are made with an interlaced log system (Saatci, Gürsoy and Turcan, 2022).



Figure 20: Timber Masonry Wall Technique ‘Çantı’ (Source: Başkan, 2008)

According to E. L. Alemdağ et al., shelters have been constructed to fulfil basic human needs, starting with primitive structures built for protection. In rural areas, secondary buildings often accompany primary residences, serving specific practical purposes. One notable example from Turkey's Eastern Black Sea Region is the serender, a traditional storage structure designed to preserve agricultural produce.

Serenders are commonly found in provinces such as Trabzon, Rize, and Artvin, though variations exist across the region. The hórreo in Spain and the lofts of Norway are similar structures in other parts of the world. Typically built from local materials, this two-storey serender structure stands on 4 to 12 wooden or stone columns, 150-200 cm above the ground. This height protects the stored products from moisture and pests while ensuring proper ventilation. The lower part of the structure, which is usually open, is used to store firewood and dry fodder or provide a rest area, while the closed upper floor serves as the main storage area for crops.

These structures effectively preserve seasonal harvests, such as corn, beans, and hazelnuts, offering a sustainable and practical alternative to modern storage facilities or cold storage systems. (Lakot Alemdağ et al., 2023)



Figure 21: Timber Serender Structure (Source: Başkan, 2008)



Figure 22: Secondary Structures Adjacent to the Main Building: (a) çöten, (b) serender, (c) fireplace, (d) hayloft (Source: Lakot Alemdağ et al., 2023)

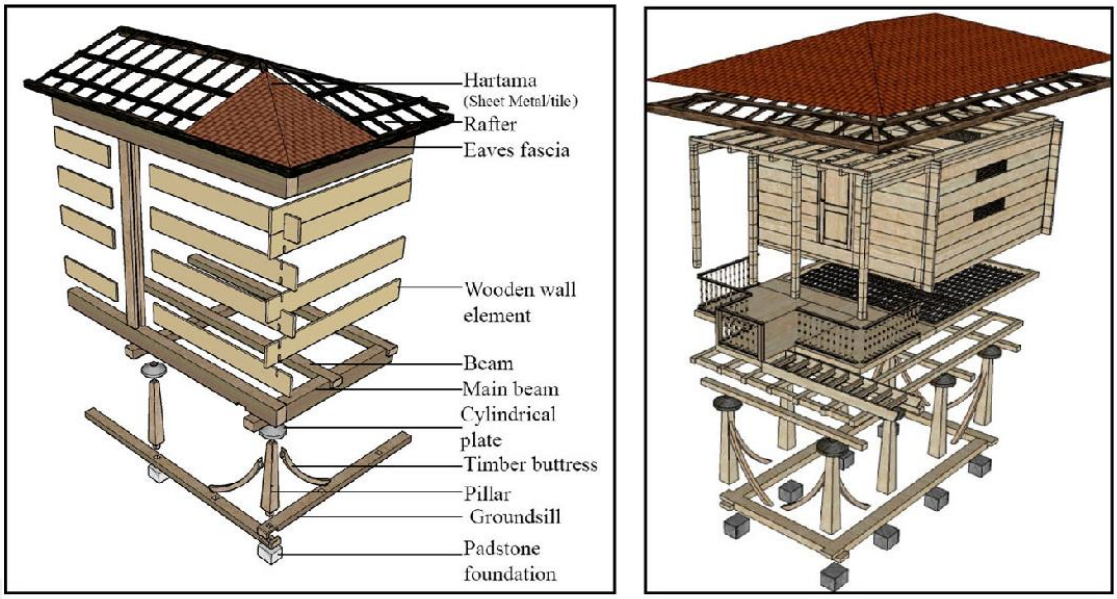


Figure 23. Structural Layers and Components of the Serender (Source: Lakot Alemdağ et al., 2023)

2.3.1.2. Post Log Construction Method (Taraba)

Using boards sourced from ser 59 trees, which vary in thickness from 2.5 to 6 cm and in width from 30 to 40 cm depending on the region, vertically oriented wooden skeleton systems are constructed as elements that transfer the entire building load to the foundation walls. These boards are used as decking material between the uprights in corners and between decking. Both vertical and horizontal installation are possible for this filler material. Specifically, using the lower and upper headers to connect the filling to the uprights ensures the system's rigidity against horizontal effects. This system lacks the buttresses found in typical frame and frame systems. The continuity between the decoupling points determines the system's integrity. The structure must be constructed collectively as a whole. Generally, this system is called' taraba' in the upper regions of Turkey, such as Rize and Artvin (Figure 24). (Bal, 2017)



Figure 24. Timber stuffing Wall ‘Taraba’ (Source: Arun, 2012)

2.3.2. Structural Panel-Based Timber Constructions

These systems are typically employed for small load-bearing walls or non-structural partitions. They are commonly used in single-story buildings and are composed of single or double timber plate panels. The same construction technique is applied to both exterior wall panels and floor panels (Saatci, Gürsoy, and Turcan, 2022).

2.3.3. Timber Structures Created from Structural System Frames (Frame Çatkı Systems)

Timber structural systems are designed to transfer the loads acting on a structure to its foundation through key elements such as posts, beams, purlins, base components, and diagonal members. In Turkey, timber structural systems are widely used as one of the most preferred construction types. The primary framework in traditional timber-framed systems consists of posts and horizontal and angular components that form the structural skeleton.

According to Merve Saatci, corner and central posts are reinforced with diagonal elements, which can take configurations such as X, V, or Λ shapes to enhance stability and strength. There are no strict guidelines regarding the size or placement of these diagonal members. The shorter diagonal elements may generate significant shear forces, affecting the system's performance.

2.3.3.1. Traditional Frame Systems

2.3.3.1.1. Walls with angular elements (Çatkı)



Figure 25. An example of a Traditional house showcasing the load-bearing system (Source: Perker and Akıncıtürk, 2011).

In the frame construction system, walls featuring angular elements are built using infill materials like brick or stone on the inner or outer surfaces. The spaces between these structural elements are occasionally filled with wood or adobe. This approach also allows for the construction of unplastered timber structures. The angular (diagonal) components integrated into the walls function as cross-shear walls, enhancing the stability of the timber structure.

In the buildings of the Northern Anatolia region, the ground floors are generally used as barns or service areas. The foundations of timber-framed buildings are simple due to the lightness of the structures (Kafescioğlu, 1955). In these buildings, large stones are commonly placed in the dug area to reach solid ground, and a stone wall is constructed with mud mortar. The foundation extends up to the ground surface, and the walls of the ground floor are usually made of stone or adobe. When the ground

floor walls are constructed using a timber frame system, the foundation is typically elevated slightly above the ground. The most common application method is to build masonry walls connected to the ground floor with wooden beams and integrate the wooden frame system on these walls (Çobancaoğlu, 1998). This method strenghtened the linkage between the ground and upper levels, while also allowing for flexible spaces by enabling wide openings in the ground floor walls.

Independent stone foundations exist in the timber-framed houses found in the Eastern Black Sea Region. Large stones placed 25-30 cm above the ground in these buildings are placed under the supporting wooden columns. The gaps between the columns are filled with non-supporting timber or masonry material. Timber foundations are generally used in structures such as country houses, summer homes, and rainy, sloping areas. The quality of the timber has also been a determining factor in this usage (Kafescioğlu, 1955).

2.3.3.1.1.1. Unfilled Çatkı Wall

The spaces between the horizontal, vertical, and angular components of the structural system create the walls. These walls are built without infill materials and are primarily divided into two categories: Bağdadi and timber cladding.

a) Bağdadi

This method fills the gaps between the vertical and horizontal structural elements with thin wooden laths. These laths are then covered with plaster or mortar to create a smooth surface.

This cost-effective and lightweight technique is suitable for structural and aesthetic purposes. In Ottoman architecture, the Bağdadi method is particularly valued for its flexibility and lightness. It contributes to improved seismic resistance and provides a degree of insulation while maintaining a visually appealing finish.

In the 1970 Gediz earthquake, Doğangün highlighted that Bağdadi timber structures performed better than Hımış timber structures, with less damage observed (Doğangün et al., 2006).

This technique, which began to be used in Istanbul in the early 18th century, gradually spread to other regions. In this system, thin wooden laths approximately 1 cm thick and 2–3 cm wide are nailed to both sides of the timber frame structure. The spaces between the timber frames are irregularly filled with materials such as bricks or adobe. To create a smooth surface, the walls are covered with evenly spaced wooden laths, which are then coated with plaster. Examples of this technique being widely used, especially in Bursa, have been documented. (Bal, 2017)

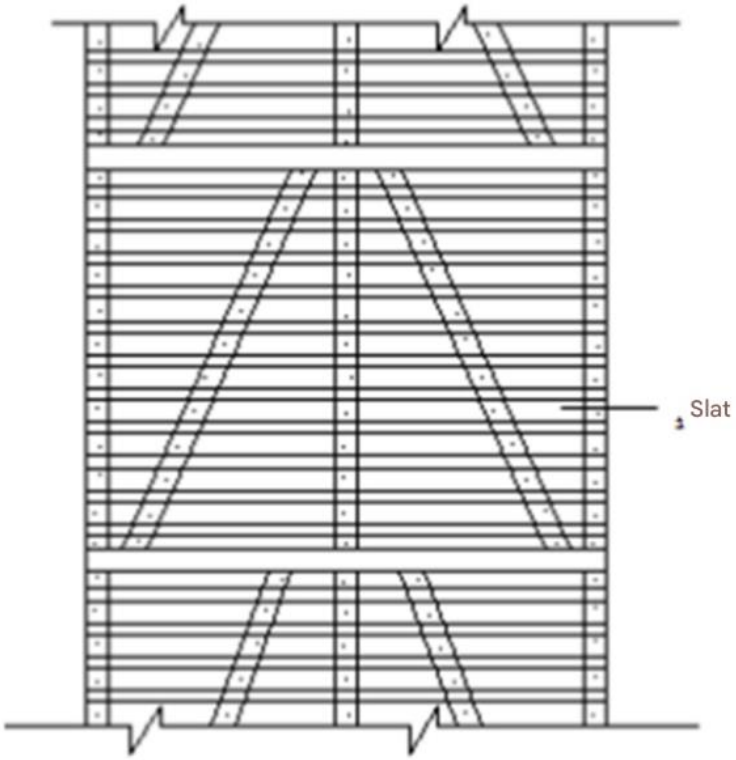


Figure 26. Baghdadi Construction System (Source: Er Akan, 2004)

The Baghdadi construction system is created by placing wooden slats 2.5-3.5 cm wide horizontally across both the interior and exterior wall surfaces. The gaps between the slats are either filled with lightweight insulation materials or left open. For finishing the surfaces, materials such as straw or mud are used for plastering. Nails are employed as connection elements in the system. The use of nails increases the flexibility and damping capacity of the structure and prevents the settlement of the infill. Although Baghdadi structures are more complex than other systems like "hımış," they require a significant number of wooden slats and skilled craftsmanship. (Er Akan, 2004)



Figure 27. Timber covered frames (Source: Arun, 2012)

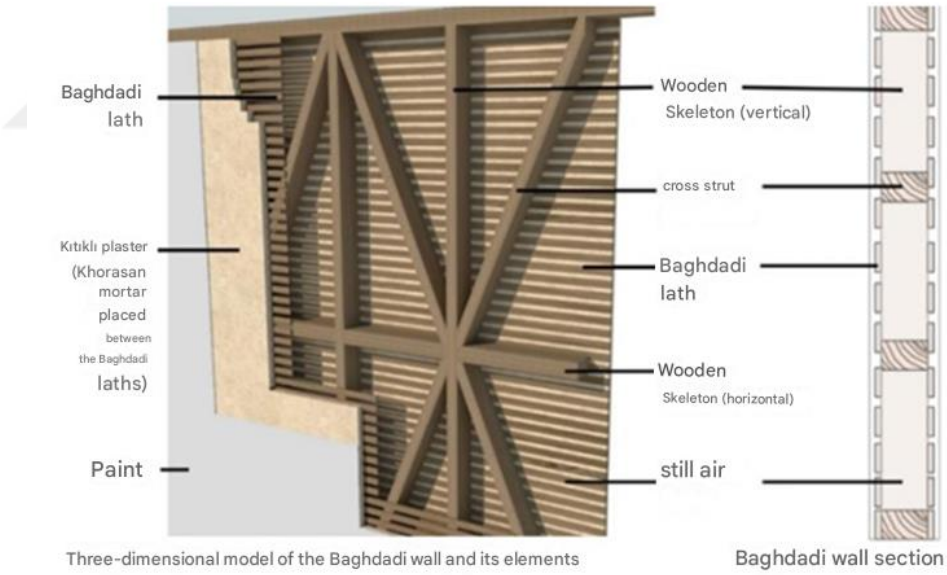


Figure 28. Baghdadi Wall System (Source: Lakot Alemdağ et al., 2023)

b) Timber Cover Frames

Timber wall construction involves applying thin layers of wood to the structural frame of a building. These boards are typically nailed in an overlapping arrangement or straight alignment, depending on the desired aesthetic or functional outcome. When

arranged to overlap, the system allows effective rainwater drainage, preventing water from penetrating the surface. This overlapping method is known as weatherboarding.

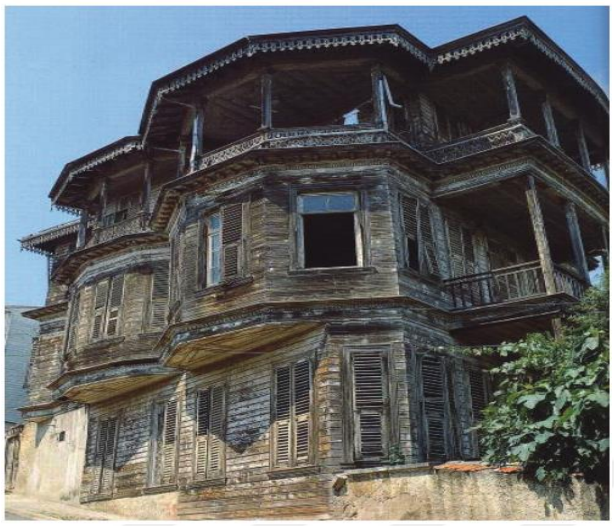


Figure 29. Timber-covered Frames (Source: Arun, 2012)



Figure 30. Examples of Timber Structures Utilizing Bağdadi and Weatherboarding Techniques (Source: Güneş, 2014)

In a frame with a timber covering, cut wooden boards are fastened to the outer side of the structural frame, forming a strong and protective exterior layer. Based on the building's structural and decorative needs, the interior side of the wall can be finished either with plaster and lath or by applying a similar timber veneer. The Baghdadi (Bağdadi) and weatherboarding techniques are examples of traditional timber construction methods (Figure 29).

2.3.3.1.1.2. Timber filled Çatkı Wall

The gaps between the structural system's horizontal, vertical, and angular components are filled with timber to form the walls. Based on the materials used and the application method, these walls are classified into the following types: çöten and dizeme.

a) Çöten (Reed Tissue + Mud Plaster)

Timber infill frames vary depending on the spacing of the studs. When the studs are placed closely together, the gaps are filled with wattle or short, rough timber pieces, typically 2-3 cm thick, which are not suitable for use in structural elements. This type of wall is referred to as "çöten (chosen)." Such constructions are commonly found in the Western and Central Black Sea regions. The spaces within the çöten are usually filled with plaster on both the exterior and interior surfaces (see Figure 31).

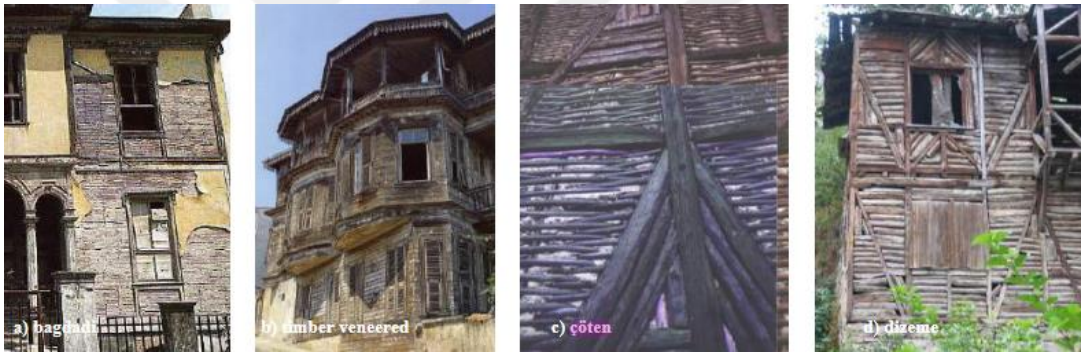


Figure 31. Totally Timber Frames (Source: Saatci, Gürsoy and Turcan, 2022)

b) Dizeme

In traditional timber frame construction, "dizeme" refers to the process of arranging horizontally and vertically treated timber components within the spaces between the structural frame elements to form the walls. Depending on the design preference, this technique can result in plastered or non-plastered wall finishes (see Figure 32). Applying plaster directly can be challenging in cases where the timber pieces are relatively thick, as they may not adhere well to the surface. A method similar to the Bağdadi technique is employed to overcome this issue. Thin wooden laths are nailed onto the timber framework.

These laths increase the durability and effectiveness of the plaster by creating a more suitable surface to adhere to. This adaptation increases the stability and life of the wall system and provides both structural support and aesthetic value (Dogangün et al., 2005). As a result, the rigidity of structures plays a key role in their ability to withstand earthquakes (Köylü, 2008). When these timber components (dizeme) were connected to the frame elements using nails, they began to function under tension and compression forces during seismic events.



unplastered plastered

Figure 32. Timber Structures Constructed Using the Dizeme Technique (Source: Saatci, Gürsoy and Turcan, 2022)

2.3.3.1.1.3. Masonry Filled Çatkı (Frame) Wall

Masonry-filled frame (çatkı) involves filling the spaces between the horizontal, vertical, and angular components of the structural system with masonry materials. These materials are categorized into two types, hımış and Muska dolma, based on how often they are used on the wall surfaces of vertical elements.

a) Hımış

The walls created by filling the spaces between the çatkı (frame) elements with materials like brick, adobe, or briquette are referred to as hımış (Figure 33). This construction system is one of Anatolia's most widely used traditional timber frame techniques. The masonry filling materials used in hımış walls vary according to the climate and regional characteristics of the structure’s location. These materials are

arranged in different patterns which include vertical, horizontal, cross, and herringbone formations. The herringbone pattern allows rainwater to flow more efficiently through the joints and minimizes damage to the timber elements compared to other patterns. In these structures, vertical load-bearing posts and intermediate columns are placed at wide intervals, connecting various parts of the building, such as the floor and the areas around windows. The gaps between these columns are filled with adobe, typically applied using a method in which the mud mortar prevents the joints from overlapping, resembling the technique used in brick masonry. The vertical posts are sometimes placed closer together, and the adobe filling is arranged diagonally, making the wall system more potent and weather resistant.



Figure 33. Timber Building Systems Made Using Brick Filling (Source: Şantiyede,2024)

The primary components of hımış structures are the roof and load-bearing elements. The walls carry the load from the roof down to the foundations. The main structural elements of hımış structures are main posts, vertical supports, diagonal braces, and beams. Additionally, the diagonal elements of this system play a critical role in enhancing the lateral strength of timber infill structures. Typically, fixed stone foundations with 1.00–1.50 meters height are used. There can be some differences among the structures studied in different regions, depending on the area's characteristics, such as the type of infill material, the type of foundation, and the timber used in the system (Er Akan, 2004).



Figure 34. Eskişehir Paşa District, Ayvazlar Mansion (Adobe Filling) (Source: Piroğlu, 2023)



Figure 35. Timber Building Systems Made Using Brick Filling (Source: Koca, 2021)

b) Amulet filled Walls (Muska dolma)

Amulet-filled walls were obtained by placing pieces of hardwood and pitch pine trees, 5-6 centimeters thick and 30-40 centimeters wide, as filling material between the pillars placed in the corners and between them. The filling material can be installed vertically as well as horizontally. The system's rigidity, particularly weak against horizontal effects, was ensured by connecting the filler to the uprights with upper and lower headings, and no buttresses were used. It became necessary to construct the structure together with the leading carriers. It was used in the Eastern Black Sea region, where wood is abundant, especially around Rize and Artvin (Çakır, 2000).

“In eye dolma and even amulet dolma systems, all the pillars on the facade are placed according to a modular system. For this reason, the size of the rooms, the location of the partition walls on the facade, and the size and location of the windows must all be by this module system. This module system is, on average, 25 cm” (Tayla, 2007).

The system is created provided that the width of the spaces between the square-shaped eyes is not more than 20 cm and not less than 17 cm. Filling stones collected from streams must be large enough to fit into these standard chambers. All openings, except for the gaps left for the windows, are filled with river stones cut neatly on one side, and the parts of the gaps other than the stone are plastered with lime mortar. “For windows, 5x10 beams are connected between the main pillars at the level of the bottom header, and gaps of 4/ 4-3 / 5-4 / 6 module size are left” (Tayla, 2007). It is possible to come across houses built with this filling technique in the coastal areas between Sürmene and Hopa. “*The purpose of applying stones together with structural elements in the formation of the facade during construction is to ensure that the stone works monolithic by being compressed with the wood, apart from its function as a filling material*” (Çakır, 2000). Figure 36 and Figure 37 show the connection details of the ground floor of a building system created with the fillet wall technique and the masonry stone wall.



Figure 36. Göz Dolma Technique (Source: Bal, 2017)



Figure 37. Muska Dolma Technique

2.3.3.1.2. Walls Without Angular Elements

In wall systems, timber carriers are created horizontally and vertically, not including angular elements. The spaces in the frame are filled with plaster. While easier to construct than walls with angular elements, timber structures lacking these elements

tend to perform poorly under horizontal forces, such as those caused by winds and seismic activity.

2.3.3.1.2.1. Eyed Wall Systems (Unfilled)

hese wall systems are formed by inserting horizontal timber beams between closely aligned vertical posts. The posts are connected with horizontal timber elements, known as kuşak, which create eye-shaped divisions on the facade of the building. Such systems are commonly referred to as "eyed systems" (Başkan, 2008). Due to the use of vertical and horizontal elements, the resistance to horizontal forces like wind and earthquakes is relatively low. As a result, additional support, such as buttresses at the corners, is often incorporated to enhance stability.

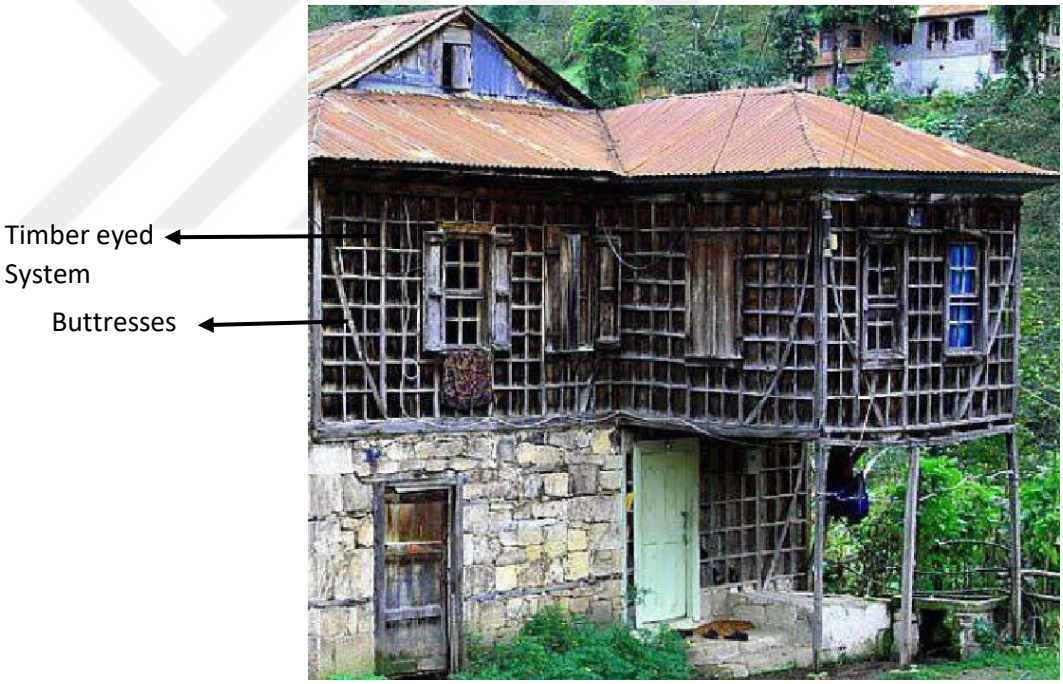


Figure 38. Perspective of Corner-Positioned Buttresses in the Timber Eyed Framework (Source: Güneş, 2014)

2.3.3.1.2.2. Eye Stuffing Wall Systems (Masonry filled)

The spaces between the horizontal and vertical connections were divided by small cross-sectional pieces, and a square-shaped eye-to-eye pattern was created with the connections in the interlocking technique. For this system, called eye filler, to resist horizontal loads, the corners are reinforced with side rings (Özgüner, 1970). The gaps on the established surface were generally filled by placing stones collected from streams and plastering with lime mortar (Çakır, 2000). Sometimes, depending on availability in the region, it was filled with solid stones, or crushed stones were used when stones were not available (Özgüner, 1970). Examples were found in residences near the coast between Trabzon and Hopa in the Eastern Black Sea Region.

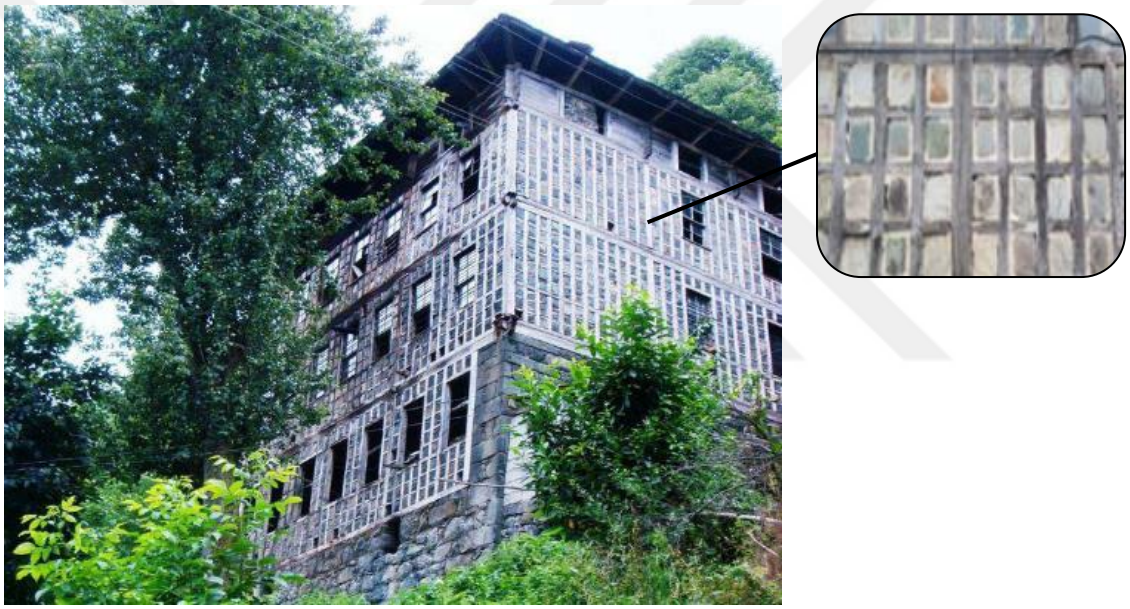


Figure 39. Hemşin, Veziroğlu Mansion, Eye Stuffing Wall System (Göz Dolma) (Source: Hemsinturk, 2025)

2.3.3.2. Timber framed Construction (Rib Frame)

Wood is applied to the timber framework in a horizontal or vertical orientation. Vertical sheathing can take the form of ribbed panels or a style known as yalı baskısı. Among these, ribbed sheathing is the most used type in Istanbul. In this technique, laths are fixed to the side of their wooden surfaces in a way that aligns them parallel to the faces of the framework (Figure 40). (Erarslan, 2019)



Figure 40. Ribbed Wood sheating used in a timber framework in Istanbul (Source: Erarslan, 2019)

Timber-framed construction is a skeletal system whose load-bearing elements are made of wooden components, and whose walls do not have load-bearing properties (Figure 41). The gaps between the carrier wooden components that make up the skeleton are filled with filling or coating material. One of the most used methods in wooden frame systems is the platform system, and the other is the balloon system.

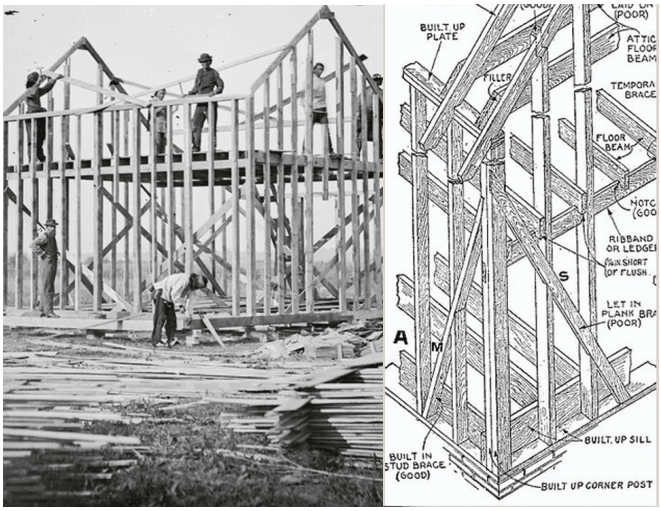


Figure 41. Timber framed construction (Source: Arrow Timber,2024)

2.3.3.2.1. Balloon Frame

The posts are constructed in balloon framing as continuous pieces, with beams connected using a hand-carved joinery. This technique works in harmony with the natural properties of the wood, utilizing long, uninterrupted framing studs that extend from the sill to the eave line, with intermediate floor structures attached to these vertical studs.

The design features long vertical studs that run continuously from the foundation to the roof, which supports the structure's load. Horizontal floor joists are fastened to the sides of the vertical studs and rest on a ledger notched into the stud for added stability. This system is commonly used in two-story buildings due to the availability of sufficiently long studs. However, it can be adapted for taller structures by building in increments of two stories. The advantage of this is the reduction of shrinkage in the floor joists. (Proyectos123, 2014)



Figure 42. Balloon Framing System (Source: Proyectos123, 2014)

2.3.3.2.2. Platform Frame

Due to its practicality and efficiency, platform framing eventually replaced balloon framing as the predominant construction method. In this system, shorter lumber pieces, typically 2x4 studs spaced 16 inches apart, are used. The walls are constructed using a

sill or sole plate, vertical studs, and two top plates, with the floor joists resting directly on the top plates. Unlike semi-balloon framing, platform framing eliminates the need for hangers.

Each level of the structure features floor joists covered by subflooring, which creates a stable platform or work surface. This design makes it easier to assemble walls and partitions. The benefit of platform framing is that walls can be assembled on the ground and lifted into position, requiring less physical effort than balloon framing. Furthermore, this method does not require notching the studs, and once the first story is completed, it provides a solid base for constructing additional stories. Platform framing also integrates well with various prefabrication techniques, making it a versatile choice for modern construction (Proyectos123, 2014).

Platform framing, a light-frame construction system, is today's most widely used method for building houses and small apartment buildings. Platform framing offers a distinct approach, unlike post-and-beam structures, assembled layer by layer, with each floor constructed separately and connected using metal brackets. The primary difference between platform and balloon framing is how the floors and walls are constructed. In balloon framing, the wall studs run continuously from the sill of the first floor to the top rafter of the second floor, creating a single uninterrupted structure. In platform framing, however, the walls and floors are built independently for each story, making the construction process more modular and adaptable. This system simplifies the construction process and enhances the ease of assembly, especially for multi-story buildings.



Figure 43. Platform Framing System (Source: Proyectos123, 2014)

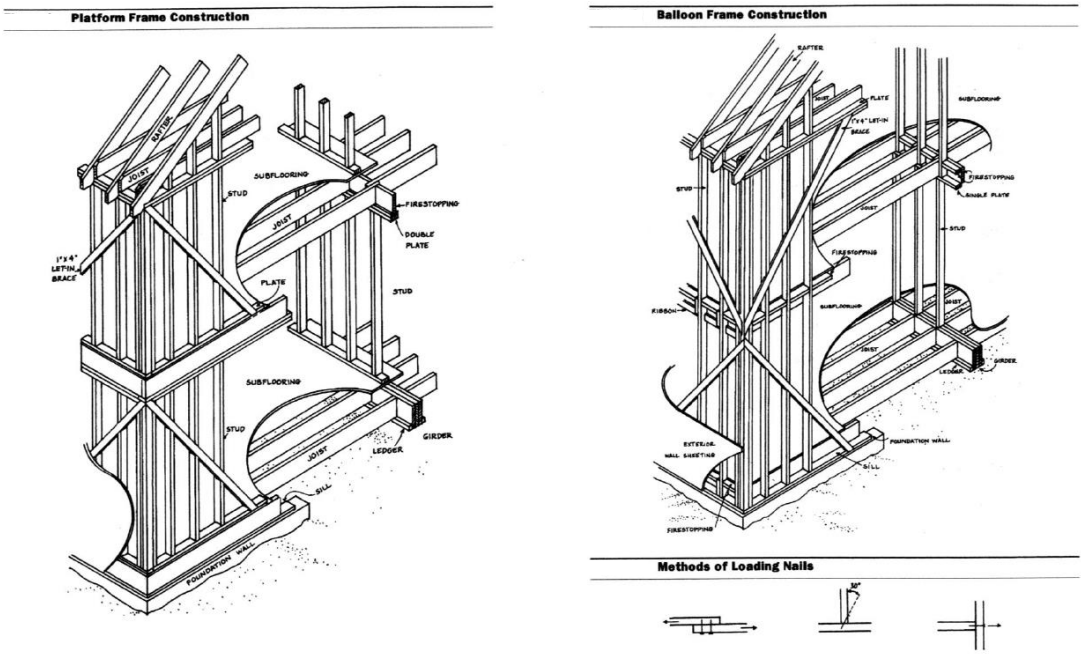


Figure 44. Platform Frame Construction and Balloon Frame Construction (Source: Proyectos123, 2014)

CHAPTER 3: RECENT DEVELOPMENTS OF WOODEN STRUCTURES

3.1. Rise of Timber Structures in the Modern Era

While high-rise buildings were built with steel and reinforced concrete in the 20th century, wooden frame systems were preferred in low-rise residential buildings. At the same time, significant structural elements, made by glueing more minor pieces of wood along the parallel grain direction, were commonly used in religious buildings. This system, known as "glued laminated timber" (glulam), was patented in Germany in the 19th century (Wallace, Cheung and Williamson, 1998).

In the 1980s and 1990s, developing new engineering timber products in North America increased the design and usage possibilities of timber structures. These products included structural composite timber materials, I-beams, and thick composite panels. These innovations allowed timber buildings to reach up to 4-5 stories.

Structures like the 32-meter pagoda in the Developing Law Learning Temple in Ikaruga, Japan, and the 67-meter Sakyamuni Pagoda built in 1056 in Yingxian, China, demonstrate the longevity of timber. These durable structures also showcase that timber surpasses steel and concrete in weight and performs excellently in earthquake-resistant contexts.

Timber is recognised in the construction industry for its fire resistance and versatility. Contrary to common belief, timber chars at a predictable rate, which helps to preserve its structural integrity more effectively than steel, which melts, or concrete, which deteriorates under intense heat. This predictable behaviour has increased interest in timber for urban construction, especially in earthquake-prone areas. Research, including studies supported by the U.S. National Science Foundation, has shown that tall timber buildings can perform as well as, or even outperform, steel and concrete buildings during seismic events. For example, advanced tests on seismic resilience for the Tall Wood Project have produced positive results from experiments conducted on earthquake simulation platforms (Tollefson, 2017).

The development of cross-laminated timber (CLT) technology marked the turning point in constructing high-rise timber buildings. CLT consists of layers of wood placed in different directions, creating dense and large panels. The material's fire resistance, carbon storage capacity, renewability, and ability to be produced from low-quality timber provide economic advantages (Bowyer, 1995).

In Europe, CLT technology was initially employed in roof systems during the 1970s and was officially registered for general use in the 1980s. In the 1990s, commercial production became widespread in Switzerland, Germany and Austria (Brandner, R. 2013). In North America, the usage of CLT began to gain traction in the early 2000s, and studies conducted in Canada and the United States have yielded positive results regarding the material's earthquake resistance. For example, Japan, a seismically active region, tried to explore timber as an alternative. A 7-storey CLT building was subjected to shake table tests, and the structure managed to withstand the test without significant damage.

In recent years, wooden skyscraper projects have attracted world attention. Timber has gone beyond its traditional use and has begun to gain a place in the landscape and building stock of modern cities. In Europe and North America, high-rise timber projects have demonstrated the material's contribution to sustainability goals. In 2015, two high-rise timber building designs in Portland and New York won awards at a competition organized by the U.S. Department of Agriculture, contributing to the global recognition of modern timber architecture (USDA/SLB/BiNational SWLC, 2015).

In Turkey, the preference for wooden construction materials remains lower compared to other building systems, especially when compared to global trends. After 1940, with technological advancements, materials like cement, stone, and steel became more widely used. As a result, the use of wood as a structural material in building design declined. Countries like the United States, Finland, Canada, Japan, and New Zealand utilise wooden materials much more frequently than Turkey. Cross-laminated timber systems, now used in tall wooden buildings widely, were developed following the invention of glued laminated timber. This approach has enabled the construction of tall wooden buildings in countries like Germany, Norway, and Austria. In Europe, high-rise wooden structures are increasingly being built using this system. In

earthquake-prone regions like Canada, Japan, and the United States, wooden structural systems are commonly used in residential and educational buildings. For instance, approximately 90% of buildings in Canada, 42% in Japan, and 92% in northern parts of the U.S. are constructed with wooden systems (Akça, et al., 2013-2014).

Table 1. The ratio of houses built with timber structures to the total number of houses in Turkey, the USA, and Japan in 2010 (Source: TÜİK, 2011, U.S. Census Bureau. 2017, E-Stat, 2015; Piroğlu, 2023)

	Turkey	**USA**	**Japan**
Total number of houses	363053	651000	605700
Number of houses built with wooden structural systems or wooden materials	166	580000	298600
Percentage	0.05%	89%	49%

Wood stands out as an alternative in the construction sector in terms of sustainability. According to a study by the Scottish Forestry Commission, using wood as a building material reduces carbon emissions by 80% (Kartal, 2015). In addition, there are misconceptions regarding wood's fire resistance. Wood can maintain its structural integrity by charring in a controlled manner, making it a safer material than steel or concrete (Tollefson, 2017).

Thus, the use of wood in tall and commercial buildings is growing, and governments, architects, engineers, and researchers support it. Economic development, innovative design ideas, climate change efforts, and better forest management drive this trend. Wood construction offers climate benefits because it produces low carbon emissions and stores carbon over time. Policies encouraging wood use have played a role in this growth. As shown in Table 2, many governments have launched programs to promote wood buildings, most of them in the past ten years (Bowyer, 2016).

Additionally, various studies are being conducted in Turkey on this subject. An example of these efforts is the development of the "Regulation on Design, Calculation and Construction Principles of Wooden Buildings" which was created to address the

challenges faced due to the lack of wooden building regulations and the establishment of the National Timber Association.

Table 2. Global Initiatives in Wooden Architecture (Source: Bowyer, et al. 2016)

Initiative	Location	Pilot Year	Description
Timber Sales Promotion Fund Act 1990	Germany	1990	This program works much like a check off program in the U.S., with provisions for promotion of wood products, but differs in that the government mandates participation.
Land Use Planning Incentives for Wood in Construction	Finland	2004	Encourages increased use of wood in small house construction.
BC Wood First Initiative / Wood First Act	British Columbia, Canada	2009	As of December 2014, 53 communities across B.C. had passed or endorsed resolutions or policies indicating their intent to adopt wood in public buildings. On average, the Province annually funds almost $3 billion worth of capital investments in buildings such as hospitals, schools and social housing.
Wood Use Strategy for Construction in Québec	Québec, Canada	2009	This measure specifically aims to increase the use of wood products in the nonresidential sector in Québec and in the construction of multifamily homes as well as to intensify the use of appearance wood products. The initiative encourages environmental performance as well as use of wood. Under this policy, construction project promoters must use wood instead of other materials and fall within 5% of the cost of the proposed solution.
Threshold of wood use in construction (Decree 2010-273)	France	2010	Required new public buildings to have at least 0.2 m^2 of wood building materials for every 1 m^2 of occupancy. Subsequently rescinded.
Wood First Law	Japan	2011	Patented after the law in British Columbia, this measure requires that wood be considered as the primary building material for any government funded building of up to 3-stories, and for any privately funded buildings used in a public manner.
Construction Product Regulation	EU	2011	While not mandating the use of wood, two requirements of this regulation favor wood use. One requirement relates to greenhouse gas emissions of construction products and another requires the use of 'environmentally compatible materials.' The metric is the carbon footprint as determined using EU-level calculation rules for all construction materials over the entire life cycle of a building.
Timber First	Hackney Borough Council, London, UK	2012	Encourages use of timber as a first choice building material for construction projects.
Wood First	Ontario, Canada	2012	The Act aims to facilitate a culture of wood by requiring the use of it as the primary building material in the construction of provincially funded building. The Act also increased the maximum allowed height for wood frame construction from 4-stories to 6-stories. The measure was originally envisioned as not gaining legislative approval, although the proposed increase in maximum allowed height was ultimately approved.
Dutch Design Initiative – A Dime for a House	Netherlands	2013	Measure makes it compulsory to provide environmental impact information for all new buildings. This will largely benefit wood building materials due to their significantly lower environmental impact.
USDA Tall Wood Building Competition	United States	2014	This initiative aimed to demonstrate the architectural and structural feasibility of wood building construction with the objectives of helping mitigate climate change, facilitate forest health, and support rural economies.
Wood Encouragement Policies	Australia (City Councils of Latrobe, Wellington Shire, and Wattle Range)	2015	Ensures that all new Council projects are required to use timber as the preferred material for both construction and interior finishing, where wood is deemed a suitable material for the proposed application, and ensures that all comparisons to the cost of building with other materials take into account all long-term and life cycle benefits of using wood products.
Wood First Policy	Rotorua District Council, New Zealand	2015	Provides for development of an assessment toolkit for all council-led building projects to see how wood might be incorporated in design and encourages contractors to include wood options in their proposals to Council.

As a result, wood is coming to the fore in contemporary architecture due to its renewability, sustainability, positive performance under seismic forces, and

adaptability to technological developments. Developments in wooden construction technologies have made this material applicable even in high-rise buildings. Wood is shaping the future of architecture as an eco-friendly, aesthetic, and durable building material in the modern era.

3.2. Types of Wood Materials and Their Properties

Wood has been a material in construction for centuries due to its versatility, aesthetic appeal, and structural properties. Wood can be categorized into two main groups: softwood (e.g., pine and spruce) and hardwood (e.g., oak and beech). While softwoods are generally preferred for lightweight applications, hardwoods are more suitable for projects requiring high durability and longevity.

The wood has natural insulation properties, which raise thermal and acoustic performance. With technological advancements, wood's fire resistance and biological durability have been improved. Innovative engineered products such as cross-laminated timber (CLT) and glue-laminated timber (GLT) have revolutionized the use of wood in construction, particularly for multi-story structures, by providing high strength, flexibility, and environmental sustainability (Wallace, Cheung and Williamson, 1998).

While steel and concrete have dominated high-rise construction throughout the 20th century, wood retained its significance in single-family homes and low-rise buildings. Engineered products such as glulam—developed in Europe in the mid-19th century—enabled the creation of significant structural elements by laminating smaller pieces of wood, paving the way for wood's use in larger-scale projects like churches and halls (Wallace, Cheung and Williamson, 1998). In North America, the 1980s and 1990s witnessed the introduction of new engineered wood products, including structural composite lumber, wood I-joists, and composite panels. These innovations broadened design options and facilitated the construction of four- and five-story timber buildings by the early 2000s.

The introduction of CLT, developed in Austria in the 1990s, marked a turning point. CLT panels are composed of lumber-lued layers in alternating grain directions such as plywood. This structure ensures stability, fire resistance, and long-term carbon storage

while accommodating lower-grade timber. CLT panels can reach dimensions as large as 20 inches thick and 10 by 60 feet, making them ideal for large-scale construction. Additionally, related products like nail-laminated timber (NLT) have extended the range of applications for engineered wood (Wallace, Cheung and Williamson, 1998).

Europe has led the way in promoting wood use, driven by energy efficiency and emissions reduction regulations. From the 1990s to now, wood's share in residential construction increased from 5-10% to approximately 25%. Architects are increasingly drawn to wood for its environmental benefits and ability to reduce buildings' carbon footprints (Tollefson, 2017).

In North America, Canada took the lead in embracing CLT technology. In 2009, British Columbia raised the maximum allowable height for wood buildings from four to six stories, leading to the development of several multi-story CLT projects, including an 18-story dormitory at the University of British Columbia. This advancement sparked growing interest in the United States, where recent competitions and government incentives have helped address building code limitations, further promoting the use of wood in taller structures (Pei et al., 2016)

Despite its numerous advantages, wood faces challenges such as susceptibility to water damage, mould, and fire risks, particularly during construction. However, advancements in protective coatings, fire-resistant treatments, and moisture management address these concerns. (Tollefson, 2017).

Glulam is created by joining smaller timber pieces and laminating them with all layers' grain direction aligned along the length. This process allows for the production of significant structural components by increasing the length, width, and depth as required by the construction industry. Timber from rapidly growing trees with smaller trunk sizes, typically sourced from managed forests, is used for this purpose. The European wood species commonly used in glulam production are specified in BS EN 14080. (2013).

The typical process of glulam production in a factory includes several stages. Initially, the sawn timber is dried in a kiln, where the pieces are arranged to ensure proper airflow. The drying process is powered by electrical heaters or boilers using timber

waste and offcuts from the site. Once dried, the timber is graded for strength using a machine, with any defects that may weaken the material being identified and removed by a cross-cut saw. The timber is then cut to the desired length using a finger-joint cutter, joined with adhesive, and left to set. After the curing process, the surfaces are planed, and the adhesive is uniformly applied to ensure a strong bond. The bonded timber is then clamped and allowed to cure. Finally, the glulam will remove adhesive residue from the surface and shape it to the necessary construction dimensions (Ong, 2015).

Advantages of Glue-Laminated Timber (GLT):

-Structural Strength: GLT is more potent than solid timber of equivalent size due to eliminating natural defects like knots and grain irregularities.
-Design Flexibility: It can be manufactured in various shapes, including straight beams, curved arches, and even complex geometric forms, making it ideal for innovative architectural designs.
-Large Spans: GLT beams can span significant distances, reducing the need for intermediate support and allowing open, unobstructed spaces.
-Sustainability: Using smaller pieces of wood maximizes resource efficiency.

Disadvantages of GLT:

-Cost: The production process and adhesive use are more expensive than traditional timber.
-Moisture Sensitivity: GLT requires protection against prolonged exposure to moisture, as adhesives and wood may degrade over time.
-Fire Risk During Construction: While finished GLT has good fire performance, unfinished elements are vulnerable during installation.
-GLT is widely used in bridges, sports halls, and long-span roof systems due to its strength and adaptability.

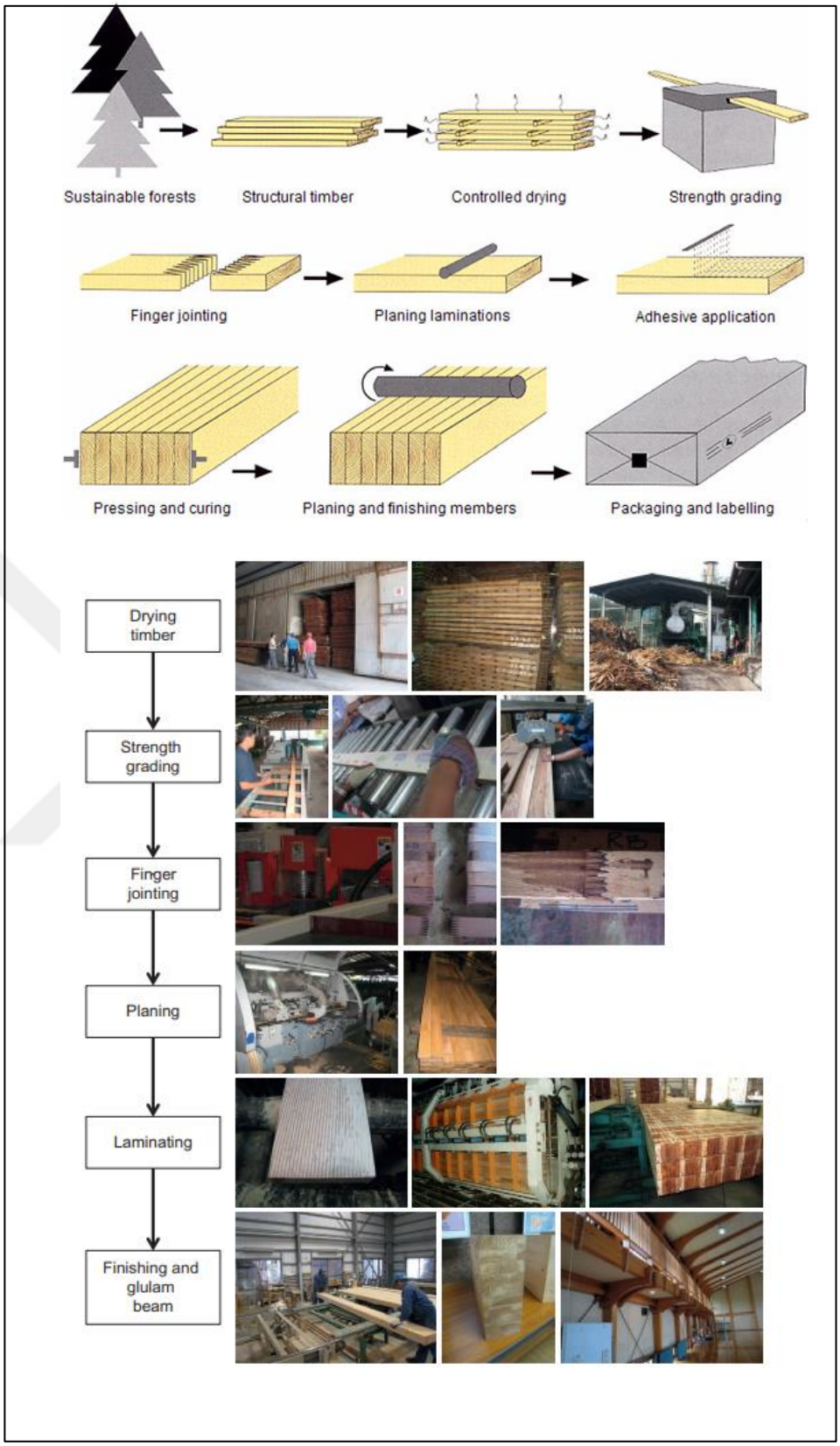


Figure 45. Typical Stages of Glulam Production (Source: Ong, 2015)

Mass timber systems are based on cross-laminated timber (CLT) panels made by laminating wood boards perpendicular to each other. These panels eliminate wood's natural anisotropic (direction-dependent) properties, creating a homogeneous, rigid, and dimensionally stable building material (Kaufmann, Krötsch and Winter, 2018).

Cross-laminated timber (CLT) is a type of engineered wood product designed in a plate-like form, designed to resist both in-plane and out-of-plane forces. This comprises multiple layers, usually three, five, or seven, although there can be even more. Each layer consists of boards or beams placed side by side, with the layers arranged perpendicular to one another, typically at a 90° angle. These layers are then bonded using adhesive, creating a composite structure with nearly rigid connections. The continuous bonding between the layers results in a highly compact and versatile material. (Brandner, et al., 2016).

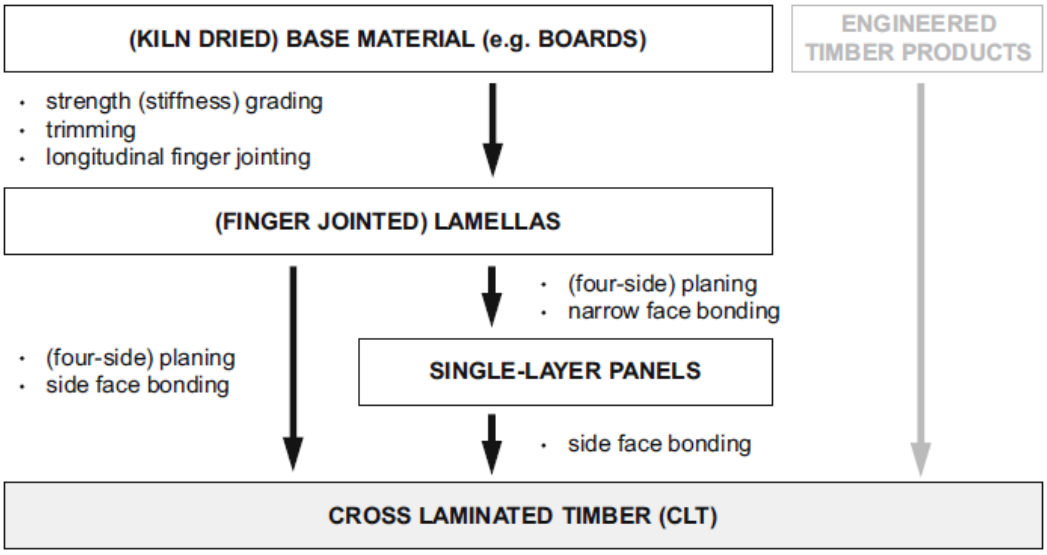


Figure 46. CLT Production Process: Overview. (Source: Brandner, et al., 2016)

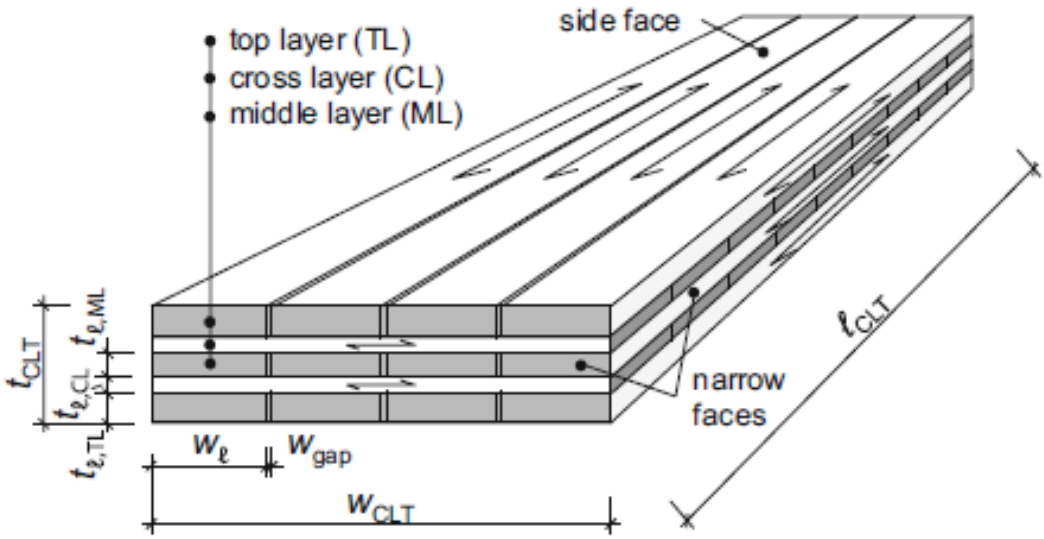


Figure 47. Detailed Schematic of a CLT Component: Key Dimensional Specifications, Critical Variables, and Terminology (Source: Brandner et al., 2016)

Advantages of CLT:

-Dimensional Stability: Dimensional stability reduces expansion, contraction and warping.

-Load Carrying Capacity: CLT panels support load-bearing loads, allowing multi-storey construction.

-Fire Resistance: CLT panels char and form a protective layer that slows down fire progress.

-Precision and Efficiency: Prefabricated CLT panels reduce construction time and improve construction quality.

-Environmental Benefits: It uses lower quality and smaller diameter timber and stores carbon in line with sustainability targets.

Disadvantages of CLT:

-Weight: Although CLT panels are lighter than concrete, they are heavier than GLT beams, which can cause logistical difficulties during transportation and installation.

-Cost: Special machines are required for CLT production, and costs increase in regions with limited production facilities.

-Moisture Concerns: Like GLT, CLT is sensitive to moisture during construction and must be adequately insulated.

Table 3: Comparison of GLT and CLT Panels

FEATURE	GLT	CLT
Structure	Parallel grain layers	Alternating grain layers
Primary Application	Beams, columns, arches	Walls, floors, and roofs
Design Flexibility	High (complex shapes possible)	Moderate (large panels dominate)
Load-Bearing Capacity	Ideal for linear elements	Excellent for planar elements
Fire Resistance	Good, char layer protects core	Excellent, similar performance
Moisture Sensitivity	Requires protection	Requires protection
Cost	Moderate	Higher

Consequently, advancements in wood production technology in the 21st century and the easy production of engineering products such as CLT and GLT offer wood as an alternative to concrete and steel structures. Its renewability, carbon warehouse capacity and design flexibility make it an environmentally friendly material.

3.3. Technologies Used in High-Rise Wooden Structures

Wooden construction technologies have increased the use of this material in multi-story buildings. Wood is an alternative for the construction sector due to its sustainability, low carbon footprint, and aesthetic appeal. In addition, developments in prefabrication technologies have mainly facilitated the construction and design processes of multi-story timber structures.

However, timber requires specific design considerations due to certain structural and physical limitations, such as its low modulus of elasticity, anisotropic nature, and sensitivity to moisture (Leskovar and Premrov, 2013). In this context, contemporary timber structural systems have been examined as hybrid systems.

Hybrid systems enhance structural performance by combining timber with concrete, steel, or other materials. This approach is particularly indispensable for the construction of taller buildings.

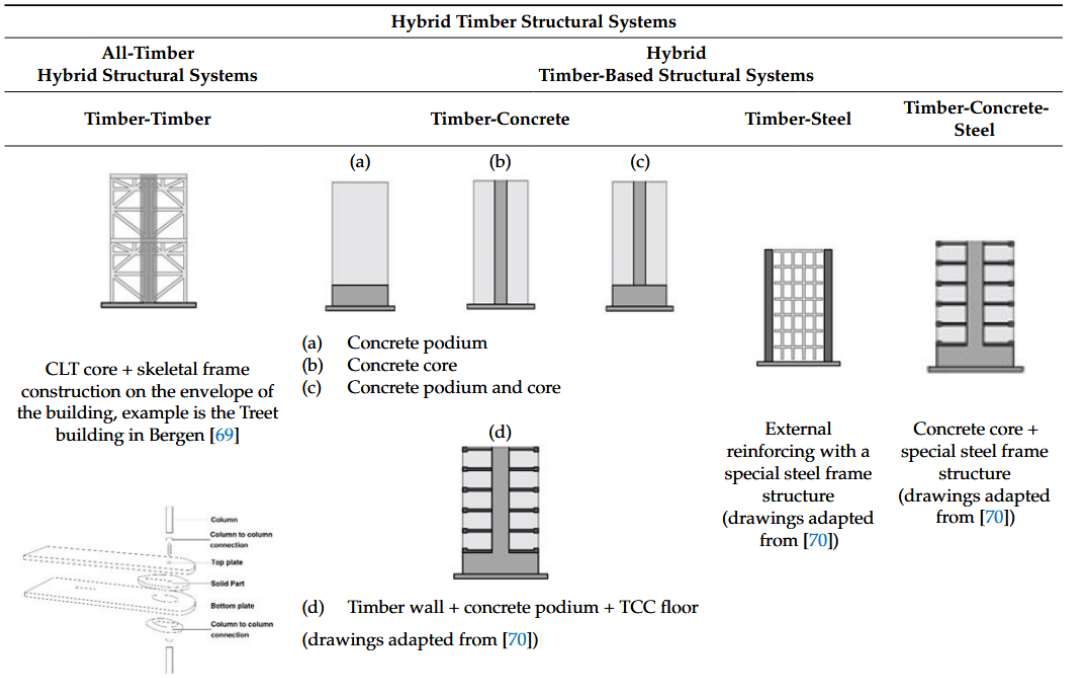


Figure 48. Graphic Presentation of Timber Hybrid Structural Systems. (Source: Premrov and Leskovar, 2023)

Timber-Concrete Composite Systems (TCC)

Timber-concrete composites (TCC) are systems that combine timber and concrete. TCC floors resist vibrations and horizontal rigidity (Adema et al., 2022). Additionally, these systems enhance acoustic performance, meeting sound insulation requirements. They are commonly used as flooring elements in multi-story buildings. For instance, concrete-reinforced CLT floors span large openings (Buka-Vaivade and Serdjuks, 2022).

Timber-Steel Composite Systems (STC)

Timber-steel composite systems overcome timber's limitations by incorporating steel elements, such as its low modulus of elasticity. Steel increases ductility which offers advantages in seismic resistance (Iovane, Olivia, Faggiano, 2023). These systems are

employed in mid-rise and high-rise structures. Practical examples demonstrate the potential of hybrid systems:

HoHo Tower (24 Stories, Vienna): This project used timber elements reinforced with a concrete core, showcasing excellent performance against high wind loads and torsional effects (Pastori et al., 2022).

Mjøstårnet (18 Stories, Brumunddal): Constructed with CLT and glulam, this building is considered the tallest designed using an all-timber system (Kaufmann et al., 2018).

In addition, timber reduces environmental impacts due to its carbon storage capacity (Duan et al., 2022). Prefabrication methods minimise construction waste and shorten building times (Leskovar and Premrov, 2013). In this way, hybrid systems overcome timber's inherent limitations while optimising structural and energy performance.

Timber construction technologies provide sustainable architectural solutions and emerge as a key alternative in multi-story buildings. Hybrid systems are indispensable for taller structures. The widespread use of innovative materials such as timber-fiber composites is anticipated (Pérez et al., 2022).

3.4. High-Rise Wooden Structures in the World

Wood, a material with a history in construction, meets the design needs of high-rise buildings along with developing technology. Fueled by technological developments and growing environmental awareness, it sheds light on a traditional view and the future. Today, wood is appreciated for its aesthetic appeal and has come to be respected as a structural material that rivals steel and concrete.

No longer limited to low-rise and residential buildings, wood is a material that demonstrates its strength, adaptability, and environmental advantages in high-rise and complex structures.

