E_E Environment & Energy Studies Program
Architectural Association School of Architecture

ADAPTIVE SCHOOL ENVIRONMENTS

Elementary school design through the investigation of vernacular architecture in Mardin, Turkey

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MArch Sustainable and Environmental Design 2010 - 2012
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ABSTRACT

Education is one of the major issues in Turkey as it is in most areas of the world. South east Turkey is one of the least developed regions in Turkey. Despite major demand, very few school buildings are present. Education is the major step into civilization and youth is the core of a society. A school environment that is adaptive to its climate conditions and the occupant activities is an ideal starting point for a bright and educated youth to grow.

Vernacular housing architecture of Mardin has been studied for many decades. There is no doubt that the architectural and environmental attributes of these houses would inspire contemporary buildings. The focus of this dissertation is to bring the valuable characteristics of Mardin vernacular architecture into primary school environments. Investigating how these houses have occupied diverse cultures for centuries is the key to open the door to sustainability and adaptivity of school environments.

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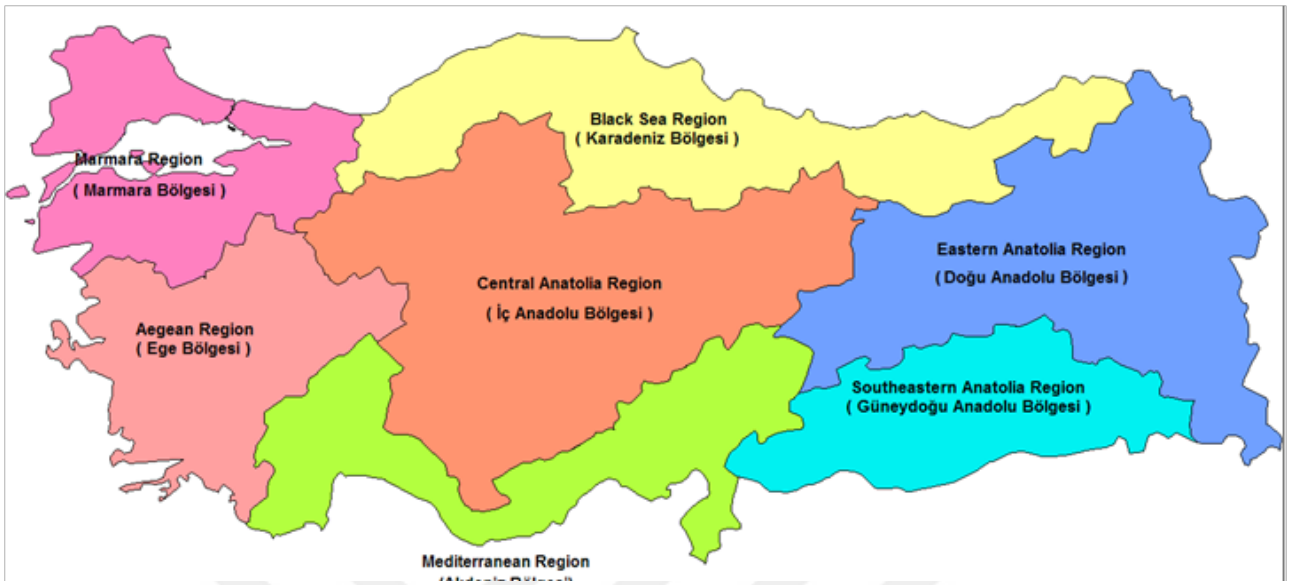
INTRODUCTION

TURKEY'S APPROACH TO SOUTHEAST TURKEY - GAP PROJECT

FOCUS ON EDUCATION



Turkey's approach to Southeast Turkey - GAP project

Turkey is a transcontinental country located stretching across the Anatolian peninsula in Western Asia and Thrace in the Balkan region of south-eastern Europe. Having an 814.578 km2 surface area, Turkey is surrounded by Mediterranean and Black Sea on three sides. Various climate types can be observed around the 7 geographic regions of the country.

Akdeniz (Mediterranean) Region: The land is Mountainous. Summers are hot and arid, while in winter it is warm and rainy.

Karadeniz (Black Sea) Region: The highest precipitation percentage is ob served in this region throughout the year. Due to the high humidity, the temperature differences are very low.

Ic Anadolu (Central Anatolian) Region: This region is plateau-like and semiarid highlands. The least amount of precipitation is observed here.

Ege (Aegean) Region: It has a very fertile soil and the climate is similar to Mediterranean Region

Marmara Region: The transition of Mediterranean, Black sea and Central Anatolian climates can be seen in this region.

Dogu Anadolu (Eastern Anatolia) Region: Rugged country with higher elevations with long and snowy winters.

Guneydogu Anadolu (South Eastern) Region: Very hot and dry summers are observed in this region due to the desert effect from south. Solar radia tion is also very high in this region. Mardin is a city located in South Eastern Region of Turkey close to the Syria border.

In terms of economical and social development, it is possible to separate Turkey into two regions: East and West. Due to the number of metropolitan cities and the closeness to the western countries and the plain topography, West Turkey has always followed the recent advancements closely inspiring rest of the country; the growth moves from west to east.

Turkey's approach to Southeast Turkey - GAP project

The last two decades, the advancements have been in greater pace which jeopardizes the economical conditions of South east Turkey. The topography has been retarding the infrastructure developments which slows the growth rate. Government took the first step for awareness with the GAP project. The Southeastern Anatolia Project (GAP) is a multi-sector and integrated regional development effort approached in the context of sustainable development. Its basic objectives include the improvement of living standards and income levels of people so as to eliminate regional development disparities and contributing to such national goals as social stability and economic growth by enhancing productivity and employment opportunities in the rural sector. The project area covers 9 administrative provinces (Adiyaman, Batman, Diyarbakir, Gaziantep, Kilis, Mardin, Siirt, Sanliurfa and Sirnak) in the basins of the Euphrates and Tigris and in Upper Mesopotamia (www.gap.gov.tr)

The development program encompasses such sectors as irrigation, hydraulic energy, agriculture, rural and urban infrastructure, forestry, education and health." The project rests upon the philosophy sustainable human development, which aims to create an environment in which future generations can benefit and develop. The basic strategies of the project include fairness in development, participation, environmental protection, employment generation, spatial planning and infrastructure development. The project is still ongoing. Although the progress has slowed down in great deal, it has been a source of inspiration for young people in Turkey. The recognition of these cities to be developed is one of the reasons for the choice of the dissertation site, Mardin.

Most of the cities in South-east region has a vast history of civilizations. Especially in Mardin, people still live in houses that go back to more than a century. Therefore it is easier to observe the architecture in terms of its environment. First of all, the climate with hot sunny summers and cold and dry winters, has shaped the dwelling type of the area. The density of the city, the narrow streets filled with people, the endless stairs all represent the close relationship of multiple cultures living in one city. The houses represent the privacy of each culture...The stone walls, pavements and stairs lead to the bare looking house doors. The naked elevations turn into colorful courtyards and ornamented corners once a step is taken into the house.

The investigation of vernacular architecture would certainly teach a lot of environmental and sustainable design. This is the other reason why Mardin is chosen as the dissertation site. Architectural elements lead into environmental reasons, and these reasons has lead to a sustainable city that has survived for many centuries.

Focus on Education

Being civilized goes parallel with education today. And in South-east the buildings of schools have been neglected for a long time. Due to the constant population growth more and more children grow to be a primary school student, and yet find themselves cramped in small classrooms. There are two major issues in education field : scarcity of teacher to assign to Southeast and density of students. This dissertation topic and the site is chosen in order to bring out solutions to these problems which is strongly linked to the sustainability.

A considerable amount of schools have been built all around South-east Turkey since the project has started. But there is still a large demand. Primary schools are the first encounter to education for a child which requires a lot of attention in order for them to be more efficient in the future. During the visitations of two school, Ataturk Primary School and Gazi Pasa Primary Schools, it has been concluded that the number of students exceed the given school area. Even so every possible space is used to accommodate more students. Inefficient rooms are turned into classrooms with inadequate lighting and heating.

The residential architecture of Mardin is quite sustainable by taking advantage of the climate, topography and social aspects whereas the recently built schools are concrete rectangular boxes that are not local. The typical inefficient design of schools all around Turkey was also brought to Mardin, and they clearly do not achieve occupant satisfaction.

In today's school buildings, the rooms are designed according to specific functions. Classroom dimensions are fixed as well as the furniture and the location of the teacher. As the western world is growing technologically, innovative ideas about education are emerging. The current educational systems are being challenged and questioned. For this dissertation the main question is ,what kind of classroom environments would a primary school child be efficient at? What is the ideal classroom layout?

Advancements in the field indicate that even an ideal layout is not the issue. Relationship of a classroom with nearby spaces, the possibility to use a space in multiple functions are the new directions to take in the field. Flexibility is what is missing in school buildings. The aim of the project is to learn from the spatial and environmental attributes of Mardin houses. The flexilibity of vernacular architecture has much to inspire educational field. Instead of bigger spaces, multi-functional classrooms would reduce the need for additional spaces.

CONTEXT : MARDIN

THE CITY

- Location
- Climate
- Topography
- Urban Texture

THE PEOPLE

THE BUILDING

- Spatial Organization
- Closed Spaces
  - Earth Dug Room
- Semi-Open / Transitional Spaces
  - Eyvan
  - Revak
- Courtyard
- Elevation Design
- Modular System
- Materials & Construction

CONCLUSION

Figure 1. Perspective view of the Mardin City

INTRODUCTION

Mardin has been one of the cities with the richest history and culture in Turkey. Although Turkish nation has been dominating the area for several centuries, it has accommodated various cultures including Mesopotamia civilizations. The unique stone architecture of Mardin has been recognized by many people in recent years and accepted as one of the most visited cities in Turkey. Obviously the city has not appeared overnight; it has evolved collectively following a similar architectural pattern both in small and greater scale over hundreds of years. This paper investigates how the environmental and social elements shaped the architecture of Mardin for centuries. The environmental elements include climate and topography whereas the cultural richness of the area is studied under social factors.

THE CITY

Location

Mardin is strategically in a very critical location exactly at 37° 19’ 0” North and 40° 44’ 16” East. Situated in South-eastern Turkey, it is surrounded by Siirt and Sirnak in east, Diyarbakir and Batman in north and Sanliurfa in west. Most importantly Mardin is border city to Syria in South. Between Dicle (Tigris) and Firat (Euphrates) rivers, Mesopotamia is defined with a very rich history of civilization.

Mardin is one of the cities that lie on these fertile lands with a 1000-1500 meter elevation. The city consists of two hills called Midyat and Mardin thresholds. Both thresholds face south to a land of plains including Kiziltepe and Nusaybin where the south Mesopotamia begins. The city centre is located in Mardin threshold that lies between Karacadag volcano and Tigris River.

Figure 2. *Turkey map indicating Mardin in South East (Source: Ozbek, 2004)*

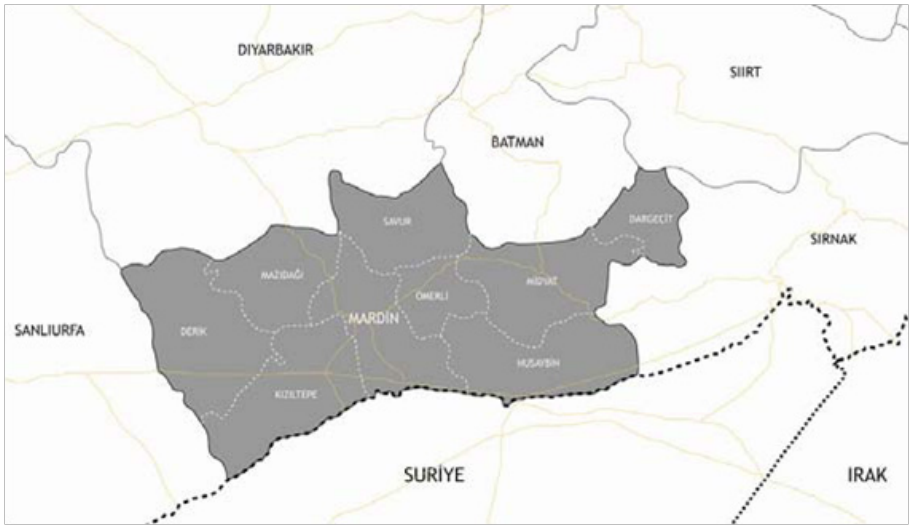


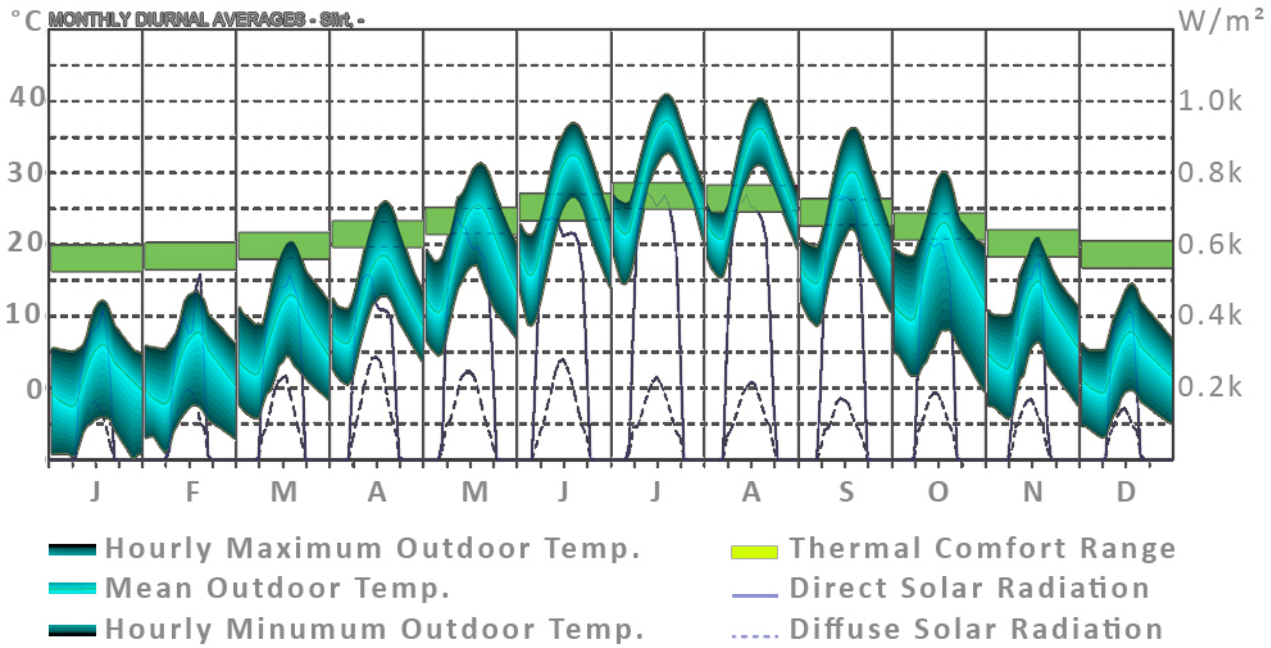
Figure 3. *Mardin Map indicating towns (Source: Ozbek, 2004)*

The Climate

Mardin has a semi-arid climate with very hot and dry summers and cold and wet and occasionally snowy winters. Similar to the South-Eastern region, the city is under the influence of tropical and arctic air masses .The climate resembles a continental steppe. The winters are severely cold (Although recent years, warmer winters are experienced) and summers

Additionally the high elevation, the way the mountains lie and the aridity degree of the land also affects the climate in Mardin city centre. South East Region coasts Mediterranean Sea that brings high humidity mass into the Mardin & Midyat Mountains creating higher precipitation values than expected from a hot arid climate. Mardin threshold is divided into two sections when it comes to temperature variations: the centre, situated on the skirts of the hill and the surrounding villages on southern plains.

The mean outside temperatures increase from north to south. For instance the mean outside temperature in Mardin city in 1997 was measured 15.5 C while the Nusaybin Plain, located 600 meters lower in elevation goes up to 18.9 C. (D.M.I Genel Mudurlugu). The plains are protected by the hill (Mardin threshold) from the northern cold winter wind creating a warmer micro climate.



Graph 1. *Mardin Monthly Averages (Source: ECOTECT)*

Mardin is one of the few cities that are affected by Mediterranean Climate bringing rain into Southeast region. Yearly average precipitation value is 716.5mm (1997) in the city centre while in the plains it goes down to 400-500 mm. Although March and December are the maximum precipitation values, it mostly rains in winter unlike summer where hardly any rain is expected. Because it rains less and the humidity is higher in summer, the temperatures rise considerably. While the humidity in the plains is around 40%, in city centre this value reaches up to %58 .The city is mostly exposed to the northern winds in winter coming from North East. Secondary winds come from South West with average speed of 2.9m/sec.

The Topography

The city Mardin is located on a hill (Mardin threshold) facing south to the Syria border. The centre has grown north-south with terraced housing, but today the growth continues east and west. The elevation difference between the north and south edge of the city varies between 50,000 and 150,000 meters. This challenging topography has a great deal of effect on the architecture of Mardin. The dwellings are located on inclined slopes of hills with terraces directed to prevailing wind. Mardin streets designed on upright of slope don't let transportation. So the streets are quite narrow and only for people.

Figure 5. *Mardin Threshold / Old City Mardin*

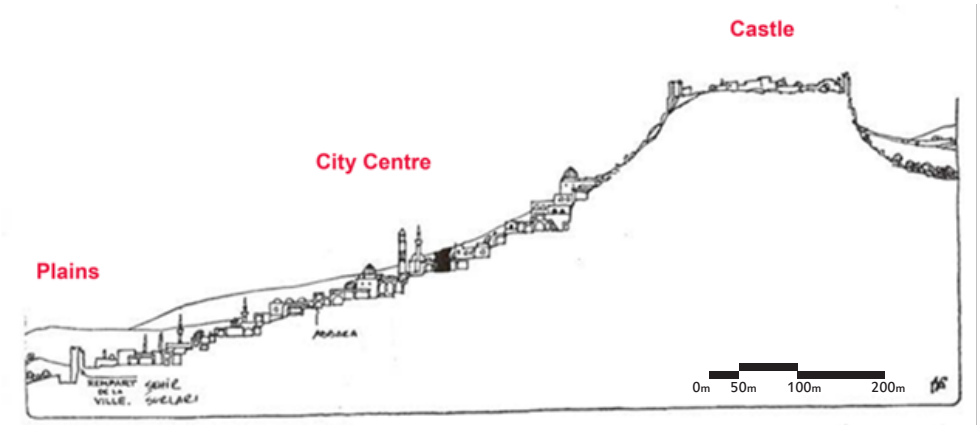


Figure 6. *Section through Mardin threshold (hill) showing the relationship of the city with the topography (Source: Ozbek, 2004)*

Urban Texture

Looking like large stairs, the stepped settlement allows every house to have a view to the magnificent Mesopotamia plains with satisfactory amount of privacy. Mardin centre has kept this settlement model since X. Century. The extremely dense texture of the city has been evolved by large families taking over several plots and building houses connected to each other. The social interaction between the houses in neighbouring plots creates an organic planning system in the city. During summer the tall walls of the buildings create shade for the streets, which makes it pleasant to walk around the city even in peak temperatures.

Figure 7. *Old Mardin City map indicating neighbourhoods (Source: Alioğlu, 1989)*

The streets being a unique character of Mardin's urban plan mostly lie on North-South and East-West axis. Running parallel to the hill, East-West streets are slightly sloped whereas North-South streets are steeper. The slope creates stepped streets at several locations.(Figure.11) Because the settlement is not centralized to one location as a town centre, the streets create smaller scale centres at intersections all around the city forming a fountain, market place or the courtyard of a public building.(Figure.10) The houses are separated from the streets by tall stone walls defining ground floor. They only allow the exterior door and ventilation openings to ensure the privacy in ground floor.

Figure 8. *Organic settlement of Mardin City (Source: Tural,2009)*

Figure 9. *Aerial view of Mardin (Source: Tural,2009)*

There seems to be no order of significance in the evolution of streets. Some streets lead to certain neighbourhoods and the entrance of their houses. And in some instances ‘’abbaras” (Figure.11) are built where the streets go through the buildings with arched openings in ground floor. The rooms on the Abbara’s were used to identify the guests at the outside door before greeting them properly. Nowadays it improves the interaction of the street life with the occupants by having a view to the street.

It is clear that the city does not sit on a previously planned grid. The organically evolved streets are quite narrow as they emerged before industrialized times. They were designed according to pedestrians, and transportation animals used at the time such as horses, donkeys and camels. Even today certain services are provided by these animals because it is hard to reach most houses by vehicles.

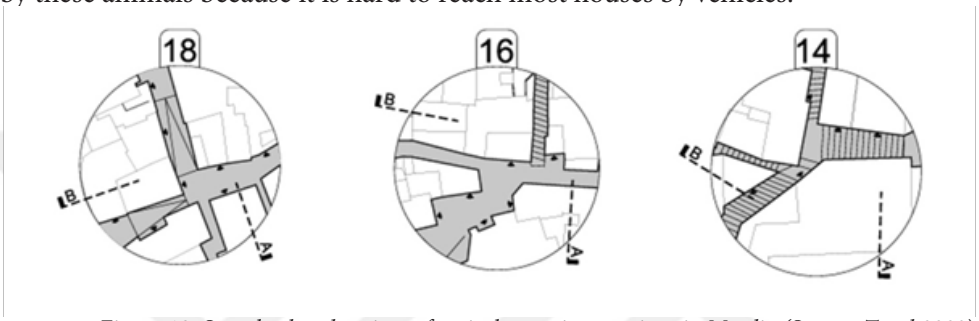


Figure 10. *Sample plan drawings of typical street intersections in Mardin (Source: Tural,2009)*

Figure 11. *Photographs of narrow streets in Mardin*

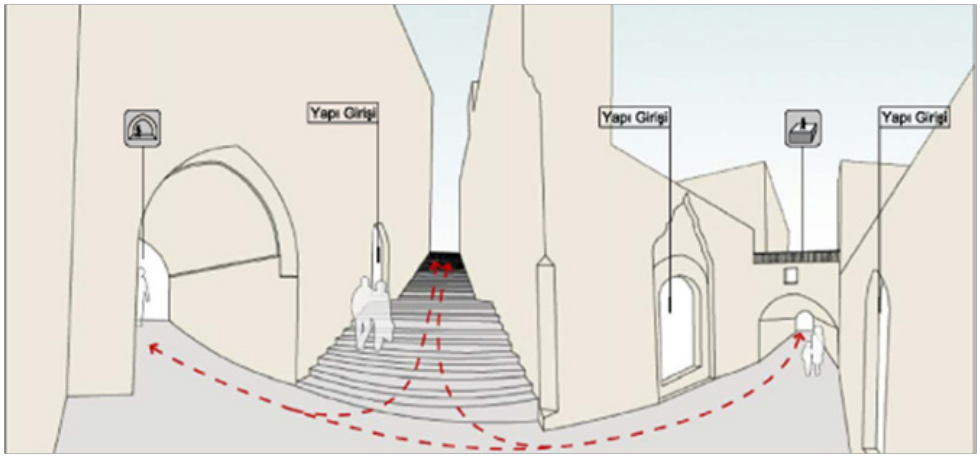


Figure 12. *Diagram of Street Circulation in Mardin (Source: Tural,2009)*

Mardin had been on important trade routes from Middle East to Europe throughout history. Therefore the market place is a very important aspect of Mardin urban tissue. Starting from Abdulaziz mosque with one small street, the market place stretch out to Ulu Mosque and Reyhaniye Mosque growing in size. It creates a lively environment in the city where people socialize, meet and shop.