Some of the most notable examples of high-rise wooden buildings include Mjøstårnet in Norway, which, at 85.4 meters (18 stories), currently holds the record as the tallest wooden structure globally. This mixed-use structure combines residential, office, and hotel spaces. Likewise, the HoHo Tower in Vienna, Austria, stands at 84 meters and

features a hybrid wood-concrete system, demonstrating the potential of combining materials to achieve strength and sustainability.

Wooden high-rise buildings are also gaining traction outside Europe with North American and Asia projects. For instance, Canada's Brock Commons Tallwood House, a 53-foot student residence, was built using CLT and Glulam. In addition, The W350 Project in Japan, a proposed 350-meter wooden skyscraper, aims to demonstrate the role of sustainable materials in urban development.

These developments show the environmental benefits of wood-based structures. Wood includes a much lower carbon footprint than steel and concrete and is a carbon sink throughout its life cycle. Modern fireproofing technologies and the natural insulating properties of engineered wood have addressed safety concerns, making wooden high-rise buildings a feasible and safe option for urban growth.

With the development of cities, the need for sustainable structure solutions increases. In this regard, timber structures provide an alternative to traditional construction methods, promoting more sustainable practices driven by technological innovations, collaborative initiatives to update building codes, and increasing public awareness of their environmental and structural advantages. The potential of wood in urban development is a cause for optimism in the construction industry.

3.4.1. International Examples and Analysis

According to the analysis made by CTBUH in 2020, the graph showing the schematic drawings of the structures built as concrete and wooden structures is ranked according to their heights. The Mjostarnet building in this graph is 85 m high and is built entirely of wood, highlighting the fact that skyscrapers with completely wooden construction can also be built thanks to developing technologies and construction techniques. It is possible to see wooden hybrid structures for a sustainable future in many parts of the world. (Figure 49)

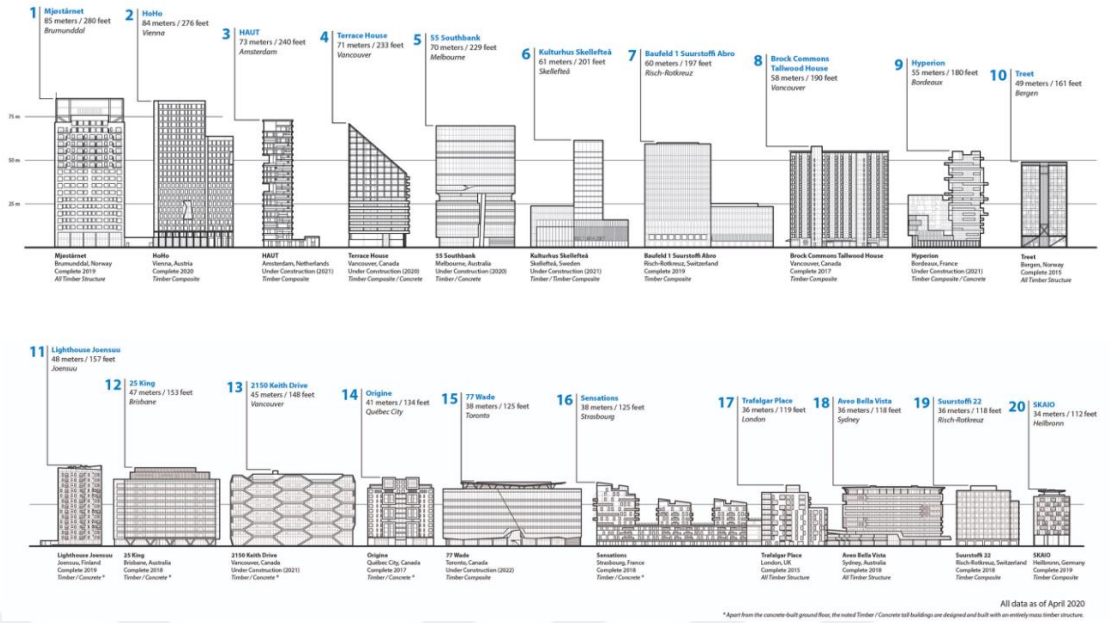


Figure 49. The Schematical view of the constructed 20 Tallest Building (Source: CTBUH, 2020)

In recent years, high-rise buildings have come to fore with hybrid systems that combine materials such as wood, concrete and steel in terms of sustainability and structural durability. Such structures both reduce environmental impacts and offer new opportunities in terms of aesthetics and engineering. Projects such as C6 Perth (Perth) and Atlassian Central (Sydney) are constructed with concrete-steel-wood composite systems and demonstrate the potential of using wood in high-rise buildings. At 183.5 meters, C6 Perth will be the world's tallest hybrid structure when completed. Similarly, Atlassian Central will be 182.6 meters high and will house office and hotel functions together.

Gliwice Radio Tower (Gliwice), completed in 1935 and for a long time the world's tallest wooden structure at 118 meters, is one of the pioneering structures in this field. Today, projects such as the 96-meter-high Burj Zanzibar (Zanzibar) and the Rocket&Tigerli (Winterthur), which will reach 100 meters, are being built entirely with wood systems. Projects where wood and concrete are used as hybrids are drawing attention in terms of architectural diversity. For example, the Tree House (Rotterdam) and Dutch Mountains I (Eindhoven) projects are being built with concrete-wood composite systems and combine residential and office functions.

Below is a detailed exploration of some of the most significant timber and hybrid structures globally, including their technical features, material compositions, and environmental contributions. (Table 4)

Table 4. The Contemporary List of The Wooden Tall Buildings in The World (revised from Skyscraper Center and CTBUH, 2025), (See Appendix A)

RANK	NAME	CITY	STATUS*	COMPLETION	HEIGHT	FLOORS	FUNCTION	MATERIAL	ARCHITECT
1	C6 Perth	Perth	P	-	183.5m	50	Residential	Concrete-Steel-Timber Composite Over Concrete	Fraser and Partners
2	Atlassian Central	SYDNEY	UC	2026	182.6m	42	Office/Hotel	Concrete-Steel-Timber Composite	BVN Shop Architects
3	The Dutch Mountains I	Eindhoven	P	-	130m	38	Residential/Office	Concrete-Timber Composite	OMT Architects
4	Tree House	Rotterdam	P	2025	130m	37	Residential/Office	Concrete-Timber Composite	PLP Architecture
5	Upper House	Brisbane	C	2023	119.7m	34	Residential	All-Concrete	Koichi Takada Architects
6	Gliwice Radio Tower	Gliwice	C	1935	118m	-	Telecommunications	All-Timber	-
7	Rainbow Tree	Cebu	P	-	115m	32	Residential	All-Timber	Vincent Callebaut Architecture
8	The Dutch Mountains II	Eindhoven	P	-	102m	29	Hotel/Serviced Apartments/ Office	Concrete-Timber Composite	OMT Architects
9	Rocket&Tigerli	Winterthur	P	2026	100m	32	Residential	All-Timber	Schmidt Hammer Lassen Architects
10	Marunouchi Tokio Marine	Tokyo	P	2028	100m	20	Office	Composite	J. Moolhuijzen, A. Giralt, H. Nakatani
11	Metropolitan Park Building 7/8	Arlington	C	2023	99.2m	23	Office	Concrete Over Concrete-Steel-Timber Composite Over Concrete	ZGF Architects
12	Woho	Berlin	P	-	98m	29	Residential	Concrete-Timber Composite	Mad Arkitekter
13	Burj Zanzibar	Zanzibar	UC	-	96m	28	Residential	All-Timber	OMT Architects
14	2011 Locust Street	St. Louis	P	2025	95.5m	29	Residential	Concrete-Timber Composite	Korb + Associates Architects
15	191 College Street	Toronto	P	-	95.4m	31	Residential	All-Timber	Diamond Schmitt Architects
16	Ascent	Milwaukee	C	2022	86.6m	25	Residential	Concrete-Timber Composite Over Concrete	Korb+ Associates Architects
17	Mjøstårnet	Brumunddal	C	2019	85.4m	18	Residential/Hotel/ Office	All-Timber	Voll Arkitekter
18	Tilia Tower	Lausanne	UC	2026	85m	28	Residential/Hotel	Concrete-Timber Composite	3XN Architects
19	HoHo Wien	Vienna	C	2020	84m	23	Serviced apartments / Hotel / Office	Concrete-Timber Composite	RLP Rüdiger Lainer
20	TRÆ	Aarhus	C	2024	81.7m	20	Office	Composite	Lendager

**P: Proposed, C: Constructed, UC: Under construction*

1. C6 Perth

City: Perth, Australia
Status: Proposed
Height: 183.5 meters
Floors: 50
Function: Residential
Material: Concrete-Steel-Timber Composite over Concrete



Figure 50. Perth, Austria (Source: Skyscraper Center (n.d.),2024)

Once completed, C6 Perth will be the tallest residential tower designed with timber in the Southern Hemisphere. The design of the 50-storey skyscraper is a combination of concrete, steel and engineered timber. C6 Perth incorporates sustainable building practices such as energy-efficient systems and renewable materials.

2. Atlassian Central

City: Sydney, Australia
Status: Under Construction
(Expected Completion: 2026)
Height: 182.6 meters
Floors: 42
Function: Office/Hotel
Material: Concrete-Steel-Timber Composite



Figure 51. Sydney, Australia (Source: Skyscraper Centre (n.d.),2024)

Designed to redefine green high-rise construction, Atlassian Central will stand as a 42-story tower housing office spaces and a hotel. The hybrid structure employs mass timber floor systems supported by a steel exoskeleton, ensuring flexibility, fire resistance, and enhanced load distribution. The project aims to achieve zero emissions through the use of renewable energy and intelligent building management systems.

3. The Dutch Mountains I

City: Eindhoven, The Netherlands
Status: Proposed
Height: 130 meters
Floors: 38
Function: Residential/Office
Material: Concrete-Timber Composite



Figure 52. Eindhoven, The Netherlands (Source: Skyscraper Center (n.d.),2024)

The Dutch Mountains I is envisioned as a multifunctional complex integrating living and working spaces within a sustainable framework. This project utilizes a hybrid

concrete-timber structural system to provide the necessary strength for a 130-meter building while maintaining a focus on sustainability. The building's modular design includes renewable energy solutions, green facades, and advanced insulation systems.

4. Tree House

City: Rotterdam, The Netherlands
Status: Proposed (Expected Completion: 2025)
Height: 130 meters
Floors: 37
Function: Residential/Office
Material: Concrete-Timber Composite



Figure 53. Rotterdam, The Netherlands (Source: Skyscraper Center (n.d.),2024)

Tree House is a pioneering project combining biophilic design with modern timber construction. Its hybrid concrete-timber system ensures structural stability while enabling the use of sizeable, prefabricated timber modules. The design focuses on integrating green spaces within the urban context with features such as vertical gardens, roof terraces, and communal outdoor areas. Tree House contributes to its occupants' well-being and aligns with broader sustainability goals by fostering a connection to nature.

5. Upper House

City: Brisbane, Australia
Status: Completed (2023)
Height: 119.7 meters
Floors: 34
Function: Residential
Material: All-Concrete



Figure 54. Upper House, Brisbane, Australia (Source: Skyscraper Center (n.d.),2024)

The Upper House, an all-concrete structure, is a high-rise building that uses passive design strategies, energy efficiency systems and water recycling technologies. Although structures such as the Upper House (Brisbane), which are built entirely using concrete, still find a place in high-rise buildings, the use of wood and concrete together is increasingly preferred due to its aesthetic and structural advantages.

6. Gliwice Radio Tower

City: Gliwice, Poland
Status: Completed (1935)
Height: 118 meters
Function: Telecommunications
Material: All-Timber



Figure 55. Gliwice Radio Tower, Gliwice, Poland (Source: Skyscraper Center (n.d.), 2024)

Gliwice Radio Tower is a historical testament to the durability and versatility of wood in construction. Made entirely of larch wood, this telecommunication tower has resisted time by demonstrating its durability against environmental conditions. At 118 meters high, it remains the tallest all-wooden structure in the world.

7. Rainbow Tree

City: Cebu, Philippines
Status: Proposed
Height: 115 meters
Floors: 32
Function: Residential
Material: All-Timber



Figure 56. Rainbow Tree, Cebu, Philippines (Source: Skyscraper Center (n.d.), 2024)

Rainbow Tree, the 32-story tower, includes laminated timber systems designed to withstand the high humidity and typhoon-prone conditions of the Philippines. The

building also features extensive greenery, creating a vertical forest that reduces the urban heat island effect and increases biodiversity.

8. The Dutch Mountains II

City: Eindhoven, The Netherlands
Status: Proposed
Height: 102 meters
Floors: 29
Function: Hotel/Serviced Apartments/Office
Material: Concrete-Timber Composite



Figure 57. The Dutch Mountains II, Eindhoven, The Netherlands (Source: Skyscraper Center (n.d.), 2024)

Dutch Mountains II is built with advanced hybrid timber construction methods. Its design prioritises energy efficiency through passive heating and cooling systems and renewable energy integration.

9. Rocket & Tigerli

City: Winterthur, Switzerland
Status: Proposed (Expected Completion: 2026)
Height: 100 meters
Floors: 32
Function: Residential
Material: All-Timber



Figure 58. Rocket & Tigerli, Winterthur, Switzerland (Source: Skyscraper Center (n.d.), 2024)

Rocket & Tigerli is 100 meters high, making it one of the tallest wooden residential buildings in the world. The structure consists of load bearing CLT walls and bonding elements that provide structural integrity and seismic performance.

10. Marunouchi Tokio Marine

City: Tokyo, Japan
Status: Proposed (Expected Completion: 2028)
Height: 100 meters
Floors: 20
Function: Office
Material: Composite



Figure 59. Marunouchi Tokio Marine, Tokyo, Japan (Source: Skyscraper Center (n.d.), 2024)

Using a combination of wood, steel and concrete, the Marunouchi Tokio Marine hybrid building was designed to meet Tokyo's strict seismic regulations. It includes the building's energy efficiency systems and rainwater harvesting technologies.

11. Metropolitan Park Building 7/8

City: Arlington, USA
Status: Completed (2023)
Height: 99.2 meters
Floors: 23
Function: Office
Material: Concrete over Concrete-Steel-Timber Composite



Figure 60. Metropolitan Park Building 7/8, Arlington, USA (Source: Skyscraper Center (n.d.), 2024)

This office building integrates timber into a hybrid composite system to achieve sustainability without compromising structural strength. Prefabricated CLT panels are used alongside concrete and steel, ensuring efficient construction and reduced carbon emissions.

12. Woho

City: Berlin, Germany
Status: Proposed
Height: 98 meters
Floors: 29
Function: Residential
Material: Concrete-Timber Composite



Figure 61. Woho, Berlin, Germany (Source: Skyscraper Center (n.d.), 2024)

Woho represents Berlin's ambition to combine urban density with sustainability. The building uses a modular design with prefabricated timber elements for rapid construction and future adaptability. Its hybrid structure combines timber and concrete, providing lateral stability for high-rise construction. The project incorporates extensive green spaces like communal gardens and rooftop terraces, emphasizing a community-oriented living experience.

13. Burj Zanzibar

City: Zanzibar, Tanzania
Status: Under Construction
Height: 96 meters
Floors: 28
Function: Residential
Material: All-Timber



Figure 62. Burj Zanzibar, Zanzibar, Tanzania (Source: Skyscraper Center (n.d.), 2024)

Burj Zanzibar is the tallest wooden building in Africa. Its structure uses cross-laminated wood and glue to create a lightweight yet sturdy frame. Its design also incorporates cultural elements, taking inspiration from Zanzibar's architectural heritage. It has solar panels and natural ventilation systems.

14. 2011 Locust Street

City: St. Louis, USA
Status: Proposed (Expected Completion: 2025)
Height: 95.5 meters
Floors: 29
Function: Residential
Material: Concrete-Timber Composite



Figure 63. 2011 Locust Street St. Louis, USA (Source: Skyscraper Center (n.d.), 2024)

St. Located in the heart of St. Louis, 2011 Locust Street is structurally composed of a concrete core and prefabricated wood elements. The project features renewable energy systems and advanced insulation techniques by green building standards.

15. 191 College Street

City: Toronto, Canada
Status: Proposed
Height: 95.4 meters
Floors: 31
Function: Residential
Material: All-Timber



Figure 64. 191 College Street, Toronto, Canada (Source: Skyscraper Center (n.d.), 2024)

191 College Street is a bold project aiming to push the boundaries of all-timber construction. The 31-story residential building relies on cross-laminated timber panels for structural and aesthetic purposes. The project emphasizes sustainability through responsibly sourced timber and energy-efficient systems, aspiring to achieve carbon neutrality.

16. Ascent

City: Milwaukee, USA

Status: Completed (2022)

Height: 86.6 meters

Floors: 25

Function: Residential

Material: Concrete-Timber Composite Over Concrete



Figure 65. Ascent, Milwaukee, USA (Source: Skyscraper Center (n.d.), 2024)

Located in the heart of downtown Milwaukee, the Ascent is currently the world's tallest wooden building at 86.6 meters tall. It is considered the tallest and tallest wood-concrete hybrid structure, surpassing Mjøstårnet in Norway. The project's construction, designed by Korb + Associates Architects (KA), started in 2020 and was completed in two years. Ascent's design incorporates biophilic elements, focusing on natural materials such as wood to create a deeper connection with nature. The building includes a six-storey podium, and 19 floors comprise residential buildings. The building's wooden structure is glued veneer, and CLT is a carbon sink. It captures enough CO2 to offset the annual emissions of approximately 2,400 cars.

Additionally, its wood-based structure shortened the overall construction time by several months. According to Decent (2022), Ascent represents a significant advance in sustainable architecture. However, it is expected to compete with future projects such as the 100-metre residential block in Switzerland and the 90-metre mass timber tower in Toronto (Dezeen, 2022).

17. Mjøstårnet

City: Brumunddal, Norway
Status: Completed (2019)
Height: 85.4 meters
Floors: 18
Function: Residential/Hotel/Office
Material: All-Timber



Figure 66. Mjøstårnet, Brumunddal, Norway (Source: Skyscraper Center (n.d.), 2024)

Mjøstårnet, located in Brumunddal, Norway, is an 85.4-meter-tall structure completed in 2019. This mixed-use project includes various functions such as offices, residences, a hotel, and a restaurant situated near Lake Mjøsa. Additionally, the complex features a swimming hall constructed with timber materials. In 2019, Mjøstårnet was recognized as the tallest timber building of the year. The structure incorporates LVL, glulam, and CLT materials in its design. While glulam and LVL were used in the primary load-bearing system, CLT was utilized exclusively for stairwells and balconies. With a total construction area of 10,500 m², the project also includes a 4,900 m² area designated for the swimming hall. The building materials consist of Norwegian spruce and pine, emphasizing sustainability with a notably low carbon footprint.

The structural system is reinforced by glulam columns and beams, with glulam trusses on the facade to transfer horizontal and vertical loads. The structural components are significant in size, and the floors, made from a combination of glulam and LVL, are reinforced with concrete to ensure stability against external forces such as wind and vibrations. For enhanced durability, foundation piles were driven to a depth of 50 meters. (Abrahamsen, 2017).

Mjøstårnet is an iconic all-timber building showcasing strength and flexibility of mass timber systems. Constructed with CLT and glulam, the 18-story tower serves multiple functions, including residential, hotel, and office spaces. The project, featuring geothermal heating and solar panels, emphasizes prefabrication and energy efficiency.

18. Tilia Tower

City: Lausanne, Switzerland
Status: Under Construction (Expected Completion: 2026)
Height: 85 meters
Floors: 28
Function: Residential/Hotel
Material: Concrete-Timber Composite

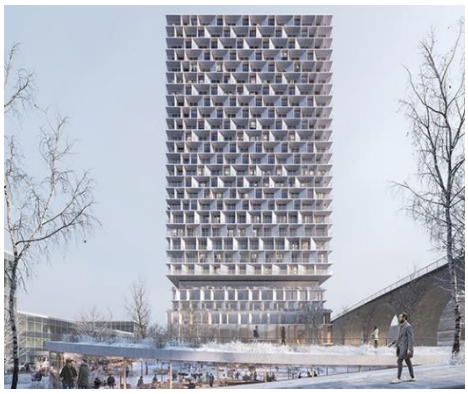


Figure 67. Tilia Tower, Lausanne, Switzerland (Source: Skyscraper Center (n.d.), 2024)

Tilia Tower is a hybrid wooden project that blends residential and accommodation areas. Concrete and wood provide stability while reducing the building's carbon footprint.

19. HoHo Wien

City: Vienna, Austria
Status: Completed (2020)
Height: 84 meters
Floors: 23
Function: Serviced Apartments/ Hotel/ Office
Material: Concrete-Timber Composite



Figure 68. HoHo Wien, Vienna, Austria (Source: Skyscraper Center (n.d.), 2024)

The HoHo Wien project, completed in Seestadt Aspern, Vienna, in 2019, is an example of hybrid timber construction. The 84-meter-tall hybrid structure provides durability and efficiency by integrating wooden elements into a reinforced concrete frame. The main structural components, including the load-bearing core, are reinforced concrete. Cross-laminated timber (CLT) elements make up the rest of the design. Timber elements such as ceiling panels, edge beams, and supporting beams work together to transfer loads throughout the building effectively.

The load-bearing system directs forces from the upper structure to the foundation, utilising composite timber-concrete (TCC) floors, cross-laminated timber (CLT) panels, concrete slabs, and shear keys. TCC systems bond wood and concrete together and prefabricated elements manufactured in controlled factory settings are assembled on-site for optimum construction accuracy and efficiency. Designed as a continuous system, Glulam edge beams help transfer vertical loads to the foundation and are supported by glued laminated timber columns.

20. Træ

City: Aarhus, Denmark
Status: Under Construction (Expected Completion: 2024)
Height: 81.7 meters
Floors: 20
Function: Office
Material: Composite



Figure 69. Træ, Aarhus, Denmark (Source: Skyscraper Centre (n.d.), 2024)

TRÆ is a wooden office tower designed according to commercial architecture. Its composite structure consists of wood, steel, and concrete.

3.5. Regulations on Timber Structures

3.5.1. National Wood Association and Support Activities (NTA)

Founded in 2000, the National Timber Association (NTA) is a non-governmental organization based on principles of participation and collaboration. Timber's climate change mitigation properties are widely recognized globally, and policies are being developed to promote its use as a structural material. However, despite Turkey's rich history with timber, its usage has significantly declined over the past 50 years for various reasons.

Modern engineered timber is being produced, enabling the construction of multi-story buildings with enhanced resistance to fire, earthquakes, and pests. Timber emerges as an alternative to steel and reinforced concrete in contemporary architecture.

The NTA represents a diverse group of stakeholders, including architects, academics, engineers, manufacturers, and contractors. The organization improves the understanding and promotion of timber and emphasizes its economic and ecological importance. It facilitates timberacilitates' rediscovery and raises the standards of Turkey's timber industry.

NTA organizes numerous face-to-face and online events annually, engages with public and private sectors, participates in meetings, and implements educational programs. It also collaborates with fairs and university events to showcase various aspects of timber and address challenges within the sector.

In addition to the NTA, the Young Timber Engineers and Architects Group (GAMM) was established on March 1, 2021. This group operates primarily via Telegram and aims to facilitate knowledge sharing on timber construction and engineering, discuss evolving methods and materials, and analyze all phases of design and construction processes, including regulatory issues.

The group’s activities include:

-Sharing noteworthy projects and tracking trends related to timber structures and materials.

-Providing master's students with opportunities to present their work and receive mentorship.

-Guiding professionals on research topics and offering solutions to inquiries.

GAMM is open to anyone interested in the timber sector and operates based on the following principles:

-To promote interdisciplinary knowledge sharing and collaboration.

-Treating all participants equally and benefiting from their expertise and experience

-Carrying out activities transparently and respectfully, without seeking personal interest.

NTA's training programs, conferences and workshops benefit industry professionals and students. Webinars, training sessions, interviews, and seminars are promoted through official websites and social media channels and implemented in collaboration with universities.

These activities effectively communicate structural timber's applications, advantages, and disadvantages, expand access networks, and increase awareness about timber construction.

3.5.2. History and Development of Regulations

This thesis examines the role of timber structures in the construction industry and the efforts to make this material more prevalent in the future. Specific rules, regulations, and standards are essential to building durable, high-quality, and controllable timber structures. Designers, practitioners, and inspectors must be aware of and apply these rules, which define the boundaries and methods to be followed in construction production (Ohanesyan, 2012).

Since the early 20th century, developed countries have researched timber materials and structural systems and established associations to develop regulations. In 1917, Germany founded the German Industry Standards Association (Normenausschuss der Deutschen Industrie-NADI). 1975, the organization was renamed the German Institute for Standardization (Deutsches Institut für Normung-DIN). The institute published DIN-1052, the first standard for timber structures in 1933, titled Design of Timber Structures- General Rules and Rules for Buildings. In the United Kingdom, the Timber Development Association (TDA), established in 1935, created a resource specifying the guidelines to be adhered to in timber construction (Çakır, 2000).

In the United States, the American Wood Council (AWC) was founded in 1944, and the National Design Specification for Wood Construction (NDS) was published in the same year. The discovery of resin-based adhesives and the widespread use of glued timber products highlighted regulatory gaps in this area. The American Institute of Timber Construction (AITC) was founded in 1952, and the Timber Construction Manual was published in 1966.

In Europe, with the establishment of the European Union, harmonising regulations and standards in the construction sector was adopted. The European Committee for Standardization (CEN) was established in 1961 to work on Eurocodes, and an action plan was prepared. In 1975, the European Union Commission implemented a joint activity program for the construction sector. This program aimed to remove technical trade barriers and harmonise technical rules, creating an alternative to national regulations. Within this framework, Eurocode 5: Design of Timber Structures (EN 1995-1-1:2004) was approved and implemented by the European Committee for Standardization on April 16, 2004.

Following the publication of Eurocode 5, many countries, especially in Europe, adopted this standard, translated it into their languages, and integrated it into their national regulations. These rules, which define how production should be carried out according to local conditions, the methods to be used, and the limits to be observed, must be understood and applied by designers, practitioners, and inspectors. The design of timber structures is regulated by various standards and codes, both in Turkey and internationally.

Significant global standards for timber structures include:

''-DIN 1052: Deutsches Institute für Normung, Design of Timber Structures- General Rules for Buildings.

-NDS: American Wood Council, The National Design Specification for Wood Construction.

-Eurocode 5 (EN 1995-1-1:2004): European Committee for Standardization, Design of Timber Structures.'' (Piroğlu, 2023)

While developed countries have detailed and universal regulations for timber structures aligned with technological advancements and contemporary requirements, Turkey has not given this area sufficient attention.

Existing Turkish regulations and standards for timber structures include:

-TS 647: Rules for Calculation and Construction of Timber Structures, 1979.

-General Technical Specification, (1985).

-TS EN 1995-1-1: Design of Timber Structures- Part 1-1.

-ABYYHY 1997: Regulation on Buildings to be Constructed in Disaster Areas.

-Istanbul Zoning Regulation, 2007.

-TBDY 2018: Turkish Building Earthquake Code.

-TBDY 2023: Turkish Building Earthquake Code.

-Regulation on Timber Buildings' Design, Calculation, and Construction (March 24, 2024).

TS 647 is one of Turkey's earliest standards, outlining basic rules for calculating and constructing timber structures. It covers timber types, allowable stresses, connection methods, and methods for checking bending, tension, compression, deflection, and support conditions. However, this standard does not address modern timber construction techniques or advanced technological products such as laminated timber.

The General Technical Specification and Istanbul Zoning Regulation provide limited information on timber structures. TS EN 1995-1-1, however, offers detailed guidance on the design, material properties, durability, connection elements, and control processes for timber structures. It adopts design rules based on the load-carrying capacity method. Unlike TS 647, which is limited to solid wood and plywood, TS EN 1995-1-1 includes details on laminated timber, structural wood products, and mechanical connection elements.

The ABYYHY 1997 regulation, published on September 2, 1997, and effective from January 1, 1998, provided basic guidelines under the section "Seismic Design Rules for Timber Buildings." However, it lacked detail and applied only to traditional timber structures, falling short of addressing modern requirements.

TBDY 2018, published on March 13, 2018, and effective from January 1, 2019, introduced specific design rules for timber structural systems under seismic loads in Chapter 12. This regulation formally adopted TS EN 1995-1-1 standards for the first

time and included calculation methods for beams, slabs, columns, and timber panels consistent with modern techniques.

The regulation on Timber Buildings' Design, Calculation, and Construction, published in 2024, represents the latest and most comprehensive update.

It deals with modern wooden construction techniques, the use of laminated wood and prefabricated wooden structural elements. It ensures that the design and construction of wooden structures in Turkey comply with international standards.

3.5.2.1. Fundamental Principles and Standards in the Current Regulation (Regulation on Design Calculation and Construction Principles of Wooden Buildings)

3.5.2.1.1. General Rules

The general provisions section of the Specification for Regulation on Design Calculation and Construction Principles of Wooden Buildings, published in the official newspaper on March 24, 2024, states, *'These principles include the methods, rules and conditions regarding the design and construction of structural wooden and composite building elements and building systems with sufficient safety, by their intended use.'*

Design of wooden high-rise buildings, performance analysis and performance evaluation of existing wooden buildings, repair and strengthening of historical and/or monumental wooden structures, design of wooden buildings with active and/or passive behaviour control, ultraviolet (UV) insulation in wooden buildings, design of wooden buildings in environments with temperatures above 60°C for long periods, design of wooden buildings in constant contact with water, and design of unique structures such as wooden towers and wooden fixed roofs are outside the scope of these Principles. (Regulation on Design Calculation and Construction Principles of Wooden Buildings, 2024)

As a natural and renewable resource, wood holds significant importance as a sustainable construction material. However, it must be used according to specific standards for structural safety and durability. These standards include wood

classification, quality control methods, production and processing processes, and preservation techniques.

To ensure building safety, specific state limit methods are used in the design. When limit state design methods are evaluated together with the rules in TS EN 1990, certain conditions must be taken into consideration:

- *‘ Differences in material properties (strength, rigidity, etc.),*
- *Differences in the temporal behavior of materials (loading time, creep),*
- *Varying thermal and moisture conditions,*
- *Different design situations (construction stages, change of ground and support conditions)’* (Regulation on Design Calculation and Construction Principles of Wooden Buildings, 2024)

Different types of wood are classified according to their properties, such as density and durability, determining which structural elements each material can use. Wooden materials are subjected to mechanical tests and separate according to their load-bearing capacity, and the usage conditions appropriate to these classifications are defined in the regulation. The load duration classification table is shown in the regulation at table 1.1.

Table 1.1. Load Duration Classification Table (Source: Regulation, 2024)

Table 1.1 Load Duration Classification Table

Load Duration Class	Description
Permanent Load	The load affects for more than 6 months (e.g., dead and live loads).
Medium-Term Load	The load affects from 1 week to 6 months (e.g., snow load).
Instantaneous Load	The load affects from an instant to 1 week (e.g., wind and earthquake loads).

Proper processing, drying, and preserving wood determine production and processing standards. Careful moisture content and surface treatment of wooden materials are necessary to ensure high durability. Incorrect operations performed during production

may cause the wood to deteriorate over time. For this reason, the regulation provides technical details about the material's processing methods. Standard production processes have been defined for wooden structures in Turkey.

Table 1.2. Usage Classes Based on Ambient Humidity Ratio (Source: Regulation, 2024)

Table 1.2 Usage Classes Based on Ambient Humidity Ratio		
Usage Class	**Average Moisture Content**	**Climatic Conditions**
KS1 (Low Humidity Level)	≤ 12	max. 65% relative humidity (at 20°C)
KS2 (Medium Humidity Level)	≤ 20	max. 85% relative humidity (at 20°C)
KS3 (High Humidity Level)	> 20	Outside of Usage Classes 1 and 2

The regulation mandates quality control and certification to ensure building safety. Wooden materials must be certified and subjected to regular inspections by both manufacturer companies and independent auditors.

3.5.2.1.2. Material

Table 5. Classification of Wood Types (Source: Regulation, 2024)

Tree Type	CLASS I	CLASS II	CLASS III
Larch (Karaçam)	C35	C24	C18
Fir(Göknar)	C27	C24	C18
Scots Pine (Sarı Çam)	C35	C27	C20
Red Pine (Kızılçam)	C35	C24	C18
Cedar (Sedir)	C24	C20	C16
Spruce (Ladin)	C27	C22	C20

In this part of the regulation, 6 native tree species (black pine, fir, Scots pine, red pine, cedar, spruce) are classified. Softwoods are classified as Class C and hardwoods as Class D. While oak, beech and maple are included as hardwoods, softwoods are specified as spruce, pine, fir and black pine. In addition, tables have been added for homogeneous and composite properties for glued laminated timber.

According to the regulation, certified, standardised quality and feature wood materials are required. The strength and mechanical properties of materials obtained from solid wood should be taken from TS EN 338.

Section 2 of the Regulation specifies the calculation method of dimensional coefficients for solid wood, glued laminated wood, laminated board wood, and the TSE standards that must be compatible. *Board wood products are created by glueing wooden pieces together with glue.* (Regulation, 2024) Board Wood and its standards are stated below. (Table 1.7)

Table 1.7. Correction Factor (k def) for Time-Dependent Deformation Behavior (Source: Regulation, 2024)

Material	Standard	Usage Class		
		UC1	UC2	UC3
Solid Wood	TS EN 14081-1+A1	0.60	0.80	2.00
Glued Laminated Timber	TS EN 14080	0.60	0.80	2.00
Laminated Veneer Lumber (LVL)	TS EN 14374, TS EN 14279+A1	0.60	0.80	2.00
Plywood	TS EN 636:2012+A1, Part 1	0.80	-	-
	TS EN 636:2012+A1, Part 2	0.80	1.00	-
	TS EN 636:2012+A1, Part 3	0.80	1.00	2.50
Oriented Strand Board (OSB)	TS EN 300, OSB/2	2.25	-	-
	TS EN 300, OSB/3, OSB/4	1.50	2.25	-
Particleboard	TS EN 312, Part 4	2.25	-	-
	TS EN 312, Part 5	2.25	3.00	-
	TS EN 312, Part 6	1.50	-	-
	TS EN 312, Part 7	1.50	2.25	-
Hardboard	TS 64-2 EN 622-2, HB.LA, HB.HLA 1	2.25	-	-
	TS 64-2 EN 622-2, HB.HLA 2	2.25	3.00	-
Medium Hardboard	TS 64-2 EN 622-3, MBH.LA1, MBH.HLA 2	3.00	-	-
	TS 64-2 EN 622-3, MBH.HLS1, MBH.HLS2	3.00	4.00	-
Medium Density Fiberboard (MDF)	TS EN 622-5, MDF.LA	2.25	-	-
	TS EN 622-5, MDF.HLS	2.25	3.00	-

Fasteners must also adhere to TS EN 14592 and TS EN 14545 standards. Nails, zumba, bolts, rod wedges, screws, and perforated metal plate fasteners can be used as fasteners (Regulation, 2024).

In addition, adhesives intended for structural use must create a connection with sufficient durability by its usage class. Wooden structural glues must comply with TS EN 301, TS EN 15425, and TS EN 16254 standards.

Table 2.4. Adhesive Types for Different Temperature Conditions (Source: Regulation, 2024)

Table 2.4 Adhesive Types for Different Temperature Conditions

Temperature	Climate Equivalent[1]	Example	Adhesive Type
>50°C	Undefined	Wooden structures exposed to high temperatures for a long time	I
≤50°C	>85% relative humidity (at 20°C)	Wooden structures fully exposed to air	II
	≤85% relative humidity (at 20°C)	Heated and ventilated buildings. Exterior parts protected from air. Wooden structures exposed to air for a short time.	III
At 20°C and 85% relative humidity, soft and hardwoods will have approximately 20% moisture content, while wood-based panels will have significantly lower moisture content.			

3.5.2.1.3. Structural Modelling, Analysis and Calculation Method

This part of the regulation discusses engineering-based analysis and design processes for wooden structures. It explains in detail how to model wooden structural elements, use analysis methods, and make the necessary calculations for safe dimensioning.

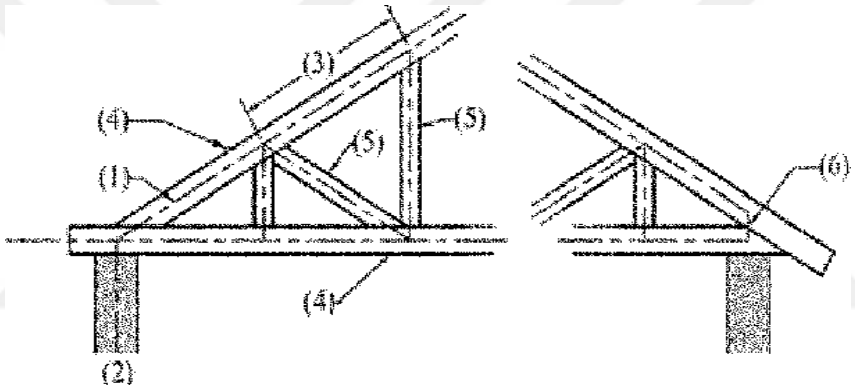
Firstly, it is emphasised that in the structural modelling phase of wooden structures, the elements should be analysed using three-dimensional analytical modelling methods. Building elements such as floors, columns, and load-bearing walls are modelled in line with the acting forces, and the stiffness and horizontal force transfer between these elements are calculated. When sizing building elements, the design is made based on these calculations.

Changes in the elastic properties of wooden materials may occur over time, affecting their load-bearing capacity. The creep effect of wooden elements occurring during the

process should also be considered in modelling. These effects should be considered in long-term analyses, and the design process should be planned accordingly.

The Finite Element Analysis (FEA) is a technique used to evaluate the structural integrity of wooden structures. This analysis considers the different behaviour of wood materials in different directions (anisotropic behaviour). The finite element modelling technique performs stress and deformation analyses at different points of the structure.

Additionally, within the scope of earthquake calculations, earthquake-resistant building design is carried out by the Turkish Building Earthquake Regulation. By determining how the structure will react during an earthquake, roofs are designed using lightweight materials to perform better in an earthquake.



(1) Bar element connection, (2) Support, (3) Span between nodes, (4) External connection, (5) Internal element, (6) Virtual rigid beam element

Figure 3.1. Elements Forming the Analytical Model of the Truss System (Source: Regulation, 2024)

The properties of the stiffness and stability of the elements are considered in the modelling and analysis of roof truss systems. External factors, such as snow and water accumulation, are evaluated for the safety of these systems, and the design takes these effects into consideration.

Finally, in the analytical modelling for Cross-Laminated (CLT) and Light Frame Wall Systems, the strength of the fasteners and the stiffness of the walls are analysed to determine the structure's general stability and load-carrying capacity.

As a result, the regulation outlines the engineering-based design process for wooden structures, including 3D analytical modelling of structural elements like floors, walls, and columns. Limit states for strength, usability, fire and insulation design are determined. Calculation methods according to strength: Axial tension, bending, pressure, shear force and combined effects. The combination of load effects and performance criteria in timber elements are detailed. In roof truss systems, external loads such as snow and water are analysed, and the stiffness and support conditions of the structure are modelled. For CLT and light frame wall systems, the strength of fasteners and wall stiffness are assessed to ensure structural stability (Regulation, 2024).

3.5.2.1.4. Design According to Strength

This section of the Regulation outlines the design principles that must be followed based on the strength of the components, considering the internal forces derived from structural analyses. It also provides detailed information on the structural modeling and analysis methods necessary for the safe and durable construction of wooden structures. It explains how to make calculations, what methods to use, and how to ensure structural safety.

When using structural wood, tensile stress control in the direction parallel to the fibres should be ensured and loads that would create tension perpendicular to the fibres should be avoided when designing.

Considering how the axial pressure force affects the structural wood, the compressive stress and shear force of rectangular columns with vertical, parallel, or variable cross-sections are calculated according to the design.

Safe element dimensions are determined by considering the forces and deformation capacities that can directly affect structural wooden elements. While linear analysis methods are used, especially in wooden structures, non-linear analysis methods are also used in exceptional cases. Both linear and nonlinear analyses are performed to evaluate the stability and deformation of elements such as floor and wall systems.

Creep and other deformations in structural wood are considered in the analysis of structural elements such as columns, beams, and walls. Changes may occur in the

elasticity and shear modulus of wooden materials over time, so these changes must be considered and analyzed when evaluating the long-term performance of structural elements.

In addition, roof trusses can transfer load at different angles depending on fibre directions. The relevant section of the regulation is considered when designing. In the fire-resistant design of the roof, the remaining cross-section during and after burning must be capable of carrying the roof loads. Additional loads are calculated by considering the potential for snow and water accumulation in both the architectural and static design of the roof truss.

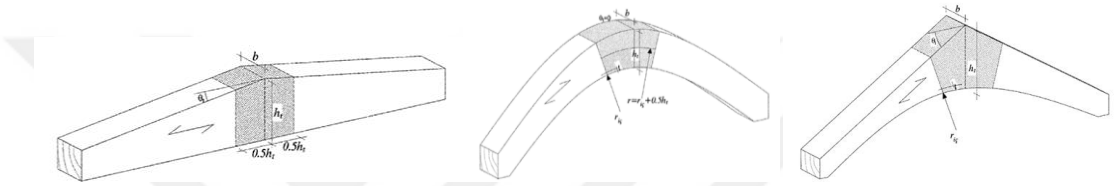


Figure 70. Structural beams in order; double tapered beam, curved beam and pitched cambered beam (Source: Regulation, 2024)

'For the roof truss system and the elements that form the truss, the areas that work under pressure are generally critical in buckling. In cases where reverse loading occurs under the effects of suction from above and inflation from the inside in the wind, checks should be made, and precautions should be taken, when necessary, on the lower head and diagonal and vertical elements of the truss that try to pull under vertical loads under normal conditions.' (Regulation, 2024)

For stability control of structural wood:

-Structural modelling,

-Analysis of structural components such as beams, columns and walls,

-Analysis against earthquake and wind loads,

-Stability of roof trusses and truss systems,

-Analytical modeling of cross-laminated (CLT) and light frame wall systems is required.

For CLT and light frame wall systems, the strength of fasteners and wall stiffness are assessed to ensure structural stability.

As a result, the load-bearing element arrangement and shear details for lightweight frame walls have been added. Diaphragm effect and constructive rules for floors have been described. Calculations of section properties according to the status of layers, element behaviors in the CLT panel plane and under effects perpendicular to its plane are given in detail. The usability limit states of CLT elements are defined in detail and an alternative vibration and damping calculation are also shown. Apart from the connection calculations of wooden structures, the connection calculations of CLT elements are presented as a section (Regulation,2024).

3.5.2.1.5. Design For Usability Limit State

This section in the Regulation discusses design criteria within the wooden structures' usability limit state. The usability limit state keeps vibration, deformation, and time-related deformations at specific limit values, which ensures that wooden structures provide comfort and durability in the long term. In this context, elements such as vibration and deformation of wooden structures during use must be evaluated.

Vibration and deformation control is an important issue throughout the lifespan of wooden structures. Sudden deflections that occur because of loads on structural elements and permanent deformations that may occur over time are calculated in line with the elastic properties of wood. Instantaneous and long-term deformations of beams may differ depending on environmental factors. External conditions, such as fluctuations in humidity, can increase the amount of wood creep, creating more deformation than expect. For this reason, volume changes that may occur in wooden materials due to humidity changes need to be analyzed in advance and integrated into the design.

Floor drifts and connection slips that the structure may be exposed to under horizontal loads also directly affect the building's performance. In wooden structures, the displacement of building floors and elements against horizontal loads such as

earthquakes and wind should be limited to certain limits. For such cases, the shear stiffness of the structural elements is calculated, especially at the connection points, to ensure the durability of the connection elements. Evaluation of sudden deformations and connection shifts is important for designing a long-lasting structure.

Wooden structural elements should be kept under vibration control so that the vibrations during use do not affect user comfort. Vibration levels in structural elements such as flooring are calculated by considering the elements' stiffness and modal damping ratios. Vibrations caused by mechanical elements, especially rotating machines, are controlled to ensure that certain limits are not exceeded. In such cases, vibration levels are evaluated through simplified methods using features such as floor frequency, and necessary measures are taken. Thus, vibration is kept at a level suitable for building use without exceeding comfort limits.

Volume changes in wooden materials caused by humidity and temperature changes can impact on the durability and aesthetics of building elements. In wooden materials, humidity fluctuations can cause deformations such as creep and volume increase due to seasonal changes. It is important to take the necessary precautions in building design to minimize the effects of this situation to ensure the building's durability over time.

In this context, usability limit state criteria provide a guide to increase the building's durability over time of wooden structures. They cover the effects of environmental factors on building elements and time-dependent deformations of structures. Design requirements appropriate to this limit state must be provided to preserve wooden structures' durability and user comfort.

3.5.2.1.6. Fire Resistance

The behaviour of timber structural elements during a fire is evaluated based on specific design criteria to ensure structural safety. The main goal of fire safety design is to preserve the performance of structural components during a fire, limit the spread of fire within the building, and ensure the safety of evacuation routes.

The safety of structural timber elements during a fire is ensured by considering cross-sectional losses, thermal expansion effects, and the continuity of structural strength. When timber is exposed to fire, it undergoes charring, and the carbonized layer formed

on the surface acts as a protective barrier, slowing down the burning of inner layers. Therefore, the formation time of the char layer and the charring rate must be considered during the design process. Additionally, the tendency of wood to expand when heated should be considered, and clearance should be left around structural members to allow for this expansion.

The design of fire-resistant structures also involves calculating load-bearing connections and assessing their strength. Horizontal elements such as roof trusses and beams must be dimensioned by considering their load-bearing capacity under fire loads. Timber members must maintain their load-bearing capacity throughout the specified fire duration. In this context, the timeframes established by the Turkish Standards Institute are taken as a basis, and structural calculations are carried out by considering the thermal effects throughout the fire exposure period.

Because timber's charring rate is regular and predictable, it provides the designer with a specific safety timeframe. During a fire, the thickness and cross-sectional dimensions of building elements, such as walls and floors, should be sufficient to ensure structural integrity. Elements with adequate thickness and appropriate dimensions should be selected for fire resistance.

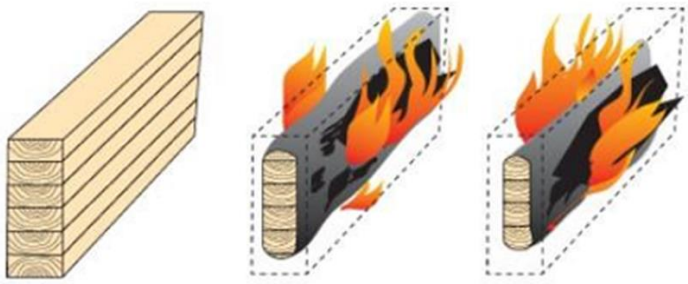


Figure 71. Schematic Illustration showing the Cross-Section of a Wooden Block after a Fire (Source: Glulamexperts, 2025)

The regulation documents the reduction in wood's mechanical properties, such as bending, compression, and tensile strength, during fire exposure, particularly in Table 6.2, which provides characteristic values used in the design of fire-resistant timber elements (Regulation, 2024, Table 6.2).

Figures 6.1 and 6.2 illustrate the structural geometry of timber elements exposed to fire—including the perimeter and area of the cross-section, the carbonized layer, and the persisting effective section—guiding how to evaluate the mechanical effects of fire (Regulation, 2024, Figures 6.1–6.2).

Special attention must be paid to the charring rate, which varies by wood type. The regulation outlines standard values for these rates, particularly for softwoods and hardwoods with specific density ranges, as found in Table 6.3 (Regulation, 2024, Table 6.3).

For wall and floor systems, when both sides of a component are exposed to fire simultaneously, the design must follow the criteria found in Annex 6E of the regulation. Similarly, joints such as nails, bolts, dowels, and plates have specific fire resistance durations defined in Table 6.7, which guides unprotected wooden connections (Regulation, 2024, Table 6.7).

Fire-protected connections, such as those using gypsum boards or additional wood-based panels, follow different resistance calculations illustrated in Figures 6.24 and 6.25. The regulation also requires specific detailing guidelines regarding the placement of fasteners and the distance from edges to ensure the integrity of the protective covering during a fire (Regulation, 2024, Figures 6.24–6.25).

For steel plates embedded in timber joints, permissible dimensions and protection requirements are detailed in Table 6.8 and illustrated in Figure 6.15. This figure shows various protection techniques, such as leaving plates unprotected, partially covered, or fully enclosed with insulation panels (Table 6.8; Figure 6.15, Regulation, 2024).

Fire protection design is evaluated under the following categories:

-Design principles

-Material properties

-Design procedures for mechanical strength

-Design methods for wall and floor systems

-Load combinations

-Detailing rules

Under design principles, it is emphasized that the structure should be built in a way that maintains its load-bearing function throughout the fire exposure period. In mandatory cases, the elements that form fire compartments must maintain their separation function during a fire. Load-bearing structural elements are expected to meet deformation criteria; however, in some cases, such deformation may be disregarded if fire protection devices are used in accordance with the regulation.

The mechanical properties of timber at 20°C are taken as reference under normal temperature conditions. For sections directly exposed to fire, the depth of charring must be calculated and considered in the cross-sectional design. This includes determining the charred line location at the 300°C isothermal curve, as explained in Figure 6.3 (Regulation, 2024, Figure 6.3).

Additional systems such as sprinklers, fire-retardant paints, and plasters should be employed to enhance fire safety according to the Regulation on Fire Protection of Buildings. If these protective measures are implemented, detailed fire resistance calculations may not be required for all wooden structures. (See Appendix 6A for the tables that took part in the ‘fire resistance’ part of the Regulation)

3.5.2.1.7. Insulation Design

This section in Regulation focuses on insulation design in wooden buildings and the control of heat, water, humidity and noise effects. By applying the relevant standards and regulations, energy efficiency and user comfort are increased while the life of the structure is extended.

Regarding heat insulation, wooden buildings' environmental separating elements (walls, floors, roofs) should be designed to provide sufficient thermal resistance according to the conditions on both sides. In cases where thermal resistance is insufficient, the thickness of the insulation material should be increased, or materials with higher thermal resistance should be used. Additional insulation layers can be added where structural dimensions cannot be changed. However, adding

waterproofing with high vapour permeability behind the coating is necessary to prevent condensation.

Appendix 7A.1 shows a cross-section of thermal insulation at the junction points of walls, floors, and roofs in wooden buildings. It is emphasized that continuous insulation is necessary to prevent thermal bridge formation, and vapour balancing layers are used to prevent condensation. Additionally, it was stated that metal elements should be prevented from continuing, and wooden components should be preferred.

In Appendix 7A.2, the relationship between the wooden structure's upper floor flooring and the external wall is detailed. It has been explained that condensation should be prevented by adding vapour-permeable waterproofing behind the exterior covering material, and the points where the wooden elements come into contact in the wall section should be adequately insulated. (See Appendix 7A.1 and 7A.2 for detailed solutions of thermal insulation)

Thermal bridges increase the energy loss of the structure and can also trigger condensation problems. Therefore, continuity in insulation should be ensured, and wooden components should be preferred over metal fasteners. Thermal conductivity calculations must be made according to the TS 825 standard, and the structure must meet heat loss values appropriate to the climate region.

Water insulation is essential to protect wooden structures from water ingress from the external environment. Vapour barriers can be used to control vapour flow in exteriors and interiors. Insulation layers should be detailed to prevent water from penetrating into the structure. Inclined surfaces should be designed to ensure water drainage on building facades, and the junctions between the exterior and the building elements should be carefully insulated.

During installation, the humidity rate of wooden elements should be kept below 16%. In cases where humidity cannot be controlled, the structure should be supported with temporary protection measures. Sectional solutions for waterproofing details are given in Appendix 7A.3 and Appendix 7A.4.

Wood is a material with high sound absorption that is widely used to provide acoustic comfort in interior spaces. Designs with an air gap perform better in terms of sound

insulation than narrow ones. By ensuring discontinuity in floor and wall systems, the transmission of impact sound is minimized. For example, it is recommended to cover floors with flexible materials to reduce impact sound between floors.

Sound insulation in timber frame systems depends on the design of the building components. Plasterboards can be mounted with flexible connections to prevent sound transmission. Additionally, the surroundings of installation elements can be insulated with sound-absorbing materials to contribute to acoustic and moisture management.

This section includes the basic principles of insulation design. Recommended detailed solutions and calculation methods, in accordance with the TS 825 standard, enable wooden structures to be designed for energy efficiency and comfort conditions.

3.6. Evaluation of the Regulation

The "Regulation on Design, Calculation and Construction Principles of Wooden Buildings" was published in the Official Gazette on 24 March 2024 and entered into force on 1 January 2025, following the necessary regulations. This regulation has brought many innovations, from engineering calculations to design methods. In addition, the "Design Samples Guide", published with the new regulation, will create an excellent guide for engineers and designers in the sector.

This regulation, prepared by the General Directorate of Vocational Services, aims to encourage the use of wood, an environmentally friendly material, in the construction sector. It considers wood's advantages, such as flexibility, recyclability, low environmental footprint, and safe performance against earthquakes.

The regulation, which determines the principles regarding the design, calculations and construction of wooden structures, foresees the use of tree species included in the TS EN 1912 standard. This standard details the materials suitable for construction timber, covering strength classes and visual classifications. Tree species from Turkey, such as larch, fir, Scots pine, red pine, cedar and spruce, are also included in this standard and are classified together with internationally preferred species such as pine, spruce and fir.

The six native tree species are grouped as follows:

-Divided into softwoods (class C) and hardwoods (class D).

-Tables have been prepared according to homogeneous and composite properties for glued laminated wood materials.

The regulation contains technical principles for experts who will design wooden buildings and administrations with licensing authority. Within the scope of design:

-Limit states are defined based on criteria such as strength, usability, fire and insulation.

-Strength calculation methods for axial tension, bending, pressure, shear force and combined effects are detailed.

-Load combinations and performance criteria of wooden elements are discussed.

In addition to traditional light frame systems, cross-laminated timber (CLT) systems, which have a very high carrying capacity and are widely used worldwide, are also included in the scope of this regulation. The cross-sectional properties of CLT panels and their behaviour in the plane and under effects perpendicular to the plane are explained in detail. Additionally, usability limit states of CLT elements and alternative vibration and damping calculations are included. Connection calculations of CLT systems are discussed in a separate section, together with the connection calculations of wooden elements.

Regulation is important for the fire resistance of wooden structures. It details issues such as carbonization depth, material performance during fire, and combinations' fire behavior. The regulation also includes explanations regarding fire-protected and unprotected connections.

Insulation design for regulating effects such as heat, water, humidity and noise is addressed as a separate heading in the regulation. Solution suggestions for heat, sound and water insulation are supported with figures, and thermal insulation calculation steps are presented in detail.

As a result, the preparation of a regulation on wooden structures will increase wooden building construction and make significant contributions to the sector. Using trees from local forests will both support the local economy and reduce construction costs.

CHAPTER 4: COMPARATIVE ANALYSIS OF WOODEN HYBRID STRUCTURES AND REINFORCED CONCRETE STRUCTURE

4.1 Information about Structures and Evaluation Methodologies

In today's context of creating cities with identity and livability, the importance of using environmentally sustainable building materials is increasing. Although wooden structures were quite common in Turkey in the past century, they have lost their value today, reducing the quality of our livable cities and beginning to affect our quality of life. Wood is important among ecological building materials due to its lightness, low carbon emissions, high thermal insulation capacity, and being a renewable resource (Gustavsson and Sathre, 2011). However, reinforced concrete structural systems are a type of construction that is long-lasting, has high load-bearing capacity, and is widely used, offering specific advantages in terms of economy and engineering. In this direction, reinforced concrete structures have become widespread in the modern era.

Contrary to our country's situation, there has been an increasing tendency toward wooden structures, considering their advantages. Multi-story buildings constructed with wooden structures have started to stand out in city skylines. In Turkey, the use of wood has not become widespread. This is primarily due to the lack of regulations for designing wooden structures, the limited production of structural wood that meets load-bearing system criteria, and prevailing misconceptions about wood.

Traditional wooden construction techniques, which were used until a century ago, have been replaced by reinforced concrete constructions. However, the architectural design ideology brought by reinforced concrete has proven to be insufficient in terms of sustainability.

Within the scope of this thesis, a wood-concrete lodging building constructed in Kahramanmaraş-Andırın was redesigned in STA4CAD and STA Steel programs using two different construction techniques, as wood-steel and concrete structures. In addition, the architectural projects are redesigned in Archicad with same form and function. These three structures are shown below. (Figure 72)

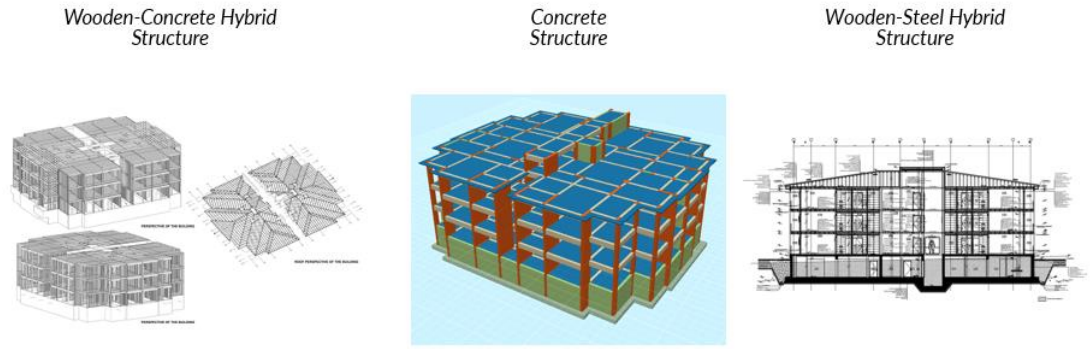


Figure 72. A Wooden-Concrete Hybrid Structure, located in Andırın/Kahramanmaraş, a Hybrid Wooden-Steel Structure and a Concrete Project, designed for the case study

This wooden-concrete hybrid structure, located in the Andırın district of Kahramanmaraş, was constructed in accordance with the *Regulation on the Design, Calculation, and Construction of Timber Buildings*, published in the Official Gazette dated March 24, 2024, which addresses technical and safety standards related to fire safety, earthquake resistance, and load-bearing systems. The reinforced concrete and wooden-steel hybrid structures, designed with the same form and function, were planned in accordance with the *Turkish Building Earthquake Code* published in the Official Gazette dated March 18, 2018. The building consists of a total of 3 floors, including one basement level.

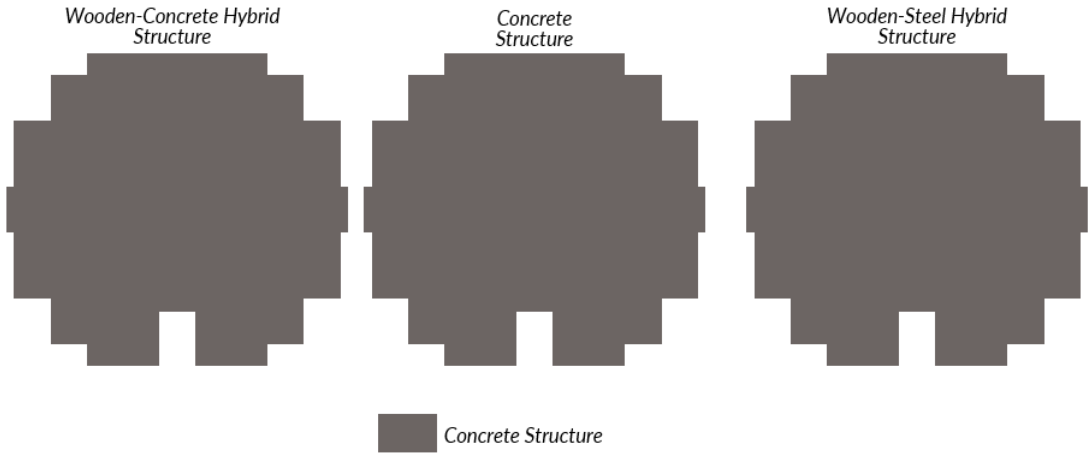


Figure 73. The Basement Floor Schematic Plans of these Three Structures

Based on the lodging building in Andırın District of Kahramanmaraş, the basement floors of the newly designed hybrid wooden-steel structure and the reinforced concrete structure were designed as reinforced concrete. (Figure 73)

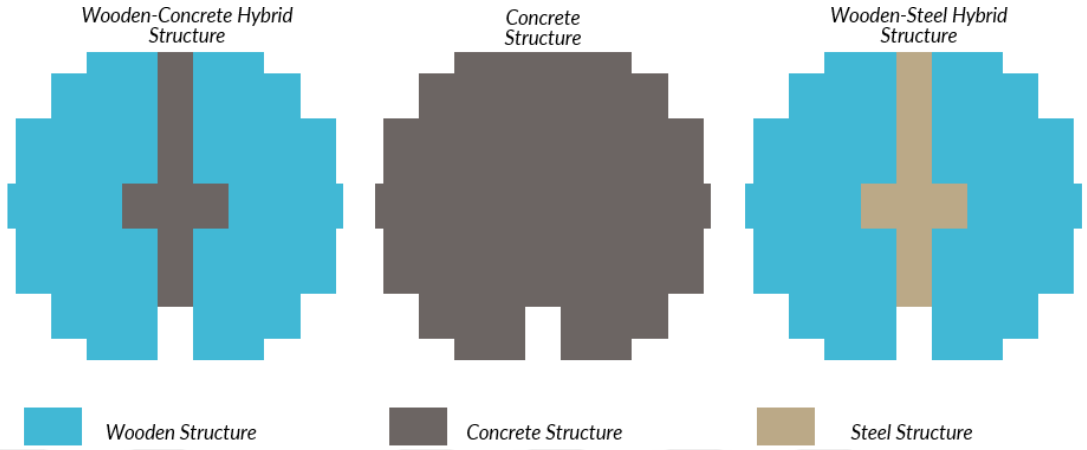


Figure 74. The Ground, First and Second Floor Schematic Plans of these Three Structures

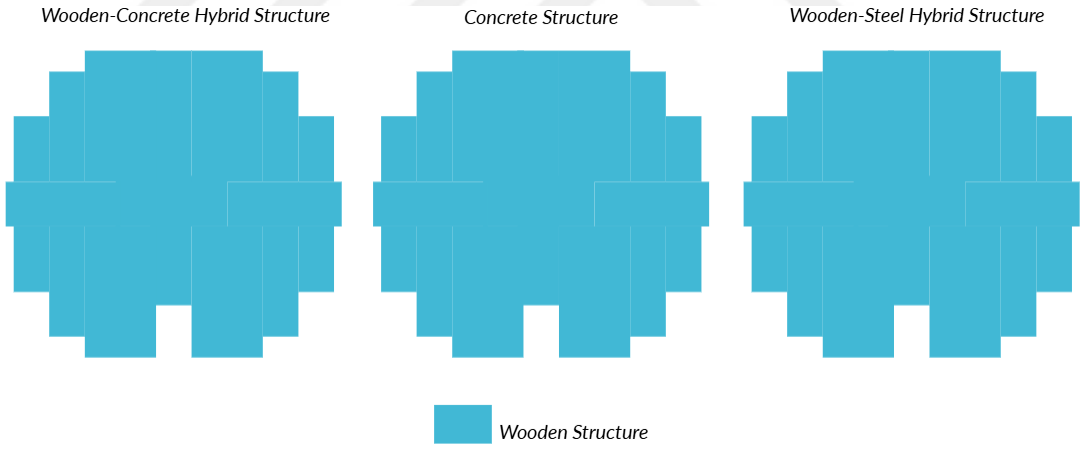


Figure 75. Roof Floor Schematic Plans of these Three Structures

While the core part of the hybrid wooden lodging building constructed in the Andırın District of Kahramanmaraş was built with reinforced concrete, the core part of the newly designed hybrid wooden-steel structure was designed with steel. Additionally, no wooden materials were used in the building designed as reinforced concrete. Subsequently, the buildings constructed with these three techniques were analysed regarding cost, construction speed, and environmental impact. (Figure 76)

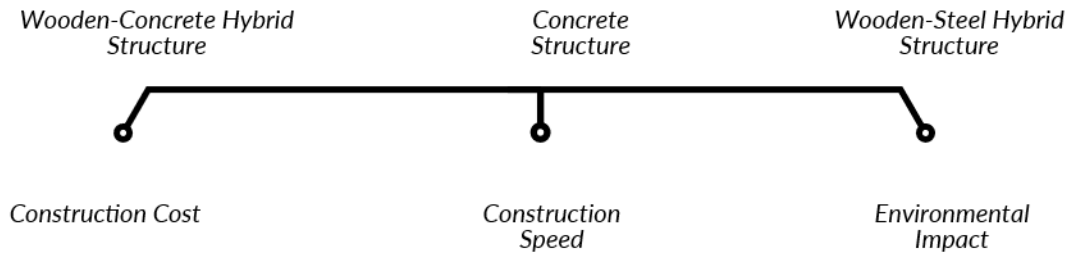


Figure 76. The Graphic of the Anaylzing Methodology of the Hybrid Wooden and Concrete Structures

The rough construction quantities were taken as a reference to performing the necessary analyses for construction costs and construction speeds. These are presented in detail in the quantity, cost, and construction speed tables.

The Wood-Concrete Hybrid Structure, located in Andırın/Kahramanmaraş

The building selected as the case study for the thesis is a wooden structure located in Andırın, Kahramanmaraş. The central core of the building constructed in Kahramanmaraş-Andırın is entirely made of reinforced concrete. The building consists of a basement floor and a ground floor plus two additional floors. The foundation and basement floor are reinforced concrete structures. The remaining floor slabs, columns, and walls are constructed from wood.

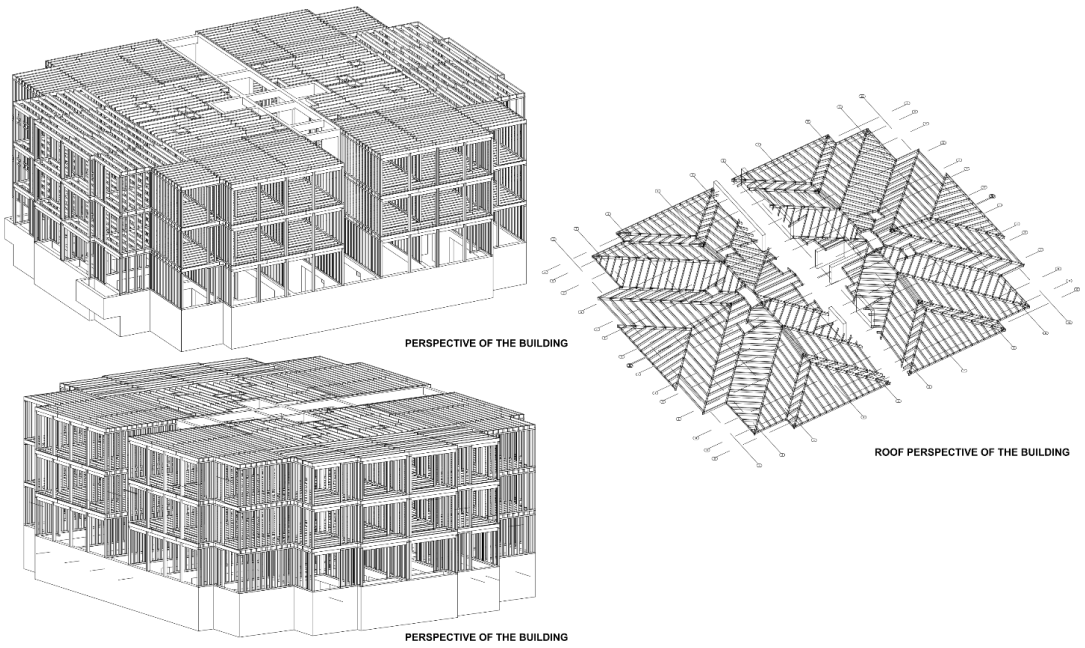
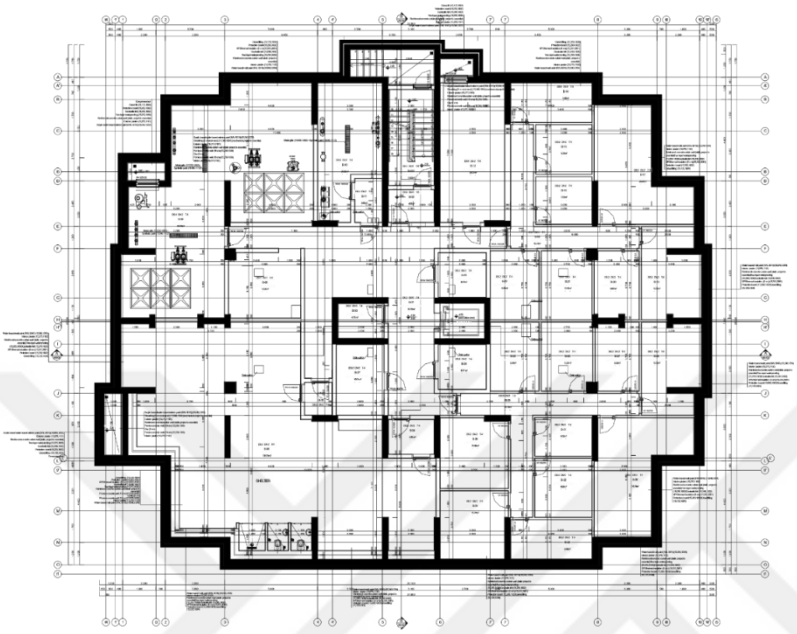


Figure 77. Perspectives of the Structure (Static Project), (Source: Demirkıran, 2023)

This building is, in fact, a hybrid structure that incorporates both wood and reinforced concrete. The building has been referred to as a wood-concrete hybrid structure. The architectural floor plans of the building are shown below. (See detailed plans for wood-concrete hybrid structure in Appendix B)



-Wall: Curtain Concrete Wall

-Floor: Concrete Flooring

-Column and beams: Concrete Structural System

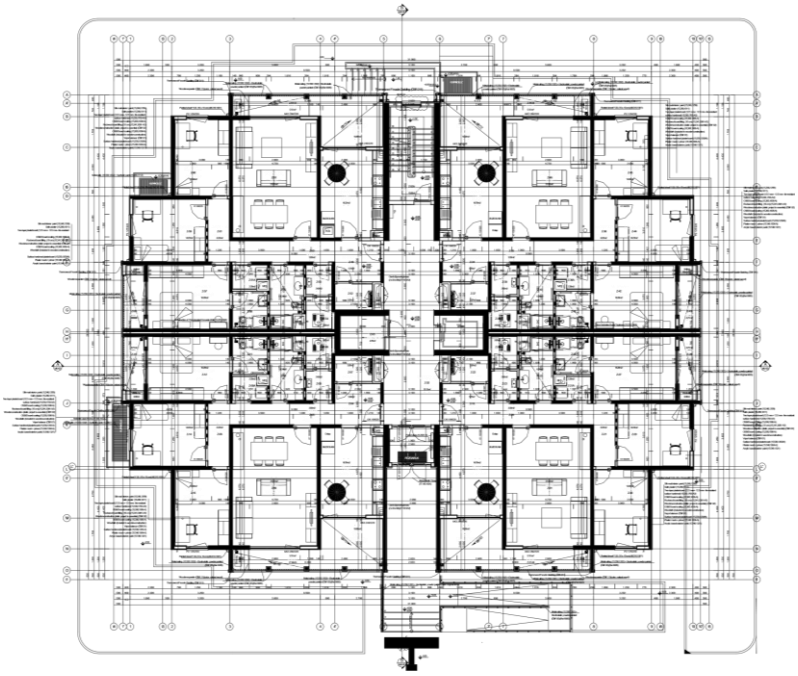
***For Core of the Wood-Concrete Building:**

-Walls: Curtain Concrete Wall

-Floor: Concrete Flooring

-Colums and Beams: Concrete Structural System

Figure 78. Basement Floor Plan (-3.00) (Architectural Plan), (Source: Çetinkaya,2023)



-Wall: Gypsum Board

Rockwool board filling (10 cm)

Wooden construction

OSB/3 board coating

-Floor: Laminate flooring

OSB/3 board covering

Rockwool board filling (10 cm)

Wooden construction

-Ceilling: Gypsum Board

-Column and beams: Wooden Structural System

***For Core of the Wooden Building:**

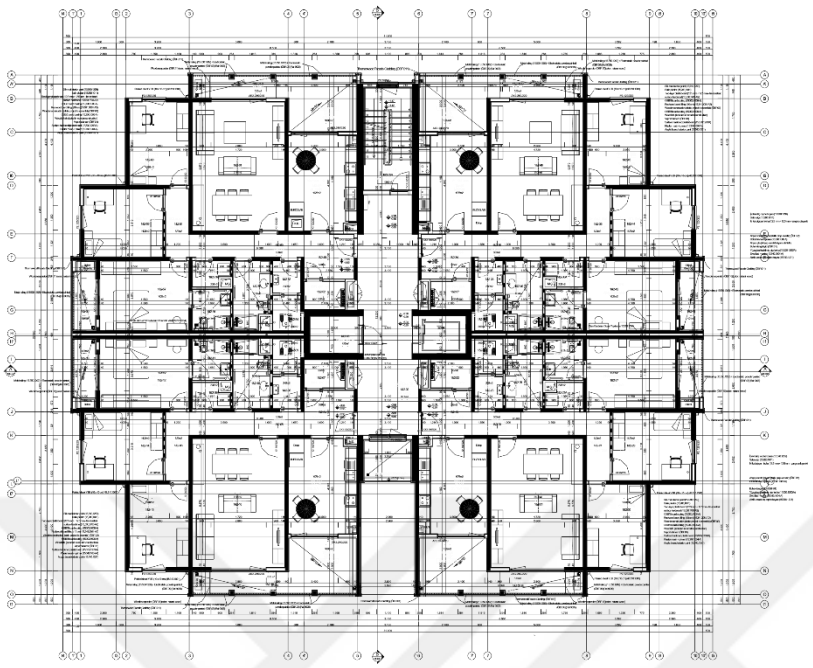
-Walls: Gypsum Board- Rockwool board filling (10 cm) -OSB/3 board coating

-Floor: Reinforced Concrete Flooring

-Ceilling: Gypsum Board

Colums and Beams: Concrete construction

Figure 79. Ground Floor Plan (±0.00) (Architectural Plan), (Source: Çetinkaya,2023)



-Wall: Gypsum Board

Rockwool board filling (10 cm)

Wooden construction

OSB/3 board coating

-Floor: Laminate flooring

OSB/3 board covering

Rockwool board filling (10 cm)

Wooden construction

-Ceilling: Gypsum Board

-Column and beams: Wooden

Structural

System

***For Core of the Wooden Building:**

-Walls: Gypsum Board- Rockwool

board

filling (10 cm) -OSB/3 board coating

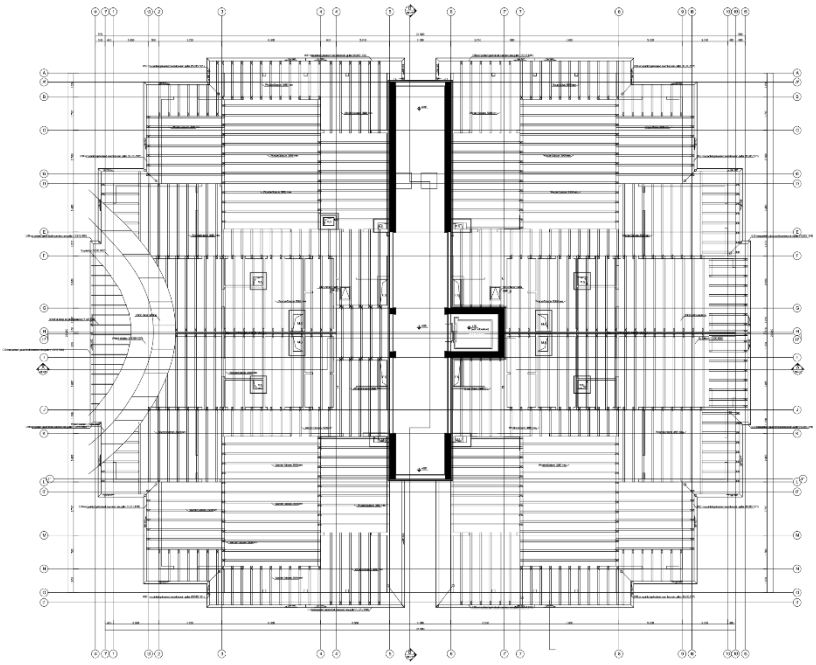
-Floor: Reinforced Concrete Flooring

-Ceilling: Gypsum Board

Colums and Beams: Concrete

Construction

Figure 80. 1st and 2nd Floor Plan (+2.95, +5.90) (Architectural Plan), (Source: Çetinkaya, 2023)



-Roof: OSB/3 Board covering

Wooden Structural System

***For Core of the Wooden Building:**

-Walls: Gypsum Board- Rockwool

board filling (10 cm) -OSB/3 board

coating

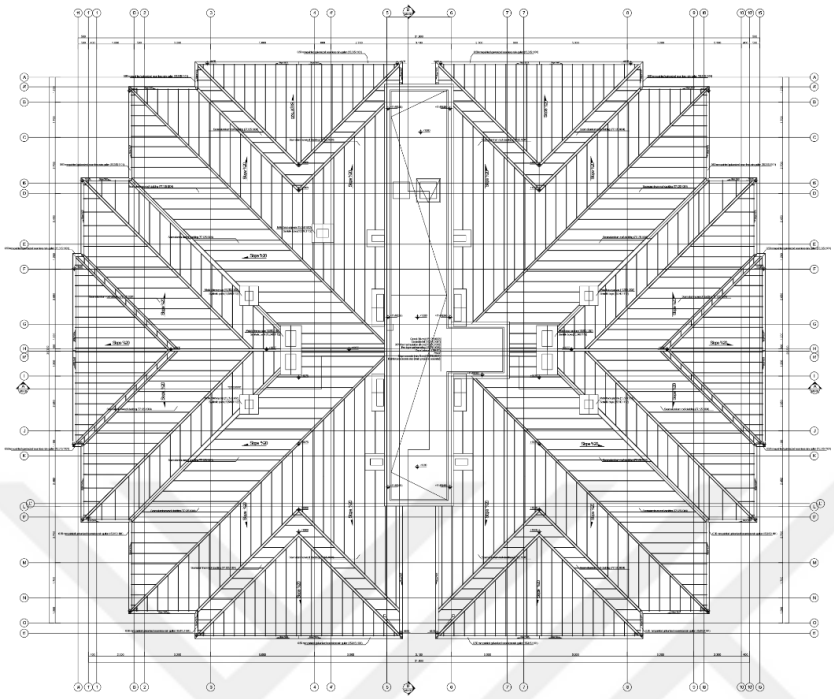
-Floor: Reinforced Concrete Flooring

-Ceilling: Gypsum Board

-Colums and Beams: Concrete

construction

Figure 81. Roof Floor Plan (+8.85) (Architectural Plan), (Source: Çetinkaya, 2023)



-**Roof:** OSB/3 Board covering Wooden Structural System

***For Core of the Wooden Building:**

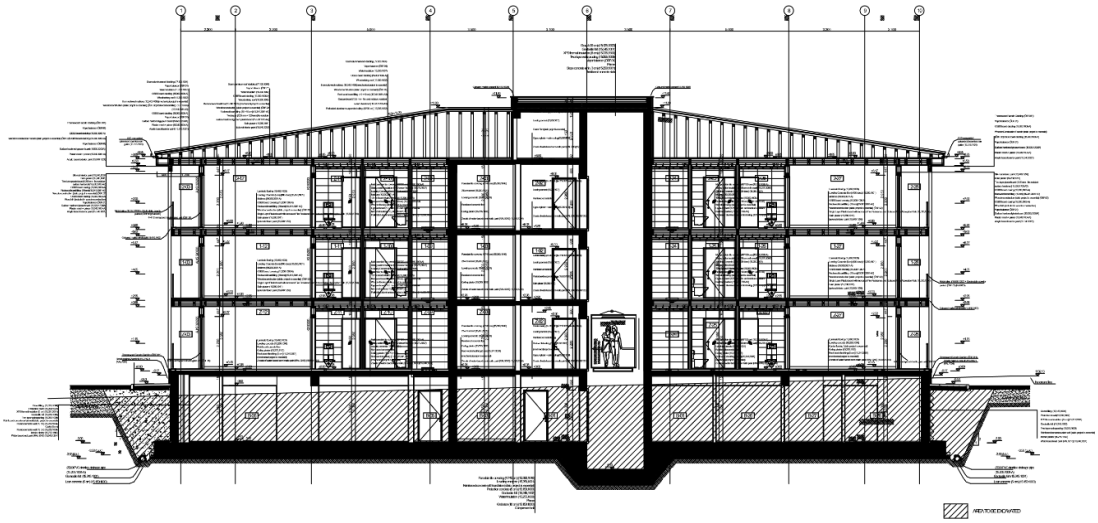
-Walls: Gypsum Board- Rockwool board filling (10 cm) -OSB/3 board coating

-Floor: Reinforced Concrete Flooring

-Ceilling: Gypsum Board

-Colums and Beams: Concrete construction

Figure 82. Roof Plan (+10.80) (Architectural Plan), (Source: Çetinkaya, 2023)



83. Section AA (Architectural Plan), (Source: Çetinkaya,2023)

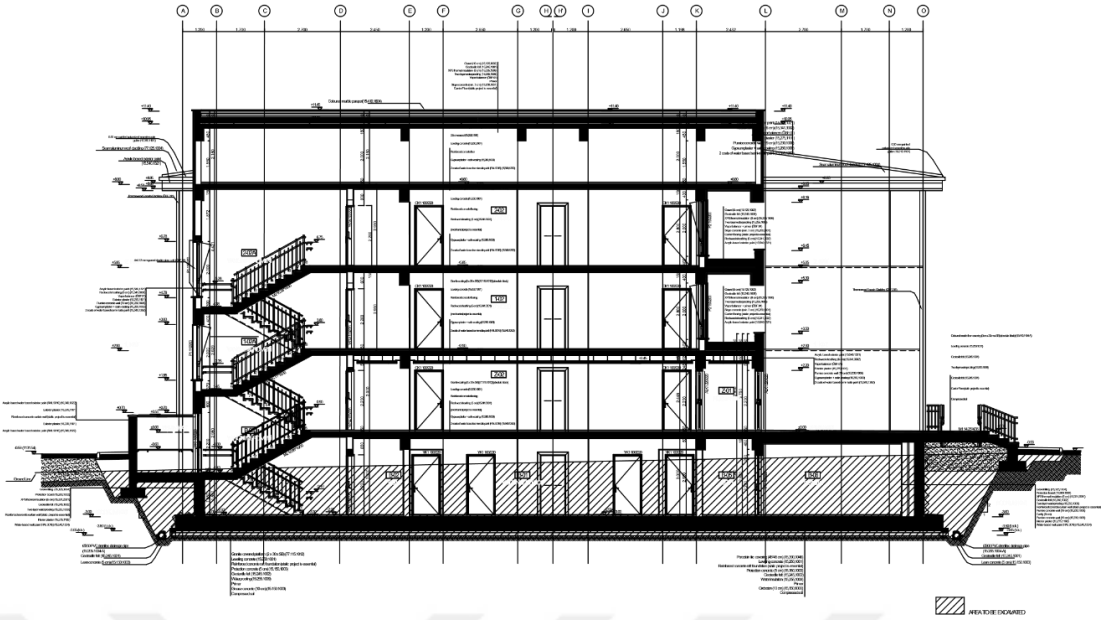


Figure 84. Section BB (Architectural Plan), (Source: Çetinkaya, 2023)

In the wooden-reinforced concrete hybrid structure, rough construction quantities were taken into consideration. In the basement floor, concrete was used for shear walls, reinforced concrete slabs, columns, and beams. In the core part of this hybrid structure, the same materials were also used for the walls.

On the ground floor, first floor, and second floor, wooden construction was utilized by using drywall, rockwool board filling, and OSB/3 boarding coating on the walls. The floor was constructed with a wooden structure covered with rockwool board filling, OSB/3 board covering, and finished with laminate. The suspended ceilings were made of drywall. The columns and beams were constructed of wood.

In the core part of the wooden-reinforced concrete hybrid structure, drywall, rockwool board, and OSB/3 board were used for the walls. The floor and columns were made of reinforced concrete, while the suspended ceiling was made of drywall.

The shear wall application plans for each floor of the wood-concrete hybrid structure are shown below.

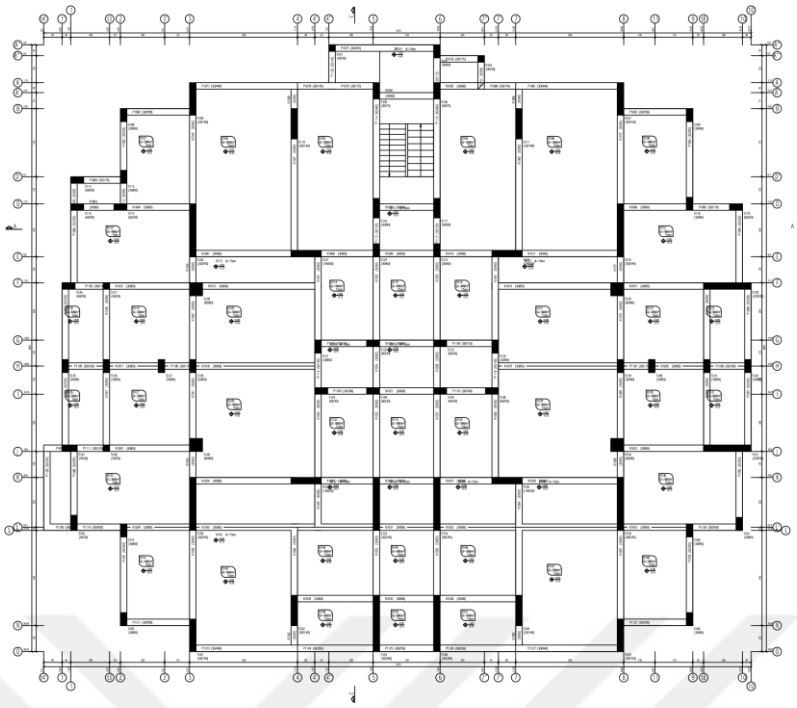


Figure 85. Basement Floor Formwork Plan (Static Project),(Source: Demirkıran, 2023)

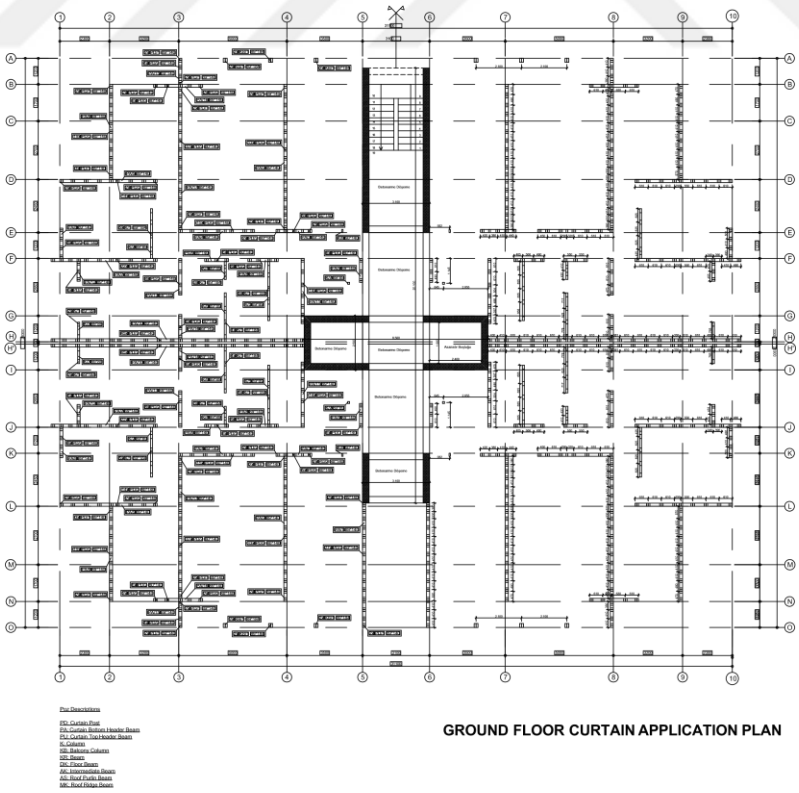


Figure 86. Ground Floor Formwork Plan (Static Project), (Source: Demirkıran, 2023)

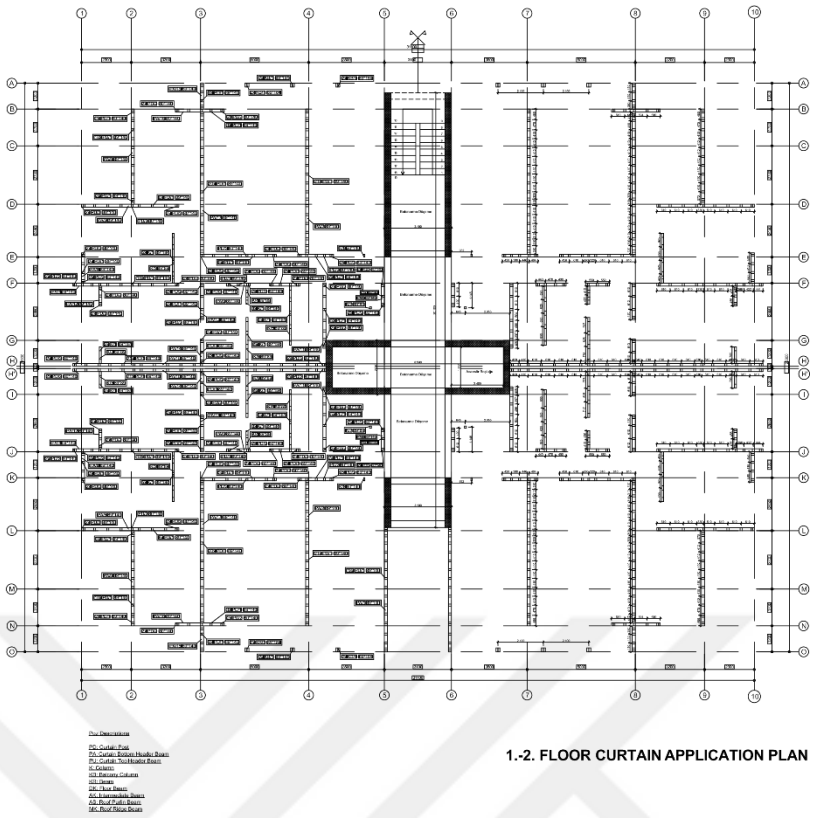


Figure 87. 1st and 2nd Floor Formwork Plan (Static Project), (Source: Demirkıran, 2023)

The Reinforced Concrete Structure

Secondly, the building constructed in Kahramanmaraş-Andırın has been modeled in STA4CAD as a reinforced concrete structure while maintaining the same form and characteristics for comparison purposes. The architectural plans are made in ArchiCAD.

Since the structure was designed as reinforced concrete, aerated concrete blocks were used for the walls. Within the scope of this thesis, this structure has been classified as a reinforced concrete building. Below are the architectural floor plans of the reinforced concrete structure. (See detailed plans for reinforced structure in Appendix C)

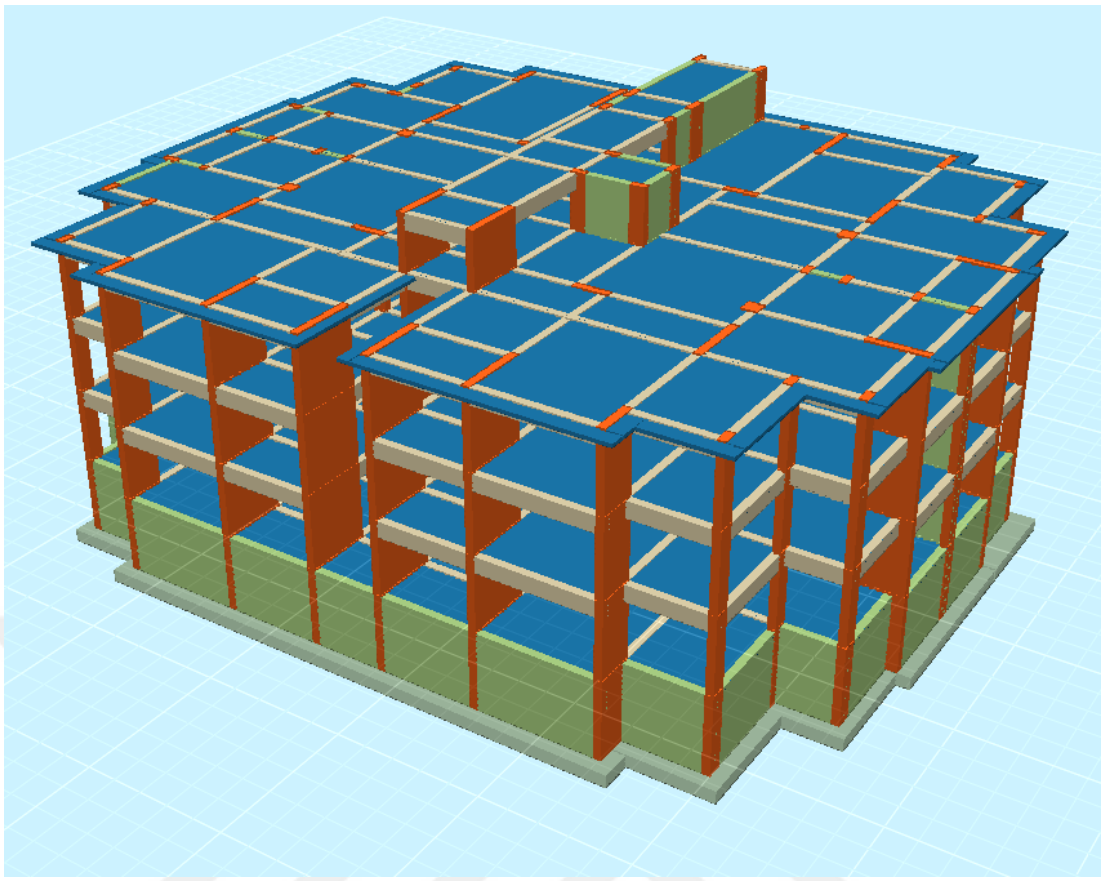


Figure 88. Perspective of the Structural System

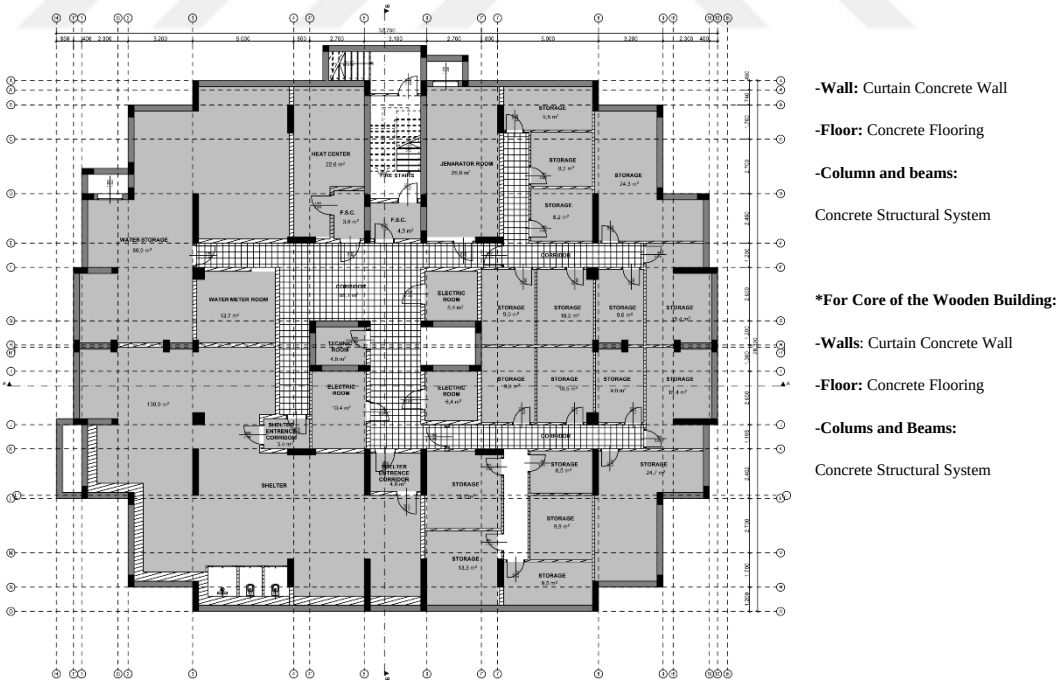
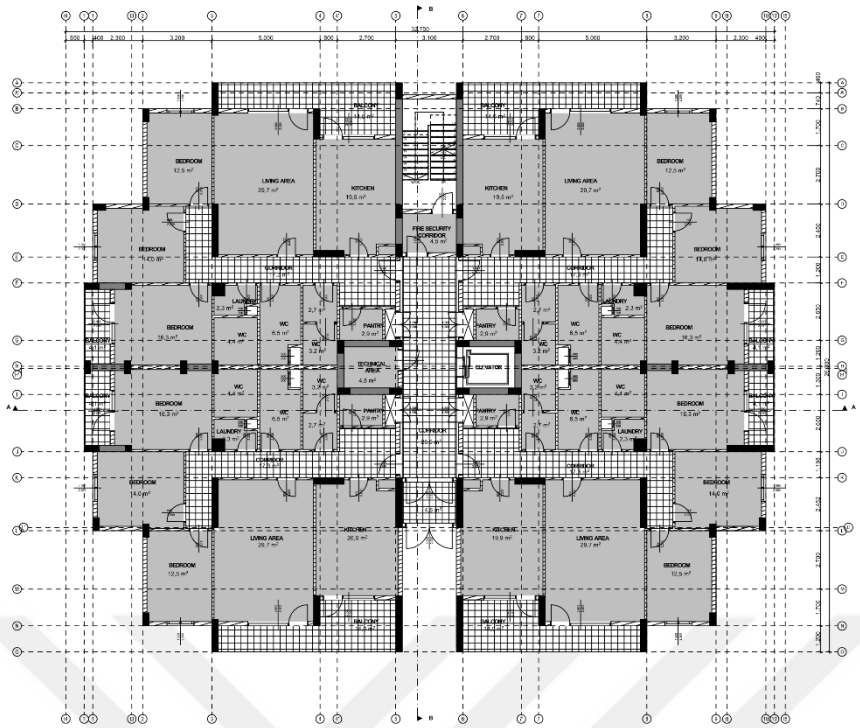


Figure 89. Basement Floor Plan (-3.00) (Architectural Project)



-Wall: Aerated concrete (Bims Wall)

-Floor: Concrete Structural System

-Ceilling: Gypsum Board

-Column and beams: Concrete Structural System

For Core of the Wooden Building:

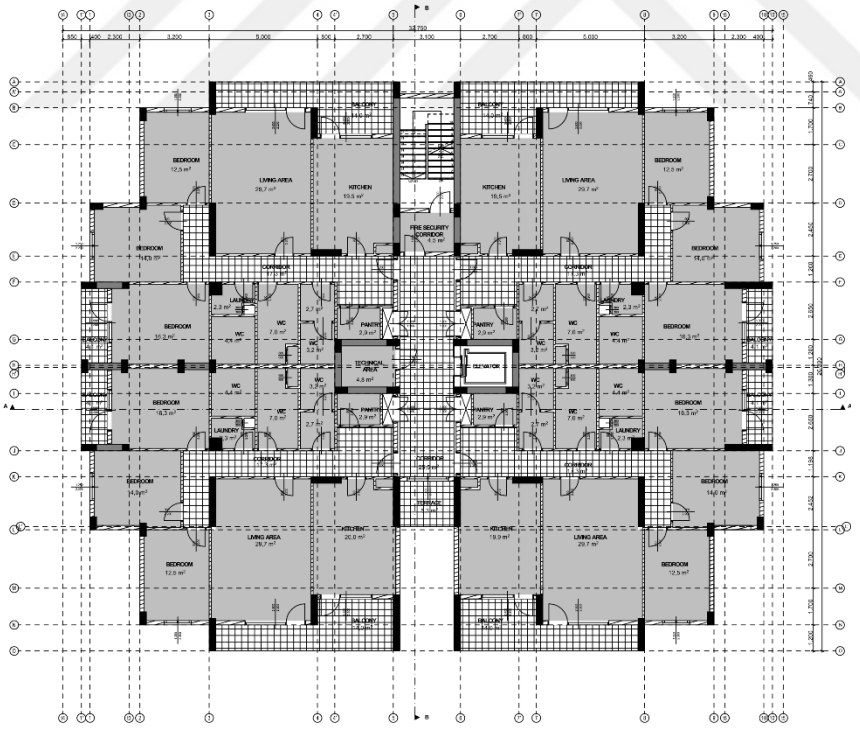
-Walls: Aerated concrete (Bims Wall)

-Floor: Concrete Structural System

-Ceilling: Gypsum Board

-Colums and Beams: Concrete Structural System

Figure 90. Ground Floor Plan (±0.00) (Architectural Project)



-Wall: Aerated concrete (Bims Wall)

-Floor: Concrete Structural System

-Ceilling: Gypsum Board

-Column and beams: Concrete Structural System

***For Core of the Wooden Building:**

-Walls: Aerated concrete (Bims Wall)

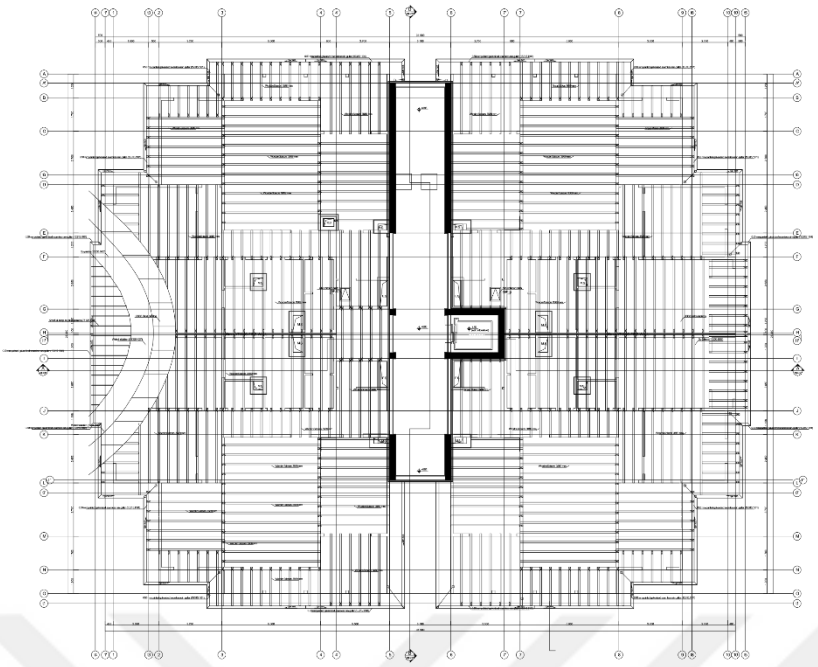
-Floor: Concrete Structural System

-Ceilling: Gypsum Board

-Colums and Beams:

Concrete Structural System

Figure 91. 1st and 2nd Floor Plans (+2.95, +5.90) (Architectural Project)



-Wall: Aerated concrete (Bims Wall)

-Floor: Reinforced Concrete Flooring

-Ceilling: Gypsum Board

-Column and beams: Concrete Structural System

-Roof: OSB/3 Board covering Wooden Structural System

***For Core of the Wooden Building:**

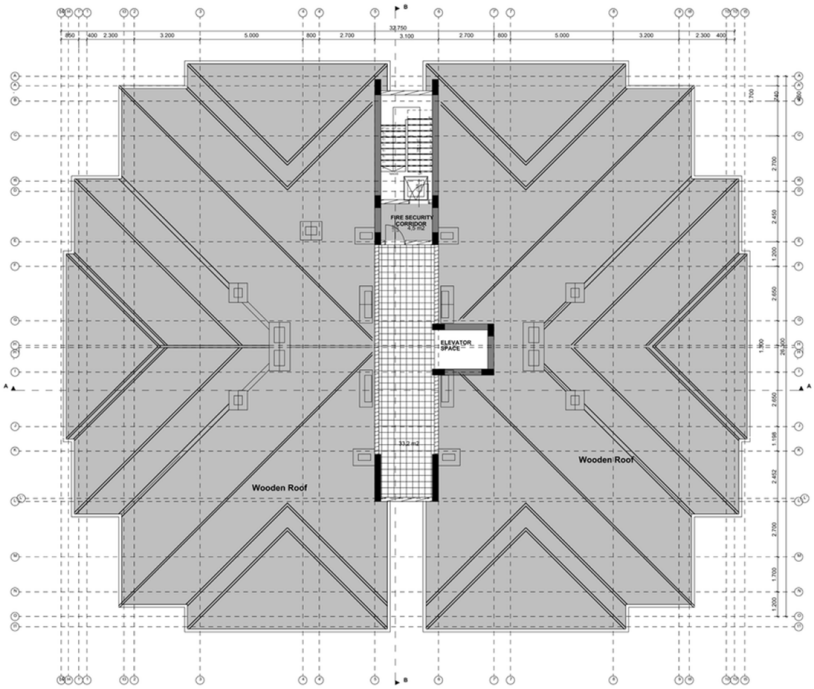
-Walls: Aerated concrete (Bims Wall)

-Floor: Reinforced Concrete Flooring

-Ceilling: Gypsum Board

-Colums and Beams: Concrete Structural System

Figure 92. Roof Floor Plan (+8.85) (Architectural project)



Wall: Aerated concrete (Bims Wall)

-Floor: Reinforced Concrete Flooring

-Ceilling: Gypsum Board

-Column and beams: Concrete Structural System

-Roof: OSB/3 Board covering Wooden Structural System

***For Core of the Wooden Building:**

-Walls: Aerated concrete (Bims Wall)

-Floor: Reinforced Concrete Flooring

-Ceilling: Gypsum Board

-Colums and Beams: Concrete Structural System

Figure 93. Roof Plan (+10.80) (Architectural Project)

The roof floor of the concrete structure is designed similar with the Andırın/ Kahramanmaraş lodging project as wooden structure.

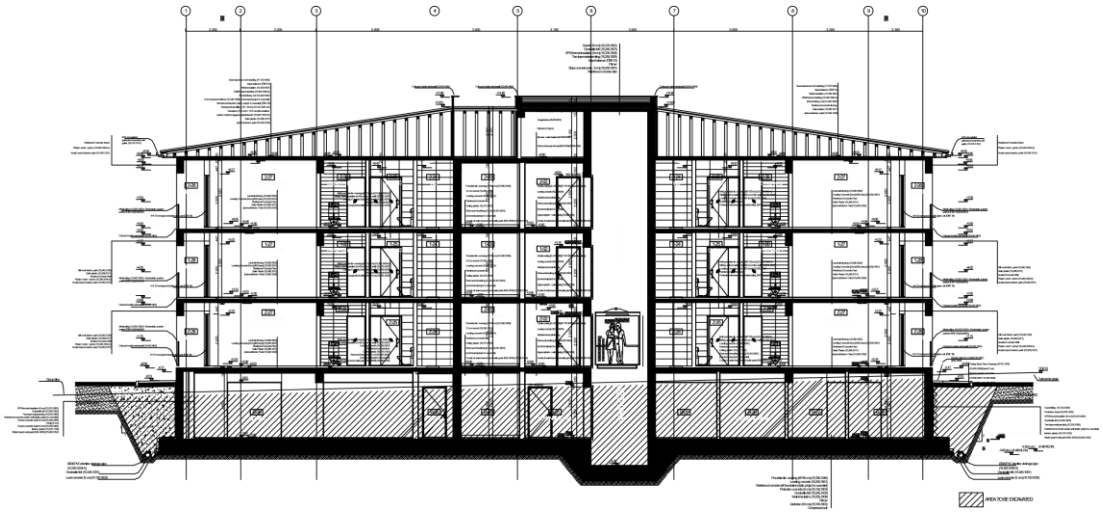


Figure 94. Section AA (Architectural Project)

The floor plans included in the structural project of the reinforced concrete building are shown below.

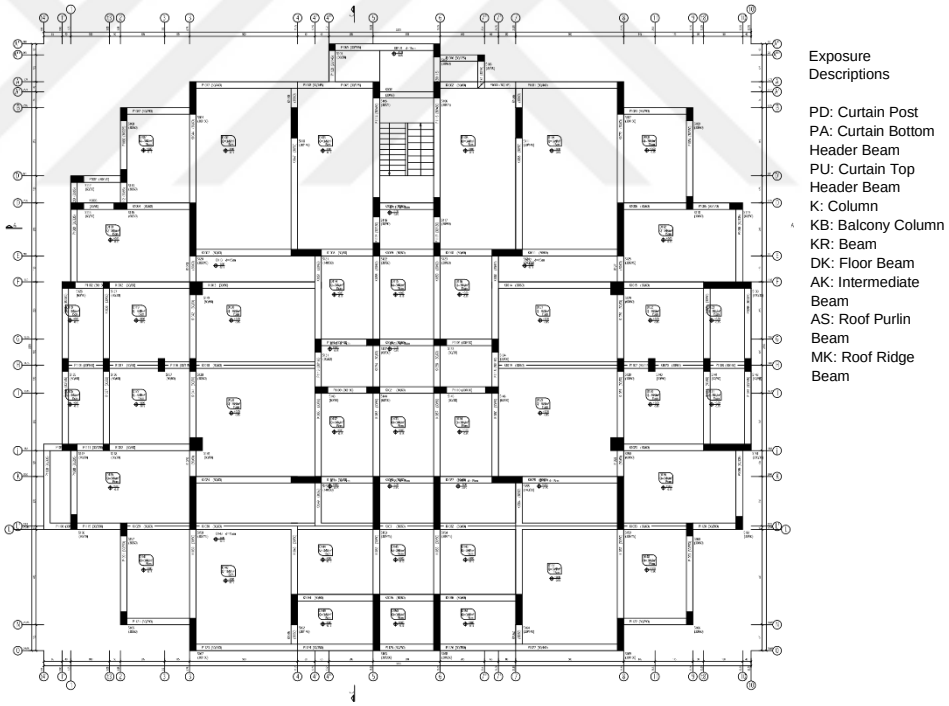
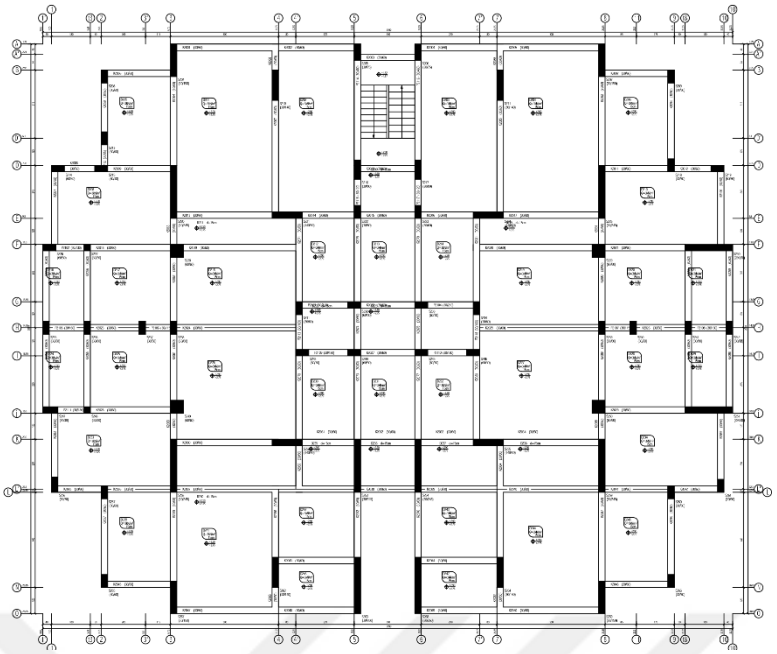


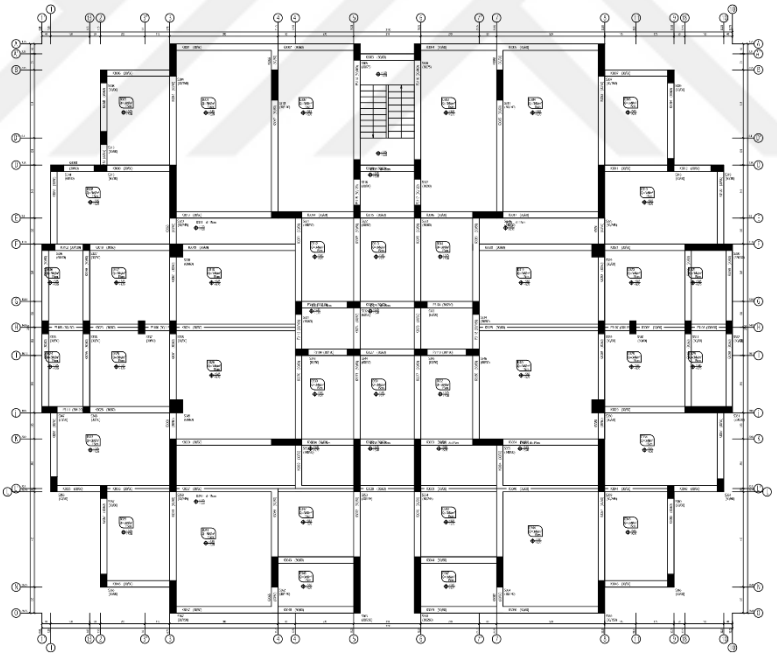
Figure 95. Basement Floor Formwork Plan (Static Project)



Exposure Descriptions

PD: Curtain Post
PA: Curtain Bottom Header Beam
PU: Curtain Top Header Beam
K: Column
KB: Balcony Column
KR: Beam
DK: Floor Beam
AK: Intermediate Beam
AS: Roof Purlin Beam
MK: Roof Ridge Beam

Figure 96. Ground Floor Formwork Plan (Static Project)



Exposure Descriptions
PD: Curtain Post
PA: Curtain Bottom Header Beam
PU: Curtain Top Header Beam
K: Column
KB: Balcony Column
KR: Beam
DK: Floor Beam
AK: Intermediate Beam
AS: Roof Purlin Beam
MK: Roof Ridge Beam

Figure 97. 1st and 2nd Floor Formwork Plan (Static Project)

The Wood-Steel Hybrid Structure

Finally, in the same structural context, while the basement floor remains reinforced concrete, the reinforced concrete area in the middle section of the building has been designed as steel core construction in STA Steel. The architectural plans are drawn ArchiCAD. The wood used in the floors, along with the slabs, columns, and walls, are identical to the details in the architectural project. This structure has been classified as a wood-steel hybrid structure within the scope of this thesis. (See detailed plans for wood-steel hybrid structure in Appendix D)

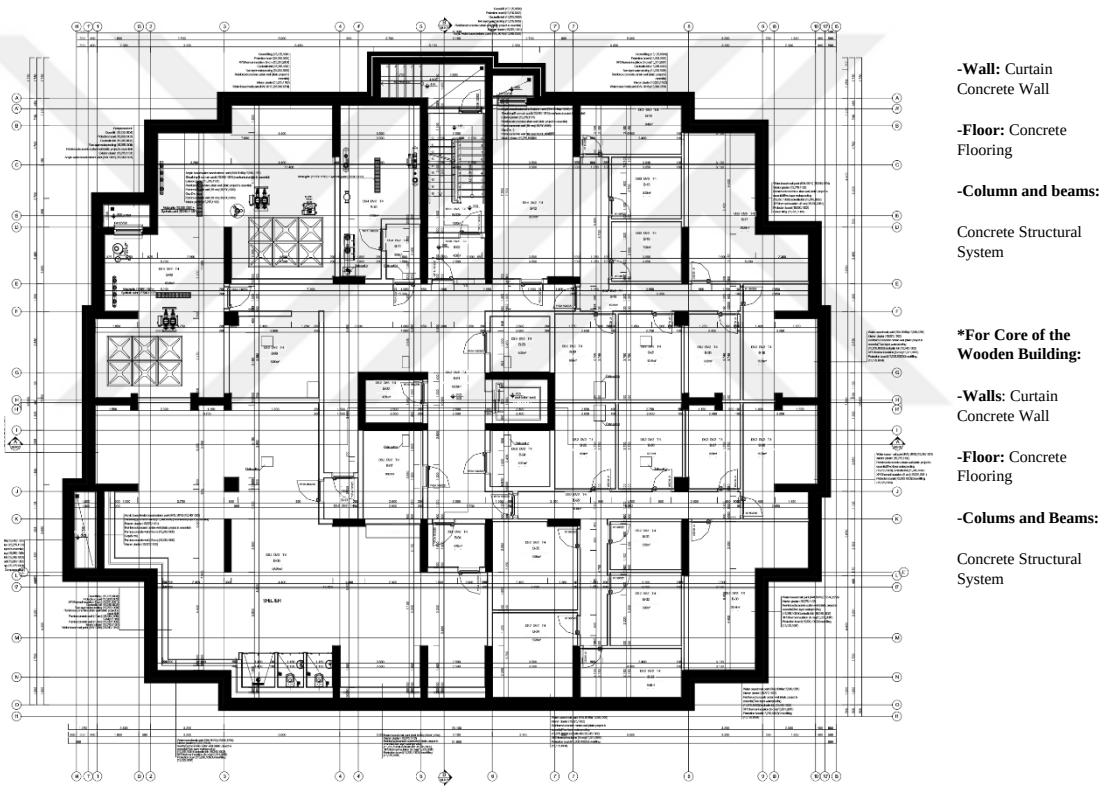
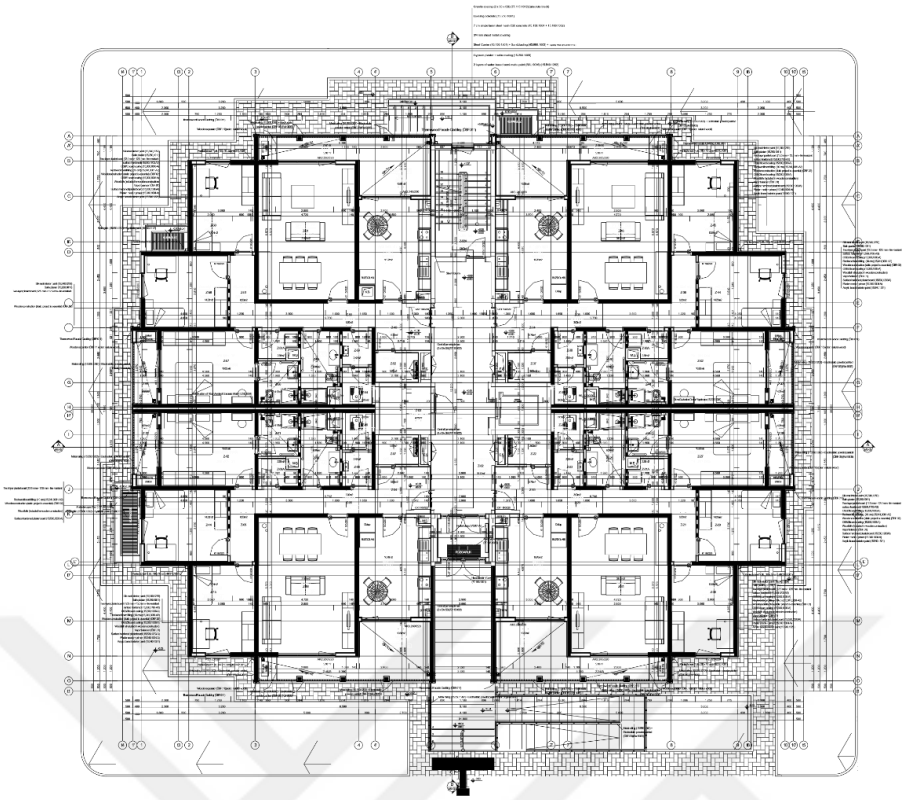


Figure 98. Basement Floor Plan (-3.00) (Architectural Project)



-Wall: Gypsum Board

Rockwool board filling (10 cm)

Wooden construction

OSB/3 board coating

-Floor: Laminate flooring

OSB/3 board covering

Rockwool board filling (10 cm)

Wooden construction

-Ceilling: Gypsum Board

-Column and beams: Wooden Structural System

***For Core of the Wooden Building:**

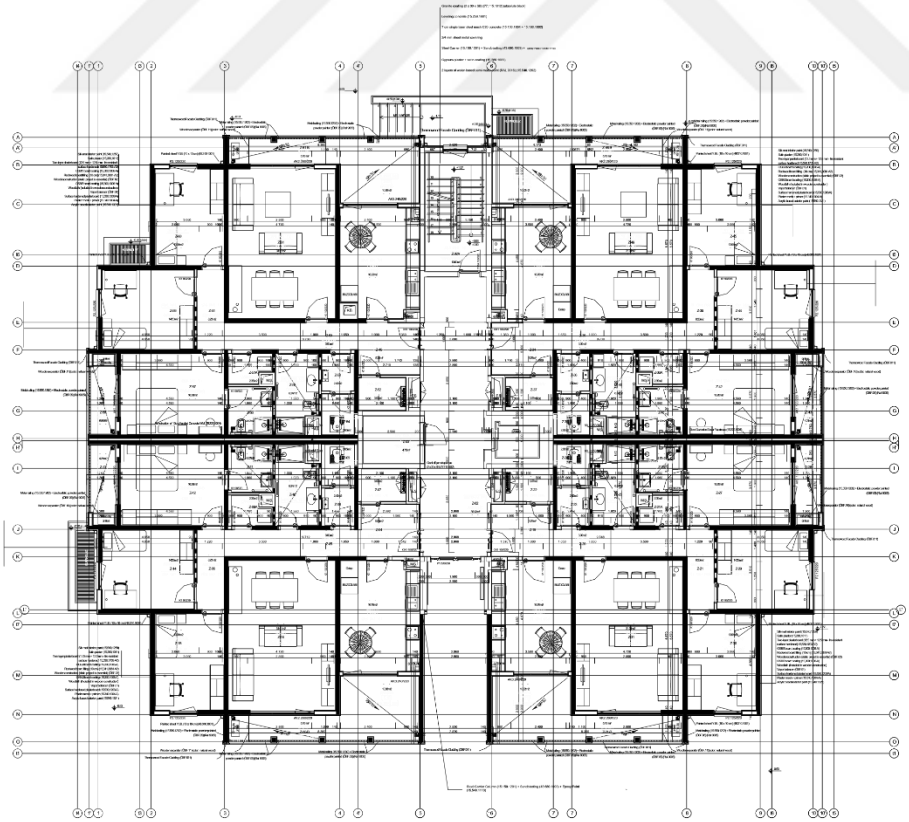
-Walls: Gypsum Board- Rockwool board filling (10 cm)- Gypsum Board

-Floor: Steel Construction- Trapezoidal Sheet Metal Coating- Leveling Concrete

-Ceilling: Gypsum Board

-Colums and Beams: Steel construction

Figure 99. Ground Floor Plan (±0.00) (Architectural Project)



-Wall: Gypsum Board

Rockwool board filling (10 cm)

Wooden construction

OSB/3 board coating

-Floor: Laminate flooring

OSB/3 board covering

Rockwool board filling (10 cm)

Wooden construction

-Ceilling: Gypsum Board

-Column and beams: Wooden Structural System

***For Core of the Wooden Building:**

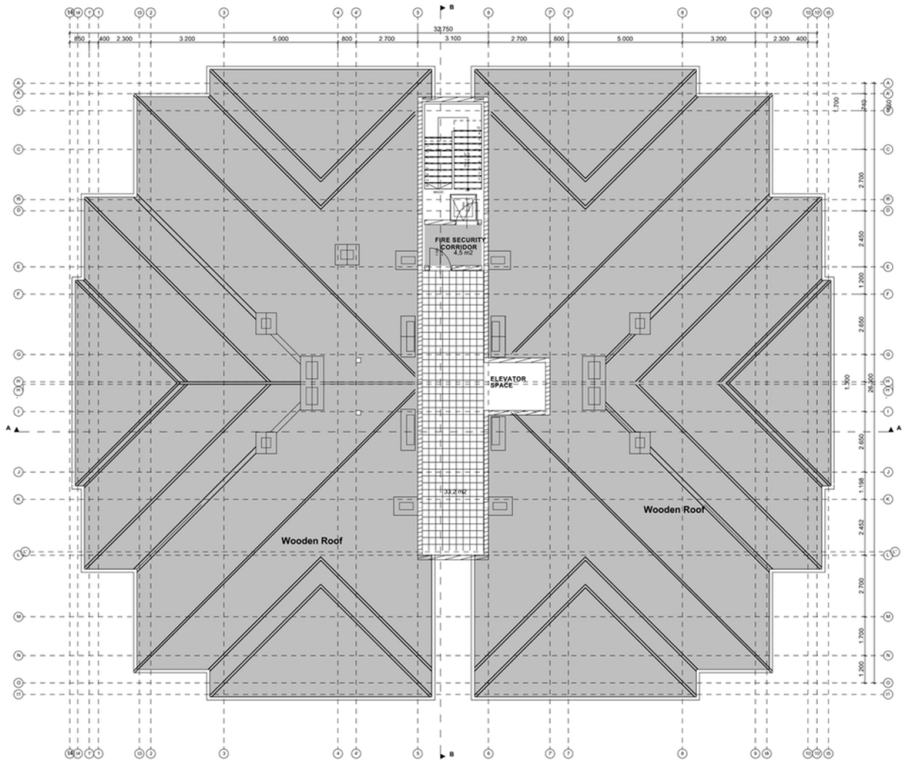
-Walls: Gypsum Board- Rockwool board filling (10 cm)- Gypsum Board

-Floor: Steel Construction- Trapezoidal Sheet Metal Coating- Leveling Concrete

-Ceilling: Gypsum Board

-Colums and Beams: Steel construction

Figure 100. 1st and 2nd Floor Plan (+2.95, +5.90) (Architectural Project)



Roof: OSB/3 Board covering Wooden Structural System

For Core of the Wooden Building:

Walls: Gypsum Board- Rockwool board filling (10 cm)- Gypsum Board

Floor: Steel Construction- Trapezoidal Sheet Metal Coating- Leveling Concrete

Ceilling: Gypsum Board

Colums and Beams: Steel construction

Figure 101. Roof Plan (+10.80) (Architectural Project)

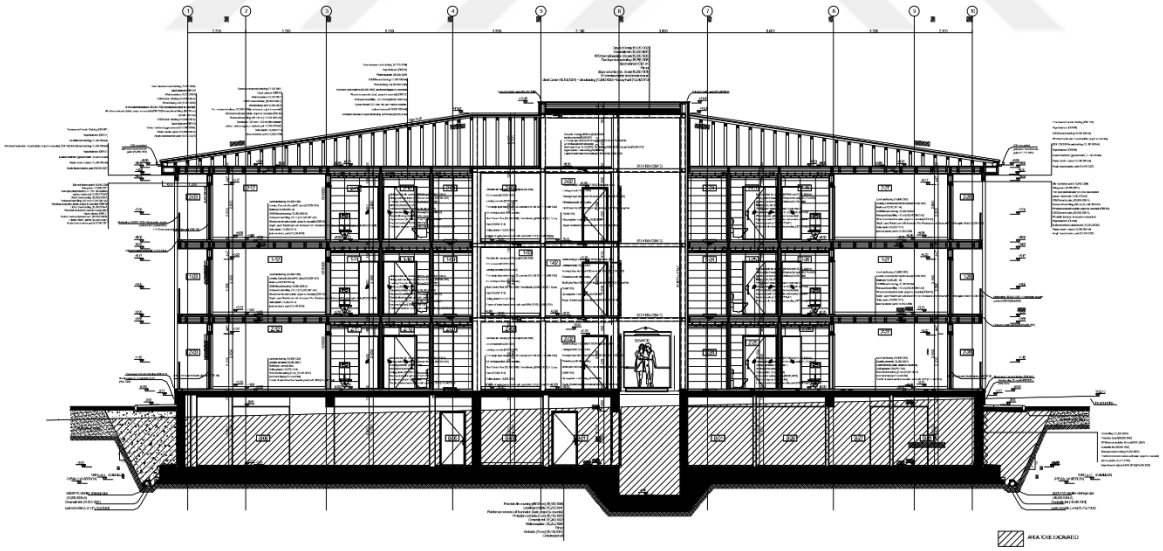


Figure 102. Section AA (Architectural Project)

The structural project of the wood-steel hybrid building for each floor is shown below.