Today due to the harsh topography of South-eastern Turkey, it is quite hard to transport to Mardin. Therefore the industrial development happening last century all around Turkey, was slower in Mardin. It is accepted as a still developing city.

Figure 13-14. *Photographs of market place in Mardin*

The market place still holds importance in the city centre shifting its focus from trading into tourism and residential life. The local people of Mardin are gold, silver and copper craftsmen creating valuable accessories and kitchenware which are the sold in most of the shops. The borders of the market place have grown along the only car road in Mardin (Figure.7). Because the industrial zones are far from the city, the rest of the market shops are convenient stores, butcher shops, bakers and other shops for daily needs.

THE PEOPLE

Mardin has been under Christian rule until the Seljuk Empire invaded Anatolia and populated the area with Muslim Artuklu people in 11th century. The city has been populated by many ethnicity and religions since then. The majority of people are Syrian Christians, Muslim Arabs, Kurdish and Turkish people. Despite the differences, people in Mardin are known to celebrate both religions holidays together for hundreds of years and respect each other's beliefs. Even today in the city centre it is common to hear different languages. This situation has affected the urban structure of the city. People with same religion populated around their own sacred places such as mosques or churches around the city. Mardin has been under many rules throughout the history and it has always been enriched with the variety of the cultures.

The Syrian Christians are sent to Syrian Monasteries on the outskirts of Mardin where they experience receive religious education for several years. The Syrians are mostly gold and silver craftsmen 'telkari' (a craftsman who create jewellery by wowing silver or gold string) because they tend to jobs that require much calmness and concentration after they return from the monasteries. The churches and monasteries they have built have been an inspiration to the Mardin architecture for many years.

Muslim inspired cultures such as Arabs, Kurds and Turks, are very sensitive to the family life and its privacy due to the culture. The religion requires man and woman to practice some of their activities in different rooms which affects the internal layout of a typical Mardin house. On the other hand it is very typical for people to live collectively as a large family in South Eastern Region. This collective living is called 'asiret' which is simply colonies with same blood. They live in same streets ,and can be as big as a small village.

Although different ethnic groups live collectively with each other, they have blended in and created a unique mixture of cultures. ''The reason Mardin is designed so dense and the streets are so small is because this variety of people have been living together in harmony. Even though their belief system and backgrounds are different, they are in fact very close to each other, which resembles the way the houses are so densely placed on top of and next to each other. People face each other every day through terraces, balconies and even ground floor windows in the streets.'' (Noyan,2008)

Figure 15. *A Syrian family in Mardin (Köker, 2005)*

Figure 16. *Elderly in Mardin (Karagulle, 2009)*

Because people live in such harmony, despite the religious differences, their family lives resemble each other in great deal. The way people live had a considerable effect on shaping Mardin housing typology. Throughout history, similar to other regions in Turkey, ataerkil (man oriented) society has been dominating Mardin. When a son gets married, the house is extended to the next lot so that he could have a place for his new family. It is very possible that with this system, the houses turned into streets, and finally the city emerged.

Figure 17. *Family having dinner (Köker, 2005)*

Figure 18. *Girl serving tea after dinner*

THE BUILDING

A typical Mardin house is stepped stone building situated on a sloped site. One of the main elements of these houses is the ‘’view”. The growth of urban structure has always been horizontal instead of vertical in order to allow all the buildings to have an obstructed view of the Mesopotamia plains by south. The main facade is South facade receiving direct solar radiation for most of the day. The hot and arid climate of South East region receives the highest amount of solar radiation in Turkey. The intense effect of the climate has been moderated by the sloped structure of the city receiving considerable amount of wind along the year. The problem of dense settlement in a hot-arid climate has been solved by the stepped building forms allowing more exposure to the outside air.

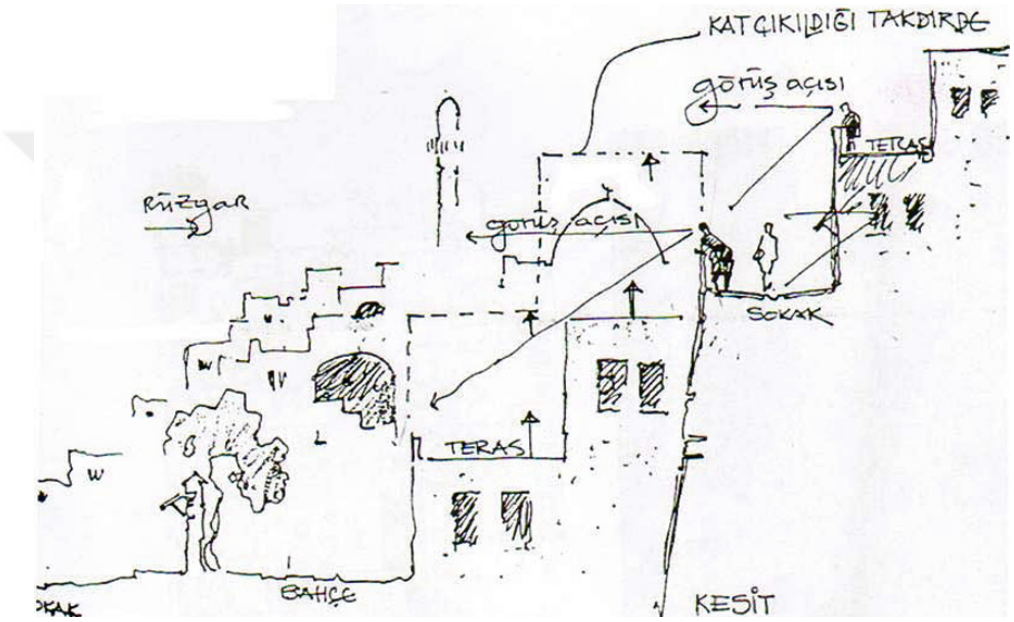


Figure 19. *Sketch of a section through the slope of Mardin*

The organic tissue of Mardin has been created by constant growth in the structures over many years. Looking into a house, variation of the architectural details show that the entire structure has evolved from a single floor. Ground floor is the first section to be built. Other floors were built by stepping back the form due to the expansion of a family or increase of wealth. A courtyard is placed on the ground floor where all the rooms look into. The traditional courtyard is the centre element of the house where the activities are focused into. Because of the privacy issues, the house is enclosed in all facades except for South which is left open in order to benefit from the view.

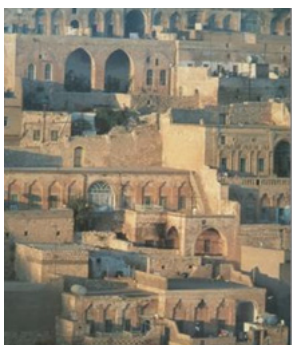


Figure 20 - 21 *Typical stepped Mardin houses (Köker, 2005)*

Spatial Organization

Ground floor, being the first built section of the house, has gone through evolution of functions overtime. It used to be able to accommodate all the activities of a family before new floors are built. This allowed ground floor to be designed more flexible.

Cooking, laundry, taking care of animals, stocking of seasonal food, accommodation for servants are among the common functions of ground floor. Because most of these activities are done by women in Mardin, this floor is used by them. This indicated that the separation of the gender in floors comes from both cultural and functional reasons.

The general layout of ground floor is inverted because the women's privacy is very important to the culture. The openings of tall stone walls to the street are limited by ventilation openings and the entrance door. The courtyard is located in the ground floor where the service areas are moved to after additional floors are built. The interior spaces are placed around this outdoor space.

The internal layout of a Mardin house can be investigated in three categories,

- Closed Spaces
- Semi-open Spaces
- Open Spaces

Closed Spaces

Figure 22. *Courtyard house floorplan*

Figure 23. *Living Room (Köker, 2005)*

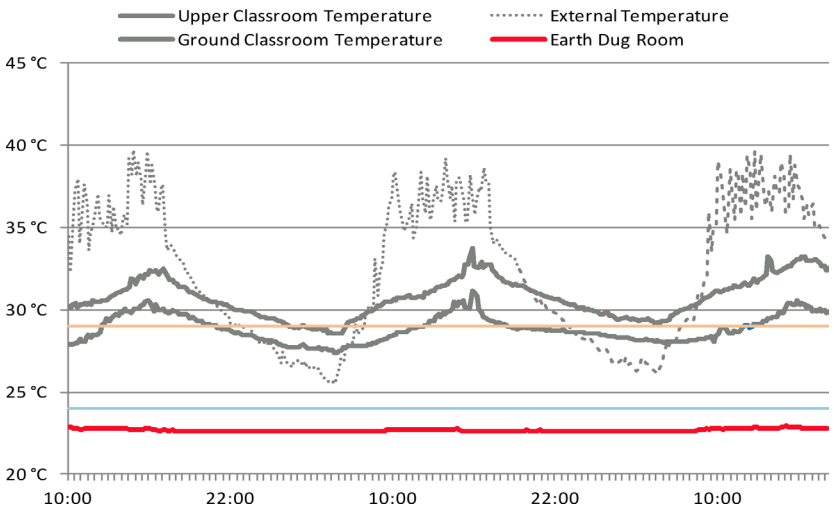
Flexibility is the key element in a Mardin house. Rooms are rarely designed to fit one specific activity. In terms of function and architectural layout interior spaces can be
referred as "living units" These living units are able to respond to several occupant activities such as sleeping, eating, resting and showering. Alioglu looks into these spaces in detail and states that they consist of two sections : sekialti,a transitional space and sekiustu ,main room. Sekialti is a transitional space before entering the living area where the outdoor shoes are taken off. .In a traditional Anatolia house the showers are located inside the fixed in closet space at the corner of a bedroom rather than inside the bathroom space.

Figure 24. *Living Unit (Source: Alioğlu, 1989)*

Mardin house followed the tradition by locating the shower closer in the sekialti. By stepping one step up ,one can enter sekiustu. Sekiustu is a multifunctional room. On one side of the room a traditional kitchenette is fixed in where food is cooked or warmed. In the same room guests are hosted and food is served during the day. At nights sekiustu is turned into a bedroom by taking out the portable mattresses from the closet and placing them on the floor. These living units are located in a typical Mardin house with various placement systems. Square ,Rectangle, L shaped and T shaped unit organization are observed among examples.

Earth Dug Room

Earth Dug rooms are typical underground rooms in vernacular architecture. Every Mardin house would have this room which is 3 meters sunk and ground coupled on three sides. Ground temperature in Mardin area varies between 17-18 degrees Celsius. Because it provides a large scale thermal mass, the more a room is coupled with ground, the more the temperatures come close to this value. During the hot summer days, this room is the coolest space in the house. In the Case Study chapter, the earth dug room shows a highly stable temperature range in July (the hottest month). Occupants mentioned that they even need blankets if they spend the night in this room in a hot summer day. Recent function of this room is living and sleeping in summer. But in the past occupants used this room for food and drink storage because the room is cool and stable almost throughout the year.



Graph 2. *Gazipasa Earth Dug Data Logger Measurements (July 4-7)*

Figure 25. *Earth Dug Room*

Figure 26. *Earth Dug Room*

Semi-Open / Transitional Spaces

There are two types of semi-open spaces in a Mardin house; ‘’eyvan” and ‘’revak”. One of the most important elements of Mardin houses are these spaces. People in Mardin enjoy being outside, during the day or night. The hot summer days make it less enjoyable and this is why a transition between the inside and outside is necessary in such climate. Because it is a dry climate, being in a shaded area would be enough to cool the human body. Occupants of these houses decorate eyvan and revak like their living rooms. They are alternative living spaces for hot summer days.

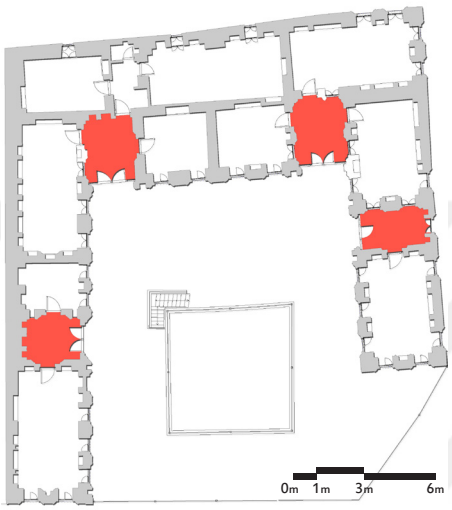


Figure 27. *Plan highlighting Eyvan*

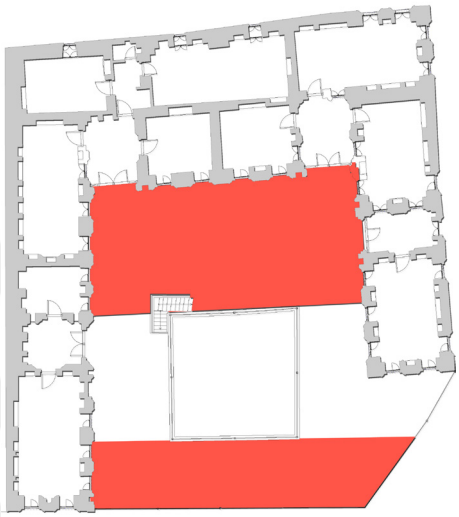


Figure 28. *Plan highlighting Revak*

Eyvan

Eyvan is a semi-open transitional space, typically seen in a Mardin house. This rectangular space is closed on three sides and opens to the courtyard. The roof is arched ,vaulted or domed in various examples. Eyvan provides an entry space for the adjacent rooms. A house has multiple eyvan which occupants use as a communal living room. It could be seen as a covered extension to the courtyard space, where occupant enjoy shaded summer days. There are eyvans directed towards the south against the morning sun and there are the others which are directed towards the east against the mid afternoon sun.

Figure 29. *Eyvan*

Figure 30. *Eyvan*

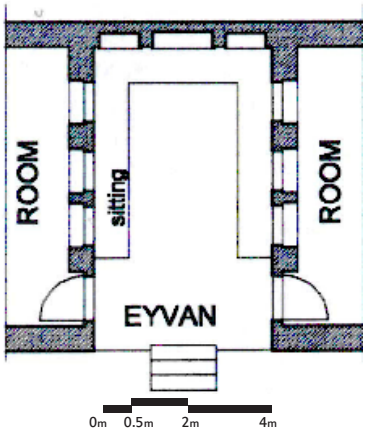


Figure 31. *Eyvan Plan*
(Source: Korumaz, 2006)

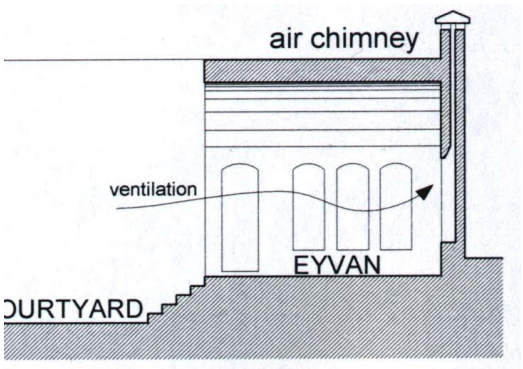


Figure 32. *Eyvan Section*
(Source: Korumaz, 2006)

In addition to architectural aspects, eyvan has environmental characteristics that is vital for a Mardin house. There are air chimneys or windows located on the back wall of eyvan, providing the cooling air ventilation inside the space. Eyvan faces the courtyard which contain water pools. The inlet faces the prevailing south wind while the outlet faces the opposite direction. This is why most eyvans are oriented to south in order to catch the prevailing wind. Therefore the water cools the air in the courtyard which is directed inside eyvan by the prevailing wind. The cool air enters eyvan and get heated which is exhausted by back window or air chimney.

Alternatively chimneys have outlet and inlets. It is better to expose the outlet to the sun, so that the heated air could rise faster for exhaustion. Therefore the cool wind air is captured from the eyvan door while the heated air is exhausted from the outlet of the chimney. Dimensions of the air chimney varies according to the wind direction and amount. On a plan, chimney dimension vary between 0.4x0.8m and 5x5m. The ratio between the width and the height can be 1:1 , 2:5 and most commonly 1:2. Some house owners in Mardin preferred to made eyvan a closed space by glazing the opening. They say this case provides a warmer environment in winter and the snow does not go inside. This indicated that even though eyvan is an ideal space for summer, it creates problems in winter which needs to be investigated.

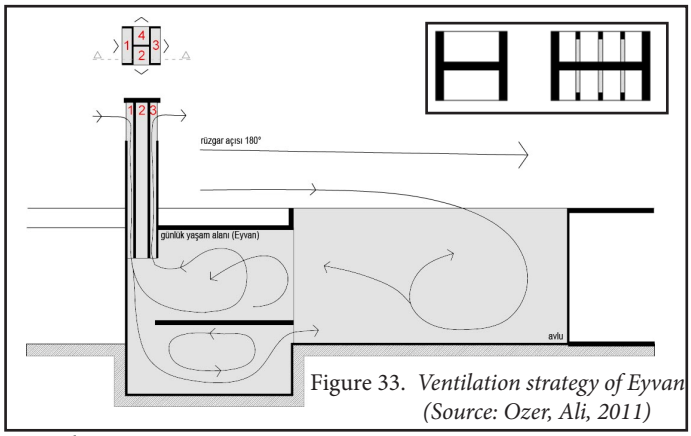


Figure 33. *Ventilation strategy of Eyvan*
(Source: Ozer, Ali, 2011)

Figure 34. *Plants and water in eyvan*

Revak

Revak is also closed at the top and three sides, providing a transitional space. The open side to the courtyard is usually colonnaded. It is a shaded area providing cooling effect where daily leisure activities are performed like eyvan. Revak also provide shading for the adjacent rooms. The rooms facing revak is barely exposed to the sun. In terms of architectural space, eyvan is a deeper space whereas revak is a longer colonnaded space with less depth.

Open Spaces / Courtyard

The most significant element in designing in South-east region is courtyard. It is an open space located in ground floor surrounded with stone walls. ‘’The main character of Mardin houses is that the courtyards are transformed into vast terrace opening towards the valley. The heights of the walls are high in order to be able to ensure the intimacy and safety. It has succeeded in setting up the life by collecting people and semi-open spaces around it. The feature of gathering and distributing functions has made the courtyard the centre of the house.” (*Korumaz, 2006)*

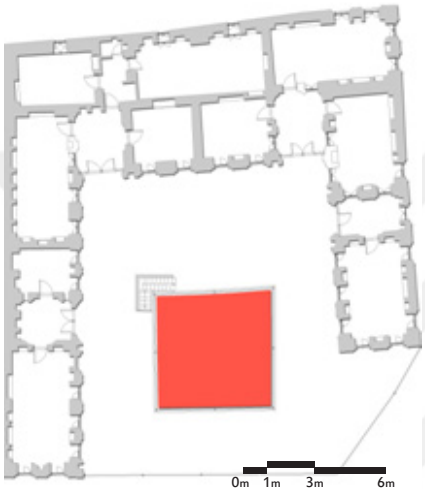


Figure 35. *Plan highlighting Courtyard*

Figure 36. *Courtyard*

In Mardin houses the courtyards are either transformed into terraces or both are used. The outside walls are built high with hardly any openings to provide intimacy and privacy in these spaces. The courtyards are mostly used in ground floors connected with stairs to the first floor terrace. Terrace is formed by the slope of the site ensuring a view of plains for both spaces.

Vegetation is not common in the space organization of the courtyard due to the dense dwelling fabric of Mardin. Occasionally water units and small pools are situated there in order to decrease the temperature by evaporative cooling.

Courtyards and terraces serve are widely used in summer. Once the temperature go up to peak values in summer, all the household activities are moved to these spaces including sleeping which is very common in similar climate regions.

Figure 37. Food preparation in *Courtyard (Köker, 2005)*

Figure 38. Beds for summer nights in *Courtyard (Köker, 2005)*

Figure 39. Gazipasa Primary Elevation

Elevation Design

The elevations of traditional Mardin house was designed according to the functions of the rooms in the floorplan. The composition of an elevation is the coming together of individual room elevations rather than designing an entire elevation as a whole. Therefore it is very difficult to see similar elevation typologies. It is more rational to analyse a Mardin house elevation from pieces to the whole in modules .The pieces or the rooms are called the living units. The elevations also change in accordance to the closed, semi-open and open living units attached to the outer skin.

The floorplans of typical courtyard houses are square , rectangular, L and inverse T shaped. They are all formed on a structural modular system which follows on the elevation studies. Each room is composed by bringing one of more module together on floor plan depending on the function. The placement of the doors and the windows is determined by the modules. For example if the entrance to a single module room is from the side elevation, the windows are placed on the front elevation. Single window is centered on the module face whereas if two windows are desired they are placed on two sides of the façade symmetrically. If the windows and the door is on the same façade, the door is centered while the two windows are again on each side of the façade.

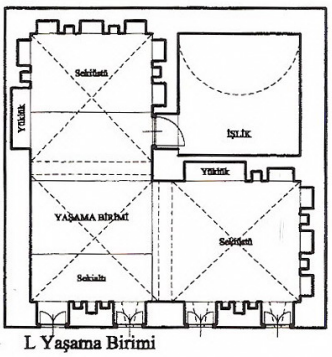


Figure 40. L-Shaped Unit
(Source: Alioğlu, 1989)

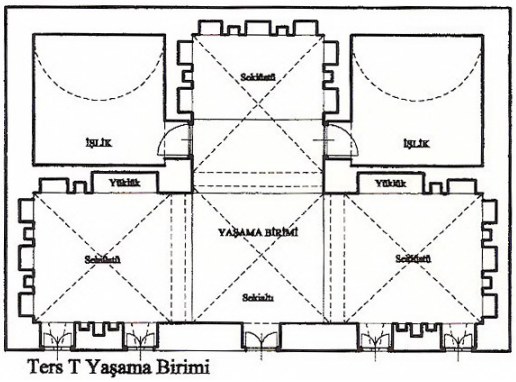


Figure 41. T-Shaped Unit
(Source: Alioğlu, 1989)

The elevations of closed spaces in a Mardin house usually have a plain look with yellow limestone blending into the landscape. This simple look is enriched with the punched openings and the dynamic facades of transitional spaces; eyvan and revak. The light and shadow created by these transitional spaces gives the elevation a sense of depth providing a more blended look to the city rather than detached housing settlement

Modular System

Mardin Courtyard housed has a systematic design process. The plan is formed with a modular system. The architecture of these houses offer three kinds of spaces: closed, semi-open and open. First a grid is laid out on the site plan. Then square shaped closed spaces (minimum 4 x 4m) are placed on the grid according to the sun and the wind direction.

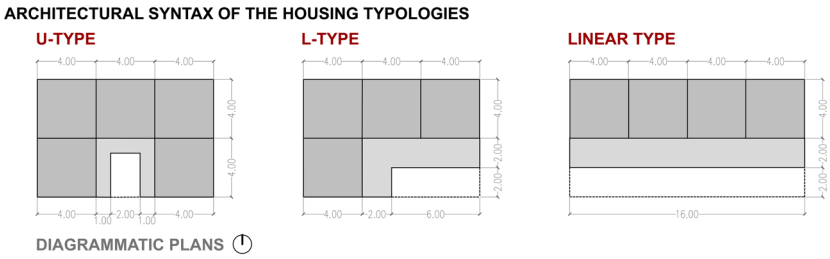


Figure 42. Diagrammatic Plans (Source: Hasman Dissertation,2012)

Depending on the functions of these closed spaces, are placed adjacent to some rooms. Because multiple families live in these houses, eyvan is located in between bedrooms. This way two families can share a semi-open living room. Once the linear arrangement is achieved, revak is placed between the courtyard and the rooms in order to provide shading to the facades. Finally the remaining grids are left as the shared couryard. This arrangement starts from the ground floor and continues on the upper floors with the same modular system.