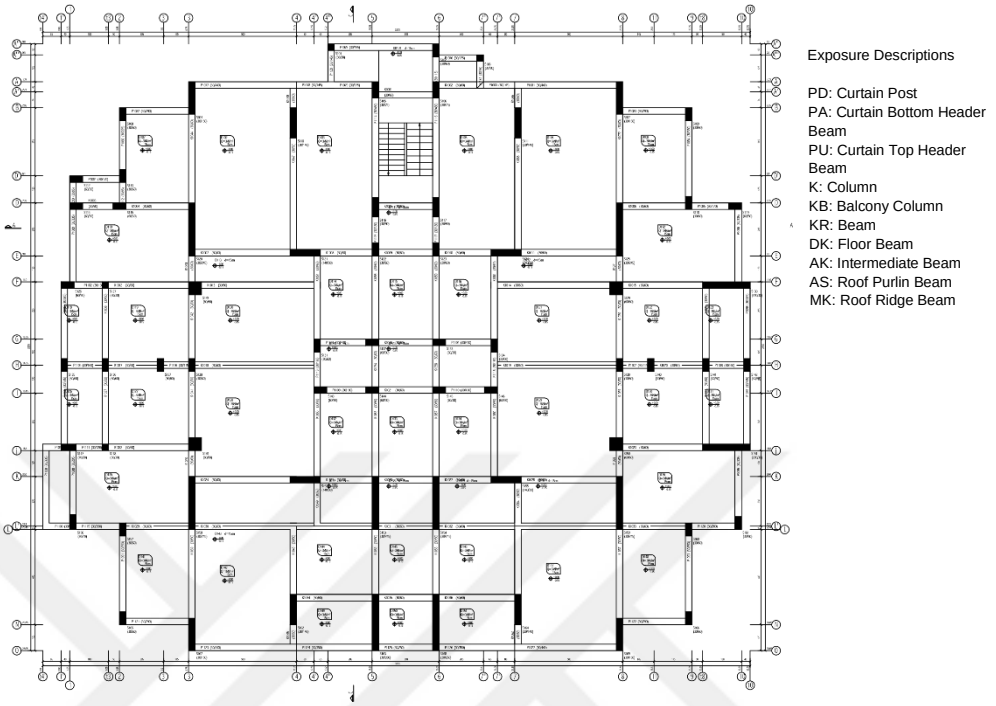


Figure 103. Basement Floor Formwork Plan (Static Project)

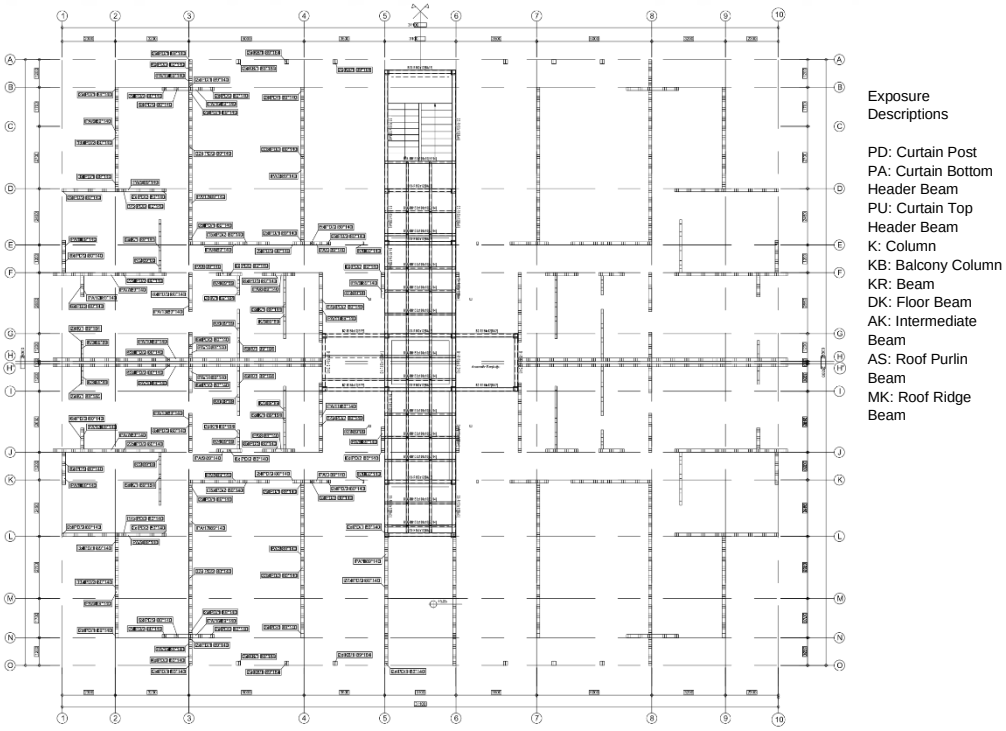


Figure 104. Ground Floor Curtain Application Plan (Static Project)

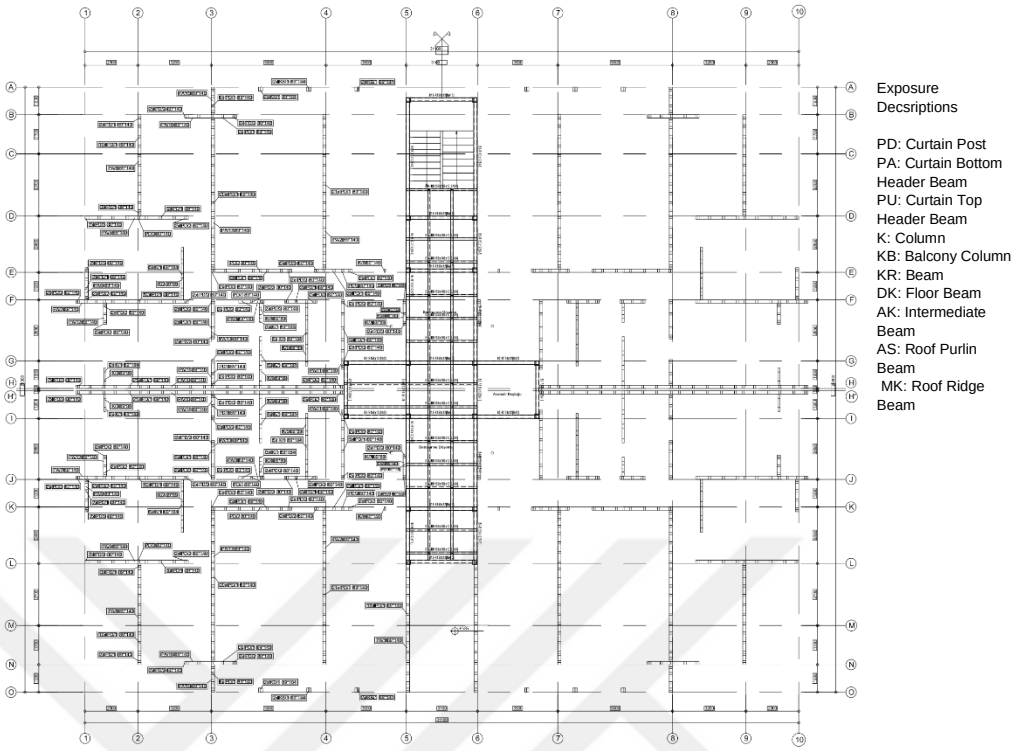


Figure 105. 1st and 2nd Floor Curtain Application Plan (Static Project)

This study thoroughly investigates the building process of the three structural systems, analyzing cost factors, construction speed, and environmental impact. The following methods were used for comparative analysis:

-Bill of Quantities and Cost Analysis: The wooden-reinforced concrete structure located in the Andırın district of Kahramanmaraş was obtained from the architectural and structural project authors. Initially, a structure with a reinforced concrete load-bearing system of the same form and function was designed in Sta4CAD. Additionally, a different structure, where the reinforced concrete area in the central core of the wooden structure was replaced with steel, was designed in STA Steel. The architectural projects were drawn using ArchiCAD. Construction quantities for all three types of structures were calculated based on rough construction data, and cost analyses were performed based on the 2025-unit prices (1 January-1 July) from the Ministry of Environment, Urbanization, and Climate Change.

-Construction Speed Evaluation: The construction processes of the timber-concrete, timber-steel hybrid, and reinforced concrete structures were analyzed and compared

using the Critical Path Method (CPM) in Microsoft Project. Through this method, the critical activities affecting the overall project duration were identified, and the differences in the construction timelines of the three structural systems were evaluated.

In addition, Gantt charts were utilized to visually illustrate the scheduling of tasks, dependencies between activities, and the overall workflow. This approach allowed for a comparison of the time efficiency and construction planning of each structural system.

-Environmental Impact Analysis: National and international scientific sources were utilized in the study. The study also references data from the General Directorate of Forestry. The carbon dioxide emissions of wood-concrete, wood-steel, and reinforced concrete structures were calculated based on data of General Directorate of Forestry, and evaluations were made in the context of environmental impact.

4.1.1. Cost Analysis

4.1.1.1. Cost Analysis for the Wood-Reinforced Concrete Structure

The rough construction quantities for the wood-concrete structure have been prepared, and a cost calculation has been carried out. When calculating the cost for the wood-concrete structure, two different types of wood were considered, resulting in two different cost estimations. This demonstrates the impact of the type of structural wood used on the cost. The types of wood selected for the cost calculation were oak and pine. The rough construction quantity details for the wood-concrete structure are provided below.

Table 6. Structural Wood Quantity Summary

STRUCTURAL WOOD QUANTITY SUMMARY				
NO	**LOCATION**	**DESCRIPTION**	**UNIT**	**QUANTITY**
1	**GROUND FLOOR**	Manufacturing of oak timber (1st class)	M^3	83,10
2	**1ST FLOOR**	Manufacturing of oak timber (1st class)	M^3	71,13
3	**2ND FLOOR**	Manufacturing of oak timber (1st class)	M^3	71,13
		TOTAL:		225,36

Table 7. OSB/3 Panel, Gypsum Board and Rock Wall Quantity Summary

	OSB/3 PANEL	GYPSUM BOARD	ROCK WOOL
GROUND FLOOR	2.474,08	2.203,90	1.793,75
1.FLOOR	2.474,08	2.203,90	1.793,75
2.FLOOR	2.474,08	2.203,90	1.793,75
TOTAL	7.422,25	6.611,69	5.381,26

Table 8. Wall Quantity Summary

WALL QUANTITY SUMMARY					
NO	**FLOORS**	**WALL (15cm)**	**WALL (19)**	**UNIT**	**TOTAL QUANTITY**
1	**BASEMENT**	258,30	230,66	M²	488,96
2	**GROUND FLOOR**	0,00	46,44	M²	46,44
3	**1ST FLOOR**	0,00	46,44	M²	46,44
4	**2ND FLOOR**	0,00	46,44	M²	46,44
5	**CORE**	0,00	46,44	M²	46,44
	TOTAL:	**258.30**	**416.42**	M²	**674.72**

Table 9. Scaffoldıng Quantıty Summary (M3)

SCAFFOLDING QUANTITY SUMMARY (M3)								
NO	**LOCATION**		**CONSTRUCTION AREA (M²)**	**FLOOR HEIGHT**	**LENGTH**	**FACTOR**	**TOTAL**	**GRAND TOTAL**
1	**BASEMENT**	**SLAB**	740,00	2,85		1,00	2.109,00	**2.865,77**
		CURTAIN WALL	525,54	2,40	1,20	0,50	756,77	
2	**GROUND FLOOR**	**SLAB**	65,00	2,70		1,00	175,50	**300,08**
		CURTAIN WALL	98,00	2,25	1,13	0,50	120,25	
3	**1ST FLOOR**	**SLAB**	65,00	2,70		1,00	175,50	**300,08**
		CURTAIN WALL	98,00	2,25	1,13	0,50	120,25	
4	**2ND FLOOR**	**SLAB**	65,00	2,70		1,00	175,50	**300,08**
		CURTAIN WALL	98,00	2,25	1,13	0,50	124,58	
5	**ROOF FLOOR**	**SLAB**	65,00	1,85		1,00	120,25	**163,92**
		CURTAIN WALL	89,12	1,40	0,70	0,50	43,67	
							TOTAL	**3.929,94**

Table 10. Lean Concrete Quantity Summary

LEAN CONCRETE QUANTITY SUMMARY							
NO	**LOCATION**	**TYPE**	**QUANTITY**	**FACTOR**	**AREA (M^2)**	**HEIGHT (M)**	**TOTAL (M^3)**
1	UNDER FOUNDATION	WALL	1,00	1,00	925,75	0,10	**92,575**
						TOTAL:	**92,58**

The cost analyses prepared based on these rough construction quantity details are shown below. The cost analyses are based on the 2025 unit prices from the Ministry of Environment, Urbanization, and Climate Change.

Table 11. Approximate Cost of Oak (Wood) Construction

APPROXIMATE COST OF OAK (WOOD) CONSTRUCTION					
ITEM NO	**WORK ITEM**	**UNIT**	**QUANTITY**	**MINISTRY UNIT PRICES (TL)**	**TOTAL (TL)**
15.120.1001	Excavation of soft and hard soil by machine (free excavation)	M^3	3.663,48	47,54	₺174.161,84
15.185.1005	Construction of scaffolding with steel pipes (0.00-4.00 m)	M^3	3.929,94	103,20	₺405.569,81
15.150.1003	Ready-mix concrete C 16/20, produced or purchased at a batching plant, pumped with a concrete pump (including transportation)	M^3	92,58	2.901,28	₺268.600,50

Table 11. Approximate Cost of Oak (Wood) Construction (Continued)

15.150.1006	Ready-mix concrete C 30/37, produced or purchased at a batching plant, pumped with a concrete pump (including transportation)	M³	921,02	3.276,28	৳3.017.519,41
15.180.1003	Formwork construction with plywood (smooth-surface)	M²	3.424,82	824,39	৳2.823.387,36
15.160.1003	Ø 8-Ø 12 mm ribbed reinforcing steel bars, cutting, bending, and placement	Metric Ton	52,05	39.429,35	৳2.052.360,75
15.160.1004	Ø 14-Ø 28 mm ribbed reinforcing steel bars, cutting, bending, and placement	Metric Ton	37,76	38.016,85	৳1.435.333,78
V.0208/012	Manufacturing with first-class oak timber	M³	225,36	103.198,13	৳23.256.730,58
15.230.1004	Non-load bearing 15 cm thick pumice concrete block wall construction (with pumice concrete adhesive, min. 1.50 N/mm² and 600-900 kg/m³, excluding 900 kg/m³)	M²	258,30	535,24	৳138.252,49

Table 11. Approximate Cost of Oak (Wood) Construction (Continued)

15.230.1006	Non-load bearing 19 cm thick pumice concrete block wall construction (with pumice concrete adhesive, min. 1.50 N/mm² and 600-900 kg/m³, excluding 900 kg/m³)	M²	416,42	607,75	₺253.079,26
15.300.1002	Wooden gable roof construction (OSB/3 sheathing under roof covering)	M²	740,00	1.253,14	₺927.323,60
15.300.1006-A	OSB3 11mm sheathing installation	M²	7.422,25	405,56	₺3.010.166,09
15.530.1726	Gypsum board cladding with adhesive method (12.5 mm fire-resistant gypsum board) (12.5 mm single-layer fire-resistant gypsum board)	M2	6.611,69	544,76	₺3.601.783,15
15.341.3081-A	10 cm thick rock wool insulation for suspended ceilings, partition walls, and raised floors (average sound absorption coefficient >= 0.80)	M²	5.381,26	211,88	₺1.140.181,37
			TOTAL COST (TL): ₺42.504.449,98		

When the same wooden structure is constructed using structural wood made from pine, the construction cost changes significantly.

Table 12. Approximate Cost of Pine (Wood) Construction

APPROXIMATE COST OF PINE (WOOD) CONSTRUCTION					
Item No.	**Work Description**	**Unit**	**Quantity**	**Ministry Unit Prices (TRY)**	**Total**
15.120.1001	Excavation of soft and hard soil by machine (Free excavation) (m³)	m³	3.663,48	47,54	₺174.161,84
15.185.1005	Construction of scaffolding with steel pipes (0.00-4.00 m)	m³	3.929,94	103,20	₺405.569,81
15.150.1003	Concrete poured in the field, with C 16/20 pressure strength class, gray color, normal ready-mix concrete (including transportation)	m³	92,58	2.901,28	₺268.600,50
15.150.1006	Concrete poured in the field, with C 30/37 pressure strength class, gray color, normal ready-mix concrete (including transportation)	m³	921,02	3.276,28	₺3.017.519,41
15.180.1003	Concrete formwork made with plywood for smooth surfaces	m²	3.424,82	824,39	₺2.823.387,36
15.160.1003	Ø 8- Ø 12 mm ribbed steel rebar, cutting, bending, and placement	ton	52,05	39.429,35	₺2.052.360,75
15.160.1004	Ø 14- Ø 28 mm ribbed steel rebar, cutting, bending, and placement	ton	37,76	38.016,85	₺1.435.333,78
V.0208/010	Pine (Class 1) wood manufacturing	m³	225,36	49.875,00	₺11.239.830,00

Table 12. Approximate Cost of Pine (Wood) Construction (Continued)

15.230.1004	Wall construction with 15 cm thick non-load bearing bimsbeton blocks (using bimsbeton adhesive)	m²	258,30	535,24	₺138.252,49
15.230.1006	Wall construction with 19 cm thick non-load bearing bimsbeton blocks (using bimsbeton adhesive)	m²	416,42	607,75	₺253.079,26
15.300.1002	Wooden pitched roof construction (roof covered with OSB/3 board)	m²	740,00	1.253,14	₺927.323,60
15.300.1006-A	OSB3 11mm paneling	m²	7.422,25	405,56	₺3.010.166,09
15.530.1726	Gypsum board cladding with adhesive method (12.5 mm fire-resistant gypsum board)	m²	6.611,69	544,76	₺3.601.783,15
15.341.3081-A	Thermal and acoustic insulation with 10 cm thick rock wool boards in suspended ceilings, partition walls, and raised floors, with an average sound absorption coefficient >= 0.80	m²	5.381,26	211,88	₺1.140.181,37
					TOTAL COST (TRY): ₺30.487.549,40

As can be seen, the cost difference between using Oak and Pine wood is quite significant.

Cost of construction with Oak: ₺42.504.449,98

Cost of construction with Pine: ₺30.487.549,40

Difference: ₺12.016.900,58 (Oak is approximately 38% more expensive than Pine)

The main reason for this difference is that the unit price of oak timber (₺103.198,13/m³) is approximately 107% more expensive than the unit price of pine timber (₺49.875,00/m³). If a budget-oriented choice is to be made, pine is a more economical option in the wooden construction technique.

Table 13. Comparison of Estimated Construction Costs: Oak vs. Pine

Comparison of Estimated Construction Costs: Oak vs. Pine					
Item No	**Work Description**	**Unit**	**Quantity**	**Ministry Unit Prices (TL)**	**Total Cost (TL)**
OAK CONSTRUCTION COST (Quercus spp.)					**₺42.504.449,98**
V.0208/012	1st Class Oak Timber Manufacturing	m³	225,36	103.198,13	₺23.256.730,58
PINE CONSTRUCTION COST (Pinus spp.)					**₺30.487.549,40**
V.0208/010	1st Class Pine Timber Manufacturing	m³	225,36	49.875,00	₺11.239.830,00
Total Cost Difference					**₺12.016.900,58**

4.1.1.2. Cost Analysis for Reinforced Concrete Structure

For the reinforced concrete structure, the rough construction quantities were first prepared, and a cost calculation was carried out. The rough construction quantity details for the reinforced concrete structure are provided below.

The cost analyses prepared based on these rough construction quantity details are shown below. The cost analyses are based on the 2025-unit prices from the Ministry of Environment, Urbanization, and Climate Change.

Table 14. Wall Quantity Summary

WALL QUANTITY SUMMARY					
NO	**FLOORS**	**WALL (15cm)**	**WALL (19cm)**	**UNIT**	**TOTAL QUANTITY**
1	**BASEMENT**	258,30	230,66	M2	488,96
2	**GROUND FLOOR**	494,85	161,09	M2	655,94
3	**1ST FLOOR**	494,85	248,18	M2	743,03
4	**2ND FLOOR**	494,85	248,18	M2	743,03
5	**CORE**	0,00	46,44	M2	46,44
TOTAL		**1.742,84**	**934,56**		
TOTAL:					**2.677,41**

Table 15. Scaffoldıng Quantıty Summary (M3)

SCAFFOLDING QUANTITY SUMMARY (M3)								
NO	**LOCATION**		**CONSTRUCTION AREA (M²)**	**FLOOR HEIGHT**	**LENGTH**	**FACTOR**	**TOTAL**	**GRAND TOTAL**
1	**BASEMENT**	SLAB	740,00	2,85		1,00	2.109,00	**2.865,77**
		CURTAIN WALL	525,54	2,40	1,20	0,50	756,77	
2	**GROUND FLOOR**	SLAB	740,00	2,70		1,00	1.998,00	**2.379,38**
		CURTAIN WALL	300,00	2,25	1,13	0,50	381,38	
3	**1ST FLOOR**	SLAB	730,00	2,70		1,00	1.971,00	**2.352,38**
		CURTAIN WALL	300,00	2,25	1,13	0,50	381,38	
4	**2ND FLOOR**	SLAB	805,00	2,70		1,00	2.173,50	**2.554,88**
		CURTAIN WALL	300,00	2,25	1,13	0,50	381,38	
5	**ROOF FLOOR**	SLAB	65,00	1,85		1,00	120,25	**163,92**
		CURTAIN WALL	89,12	1,40	0,70	0,50	43,67	
						TOTAL		**10.316,32**

Table 16. Lean Concrete Quantity Summary

LEAN CONCRETE QUANTITY SUMMARY							
NO	**LOCATION**	**TYPE**	**QUANTITY**	**FACTOR**	**AREA (M^2)**	**HEIGHT (M)**	**TOTAL (M^3)**
1	UNDER FOUNDATION	WALL	1,00	1,00	925,75	0,10	**92,575**
						TOPLAM	**92,58**

Table 17. Reinforced Concrete Construction Approximate Cost

REINFORCED CONCRETE CONSTRUCTION APPROXIMATE COST					
ITEM NO	**WORK ITEM DESCRIPTION**	**UNIT**	**QUANTITY**	**MINISTRY UNIT PRICES (TRY)**	**TOTAL (TRY)**
15.120.1001	Excavation of soft and hard soil by machine (Free excavation) (M3)	M3	3.663,48	47,54	₺174.161,84
15.185.1005	Scaffold construction made of steel pipe (0.00-4.00 m height)	M3	10.316,32	103,20	₺1.064.644,22
15.150.1003	Casting of ready-mixed concrete produced at the plant or purchased, pumped with a concrete pump, C 16/20 strength class, gray color, normal ready-mixed concrete (including concrete transport)	M3	92,58	2.901,28	₺268.600,50

Table 17. Reinforced Concrete Construction Approximate Cost (Continued)

15.150.1006	Casting of ready-mixed concrete produced at the plant or purchased, pumped with a concrete pump, C 30/37 strength class, gray color, normal ready-mixed concrete (including concrete transport)	M3	1.529,99	3.276,28	৳5.012.675,64
15.180.1003	Formwork made of plywood for flat-surfaced reinforced concrete	M2	7.622,87	824,39	৳6.284.217,80
15.160.1003	Ø 8- Ø 12 mm ribbed reinforcing steel bars, cutting, bending, and placement	Ton	93,40	39.429,35	৳3.682.768,32
15.160.1004	Ø 14- Ø 28 mm ribbed reinforcing steel bars, cutting, bending, and placement	Ton	82,09	38.016,85	৳3.120.685,36
15.230.1004	Non-load-bearing walls built with 15 cm thick bims concrete wall blocks (with bims concrete adhesive) (min. 1.50 n/mm² and 600-900 kg/m³, excluding 900 kg/m³)	M2	1.742,84	535,24	৳932.839,82
15.230.1006	Non-load-bearing walls built with 19 cm thick bims concrete wall blocks (with bims concrete adhesive) (min. 1.50 n/mm² and 600-900 kg/m³, excluding 900 kg/m³)	M2	934,56	607,75	৳567.979,45
15.300.1002	Wooden saddle roof construction (roof covering underneath OSB/3 coated)	M2	740,00	1.253,14	৳927.323,60
TOTAL: ৳22.035.896,56					

4.1.1.3. Cost Analysis for Wood-Steel Structure

For the wood-steel structure, the rough construction quantities were first prepared, and a cost calculation was carried out. The rough construction quantity details for the wood-steel structure are provided below.

Table 18. Structural Steel Quantity Summary (kg)*

STRUCTURAL STEEL QUANTITY SUMMARY (KG)*									
NO	**FLOOR/AREA**	**PROFILE TYPE**	**UNIT**	**PIECE**	**REPETITION**	**LENGTH**	**UNIT WEIGHT**	**TOTAL LENGTH**	**TOTAL WEIGHT(KG)**
1	**GROUND FLOOR**								
2	COLUMNS	200*200*12 MM BOX PROFILE	KG	18	1	2,90	70,67	52,20	3.688,97
3	BEAMS	150*100*10		14	1	3,10	36,03	43,40	1.563,70
4				1	2	16,09	36,03	32,18	1.159,45
5				1	2	2,70	36,03	5,40	194,56
6				1	2	2,50	36,03	5,00	180,15
7		150*150*12		7	1	3,10	51,88	21,70	1.125,80
8				4	1	2,70	51,88	10,80	560,30
9				1	2	20,09	51,88	40,18	2.084,54
10				1	2	2,50	51,88	5,00	259,40
11		60*60*2 L PROFILE		4	18	0,10	7,02	7,20	50,54
12		400*20 PLATE		1	18	1,00	25,06	18,00	451,08
13	**1. FLOOR**								**11,32**
14	COLUMNS	200*200*12 MM BOX PROFILE	KG	18	1	2,95	70,67	53,10	3.752,58
15	BEAMS	150*100*10		14	1	3,10	36,03	43,40	1.563,70
16				1	2	16,09	36,03	32,18	1.159,45
17				1	2	2,70	36,03	5,40	194,56
18				1	2	2,50	36,03	5,00	180,15
19		150*150*12		7	1	3,10	51,88	21,70	1.125,80
20				4	1	2,70	51,88	10,80	560,30
21				1	2	20,09	51,88	40,18	2.084,54
22				1	2	2,50	51,88	5,00	259,40
23		60*60*2 L PROFILE		4	18	0,10	7,02	7,20	50,54
24		400*20 PLATE		1	18	1,00	25,06	18,00	451,08
25	**2. FLOOR**								**11,38**
26	COLUMNS	200*200*12 MM BOX PROFILE	KG	18	1	2,95	70,67	53,10	3.752,58
27	BEAMS	150*100*10		14	1	3,10	36,03	43,40	1.563,70
28				1	2	16,09	36,03	32,18	1.159,45
29				1	2	2,70	37,03	5,40	199,96
30				1	2	2,50	38,03	5,00	190,15
31		150*150*12		7	1	3,10	51,88	21,70	1.125,80
32				4	1	2,70	51,88	10,80	560,30

Table 18. Structural Steel Quantity Summary (kg)* (Continued)

33				1	2	20,09	51,88	40,18	2.084,54
34				1	2	2,50	51,88	5,00	259,40
35		60*60*2 L PROFILE		4	18	0,10	7,02	7,20	50,54
36		400*20 PLATE		1	18	1,00	25,06	18,00	451,08
37	**CORE**								**11,40**
38	COLUMNS	200*200*12 MM BOX PROFILE	KG	16	1	2,10	70,67	33,60	2.374,51
39	BEAMS	150*100*10		14	1	3,10	36,03	43,40	1.563,70
40				1	2	16,09	36,03	32,18	1.159,45
41				1	2	2,70	37,03	5,40	199,96
42				1	2	2,50	38,03	5,00	190,15
43		150*150*12		7	1	3,10	51,88	21,70	1.125,80
44				2	1	2,70	51,88	5,40	280,15
45				1	2	20,09	51,88	40,18	2.084,54
46				1	1	2,50	51,88	2,50	129,70
47		60*60*2 L PROFILE		4	18	0,10	7,02	7,20	50,54
48		400*20 PLATE		1	18	1,00	25,06	18,00	451,08
49	STAIRS	3/4 SHEET METAL STEP L=135/46,5 CM	KG	18	3	0,63	27,00	33,90	915,26
50									**10,52**
*Carcass (frame) construction with all kinds of profiles, steel bars and steel sheets							**TOTAL (Ton):**		**44,62**

Table 19. Structural Steel Quantity Summary (m2) **

STRUCTURAL STEEL QUANTITY SUMMARY (M2) **								
NO	**FLOOR/AREA**	**PROFILE TYPE**	**UNIT**	**QUANTITY**	**REPETITION**	**LENGTH (m)**	**PERIMETER**	**TOTAL AREA (M2)**
1	**GROUND FLOOR**							
2	COLUMNS	200*200*12 MM BOX PROFILE	M2	18	1	2,90	0,80	41,76
3	BEAMS	150*100*10	M2	14	1	3,10	0,50	21,70
4			M2	1	2	16,09	0,50	16,09
5			M2	1	2	2,70	0,50	2,70
6			M2	1	2	2,50	0,50	2,50
7		150*150*12	M2	7	1	3,10	0,60	13,02
8			M2	4	1	2,70	0,60	6,48
9			M2	1	2	20,09	0,60	24,11
10			M2	1	2	2,50	0,60	3,00
11		60*60*2 L PROFILE	M2	4	18	0,10	0,24	1,73
12		400*20 PLATE	M2	1	18	1,00	0,32	5,76
13	**1. FLOOR**		M2					0,00
14	COLUMNS	200*200*12 MM BOX PROFILE	M2	18	1	2,95	0,80	42,48

Table 19. Structural Steel Quantity Summary (m2) ** (Continued)

15	BEAMS	150*100*10	M2	14	1	3,10	0,50	21,70
16			M2	1	2	16,09	0,50	16,09
17			M2	1	2	2,70	0,50	2,70
18			M2	1	2	2,50	0,50	2,50
19		150*150*12	M2	7	1	3,10	0,60	13,02
20			M2	4	1	2,70	0,60	6,48
21			M2	1	2	20,09	0,60	24,11
22			M2	1	2	2,50	0,60	3,00
23		60*60*2 L PROFILE	M2	4	18	0,10	0,24	1,73
24		400*20 PLATE	M2	1	18	1,00	0,32	5,76
25	**2. FLOOR**		M2					0,00
26	COLUMNS	200*200*12 MM BOX PROFILE	M2	18	1	2,95	0,80	42,48
27	BEAMS	150*100*10	M2	14	1	3,10	0,50	21,70
28			M2	1	2	16,09	0,50	16,09
29			M2	1	2	2,70	0,50	2,70
30			M2	1	2	2,50	0,50	2,50
31		150*150*12	M2	7	1	3,10	0,60	13,02
32			M2	4	1	2,70	0,60	6,48
33			M2	1	2	20,09	0,60	24,11
34			M2	1	2	2,50	0,60	3,00
35		60*60*2 L PROFILE	M2	4	18	0,10	0,24	1,73
36		400*20 PLATE	M2	1	18	1,00	0,32	5,76
37	**CORE**		M2					0,00
38	COLUMNS	200*200*12 MM BOX PROFILE	M2	16	1	2,10	0,80	26,88
39	BEAMS	150*100*10	M2	14	1	3,10	0,50	21,70
40			M2	1	2	16,09	0,50	16,09
41			M2	1	2	2,70	0,50	2,70
42			M2	1	2	2,50	0,50	2,50
43		150*150*12	M2	7	1	3,10	0,60	13,02
44			M2	2	1	2,70	0,60	3,24
45			M2	1	2	20,09	0,60	24,11
46			M2	1	1	2,50	0,60	1,50
47		60*60*2 L PROFILE	M2	4	18	0,10	0,24	1,73
48		400*20 PLATE	M2	1	18	1,00	0,32	5,76
49	STEPS	3/4 SHEAT METAL STEP L=135/46,5 CM	M2	18	3	0,63	1,00	33,90
50								0,00
** Blasting the iron surfaces with special (silica quartz) sand using a compressor and sandblasting until a shiny surface is obtained.							**TOTAL (M2):**	**571,10**

Table 20. Structural Steel Quantity Summary (m2)***

STRUCTURAL STEEL QUANTITY SUMMARY (M2) ***								
NO	**FLOOR/AREA**	**PROFILE TYPE**	**UNIT**	**PIECE**	**REPETITION**	**LENGTH**	**PERIMETER**	**TOTAL AREA**
1	**GROUND FLOOR**							
2	COLUMNS	200*200*12 MM BOX PROFILE	M2	18	1	2,90	0,80	41,76
3	BEAMS	150*100*10	M2	14	1	3,10	0,50	21,70
4			M2	1	2	16,09	0,50	16,09
5			M2	1	2	2,70	0,50	2,70
6			M2	1	2	2,50	0,50	2,50
7		150*150*12	M2	7	1	3,10	0,60	13,02
8			M2	4	1	2,70	0,60	6,48
9			M2	1	2	20,09	0,60	24,11
10			M2	1	2	2,50	0,60	3,00
11		60*60*2 L PROFILE	M2	4	18	0,10	0,24	1,73
12		400*20 PLATE	M2	1	18	1,00	0,32	5,76
13	**1. FLOOR**		M2					**138,85**
14	COLUMNS	200*200*12 MM BOX PROFILE	M2	18	1	2,95	0,80	42,48
15	BEAMS	150*100*10	M2	14	1	3,10	0,50	21,70
16			M2	1	2	16,09	0,50	16,09
17			M2	1	2	2,70	0,50	2,70
18			M2	1	2	2,50	0,50	2,50
19		150*150*12	M2	7	1	3,10	0,60	13,02
20			M2	4	1	2,70	0,60	6,48
21			M2	1	2	20,09	0,60	24,11
22			M2	1	2	2,50	0,60	3,00
23		60*60*2 L PROFILE	M2	4	18	0,10	0,24	1,73
24		400*20 PLATE	M2	1	18	1,00	0,32	5,76
25	**2. FLOOR**		M2					**139,57**
26	COLUMNS	200*200*12 MM BOX PROFILE	M2	18	1	2,95	0,80	42,48
27	BEAMS	150*100*10	M2	14	1	3,10	0,50	21,70
28			M2	1	2	16,09	0,50	16,09
29			M2	1	2	2,70	0,50	2,70
30			M2	1	2	2,50	0,50	2,50
31		150*150*12	M2	7	1	3,10	0,60	13,02
32			M2	4	1	2,70	0,60	6,48
33			M2	1	2	20,09	0,60	24,11
34			M2	1	2	2,50	0,60	3,00
35		60*60*2 L PROFILE	M2	4	18	0,10	0,24	1,73
36		400*20 PLATE	M2	1	18	1,00	0,32	5,76
37	**CORE**		M2					**139,57**
38	COLUMNS	200*200*12 MM BOX PROFILE	M2	16	1	2,10	0,80	26,88
39	BEAMS	150*100*10	M2	14	1	3,10	0,50	21,70

Table 20. Structural Steel Quantity Summary (m2)*** (Continued)

40			M2	1	2	16,09	0,50	16,09
41			M2	1	2	2,70	0,50	2,70
42			M2	1	2	2,50	0,50	2,50
43		150*150*12	M2	7	1	3,10	0,60	13,02
44			M2	2	1	2,70	0,60	3,24
45			M2	1	2	20,09	0,60	24,11
46			M2	1	1	2,50	0,60	1,50
47		60*60*2 L PROFILE	M2	4	18	0,10	0,24	1,73
48		400*20 PLATE	M2	1	18	1,00	0,32	5,76
49	STAIRS	3/4 SHEET METAL STEP L=135/46,5 CM	M2	18	3	0,63	1,00	33,90
50								**153,12**
***Applying two coats of solvent-based epoxy paint to iron surfaces							**TOPLAM (M2) :**	**1.142,21**

The approximate cost table for the wood-steel structure is shown below. The cost analyses are based on the 2025-unit prices from the Ministry of Environment, Urbanization, and Climate Change.

Table 21. Approximate Construction Cost Of The Building With Steel Core ; Wood (Oak)

APPROXIMATE CONSTRUCTION COST OF THE BUILDING WITH STEEL CORE WOOD (OAK)					
ITEM NO	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE (TL)	TOTAL (TL)
15.120.1001	Excavation of soft and hard soil with machine (Free excavation) (M3)	m³	3.663,48	47,54	₺174.161,84
15.185.1005	Installation of scaffolding with steel pipe (0.00-4.00 m height)	m³	2.865,77	103,20	₺295.747,46
15.150.1003	Ready-mixed concrete production or purchase from batching plant and pumping, C 16/20 strength class, grey color (including concrete transportation)	m³	92,58	2.901,28	₺268.600,50
15.150.1006	Ready-mixed concrete production or purchase from batching plant and pumping, C 30/37 strength class, grey color (including concrete transportation)	m³	748,37	3.276,28	₺2.451.869,66
15.180.1003	Flat surface plywood formwork application	m²	2.249,54	824,39	₺1.854.498,28
15.160.1003	Ø 8 - Ø 12 mm ribbed steel reinforcement bar, cutting, bending, and placement	ton	38,38	39.429,35	₺1.513.298,45
15.160.1004	Ø 14 - Ø 28 mm ribbed steel reinforcement bar, cutting, bending, and placement	ton	32,28	38.016,85	₺1.227.183,92
15.150.1004	Ready-mixed concrete production or purchase from batching plant and pumping, C 20/25 strength class, grey color (including concrete transportation)	m³	12,60	3.026,28	₺38.131,13
15.165.1003	Construction and fixing of frame structures made of all types of profiles, steel bars, and steel plates	ton	44,62	70.730,60	₺3.155.999,37
15.160.1002	Placement of ribbed steel mesh reinforcement 3,001-10,000 kg/m² (including 10,000 kg/m²)	ton	0,54	37.421,88	₺20.207,82
43.680.1003	Sandblasting of iron surfaces with special silica quartz using a compressor until a bright surface is obtained	m²	571,10	765,64	₺437.257,00
15.540.1123	Application of two-coat solvent-based epoxy paint on iron surfaces	m²	571,10	328,90	₺187.834,79

Table 21. Approximate Construction Cost Of The Building With Steel Core ; Wood (Oak) (Continued)

V.0208/012	Manufacturing with 1st class oak timber	m³	225,36	103.198,13	₺23.256.730,58
15.230.1004	Construction of non-load-bearing 15 cm thick bims concrete block wall (with bims concrete adhesive) (min. 1.50 n/mm² and 600-900 kg/m³, excluding 900 kg/m³)	m²	258,30	535,24	₺138.252,49
15.230.1006	Construction of non-load-bearing 19 cm thick bims concrete block wall (with bims concrete adhesive) (min. 1.50 n/mm² and 600-900 kg/m³, excluding 900 kg/m³)	m²	230,66	607,75	₺140.183,62
15.300.1002	Construction of timber gable roof (OSB/3 panel under roof covering)	m²	740,00	1.253,14	₺927.323,60
15.300.1006-A	Application of OSB3 panel cladding, 11 mm thick	m²	7.422,25	405,56	₺3.010.166,09
15.530.1726	Construction of single skeleton gypsum board partition walls (Single ceiling C60 profile- 60 cm axis distance) (12.5 mm single layer standard gypsum board)	m²	6.611,69	544,76	₺3.601.783,15
15.341.3081-A	Thermal and acoustic insulation with 10 cm thick rock wool panels for suspended ceilings, partition walls, and raised floors (average sound absorption coefficient >= 0.80)	m²	5.381,26	211,88	₺1.140.181,37
TOTAL (TL)					**₺43.839.411,13**

When pine is used instead of oak, the approximate cost is determined to be ₺31,822,510.55. The cost analysis table created for these three structures is shown below.

Table 22. Approximate Construction Cost of Buildings Constructed With Different Construction Techniques

Construction Technique of the Structures	The Structure, built with Wood-Reinforced Concrete	The Structure, built with Wood-Steel-Reinforced Concrete	The Structure, built with Reinforced Concrete
Approximate Cost (TL)*	If Oak (Wood) is used: ₺42.504.449,98 (1.093.771,24 USD) If Pine (Wood) is used: ₺30.487.549,40 (784.539,13 USD)	If Oak (Wood) is used: ₺43.839.411,13(1.128.123,95 USD) If Pine (Wood) is used: ₺31.822.510,55 (818.891,85 USD)	₺22.035.896,56 (567.051,96 USD)

As a result of the quantity surveying and the 2025-unit price analyses from the Ministry of Environment, Urbanization, and Climate Change, it has been determined that wooden structures have higher initial costs compared to reinforced concrete structures in terms of material procurement and labor costs. The importation of wood components, the need for specialised labor, and the requirement for special connection elements in assembly and anchoring contribute to the increase in costs. However, when comparing the costs of 3-5 story buildings in the United States, it was found that reinforced concrete buildings are on average 23% more expensive than wood-framed buildings (Schires, 2019). This suggests that wooden structures may provide long-term economic advantages.

4.1.2 Comparative Analysis in the Context of Construction Time

The construction durations of three different structural systems, Wood-Reinforced Concrete Hybrid Structure, Wood-Steel Hybrid Structure, and Traditional Reinforced Concrete Structure were comparatively analysed in the case study. The analysis was conducted using MS Project software, employing the Critical Path Method (CPM) to schedule and sequence construction activities. It determines the tasks that require the most time to complete while ensuring that all essential activities are addressed. This sequence, known as the critical path, dictates the overall project duration. A CPM schedule assigns both an earliest and a latest possible start date to each task. The resulting timeline is typically displayed using a network diagram or a Gantt chart.

Labor productivity rates and activity durations were primarily determined according to the unit price analysis reports published by the Ministry of Environment, Urbanization, and Climate Change of the Republic of Türkiye. However, adjustments were made where necessary based on current market conditions and site-specific considerations. Below is a summary of the key assumptions and productivity rates used in the analysis:

Formwork Works: To calculate the necessary workforce for formwork tasks, the unit price analysis issued by the Ministry of Environment and Urbanization, combined with market assumptions, was utilized. Based on the data of analysis, it is calculated that one craftsman spends 1.1 hours on manufacturing 1 m². With an 8-hour workday, a craftsman can set up, dismantle, and stack 7.27 m² of formwork on site. However, when considering only the installation, since the structure is not complex, it is assumed that one craftsman can install 20 m² of formwork per day as per market assumptions.

Drywall Works: In the unit price analysis published by the Ministry of Environment and Urbanization, the labor value for drywall work is 0.7 hours per 1 m² of drywall. Within an 8-hour workday, 11.5 m² of profile framework can be installed. Since the building has a wooden framework and does not require profile framing, based on market assumptions, it is considered that one craftsman can produce approximately 23 m² of installation per day.

Concrete Pouring: For C30 concrete pouring, the labor value in the unit price analysis published by the Ministry of Environment and Urbanization is 0.15 hours per 1 m³ of concrete. Within an 8-hour workday, one craftsman can pour 53.33 m³ of concrete. However, in the market, for one concrete pump, two craftsmen (mastarcı), one hoseman (laborer), and one vibrator operator (laborer) assist. One pump can pour 30 m³ (3 x 10 m³) per hour, meaning that in 8 hours, a total of 240 m³ of concrete can be poured.

Structural Wood Works: For structural wood manufacturing, the labor value from the unit price analysis published by the General Directorate of Foundations is 20 hours per 1 m³ of wood. Within an 8-hour workday, one craftsman can produce 0.40 m³ of woodwork (8/20 = 0.40 m³). Since the woodwork preparation will be done in the factory, only the installation will take place on-site. Based on our market research, one

craftsman can install approximately 30 columns or beams per day, which is roughly equivalent to 1 m³ of material.

Steel Works: For steel frame manufacturing, the labor value in the unit price analysis published by the Ministry of Environment and Urbanization is 1.8 hours per 1 ton of steel construction. Within an 8-hour workday, one craftsman can produce 4.44 tons of steel work (8 / 1.8 = 4.44 tons). Since sandblasting and painting will be done in the workshop, 1 day is allocated for each process in the time calculations.

For materials such as rock wool, OSB, Q8-12 steel, wooden roof, excavation, pumice block walls, and scaffolding, the accepted values are determined according to the unit price analysis data from the Ministry of Environment and Urbanization.

4.1.2.1. Construction Time for the Wood-Reinforced Structure

Below are MS Project Gantt charts showing the construction timelines for the wood-reinforced concrete structure, prepared using the critical path method. The durations for each floor vary, and concurrent activities have been considered. The critical path calculations assume construction starts on 03.03.2025 and ends on 08.07.2025. The total construction duration for the wood-reinforced concrete structure is 110 days.

The foundation and basement construction were carried out using traditional reinforced concrete methods. The superstructure used prefabricated wooden columns, beams, and panels, significantly reducing the assembly time. The production of the wooden elements off-site and transportation to the construction site allowed the production process to proceed in parallel, thus reducing the total construction time. The critical path continued with the installation of the wooden structural elements after the foundation works, followed by facade cladding and roof installations, completing the construction. (See Gantt Diagram of and Timeline Table of Wood-Reinforced Structure in Appendix E)



Figure 106. Gantt Diagram of Wood-Reinforced Concrete Structure

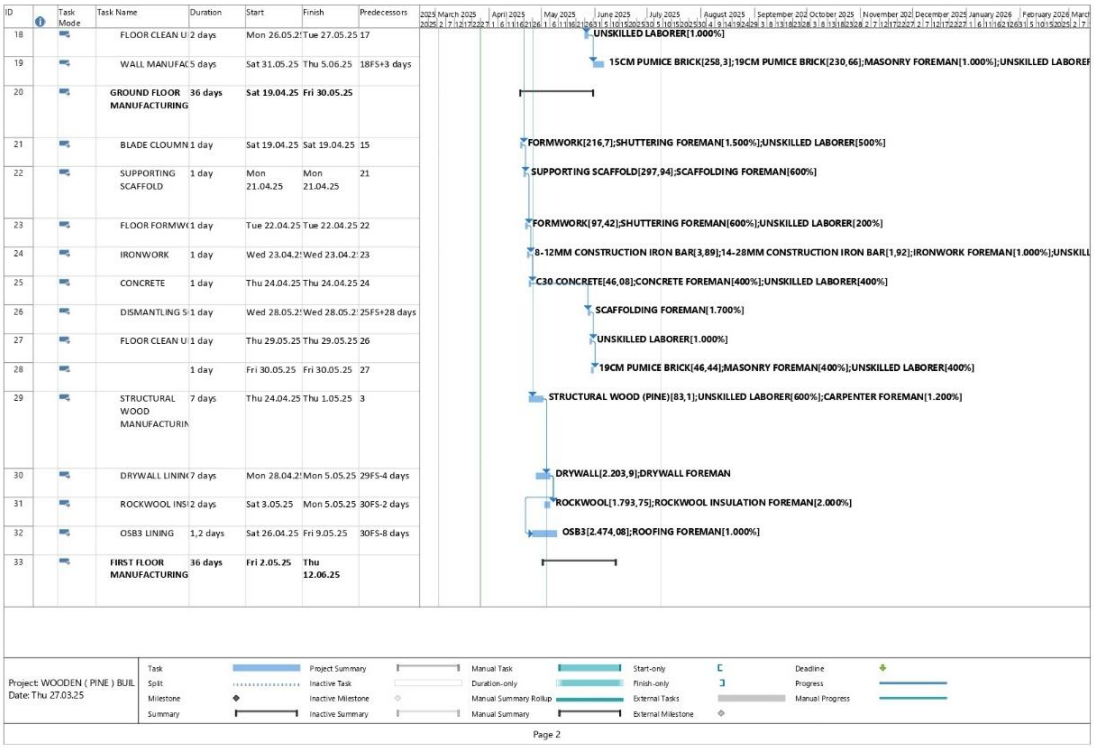


Figure 106. Gantt Diagram of Wood-Reinforced Concrete Structure (continued)

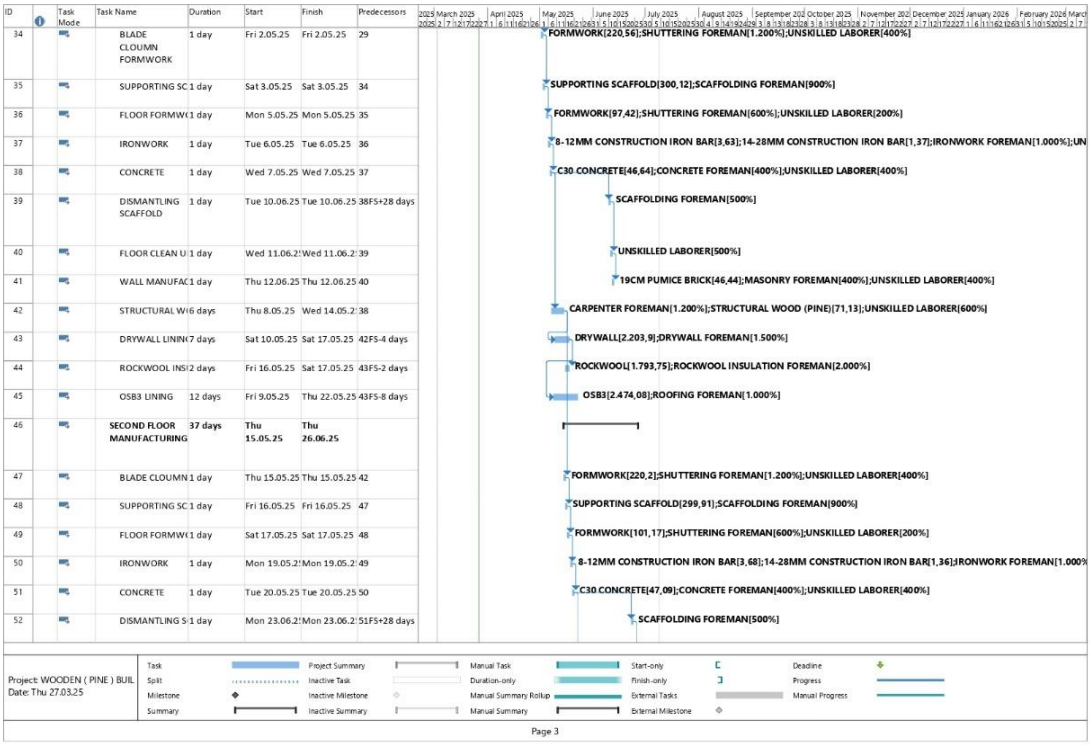


Figure 106. Gantt Diagram of Wood-Reinforced Concrete Structure (continued)

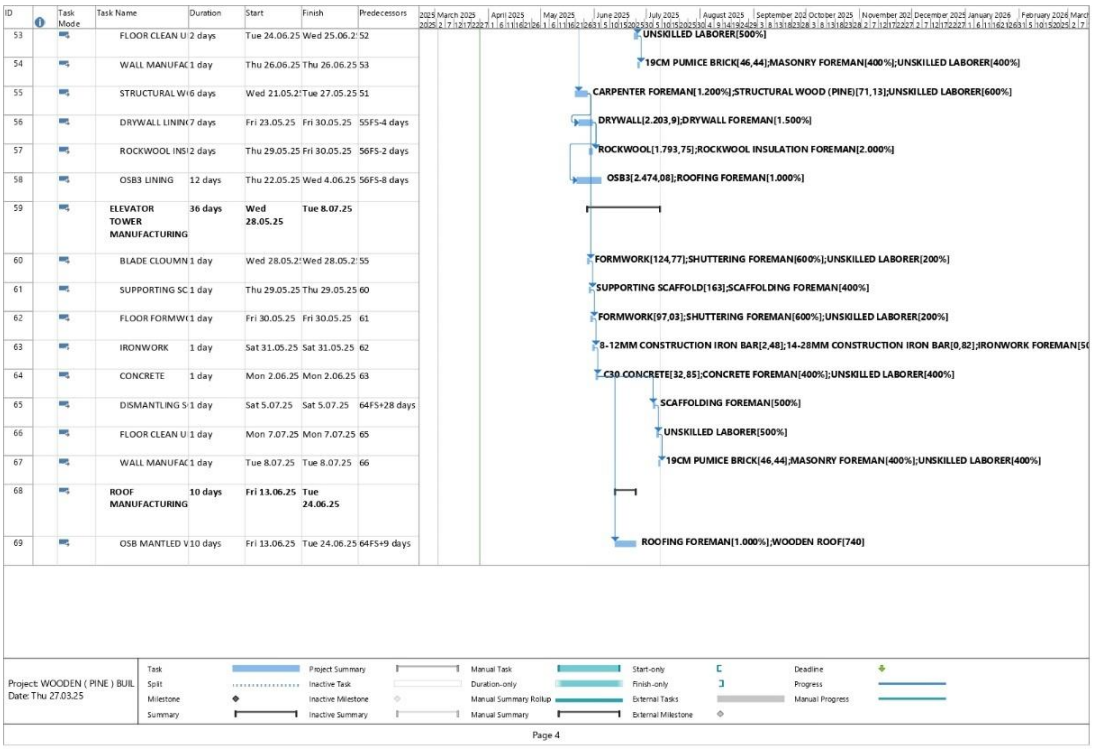


Figure 106. Gantt Diagram of Wood-Reinforced Concrete Structure (continued)

4.1.2.2. Construction Time for the Reinforced Concrete

Below are MS Project Gantt charts showing the construction timelines for the reinforced concrete structure, prepared using the critical path method. The durations for each floor vary, and concurrent activities have been considered.

The critical path calculations assume that construction starts on 03.03.2025 and ends on 06.08.2025. The total construction duration for the reinforced concrete structure is calculated to be 135 days.

The entire load-bearing system of the structure uses reinforced concrete. The high time requirements for formwork, reinforcement, and concrete pouring labor extended the project duration. The dependency of wet construction processes on site conditions and the time losses between floor slabs were among the main factors affecting the critical path. (See Gantt Diagram of and Timeline Tables of Wood-Reinforced Structure in Appendix F)

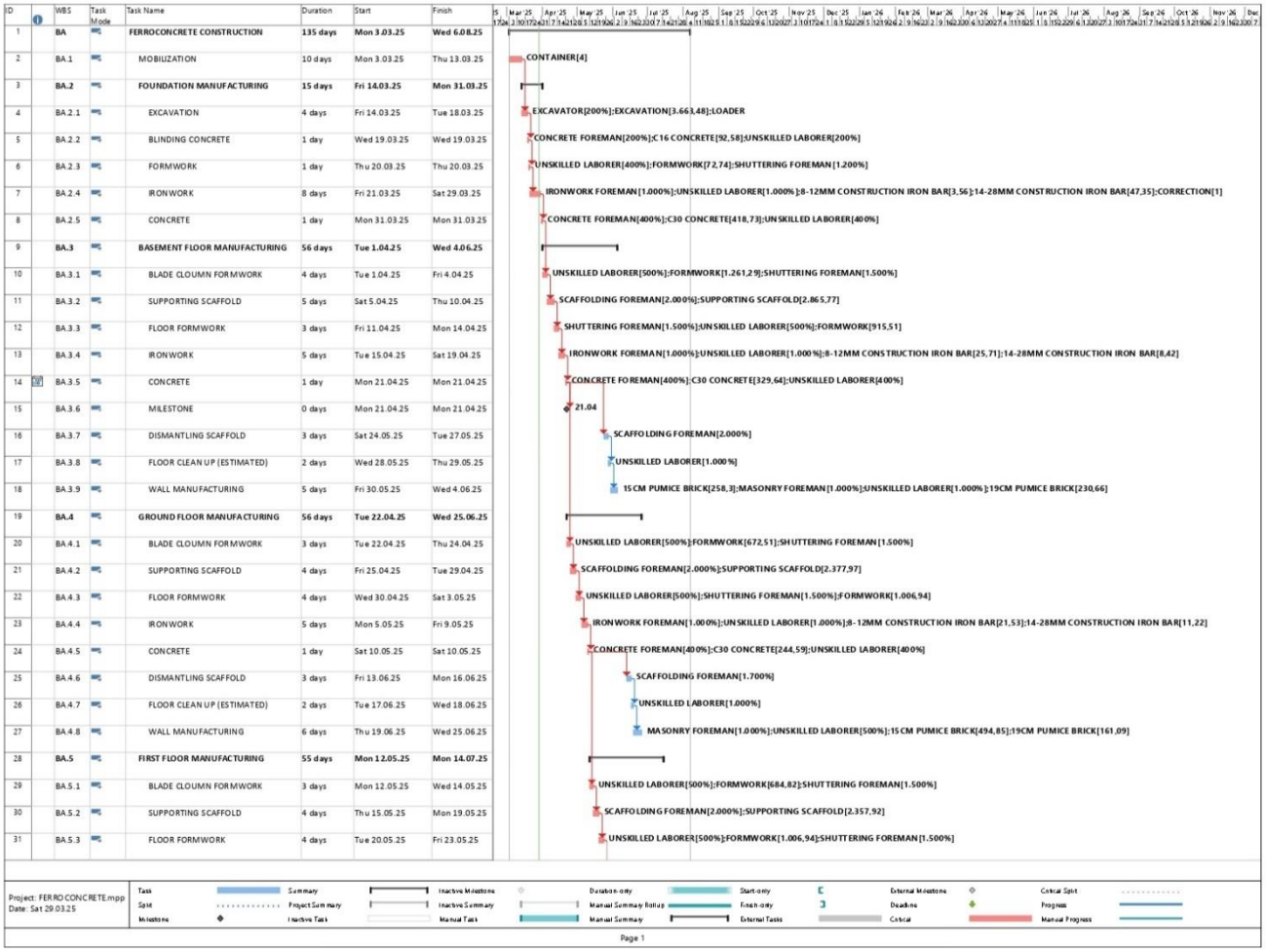


Figure 107. Gantt Diagram of Reinforced Concrete Structure

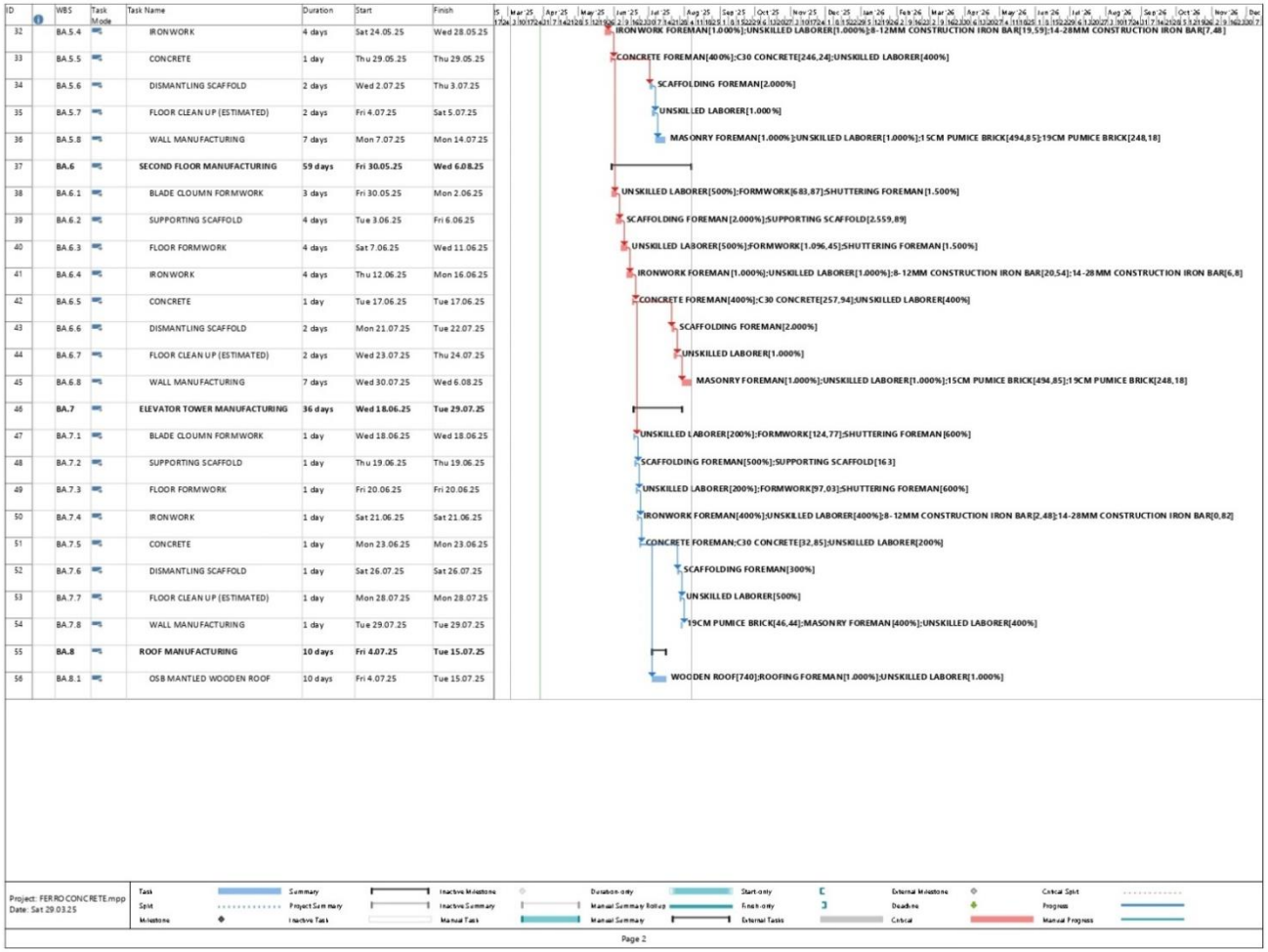


Figure 107. Gantt Diagram of Reinforced Concrete Structure (continued)

4.1.2.3. Construction Time for the Wood-Steel Structure

Below are MS Project Gantt charts showing the construction timelines for the wood-steel structure, prepared using the critical path method. The durations for each floor vary, and concurrent activities have been considered.

When performing the cost analysis, separate cost calculations were made for pine and oak, but since the construction speed for both is the same, the wood type was not considered in the construction speed evaluation.

The critical path calculations assume that the construction starts on 03.03.2025 and the completion date is determined as 05.06.2025. The estimated construction time for the wood-steel structure is 82 days.

The building core was designed as a steel system, allowing fast on-site assembly. CLT panels and Glulam beams were used in the superstructure; most of the assembly processes were completed in a factory setting, minimising the on-site construction time. The critical path continued with simultaneous wood panel assembly on several floors after installation of the foundation and steel core. Facade and roof installations were integrated with modular systems. (See Gantt Diagram and Timeline Table of Wood-Reinforced Structure in Appendix G)

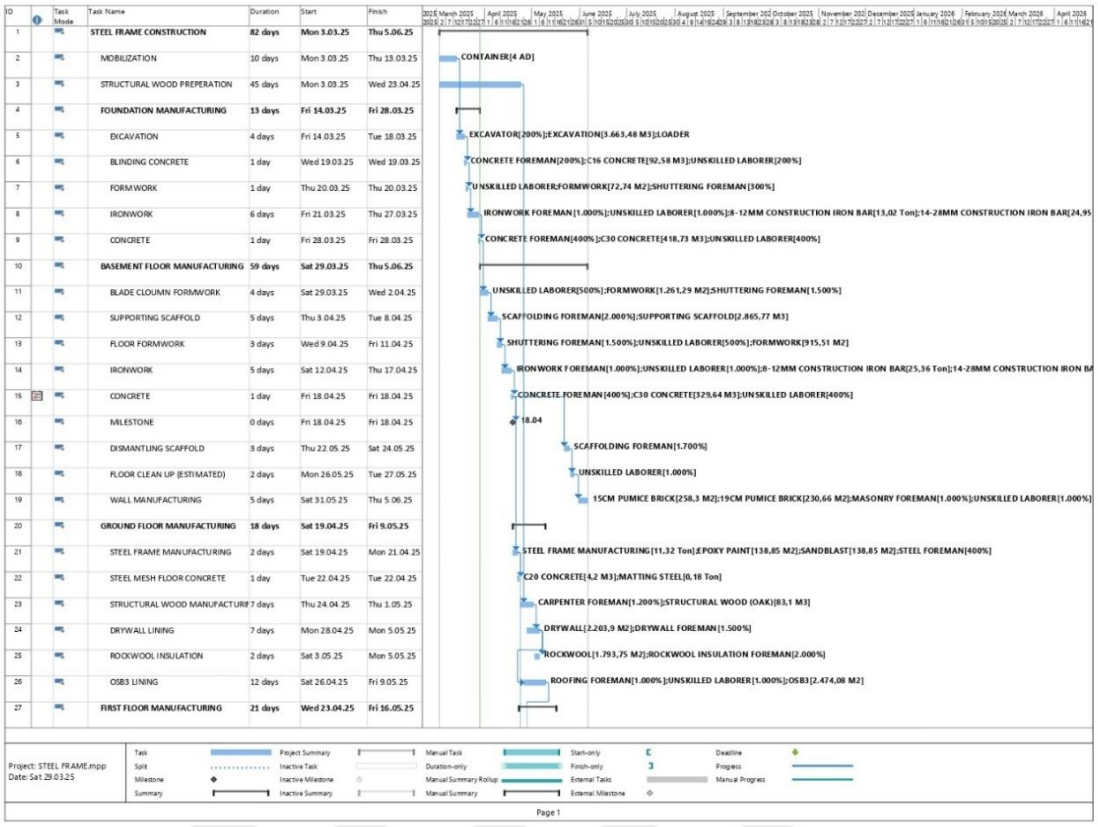


Figure 108. Gantt Diagram of Wood-Steel Structure

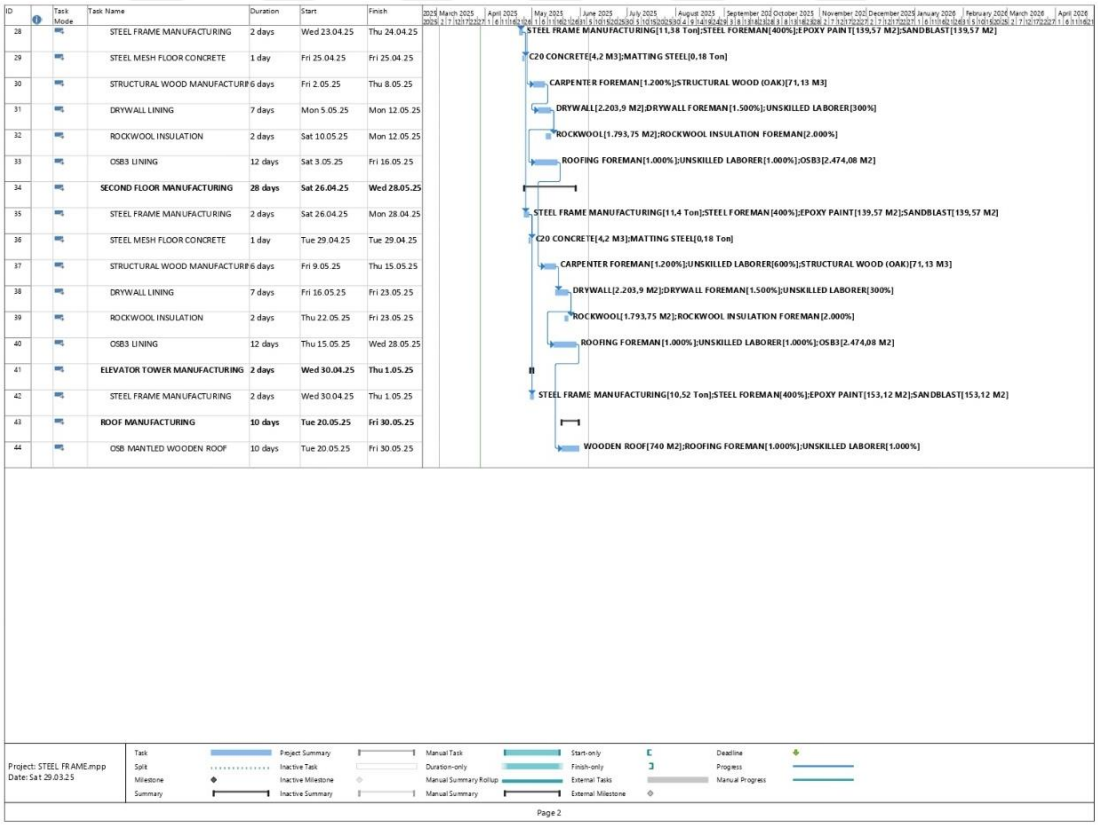


Figure 108. Gantt Diagram of Wood-Steel Structure (continued)

According to the CPM analysis, the construction duration of the Wood-Steel Hybrid Structure is approximately 39% shorter than that of the traditional reinforced concrete structure. The Wood- Concrete Hybrid Structure was completed in about 19% less time than the reinforced concrete system. The long drying and waiting times in the reinforced concrete structure were minimised in the hybrid structures.

The preparation of wooden and steel elements off-site and the possibility of quick assembly on-site reduced the manufacturing time. The modular integration of wooden panels and facade elements also yielded positive results in speed.

Table 23. Manufacturing Speed Created According to The Construction Technique of The Structure

Structural System	Total Construction Duration (Days)	Time Saved Compared to RC (Days)	Time Reduction (%)
Reinforced Concrete Structure	135 days	-	-
Wood-Reinforced Concrete Hybrid	110 days	25 days	0,19
Wood-Steel Hybrid	82 days	53 days	0,39

4.1.3. Comparative Analysis in Environmental Impact Context

According to the CPM analysis, the construction pace of the reinforced concrete structure is comparatively slower. This can be explained by the ability to prefabricate wooden structural elements and the faster assembly process of modular wooden elements on-site. On the other hand, reinforced concrete structures take longer to complete due to the formwork, reinforcement, and concrete pouring processes. Below is a table showing the manufacturing speed based on the construction technique used for the structure.

4.1.3.1. Wooden Structure- Environmental Effects

Globally, forest resources vary significantly between countries due to geographical and climatic factors. According to Our World in Data, the amount of forest resources in selected countries as of 2020 is presented in the table (Table 24).

Table 24. Forest Areas according to Countries (Our World in Data, 2023)

Country	Status of Forest Area (2020) (Hectare)	Certified Forest Area (2023) (Hectare)
Brazil	496,619,600 ha	9,077,120 ha
Canada	346,928,100 ha	156,495,560 ha
United States	309,795,000 ha	41,356,610 ha
China	219,978,180 ha	4,998,030 ha
Sweden	27,980,000 ha	23,386,280ha
Japan	24,935,000 ha	2,576,110 ha
Turkey	22,933,000 ha	8.265.709 ha
Spain	18,572,170 ha	3,014,390 ha
France	17,253,000 ha	8,170,420 ha
Norway	12,180,000 ha	7,351,500 ha
Germany	11,419,000 ha	8,840,560 ha

The most notable country in terms of forest resources is Brazil, primarily due to its vast Amazon rainforest. Brazil leads the world with approximately 496 million hectares of forested area. This extensive forest cover makes a significant contribution to the global carbon cycle and biodiversity.

Canada and the United States follow Brazil, with forest areas of 347 million hectares and 310 million hectares, respectively. Due to their large land areas and locations at northern latitudes, these countries host substantial boreal forests.

In Asia, China and Japan stand out with forest areas of 220 million hectares and 24.9 million hectares, respectively. Notably, China has seen a significant increase in recent years due to reforestation projects and forestry policies. Japan, on the other hand, is distinguished by its commitment to conserving natural forest resources and promoting sustainable forestry practices.

In Europe, Turkey is one of the prominent countries with a forest area of 22.2 million hectares, followed by Spain (18.6 million hectares) and France (17.3 million hectares). Turkey's efforts to preserve and expand its forest resources are particularly significant within the framework of rural development and biodiversity enhancement policies.

Among the countries with smaller forest areas are Norway (12 million hectares) and Germany (11 million hectares). Despite their limited land area, these countries implement effective policies for forest conservation and sustainable management. Italy and Greece rank at the bottom of the list, with forest areas of 9.6 million hectares and 3.9 million hectares, respectively.

Countries like Brazil, Canada, and the United States, which lead in forest resources, emphasize forest management and sustainability to mitigate environmental impacts and preserve natural resources. In this context, international certification systems promoting sustainable forest management play a critical role. Among these systems, the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) stand out. Both FSC and PEFC are globally recognized certification systems aimed at ensuring the environmental, social, and economic sustainability of forests. However, there are significant differences between these two systems regarding their implementation approaches and standards.

The FSC, established in 1993, is a widely recognized forest certification system with a primary goal of minimizing the environmental impacts of forests, preserving biodiversity, and protecting the rights of forest workers. Additionally, FSC acknowledges the traditional rights of local communities and ensures transparency in the global forest supply chain by making forest product trade traceable. FSC-certified forests prioritize not only environmental sustainability but also social justice. This certification aims to prevent the trade of illegal forest products, improve working conditions for forest workers, and enhance the economic well-being of local communities. As a result, FSC is widely accepted and practiced worldwide (FSC,

2020). Research has shown that FSC certification sets stringent standards for environmental and social responsibility in forest management and positively impacts global forest management practices (Klooster, 2010). Particularly, the strict standards for monitoring environmental impacts guarantee the proper management of forests.

PEFC, founded in 1999, is another prominent forest certification system that primarily supports small and medium-sized forest owners in transitioning to sustainable forest management. PEFC's flexible certification standards accommodate national forest certification systems, allowing local administrations to tailor the system according to their specific needs. This adaptability enables PEFC to be more widely adopted and suited to local conditions. The advantages of PEFC include promoting environmental sustainability, improving the economic well-being of local communities, and ensuring traceability in the forest supply chain. It also helps forest owners integrate into global markets while promoting socially and environmentally responsible management (PEFC, 2020). According to Mikulková (2015), PEFC's flexible and locally adaptable structure significantly contributes to spreading sustainable forest management in emerging markets.

The fundamental difference between FSC and PEFC stems from their approaches to environmental and social responsibility. While FSC enforces more stringent standards, PEFC offers a more adaptable framework that caters to local governance needs. Despite these differences, both systems play a crucial role in sustainable forest management and ensuring the traceability of forest products. As the application of these certification systems expands globally, including in Turkey, their impact on the global forest supply chain is expected to grow in the future.

One of the most important criteria for wooden construction is sustainable forestry. Without establishing industrial forestry, it is challenging to spread wooden construction due to both cost and environmental impact. According to the General Directorate of Forestry's data, the amount of industrial wood increased between 2014 and 2020, but after 2021, industrial wood production declined. The amount of firewood, on the other hand, decreased until 2017 but has shown an increase since then. (Table 25)

Table 25. Tree Productıon Amounts Accordıng to Years (The General Directorate of Forestry, 2023)

TREE PRODUCTION AMOUNTS ACCORDING TO YEARS		
	Industrial roundwood (m³)	**Fuel wood (Stere)(m³)**
2014	14 923 209	5 257 994
2015	16 637 598	5 022 986
2016	17 009 998	4 877 067
2017	15 521 622	4 359 646
2018	19 080 137	4 890 455
2019	22 113 248	5 589 798
2020	24 751 066	5 396 680
2021	27 735 268	5 487 368
2022	25 480 940	6 128 791
2023	22 606 763	5 166 656
TOTAL	**205 859 849**	**52 177 441**

In addition, in Turkey, various steps are being taken within the scope of sustainable forest management. A forest management certificate (FSC) has been obtained for a forest area of 8,265,709 hectares, covering 101 forest enterprise directorates under the Regional Forestry Directorates of Muğla, Kastamonu, Zonguldak, Bolu, Bursa, Istanbul, Adana, Antalya, Mersin, Balıkesir, Çanakkale, Sinop, Konya, and Amasya. The Certificated Forest areas have increased by 1.688.567 hectares (Table 26).

The growing stock of forest in 2023 is 1,773,672,287 m³, based on the statistics of the General Directorate of Forestry. According to the 2023 activity report of the General Directorate of Forestry, it has been reported that forest areas have shown a volumetric increase of 50,135,846 m³. In the 2023 activity report of the General Directorate of Forestry, assuming an annual increase of 50.135.846 m³, it is estimated that a daily volumetric increase of approximately 137.360 m³ is observed in Turkey’s forests.

Given that one day consists of 1440 minutes, the average increase per minute is calculated to be 95.38 m³.

Table 26. Forest Areas Accordıng to Years in Turkey (Activity Report of The General Directorate of Forestry, 2023)

FOREST AREAS ACCORDING TO YEARS		
	Status of Forest Areas (Hectare)	**FSC Certified Forest Area (Hectare)**
2019	**22.740.297**	**4.276.219**
2020	**22.933.000**	**6.577.142**
2021	**23.110.000**	**6.577.142**
2022	**23.245.000**	**6.577.142**
2023	**23.363.071**	**8.265.709**

In the wooden structure evaluated in the thesis, the volume of structural wood used is 225,36 m³, and the amount of wood used in the roof (wood for roof is 740m2. It is calculated according to market conditions. The %7 of the roof area(m2) gives the m3 of the wood used in roof construction.) is 50 m³, giving a total of 275,36 m³ of wood. As a result, for a 3-story wooden building with a total of 275,36 m³ of wood, the required amount of wood can be obtained in approximately 2.88 minutes in Turkey.

Considering this data, wooden structures can be a sustainable option for our forests, provided that the right incentive policies are implemented. Forests produce 1 ton of oxygen for every ton of wood while storing 1.4 tons of carbon dioxide. (Dündar, 2019)

4.1.3.2. CO2 Emissions of Wood-Reinforced Concrete, Reinforced Concrete and Wood-Steel Structures

Wood materials are part of a construction system that reduces carbon emissions during the building process and captures carbon from the atmosphere, storing it in the structure. When considering the net carbon balance, it can be said that the use of wood has a carbon-negative effect. Therefore, the preference for wood in sustainable building designs is crucial in reducing greenhouse gas emissions.

While traditional wood construction techniques used in our country do not have a negative environmental impact, using industrial wood building elements in multi-story wooden buildings leads to minimal carbon emissions due to the adhesives and chemical components used. (Gün, 2020)

The table below shows the carbon emissions and storage capacity from producing 1 m^3 of different wood types.

Table 27. Production-Based CO2 Emissions. Compiled from the articles of Gustavsson and Sathre (2011), Leskinen (2018), and Ritter, (2011)

	Production-Based Emissions (kg CO_2/m^3)	**Carbon Storage (kg CO_2/m^3)**	**Net CO_2 Balance (kg CO_2/m^3)**
Solid Timber	50 - 100	-800 to -1000	-700 to -900
Glued Laminated Timber (Glulam)	150 - 300	-800 to -1000	-500 to -700
Cross-Laminated Timber (CLT)	200 - 350	-800 to -1000	-450 to -650

The raw materials used in the production of building materials are primarily derived from naturally occurring resources. In reinforced concrete structures, the required materials include sand aggregates, water, iron, and various chemical additives. In contrast, timber structures primarily depend on forests and trees as their main source of raw materials.

Ahmet Vefa Orhon (2012), in his article “Beton Yapıların Karbon Ayak İzi” (The Carbon Footprint of Concrete Structures), highlights that life cycle assessments aiming to quantify the environmental impact of concrete generally rely on standardised mix proportions. A widely accepted mix design consists of approximately 11% cement, 16% water, 6% air, 27% fine aggregate, and 40% coarse aggregate (Athena, 2005, cited in Orhon, 2012). In line with this, it is well known that the formation of reinforced concrete necessitates the extraction of substantial quantities of materials from nature. To produce 1 m^3 of concrete, approximately 800 kg of sand, 1100 kg of aggregates (such as gravel and crushed stone), 200 litres of clean water, and 300 kg of cementitious materials are consumed (Topçu, 2015).

Among these constituents, cement plays a particularly critical role in terms of environmental impact. The production of 1 kg of cement requires nearly 2 kg of raw materials. Furthermore, the manufacturing process emits significant amounts of CO_2. According to Yıldız (2015), the production of one ton of cement emits approximately 0.55 tons of CO_2 from chemical reactions and an additional 0.4 tons from the fuel used to reach the 1450°C temperature required for clinker production. Therefore, in total, cement production is estimated to release roughly 1 ton of CO_2 per ton of cement produced, with 60% of emissions stemming from calcination and 40% from combustion.

Orhon (2012) presents a comparative analysis of the ECO_2 values of concrete in the UK and Denmark, revealing significant discrepancies despite similar mix designs. In the UK, the average ECO_2 value of concrete is around 225 kg-CO_2/ m³ (270 kg-CO_2/ m³ for reinforced concrete), while in Denmark, the corresponding values are 357 kg-CO_2/ton and 387 kg-CO_2/ m³, respectively (MPA, 2008b; Nielsen, 2008, cited in Orhon, 2012). These differences are primarily attributed to the national benchmarks assigned to cement-related emissions. For example, the CO_2 emission factor for cement is 720 kg-CO_2/ton in the UK, while it is 850 kg-CO_2/ton in Denmark (MPA, 2008a; Nielsen, 2008, cited in Orhon, 2012).

The relatively lower CO_2 emission figure in the UK is mainly due to the partial replacement of Portland cement with pozzolanic materials—industrial by-products such as fly ash and ground granulated blast-furnace slag—comprising approximately 23% of the binder content in concrete. Since these pozzolanic materials have significantly lower embodied carbon, their incorporation effectively reduces the average ECO_2 value of the final concrete product (MPA, 2008c, cited in Orhon, 2012).

In addition to raw material production, the transportation of concrete also contributes to its overall carbon footprint. As noted by Orhon (2012), transporting concrete via large vehicles such as mixer trucks results in additional emissions—approximately 0.001 kg-CO_2/ton per kilometre—depending on the distance between the batching plant and the construction site (Nielsen, 2008, cited in Orhon, 2012).

In the context of Turkey, the 2024 Ready-Mixed Concrete Sector Report published by the Turkish Ready-Mixed Concrete Association (Türkiye Hazır Beton Birliği – THBB) indicates that the carbon footprint of 1 m³ of C35 class ready-mixed concrete

is approximately 337 kg-CO_2/m^3 (THBB, 2024). This figure serves as a useful benchmark for assessing the environmental performance of conventional concrete used in Turkish construction practices.

According to these datas, environmental impact analysis are made for these three buildings based on the amount of CO_2/m^3 emissions.

Wooden- Reinforced Concrete Hybrid Structure:

- The amount of concrete used in the reinforced concrete area of the core section and the fully reinforced concrete basement of the *wooden-reinforced concrete structure* in Kahramanmaraş-Andırın District is 1013,6 m^3.

  -If the carbon footprint of 1 m^3 of C35 class ready-mixed concrete is approximately 337 kg-CO_2/m^3 (THBB, 2024), the carbonfootprint of 1 m^3 of concrete is 0.337ton CO_2/m^3.

  -If the used concrete in this building is 1003 m^3, the carbon footprint of this building is 0.337-ton CO_2/m^3 x 1003 m^3 = <u>338.01-ton CO_2</u>

Reinforced Concrete Structure:

- For a building designed with the same form, function, and specifications using *a reinforced concrete structural system*, approximately 1622,57 m^3 of concrete has been used.

  -If the carbon footprint of 1 m^3 of C35 class ready-mixed concrete is approximately 337 kg-CO_2/m^3 (THBB, 2024), the carbonfootprint of 1 m^3 of concrete is 0.337ton CO_2/m^3.

  -If the used concrete in this building is 1622,57 m^3, the carbon footprint of this building is 0.337-ton CO_2/m^3 x 1622,57 m^3 = <u>546,80-ton CO_2</u>

Wood-Steel-Reinforced Concrete Hybrid Structure:

- For *the wood-steel building* designed with the same form and specifications, calculate the concrete and steel areas in the staircase core and basement:
  - 840,95 m³ of concrete is used for the basement floor. -If the used concrete in this building is 840,95 m³, the carbon footprint of this building is 0.337-ton CO_2/m^3 x 840,95 m³ = 283,40-ton CO_2

  -According to Baş (2023) in the article "Decarbonization of the Turkish Steel Sector: Current Status" published by the Istanbul Policy Center, *"For each ton of steel produced, 2.32 tons of CO2 emissions are generated."*

The 44.62 tons of steel used in the staircase core of the building and other structural components contributed approximately 103.52 tons of CO2 based on the emission factor of 2.32 tons of CO2 per ton of steel produced. Therefore, the total CO2 emissions for the project amount to approximately 386.92 tons of CO2.

Table 28. Production-Based CO2 Emissions for the Structures Constructed With Different Techniques

Construction Technique of the Structures	The Structure built with Wood -Reinforced Concrete	The Structure built with Wood-Steel-Reinforced Concrete	The Structure built with Reinforced Concrete
Environmental Impact (CO2) *	**338,01 Ton CO2**	**386,92 Ton CO2**	**546,80 Ton CO2**
*The amount of CO2 created by the structural wood in the wooden structure during production was not considered because it was lower than the carbon sequestration contained in the wood.			

4.1.3.3. Findings and Evaluation for Wood-Reinforced Concrete Structure, Wood-Steel Structure and Reinforced Concrete Structure

Wood structures have a significantly lower carbon footprint compared to reinforced concrete buildings. The carbon footprint of reinforced concrete structures is increased not only by cement but also by the iron used in them. A study indicated that the carbon footprint value of steel is 694 kg/ton (Dündar, 2019).

According to Gustavsson and Dodoo, wood has carbon storage capacity and minimises environmental impact due to its low energy requirements during the production process (Dodoo, Gustavsson, and Sathre, 2014). In contrast, reinforced concrete

structures cause more harm to the environment due to the high carbon emissions and energy intensity during cement production. Furthermore, wooden structures are advantageous when evaluating waste management as they are recyclable and biologically decomposable.

Based on the environmental impact analysis, it has been found that the CO2 emissions released during the construction of a wood-concrete hybrid structure are lower. Even though the CO2 emissions from a wood-steel structure are higher compared to a wood-concrete hybrid structure, it still presents better results compared to reinforced concrete buildings.

In terms of cost analysis, it has been found that reinforced concrete buildings are currently the most economical construction technique. However, the lack of widespread structural wood production in Turkey results in higher costs due to export-related expenses. The analysis revealed that the cost of oak timber considerably exceeds that of pine timber. Wood-steel structures are also found to be more expensive. However, with the increase in industrialisation of wood, more favorable outcomes in terms of cost will emerge in the future.

Regarding construction speed, the analysis shows that a wood-steel structure can be built approximately 2 months faster than a reinforced concrete building. The positive results in construction speed for wood-steel buildings under current market conditions will also contribute to cost benefits. Additionally, the studies indicate that a wood-concrete hybrid structure can be completed approximately 1 month faster than a reinforced concrete building.

Table 29. Cost, Speed and Environmental Impacts of the Structures constructed with different techniques

Construction Technique of the Structures	**The Structure built with Wood -Reinforced Concrete**	**The Structure built with Wood-Steel-Reinforced Concrete**	**The Structure built with Reinforced Concrete**
Approximate Cost (TL)*	If Oak (Wood) is used: ₺42.504.449,98 (1.093.771,24 USD) If Pine (Wood) is used: ₺30.487.549,40 (784.539,13 USD)	If Oak (Wood) is used: ₺43.839.411,13(1.128.123,95 USD) If Pine (Wood) is used: ₺31.822.510,55 (818.891,85 USD)	₺22.035.896,56 (567.051,96 USD)
Construction speed (day)*	110 day	82 day	135 day
Environmental Impact (CO2) **	338,01 Ton CO2	386,92 Ton CO2	546,80 Ton CO2
*The values specified in the table have been evaluated based on the rough construction quantities. The building walls have also been included in the calculations.			
**The amount of CO2 created by the structural wood in the wooden structure during production was not taken into account because it was lower than the carbon sequestration contained in the wood.			

As a result, timber-concrete structures, while being faster and having a better environmental impact, have higher initial investment costs compared to other types of buildings. Timber-steel structures, similarly, are environmentally friendly and can be built quickly, but they also require a higher investment cost. Concrete structures, on the other hand, are slower to build, have a greater environmental impact, but offer economic solutions in terms of cost. These analyses highlight the advantages and disadvantages of each building type, suggesting that, depending on specific needs, suitable options should be considered to meet sustainability goals.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 General Evaluation

This thesis examines the use of wood as a structural system in the Turkish construction sector, analysing its historical development, current applications, and future potential. The traditional structures of Turkish wooden architecture and the construction systems used (such as Çantı, Taraba, and Çatkı) have been investigated, highlighting the evolution of wood from the past to the present and revealing its current potential. Recent developments in Turkey have been discussed, and the enhancement of the regulatory framework for wooden buildings, following the enactment of the Timber Buildings Regulation in 2024, has been evaluated. Additionally, the activities of the National Timber Association and the process of establishing standards for wooden structures have been examined.

The research conducted within the scope of this thesis has revealed that timber was widely used throughout history in Turkey, particularly in religious and public architecture. Wooden mosques such as the Eşrefoğlu Mosque, Mahmut Bey Mosque, Göğceli Mosque, and Atabey Gazi Mosque, located in various regions of Anatolia, demonstrate the advanced state of traditional wooden construction techniques. Similarly, large-scale structures like the Büyükada Greek Orphanage prove that timber was not only limited to small-scale or rural buildings but was also employed in public architecture.

These examples clearly show that timber was once a preferred material both structurally and aesthetically. However, it is observed that today this rich tradition of timber construction has largely been forgotten, having been replaced by reinforced concrete systems. This represents a significant loss in terms of preserving local architectural heritage and promoting sustainable building practices.

Although timber construction was historically widespread in Turkey, it no longer receives the attention it deserves. Reviving this traditional knowledge and integrating it with contemporary building technologies carries great potential for both sustainability and architectural identity.

Through comparative analyses of wooden and reinforced concrete structures, environmental assessments, and case studies, the challenges and opportunities related to the adoption of wooden structures in Turkey have been identified. The findings demonstrate that combining wood with reinforced concrete or steel hybrid systems offers a sustainable and innovative alternative within the Turkish construction sector. This thesis aims to present the current state and future potential of using wood as a structural system in Turkey by examining it from a historical perspective to the present day. The analyses and comparisons indicate that wooden structural systems are a sustainable and innovative alternative in the Turkish construction sector.

In terms of cost, hybrid wooden structures (Wood-Reinforced Concrete and Wood-Steel-Reinforced Concrete) require approximately 38% to 45% higher initial investment compared to traditional reinforced concrete buildings. On the other hand, considering lifecycle costs, they offer economic advantages due to energy efficiency and lower long-term operational expenses.

Regarding construction duration, prefabrication significantly reduces the time required for hybrid structures. Wood-steel hybrid structures are completed approximately two months faster, while Wood-Reinforced Concrete structures are completed about one month faster than conventional methods.

Wooden structural systems also perform well in terms of environmental impacts, carbon emissions, and energy consumption. Compared to conventional building materials, wood production results in lower carbon emissions in this thesis. In addition, Kurul (2019) explains that the production of one ton of wood emits approximately 20 times less carbon than steel, 9 times less than concrete, and about 3 times less than brick in his master's thesis, The Wood Industry in Turkey. The energy required to produce one ton of wood is one unit, while five units for cement and 24 units for steel. These data highlight that wood is an environmentally friendly building material compatible with Turkey's carbon reduction targets.

Despite these advantages, some challenges specific to Turkey persist. Among them are high initial investment costs and the limited domestic production of engineered wood products such as CLT and glulam. According to the analyses conducted within the thesis, the construction costs of timber buildings are high; however, this situation is

quite the opposite on a global scale. For instance, when comparing the costs of 3-5 story buildings in the United States, it was found that reinforced concrete buildings are, on average, 23% more expensive than wood-framed buildings (Schires, 2019).

To overcome these challenges, a holistic policy framework is needed to promote innovation, support sustainable construction practices, and increase public awareness.

International examples provide valuable lessons. Since the regulatory changes implemented in Sweden in 1997, the use of multi-story wooden buildings has increased significantly, raising the share of wooden housing from 0% to 15% (Kuzman et al., 2017). In Canada, regulations introduced in 2009 mandated the use of wood in state-supported buildings, thereby boosting the production of multi-story wooden structures (Bowyer, 2016). Switzerland and Japan have developed national wood strategies and provided financial incentives to encourage the innovative use of wood (UNECE, 2016; Goto et al., 2018).

One of the most significant developments aimed at increasing the use of wood in Turkey is the "Wood Usage Expansion Project" introduced by the Presidency of Strategy and Budget of the Republic of Turkey in 2018. This project was implemented in collaboration with the General Directorate of Forestry (OGM), the United Nations Development Programme (UNDP), the Ministry of Transport and Infrastructure (UAB), and the Turkish Timber Association (TORİD) (Şişman and Balaban Ökten, 2023). As part of the project, a comprehensive report on the solid wood sector in Turkey was prepared, and strength tests were conducted on tree species suitable for use as building materials (Özertan and Coşkun, 2021).

To promote the use of wooden structures, multi-story residential and educational building projects have been developed to guide architects and engineers. Additionally, long-term seminar series were organised in collaboration with the International Timber Association (UAB) and TORİD to raise awareness and enhance knowledge about wooden structures among professionals, including architects and engineers. Over the years, the increasing participation rates in these events indicate a growing societal awareness (Şişman and Balaban Ökten, 2023).

These incentive policies represent a significant step toward increasing the use of wooden structural systems in Turkey and play a guiding role in promoting sustainable building practices (Şişman and Balaban Ökten, 2023).

5.2. Policy Recommendations and Research Needs

The thesis examines the need for regulatory and sectoral changes to promote the effective and widespread use of wood as a structural material in Turkey.

According to the research results, the Timber Buildings Regulation, published in the Official Gazette in 2024, represents an important starting point. However, more detailed standards are needed, especially for hybrid systems and multi-story buildings. Once the harmonisation process with Eurocode 5 is completed, sectoral confidence will increase, and applications will become more straightforward.

Investments in local manufacturing facilities should be made to increase the domestic production of engineered wood. Financial support mechanisms such as low-interest loans and tax incentives for sustainable building projects would help alleviate the economic burden of initial investment costs.

Additionally, university curricula should be updated to enhance professional knowledge in the fields of timber structure design and engineering. Furthermore, vocational training programs for engineers and architects should be promoted.

Economic incentive mechanisms should be developed to address the challenge of high initial investment costs. Since timber structures have a low carbon footprint, projects that meet sustainability criteria should benefit from tax advantages, exemption from title deed fees, and increased development rights. Especially through public banks, financial support packages should be created for timber building projects. These models should also be made applicable to individual housing projects.

To boost the domestic production of industrial wood products, R&D (Research and Development) grants supported by KOSGEB and TÜBİTAK should be increased, and incentive systems should be established to reduce dependency on imports.

To enhance the adoption of timber structures in Turkey, scientific research and technical analyses should be expanded. Considering earthquake risks, laboratory and field tests should be conducted to evaluate the seismic performance of hybrid timber structures, and details specific to Turkish conditions should be included in the regulations. The sustainability potential of local tree species (such as Anatolian Oak and Red Pine) should be assessed, and life cycle analyses should be performed. In

addition, internationally recognised data on the environmental impacts of timber structures should be compiled.

A lack of knowledge regarding timber construction technologies is a significant issue within the sector. Therefore, the following educational and awareness-raising initiatives should be implemented:

- Architecture and civil engineering departments should incorporate compulsory courses on timber design and engineering.
- Master's and doctoral-level programs focusing on timber structures should be established.
- Certification programs should be organised for architects, engineers, building inspectors, and contractors.
- These programs should include international practices and offer practical field experience.
- Seminars, exhibitions, and media campaigns should be organised to address public concerns regarding fire safety, durability and maintenance of timber structures.
- These are crucial for building public trust and guiding industry stakeholders. Municipalities and ministries should prioritise hybrid timber systems in public buildings such as schools, health centres, and municipal facilities. These projects will serve as examples for local communities and encourage private sector investments. Hybrid timber structures can offer rapid and sustainable housing solutions within urban transformation projects.
- Pilot projects developed in line with international sustainability certifications like LEED and BREEAM should be promoted to facilitate the adoption of these standards in Turkey.

The policy recommendations and research areas outlined above will facilitate Turkey's progress toward its sustainable construction goals and accelerate the transformation within the timber structure sector. The successful implementation of these strategies requires intense cooperation and coordination among public institutions, universities, civil society organisations, and the private sector.

Turkey can move towards a resilient and sustainable construction sector by integrating the traditional architectural heritage of timber with modern engineering practices. Taking steps in this direction will help combat climate change. To achieve this, public institutions, universities, the private sector, and international partners must work together.

5.3. Recommendations for Upcoming Thesis

In the context of hybrid timber-steel structures and other construction systems, several critical topics, though not covered within the scope of this thesis, should be investigated in detail in future academic studies due to their significant relevance to sustainability assessments.

Firstly, the recyclability and reuse potential of steel, particularly its globally high recycling rate of approximately 84.4% for Turkey (Willeke, 2024), should be quantitatively examined in future life cycle assessments (LCA). Incorporating accurate data on post-use steel recovery can significantly alter the calculated carbon footprint and enhance the reliability of environmental impact evaluations. Furthermore, the effect of using recycled steel on embodied energy and CO_2 emissions in hybrid systems presents a valuable area for further research.

Secondly, the maintenance requirements and durability of construction materials, especially timber, should be addressed in future theses. As a natural material, wood is susceptible to environmental conditions, including humidity, biological agents, and UV exposure, which necessitate periodic maintenance. Comparative studies on long-term maintenance costs, protective treatments, and ageing behaviour of materials such as timber, concrete, and steel could provide more comprehensive insights into operational sustainability and life cycle cost evaluations.

Additionally, future studies should explore topics related to the sourcing of timber in line with sustainable forest management principles, the potential use of local tree species, fire resistance performance, and overall structural adequacy. In the context of Türkiye, it would be particularly valuable to analyze the feasibility of using native species (e.g., spruce, pine, oak) in load-bearing systems and to compare them with imported species in terms of structural performance and environmental impact. Moreover, the fire behaviour of timber structures is a critical aspect in structural design

and safety; therefore, evaluating innovative fire protection technologies and their integration into structural systems could serve as an important research direction.

In conclusion, future academic work focusing on the recyclability of steel, the maintenance and preservation requirements of timber, and the efficient use of local forest resources can contribute to a deeper understanding of sustainable construction practices. Such studies will not only strengthen the scientific foundation for architectural and engineering decisions but also support the development of environmentally responsible public policies and building regulations.

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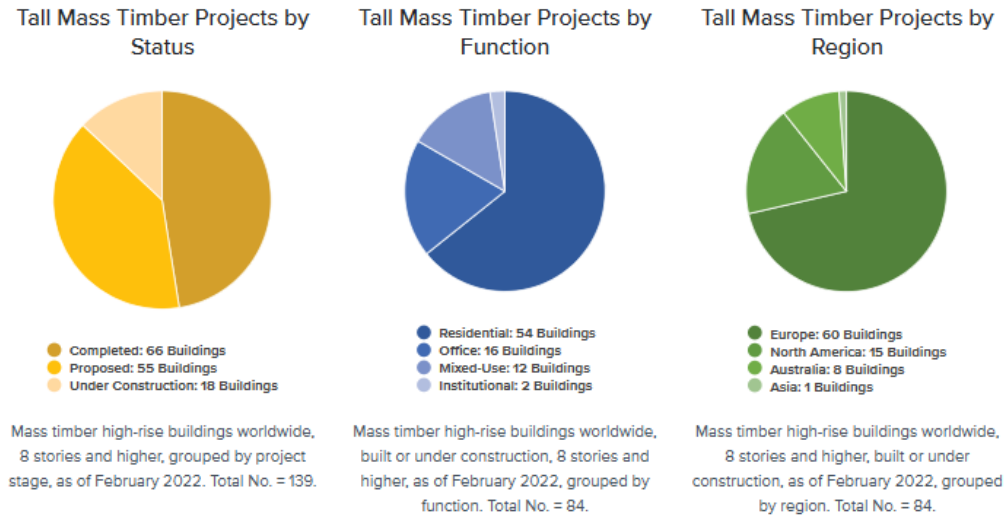
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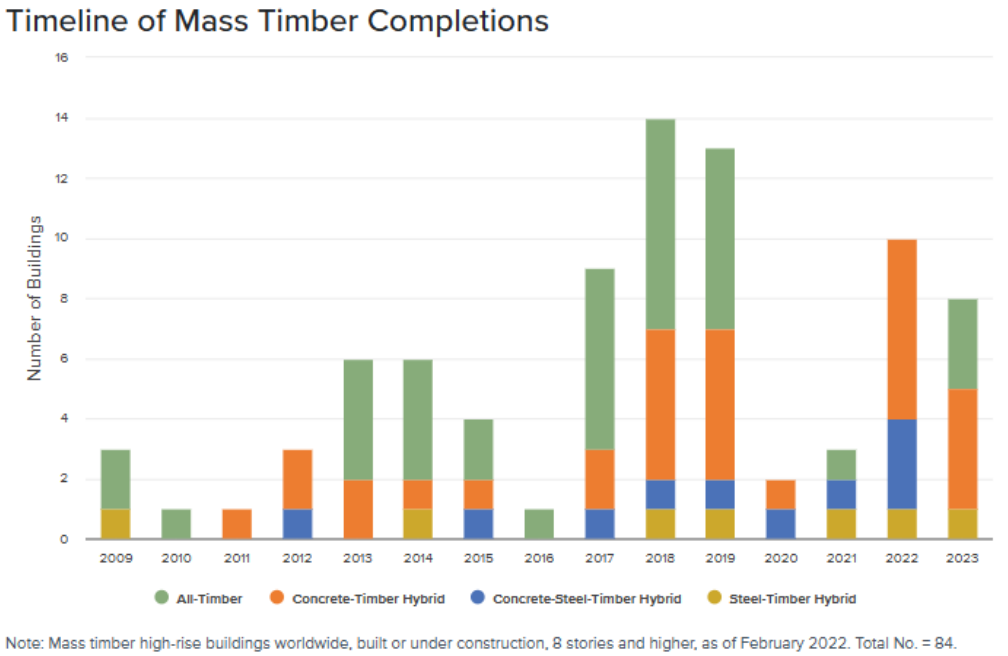
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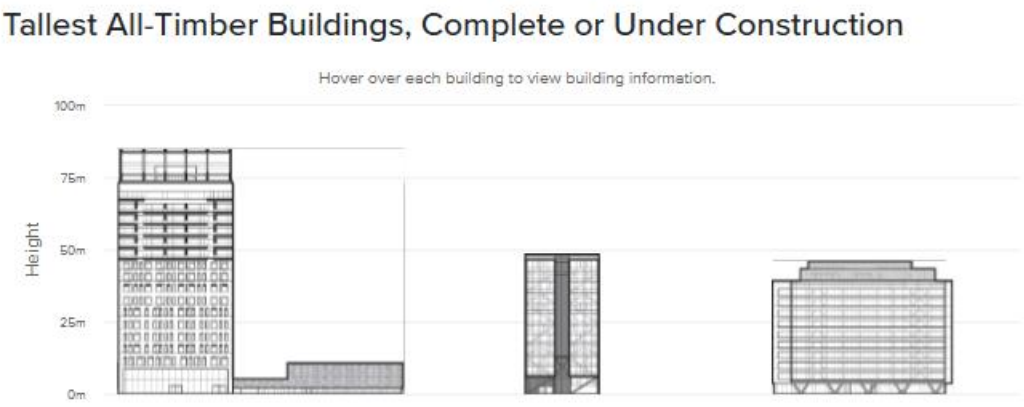
APPENDICES

Appendix A- 1. Detailed Information about the Tallest Mass Timber Buildings. (CTBUH,2025)

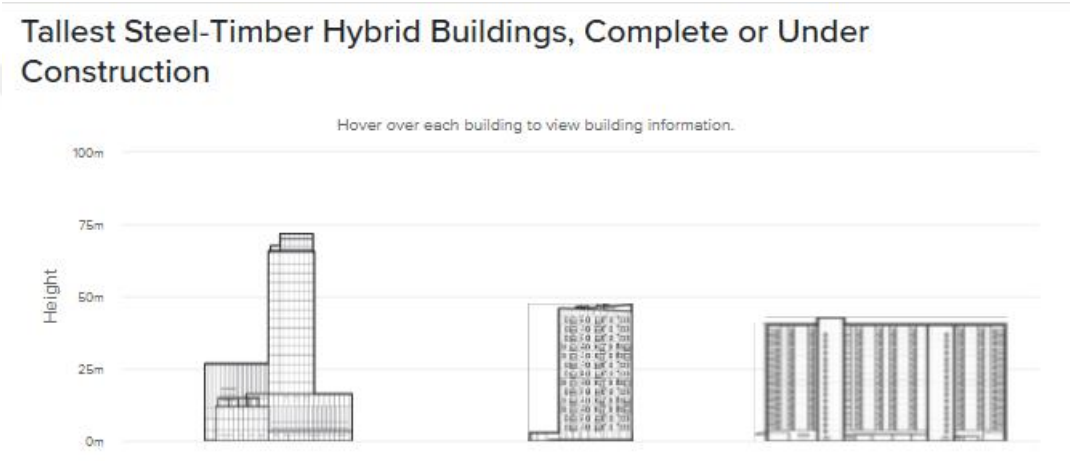




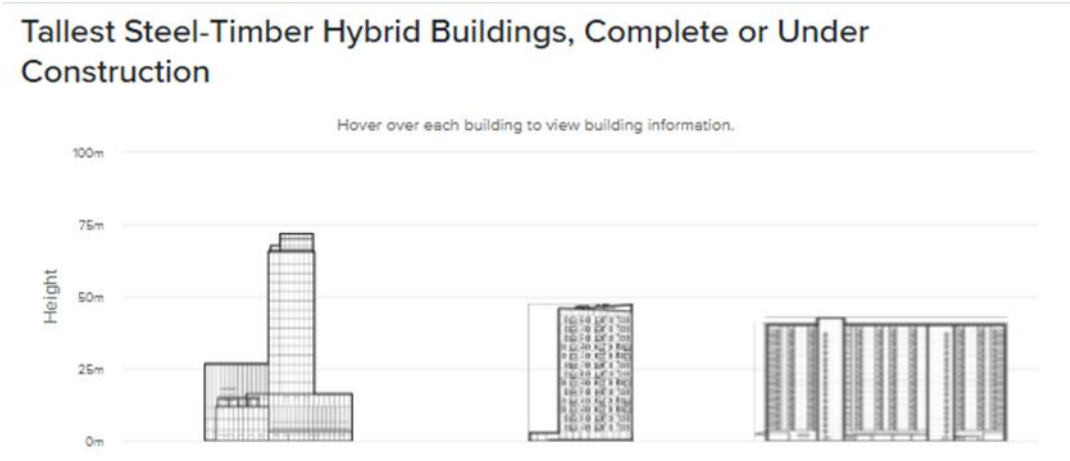
Note: Mass timber high-rise buildings worldwide, built or under construction, 8 stories and higher, as of February 2022. Total No. = 84.



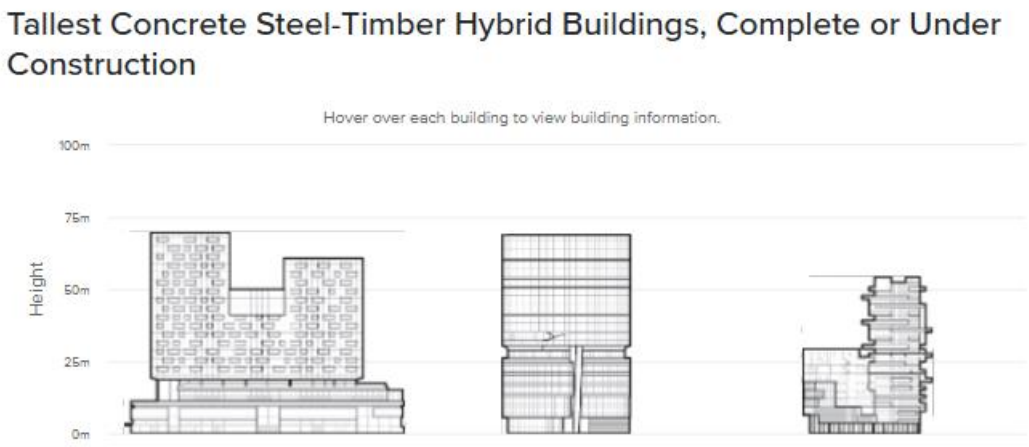
Mjøstårnet Treet 25 King



Sara Kulturhus Lighthouse Joensuu Tall Wood 1

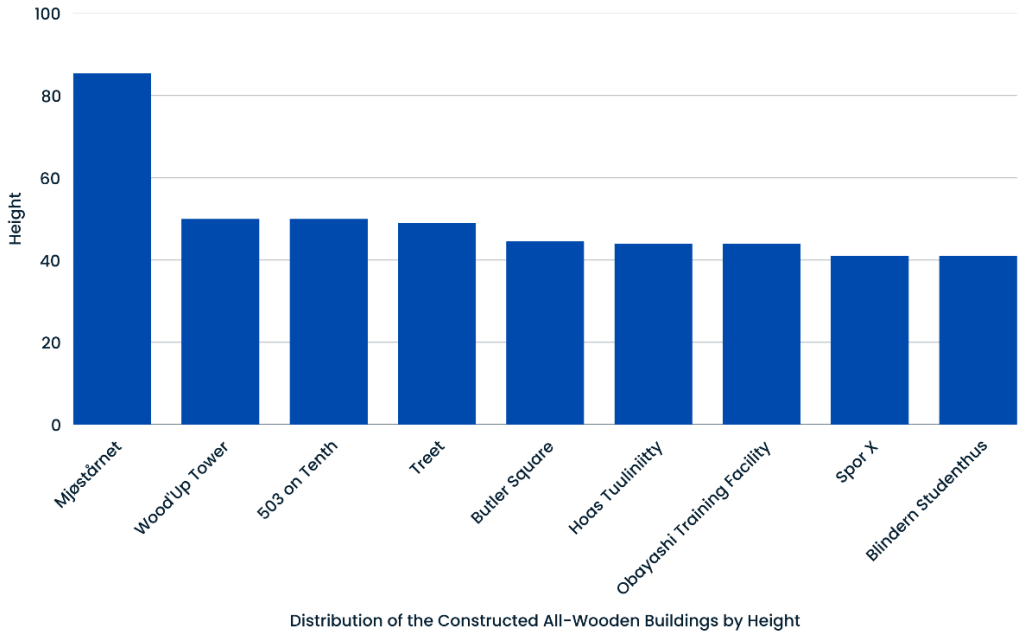


Ascent HoHo Haut



De Karel Doorman 55 South Bank Hyperion

Appendix A- 2. Distribution of the Constructed All-Wooden Buildings by Height

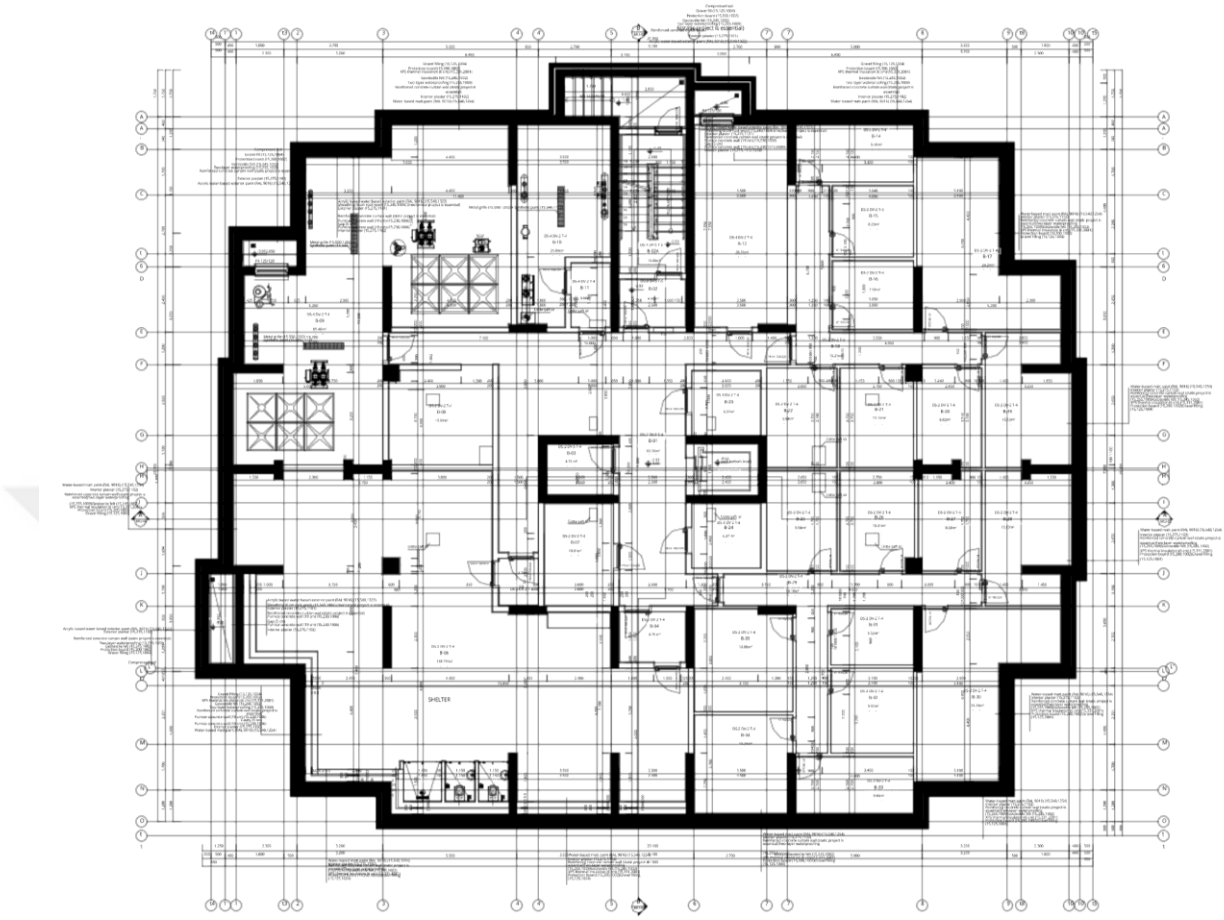


Appendix A –3. The highest Mass Timber Buildings listed according to height in the World

RANK	NAME	CITY	STATUS*	COMPLETION	HEIGHT	FLOORS	FUNCTION	MATERIAL	ARCHITECT
1	C6 Perth	Perth	P	-	183.5m	50	Residential	Concrete-Steel-Timber Composite Over Concrete	Fraser and Partners
2	Atlassian Central	SYDNEY	UC	2026	182.6m	42	Office/Hotel	Concrete-Steel-Timber Composite	BVN Shop Architects
3	The Dutch Mountains I	Eindhoven	P	-	130m	38	Residential/Office	Concrete-Timber Composite	OMT Architects
4	Tree House	Rotterdam	P	2025	130m	37	Residential/Office	Concrete-Timber Composite	PLP Architecture
5	Upper House	Brisbane	C	2023	119.7m	34	Residential	All-Concrete	Koichi Takada Architects
6	Gliwice Radio Tower	Gliwice	C	1935	118m	-	Telecommunications	All-Timber	-
7	Rainbow Tree	Cebu	P	-	115m	32	Residential	All-Timber	Vincent Callebaut Architecture
8	The Dutch Mountains II	Eindhoven	P	-	102m	29	Hotel/Serviced Apartments/ Office	Concrete-Timber Composite	OMT Architects
9	Rocket&Tigerli	Winterthur	P	2026	100m	32	Residential	All-Timber	Schmidt Hammer Lassen Architects
10	Marunouchi Tokio Marine	Tokyo	P	2028	100m	20	Office	Composite	J. Moolhuijzen, A. Giralt, H. Nakatani
11	Metropolitan Park Building 7/8	Arlington	C	2023	99.2m	23	Office	Concrete Over Concrete-Steel-Timber Composite Over Concrete	2GF Architects
12	Woho	Berlin	P	-	98m	29	Residential	Concrete-Timber Composite	Mad Arkitekter
13	Burj Zanzibar	Zanzibar	UC	-	96m	28	Residential	All-Timber	OMT Architects
14	2011 Locust Street	St. Louis	P	2025	95.5m	29	Residential	Concrete-Timber Composite	Korb + Associates Architects
15	191 College Street	Toronto	P	-	95.4m	31	Residential	All-Timber	Diamond Schmitt Architects
16	Ascent	Milwaukee	C	2022	86.6m	25	Residential	Concrete-Timber Composite Over Concrete	Korb+ Associates Architects
17	Mjøstårnet	Brumunddal	C	2019	85.4m	18	Residential/Hotel/ Office	All-Timber	Voll Arkitekter
18	Tilia Tower	Lausanne	UC	2026	85m	28	Residential/Hotel	Concrete-Timber Composite	3XN Architects
19	HoHo Wien	Vienna	C	2020	84m	23	Serviced apartments / Hotel / Office	Concrete-Timber Composite	RLP Rüdiger Lainer
20	TRÆ	Aarhus	C	2024	81.7m	20	Office	Composite	Lendager
21	Terrace House	Vancouver	C	2020	71 m		Residential	Concrete-Timber Composite	Shigeru Ban Architects
22	55 Southbank	Melbourne	C	2020	70m	17	Trading Center	Concrete-Timber	Squire & Partners ve Stanton Williams
23	Kulturhus Skelleftea	Skelleftea	C	2021	61m	20	Cultural Center	Timber-Timber Composite	White Arkitekter
24	EuroNantes	Nantes	P	-	58m	18	Residential	All-Timber	Lina Ghotmeh
25	Hyperion	Bordeaux	C	2021	55 m	16	Residential	Concrete-Timber Composite	Viguier
26	Wood'Up Tower	Paris	C	2024	50m	17	Residential	All-Timber	Local Architecture Network
27	Dock Mill	Dublin	P	-	50m	13	Residential/Office	All-Timber	Urban Egency
28	503 on Tenth	Portland	C	2024	50m	10	Office	All-Timber	Hennebery Eddy Architects
29	Quayside Building 1C	Toronto	P	-	49.2 m	12	Residential	All-Timber	Adjaye Associates
30	Treet	Bergen (NO)	C	2015	49 m	14	Residential	All-Timber	Artes AC
31	Lighthouse Joensuu	Joensuu	C	2019	48 m	14	Dormitory	Timber-Concrete	Arkadia Oy Arkkitehtitoimisto (Samuli Sallinen)
32	25 King	Barisbane	C	2018	47 m	10	Trading Center	Timber-Concrete	Bates Smart
33	2150 Keith Drive	Vancouver	C	2021	45 m	10	Office	Timber-Concrete	Dialog Architecture
34	Butler Square	Minneapolis (US)	C	1908	44.5 m	9	Office	All-Timber	E. Townsend Mix
35	Hoas Tuuliniitty	Espoo (FI)	C	2021	44 m	13	Residential	All-Timber	Arkkitehtitoimisto Huttunen-Lipasti-Pakkanen Oy
36	Obayashi Training Facility	Yokohama (JP)	C	2022	44 m	11	Office	All-Timber	Obayashi Corporation Architects
37	Spor X	Drammen (NO)	C	2021	41.4 m	10	Office	All-Timber	Dark Arkitekter
38	Origine	Quebec City	C	20217	41 m	13	Residential	Timber-Concrete	Yvan Blouin Architecture
39	77 Wade	Toronto	C	2022	38 m	7	Office	Timber Composite	BNKC Architecture + Urban Design
40	Sensations	Strasbourg	C	2018	38 m	8-10-11	Residential	Timber-Concrete	KOZ Architecture
41	Trafalgar Palace	London	C	2015	36 m	4-10	Residential	All-Timber	dRMM Architects
42	Aveo Bella Vista	Sydney	C	2018	36 m	10	Retirement Living Village	All-Timber	Jackson Teece
43	Suurstoffi 22	Risch-Rotkreuz	C	2018	36 m	10	Office	Timber Composite	Burkard Meyer Architecture
44	Skaio	Heilbronn	C	2019	34 m	10	Residential	Timber Composite	Kaden + Lager

Status*; P:Proposed, C:Completed, UC:Under Construction

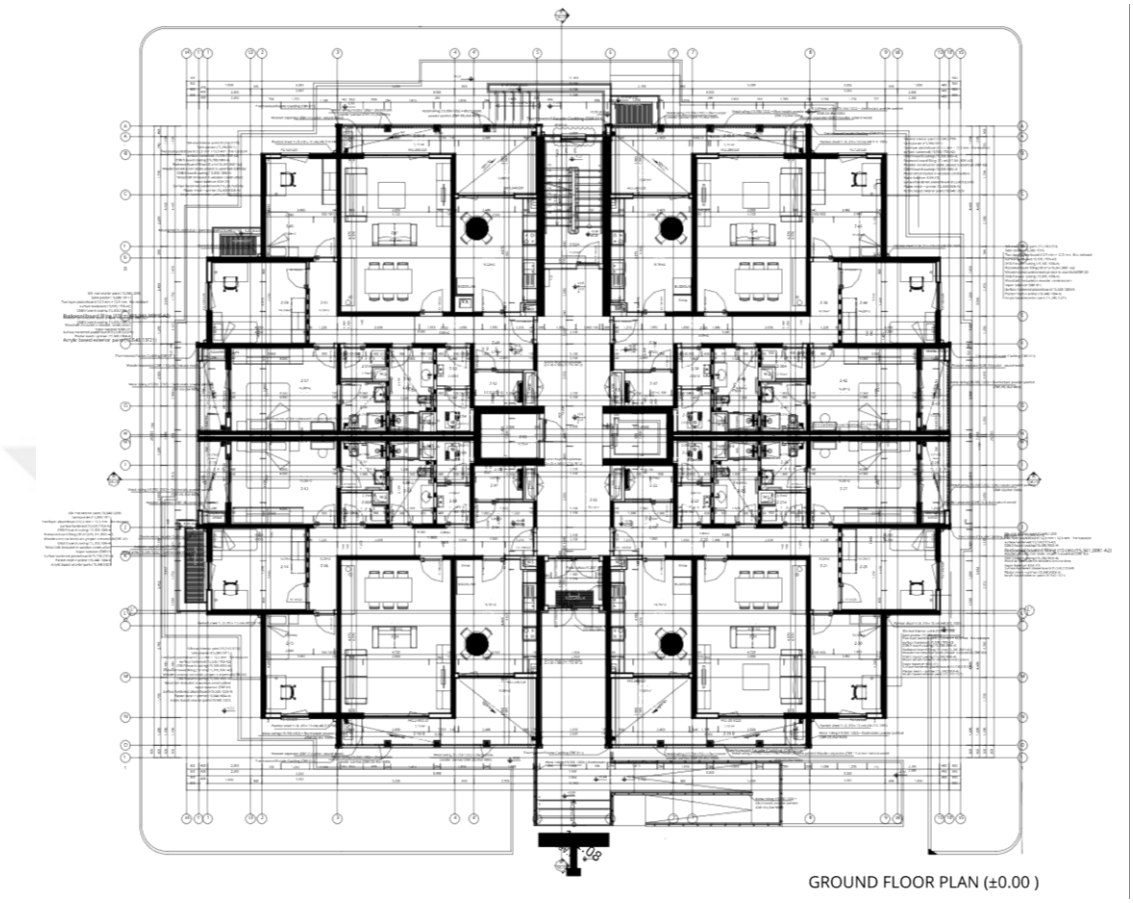
Appendix B – 1. Architectural and Static Plans for Wood-Concrete Structure: Basement Floor Plan (-3.00) (Architectural Plan, Çetinkaya,2023)