Three types of courtyard house arrangements can be made with this system. U-Type is the typical form with an enclosed courtyard. L-type is a more open form with higher exposure of rooms. Although it is not popular in Mardin, Linear Type is another category.

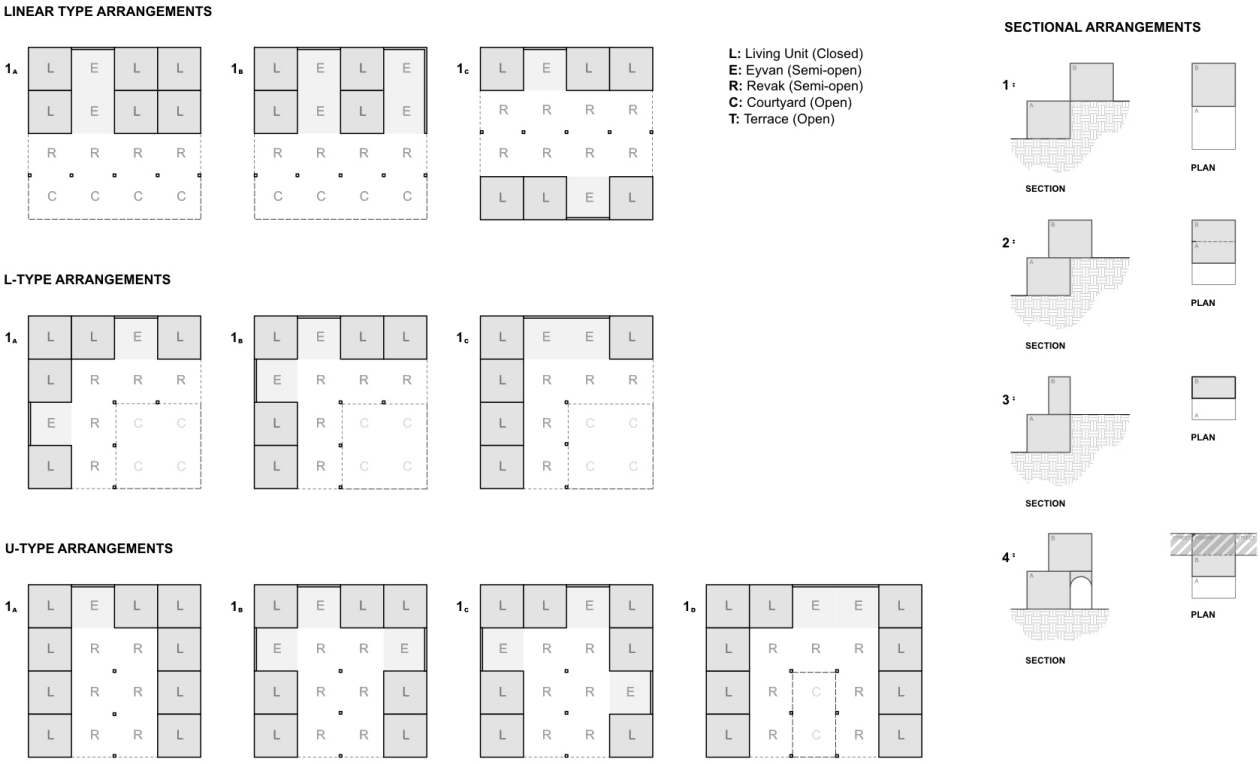


Figure 43. Spatial Organization (Source: Hasman Dissertation,2012)

Materials and Construction

Mardin local houses are constructed with stone. Kalker stone is the lime-stone type that could be found locally in Mardin. It is yellow coloured, cut limestone and constructed with mortar to create walls and floors. The stone is used in almost every element of Mardin house. This is why stone craftsmanship is very popular in the area. When it is first taken out of the quarry, condition of the stone is quite soft. It gets thicker and stronger over time. Mardin stone has four types of forms which is used in various elements of the construction,

1- Easily shaped cut stone used on elevation detailing
2- Roughly cut stone used on non-exposed elevations
3- Rubble stone used on vault and dome construction
4- Stone used for ornaments.

Figure 44. Mardin Stone

Figure 45. Stone Ornament

Figure 46. Rubble Stone

In short, light colored, hard stone is used for structural elements, while stone right out of quarry is softer for ornaments. Once the soft stone is crafted, it hardens overtime.

Thermal mass is an important environmental strategy in Mardin houses. It is achieved by using large amounts of stone for wall construction in order to retard the heat flow from outside to inside. Therefore temperature fluctuations in summer in minimized. A typical stone height varies between 0.21 and 0.25 meters. Ground floor wall thickness is 0.82-2 meters whereas upper floors have lighter skin. A typical upper floor wall thickness is 0.75 to 0.90 meters. The non-bearing interior walls are lighter ,0.25 - 0.64 meters.

Recently, providing local stone is becoming more expensive because people do not prefer to work in quarries anymore. The prices are becoming more expensive which makes it less sustainable. But the buildings rarely need maintenance because stone does not need plastering. And the thermal mass saves energy in summer. The new building code of Mardin, mandates every new construction to use stone in the old Mardin city. Therefore the yellow colored building landscape could be preserved for many years.

Figure 47. Rubble Stone

Figure 48. Stone Wall

Figure 49. Stone Ornament

Conclusion

Mardin is a city that has protected its unique architecture for years. It is obvious that this strong architectural statement has been supported by stable environmental and cultural elements. The topography has shaped the city with stepped dwelling type allowing the Mesopotamia plains view for every building. The hot and arid climate requires open areas for comfort temperatures in summer. This generated an organic stone city structure with various meeting areas and narrow streets providing shading for the pedestrians. Inside the buildings the occupants carry out their activities to the open and semi-open spaces due to the high temperatures in summer. In order to prevent major temperature differences inside and outside, transitional spaces are created such as eyvan and revak next to the courtyards.

In addition to the environmental aspects, the social structure of Mardin had a considerable effect on the architecture. People have different ethnical and religious backgrounds, and live in the same city inspiring each other over the years. Because of the variety, families feel strongly about their history. The houses inherited from their families, are carefully taken care of along with the neighbourhood. This is the reason why the city texture is still untouched. Despite the religious and ethnical variety, the family life is quite the same. People are sensitive to their privacy and intimacy which emerged interior oriented courtyard houses. Starting from single storey, as the families grew; the houses grew horizontally and vertically over the years. The evolution of structures brought the flexibility into the internal layout of Mardin house. Depending on the season, people moved from the multi- functional rooms, to the courtyards following their daily activities. All together, the city of Mardin can be analysed in more detail. Environmental and social aspects have shaped and brought this unique architecture today; they are the two key elements for sustainability. Today environment and society are in constant change; however, if one continues to design by taking these elements into consideration, the protection and development of Mardin is possible. The changes can be integrated into the organic structure of the city by adding up to its value.

BACKGROUND

SUSTAINABILITY IN EDUCATIONAL BUILDINGS

Principles
- Cool Period
- Warm Period
- Daylighting
- Ventilation

Example: Netley's Abbey Infant School

EDUCATIONAL ADVANCEMENTS IN WESTERN EUROPE

Flexible Classroom Spaces

PRIMARY EDUCATION IN TURKEY

Principles

History of School Layouts in Turkey
- Sibyan Mektebi (Primary)
- Medrese (Secondary)

CONCLUSION

SUSTAINABILITY IN EDUCATIONAL BUILDINGS

Principles

There is a close relationship between the architecture programme of educational buildings and the environmental design requirements for heating, cooling, daylighting and ventilation. Similar to the recent residential buildings, these principles were neglected or misconceived during the design of educational buildings.

In a house the occupancy is spread out throughout the day. But the occupancy of a school building is so high for a short period that the reaction of the building to this case is highly sensitive. There are certain principles to pay attention to in order to save energy, sustain the building for longer periods and create a pleasant environment. There are various parameters to control in order to achieve a comfortable school environment.

Cool Period:

- *Heat Loss Control*: When outdoor temperatures drop, it is important to keep the indoor temperatures warm and stable. This would be possible when heat loss of the building envelope is controlled. One way to establish this is to design compact building form to prevent excessive envelope exposure. Then secondly the heat loss could be controlled by thermal mass of materials or application of insulation. Therefore the cold air transfers in slower pace to the indoors, preventing temperature fluctuations inside the school building.
- *Passive Solar Heating*: The solar radiation is used as free heat gains for buildings. Souther orientation (in Northern Hemisphere) and unobstructed access to the sun would be an advantage. Because the direct sun light would create glare for students, it is important to control the size and the location of the glazing. If thermal mass is used in the building skin, the heat gained from the sun can be stored for longer periods. And finally transitional spaces such as conservatories can store the solar heat and transfer to the adjacent spaces by air circulation.

Warm Period:

- *Heat gain control*: In order to prevent overheating inside the classrooms, heat gain control is crucial. North orientation for the rooms with no need for passive solar heating in winter is ideal. The sizing and shading of the glazing in south oriented rooms should be carefully designed. Use of trees and landscape would benefit the shading of outdoor spaces. And finally, if the outdoor temperatures are above comfort level, the daytime ventilation should be avoided.
- *Passive Cooling*: Night ventilation is one way for daytime cooling where the structure is thermal mass. Another way is cooling by natural means through the use of radiative cooling processes to the sky at night, by evaporation of water during the daytime. And finally ground coupling is good for cool and stable indoor environments. Ground temperature is stable throughout the year; it cools the building in summer and warms in winter.

(Yannas ,1994)

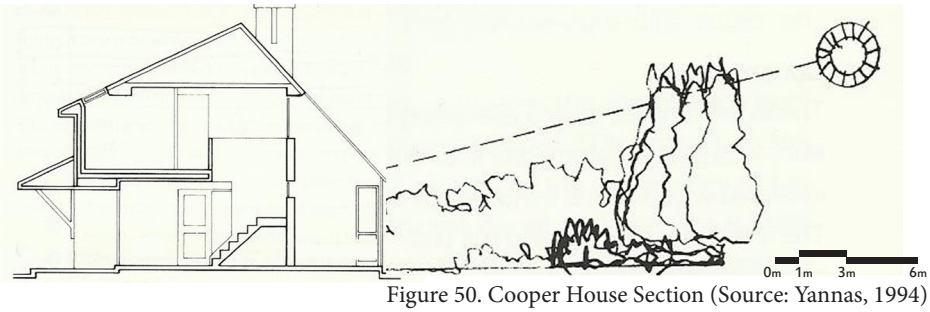


Figure 50. Cooper House Section (Source: Yannas, 1994)

Daylighting

Illumination targets of a school buildings depends on the requirements of different activities in different spaces. The classroom space require a minimum level of 300 lux (Source : Szokolay, 2008) which is efficient for reading and writing. The importance of using daylight rather than artificial is that it creates more pleasant environments by saving energy. And daylight produce less heat gain if compared to the artificial lighting which would help cooling of the classrooms.

Ventilation

In classrooms which require high air change rates and high levels of illumination, ventilation and lighting can dominate the thermal overall energy balance of the building. Ventilation is the necessary entry of adequate amounts of fresh outdoor air to maintain indoor air quality on which students depend. Ventilative or convective cooling refers to the deliberately higher intake of cooler outdoor
air to dissipate excess heat from the building lowering indoor temperatures for occupant thermal comfort. The fresh air requirement(36 cubic metres per hour per person, Source: Szokolay,2008)) depends on the density of the occupation. The air exchange can simply be provided by opening the windows to the outside air. But when the outdoor temperature is outside the comfort zone, the need for transition emerges. Attached transitional spaces with temperature closer to the comfort level, can provide ventilation to the adjacent classroom spaces. (Yannas ,1994)

Example : Netley Abbey Infants' School

Following the principles of sustainability in educational buildings, Yannas (1994) investigates these parameters through the analysis of multiple school around Europe. Netley school illustrates a successful use of the transitional space for ventilation and passive solar heating in the cold climate of Britain. Although the climate is different from Mardin, the cold period show similarities. The building form and the use of transitional spaces shows similarities to Mardin.

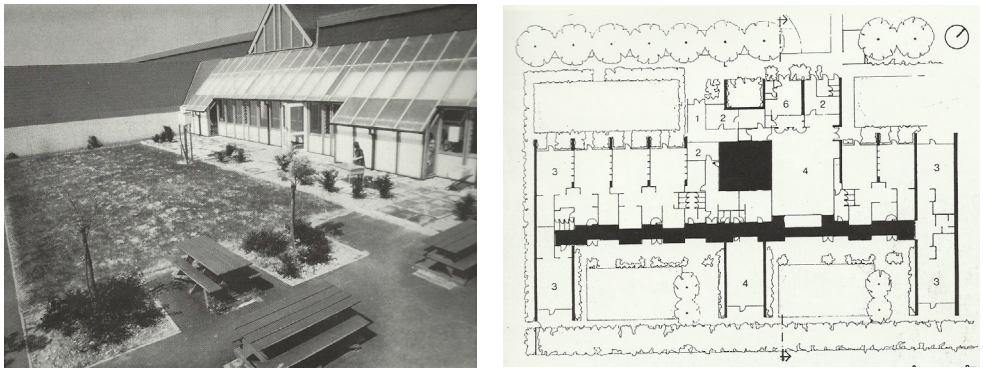


Figure 51 & 52- Netley Abbey School courtyard and floorplan (Source: Yannas, 1994)

Site & Building Layout

The school is located in Hampshire, United Kingdom. The site is flat with open fields to the north and low density two-storey housing to the south. The prevailing wind comes from south-west. The main entrance is on the centre of the north-western elevation.

The building is single-storey and essentially of linear form. The classrooms are aligned along the northern side and have individual entrances and windows to the outside on that orientation. There is a conservatory located on the southern side of the building which provides the main circulation.

The classrooms have deep plans with entrances on south and north sides. Therefore the main source of daylight for the classrooms is the conservatory. However for the administration part of the building there is a glazed atrium on north side for the primary source of daylight to these spaces. Thermal simulation studies during the design suggested that there would be advantages in facing the conservatory toward the south-east and this orientation was adopted.

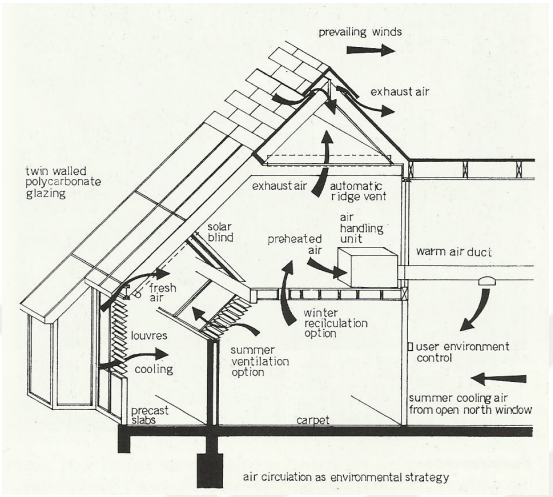


Figure 53- Netley Abbey School section (Source: Yannas, 1994)

Materials & Environmental Design

The construction of the building consists of timber frame and brick masonry elements. The timber frame roof has a transmittance of 0.25W/m2 K whereas the conservatory roof is glazed with twin-wall poly carbonate. The external walls also have a U-value of 0.4 W/m2 K. The envelope of the building is well air tightened, and in order to achieve the necessary conditions for the conservatory all the windows and doors facing there is single glazed.

This allows the solar heat gain and daylight to be transmitted in great deal while the building envelope stores the heat inside. The conservatory is situated on south east façade for southern sun. Moreover the roof of the conservatory is the steep part of the pitch which allows more direct solar radiation hitting the conservatory.

In terms of summer overheating conditions, internal blinds were placed on the roof glazing in order to provide shading. The ventilation strategy adopts itself for cooling air in summer with automatically controlled ridged vents for exhaust air. The ventilation of classrooms happens through the north gable wall grilles.

Figure 54- Netley Abbey School corridor (Source: Yannas, 1994)

Ventilation

The conservatory was typically designed in order to benefit from solar gains and thermal exchanges to the adjacent spaces. However the main heating strategy of Netley Abbey's Infant School is the pre-heated ventilation air used with mechanical means. The fresh air allowed from the conservatory, and the warm-air heating system allows the pre-heated air to circulate around the classrooms.

Every classroom has its own heating unit, and the ducts provide the heat distribution from those units. This system can be manually controlled by the occupants, which requires a great deal of training.

Performance

Although the conservatory temperature results indicate the well-designed conservatory with thermal-buffering potential, the occupant use of these spaces and mechanical systems has a great affect on the performance. The doors of the classrooms into the conservatory were usually left open during winter which moved the warm air into the conservatory and caused cold draughts across the classroom floors.

EDUCATIONAL ADVANCEMENTS IN WESTERN EUROPE

The chapter started by looking into the sustainability principles for schools that was re-emerged in Western Europe. More advancements are being made for educational buildings day by day. The school systems and school layouts are being studied to adapt the new generation's intellect. There is many interesting developments that Turkey's educational system could benefit.

Flexible Classroom Spaces

Most of the school buildings in Turkey are designed according to the traditional classroom layouts. These layouts suggests the fixed student seating and fixed area for teaching where the white board is located. In the last decade these teaching methods have been criticized and rethought. The form follows function idea is being transformed into new spaces where the form can be adapted to several functions. Flexible spaces are sought for the sustainability of school buildings for many years. This way these buildings can be modified according to new educational systems ,densities and classroom activities.

Mark Dudek (2005) investigates children's learning spaces by looking into ideal classroom layouts. He suggests that the learning process consists of the design for curriculum, instruction and assessment. As learning is viewed as a continuous process, learning inside the school and in the community are valued and closely coordinated. Learning process for a school should include;

- Integrate the subjects
- Use individual, small group and large group learning
- Include learning in multiple settings: outdoors and indoors
- Integrate learners of different ages
- Involve students in managing their learning
- Involve teachers working together and being trained in new teaching methods.

(Source: Dudek, 2005)

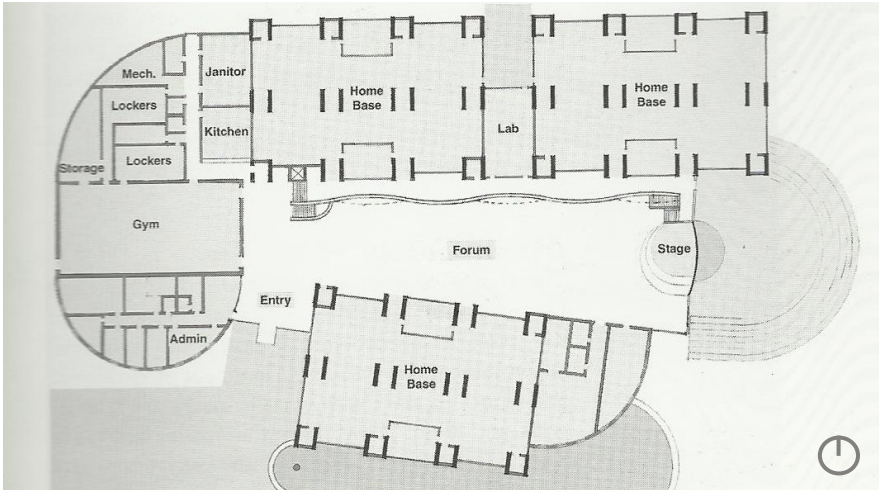


Figure 55- Ingunnarskoli school ground floor plan (Source: Dudek, 2005)

Ingunnarskoli in Reykjavik is a new school design model for Iceland. The principles above have been applied to the design. This learning environment design integrates educational planning, programming and design during decision making. The design consists of two zones: classroom units and common use units. The classroom unit is called a Home Base that can modify its dimensions in several variations with the help of movable walls. In order to accommodate these variations the space is organized into two components: the fixed, service zones where the structure,pipes,ducts are located and the flexible, served space.

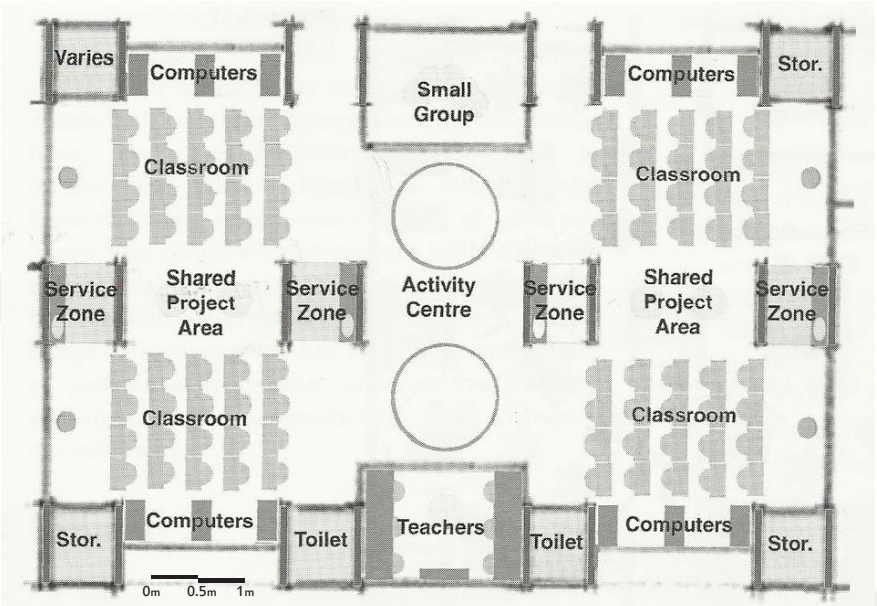


Figure 56- Traditional Classroom layout in Home Base Unit (Source: Dudek, 2005)

Traditional Classroom layout can be achieved by dividing the space into 4 zones for traditional seating layout. There is an activity space in the centre and two shared areas. 80 students can be occupied in this classroom.

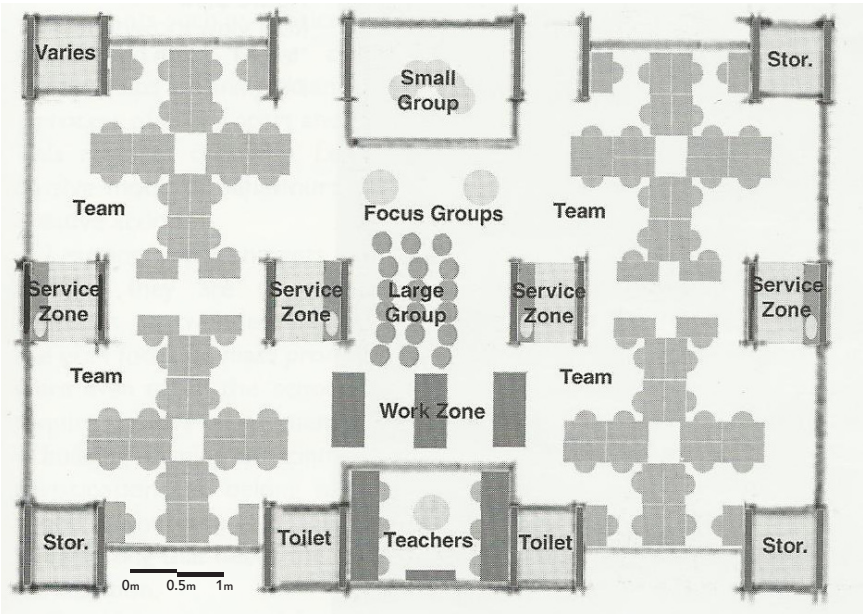


Figure 57- Cooperative Classroom layout in Home Base Unit (Source: Dudek, 2005)

Cooperative, individual workstation layout is where four team areas for 20 students each are laid out. This variation is for group project work. The common space functions for large group instruction.

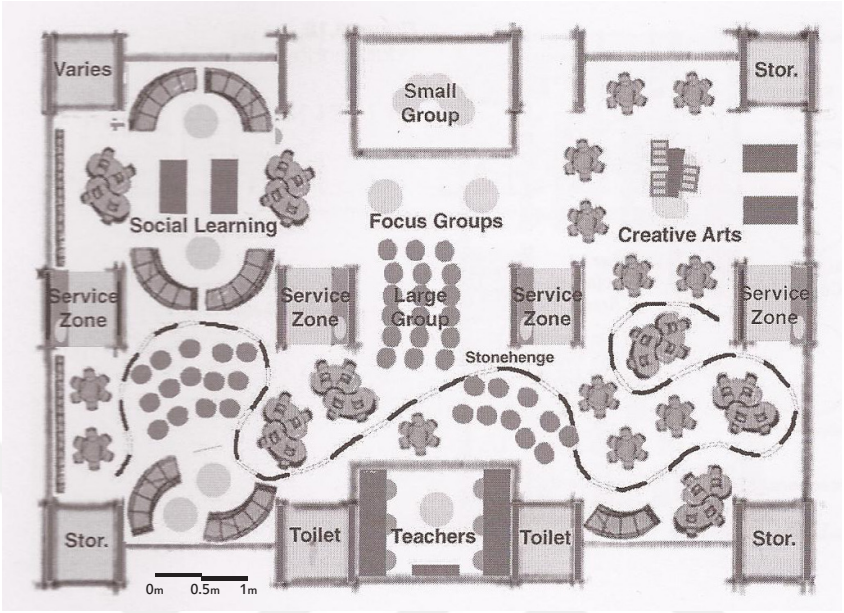


Figure 58- Creative Classroom layout in Home Base Unit (Source: Dudek, 2005)

A creative, user- determined layout. This is based on the belief that what is best for learner is best determined by the students and their teachers. This layout emphasizes that the freedom and creativity of users is let free by the built environment. (Dudek, 2005)

The design proposal in Mardin will pay attention to the need for flexible spaces. A flexible design offers a building that can be used for many years in terms of its functionality. Because it is not designed on a fixed function, the building can evolve into various occupant use overtime. This school could serve for many age-range students, and even for noneducational use. In addition to a building's environmental aspects, the functional flexibility is also a very crucial element of sustainability.

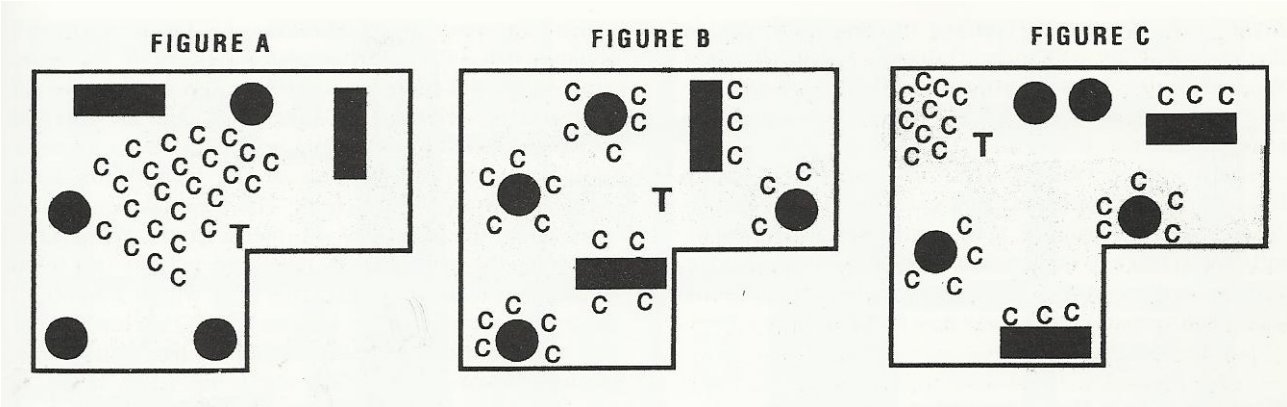


Figure 59- Variation Layouts of L-Shaped Classroom (Source: Dudek, 2005)

EDUCATION IN TURKEY

Education System

Investigating the education system of Mardin, most studies are based on published literature, government statistics and personal observations. In 1997 the compulsory education was raised to 8 years from 5 years. This change has been done in order to raise the education level in Turkey.

In southeast Turkey ,the economical situations require children to start working at an early age to contribute the family budget. Until 1997 most kids would drop out of school after the 5th grade Only children with higher income families or exceptional talent would continue their higher education. Like rest of Turkey, there are some high schools in Turkey with focused industry subjects such as textile, trading, art and nursery. Graduating these high schools ,people could work in certain industries without the need of a college degree. The immediate need of workforce around the region made these schools very popular.

The majority of the children that leave school consists of girls in South east Turkey. This is a result of a highly man-oriented culture where women are raised to be a good house-wife and mother whereas men are the providers of the house. The 8 years compulsory education, has increased the demand to the primary education But there is still an important decrease in the number of students making the transition to high school. Besides the cultural reasons, the topography has caused people to live in scattered dwellings around the city centre. The limited transportation prevented families to send their children to school after primary education. The family would seek their work power in the farming and trading which are two common businesses around the area.

Number of Schools	Number of Students			Classroom	Number of students
	Girls	Boys	Total	Density	per teacher
53	994	1076	2070	38.33	86.25

Figure 60- Table indicating School Population in Mardin (Source: Turkish Statistical Institute)

Figure 61- Girl working in the fields in Summer

Figure 62- Children working in fields

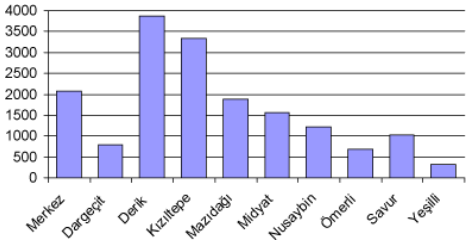


Figure 63- Tables indicating school population according to regions in Mardin

After the establishment of democracy Turkey in 1923, Mardin turned into a city municipal. Due to economical difficulties, a massive migration has happened to the neighbour cities. The intended big city image was not established because the city is so secluded between the mountains. Many schools have been closed and the emphasis given to education has faded over the years due to the need of workforce. As a result of these conditions the number of teachers assigned to the region used to be and still is limited. Very limited academic research has been done on this issue. Today the focus of Turkey has been switched to Southeast and more research is required in order to bring solutions to the problems.

The common issues are,

-The scattered and large quantities of rural settlement around the city centre has created several problems for the primary and secondary education in Mardin. Because most schools are located in the city centre, less kids continue their education after 5th grade (primary education) although 8 years is compulsory.

-Because the region is recently developing, the economical conditions have been harsh. The need for work force caused children to start working at an early age. This affected their performance in school, and affected the quality of education around the region.

-Man-oriented culture required man to be qualified with education in order to provide the household, while girls were taken out of school after primary education. This situation is referred as 'girls do not need further education as they need to be dependent to home and the husband'.

Since 1950 there has been a constant increase in the population of Mardin. Starting from 269.400 people in 1950, the number has come to 705.098 by 2000. (Figure 60) The most prominent increase has been after 1990. The area has been very sensitive due to terrorism attacks in early 90's. The conflict between Kurdish people in Southeast Turkey has affected the lifestyle of the region in great deal. Mardin city centre has been one of the relatively safer areas due to the harsh topography of the city. This is the reason why the majority of the population has moved from the rural areas and neighbour cities into Mardin after 1990. Because the city infrastructure and utilities were not prepared for such population increase,socio-economical problems has aroused such as education, health and unemployment. According to the (Turk, 2007) statistics it used to be 14 people per m2 where as in 2000 this number became 80. In addition, the average individual number in a family increased from 6 to 7.7. This shows that there are additional reasons to this growth. South-east Turkey is a developing region where the main culture in man-oriented. As a tradition from the history, families tend to be larger than 4 people. The birth rate is going up every day.

Figure 64- Typical Primary school building type in Turkey

Figure 65- Typical Primary school building type in Turkey

The population density and the economical conditions have led the government to build concrete rectangular box schools in order to fit as much students as possible. An example of this type of school building will be investigated in the upcoming Case Study chapter. The same building form was repeated all over Turkey without paying attention to the climate, local materials and the social aspects of the area. Although this building type is not the ideal environment for an education of an child in the early age, this way the government managed to provide education to many students with low budget. Over the past 20 years government has paid great deal of attention to the agricultural and infrasturctural development of South east Turkey. Recently the area has become more suitable for educational progress and open for different school typologies more adaptive to the local children.

History of School Layouts in Turkey

Sibyan Mektebi (Primary School)

Before the modernization of the education system in 1920s , the education was mainly religious in Turkey. The children would start their education with primary school, then moving on to the high school (Medrese). The children of the higher class or the highly talented children would continue to the academia in order to expertise in different fields.

The primary school (Sibyan Mekteb) provided the teachings of Koran to the children from the age of 7-11. Because they do not follow a specific system, it would be more suitable to call them teaching units. During 1900s in addition to the Koran classes, reading and writing were being taught in these units.

The school buildings are either located individually in each neighbourhood, or inside the Kulliye's (traditional complex of buildings consisting of a mosque, hospital, academy, school , and turkish bath). The characteristics of a typical primary school are,

- If inside a Kulliye, it is located on the most isolated part of the campus in order to protect the other public buildings from noise. If in a neighbourhood, it is located on a corner plot on a centralized street.
- Consists of two floors where the first floor is used for commercial. The second floor has one classroom and sometime one extra tutoring room.
- There is one teacher and an assistant for the amount of children in that specific neighbourhood.
- The number of children inside the class used to be around 30 pupils. The floorplan is square (6.50x6.50 or 8x8). These dimensions are very common in the Ottoman education system which is thought to be closer to children scale.

Figure 66- Neighbourhood Plan indicating primary school

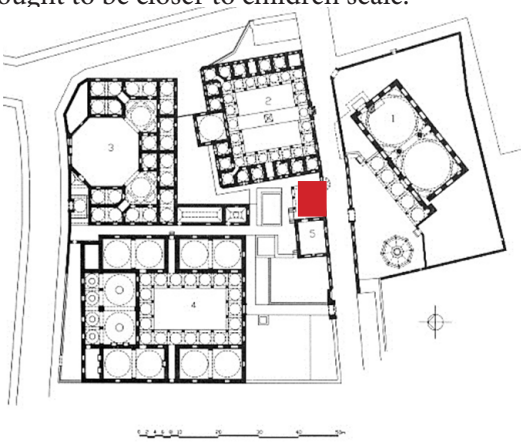


Figure 67- Suleymaniye Kulliye Plan indicating primary school

Because the building typology of Ottoman primary schools are quite simple and straightforward, more research was made into the higher educational buildings where there is a more systematic school system. This step was taken in order to investigate further the architecture of school buildings in that period.

Figure 68- Medrese teachers meeting (Turk, 2007)

Figure 69- Students having class in revak (Turk, 2007)

Medrese (Secondary & High School)

Medrese is an educational institution where a small percentage of students continue after primary school during Ottoman Empire period. It is a school where today's secondary and high school education was given. After the intensive Koran teachings in primary school, students were being exposed to a proper education system in Medrese.

Medrese's are built as courtyard buildings. The reason for this is not environmental but mainly functional because the typology does not vary in different locations. Closed spaces aligned around a courtyard are used as tutoring rooms. The Courtyard is used as a gathering space during class breaks or for intellectual discussions. Eyvan and Revak are crucial elements to Medrese architecture. While Revak provides the circulation around the classrooms and the transition between inside and outside. On the other hand Eyvan has a more significant function in Medrese apart from its environmental effect. Especially in the examples around Mardin (South east Turkey) , Eyvan is situated on east or north facade of the courtyard and serves as the only large classroom in the school. While several other closed rooms are there for more private tutoring, Eyvan is the main classroom in a Mardin Medrese.

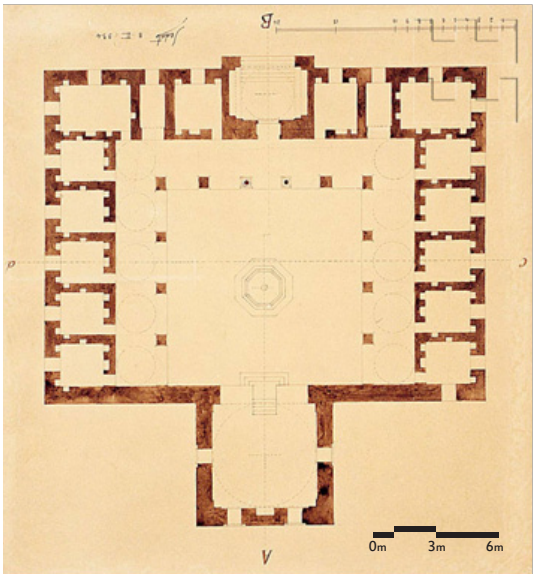


Figure 70- Bursa Muradiye Medrese Plan (Turk, 2007)

Figure 71- Bursa Muradiye Medrese Longitudinal Section (Turk, 2007)

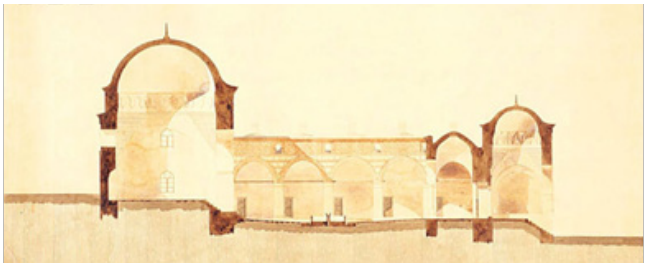


Figure 72- Bursa Muradiye Medrese Cross Section (Turk, 2007)

Figure 73- Mardin Kasimiye Medrese Eyvan (Turk, 2007)

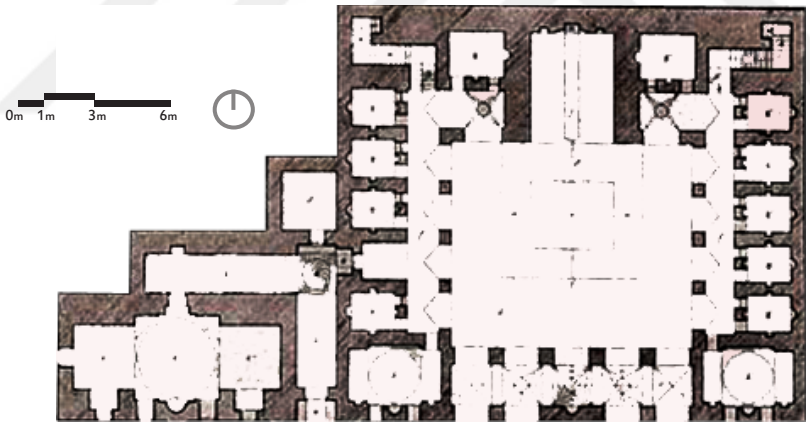


Figure 74- Mardin Kasimiye Medrese Floorplan (Turk, 2007)

Muradiye Medrese is located inside the Muradiye Kulliye in Bursa, Turkey. The school is entered through the eyvan gate on north facade into a 17m x 17m courtyard. The large classroom eyvan is located on north facade having more than 5 meter ceiling. 16 rooms surrounding the courtyard is used as student rooms for accommodating or private tutoring. The number of students tutored in the classroom does not exceed 25 pupils. In this Medrese building ,eyvan and revak (classroom and the corridor) are domed spaces whereas the examples in Mardin are vaulted.

Kasimiye Medrese, located in Mardin, has the similar courtyard building form. The school has a mosque located on the west facade, and situates one double height classroom and two floor of student rooms around the courtyard. However in this case the eyvan (double height classroom) roof is vaulted and oriented to face south. The reason for this is the prevailing wind coming from south and southwest, allowing air circulation through the north wall air shafts.

The main aspect of this school is the pool located in the courtyard. The pool evaporates with hot air in summer, increasing the relative humidity in the air and finally cools down the courtyard. Aside from the evaporative cooling aspect of the pool, it symbolizes *the life.* The water emerges north wall flowing through eyvan, which pictures *the birth and the youth.* The water turns into a big pool in the courtyard as *the adult life*, and continues to flow down through a narrow strip and ends, symbolizing the *death.* Although water is a nice aspect to provide cooling in summer, the scarcity of water around the area eliminates the use of the strategy.

Figure 75- Mardin Kasimiye Medrese Courtyard (Turk, 2007)

Conclusion

There is much to learn from the historical examples of school in Turkey because although the educational system has changed, the culture and climate has stayed. The reasons to built a courtyard form school building are still valid. It is seen that transitional spaces have even bigger effect on spatial and environmental design in school buildings. The transition between closed, open and semi-open spaces benefit the dynamics of school circulation. As well as housing, these spaces play a crucial role in educational buildings. The key elements to transfer into the new school design are,

- Classroom layout with square dimensions
- The use of eyvan as a teaching space in summer (as the occupants are more
- difficult to adapt to outdoor temperatures in winter.)
- The use of air chimneys in eyvan as cooling ventilation strategies
- Revak used for circulation purposes.
- The use of courtyard for break time activities
- School as a learning campus. Multiple courtyard buildings forming a town like environment

CASE STUDY

FIELDWORK

- Introduction of the Tools
- Gazipasa Primary & Secondary School
  - Location & Site
  - Building Form & Internal Layout
  - Interview
  - Performance
- Ataturk Primary & Secondary School
  - Location & Site
  - Building Form & Internal Layout
  - Interview
  - Performance

ANALYTICAL WORK

- Introduction of the Tools
- Comfort Studies
  - Clothing : Uniforms
  - Activity Rate
  - Comfort Band
- Thermal Simulation Studies
  - Occupancy Schedule
  - Gazipasa Primary School
  - Ataturk Primary School

DAYLIGHTING

- Gazipasa Primary School
- Ataturk Primary School

CONCLUSION

Figure 76- Students of Ataturk Primary & Secondary School

FIELDWORK

So far in the research, buildings in Mardin were investigated mainly through literature review. Starting from this chapter, the research is being focused into education. Therefore two school were chosen to be measured in order to observe the physical performance between the dates of July 4 -7. One of the school is a vernacular Mardin house, while the other one is a 60s concrete box typology. The comparison is expected to bring out the advantages and disadvantages of both during a peak period of summer in hot-dry climate of Mardin.

Introduction of the Tools

In order to investigate the thermal and daylight performance of the buildings several instruments were brought to the site. The list of instruments included

- *Data Loggers* : Tools used to measure indoor and outdoor air temperature and humidity. They record the continuous data of a room or outside for a specific amount of time.
- *3 in 1*: Spot measurement tool used to measure temperature, relative humidity and wind speed at a specific location at that moment.
- *Lux Meter*: Spot measurement tool used to measure daylight/illuminance in lux value at a specific location at that moment.
- *Surface Temperature* : Spot measurement tool used to measure the temperature of a specific surface (floor, wall, ceiling, etc.) with a 1 point laser spot at that moment.

Figure 77- Data Logger

Figure 78- 3in1 Tool

Figure 79- Lux meter

Figure 80- Surface Temperature

Figure 81- Aerial View of Mardin indicating Gazipasa and Ataturk Primary Schools

Gazipasa Primary & Secondary School

Gazipasa Elementary school is located in Mardin centre. The building is constructed in the year 1892 as a house by a local architect called Loe. The house belonged to the high class residents of Mardin until 1934 when it was converted into an elementary school.

Gazipasa is a typical representative of Mardin vernacular architecture. It was built using local Mardin limestone, and carved ornaments are done by well-known local artists. The building has four floors including a mezzanine floor. The basement was originally built as a storage where food is kept where now the caretaker of the school resides. The entrance is on the ground floor with eight rooms, and the mezzanine floor has three rooms. The courtyard and earth dug room are situated in this floor. Finally the top floor situates ten rooms with a terrace overlooking the southern view. All the rooms were turned into classrooms, offices, a computer room, a library, teacher's lounge and a kindergarten classroom.

Figure 82- Gazipasa Primary School Courtyard View

Location & Site

The school is situated in the Old Mardin on the south side of the only car road in the city centre. The main entrance is from one of the narrow residential streets which is located on the ground floor. The site is sloped and the south facade is open to the view. The prevailing wind is from south west flowing through the open south facade of the courtyard building.

Building Form and Internal Planning

The building is three storey stepped courtyard form sitting on the sloped site. Classrooms are aligned around the three sides of the square most of them facing the courtyard on ground floor and terrace on upper floor. The access to the classrooms are from the eyvan spaces located between two closed spaces. As mentioned in the context chapter ,eyvan is a transitional space providing cooled air to the adjacent spaces. In this case they are used as covered play areas and coat room. Because the school was converted from a house, the classroom sizes are fairly small for the amount of children that occupies it. Although the classrooms are small, the glazing is highly excessive. The ground floor on the other hand is shaded with the upstairs terrace, and the amount of light received inside the classrooms are very limited. Offices and other rooms are scattered around the building depending on the size of the rooms. The walls, floor and the roof are constructed with local limestone. The thermal mass is observed to cool down the building in summer, however the glazing diminishes most of this effect. An earth dug room is located on the north-west of the ground floor. Due to the slope of the site, this room is underground. The earth coupling which is a greater thermal mass stabilizes the temperatures inside. This hypothesis is also to be tested in the measurements.

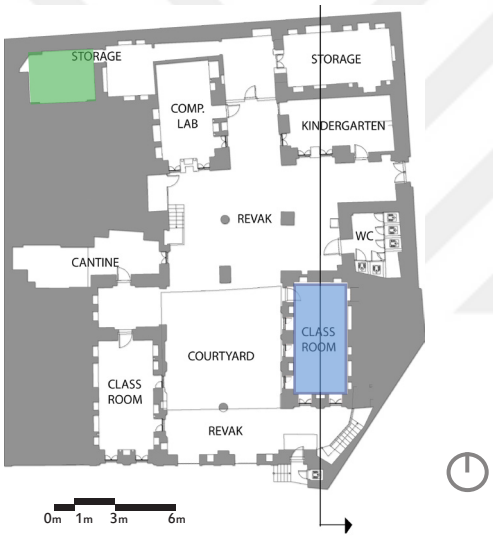


Figure 83- Ground Floor Plan

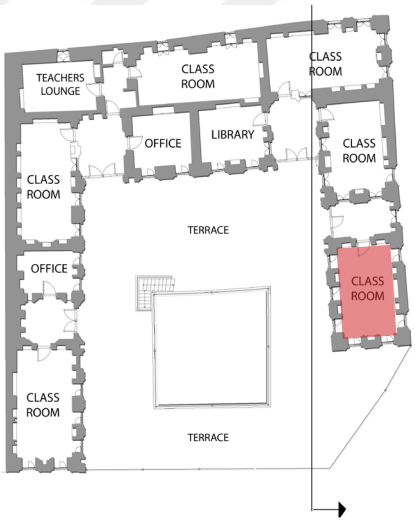


Figure 84- Upper Floor Plan

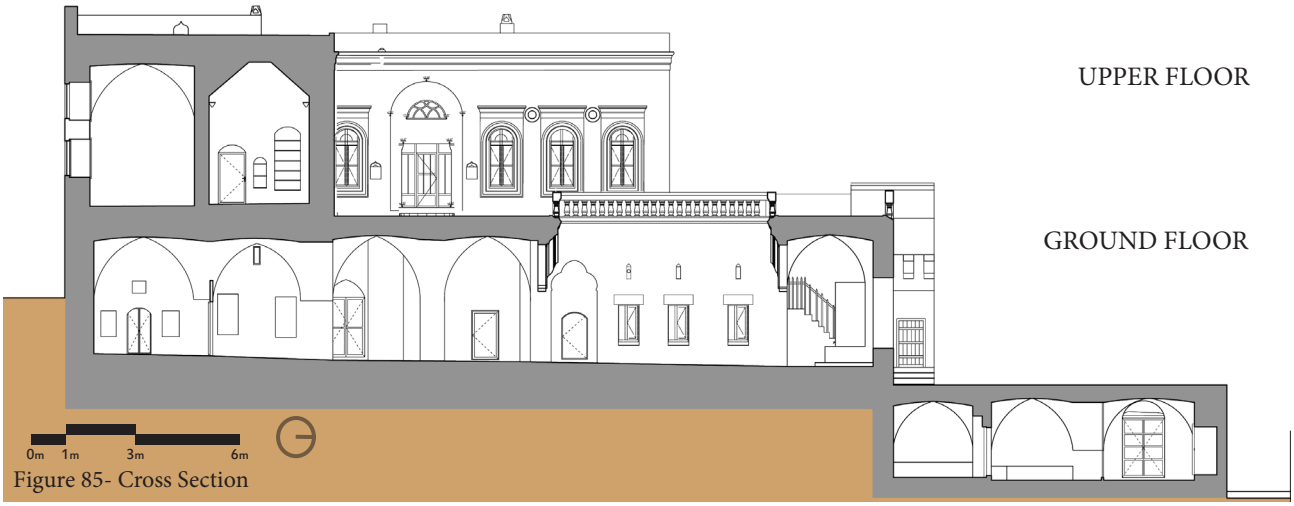


Figure 85- Cross Section

Figure 86- Gazipasa Primary School Students

Interview

While the students were in the school, a casual interview was done with them and the staff. Most of the children agrees to like being educated in this building. The main reason is the amount of space for activities such as the courtyard, the revak, eyvans and the terrace upstairs. They play at the terrace in winter due to the great solar gain, and prefer the ground floor courtyard during summer because it is mostly shaded. They also fancy this school because it is a tourist attraction for having a historical significance.