BASEMENT FLOOR PLAN (-3.00)

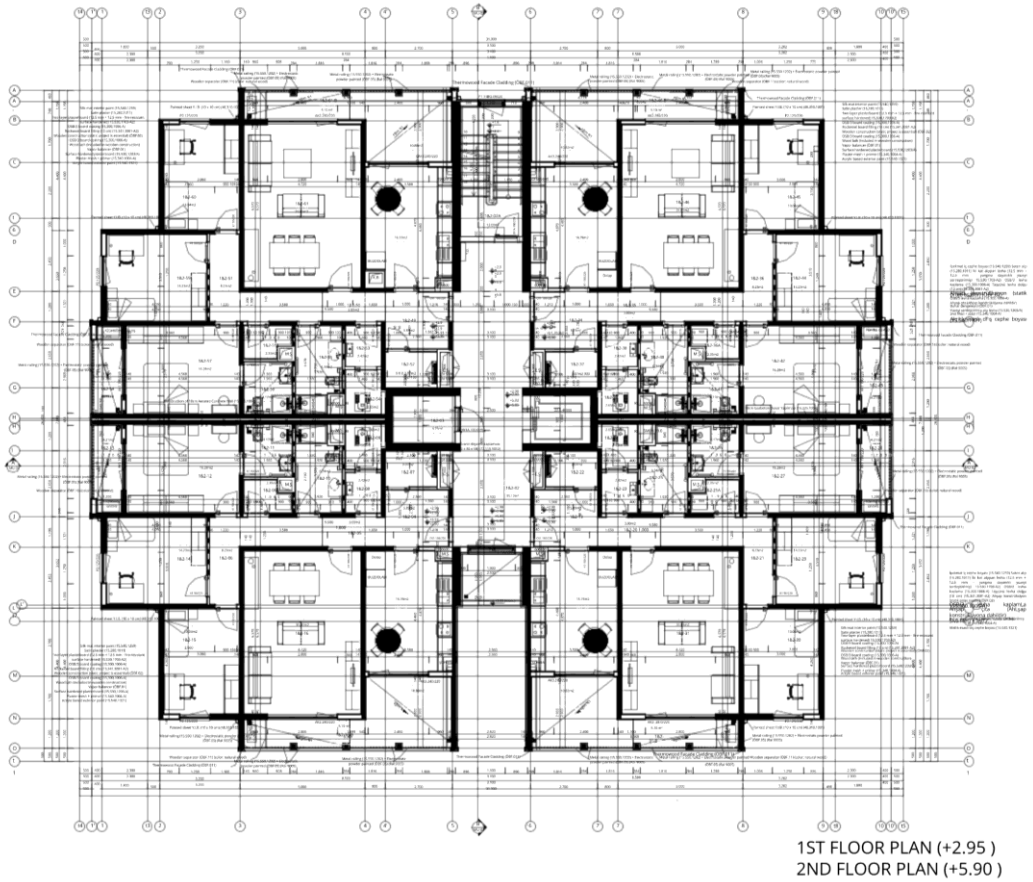
Building Element	Material Composition
Wall (General)	Curtain Concrete Wall
Floor (General)	Concrete Flooring
Columns and Beams (General)	Reinforced Concrete Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core– Wall	Curtain Concrete Wall
Core– Floor	Concrete Flooring
Core– Columns and Beams	Reinforced Concrete Structural System

Appendix B –2. Architectural and Static Plans for Wood-Concrete Structure: Ground Floor Plan (+0.00) (Architectural Plan, Çetinkaya,2023)



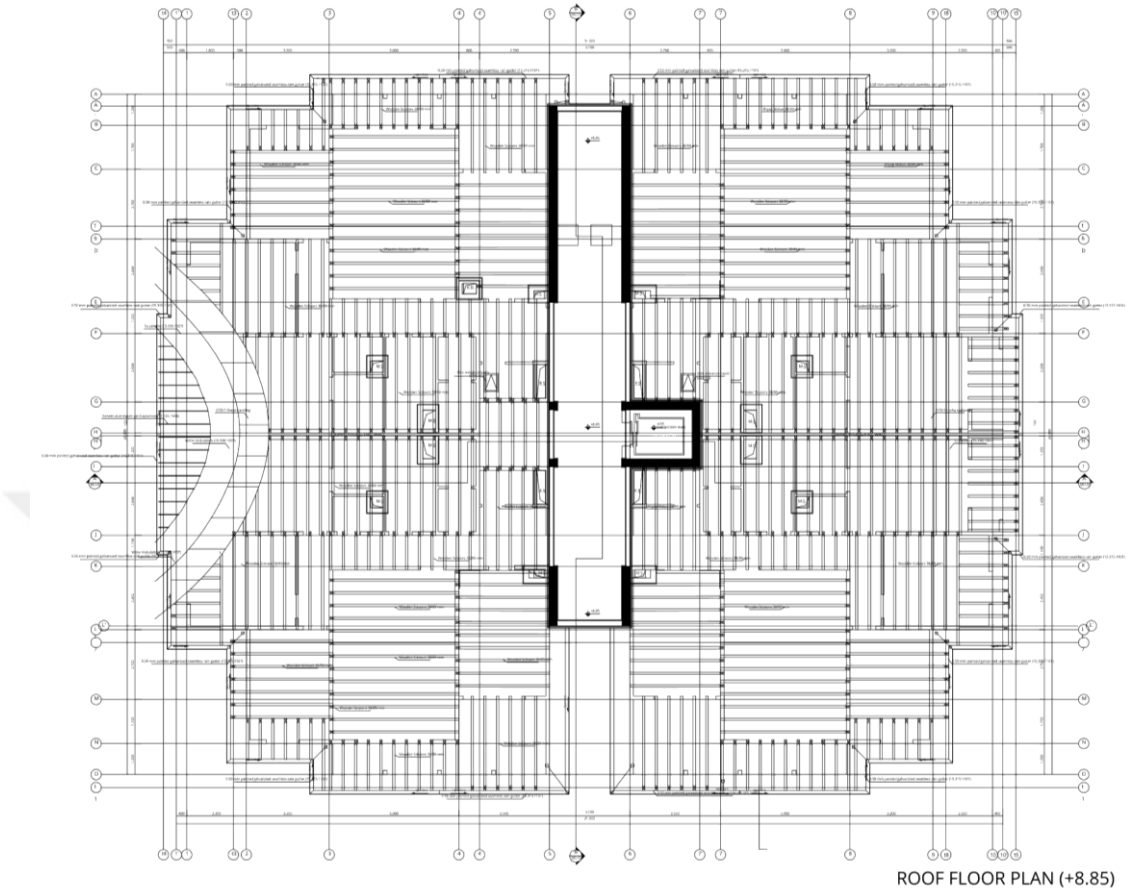
Building Element	Material Composition
Wall (General)	Gypsum Board – Rockwool Board Filling (10 cm) – Wooden Frame – OSB/3 Board Cladding
Floor (General)	Laminate Flooring – OSB/3 Board Covering – Rockwool Filling (10 cm) – Wooden Structure
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Wooden Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core of the Wooden Building – Wall	Gypsum Board – Rockwool Board Filling (10 cm) – OSB/3 Board Cladding
Core– Floor	Reinforced Concrete Slab
Core– Ceiling	Gypsum Board
Core– Columns and Beams	Reinforced Concrete Structural System

Appendix B–3. Architectural and Static Plans for Wood-Concrete Structure: 1st and 2nd Floor Plan (+2.95, +5.90) (Architectural Plan, Çetinkaya,2023)



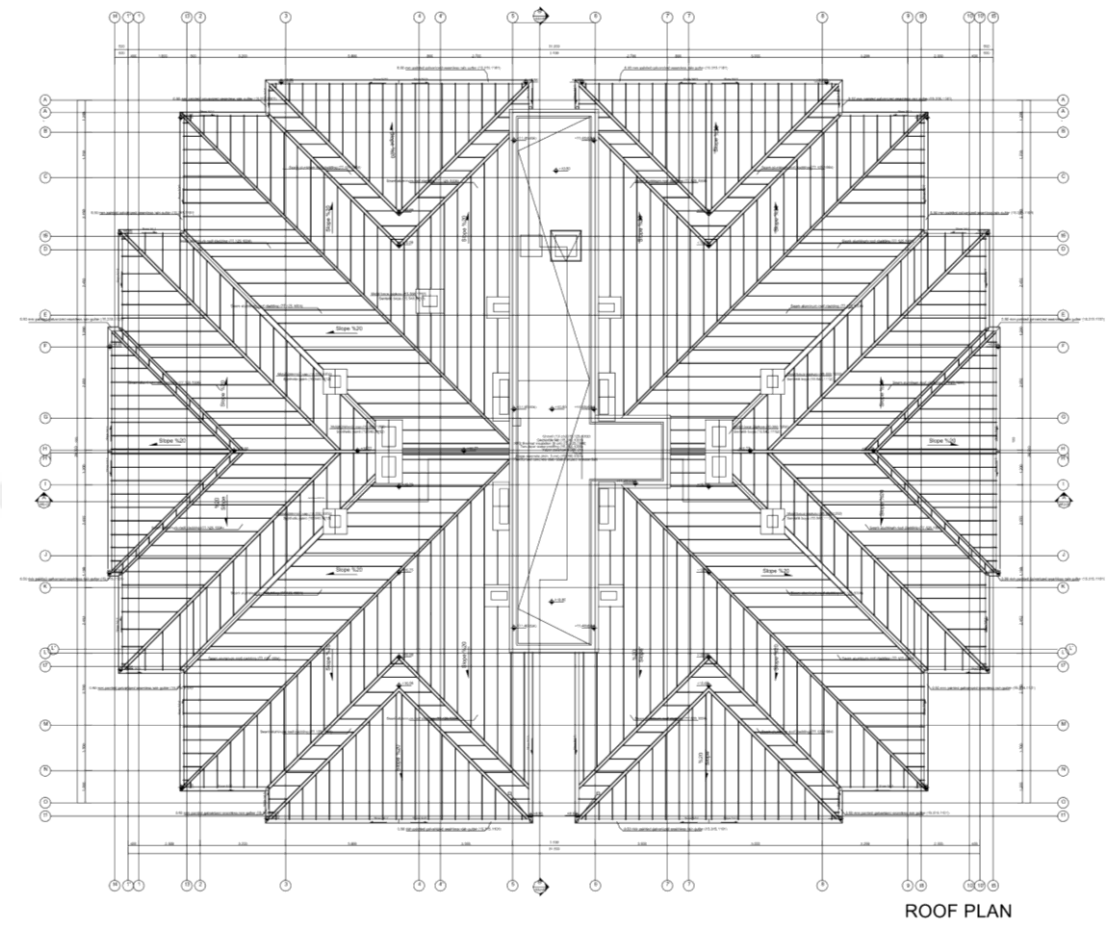
Building Element	Material Composition
Wall (General)	Gypsum Board – Rockwool Board Filling (10 cm) – Wooden Frame – OSB/3 Board Cladding
Floor (General)	Laminate Flooring – OSB/3 Board Covering – Rockwool Board Filling (10 cm) – Wooden Structure
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Wooden Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core – Wall	Gypsum Board – Rockwool Board Filling (10 cm) – OSB/3 Board Cladding
Core – Floor	Reinforced Concrete Flooring
Core – Ceiling	Gypsum Board
Core – Columns and Beams	Reinforced Concrete Structural System

Appendix B –4. Architectural and Static Plans for Wood-Concrete Structure: Roof Floor Plan (+8.85) (Architectural Plan, Çetinkaya,2023)



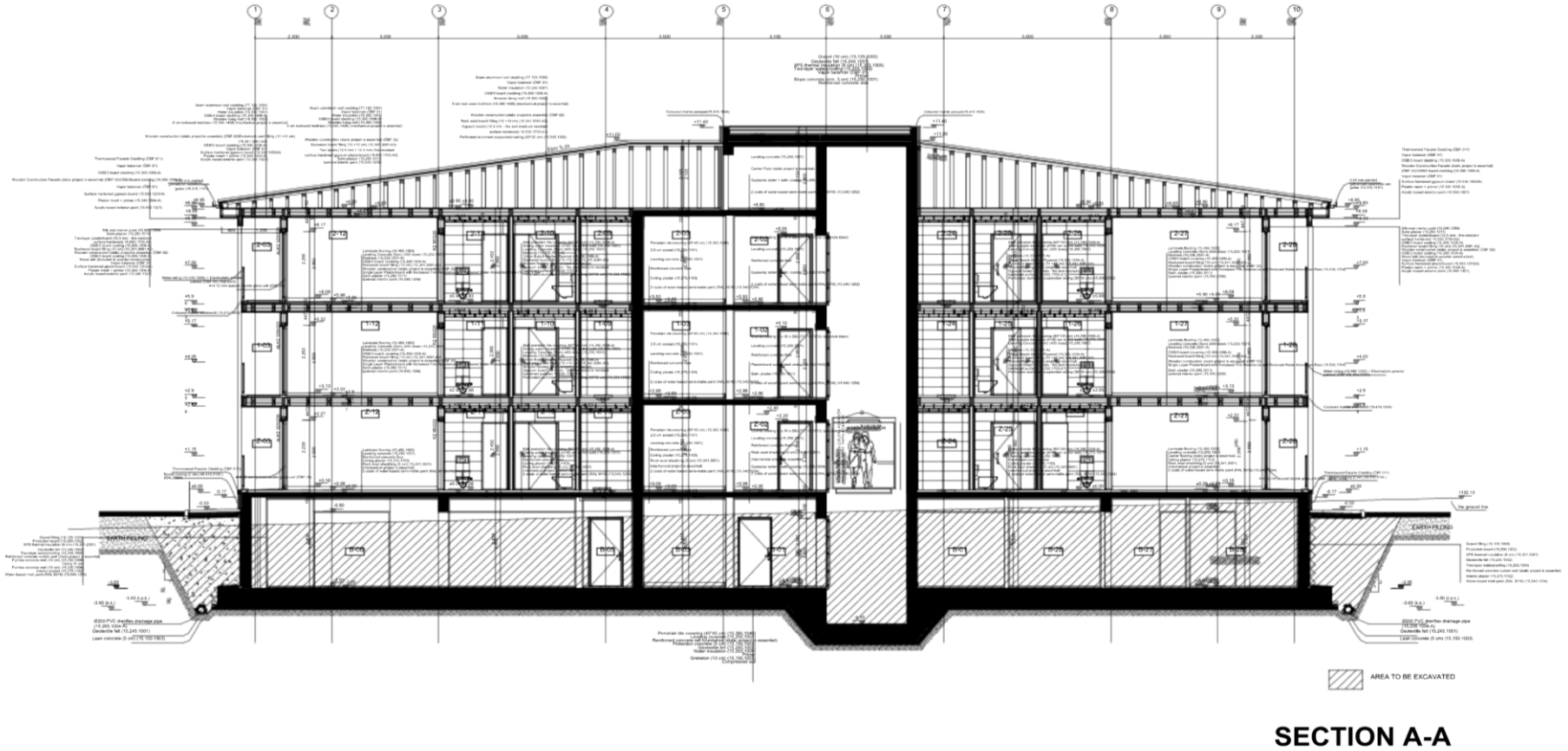
Building Element	Material Composition
Wall (General)	Gypsum Board – Rockwool Board Filling (10 cm) – Wooden Construction – OSB/3 Board Coating
Floor (General)	Laminate Flooring – OSB/3 Board Covering – Rockwool Filling (10 cm) – Wooden Construction
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Wooden Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core – Walls	Gypsum Board – Rockwool Board Filling (10 cm) – OSB/3 Board Coating
Core – Floor	Reinforced Concrete Flooring
Core – Ceiling	Gypsum Board
Core – Columns and Beams	Concrete Structural System

Appendix B –5. Architectural and Static Plans for Wood-Concrete Structure: Roof Plan (Architectural Plan, Çetinkaya,2023)



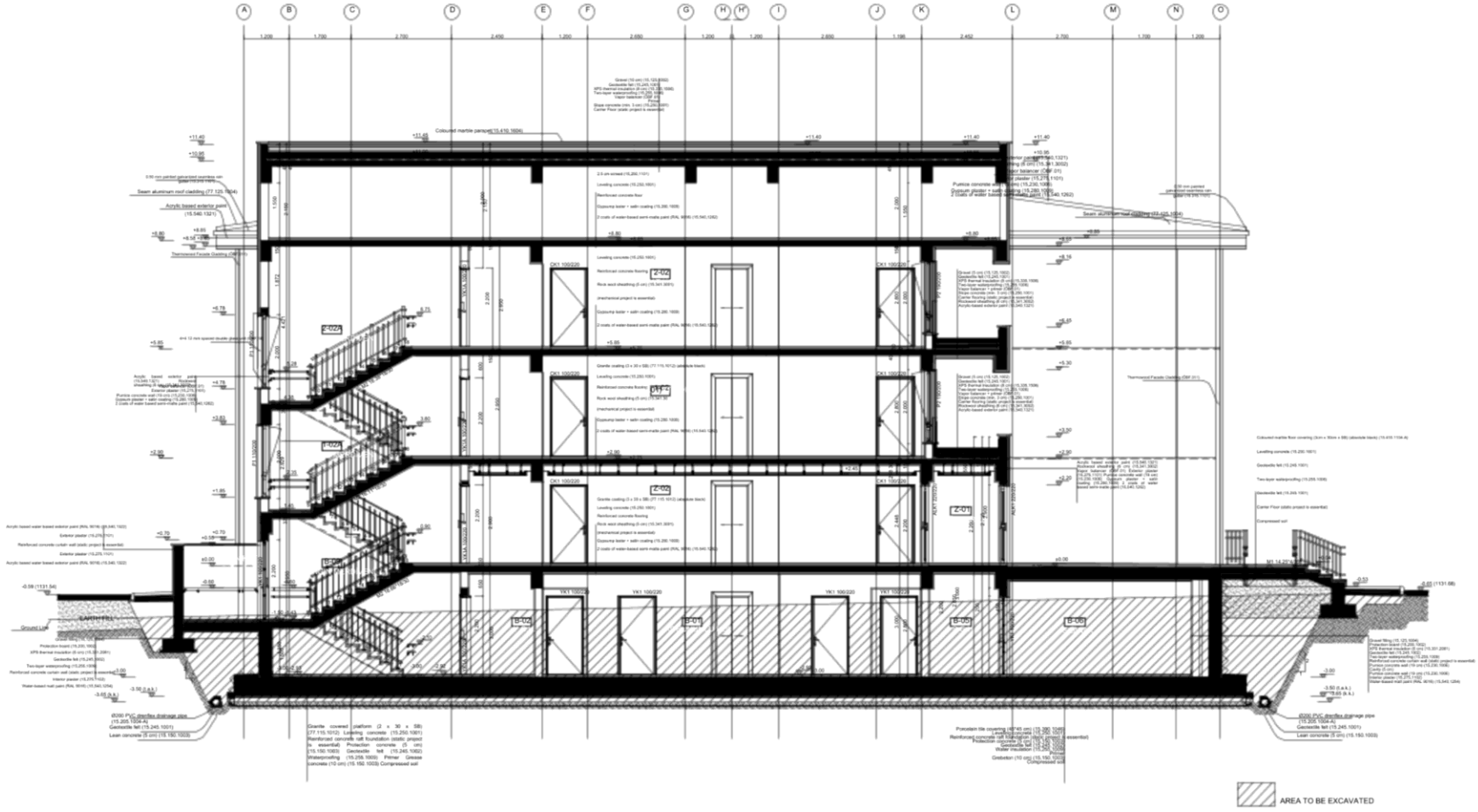
Building Element	Material Composition
Wall (General)	Gypsum Board – Rockwool Board Filling (10 cm) – Wooden Construction – OSB/3 Board Coating
Floor (General)	Laminate Flooring – OSB/3 Board Covering – Rockwool Board Filling (10 cm) – Wooden Construction
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Wooden Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core Wall	Gypsum Board – Rockwool Board Filling (10 cm) – OSB/3 Board Coating
Core Floor	Reinforced Concrete Flooring
Core Ceiling	Gypsum Board
Core Columns and Beams	Concrete Structural System

Appendix B –6. Architectural and Static Plans for Wood-Concrete Structure: Section AA (Architectural Plan, Çetinkaya,2023)



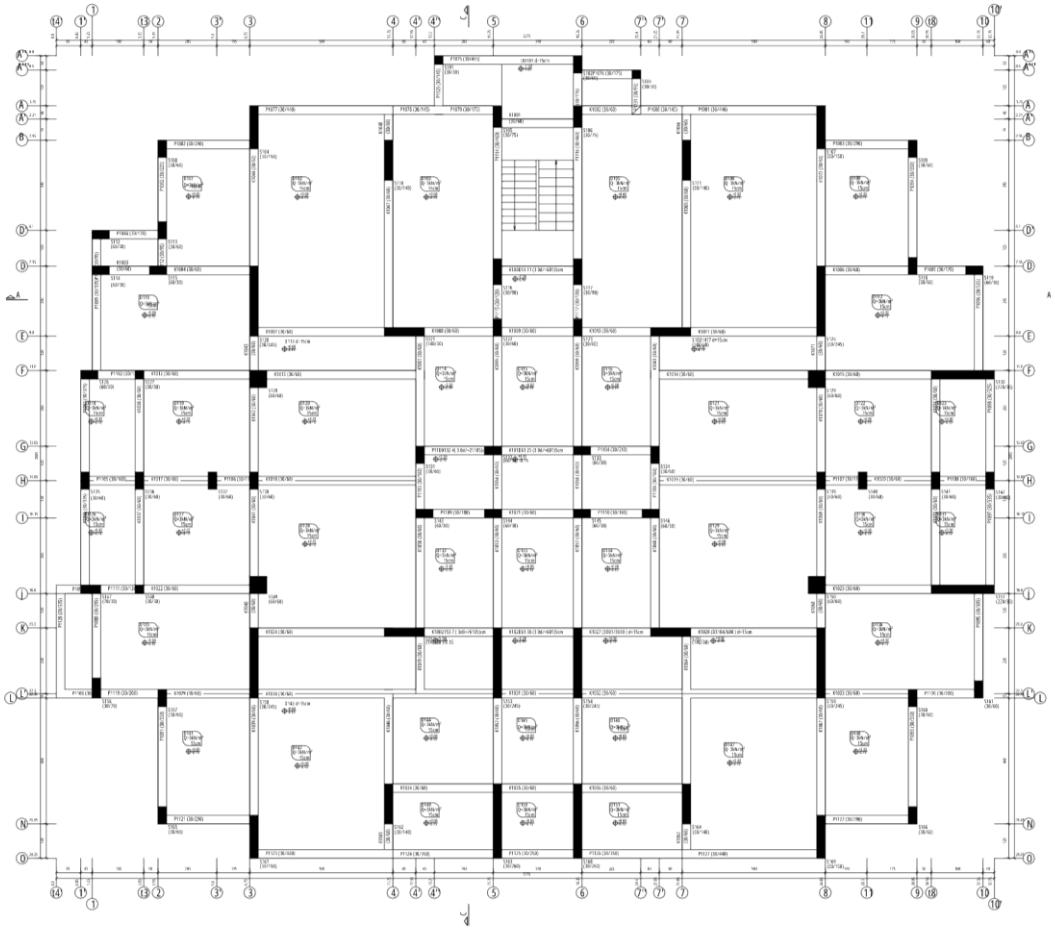
SECTION A-A

Appendix B –7. Architectural and Static Plans for Wood-Concrete Structure: Section BB (Architectural Plan, Çetinkaya,2023)



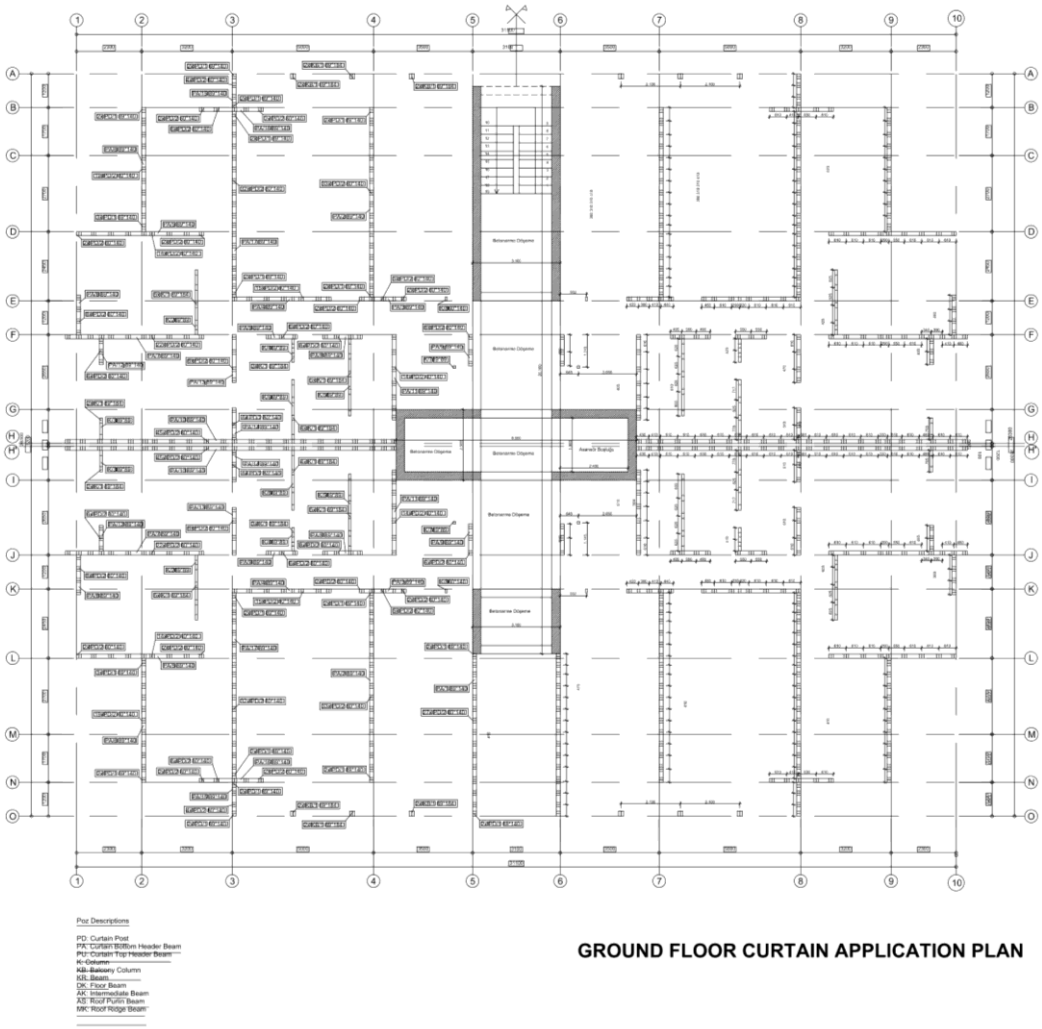
SECTION BB

Appendix B –8. Architectural and Static Plans for Wood-Concrete Structure: Basement Floor Formwork Plan (Static Project, Demirkıran,2023)

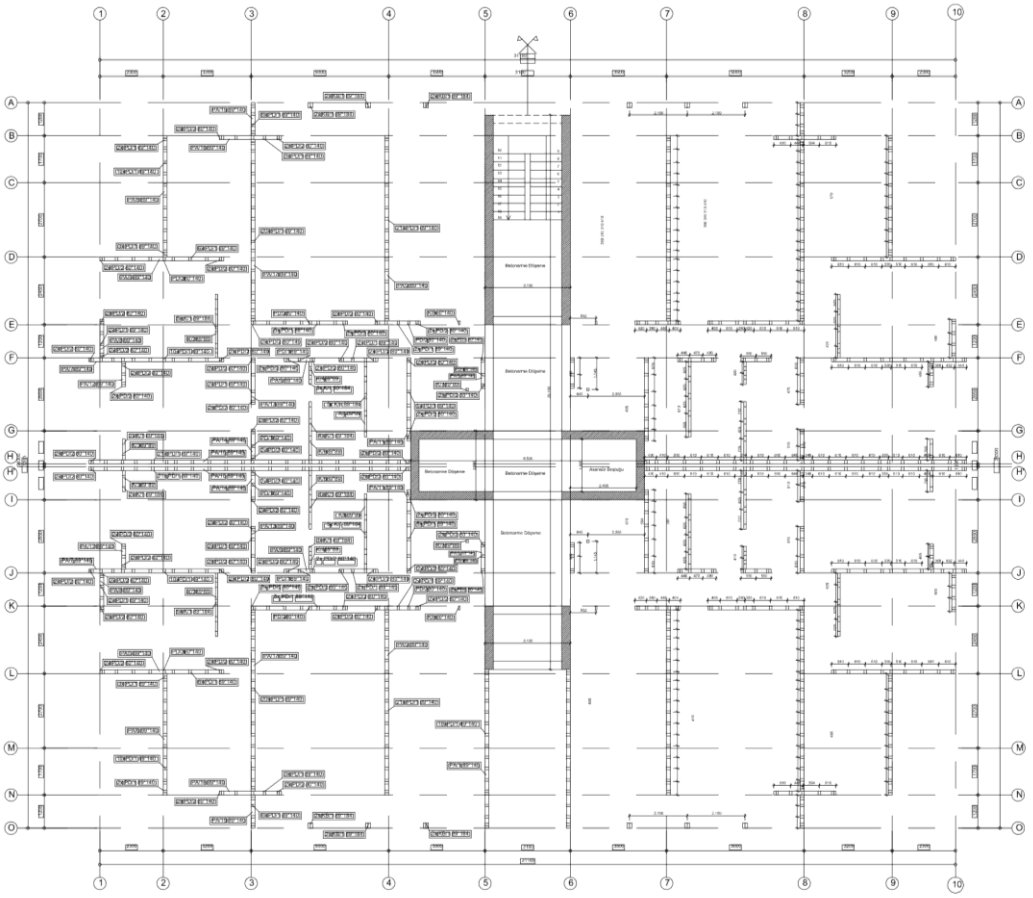


BASEMENT FLOOR FORM WORK PLAN

Appendix B–9. Architectural and Static Plans for Wood-Concrete Structure: Ground Floor Curtain Application (Static Project, Demirkıran,2023)



Appendix B –10. Architectural and Static Plans for Wood-Concrete Structure: 1st and 2nd Floor Curtain Application (Static Project, Demirkıran,2023)

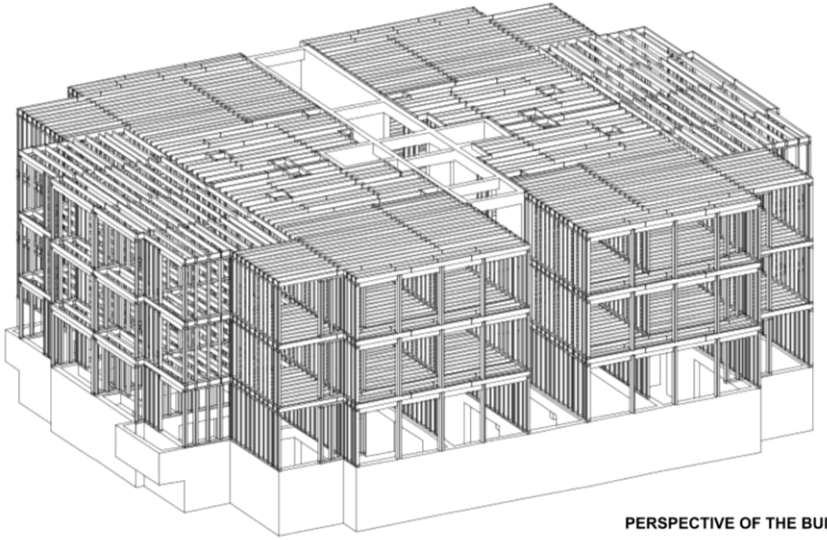


Poz Descriptions

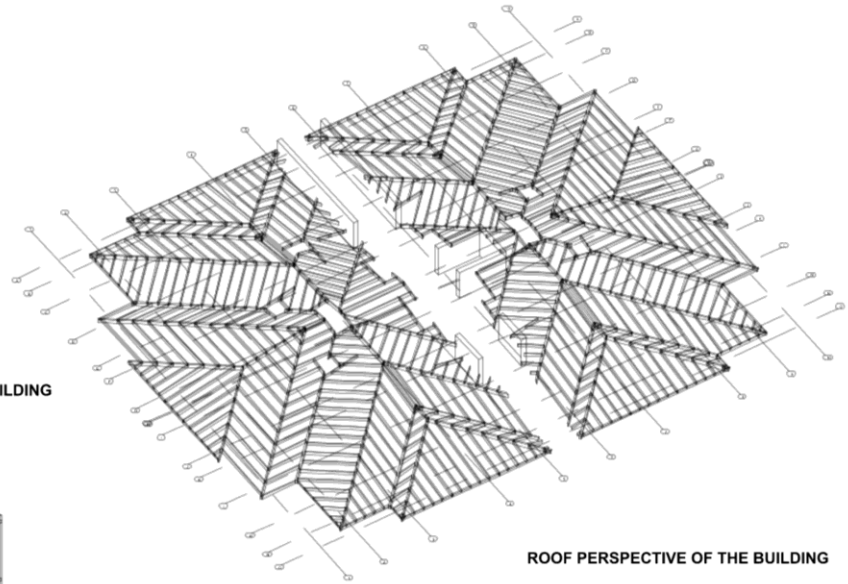
PD: Curtain Post
PA: Curtain Bottom Header Beam
PÜ: Curtain Top Header Beam
K: Column
KB: Balcony Column
KR: Beam
DK: Floor Beam
AK: Intermediate Beam
AS: Roof Purlin Beam
SK: Roof Ridge Beam

1.-2. FLOOR CURTAIN APPLICATION PLAN

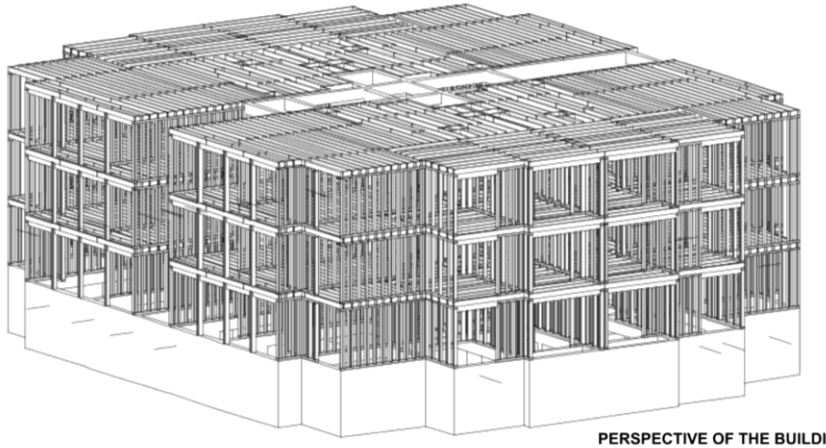
Appendix B –11. Architectural and Static Plans for Wood-Concrete Structure: Perspectives (Static Project, Demirkıran,2023)



PERSPECTIVE OF THE BUILDING

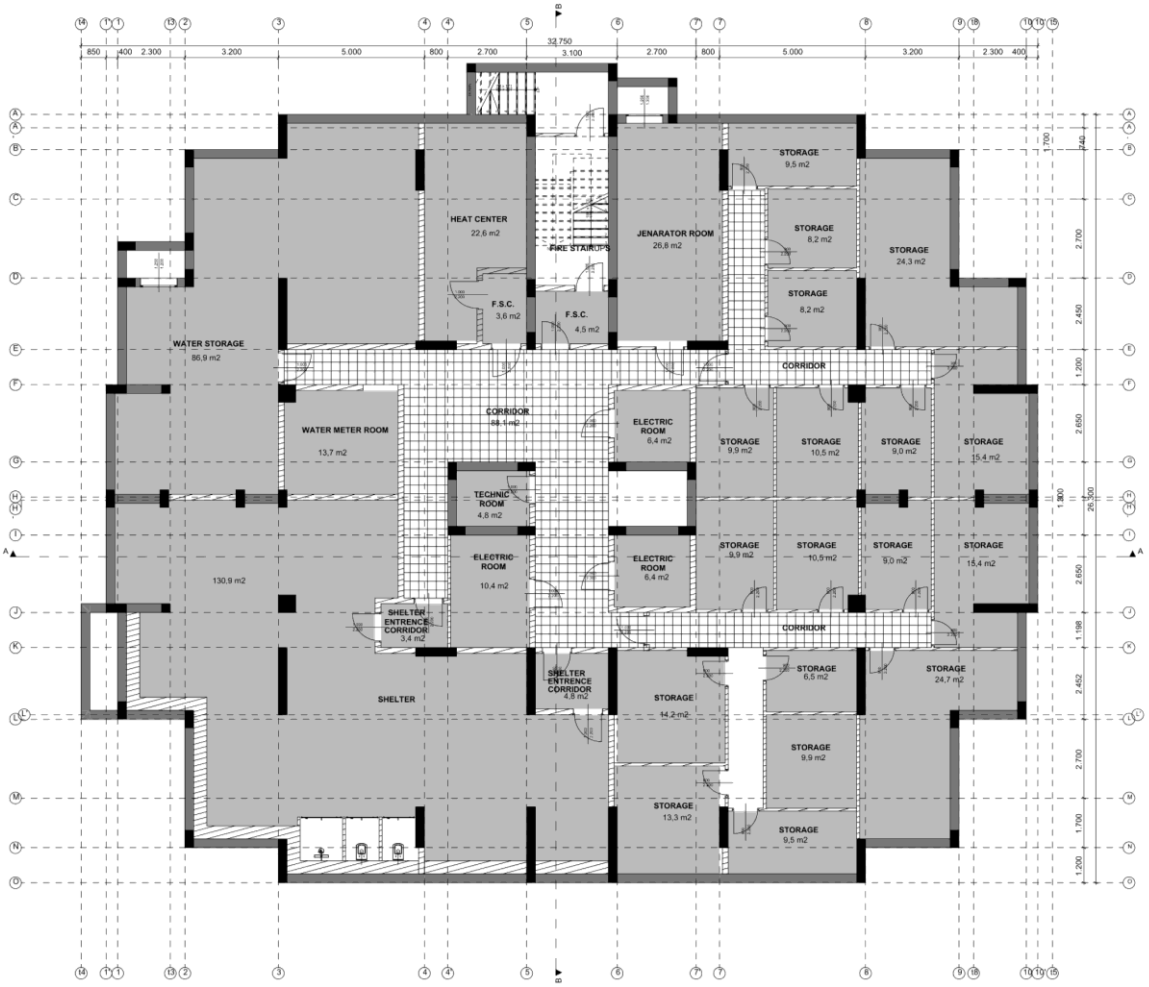


ROOF PERSPECTIVE OF THE BUILDING



PERSPECTIVE OF THE BUILDING

Appendix C-1. Architectural and Static Plans for Concrete Structure: Basement Floor Plan (Architectural Project)

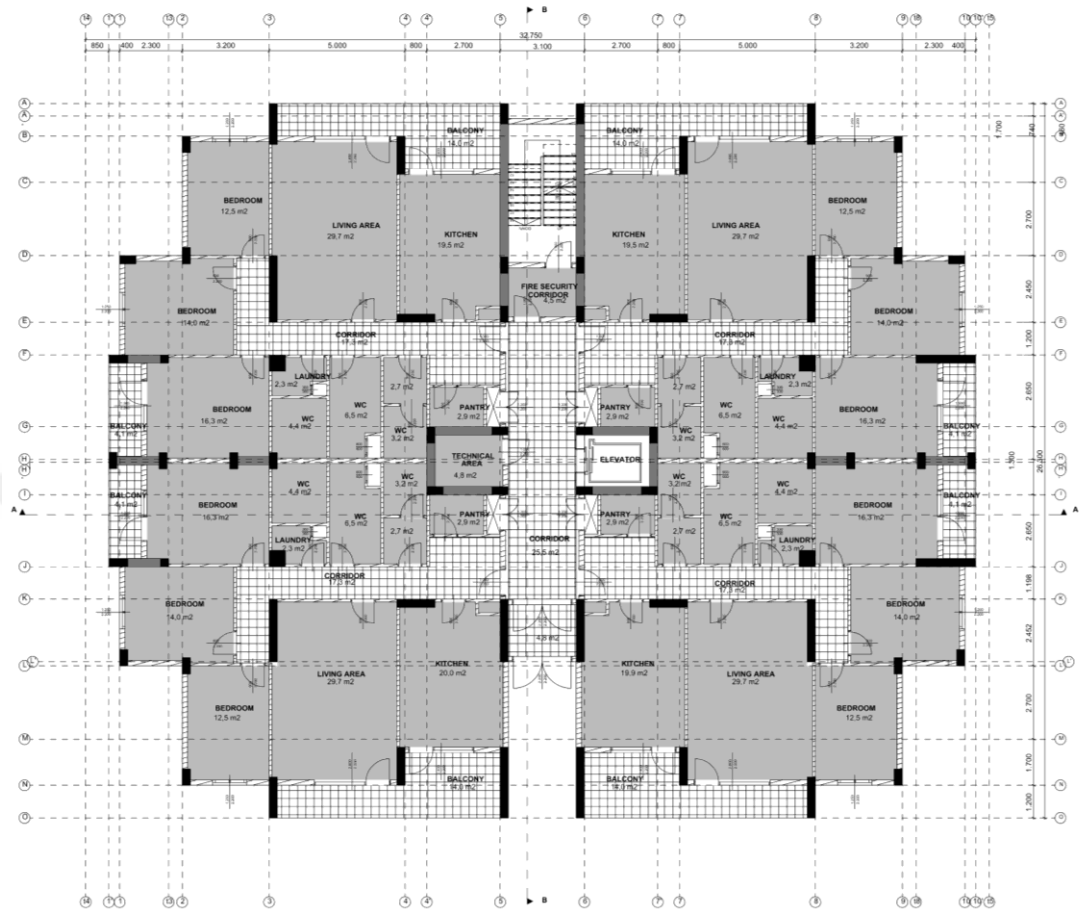


Floor: Reinforced concrete floor
Column and beams: Reinforced concrete floor
Walls: Curtain Concrete Walls and Aerated concrete walls with 10 and 20 cm width

BASEMENT FLOOR PLAN

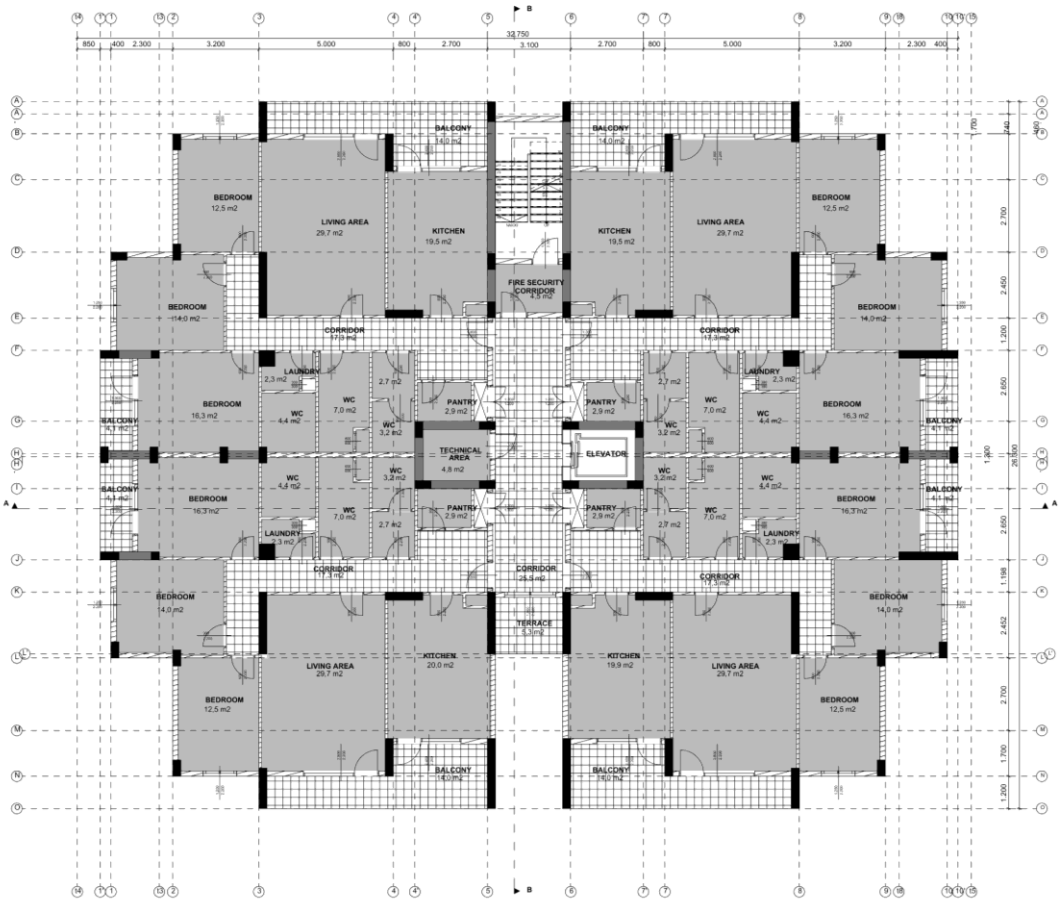
Building Element	Material Composition
Wall (General)	Curtain Concrete Wall – Aerated Concrete Wall (10 cm / 20 cm)
Floor (General)	Reinforced Concrete Flooring
Columns and Beams (General)	Reinforced Concrete Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core Wall	Curtain Concrete Wall
Core Floor	Reinforced Concrete Flooring
Core Columns and Beams	Reinforced Concrete Structural System

Appendix C-2. Architectural and Static Plans for Concrete Structure: Ground Floor Plan (Architectural Project)



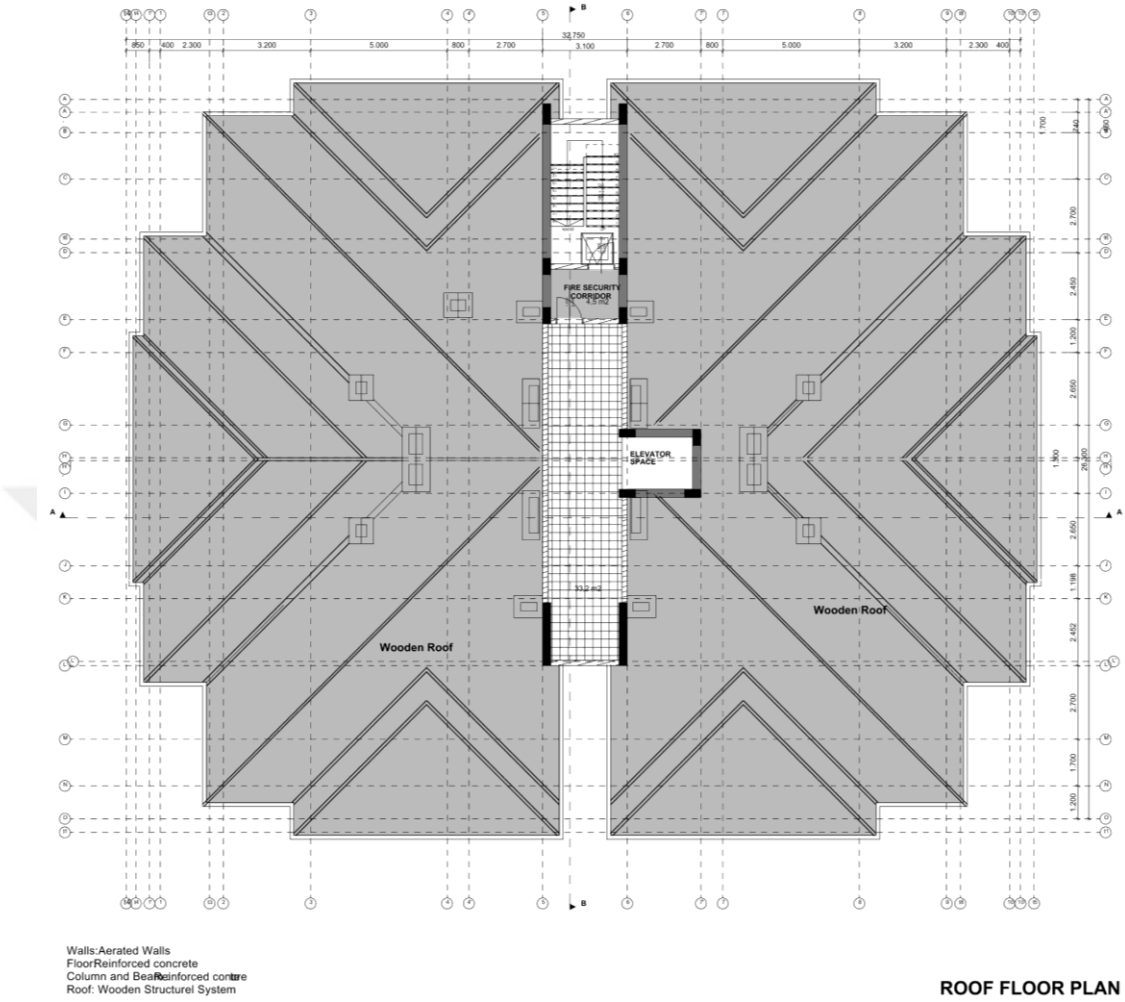
Building Element	Material Composition
Wall (General)	Aerated Concrete Wall (Bims Wall)
Floor (General)	Concrete Structural System
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Concrete Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core Wall	Aerated Concrete Wall (Bims Wall)
Core Floor	Concrete Structural System
Core Ceiling	Gypsum Board
Core Columns and Beams	Concrete Structural System

Appendix C-3. Architectural and Static Plans for Concrete Structure: 1st and 2nd Floor Plan (Architectural Project)



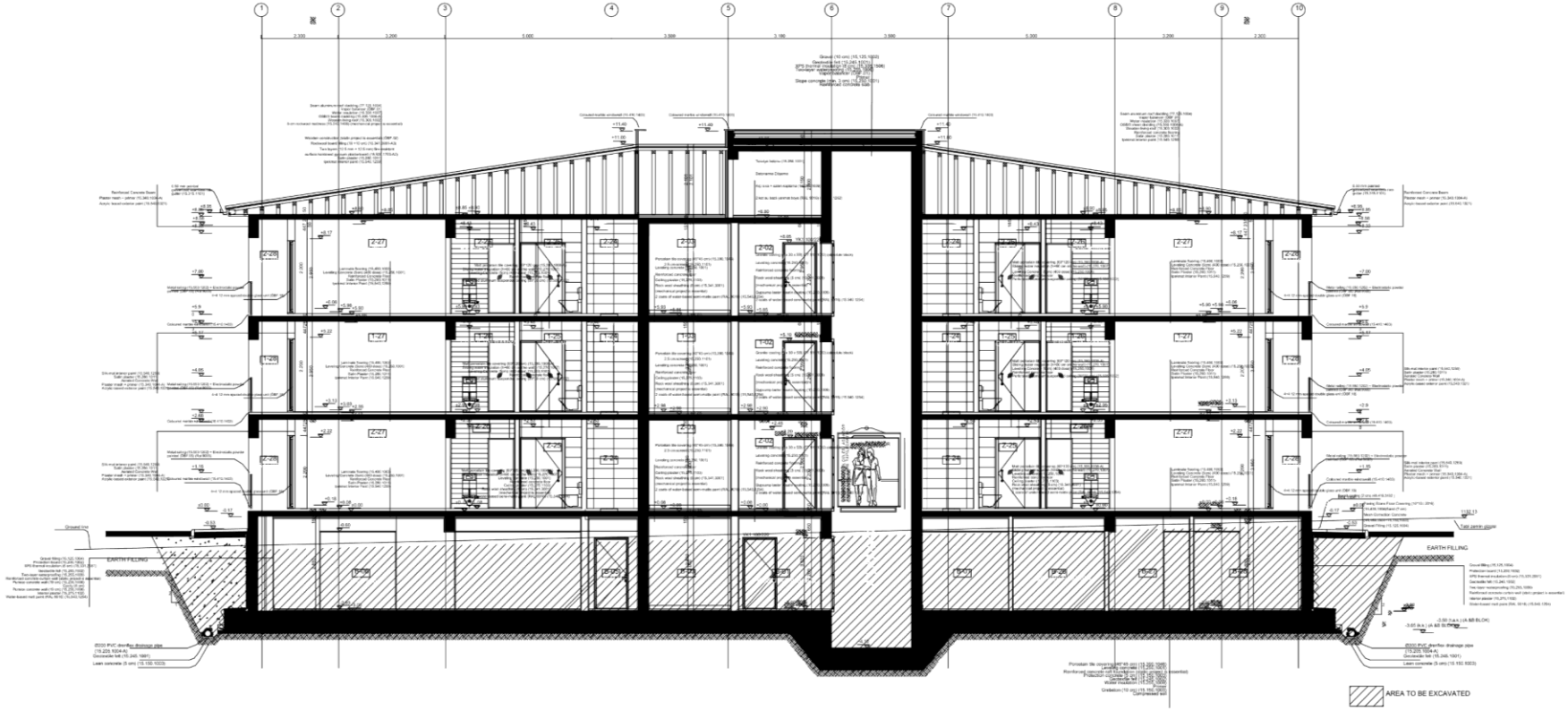
Building Element	Material Composition
Wall (General)	Aerated Concrete Wall (Bims Wall)
Floor (General)	Reinforced Concrete Flooring
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Reinforced Concrete Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core Wall	Aerated Concrete Wall (Bims Wall)
Core Floor	Reinforced Concrete Flooring
Core Ceiling	Gypsum Board
Core Columns and Beams	Reinforced Concrete Structural System

Appendix C-4. Architectural and Static Plans for Concrete Structure: Roof Floor Plan (Architectural Project)



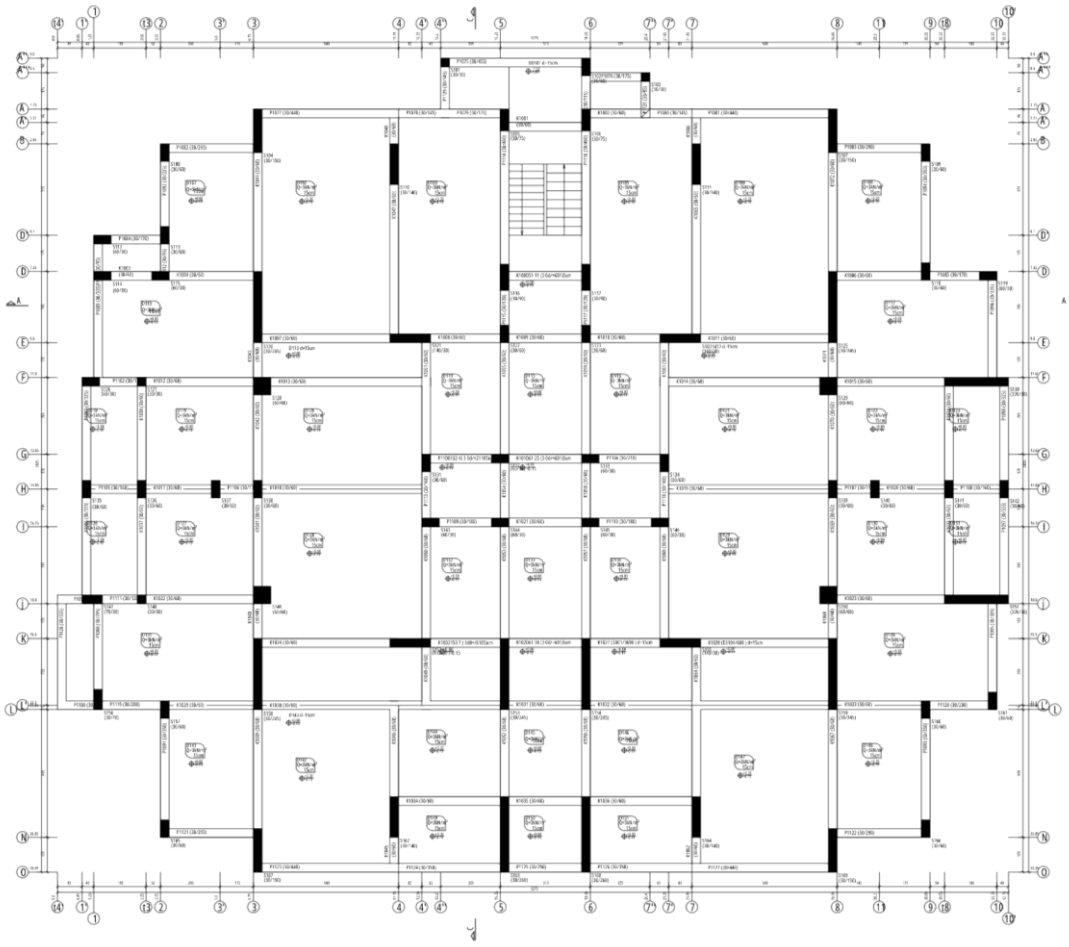
Building Element	Material Composition
Wall (General)	Aerated Concrete Wall (Bims Wall)
Floor (General)	Reinforced Concrete Flooring
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Reinforced Concrete Structural System
Roof	OSB/3 Board Covering and Wooden Structural System
Core Wall	Aerated Concrete Wall (Bims Wall)
Core Floor	Reinforced Concrete Flooring
Core Ceiling	Gypsum Board
Core Columns and Beams	Reinforced Concrete Structural System

Appendix C-5. Architectural and Static Plans for Concrete Structure: Section AA (Architectural Project)



SECTION A-A

Appendix C-6. Architectural and Static Plans for Concrete Structure: Basement Floor Formwork Plan (Static Project)

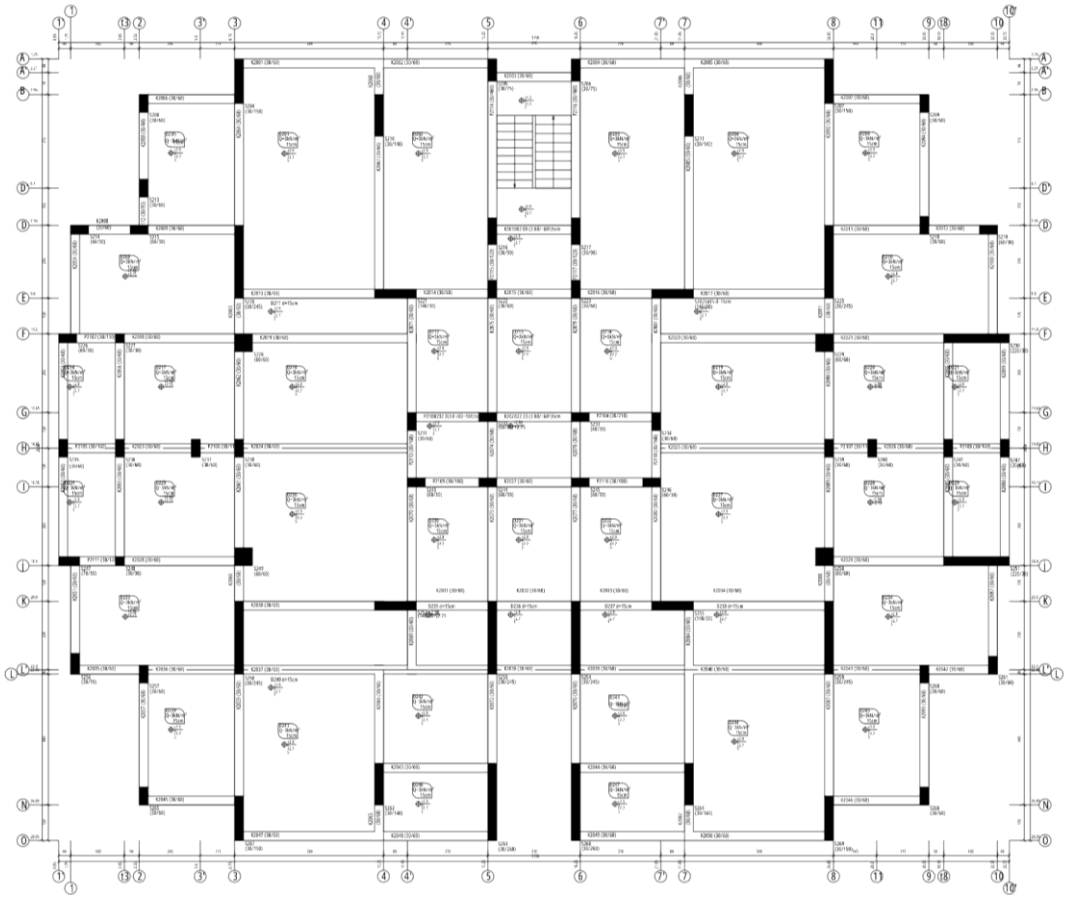


BASEMENT FLOOR FORM WORK PLAN

Exposure Descriptions

PD: Curtain Post
PA: Curtain Bottom Header Beam
PU: Curtain Top Header Beam
K: Column
KB: Balcony Column
KR: Beam
DK: Floor Beam
AK: Intermediate Beam
AS: Roof Purlin Beam
MK: Roof Ridge Beam

Appendix C-7. Architectural and Static Plans for Concrete Structure: Ground Floor Formwork Plan (Static Project)