However there are several complaints about the form and the materiality of the building. The classrooms dimensions and proportions are not suitable for 30 children. Due to the over glazing there is no space for the whiteboard. For the same reason in the upper floor classroom students complained that they cannot see the board due to the glare. The upper classroom's envelope is highly exposed causing a great deal of heat loss in winter (although the solar gain heats the classroom). The excessive glazing of the walls probably create overheating in summer. On the other hand the ground floor classroom is more desirable by the students due to its more comfortable thermal conditions. But they complain about the insufficient daylight. Because the earth dug room is used as a storage, they have not favoured or complained anything about it, but the maintenance person who lives in one of the underground rooms, he admits it had humidity problems because it is not ventilated.

The open spaces are favoured by the students, but the teachers complain about the noise coming from the students playing outside while other students are having a class. They would like to see a transition space between the inside and outside for more peaceful class environment. Also the space is limited for the students to have their regular morning and evening ceremonies singing national anthem. Finally, they mostly complain about the materiality of the building. Because the children run around and tend to fall when they play, the stone floors and stairs are not appropriate for them. Also the steel balusters surrounding the courtyard void cause several accidents overtime. Most of the complaints seem to arise because this building is originally a house. It is not suitable for a comfortable school environment, but it is quite interesting to get educated in a typical vernacular Mardin house. There are many lessons to learn from this courtyard typology for school buildings in terms of spatial organization and environmental purpose of certain spaces.

Figure 87- View of the upper floor terrace

Figure 88- View of the courtyard

Figure 89- View of Upper Classroom

Figure 90- Gazipasa School Students during interview

Figure 91- View of Upper Classroom

Figure 92- Typical student desks

Performance

The measurements were done between the dates of 4-7 July when the peak outside temperatures are observed. 30 students from around the city were brought to the school for a short period of time in order to establish more realistic measurements and have an interview with the students , teachers and maintenance.

4 data loggers were placed at the school which was converted from a traditional stone Mardin house.

-Upper Classroom : classroom facing to the terrace
-Ground Floor Classroom : classroom facing the courtyard.
-Archive (Earth Dug Room) : underground room with no glazing
-Roof : for measuring the external temperature

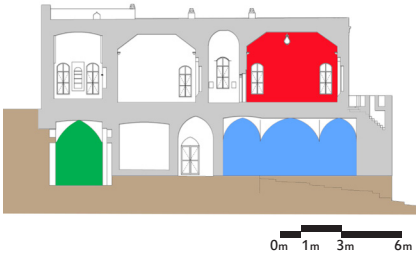


Figure 93- Cross section indicating measured rooms

Figure 94- Data Logger Location in Upper C.

Area: 23 m2
Volume: 110m3
Window Area: 12.40 m2
Window to floor ratio : 54%

Figure 94 & 96 - *Upper Classroom Interior and Elevation*

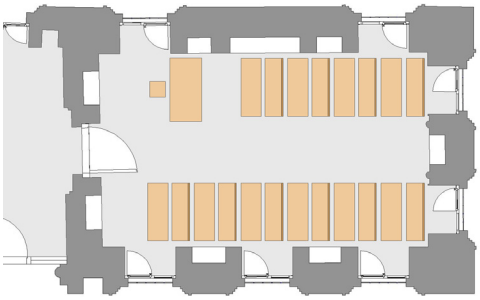
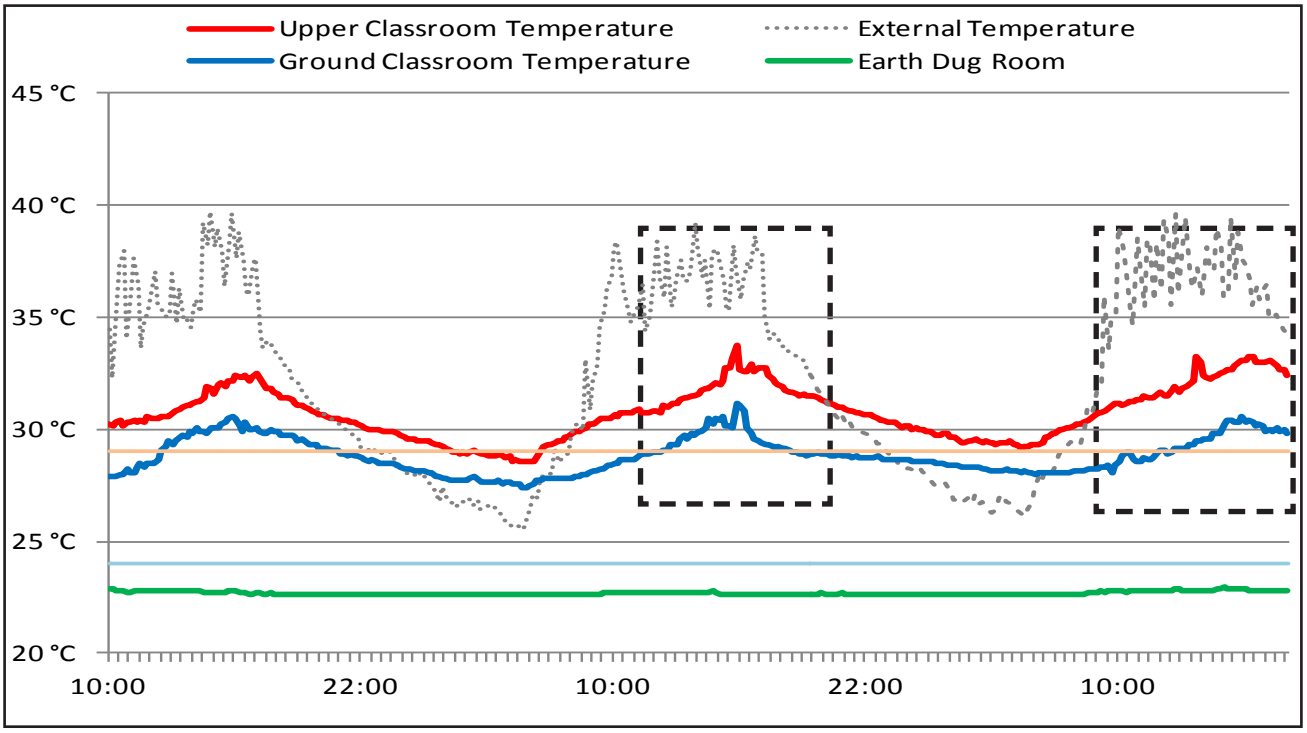


Figure 96- *Upper Classroom Floorplan*

Upper Classroom

Due to the high glazing area, the hypothesis was to see fluctuations in the measurements. But apart from the general temperature difference, the amount of fluctuation is quite similar to the ground floor classroom which is not exposed to direct solar radiation. The first measured day ,the classroom was unoccupied with the windows and doors closed, and the peak temperature was 33 degrees at 16:00 following the exterior peak temperature of 35.4 degrees. The minimum temperature is 27 degrees around 05:00 in the morning. Although the temperatures follow the fluctuation of the external temperature, the difference between day and night is not as extreme due to the thermal mass effect of 1 meter stone walls. The three windows and the door was opened on the second day to allow air circulation inside the classroom around 15:00 for 50 minutes (standard class duration). Because the windows are facing the outside air, indoor temperatures went up 2 degrees.

Finally the third day the classroom was occupied with 18 children and 2 adults for another 50 minutes in order to test the performance of the room with high internal gains. A 1.5 degree increase was observed during this 50 minutes while the children were sitting down. Once they leave the classroom the windows were opened for fresh air ventilation for 10 minutes (standard break duration). The excess heat gain due to the occupancy gains were released from the windows in this duration, and this condition decreased the temperatures back to 32 degrees from 34.



Graph 3. *Gazipasa Interior Air Temperature Data Logger Measurements (July 4-7)*

Area: 28 m2
Volume: 121m3
Window Area: 7.20 m2
Window to floor ratio : 26%

Figure 97 & 98-*Ground Classroom Interior and Elevation*

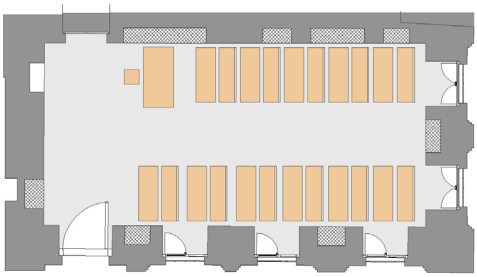
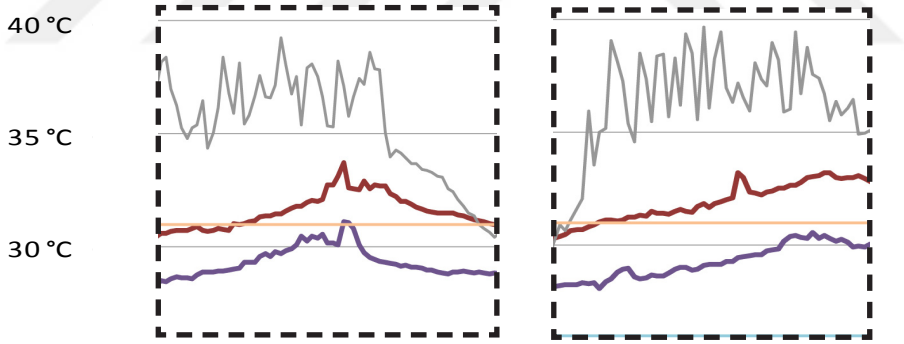


Figure 99- *Ground Classroom Floorplan*

Ground Floor Classroom

This classroom is located next to the courtyard on the ground floor. South glazing is always overshadowed by the revak while the west facade glazing receives the afternoon sun. Although there is 2 degree difference overall, the fluctuation of the temperatures is very similar to the upper floor classroom. The temperatures mostly are inside the comfort band except for the times when the classroom is ventilated the second day. The same test was performed to the classroom where the door was kept open for 50 minutes at 15:30 when it went from 30 to 31 degrees in less than 3 minutes. Resulting from the spot lux meter measurements, the room is much darker then the upper floor. Even when it received the most amount, the daylight does not reach the east side of the classroom, where artificial light is definitely needed. Internal gains test was not done to this classroom. The fact that this classroom is shaded, partly ground coupled on east facade and located on the ground floor, makes the summer conditions more desirable.



Graph 4. *Data Logger Measurements indicating the temperature difference between upper and ground floors*

Storage Room (Earth Dug Room)

Area: 16 m2
Volume: 64 m3

Figure 100 - *Earth-Dug (Storage) Room*

The measurements were taken in this room in order to investigate the performance of a possible underground classroom. The room stays cool in summer and warm in winter while the ground temperature of Mardin is 17 degrees. When there are high internal gains which is typical for a classroom with 30 occupants, the performance of an earth dug room could be beneficial in hot days.

The outcome of the room is a three day stable performance. The temperature hardly ever fluctuates for this period and stays in between 22-23 degrees. The humidity values are also recorded because in winter some humidity problems were reported by school workers which is predicted to happen from lack of ventilation. Although the temperature values are comfortable for a typical summer day, because there are no openings the room receives no daylight.

Figure 101 - *Ataturk Primary & Secondary School*

Ataturk Primary & Secondary School

Ataturk Elementary school is located in Mardin centre. The building is constructed in 1958 as a highly needed primary school for the area. This is one of the few concrete block buildings in old Mardin as recently the regulations only allow stone buildings in the city centre.

It was built with load bearing concrete block walls. This used to be a widely used low-cost construction technique, but recently hollow ceramic blocks and concrete skeleton is preferred in low cost construction around Turkey. Originally built as a linear form along east-west axis; a perpendicular block addition was made at the west end of the building in 1978. Wood windows were renewed to double glazed PVC frame windows in 2002. Latest renovation was the painting job on the ceilings in 2001.

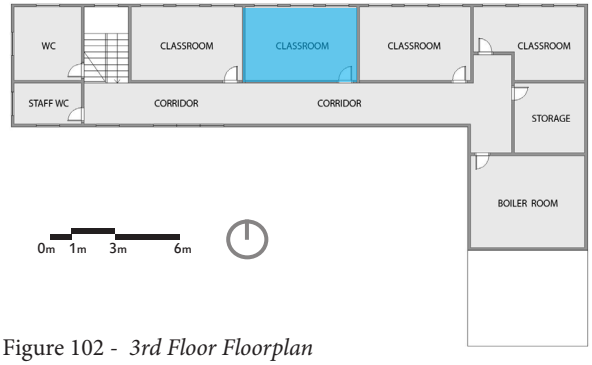


Figure 102 - *3rd Floor Floorplan*

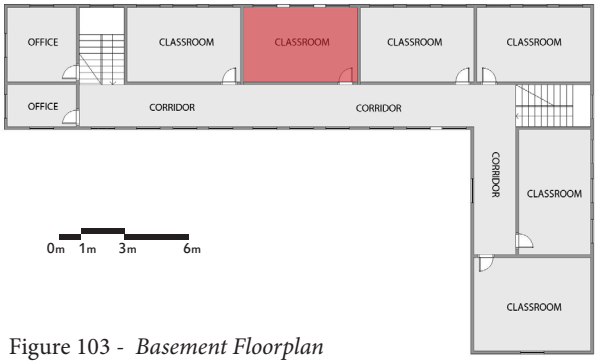


Figure 103 - *Basement Floorplan*

Location & Site

The school is situated in the Old Mardin on the main road of the city. The north facade faces the road while the view can be seen from the south facade. The classrooms located on south side faces the prevailing wind, while being highly exposed to the south sun.

Building Form and Internal Planning

The building is a three-storey linear form. Most of the classrooms are aligned along the southern side and have windows facing on that orientation. Access to these classrooms is from the linear corridor aligned on the northern side of the building.

Figure 104 - *Upper Floor Corridor*

Figure 105 - *Upper Floor Classroom*

The administration offices, the bathrooms and the canteen are located on the west end of the linear box. This form and internal layout is a very common school building type, applied to all around the country. It is ideal for stacking large number of students. The classrooms dimensions are 5m x 7.6 m allowing the daylight to reach the entire classroom by glazing the longer side. The linear form in school buildings is ideal for daylight and cross ventilation opportunities.

An addition was made to the building in 1978 by applying another 3 storey linear box perpendicular to the eastern end of the building. The building only takes up 30% of the site, leaving the rest of it as play and ceremony areas. Part of the outdoor area is shaded by the building itself, leaving the rest exposed. Because the winter temperatures are quite low, students prefer the 3m wide corridor as play area instead of covering up to go outside during the 10 minute breaks.

Interview

Another interview was established by finding some local students around the city centre. The major complaint students had about this school is the density of the students. Although Ataturk is slightly smaller than Gazipasa, it occupies more students (900 students vs 420 students). Although there is not a big problem with the sizes of classrooms, the amount of closed activity space is highly limited. During warmer periods of the year, students like having a large garden where they could have their daily national anthem ceremonies, and play during breaks. The fact that the garden is facing the northern side, children playing does not bother the classrooms, different than Gazipasa. And they could also use this garden space during the summer vacation because it is easier to access from the road.

Figure 106 - *East Side Outdoor Area*

Figure 107 - *View from the classrooms*

Figure 108 - *North side outdoor area*

Figure 109 - *Ataturk Students during interview*

Figure 110 - *Ataturk Students during interview*

The biggest complaint from the school administration is the maintenance of the building. Because it is very low cost, the appliances in the classrooms (coat hangers, desks,doors and windows) need regular repair. On the other hand the school needs painting which the government keeps postponing. These issues bring out leakage problems in the building. The later added north classrooms do not have enough openings which cause poor air ventilation and accordingly humidity problems. In terms of thermal comfort, the basement classrooms are favoured because it is ground coupled on north side. But upper classrooms receive more daylight both from north and south facade. The desks are fairly affordable, but the wood material is not efficient for them to write on. Due to the density, three students may occupy one desk at times which is not comfortable for any class activity.

Although the outdoor area is quite large, the concrete floor material is not safe for children play. Children do not prefer this space during winter because they need to spend time on covering themselves and the break is only 10 min. This space is ideal for warmer periods and summer vacation because it is very accessible from outside. People around the neighbourhood tend to complain about the noise because the school is by the main road. This was not an issue for Gazipasa where the play areas are more secluded due to the courtyard form. The outside stairs is beneficial for circulation and for principal speeches during ceremonies, but it blocks the circulation between the east and west court of the playground. Children prefer the 3 meter wide corridors for play which is not comfortable for so many students. Finally the canteen located by the entrance is quite small.

The hypothesis for the measurements is that the upper classroom would have overheating during summer because the southern windows are not shaded. And the higher exposure of the envelope would create more heat loss in winter than the basement classroom. From personal observations the basement classroom was cooler because the northern facade is ground coupled cooling down the entire floor.

Figure 111 - *Ataturk Students in the corridor*

Figure 112 - *Canteen space*

Figure 113 - *Data Logger location in classroom*

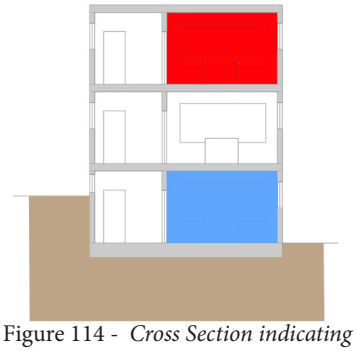


Figure 114 - *Cross Section indicating measured rooms*

Figure 115-6 - *Basement and Upper Windows*

Performance

The measurements were done between the dates of 4-7 July when the peak outside temperatures are observed. 28 students from around the city were brought to the school for a short period of time in order to establish more realistic measurements and have an interview with the students , teachers and maintenance.

2 data loggers were placed at the school which was converted from a traditional stone Mardin house.

-Upper Classroom : Classroom facing south on the 2nd floor
-Basement Classroom : Ground coupled classroom on -1st floor.

Figure 117 - *Basement Corridor*

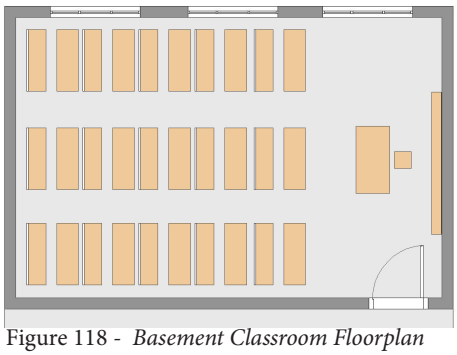


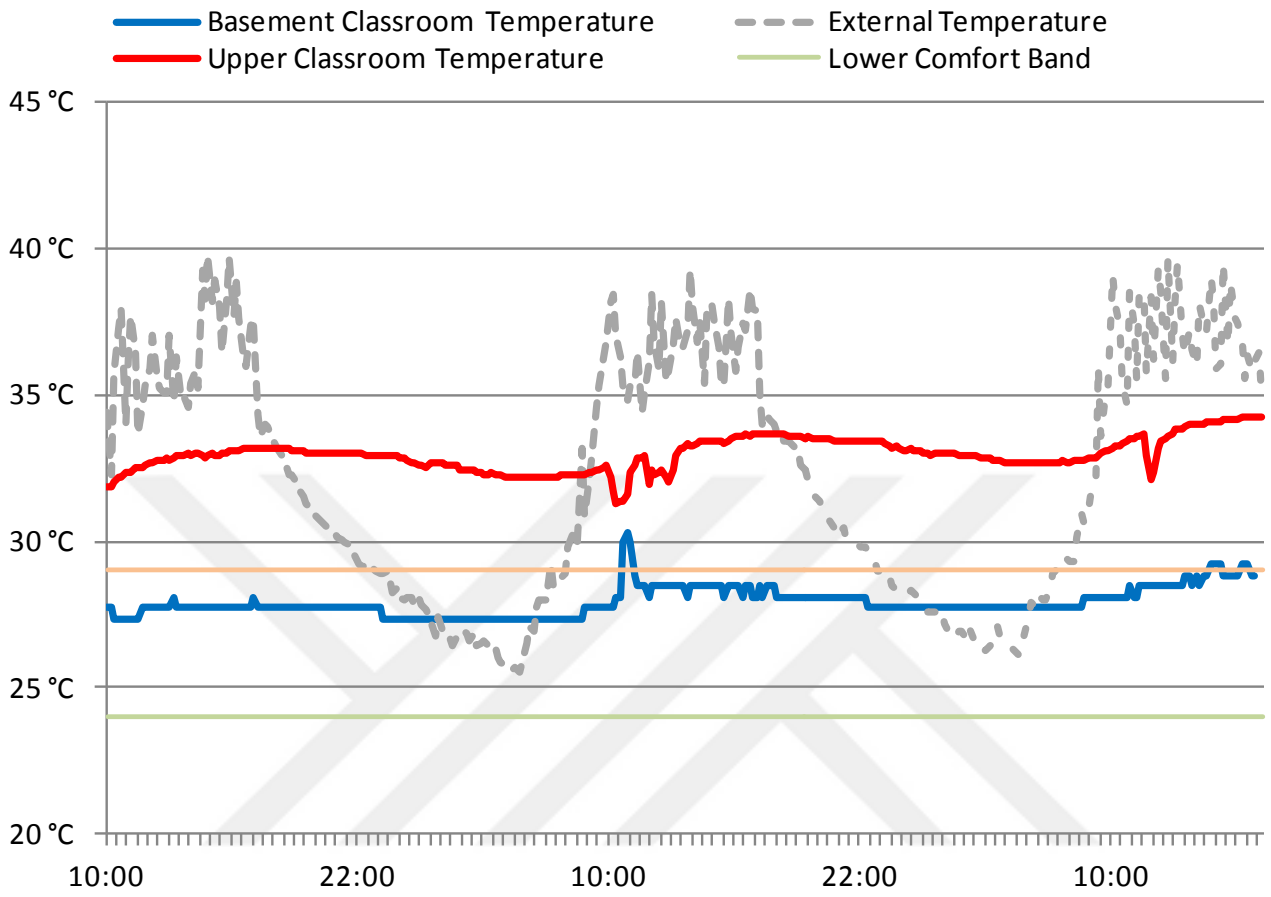
Figure 118 - *Basement Classroom Floorplan*

Basement Classroom

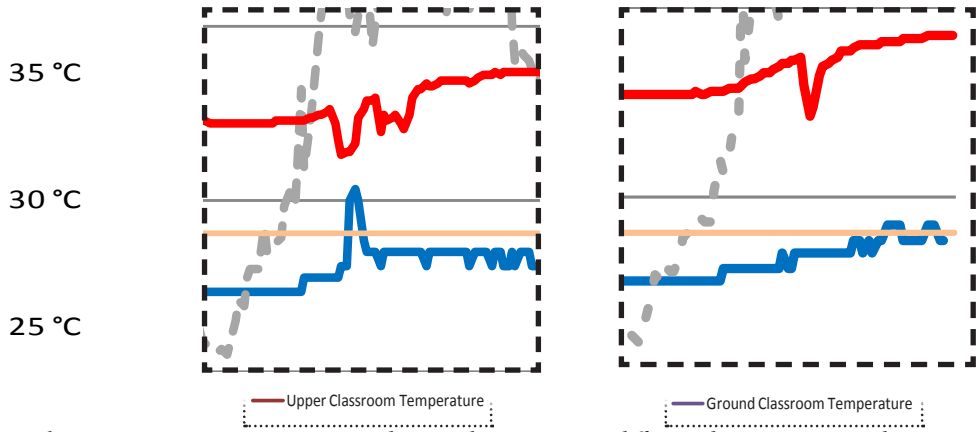
Area: 38 m2
Volume: 114 m3
Window Area: 5.28 m2
Window to floor ratio : 14%

The classrooms in this building are attached with corridor spaces on northern facade. In the basement floor the corridor is ground coupled due to the slope of the site. It was mostly complained about the humidity problems.

Overall the classroom has fairly stable temperatures ranging between 27.4 and 29 degrees under normal circumstances (empty room ,windows and door closed). The temperature difference between day and night is only 0.5 degrees. Obviously the classroom is not sensitive to the exterior temperature. The performance of the Gazipasa earth dug room shows similarities to the performance of basement classroom in terms of stability. The reason for this stability is the thermal mass the ceramic blocks are creating. The construction is similar to stone construction except the main material is ceramic blocks. However the temperatures are more stable than the upper floor due to the ground coupling of the basement floor.



Graph 5. *Ataturk Interior Air Temperature Data Logger Measurements (July 4-7)*



Graph 6. *Data Logger Measurements indicating the temperature difference between upper and ground floors*

The classroom was ventilated on the second day for 50 minutes (standard class duration) when three windows and door opened at 10:45am. Following the external temperature, the air temperature inside the classroom raised 2 degrees. Overall the temperatures of the basement classroom stayed inside the comfort zone for Mardin children in summer (comfort band between 26 and 31 degrees).

Figure 119 - *Upper Floor Corridor*

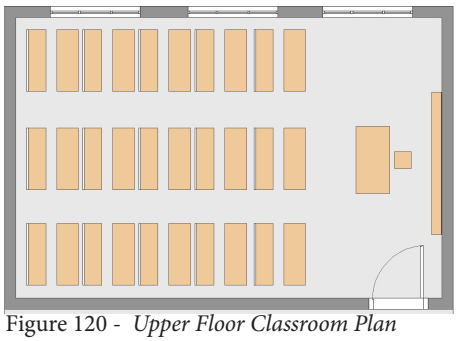


Figure 120 - *Upper Floor Classroom Plan*

Area: 38 m2
Volume: 114 m3
Window Area: 5.28 m2
Window to floor ratio : 14%

0m 1.5m 3m

Upper Classroom

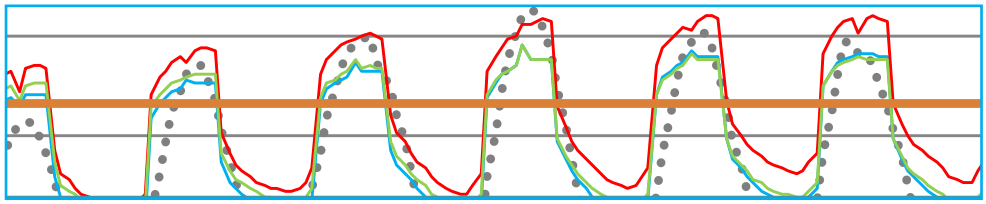
This classroom has the identical dimensions and internal layout with the basement floor classroom. Being located on top floor, it is exposed to the most solar radiation. Therefore it was complained to be the hottest floor in summer. The classroom receives the solar radiation and stores is throughout the night. Indoor temperatures are more stable than upper classroom of Gazipasa elementary, although this is a more lightweight construction. This condition is due to the excessive glazing of Gazipasa upper classroom (54% window/ floor ratio). On the other hand Ataturk upper classroom is only glazed on south side with three windows having a ratio of 14%. Daylight coming from the glazing on southern facade is distributed well throughout the classroom as the width is only 5 meters.

The maximum temperature measured is 34 degrees on the last day at 16:00. This is also the time of the day when peak temperatures are observed in Mardin. In order to test the performance, ventilation and internal gain tests were done. However once the windows and the doors were opened around 09:50am, a temperature drop was observed. Because the outdoor temperature is higher than inside, opening the door to the corridor might have caused this drop. Looking into the spot measurements done at the site, it was seen that the corridor temperature is 2 degrees lower than the classroom. Therefore ventilation from the corridor is more desired in summer because of the cooling effect.

28 children occupies the classroom to test the effect of internal gains at 11:40am on the second day. The internal heat gain from the children raises the temperature 3 degrees. When the ventilation test was done the first day, temperature drop was around 1.5 degrees. The second day with the internal gains, it only dropped 0.4 degrees. There is a high demand of cooling on the upper floor classrooms in order to bring the temperatures down to the comfort zone. But it still is a fact that during these extreme temperatures ,the school is on summer vacation. The classrooms may be occupied for workshop and etc. but this level of density is not expected.

Conclusion

The free-running condition of two schools show that thermal mass of concrete block and lime-stone is a great advantage for summer conditions as it stabilizes the temperatures. But in Gazipasa overglazing eliminates this advantage by letting excessive solar gain into the classrooms. Both schools seem to have problems in winter as they are not insulated. Although internal gains will raise the temperatures in great deal, winter condition still has problems. In both school the ground floors performs better. Firstly ground coupling stabilizes the temperatures as the ground temperature is around 18 C. Secondly in Gazipasa, the less exposure and shading of the ground floor classroom is the biggest effect on its better performance.



ANALYTICAL WORK

The fieldwork conclusions cannot be fully dependent on because the school conditions were out of the regular schedule. Although the right amount of students were brought into the classrooms during the measurements, the case of having them for an hour and a whole day would show major differences. Therefore in this chapter Gazipasa and Ataturk primary schools ' thermal and daylight performances will be investigated through simulation modelling techniques. In the end through the computer tools it will be possible to observe the typical winter and summer week performances of both schools during school year.

Introduction of the Tools

Hand calculations were performed in order to calculate the heat loss rate and the heating loads of the classrooms. In order to see how the building performs in various parameters, simulation programs are used.

- *TAS Building Designer* : This program is used to test the thermal performance of a building. Tas has a modular design and is split into three main programs. The model is created in the 3D Modeller, then parameters such as internal conditions and materials are applied to the model in Building Simulator. Then finally the outcome is taken with Results Viewer. Here results such as temperatures or loads are viewed for extensive analysis.

- *Autodesk ECOTECT Analysis* : Among the many usage of the program, in this project the daylight analysis feature is used. The daylight analysis includes incident solar radiation on windows and facades, calculating daylight factor and illuminance levels at any point in the model, and displaying the sun's position and path relative to the model at specific dat, time and location.

Comfort Studies

The variables that affect heat dissipation from the body (thus also thermal comfort) can be grouped into three sets:

1: Environmental
- a)air temperature
- b)air movement
- c)humidity
- d)radiation

2: Personal
- a)metabolic rate-activity
- b)clothing

3: Contributing factors
- a)food and drink
- b)acclimatization
- c)body shape
- d)subcutaneous fat
- e)age and gender
- f)state of health

Source: Szokolay , 2007

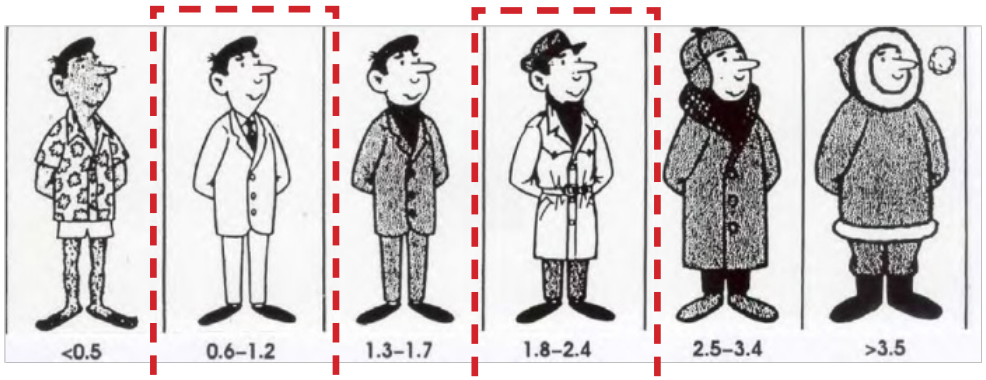


Table 1. *Insulating value of clothing elements (Source : Szokolay, 1997)*

So far in the dissertation the first set, environmental aspects are aimed to be covered. This section looks into the people aspects of thermal comfort by investigating student activity and clothing. Szokolay (1997, PLEA) states that clothing is one of the dominant factors affecting heat dissipation. For the purposes of thermal comfort studies a unit has been devised, named the clo. This corresponds to an insulating cover over the whole body of a
transmittance (U-value) of 6.45 W/m²K (i.e. a resistance of 0.155 m²K/W).

1 clo is the insulating value of a normal business suit, with cotton underwear. Table 2 gives the clo-values of various pieces of garments. On the other hand the activity rate is measured with the unit *met* ; a person in a seated position would equal to 1 met of activity rate. Table 4 gives the met-values of various activities.

Man		clo	Women		clo
underwear	singlets	0.06	underwear	bra + panties	0.05
	T-shirt	0.09		half slip	0.13
	briefs	0.05		full slip	0.19
	long, upper	0.35		long, upper	0.35
	long, lower	0.35		long, lower	0.35
shirt	light, short sleeve	0.14	blouse	light	0.20
	light, long sleeve	0.22		heavy	0.29
	heavy, short sleeve	0.25	dress	light	0.22
	heavy, long sleeve	0.29		heavy	0.70
	+5% for tie or turtle-neck)				
vest:	light	0.15	skirt	light	0.10
	heavy	0.29		heavy	0.22
trousers	light	0.26	slacks	light	0.26
	heavy	0.32		heavy	0.44
pullover	light	0.20	pullover	light	0.17
	heavy	0.37		heavy	0.37
jacket	light	0.22	jacket	light	0.17
	heavy	0.49		heavy	0.37
socks	ankle length	0.04	stockings	any length	0.01
	knee length	0.10		panty-hose	0.01
footwear	sandals	0.02	footwear	sandals	0.02
	shoes	0.04		shoes	0.04
	boots	0.08		boots	0.08

Table 2. *Insulating value of clothing elements (Source : Szokolay, 1997)*

Clothing - School Uniforms

From primary school until university, it is mandatory in public schools and most private schools to wear a representative uniform. Although the colours might change, the amount of layers and fabric is mostly the same all around Turkey. Because the low-cost fabric is the same, children tend to wear layers depending on the seasons.

Layers of clothing increase during winter providing insulation for the human body in order to adapt to the cold indoor temperatures. In a typical winter week the clothing level of a child is calculated according to the clo levels indicated on Table 2.The proposed design is supposed to provide the desired thermal comfort without the need of extra clothing. But in this case it is necessary to see the adaptive comfort opportunities of the students in Mardin. Due to the limited budget of the government, the heating ,being the highest energy consumption, is regularly cut down during winter months. Therefore it is important to design a building to keep as warm as possible without heating. Accordingly the effect of the occupant adaptivity to such conditions should be recognized from current examples.

Figure 121 - *Secondary School Uniform*

Figure 122 - *Primary School Children*

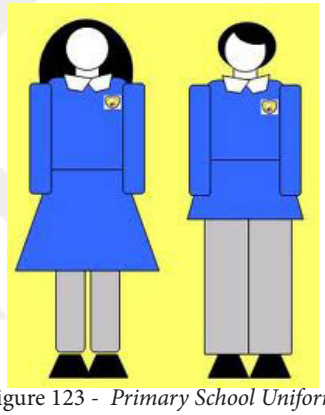


Figure 123 - *Primary School Uniform*

The primary and secondary schools have different uniforms. The primary school uniform is a blue dress with a separate collar, while the boys wear pants and one piece blue top. The secondary school students both have 3 piece set with a white shirt, jacket and pants or skirt. During winter period, girls start wearing thermal stockings, a long sleeve shirt under and sweater with a jacket over the uniform. Similar amount of layers are observed in boys. Teachers were stating during the interview that whenever they get budget cuts and reduce the heating, the children would sit inside the classroom even with coats.

Girls Clothing in Winter	
long , upper	0.22
long, lower	0.35
dress heavy	0.70
pullover heavy	0.37
boots	0.08
	1.72

Girls Clothing (Summer)	
bra + panties	0.05
heavy	0.70
panty-hose	0.01
shoes	0.04
	0.80

For instance on a warm day or at a thermally comfortable indoor condition girls uniform would be 0.80 clo value. However during more difficult winter conditions clo value without a coat on could be equal to 1.70 clo for a typical Mardin child. Because most children live in the suburb villages or outside the centre, they walk or use public transportation to school. So even though best thermal conditions are provided for these students, they still will be arriving with the clothing insulation of 1.7 clo or more.

1.7CLO	day of	time	sun	sun	Gact	Sact	Dact	Ts	Ta	Tmrt	PMV	PET	SET*
date	year	h:mm	rise	set	W/m2	W/m2	W/m2	°C	°C	°C		°C	°C
5.12.2011	2576760	12:00	4:34	18:07	321	24	297	17.3	11	41.9	0.6	19	22.3
1CLO	day of	time	sun	sun	Gact	Sact	Dact	Ts	Ta	Tmrt	PMV	PET	SET*
date	year	h:mm	rise	set	W/m2	W/m2	W/m2	°C	°C	°C		°C	°C
5.12.2011	2576760	12:00	4:34	18:07	321	24	297	17.3	11	41.9	-0.2	18	19.3

Table 3. *SET, PET, PMV values provided depending on the location, activity and clothing (Source : Rayman Pro)*

Due to the higher activity rates during the travel, it is observed that the first hour of the student in a classroom is the most adaptive state of his/her skin during the entire day. Calculating the SET values (SET gives a rational basis for measuring the equivalence of any combination of environmental factors, clothing and metabolic rate) of two Mardin child, 1.8 clo and 1 clo values equals to 22.3 °C and 19.3 °C. Wearing 1.8 clo at noon on a typical winter day in Mardin is comfortable, acceptable physiological thermal neutrality, whereas 1 clo under the same circumstances is slightly cool, slightly unacceptable initial vasoconstriction (Szokolay, 2007)

Activity Rate

Activities in a primary school building may vary depending on the space and schedule. Students are quite active especially during school hours. In a primary school in Mardin , mandatory school activities include:

Gym Class : Two hours per week where students participate in physical exercise
Music Class: Two hours per week where students get to learn music theory and play an instrument.
Art Class : Two hours per week where students learn the skills of drawing and painting

Most children work outside of school during the evenings and the weekends. This condition gives them very little time for playing. Besides time, space is also a matter; playing on the streets is not the safest environment. Children tend to come back to the school playgrounds during weekends and holidays for social activities. It is important to design a school building with spaces suitable for classroom and break time activities. Table 4 shows some typical metabolic rates, which can be expressed as power density, per unit body surface area (W/m^2), as the power itself for an average person (W) or in a unit devised for thermal comfort studies, called the met. 1 met = 58.2 W/m^2 (Szokolay,2007). A classroom activity would vary from seated to standing, sedentary work (1 - 1.2 met) while the corridors and other transitional spaces varies widely from standing to heavy work, sport activities (1.2 - 6 met).

Figure 124 - *Seated Students (1 met)*

Figure 125 - *Students during breaktime (3 met)*

Figure 126 - *Students during national anthem ceremony (1.2 met)*

Figure 127 - *Students during breaktime (5 met)*

activity	met	W/m²	W(av)
sleeping	0.7	40	70
reclining, lying in bed	0.8	46	80
seated, at rest	1.0	58	100
standing, sedentary work	1.2	70	120
very light work (shopping, cooking, light industry)	1.6	93	160
medium light work (house~, machine tool ~)	2.0	116	200
steady medium work (jackhammer, social dancing)	3.0	175	300
heavy work (sawing, planing by hand, tennis) up to	6.0	350	600
very heavy work (squash, furnace work) up to	7.0	410	700

Table 4. *Metabolic rates of different activities (Source : Szokolay, 1997)*

Comfort Band

Our bodies have the capability to physically adjust its mechanism to various temperatures. These adjustments may occur in short periods like hours, or longer periods like months and seasons. The adjustment of seasonal preferences can be quite significant, even over a period of a month. Extensive studies showed that the ' neutrality temperature' (the median of many peoples ' votes) changes with the mean temperature of the month.

Putting together the information of clothing and activity, the free running building comfort zone is calculated using the de Dear et al, 1997 formula.

Tn = 17.8 + 0.31 • Tm

1. Find the mean temperature as Tm = (Tmin + Tmax)/2

Peak Months	*Typical School Periods*
Jan: Tm = (-0.4+8.7)/2 = 4.55°C	Dec: Tm = (1.8+10.7)/2 = 6.25 C
Jul : Tm = (24.1+39.6)/2 = 31.85 °C	May: Tm=(12.9+27.7)/2 = 20.3 °C

2. Find the thermal neutrality (the mean value for the month), substituting this Tm value into eq. 3.4:

Coldest month January :	Tn= 17.8 + 0.31 . 4.55 = 19.21°C
Hottest month July :	Tn= 17.8 + 0.31 . 31.85 = 27.67°C
Typical summer month May:	Tn= 17.8 + 0.31 . 20.3 = 24.09°C
Typical winter month December:	Tn= 17.8 + 0.31 . 6.25 = 19.73°C

3. The comfort zone can then be taken as Tn-2.5 to Tn+2.5°C (i.e. 5 K wide) for 90% acceptability here

Peak Months	***Typical School Periods***
Jan: 16.71 – 21.71°C	**Dec: 17.23 – 22.23°C**
Jul: 25.17 – 30.17°C	**May: 21.60 – 26.60 °C**

The design temperatures and comfort limits calculated above are valid for activity levels of 1.1 – 1.4 met and for people wearing about 0.7 clo in summer and 0.9 clo in winter.
Children with a school uniform under the classroom circumstances this formula is valid.
In cases such as higher activity rate or thicker clothing adjustments can be made,

- each met increase (up to 3 met) : reduce temperature by 2.5 K
- each 0.1 clo added : reduce temperature by 0.6 K

Therefore various version of comfort band could be created depending on the spaces and conditions.

Classroom (heavy clothing 1.8clo in winter)
May: 24.09°C = 24.09°C (20.99°C , 25.99°C)
Dec: 19.73°C – 4.8 =14.93°C (12.43°C , 17.43°C)

Corridor (lighter clothing 1.2 clo in winter, activity rate 3 met)
May: 24.09°C – 5K = 19.09°C (16.59°C , 21.59°C)
Dec: 19.73°C - (1.8K + 5K) = 12.93°C (10.43°C , 15.43°C)

These calculations are done in order to see the possible adjustments of students in case of a heating cut off. These would be the temperatures they can temporarily tolerate. However for the proposed design conditions ,the result of the de Dear et al formula will be maintained for classroom comfort band whereas for the higher activity spaces it was modified for 2.4 met (medium light work)

Classroom	**Corridor (2.4 met)**
Dec: 17.23 – 22.23°C	**Dec : 19.10°C , 24.10°C**
May: 21.60 – 26.60 °C	**May: 14.73°C , 19.73°C**

(Source: Auliciems and Szokolay, 1997)

Figure 128 - *Students with heavy clothing inside the building (1.8 clo)*

Figure 129 - *Students with heavy clothing (1.8 clo)*

Thermal Simulation Studies

During fieldwork Gazipasa and Ataturk primary schools were investigated on the month with the highest temperatures. Although this shows a lot of aspects of the building performance, it is necessary to observe under regular school circumstances. The empty building can tell a lot, but a school needs to come to life with children and activities in order to tell more. In this chapter the school buildings will be transformed into their condition during a typical winter and summer week by modelling them with the existing materials, adding internal gains and providing the required fresh air ventilation.

Occupancy Schedule

Due to the high density of the classrooms, most schools in Turkey work with double schedule. This means half of the students would come to school in the morning until noon, while the rest would come in the afternoon. Because of the student shift they also save some time from a long lunch break. In both schools, primary students come to school in the morning schedule while the secondary students occupy in the afternoon. Ataturk has 900 students whereas Gazipasa only has 420, and at some point the two-person seats is occupied with three students. Class duration is 50 minutes and 10 minute break in between. Ataturk prefers to leave 45 minute lunch break for the staff and teachers whereas Gazipasa follows a more intense schedule.

Gazipasa Primary School Schedule	*Ataturk Primary School Schedule*
Morning: 07:00am – 11:30pm	Morning: 07:30am – 12:15pm
Afternoon: 11:40pm – 16:50pm	Afternoon: 13:00pm – 17:15pm

While doing a thermal analysis to a building, it is important to balance the performance during the day and night. Educational buildings have the advantage of the occupancy schedule as it is only occupied from 07:00 until 17:00. The night time could be used for night ventilation to let the stuffed air out , or to take advantage of the low temperatures to cool the interior in summer. Therefore the daytime performance of Gazipasa and Ataturk is the focus of this section while taking advantage of the nightime conditions. In a larger scale, the seasonal schedule also differs from housing schedule. The school term is only between the months of September until June with a 15 day semester break. The heavy internal gains will be present during this period but that does not mean the summer performance will not be crucial. Although at the moment the schools are empty during summer, there is a high possibility that they will be used in summer workshops. The city is famous for stone and jewellery craftsmanship ; providing space for those kinds of workshops in summer would be beneficial to the community. This year the school starts on 19 September and goes on until 8 June. Students would have a semester break between the dates of 23 January - 3 February (Source: Milli Egitim Bakanligi / Ministry of National Education)

Typical Winter & Summer Dates

After simulation, one part of the investigation is to look into temperatures on a typical week in winter and summer. The weeks are supposed to represent the challenging conditions of that season while keeping away from the maximum temperatures of the year.
Therefore for winter the second coldest month, December, is chosen as typical week. Because the school closes the first week of June, end of May temperatures are the closest examples to summer condition.

335-341 --> 1-7 Decemeber
138-144 - 18- 24 May

Gazipasa Primary School

Materials

Gazipasa Primary school is a vernacular Mardin house converted into school in 1920s. The environmental characteristics of Mardin houses are discussed in Chapter 2, Context. The wall thickness change according to the floor; on the ground floor the wall thickness is 80 cm whereas the upper floor goes up to 100cm. The stone is constructed with mortar to create the walls and the floors of the dwelling. In the entire construction, stone is the dominant material including the walls, ceiling, floors and detailing.