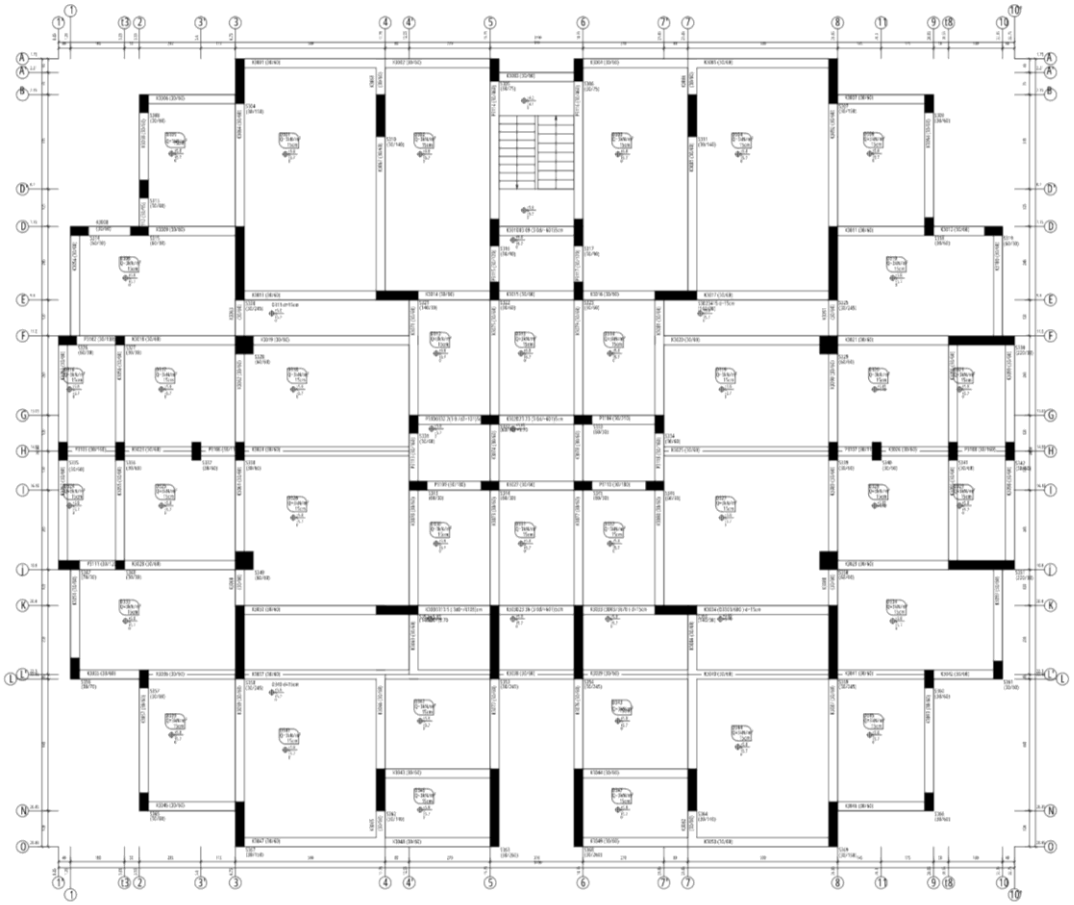


GROUND FLOOR FORMWORK PLAN

Exposure Descriptions

PD: Curtain Post
PA: Curtain Bottom Header Beam
PU: Curtain Top Header Beam
K: Column
KB: Balcony Column
KR: Beam
DK: Floor Beam
AK: Intermediate Beam
AS: Roof Purlin Beam
MK: Roof Ridge Beam

Appendix C-8. Architectural and Static Plans for Concrete Structure: Ground Floor Formwork Plan (Static Project)

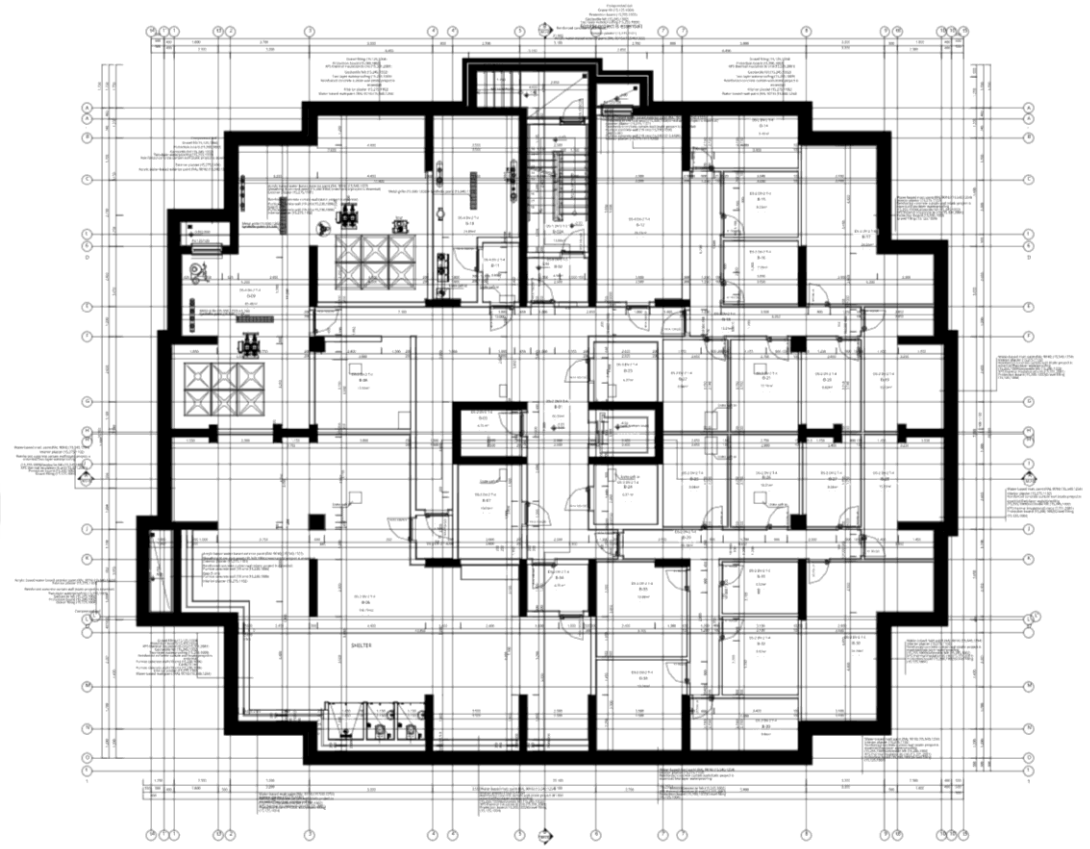


1.st & 2.nd FLOOR FORMWORK PLAN

Exposure Descriptions

PD: Curtain Post
PA: Curtain Bottom Header Beam
PU: Curtain Top Header Beam
K: Column
KB: Balcony Column
KR: Beam
DK: Floor Beam
AK: Intermediate Beam
AS: Roof Purlin Beam
MK: Roof Ridge Beam

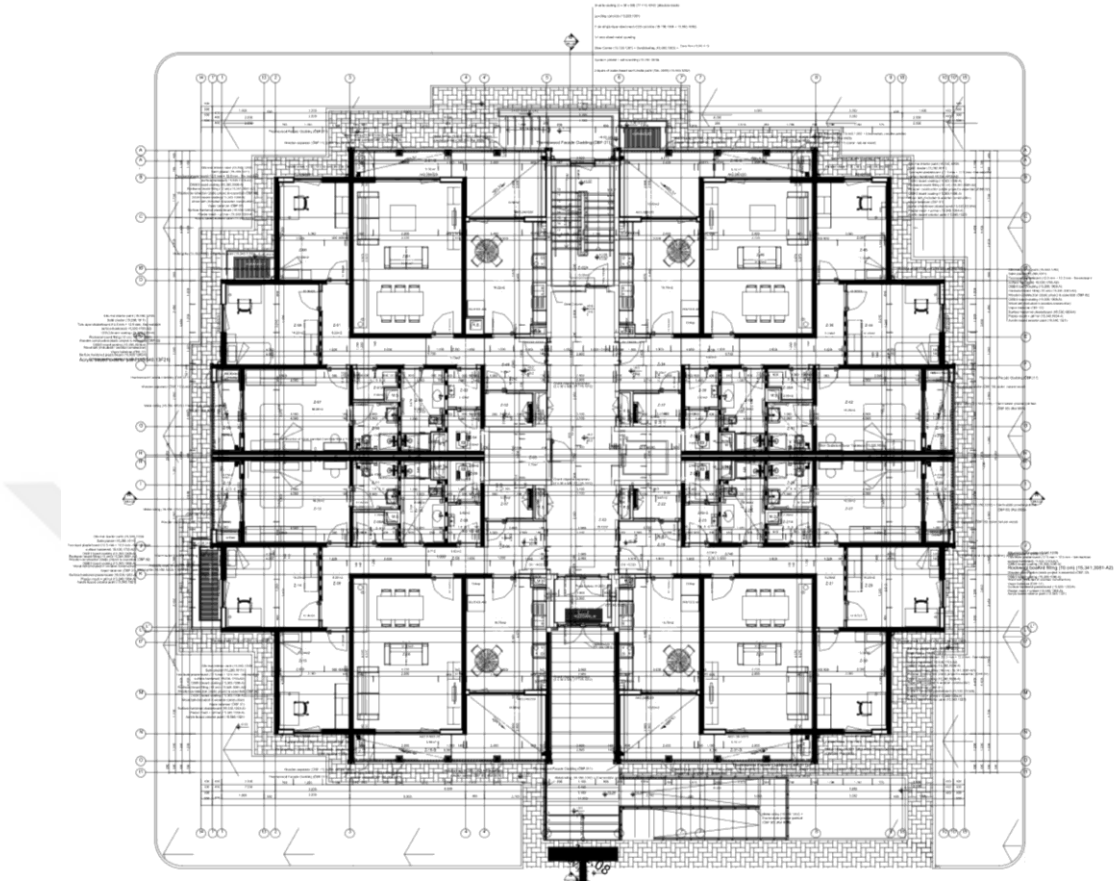
Appendix D-1. Architectural and Static Plans for Wood-Steel Structure: Basement Floor Plan (-3.00), (Architectural Project)



BASEMENT FLOOR PLAN (-3.00)

Building Element	Material Composition
Wall (General)	Curtain Concrete Wall
Floor (General)	Reinforced Concrete Flooring
Columns and Beams (General)	Concrete Structural System
Roof	OSB/3 Board Covering, Wooden Structural System
Core Wall	Curtain Concrete Wall
Core Floor	Reinforced Concrete Flooring
Core Columns and Beams	Concrete Structural System

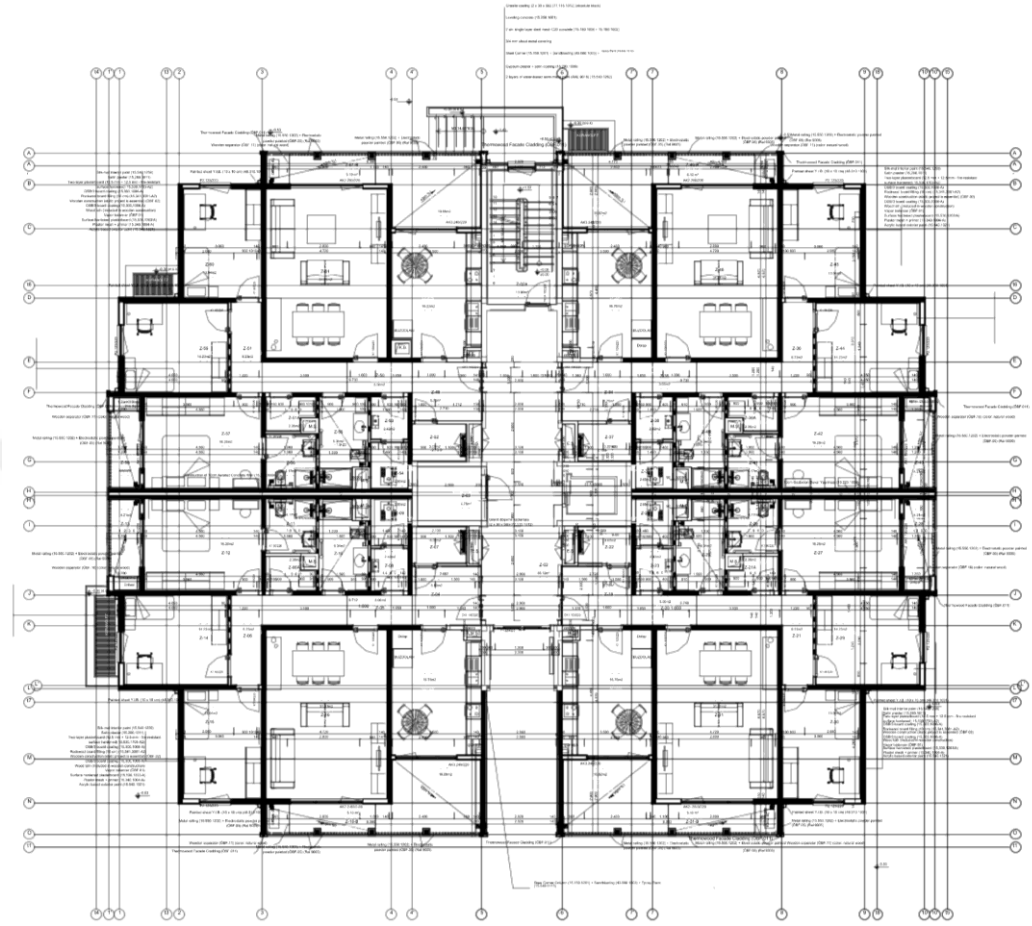
Appendix D-2. Architectural and Static Plans for Wood-Steel Structure: Ground Floor Plan (+0.00), (Architectural Project)



GROUND FLOOR PLAN (+0.00)

Building Element	Material Composition
Wall (General)	Gypsum Board – Rockwool Board Filling (10 cm) – Wooden Construction – OSB/3 Board Coating
Floor (General)	Laminate Flooring – OSB/3 Board Covering – Rockwool Board Filling (10 cm) – Wooden Construction
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Wooden Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core Wall	Gypsum Board – Rockwool Board Filling (10 cm) – Gypsum Board
Core Floor	Steel Construction – Trapezoidal Sheet Metal Coating – Leveling Concrete
Core Ceiling **Core Colums and Beams**	Gypsum Board Steel Construction

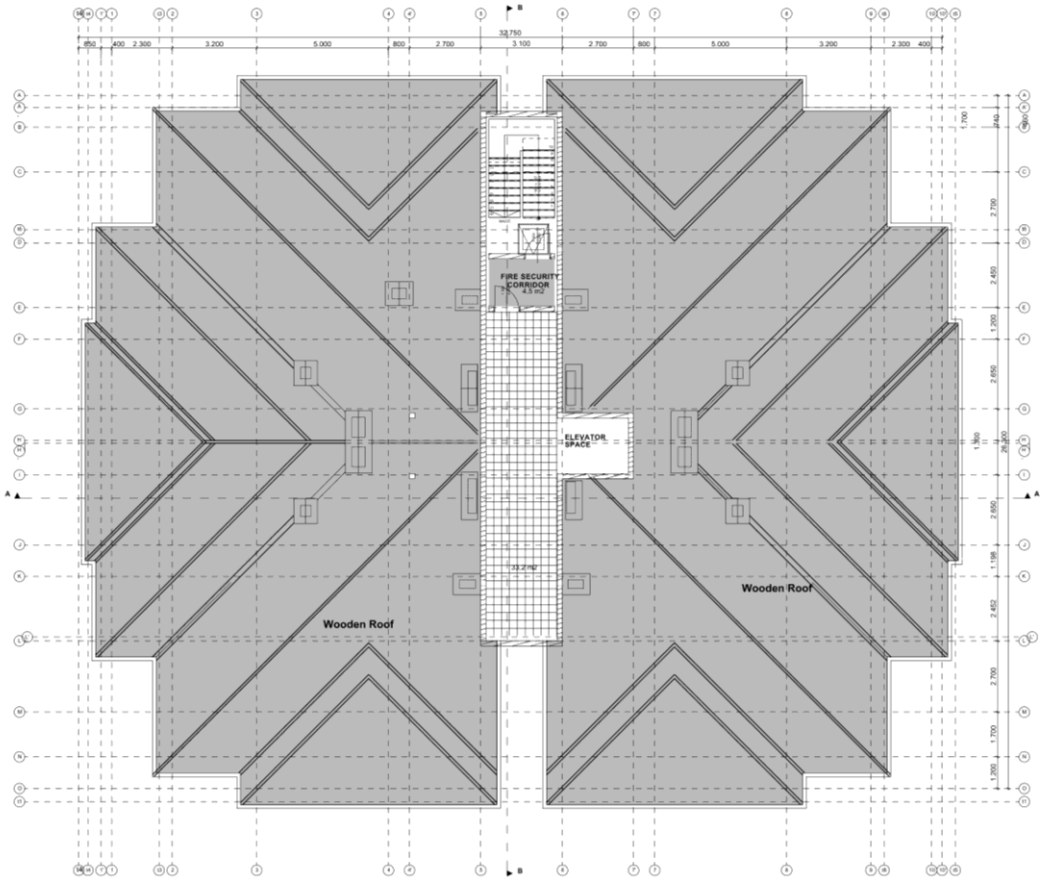
Appendix D-3. Architectural and Static Plans for Wood-Steel Structure: 1st and 2nd Floor Plan (+2.95, +5.90) (Architectural Project)



1st and 2nd FLOOR PLAN (+2.95, +5.90)

Building Element	Material Composition
Wall (General)	Gypsum Board – Rockwool Board Filling (10 cm) – Wooden Construction – OSB/3 Board Coating
Floor (General)	Laminate Flooring – OSB/3 Board Covering – Rockwool Board Filling (10 cm) – Wooden Construction
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Wooden Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core Walls	Gypsum Board – Rockwool Board Filling (10 cm) – Gypsum Board
Core Floor	Steel Construction – Trapezoidal Sheet Metal Coating – Leveling Concrete
Core Ceiling **Core Colums and Beams**	Gypsum Board Steel Construction

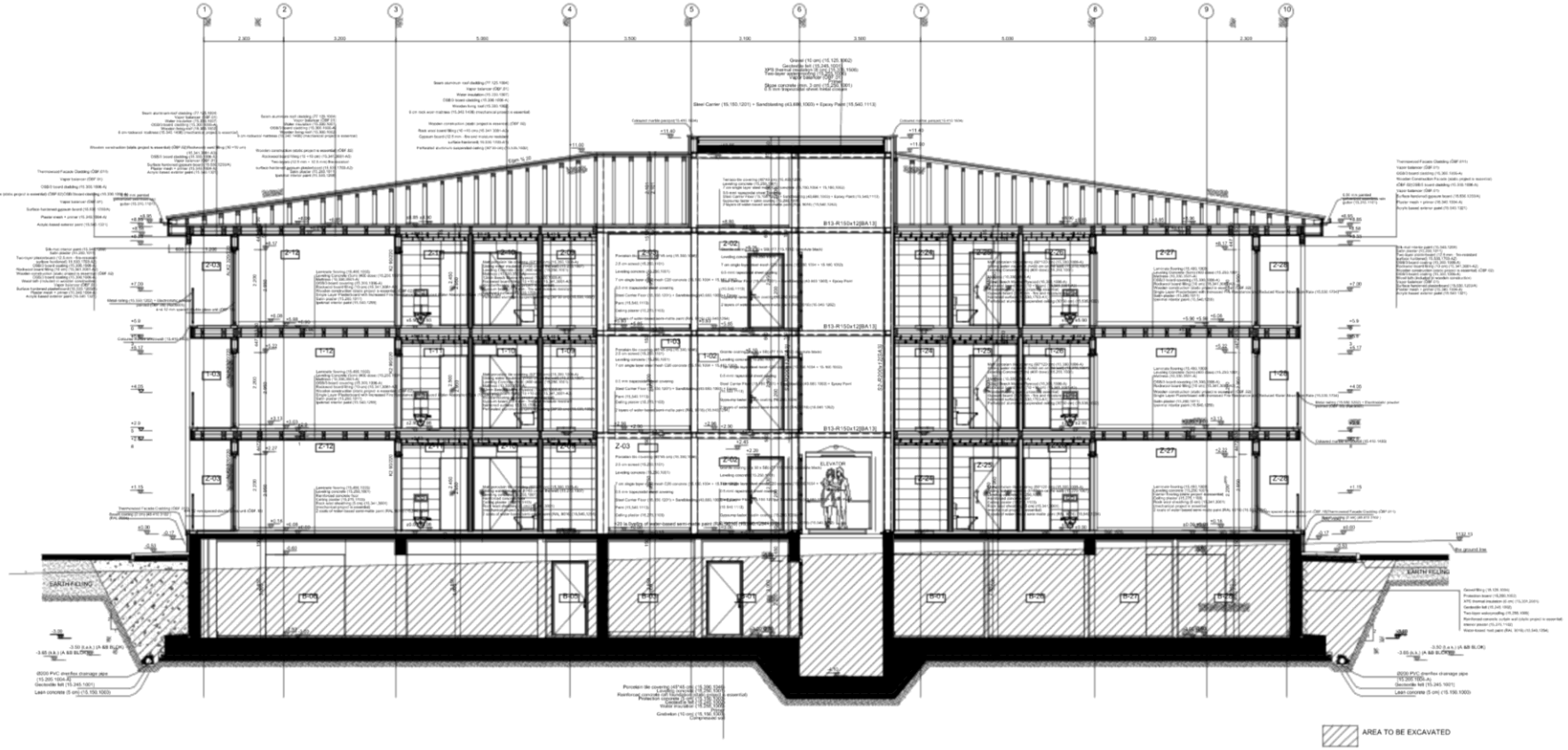
Appendix D-4. Architectural and Static Plans for Wood-Steel Structure: Roof Floor Plan (+8,85) (Architectural Project)



ROOF FLOOR PLAN

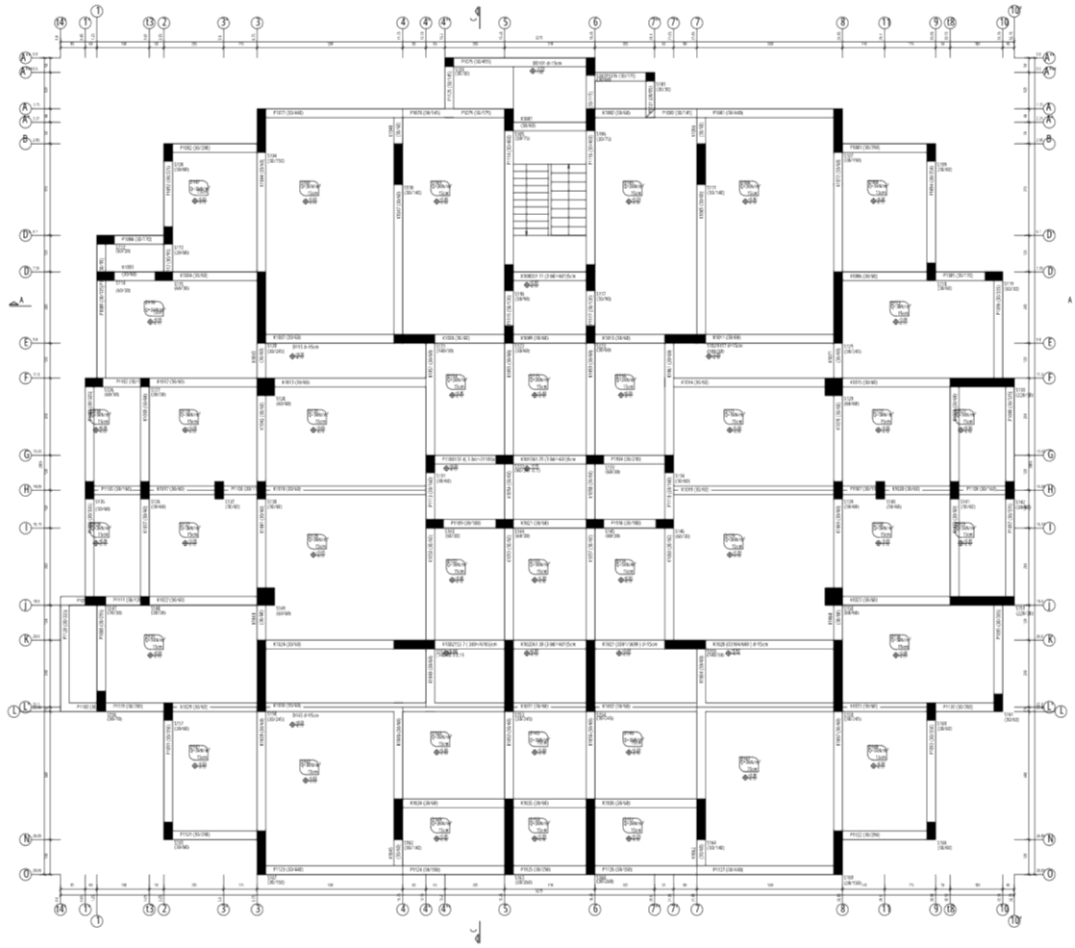
Building Element	Material Composition
Wall (General)	Gypsum Board – Rockwool Board Filling (10 cm) – Wooden Construction – OSB/3 Board Coating
Floor (General)	Laminate Flooring – OSB/3 Board Covering – Rockwool Board Filling (10 cm) – Wooden Construction
Ceiling (General)	Gypsum Board
Columns and Beams (General)	Wooden Structural System
Roof	OSB/3 Board Covering – Wooden Structural System
Core Walls	Gypsum Board – Rockwool Board Filling (10 cm) – Gypsum Board
Core Floor	Steel Construction – Trapezoidal Sheet Metal Coating – Leveling Concrete
Core Ceiling	Gypsum Board
Core Columns and Beams	Steel Construction

Appendix D-5. Architectural and Static Plans for Wood-Steel Structure: Section AA (Architectural Project)



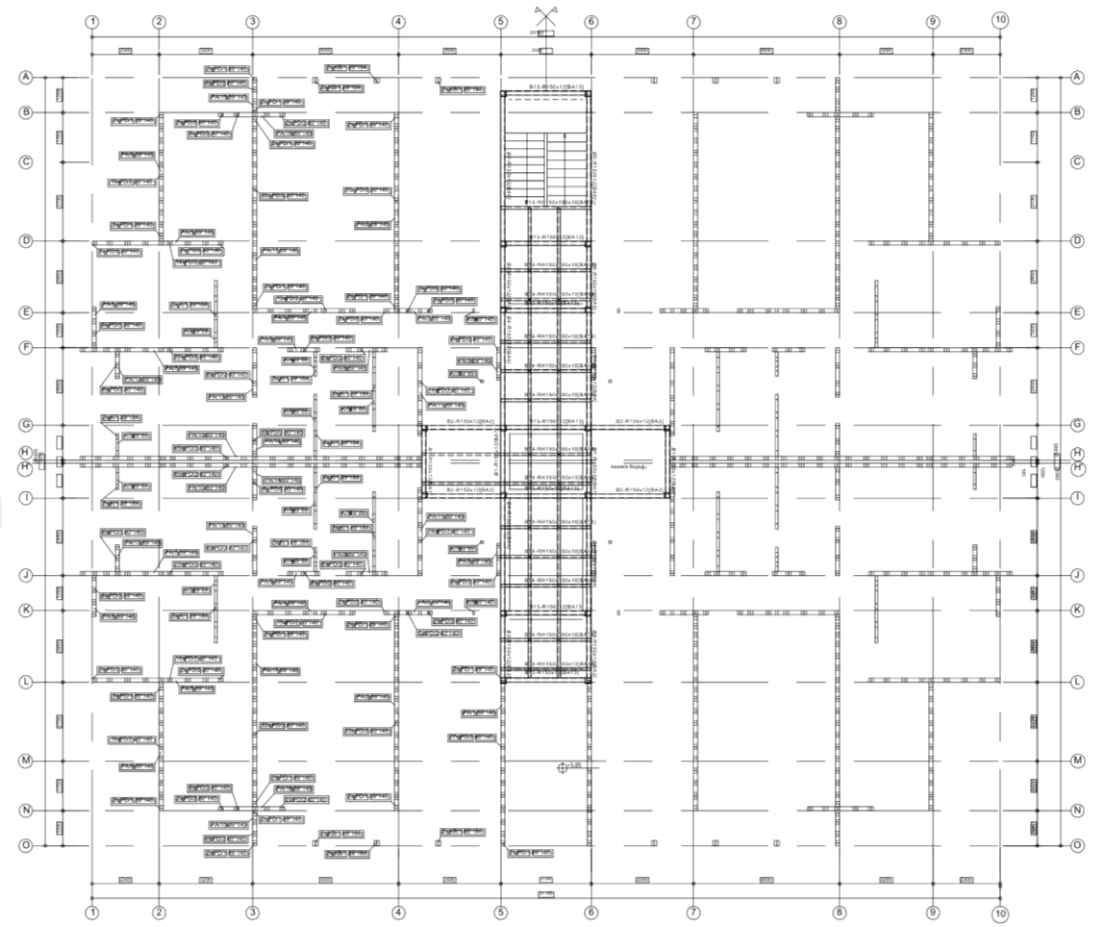
SECTION A-A

Appendix D-6. Architectural and Static Plans for Wood-Steel Structure: Basement Floor Formwork Plan (Static Project)



BASEMENT FLOOR FORM WORK PLAN

Appendix D-7. Architectural and Static Plans for Wood-Steel Structure: Ground Floor Curtain Application Plan (Static Project)

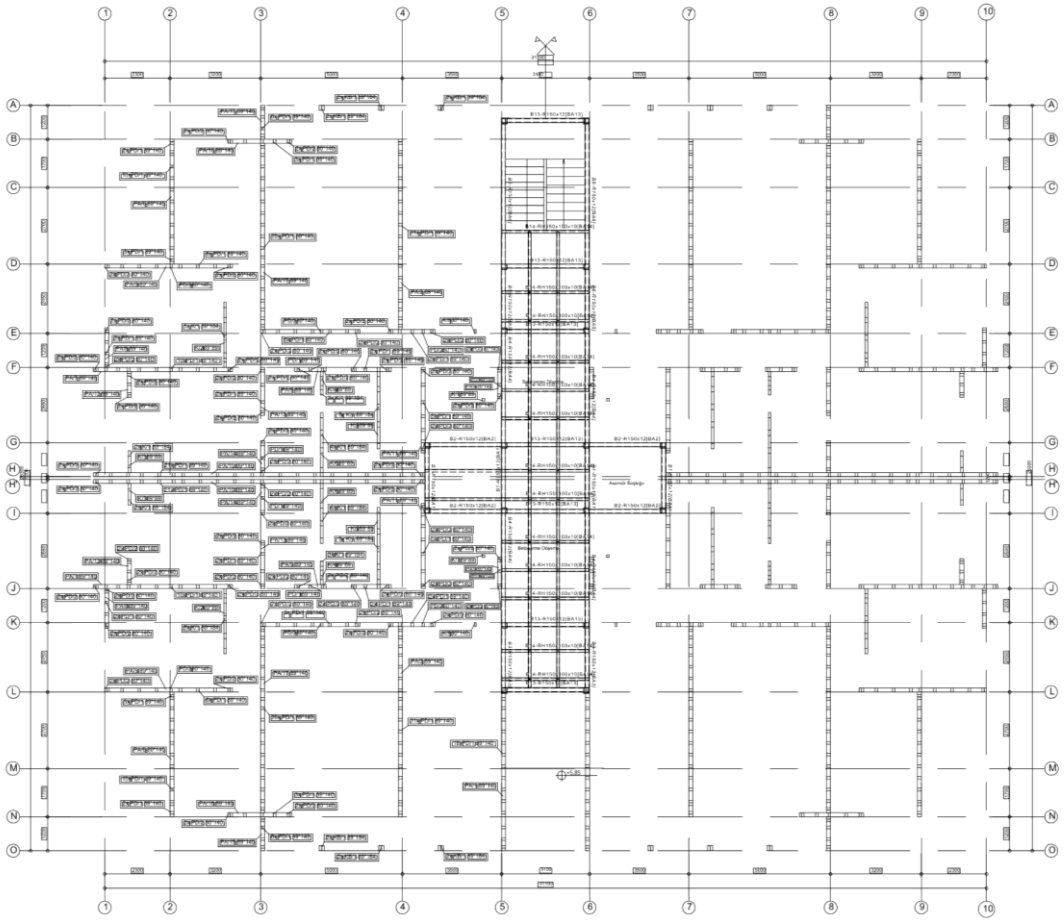


Exposure Descriptions

PD: Curtain Post
PA: Curtain Bottom Header Beam
PU: Curtain Top Header Beam
K: Column
KB: Balcony Column
KR: Beam
DK: Floor Beam
AK: Intermediate Beam
AS: Roof Purlin Beam
MK: Roof Ridge Beam

GROUND FLOOR CURTAIN APPLICATION PLAN

Appendix D-8. Architectural and Static Plans for Wood-Steel Structure: 1st and 2nd Floor Curtain Application Plan (Static Project)



Exposure Descriptions

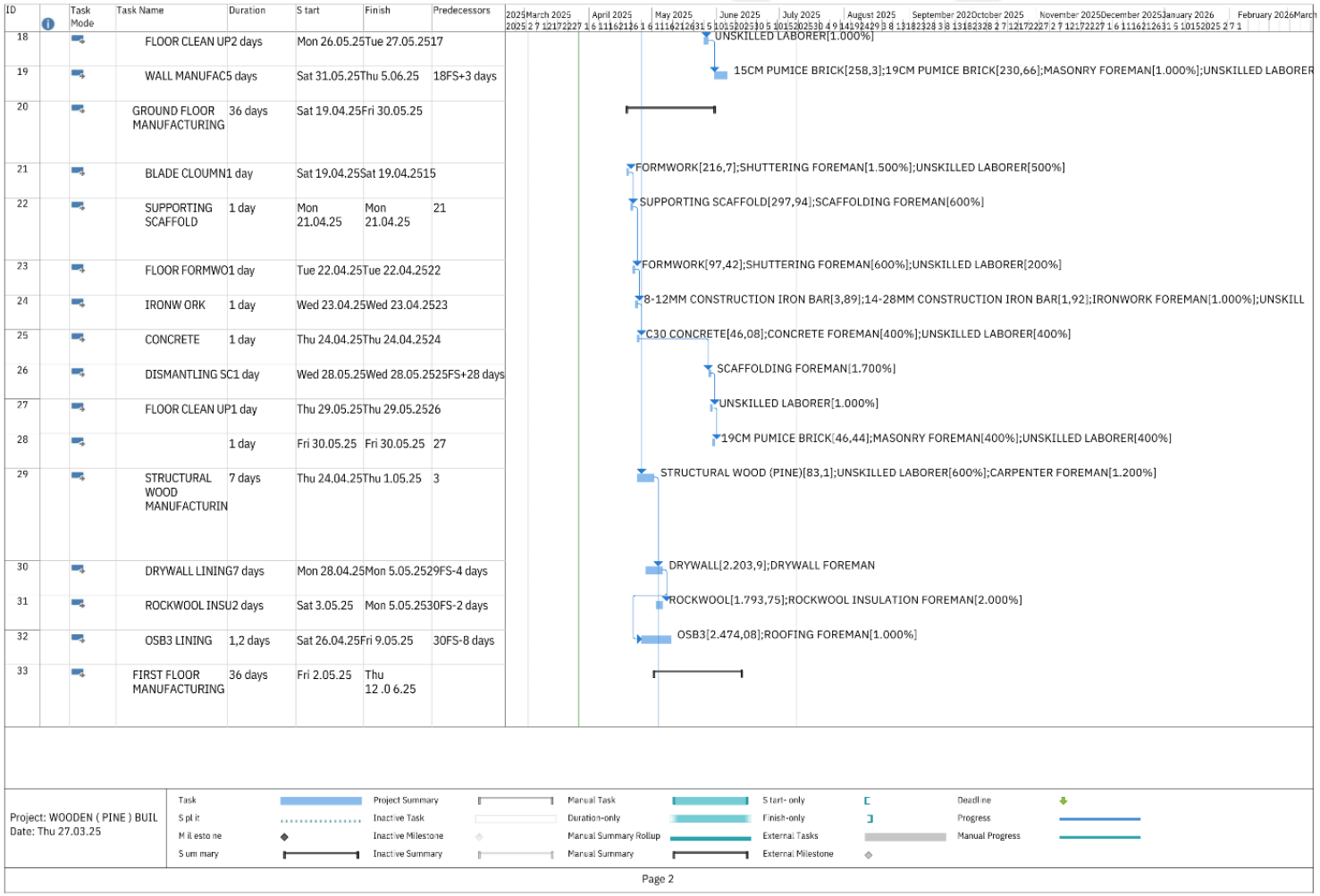
PD: Curtain Post
PA: Curtain Bottom Header Beam
PU: Curtain Top Header Beam
K: Column
KB: Balcony Column
KR: Beam
DK: Floor Beam
AK: Intermediate Beam
AS: Roof Purlin Beam
MK: Roof Ridge Beam

1.-2. FLOOR CURTAIN APPLICATION PLAN

Appendix E.1. Gantt Diagram of Wood-Reinforced Concrete Structure



Appendix E.1. Gantt Diagram of Wood-Reinforced Concrete Structure (Continued)



ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
18		FLOOR CLEAN UP	2 days	Mon 26.05.25	Tue 27.05.25	17
19		WALL MANUFAC	5 days	Sat 31.05.25	Thu 5.06.25	18FS+3 days
20		GROUND FLOOR MANUFACTURING	36 days	Sat 19.04.25	Fri 30.05.25	
21		BLADE CLOUMN	1 day	Sat 19.04.25	Sat 19.04.25	15
22		SUPPORTING SCAFFOLD	1 day	Mon 21.04.25	Mon 21.04.25	21
23		FLOOR FORMWO	1 day	Tue 22.04.25	Tue 22.04.25	22
24		IRONW ORK	1 day	Wed 23.04.25	Wed 23.04.25	23
25		CONCRETE	1 day	Thu 24.04.25	Thu 24.04.25	24
26		DISMANTLING SC	1 day	Wed 28.05.25	Wed 28.05.25	25FS+28 days
27		FLOOR CLEAN UP	1 day	Thu 29.05.25	Thu 29.05.25	26
28			1 day	Fri 30.05.25	Fri 30.05.25	27
29		STRUCTURAL WOOD MANUFACTURIN	7 days	Thu 24.04.25	Thu 1.05.25	3
30		DRYWALL LINING	7 days	Mon 28.04.25	Mon 5.05.25	29FS-4 days
31		ROCKWOOL INSU	2 days	Sat 3.05.25	Mon 5.05.25	30FS-2 days
32		OSB3 LINING	1,2 days	Sat 26.04.25	Fri 9.05.25	30FS-8 days
33		FIRST FLOOR MANUFACTURING	36 days	Fri 2.05.25	Thu 12 .0 6.25	

Appendix E.1. Gantt Diagram of Wood-Reinforced Concrete Structure (Continued)

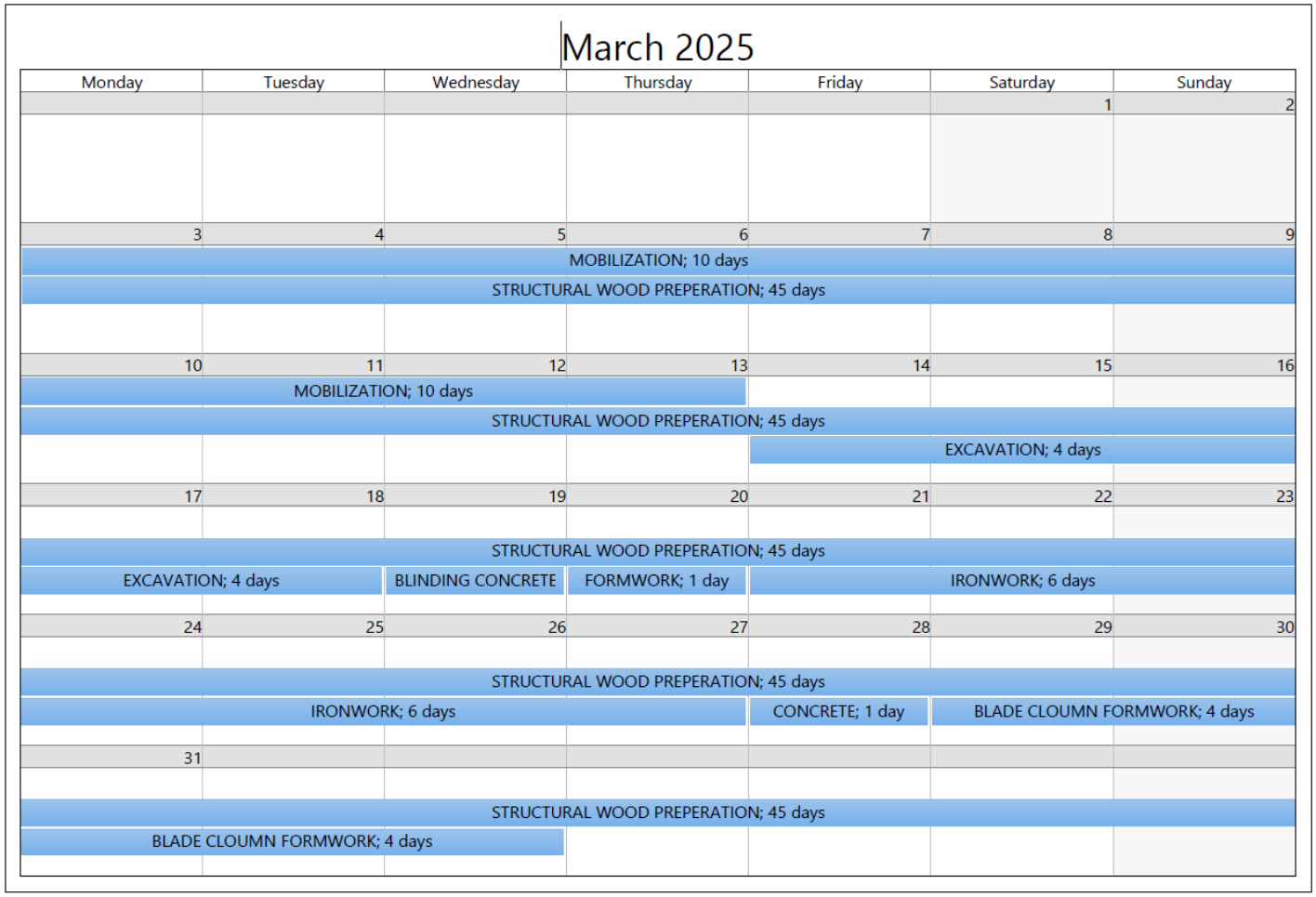


Appendix E.1. Gantt Diagram of Wood-Reinforced Concrete Structure (Continued)

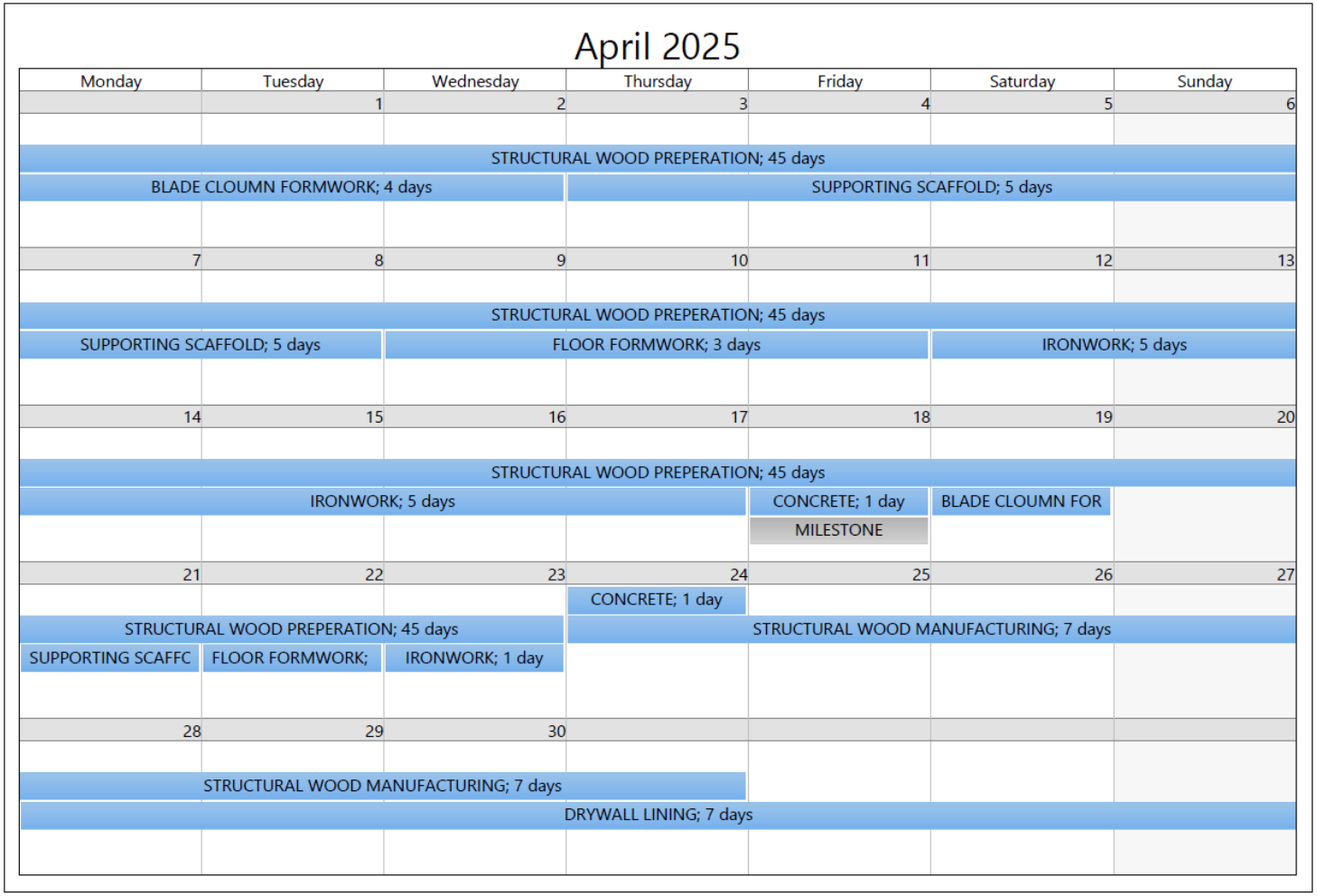


ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
53		FLOOR CLEAN UP	2 days	Tue 24.06.25	Wed 25.06.25	52
54		WALL MANUFAC	1 day	Thu 26.06.25	Thu 26.06.25	53
55		STRUCTURAL WO	6 days	Wed 21.05.25	Tue 27.05.25	51
56		DRYWALL LINING	7 days	Fri 23.05.25	Fri 30.05.25	55FS-4 days
57		ROCKWOOL INSU	2 days	Thu 29.05.25	Fri 30.05.25	56FS-2 days
58		OSB3 LINING	12 days	Thu 22.05.25	Wed 4.06.25	56FS-8 days
59		ELEVATOR TOWER MANUFACTURING	36 days	Wed 28.05.25	Tue 8.07.25	
60		BLADE CLOUMN	1 day	Wed 28.05.25	Wed 28.05.25	55
61		SUPPORTING SCA	1 day	Thu 29.05.25	Thu 29.05.25	60
62		FLOOR FORMWO	1 day	Fri 30.05.25	Fri 30.05.25	61
63		IRONW ORK	1 day	Sat 31.05.25	Sat 31.05.25	62
64		CONCRETE	1 day	Mon 2.06.25	Mon 2.06.25	63
65		DISMANTLING SC	1 day	Sat 5.07.25	Sat 5.07.25	64FS+28 days
66		FLOOR CLEAN UP	1 day	Mon 7.07.25	Mon 7.07.25	65
67		WALL MANUFAC	1 day	Tue 8.07.25	Tue 8.07.25	66
68		ROOF MANUFACTURING	10 days	Fri 13.06.25	Tue 24 .0 6.25	
69		OSB MANTLED W	10 days	Fri 13.06.25	Tue 24.06.25	64FS+9 days

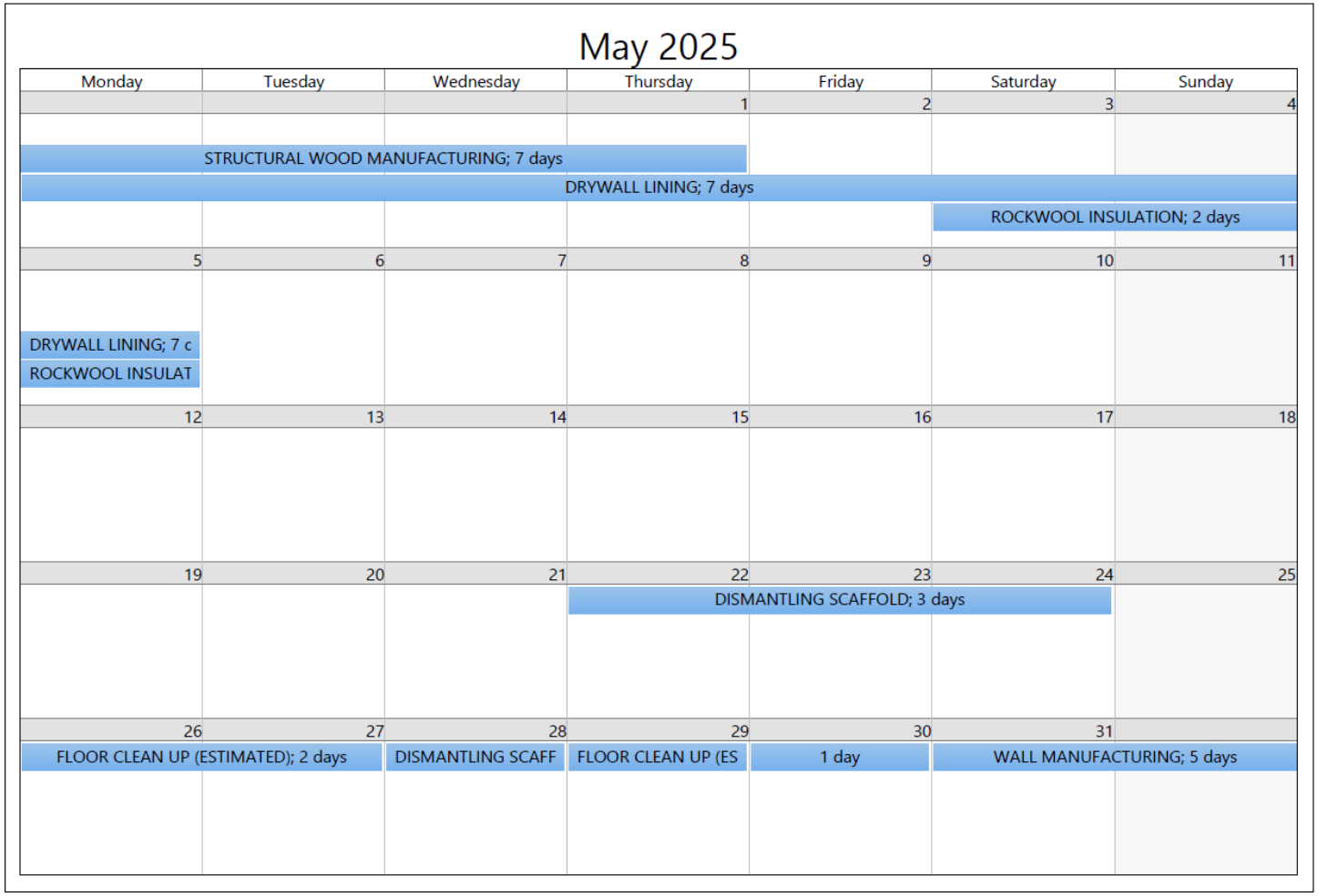
Appendix E.2. Timeline Table of Wood-Reinforced Concrete Structure



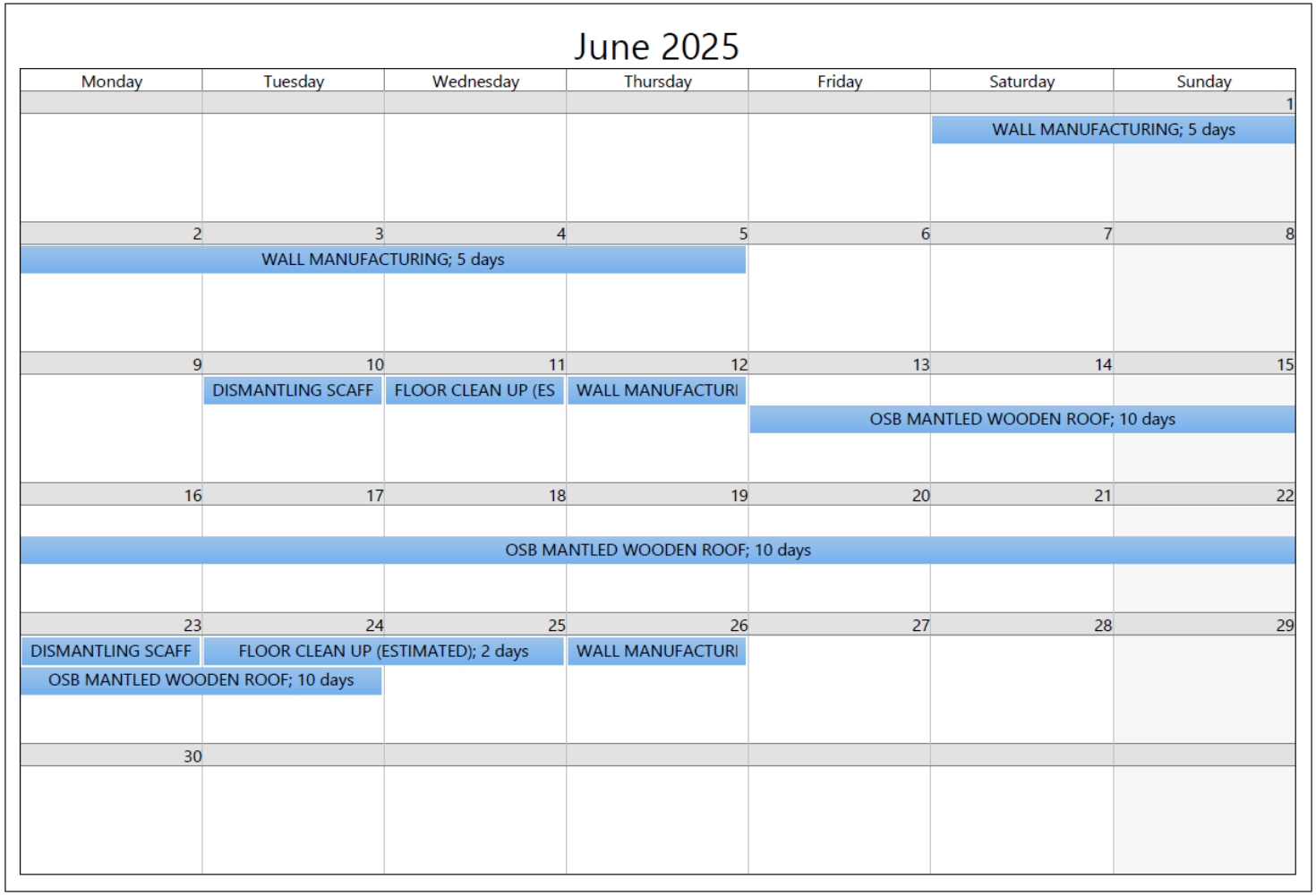
Appendix E.2. Timeline Table of Wood-Reinforced Concrete Structure (Continued)



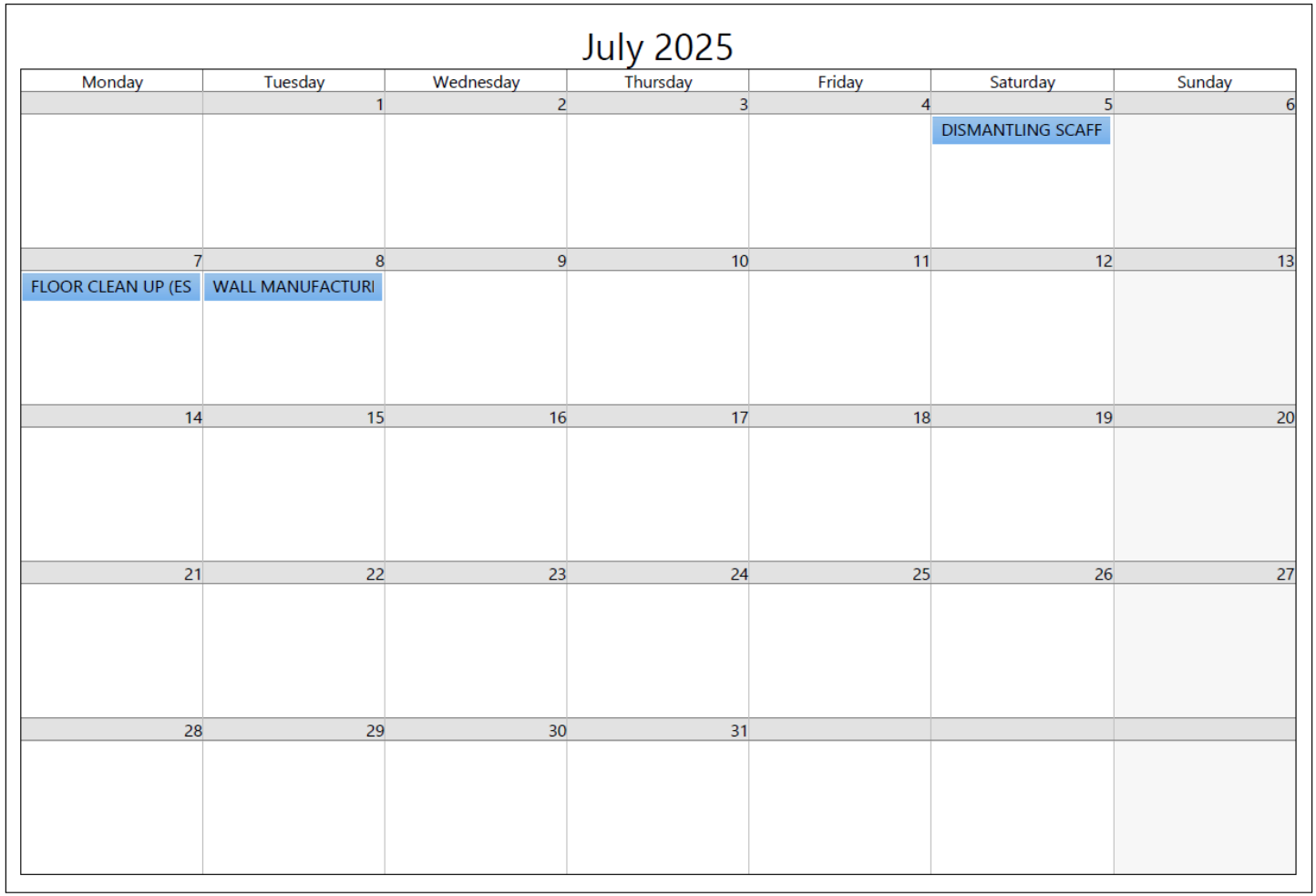
Appendix E.2. Timeline Table of Wood-Reinforced Concrete Structure (Continued)



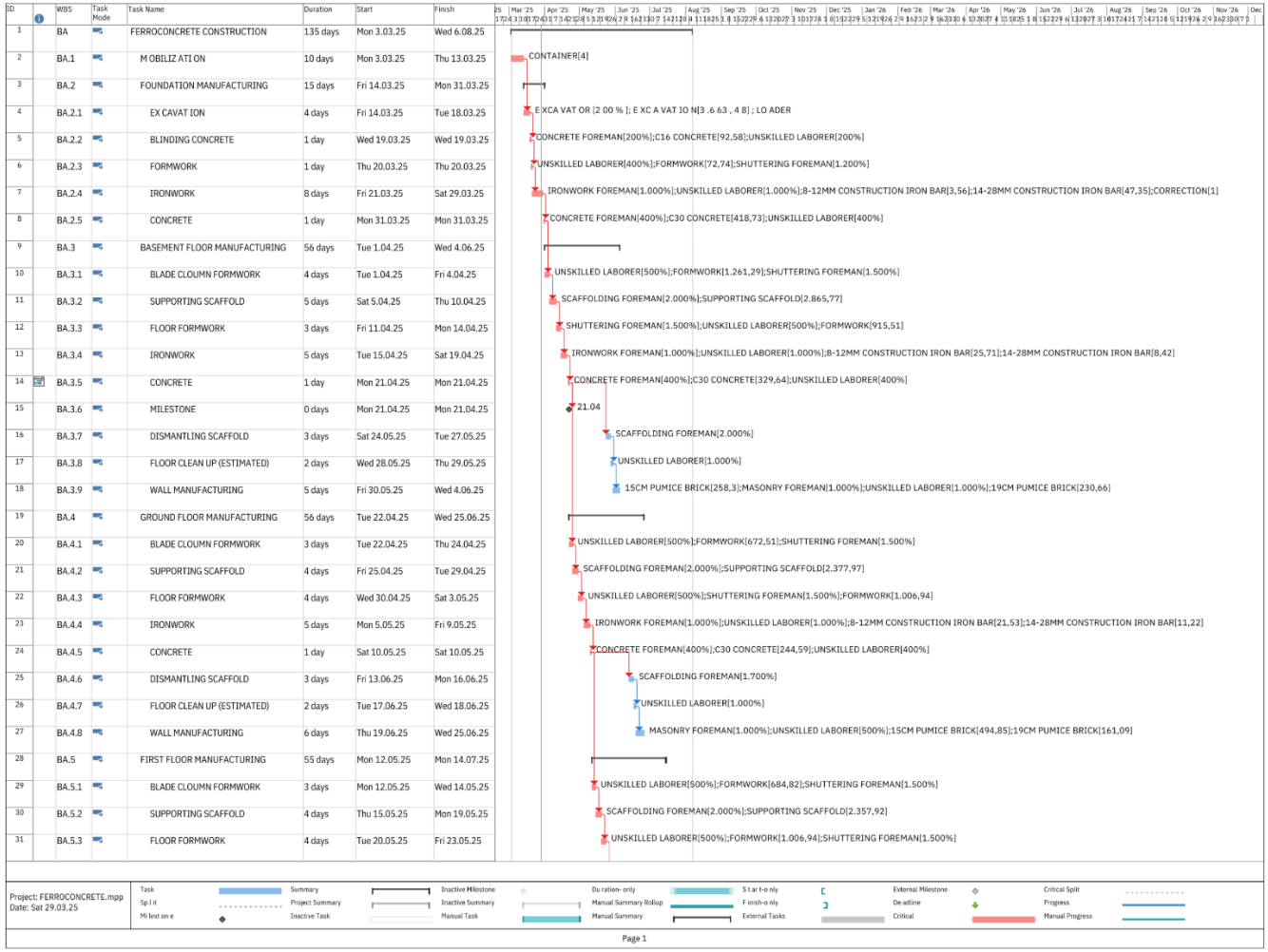
Appendix E.2. Timeline Table of Wood-Reinforced Concrete Structure (Continued)



Appendix E.2. Timeline Table of Wood-Reinforced Concrete Structure (Continued)