Figure 130 - *Flooring*

Figure 131 - *Fluorescent Light*

GAZIPASA		Thickness	Conductivity	U-value
		mm	W/mK	W/mK
External Wall	Kalker Stone	1000	2.9	
				1.94
Internal Wall	Kalker Stone	800	2.9	
				2.24
Ceiling	Kalker Stone	1500	2.9	
				1.45
Floor	Plaster	20	1.4	
	Kalker Stone	800	2.9	
				2.24
Double G. Window				1.84

Table 5. *Materials*

Figure 132. Stone Wall

Internal Gains

30 students were added as the occupancy gains to the ground and upper classroom. Using the number of students a minimum fresh air requirement is calculated for each zone as 10 litres per second per person. The remaining information about the rest of the gains are in Table 6. The earth dug room dimensions are modified in order to fit the standard classroom dimensions in Gazipasa. The measurements of the underground room were quite promising, so the simulation of the room as an actual classroom was necessary. Although the dimensions and internal gains changed, the room's window to floor ratio is still 0.

The upper and ground floor classrooms were chosen in order to compare the temperature difference of window to floor ratio and the envelope exposure. The exposure of the rooms are,

Upper Classroom : 84%

Ground Classroom : 52%

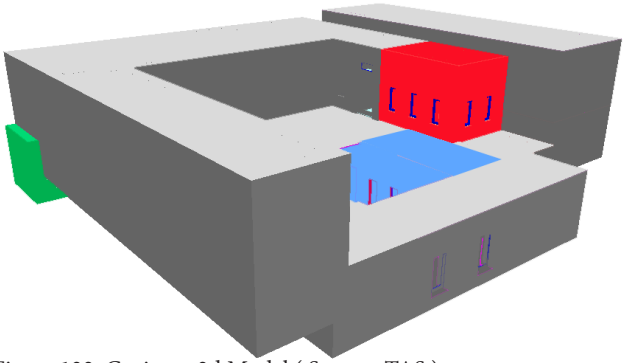


Figure 133. Gazipasa 3d Model (Source: TAS)

	Room	Volume(m3)	Area(m2)	min air quality (10lb)	Occupancy				Lighting	
					Sensible (W)	w/m2	Latent (W)	w/m2	Lighting (W)	w/m2
GAZIPASA	*Upper Classroom*	124.6	23.5	8.667736758	2100	89.3617	1350	57.44681	250	10.6383
	Ground Classroom	137	30.3	7.883211679	2100	69.30693	1350	44.55446	250	8.250825
	Earth dug	133	29.4	8.120300752	2100	71.42857	1350	45.91837	250	8.503401
	Eyvan	51	9.3	21.17647059	2100	225.8065	1350	145.1613	120	12.90323

Table 6. *Internal Gains*

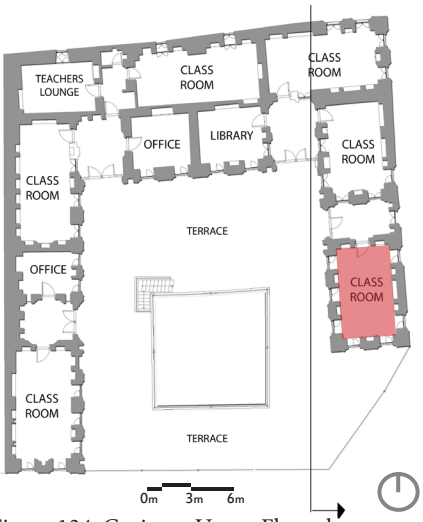


Figure 134. Gazipasa Upper Floorplan

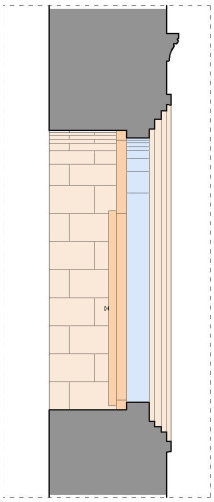


Figure 135. Wall Section

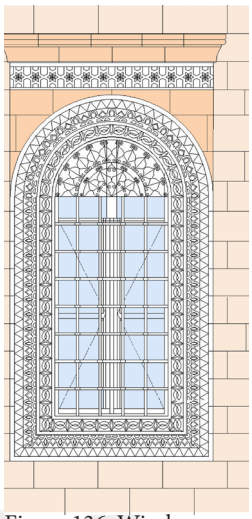
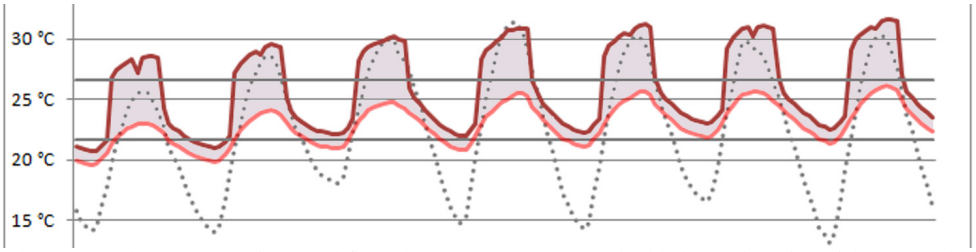


Figure 136. Window

Upper Classroom

Looking into summer temperatures, it is obvious that the students inside the classroom and lighting gains are disadvantageous for the thermal performance. The empty classroom temperatures are inside the comfort zone, however once the students arrive, the temperatures rise above it between 8am until 6pm. The almost 1 meter thick stone walls create a thermal mass which retards the transfer of outside heat to the indoor. Therefore night ventilation could be applied to the classrooms in order to receive the cool temperatures of night and preserve them inside during the day.

However the thermal mass cannot be processed with 54% window to floor ratio. While the stone wall slows down the heat exchange process, the excessive glazing create temperature fluctuations. Due to the glazing ,the temperatures of this classroom compared to the ground floor is almost 2 degrees. Of course this space is not designed as a classroom which is why the glazing is so much. In Mardin houses, it is quite common for occupants to move around the house depending on the time of the day and the seasons.

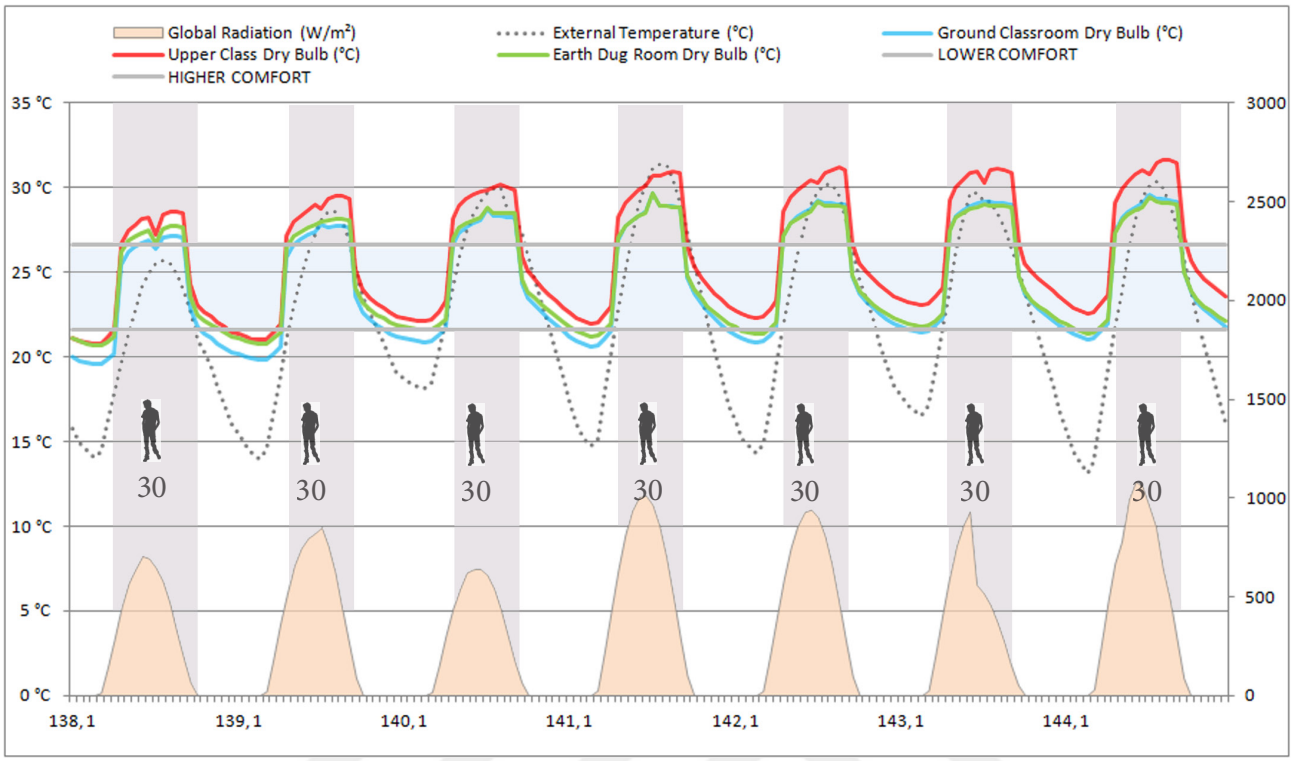


Graph 7. *Typical summer week ground floor classroom temperatures highlighting the effect of the internal gains*

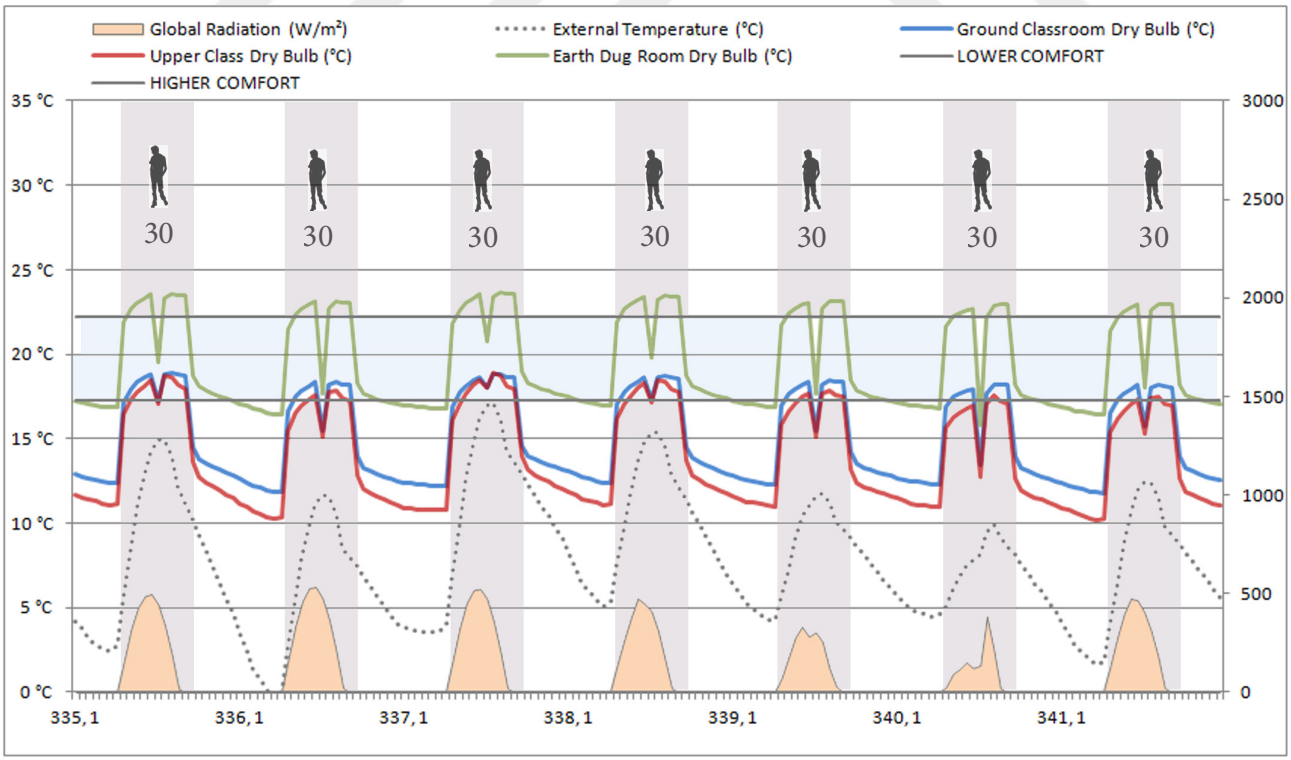
Figure 137. Upper Classroom South Elevation

Figure 138. Air Chimney

Figure 139. Upper classroom closed eyvan



Graph 8. *Typical summer week (138-144) temperatures (Source : TAS)*



Graph 9. *Typical winter week (335-341) temperatures (Source : TAS)*

One of the other ways to decrease the extra heat inside the classroom is the use of the eyvan space. Eyvan creates a constant air circulation, helping the adjacent spaces to cool down. In the existing condition the eyvan door has been glazed as opposed to its original open condition. This creates an even hotter space during summer and prevents the benefits of this eyvan space.

On the other hand, thermal mass is not the ideal strategy for winter. Although it still keeps the winter temperature more stable, the indoor air temperatures are not inside the comfort band. Although the solar gain from the windows help during the day, they create major heat loss during nightime. Only one in four sides of the walls is coupled with the eyvan; The over exposure of the envelope supports the heat loss rate. Conventional heating is applied in the existing condition. The school is heated by fuel oil which is on from the morning until the students leave. The heating loads required in order to fall inside the comfort zone can be seen on Table 7.

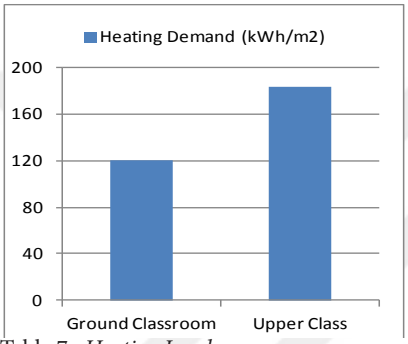


Table 7. *Heating Loads*

		w/m2		°C
U	54%	10.6	30	19
G	26%	8.2	30	19

Table 8. *Simulation Parameters*

Ground Floor Classroom

The ground floor classroom is less exposed than upper classroom. Only west elevation receives daylight although there are overshadowed windows on south facade. The advantages of sun obstruction can be observed in summer condition. Although the temperatures are still over the comfort band during class time, they are lower than upper floor. The solar gain is not the issue of overheating, but the internal gains raise the temperatures in great deal. The highest temperature is around 29 °C when the windows are open for ventilation. Ventilation is highly necessary for classrooms but the windows opening to the courtyard is not the best solution; the high air temperature immediately raises the inside temperatures. A cooler transitional space is much needed in order to provide the air exchange.

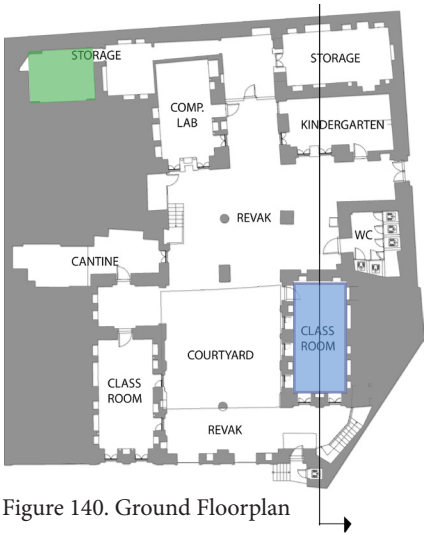
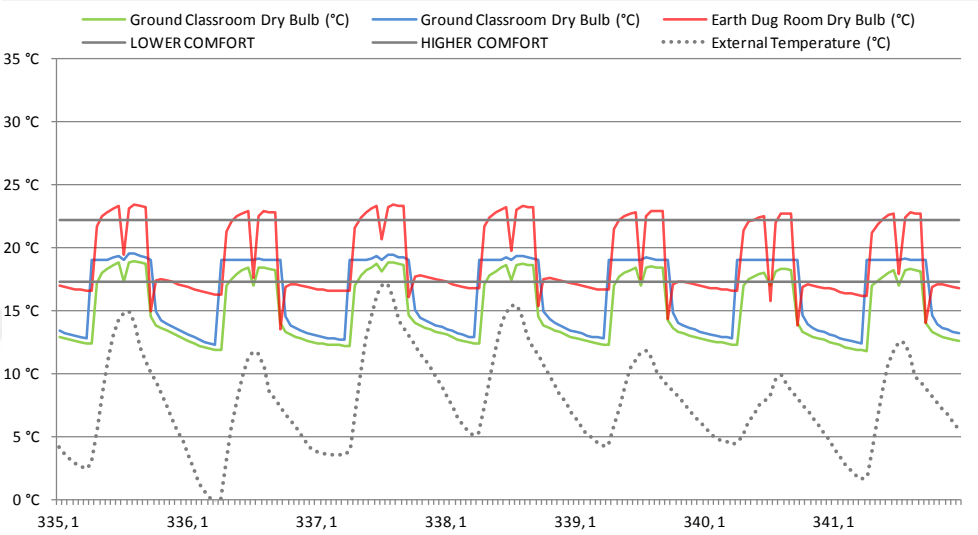


Figure 140. Ground Floorplan

Figure 141, 142. Ground Floor Classroom

The winter case is very similar to upper classroom with the internal gains. However the night temperatures are lower which means the free running case of ground floor classroom performs better than upper classroom. Internal gains help the indoor condition to go inside the comfort bad. With the help of conventional heating, the desired temperatures are achieved with less heating loads than the upper classroom.



Graph 10. *Typical winter week (335-341) temperatures with conventional heating at 17 degrees (Source : TAS)*

Earth Dug Room

During the simulations, the earth dug room was turned into classroom with the modification of the size and the application of internal gains. The fieldwork measurements showed that even when it is peak temperatures outside, the underground room is stable and cool around 22 °C. One hour of fresh air requirement is applied to the classroom during the lunch break and another hour after the students leave.

The ground temperature of Mardin is around 18 °C, and when couples with a classroom, it brings the temperatures down. When ventilation and internal gains are applied, the room still stayed windowless. And for summer this does not really make a difference in terms of thermal performance. Ground floor classroom performs almost the same with earth dug room. Therefore designing a classroom without direct solar exposure is an advantage either under or over ground.

In winter, earth dug room is the warmest room when internal gains are applied. One big reason for this is that there is a large amount of thermal mass, both soil and stone. Ground coupled on three walls, earth dug room benefits from the warm temperature of the soil. Therefore the cold air outside hardly infiltrates inside. Once the lunch hour ventilation starts , the temperature drop is drastic. Nevertheless window openings are definitely necessary for a classroom; roof lights could be an alternative without exposing the room to the outside air. In this case conventional heating is not needed, and not applied.

Ataturk Primary School

Materials

Ataturk Primary School was constructed in 1958 with load bearing ceramic blocks and concrete floors. The external wall thickness is 30 cm. The windows were renewed as PVC frame double glazing in 2001. The school requires often renovation which is a big issue for the school administration. They need to ask for budget to the government which is a long and stressful process in Turkey.

ATATURK		Thickness	Conductivity	U-value
		mm	W/m C	W/mK
External Wall	Plaster	10	1.73	
	Ceramic Brick	290	0.8	
	Plaster	10	1.73	
				1.84
Internal Wall	Plaster	10	1.73	
	Ceramic Brick	130	0.8	
	Plaster	10	1.73	
				2.9
Ceiling	Plaster	20	1.73	
	Concrete	270	1.83	
	Plaster	20	1.73	
				2.9
Floor	Plaster	20	1.73	
	Ceramic Brick	300	0.8	
				1.79
Double G. Window				1.84

Table 9. *Materials*

Figure 143. Ceramic blocks

Figure 144. Flooring

Figure 145. PVC windows

Figure 146. Fluorescent Lamb

Internal Gains

30 students were added as the occupancy gains to the basement and upper floor classrooms. Using the number of students a minimum fresh air requirement is calculated for each zone as 10 litres per second per person. The remaining information about the rest of the gains are in Table 10.

The upper and basement classrooms are picked in order to see the performance difference between floors.

Envelope Exposure
Upper Classroom : 53%
Basement Classroom: 20%

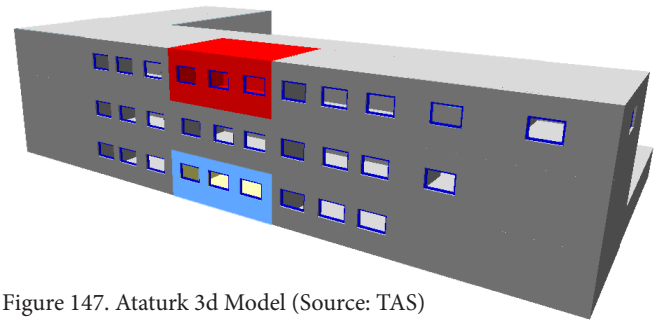


Figure 147. Ataturk 3d Model (Source: TAS)

ATATURK	Room	Volume(m3)	Area(m2)	min air quality (10lb)	Occupancy				Lighting	
					Sensible (W)	w/m2	Latent (W)	w/m2	Lighting (W)	w/m2
	Upper Classroom	120.5	38.25	8.962655602	2100	54.90196	1350	35.29412	450	11.76471
	Basement Classroom	109	38.3	9.908256881	2100	54.83029	1350	35.24804	450	11.74935
	Upper Corridor	390	124	9.230769231	7500	60.48387	7000	56.45161	240	1.935484
	Basement Corridor	322	109	11.18012422	7500	68.80734	7000	64.22018	240	2.201835

Table 10. *Internal Gains*

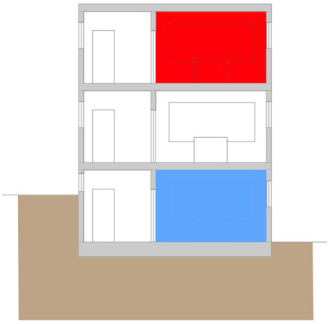


Figure 148. Cross Section

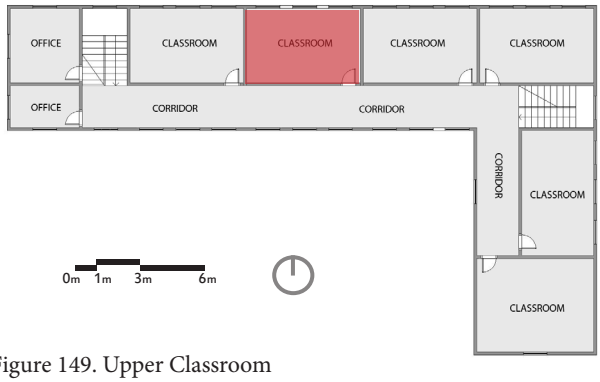


Figure 149. Upper Classroom

Upper Classroom

The overheating problem observed during the measurements is even higher when internal gains are added. At times the temperatures tend to go above 35 degrees . This classroom is definitely an unpleasant environment for children. Although the thermal mass of ceramic blocks stabilizes the temperatures (source :Fieldwork measurements), they are still; above the comfort band as empty classrooms.

In the July measurements, it was observed that opening the door to the north side corridor, drops the temperatures. The fresh air ventilation could be provided from the corridor which could also cool the classrooms. The south facing windows is only good for night ventilation. Graph 11 proves the point by comparing the upper classroom with the north facing corridor. During school hours air exchange with the corridor space would bring the temperatures down to the comfort zone.

As opposed to summer, the winter condition is more favourable in case of the upper classroom. Despite the slight overheating, the classroom manages to stay inside the comfort zone during occupation hours. The temperatures would have gone much higher, but the fact that the classroom envelope is more exposed, increases the heat loss ratio of the space. While the glazing allows free heat gain, the uninsulated roof exhausts the heat.