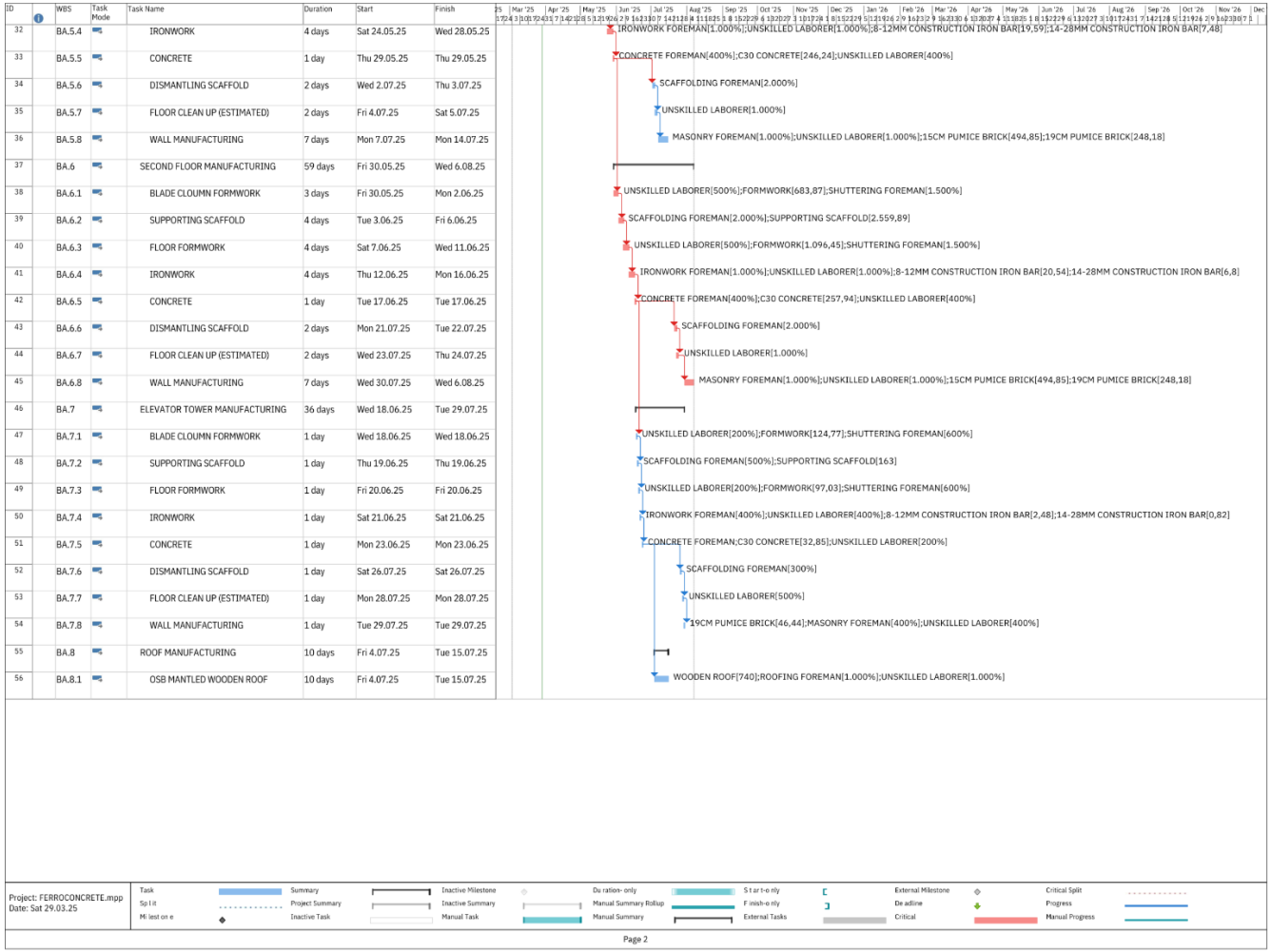


Appendix F.1. Gantt Diagram of Reinforced Concrete Structure



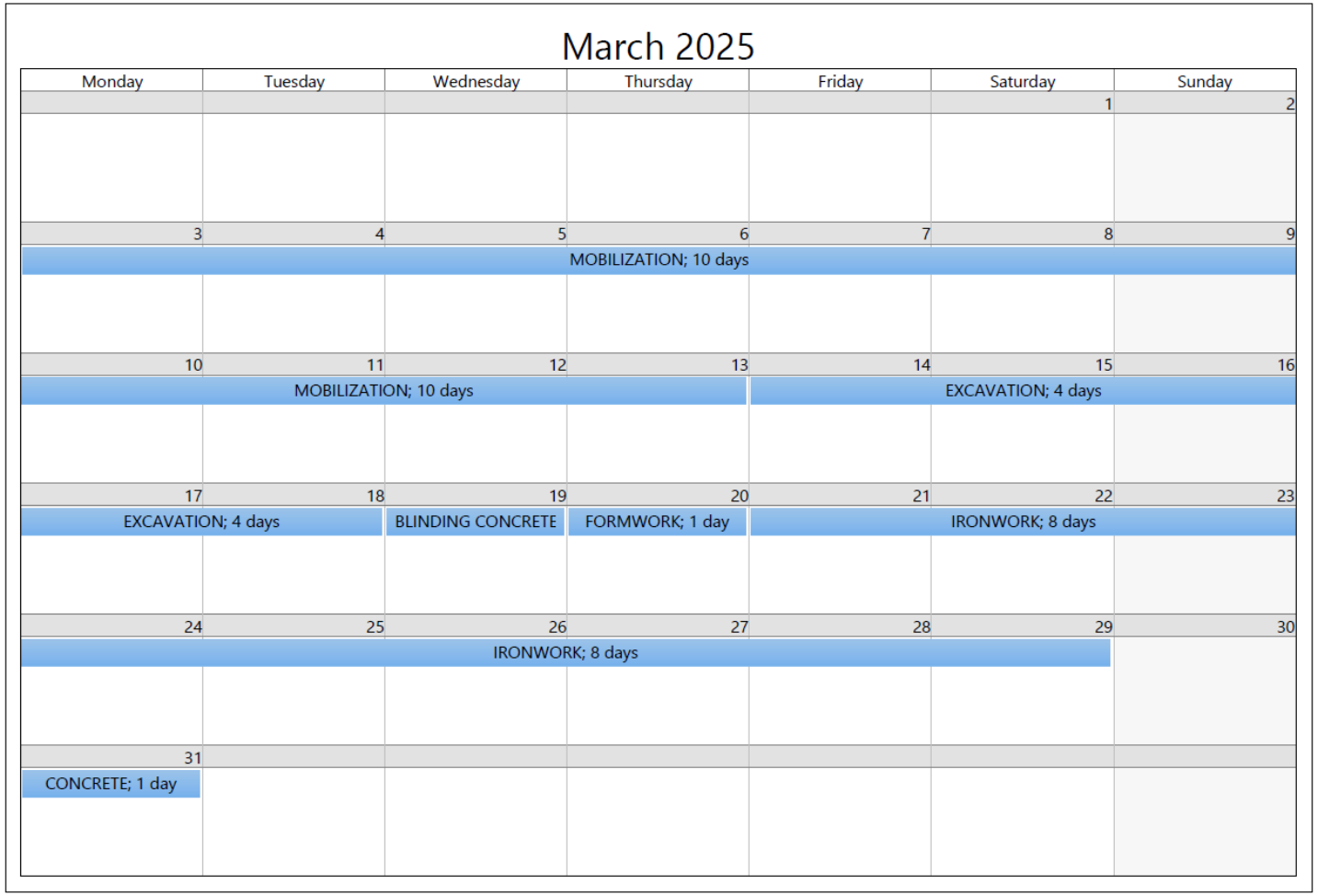
ID	WBS	Task Mode	Task Name	Duration	Start	Finish
1	BA		FERROCONCRETE CONSTRUCTION	135 days	Mon 3.03.25	Wed 6.08.25
2	BA.1		M OBILIZ ATI ON	10 days	Mon 3.03.25	Thu 13.03.25
3	BA.2		FOUNDATION MANUFACTURING	15 days	Fri 14.03.25	Mon 31.03.25
4	BA.2.1		EX CAVAT ION	4 days	Fri 14.03.25	Tue 18.03.25
5	BA.2.2		BLINDING CONCRETE	1 day	Wed 19.03.25	Wed 19.03.25
6	BA.2.3		FORMWORK	1 day	Thu 20.03.25	Thu 20.03.25
7	BA.2.4		IRONWORK	8 days	Fri 21.03.25	Sat 29.03.25
8	BA.2.5		CONCRETE	1 day	Mon 31.03.25	Mon 31.03.25
9	BA.3		BASEMENT FLOOR MANUFACTURING	56 days	Tue 1.04.25	Wed 4.06.25
10	BA.3.1		BLADE CLOUMN FORMWORK	4 days	Tue 1.04.25	Fri 4.04.25
11	BA.3.2		SUPPORTING SCAFFOLD	5 days	Sat 5.04.25	Thu 10.04.25
12	BA.3.3		FLOOR FORMWORK	3 days	Fri 11.04.25	Mon 14.04.25
13	BA.3.4		IRONWORK	5 days	Tue 15.04.25	Sat 19.04.25
14	BA.3.5		CONCRETE	1 day	Mon 21.04.25	Mon 21.04.25
15	BA.3.6		MILESTONE	0 days	Mon 21.04.25	Mon 21.04.25
16	BA.3.7		DISMANTLING SCAFFOLD	3 days	Sat 24.05.25	Tue 27.05.25
17	BA.3.8		FLOOR CLEAN UP (ESTIMATED)	2 days	Wed 28.05.25	Thu 29.05.25
18	BA.3.9		WALL MANUFACTURING	5 days	Fri 30.05.25	Wed 4.06.25
19	BA.4		GROUND FLOOR MANUFACTURING	56 days	Tue 22.04.25	Wed 25.06.25
20	BA.4.1		BLADE CLOUMN FORMWORK	3 days	Tue 22.04.25	Thu 24.04.25
21	BA.4.2		SUPPORTING SCAFFOLD	4 days	Fri 25.04.25	Tue 29.04.25
22	BA.4.3		FLOOR FORMWORK	4 days	Wed 30.04.25	Sat 3.05.25
23	BA.4.4		IRONWORK	5 days	Mon 5.05.25	Fri 9.05.25
24	BA.4.5		CONCRETE	1 day	Sat 10.05.25	Sat 10.05.25
25	BA.4.6		DISMANTLING SCAFFOLD	3 days	Fri 13.06.25	Mon 16.06.25
26	BA.4.7		FLOOR CLEAN UP (ESTIMATED)	2 days	Tue 17.06.25	Wed 18.06.25
27	BA.4.8		WALL MANUFACTURING	6 days	Thu 19.06.25	Wed 25.06.25
28	BA.5		FIRST FLOOR MANUFACTURING	55 days	Mon 12.05.25	Mon 14.07.25
29	BA.5.1		BLADE CLOUMN FORMWORK	3 days	Mon 12.05.25	Wed 14.05.25
30	BA.5.2		SUPPORTING SCAFFOLD	4 days	Thu 15.05.25	Mon 19.05.25
31	BA.5.3		FLOOR FORMWORK	4 days	Tue 20.05.25	Fri 23.05.25

Appendix F.1. Gantt Diagram of Reinforced Concrete Structure (Continued)



ID	WBS	Task Mode	Task Name	Duration	Start	Finish
32	BA.5.4		IRONWORK	4 days	Sat 24.05.25	Wed 28.05.25
33	BA.5.5		CONCRETE	1 day	Thu 29.05.25	Thu 29.05.25
34	BA.5.6		DISMANTLING SCAFFOLD	2 days	Wed 2.07.25	Thu 3.07.25
35	BA.5.7		FLOOR CLEAN UP (ESTIMATED)	2 days	Fri 4.07.25	Sat 5.07.25
36	BA.5.8		WALL MANUFACTURING	7 days	Mon 7.07.25	Mon 14.07.25
37	BA.6		SECOND FLOOR MANUFACTURING	59 days	Fri 30.05.25	Wed 6.08.25
38	BA.6.1		BLADE CLOUMN FORMWORK	3 days	Fri 30.05.25	Mon 2.06.25
39	BA.6.2		SUPPORTING SCAFFOLD	4 days	Tue 3.06.25	Fri 6.06.25
40	BA.6.3		FLOOR FORMWORK	4 days	Sat 7.06.25	Wed 11.06.25
41	BA.6.4		IRONWORK	4 days	Thu 12.06.25	Mon 16.06.25
42	BA.6.5		CONCRETE	1 day	Tue 17.06.25	Tue 17.06.25
43	BA.6.6		DISMANTLING SCAFFOLD	2 days	Mon 21.07.25	Tue 22.07.25
44	BA.6.7		FLOOR CLEAN UP (ESTIMATED)	2 days	Wed 23.07.25	Thu 24.07.25
45	BA.6.8		WALL MANUFACTURING	7 days	Wed 30.07.25	Wed 6.08.25
46	BA.7		ELEVATOR TOWER MANUFACTURING	36 days	Wed 18.06.25	Tue 29.07.25
47	BA.7.1		BLADE CLOUMN FORMWORK	1 day	Wed 18.06.25	Wed 18.06.25
48	BA.7.2		SUPPORTING SCAFFOLD	1 day	Thu 19.06.25	Thu 19.06.25
49	BA.7.3		FLOOR FORMWORK	1 day	Fri 20.06.25	Fri 20.06.25
50	BA.7.4		IRONWORK	1 day	Sat 21.06.25	Sat 21.06.25
51	BA.7.5		CONCRETE	1 day	Mon 23.06.25	Mon 23.06.25
52	BA.7.6		DISMANTLING SCAFFOLD	1 day	Sat 26.07.25	Sat 26.07.25
53	BA.7.7		FLOOR CLEAN UP (ESTIMATED)	1 day	Mon 28.07.25	Mon 28.07.25
54	BA.7.8		WALL MANUFACTURING	1 day	Tue 29.07.25	Tue 29.07.25
55	BA.8		ROOF MANUFACTURING	10 days	Fri 4.07.25	Tue 15.07.25
56	BA.8.1		OSB MANTLED WOODEN ROOF	10 days	Fri 4.07.25	Tue 15.07.25

Appendix F.2. The Timeline Table of Reinforced Concrete Structure



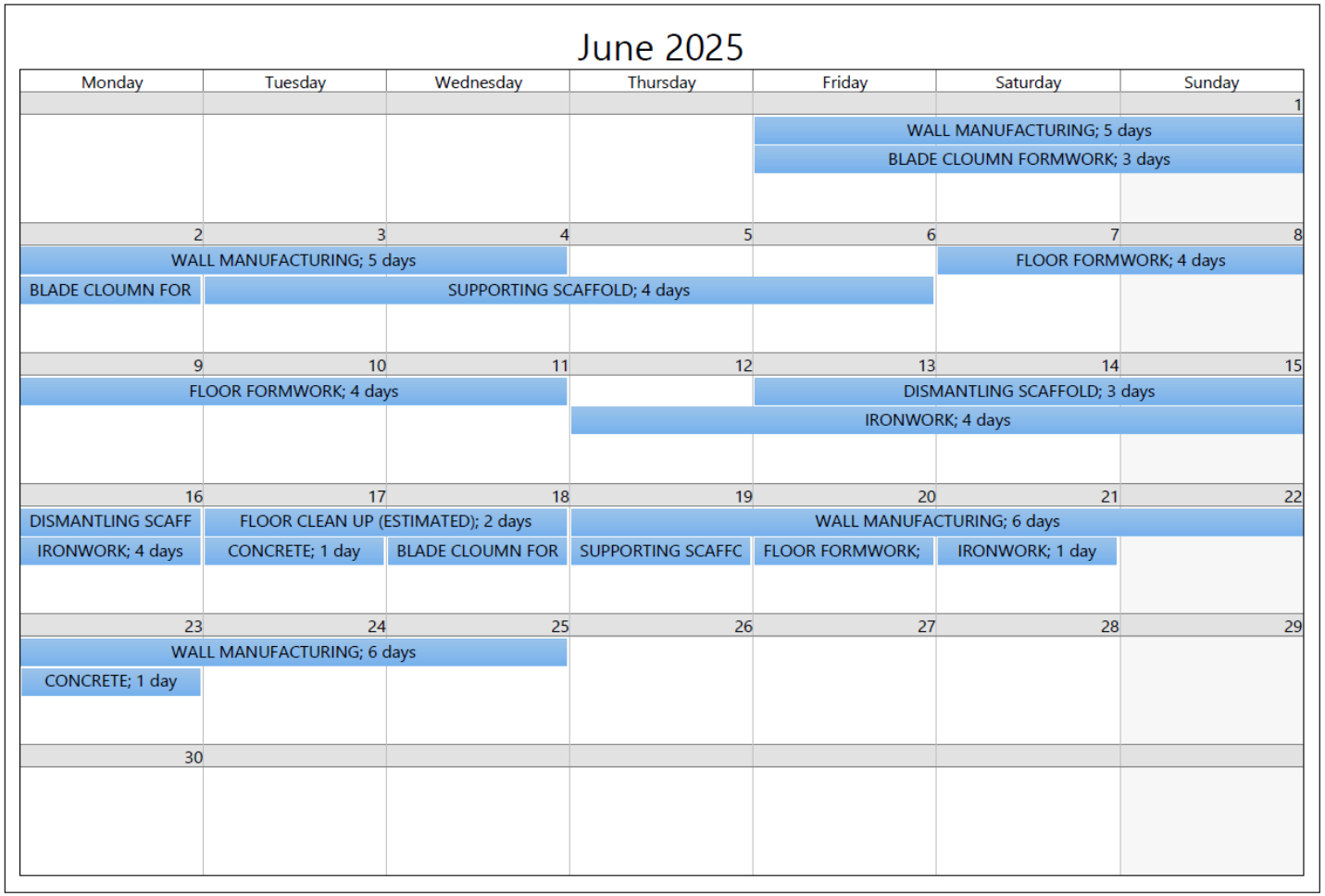
Appendix F.2. The Timeline Table of Reinforced Concrete Structure (continued)



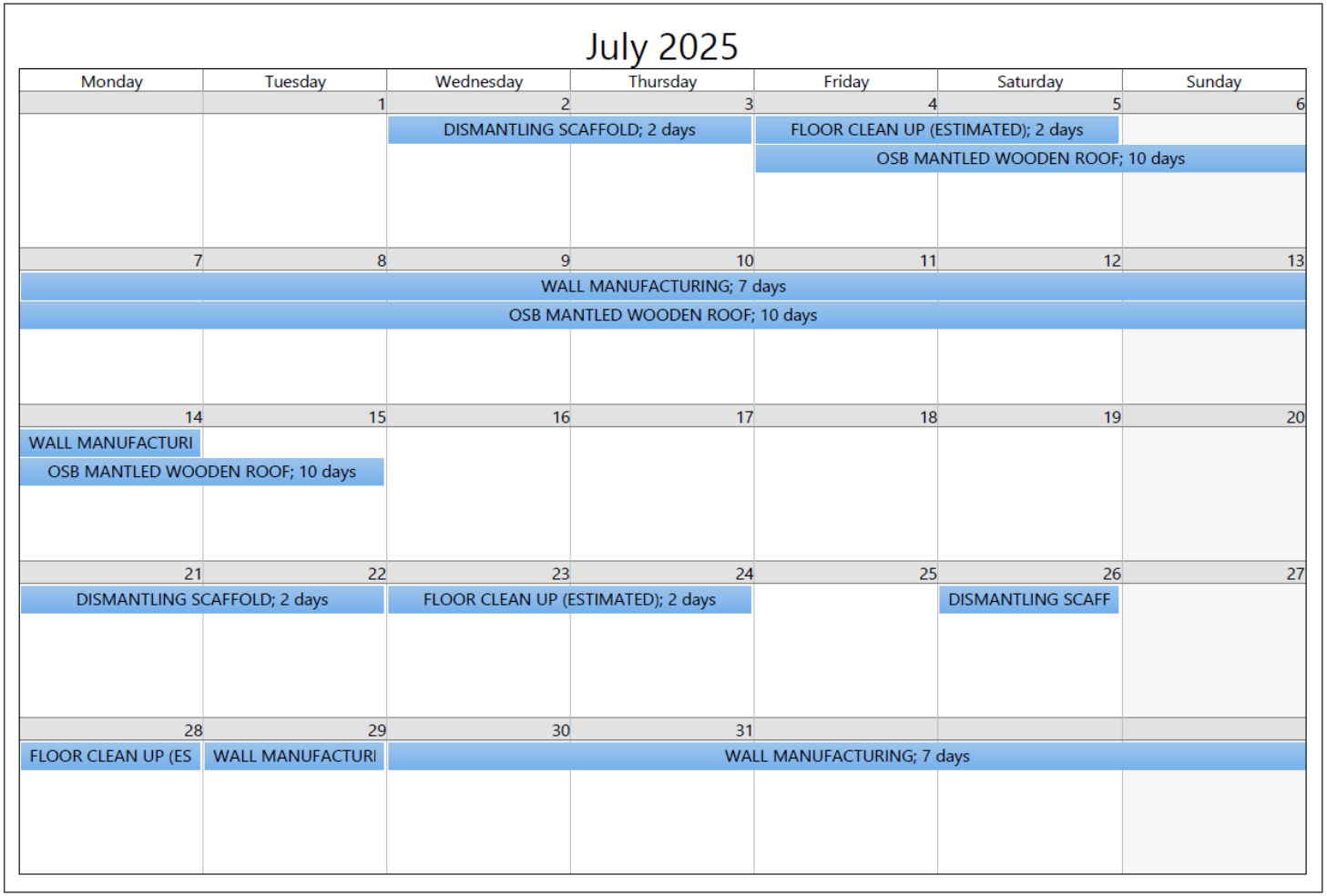
Appendix F.2. The Timeline Table of Reinforced Concrete Structure (continued)



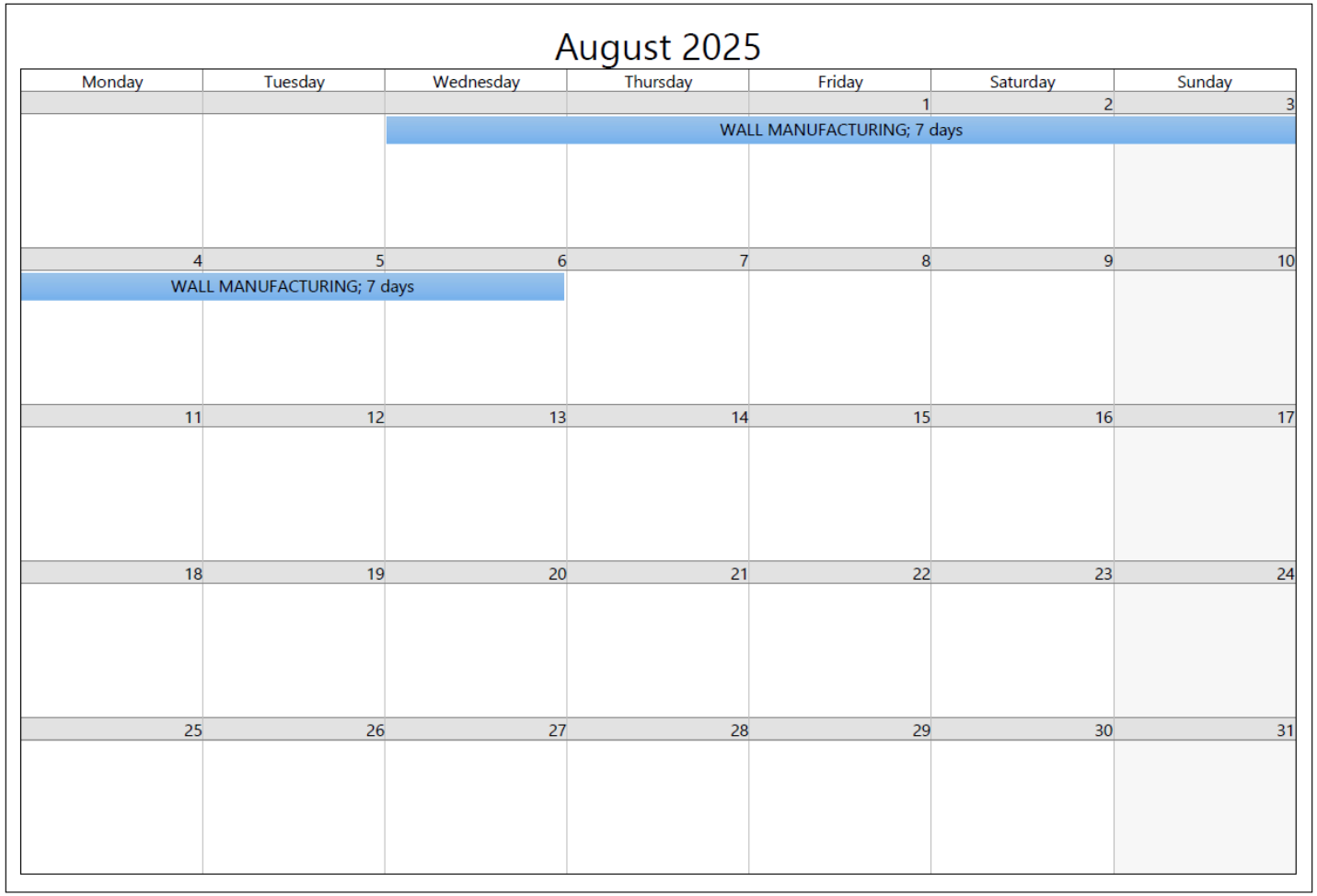
Appendix F.2. The Timeline Table of Reinforced Concrete Structure (continued)



Appendix F.2. The Timeline Table of Reinforced Concrete Structure (continued)



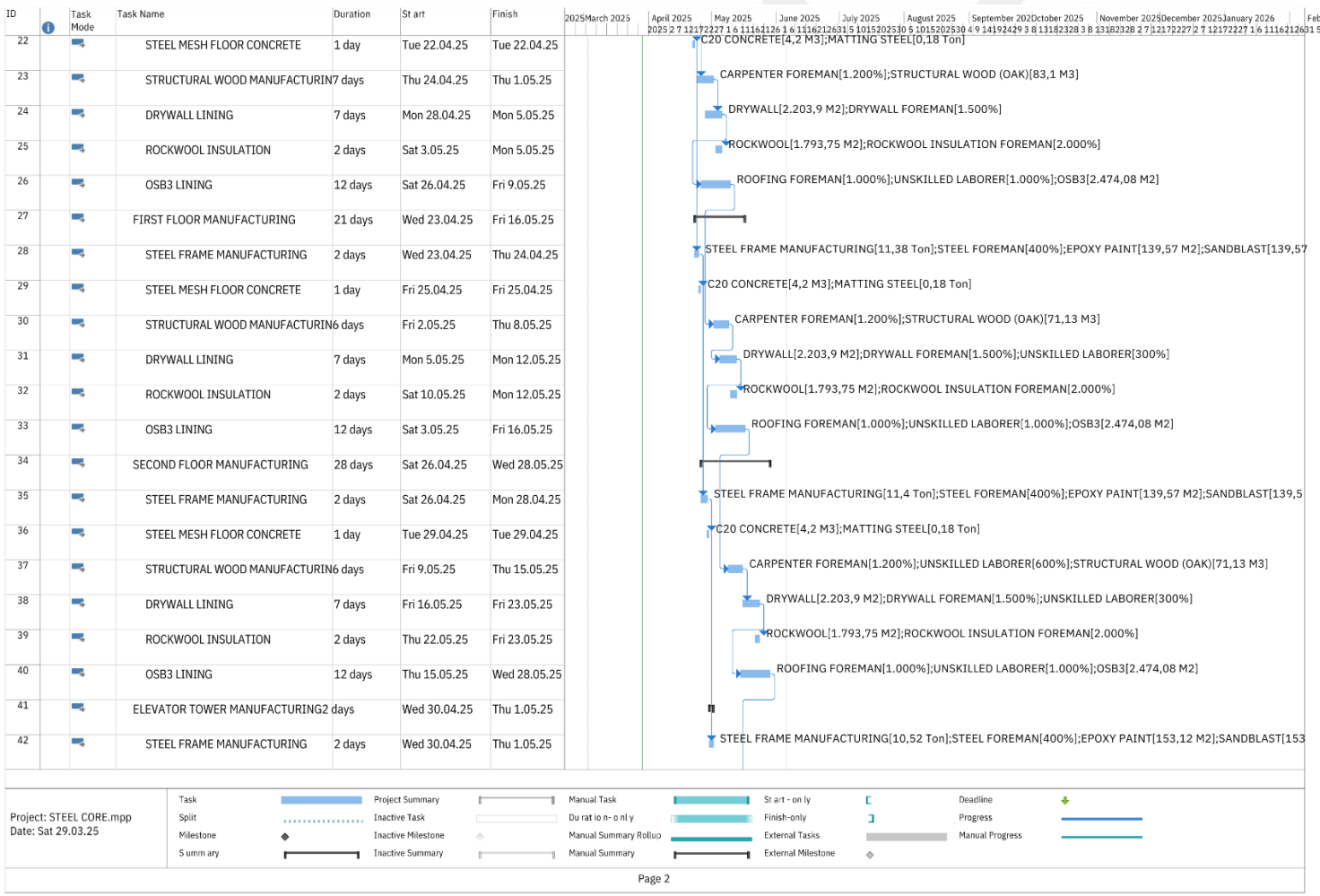
Appendix F.2. The Timeline Table of Reinforced Concrete Structure (continued)



Appendix G.1. Gantt Diagram of Wood-Steel Structure

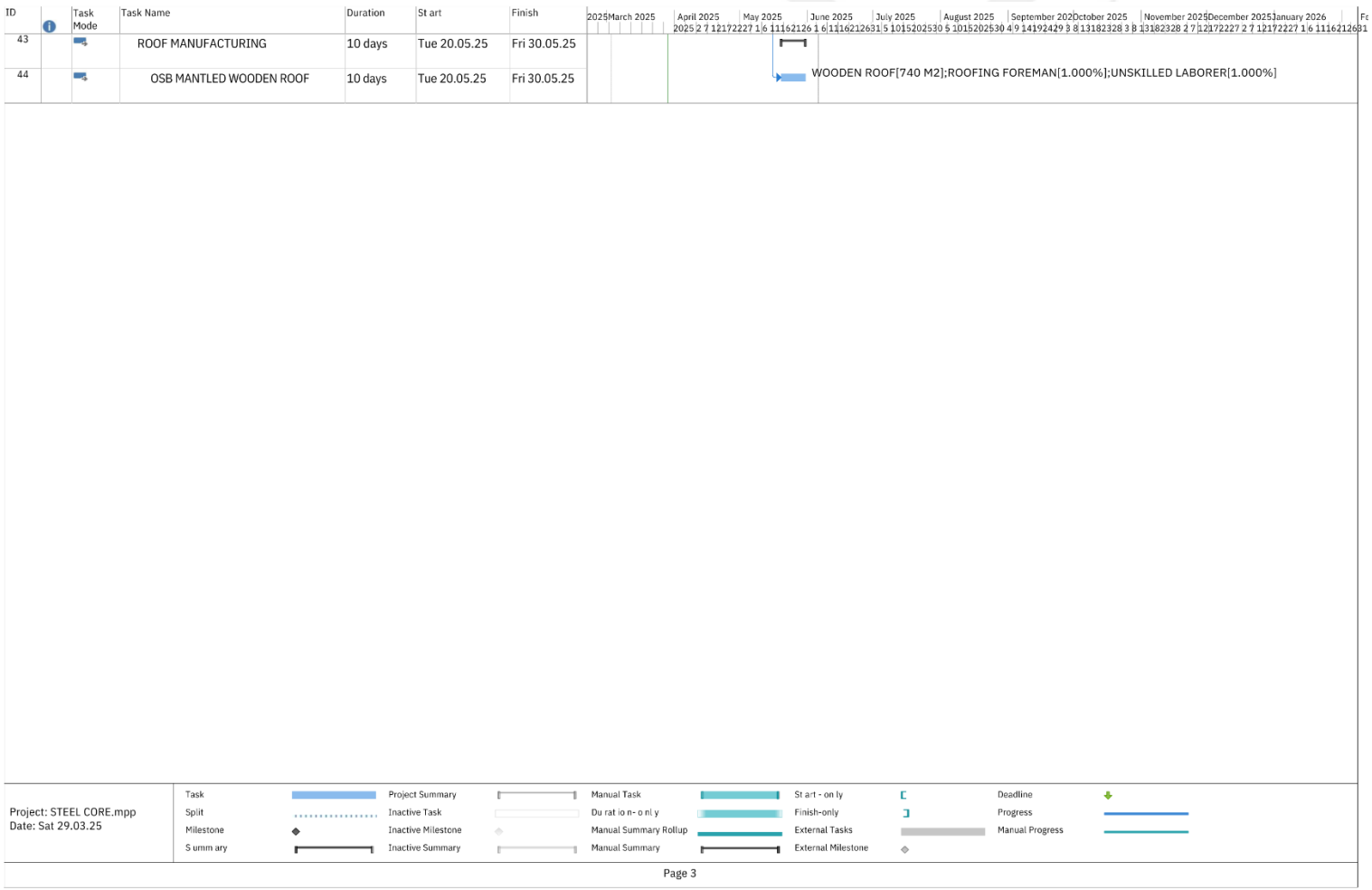


Appendix G.1. Gantt Diagram of Wood-Steel Structure (Continued)

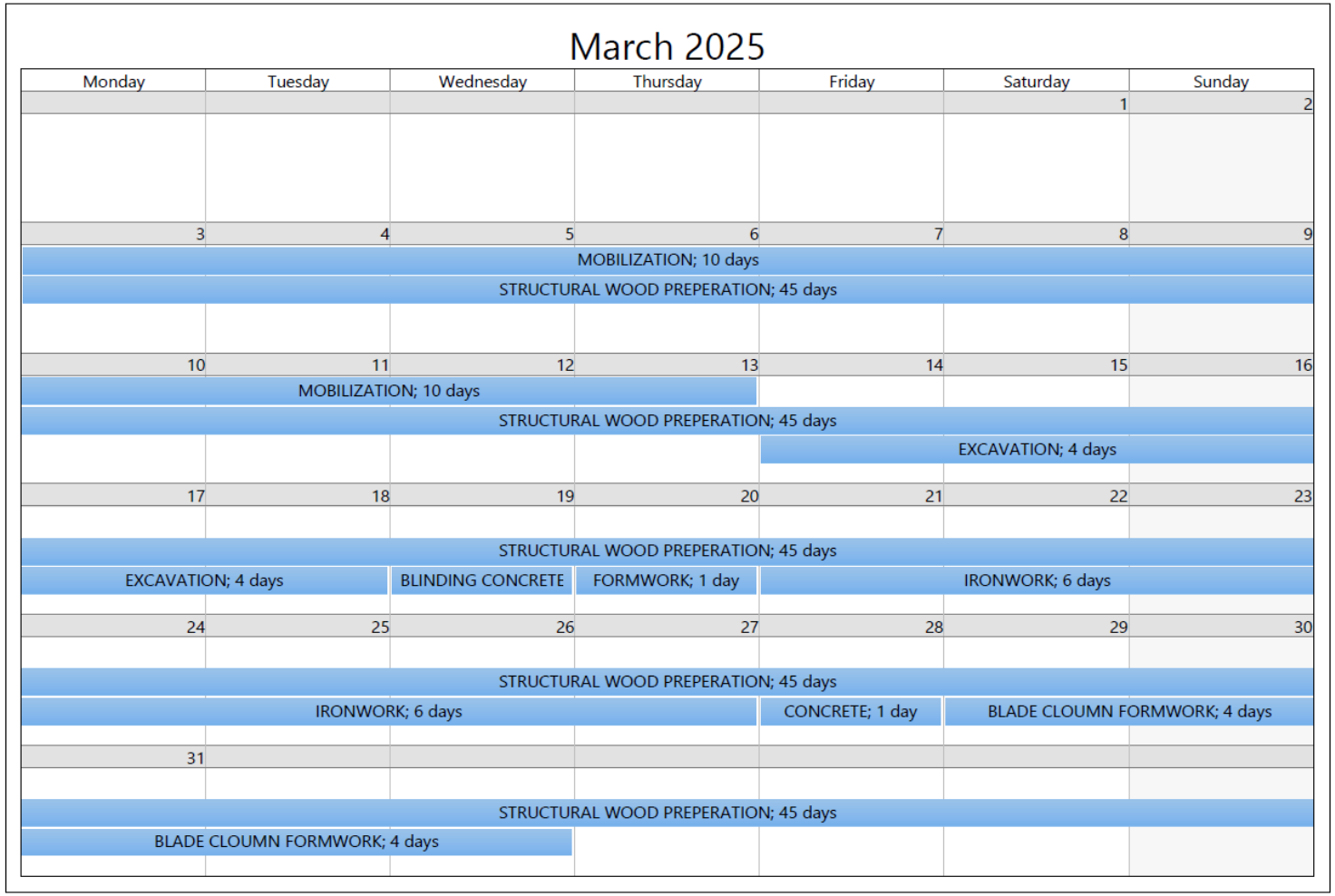


ID	Task Mode	Task Name	Duration	St art	Finish
22		STEEL MESH FLOOR CONCRETE	1 day	Tue 22.04.25	Tue 22.04.25
23		STRUCTURAL WOOD MANUFACTURIN	7 days	Thu 24.04.25	Thu 1.05.25
24		DRYWALL LINING	7 days	Mon 28.04.25	Mon 5.05.25
25		ROCKWOOL INSULATION	2 days	Sat 3.05.25	Mon 5.05.25
26		OSB3 LINING	12 days	Sat 26.04.25	Fri 9.05.25
27		FIRST FLOOR MANUFACTURING	21 days	Wed 23.04.25	Fri 16.05.25
28		STEEL FRAME MANUFACTURING	2 days	Wed 23.04.25	Thu 24.04.25
29		STEEL MESH FLOOR CONCRETE	1 day	Fri 25.04.25	Fri 25.04.25
30		STRUCTURAL WOOD MANUFACTURIN	6 days	Fri 2.05.25	Thu 8.05.25
31		DRYWALL LINING	7 days	Mon 5.05.25	Mon 12.05.25
32		ROCKWOOL INSULATION	2 days	Sat 10.05.25	Mon 12.05.25
33		OSB3 LINING	12 days	Sat 3.05.25	Fri 16.05.25
34		SECOND FLOOR MANUFACTURING	28 days	Sat 26.04.25	Wed 28.05.25
35		STEEL FRAME MANUFACTURING	2 days	Sat 26.04.25	Mon 28.04.25
36		STEEL MESH FLOOR CONCRETE	1 day	Tue 29.04.25	Tue 29.04.25
37		STRUCTURAL WOOD MANUFACTURIN	6 days	Fri 9.05.25	Thu 15.05.25
38		DRYWALL LINING	7 days	Fri 16.05.25	Fri 23.05.25
39		ROCKWOOL INSULATION	2 days	Thu 22.05.25	Fri 23.05.25
40		OSB3 LINING	12 days	Thu 15.05.25	Wed 28.05.25
41		ELEVATOR TOWER MANUFACTURING	2 days	Wed 30.04.25	Thu 1.05.25
42		STEEL FRAME MANUFACTURING	2 days	Wed 30.04.25	Thu 1.05.25

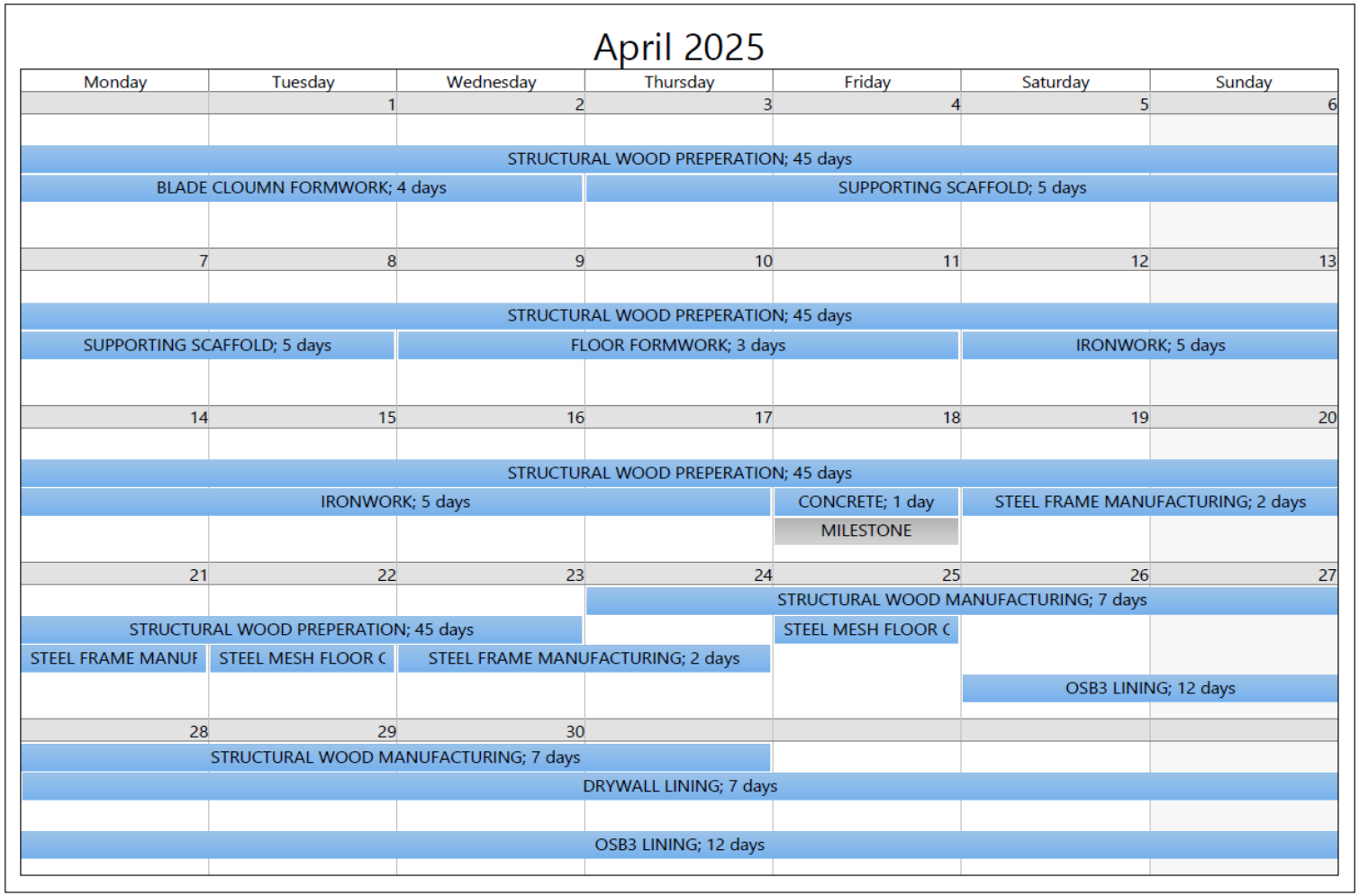
Appendix G.1. Gantt Diagram of Wood-Steel Structure (Continued)



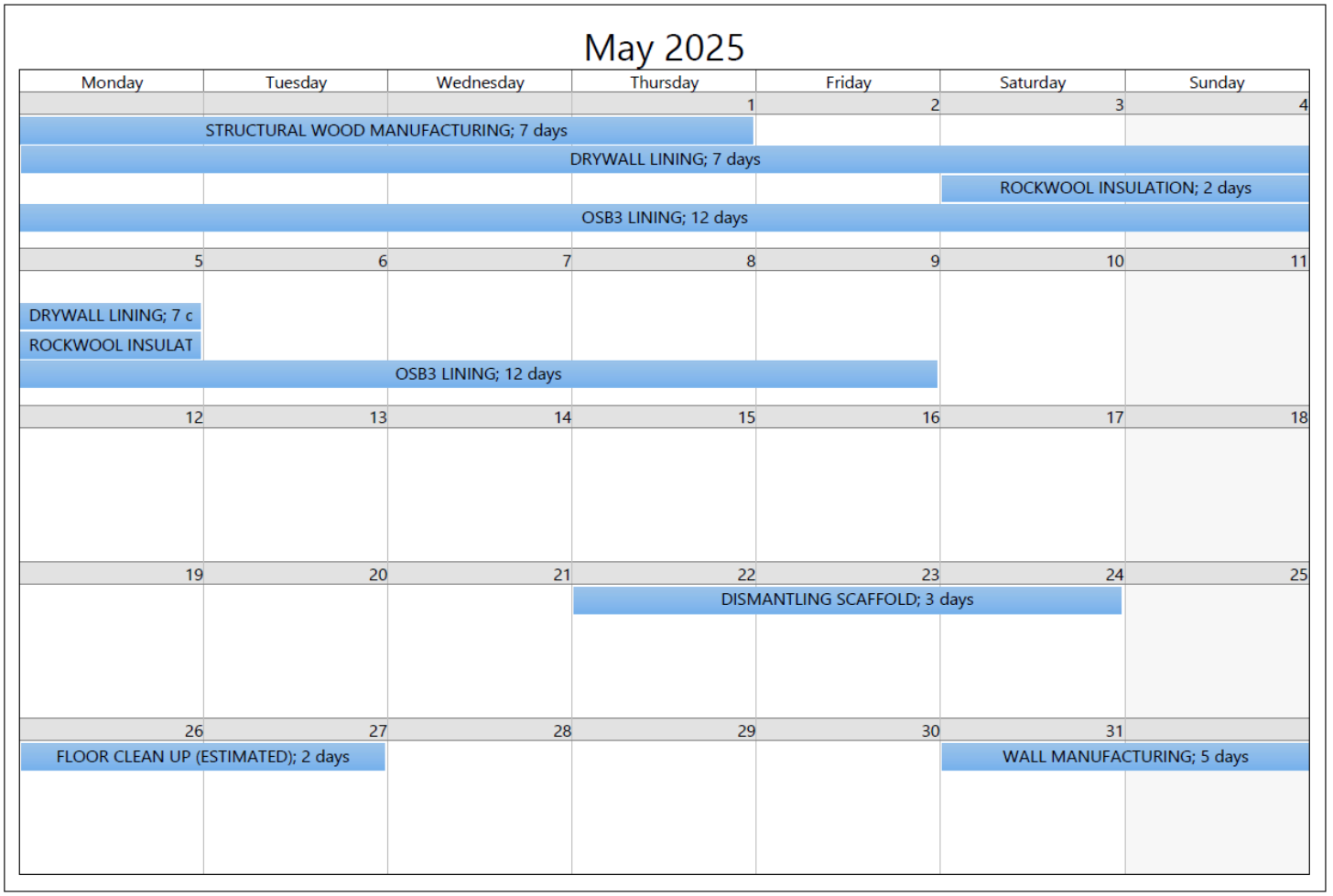
Appendix G.2. Timeline Table of Wood-Steel Structure



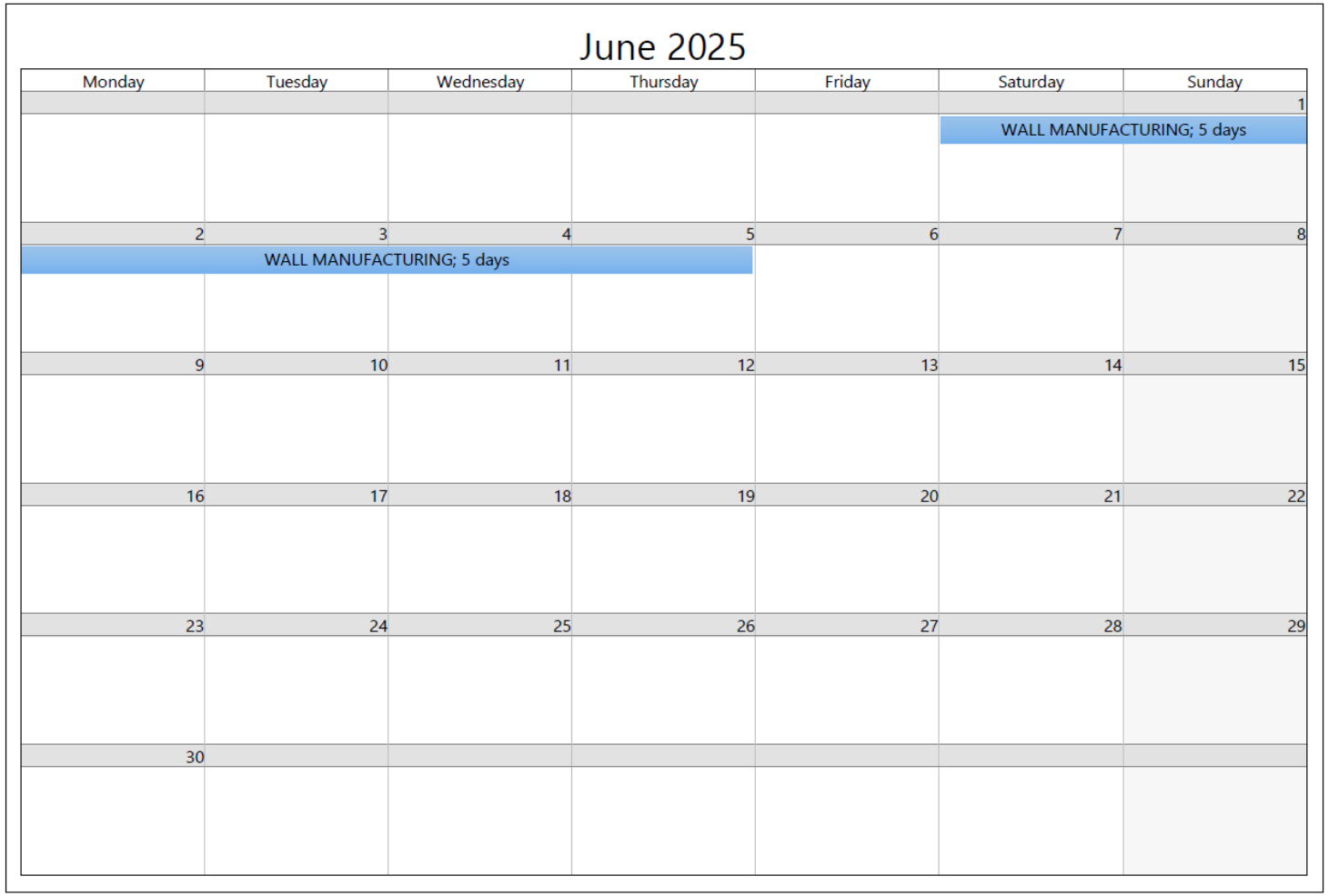
Appendix G.2. Timeline Table of Wood-Steel Structure (continued)



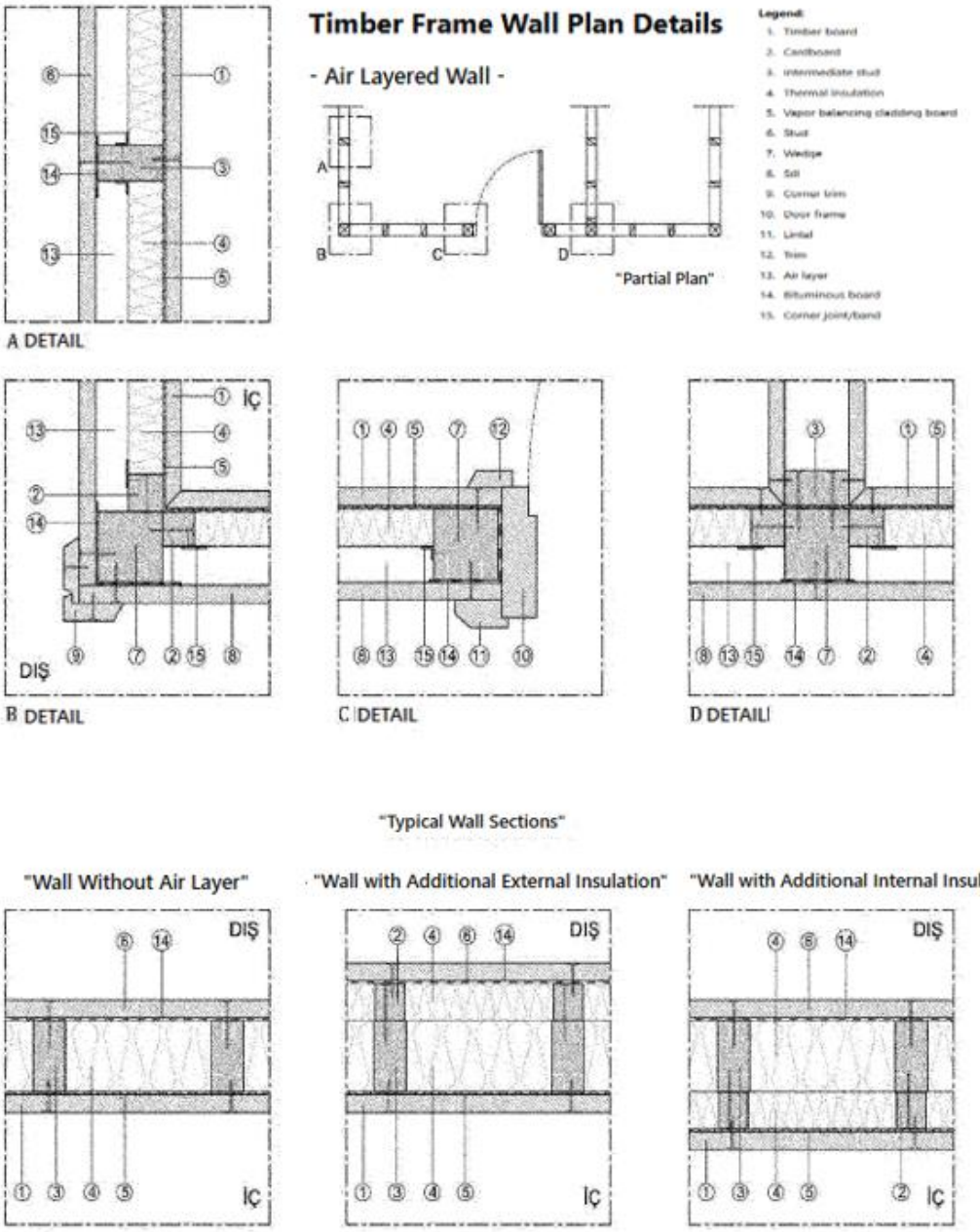
Appendix G.2. Timeline Table of Wood-Steel Structure (continued)



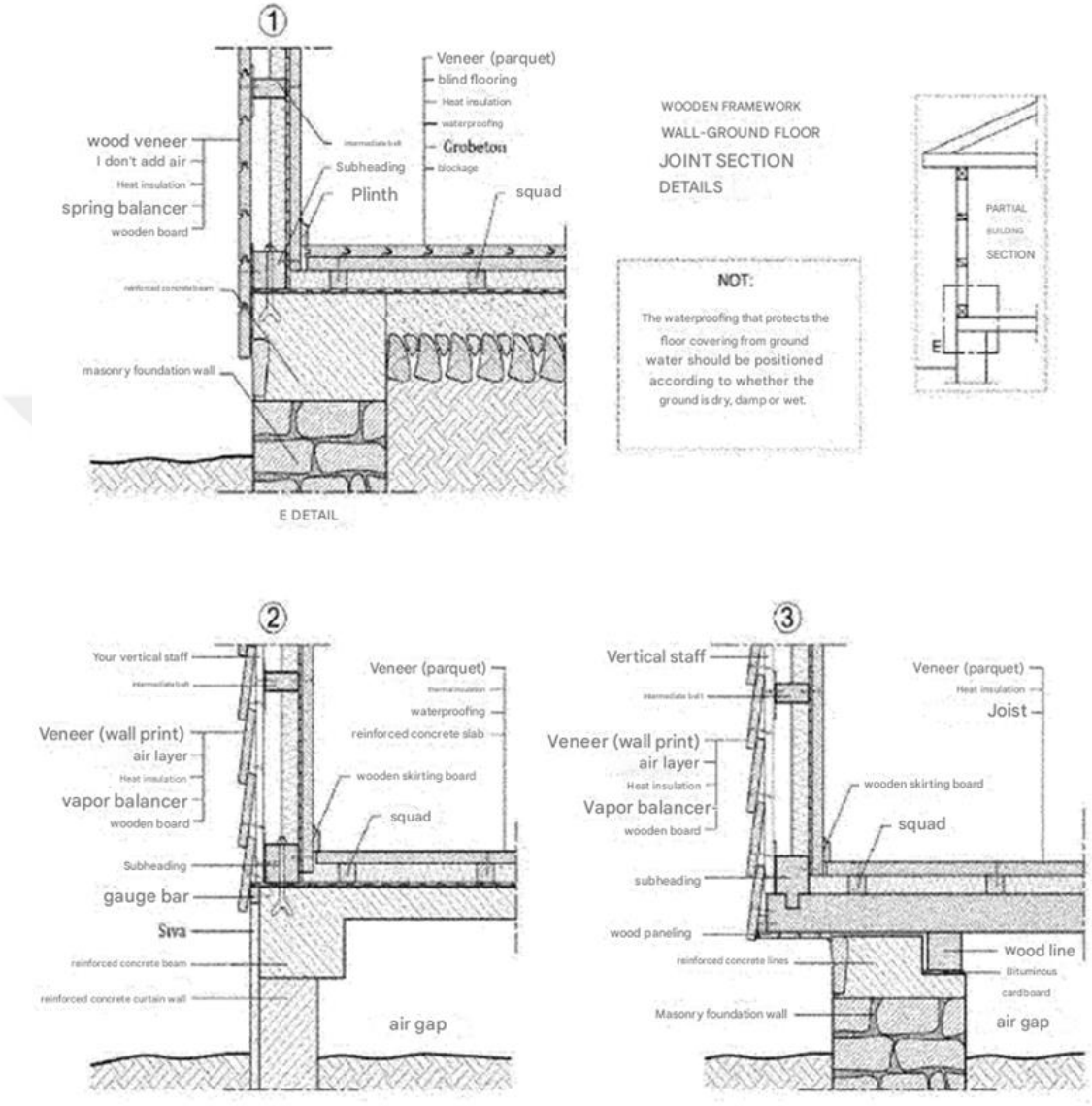
Appendix G.2. Timeline Table of Wood-Steel Structure (continued)



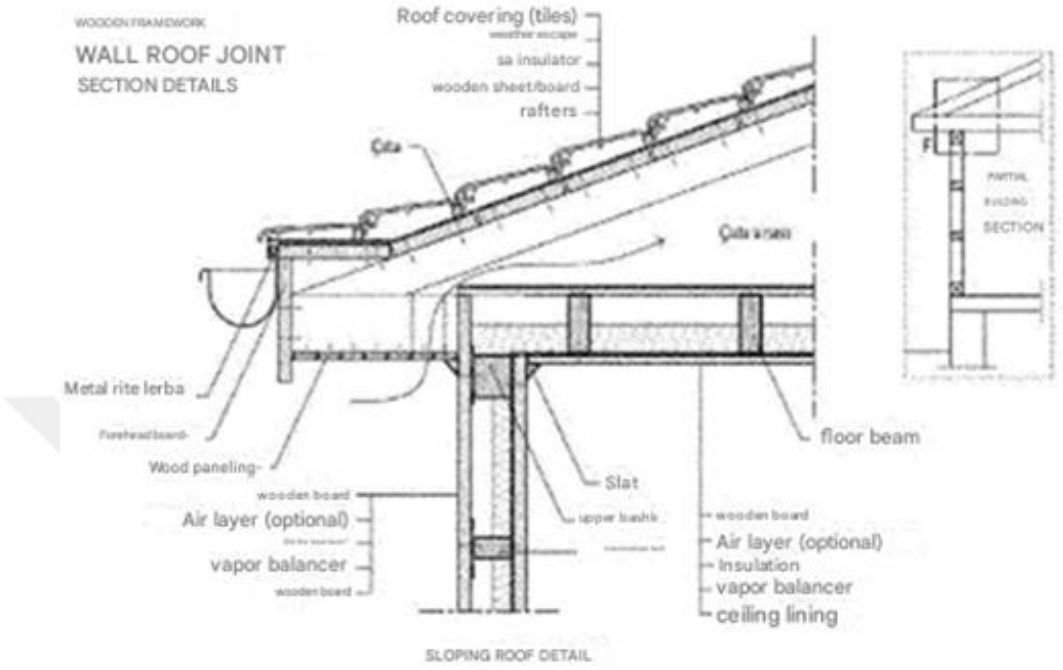
Appendix 7A.1. Guiding Plan Details For Arranging Wall Layers İn A Timber Building (Regulation, 2024)



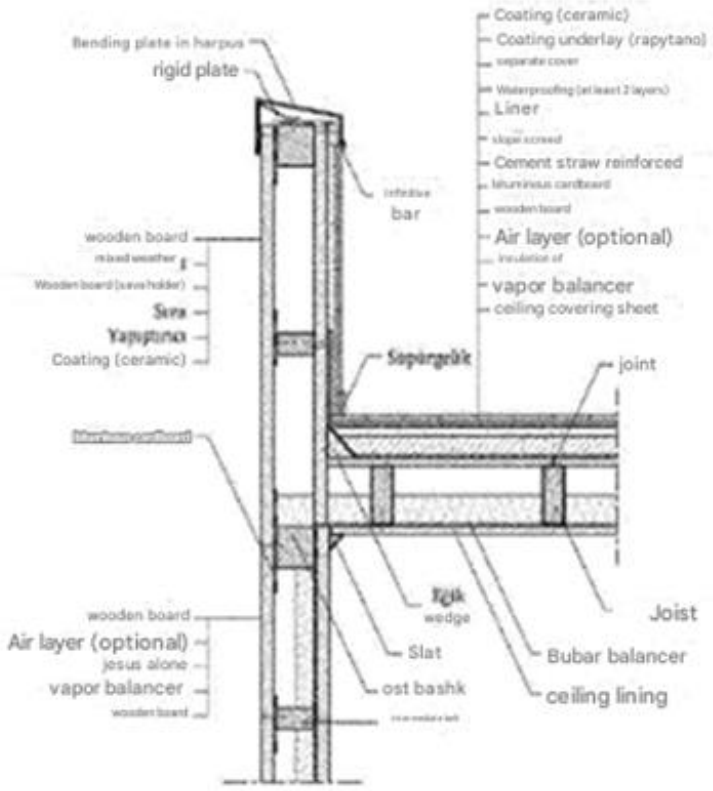
Appendix 7A.2. Guiding Section Details for the relationship between foundation, ground floor slab and external wall in a wooden building. (Regulation, 2024)



Appendix 7A.3. Guiding section details for the upper floor, external wall and roof relationship in a wooden building. (Regulation, 2024)



SLOPING ROOF DETAIL



VISIBLE TERRACE ROOF DETAIL

Appendix 7A.4. Guiding Sections for the Placement of Thermal Insulation on the Intermediate Floor of A Wooden Building (Regulation, 2024)