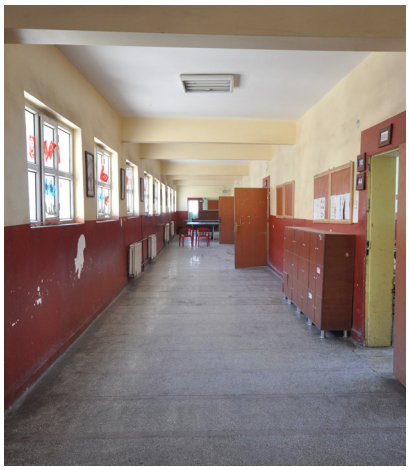
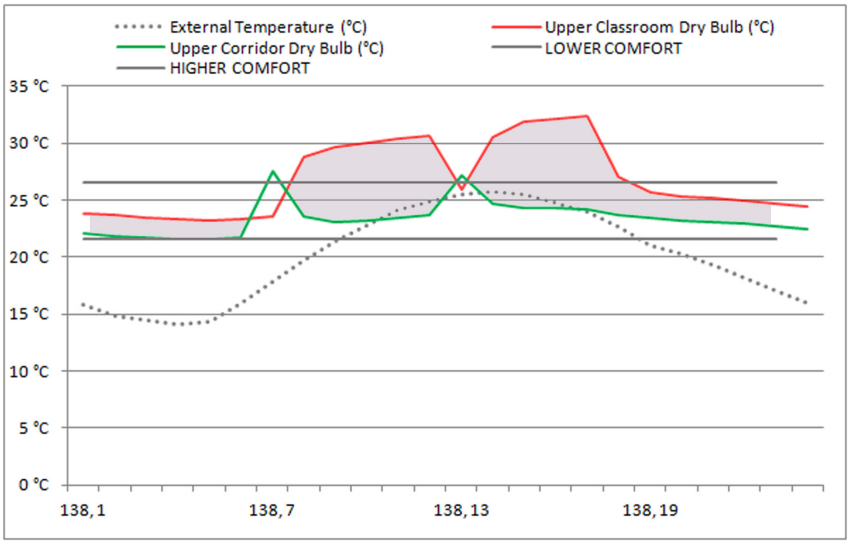
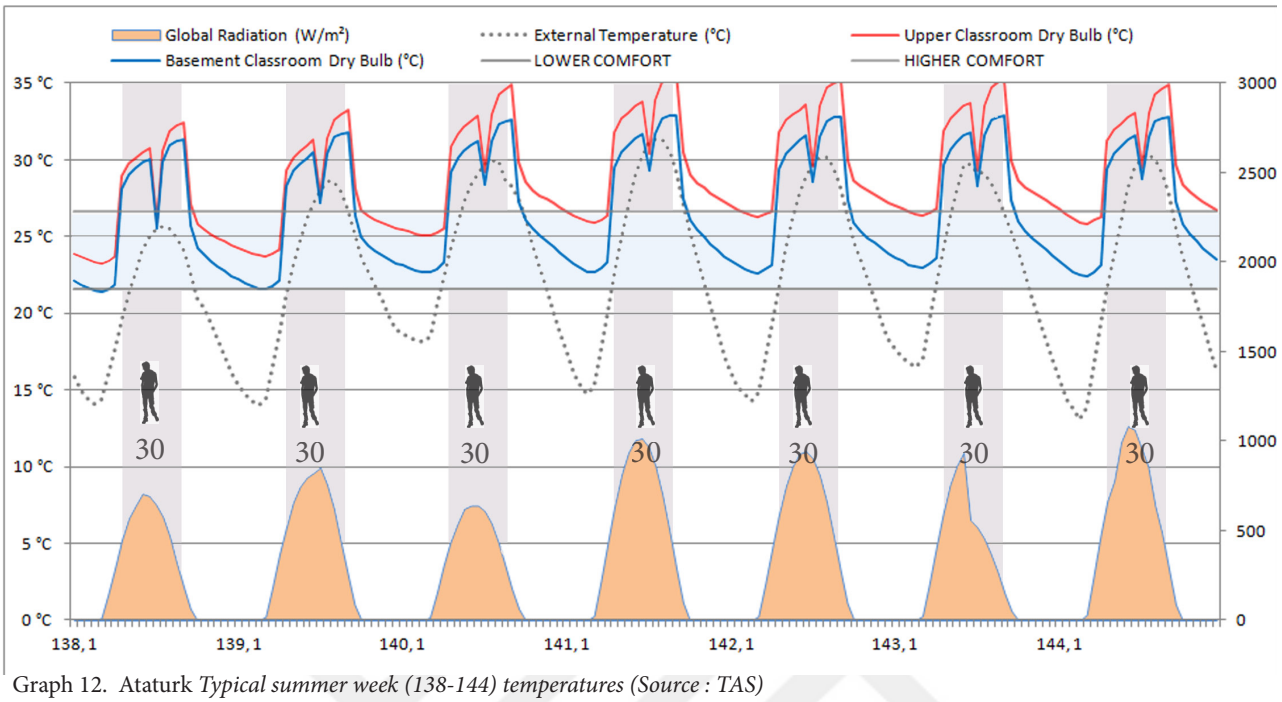


Figure 150. Upper Classroom Corridor



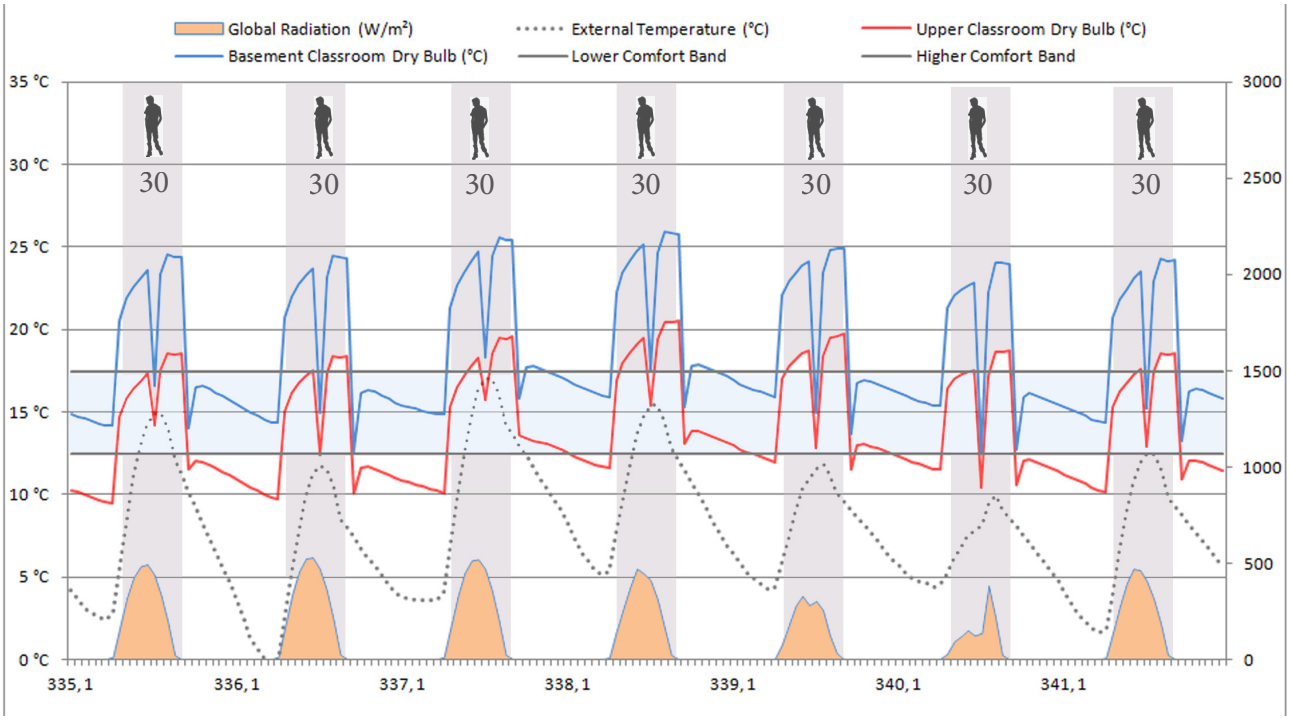
Graph 11. *Typical summer day temperatures highlighting the corridor and classroom temperature difference (Source : TAS)*



Graph 12. Ataturk *Typical summer week (138-144) temperatures (Source : TAS)*

		w/m2		ach
Upper Classroom	54%	10.6	30	9
Basement Classroom	26%	8.2	30	10

Table 11. Simulation Parameters



Graph 13. Ataturk *Typical winter week (335-341) temperatures (Source : TAS)*

Figure 151. Basement Corridor

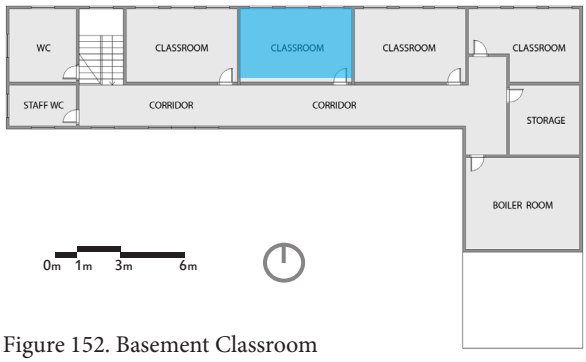


Figure 152. Basement Classroom

Basement Floor Classroom

The basement classroom is less exposed than upper classroom. Overheating is observed during summer slightly better condition than upper classroom. The unpleasant thermal condition inside is improved by cooling the space with night ventilation and shading the windows to prevent direct solar radiation. Graph 14 indicated the improved condition of the classroom with the simulations. Another advantage of this floor is that the north corridor side is ground coupled, this reduces the temperatures during summer.

The sun hits the southern windows directly during winter due to the slope of the site. Therefore a great amount of overheating is observed inside the basement classroom. The temperatures go above 25 degrees at times. The school uses fuel oil for heating. When heating is applied to the simulations, the cooling demand goes higher than the heating demand. The volume of the classroom is another factor in this condition. The ceiling height is suitable for housing, which is what this construction refers to, however for classrooms the volume is very important in terms of fresh air ventilation and cooling.

Also in this case the corridor plays an important role in the design. These transitional spaces are widely used for cooling ventilation or heating. The heated or cooled air is transferred to the adjacent classroom space by means of ventilation.

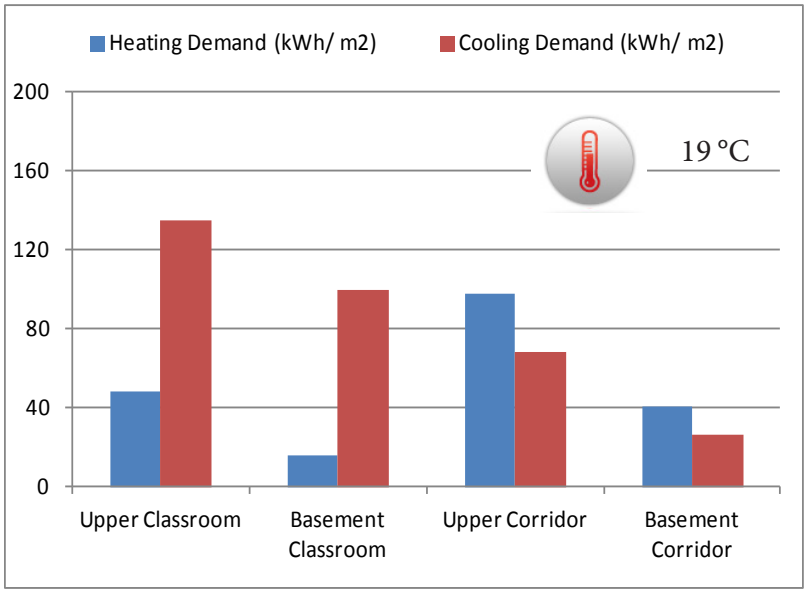


Table 12. Ataturk Heating Loads

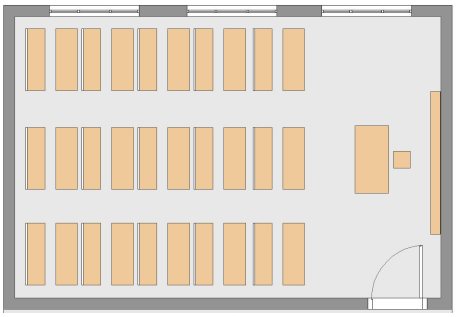
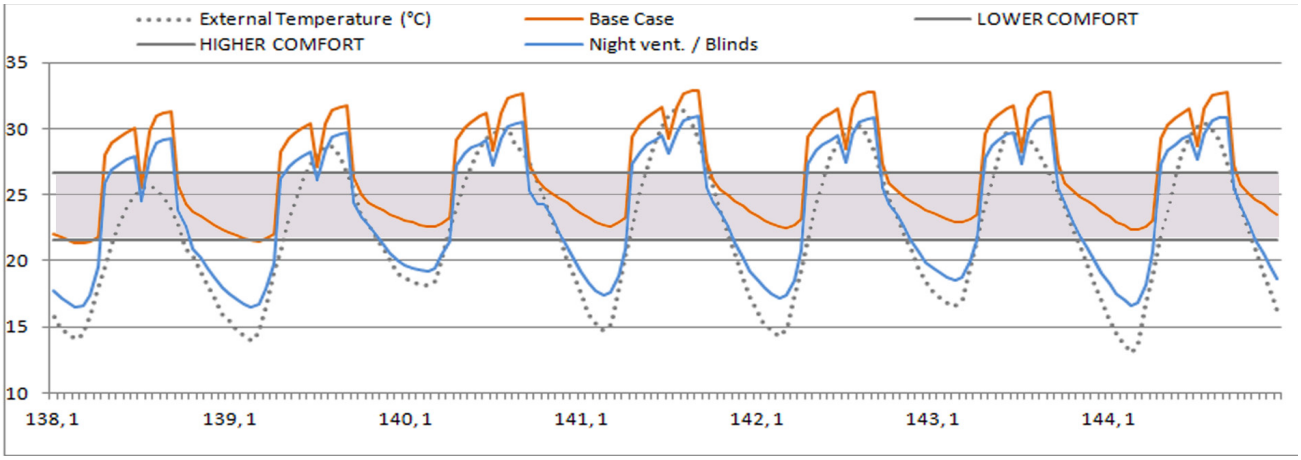


Figure 153. Basement Classroom

Figure 154. Basement Classroom



Graph 14. Temperature improvements through Night Ventilation and Shading Simulations *(Source : TAS)*

Conclusion

- Ground coupling stabilizes the temperatures. The constant ground temperature cools down the adjacent space in summer and warms in winter.
- Thermal mass is good for summer but creates problems in winter. Insulation is necessary for winter. The amount of insulation needs to be controlled considering summer conditions.
- Less envelope exposure means less heat loss rate in winter which is an advantage. It also showed better summer thermal conditions.
- The glazing on south should be avoided in summer and winter. If south glazing is inevitable, summer sun should be obstructed.
- Transitional spaces in hot-dry climate is beneficial for cooling and fresh air ventilation. These spaces are used for circulation and rarely occupied which keeps the temperatures cool in summer.
- The use of eyvan as an entry space is good for spatial transition for students. Additionally environmentally eyvan space is necessary for a school building
- The corridor space is good for classroom ventilation because it provides cooler air than the outside.
- Courtyard building type makes the school environment more lively. Courtyards provide the necessary play areas for children. The courtyard dimensions of Gazipasa primary school is ideal for thermal conditions.

Daylighting

Gazipasa Primary School- Upper & Ground Floor

Figure 155. Upper Classroom West Elevation

Figure 156. Upper Classroom West Elevation

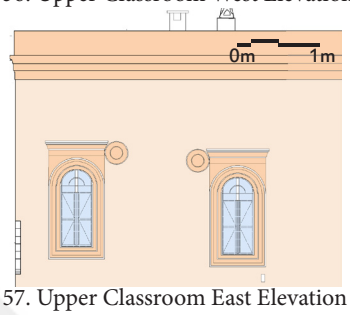


Figure 157. Upper Classroom East Elevation

Upper and Ground Floor classrooms daylight condition has been investigated through Radiance program. There is a major difference between two floors. The upper classroom is highly glazed and exposed whereas the ground floor classroom is shaded by the courtyard. The upper classroom is exposed and glazed on three facades (East, West and South facades) Firstly a classroom needs evenly distributed daylight for every student. Upper classroom receives different intensity of daylight from three orientation which cause uneven daylight distribution. Both summer and winter illuminance values are suitable for classroom conditions. Minimum illuminance is observed 300 lux in December. On the other hand in May this number goes up to 1000 lux. The daylight is excessive for comfort, and it is a disadvantage for both thermal and daylight conditions.

Upper Floor Classroom

Window Area: 12.40 m2
Window to floor ratio : 54%

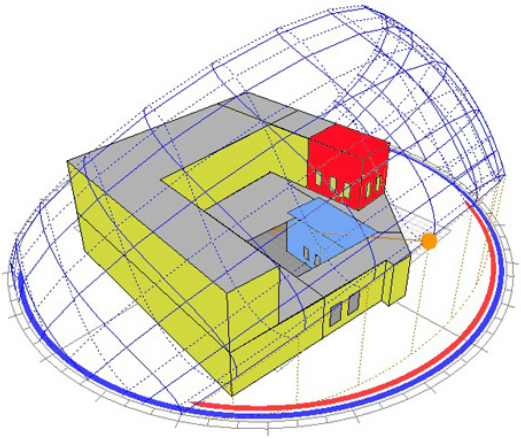


Figure 158. Annual Solar Path (ECOTECT Solar Tool)

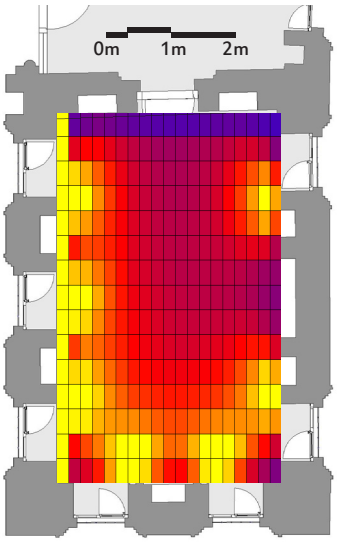


Figure 159. *Upper Classroom 21 December Illuminance (Source: Radiance)*

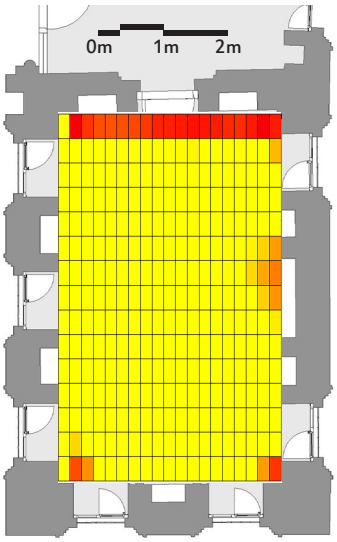


Figure 160. *Upper Classroom 21 May Illuminance (Source: Radiance)*

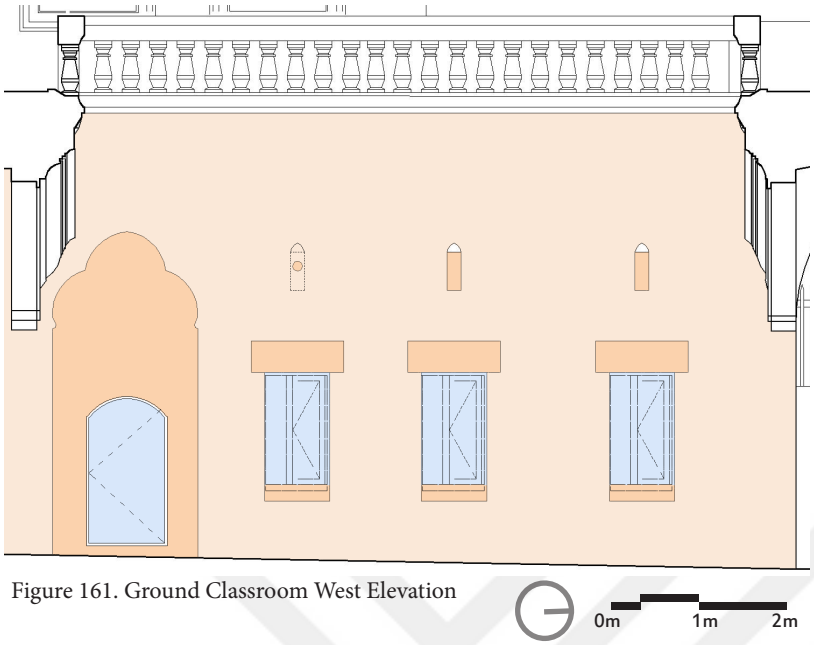


Figure 161. Ground Classroom West Elevation

Figure 162. Ground Classroom East Elevation

Figure 163 -4. Ground Classroom South and West Glazing

Window Area: 7.20 m2
Window to floor ratio : 26%

Ground Floor Classroom

The ground classroom on the other hand has very poor daylight. Both summer and winter conditions are not suitable for required classroom illuminance (300 lux) The classroom is exposed and glazed on south and west facade. The south facade is always shaded while west facade provide a small amount of daylight to the western perimeter of the classroom. The rest of the room lux value is between 0-150 lux. The classroom thermal conditions are better than upper floor, and more carefully placed glazing would improve the daylight conditions.

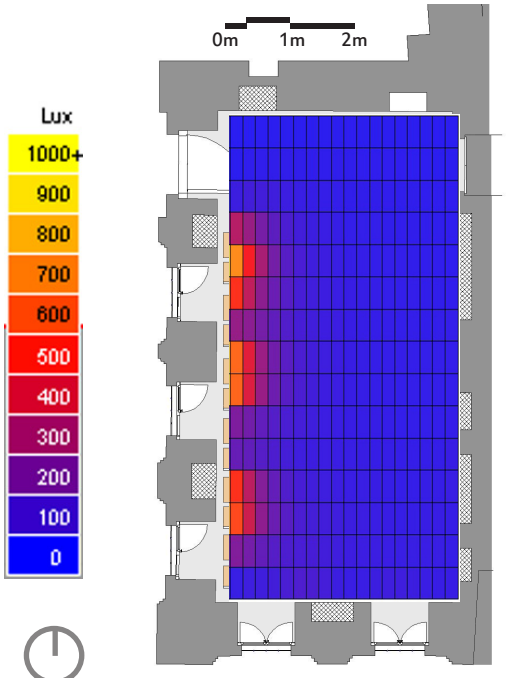


Figure 165. *Ground Classroom 21 December Illuminance (Source: Radiance)*

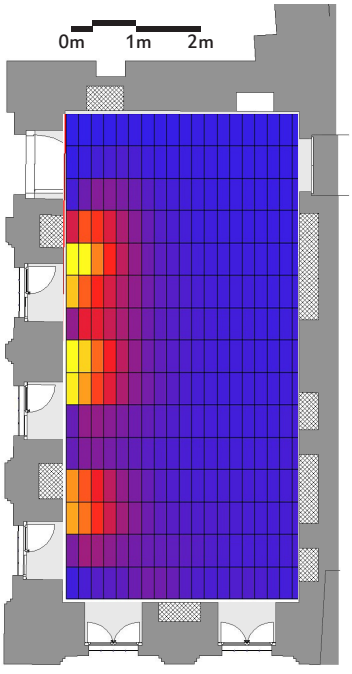


Figure 166. *Ground Classroom 21 May Illuminance (Source: Radiance)*

Ataturk Primary School- Upper & Basement Floor

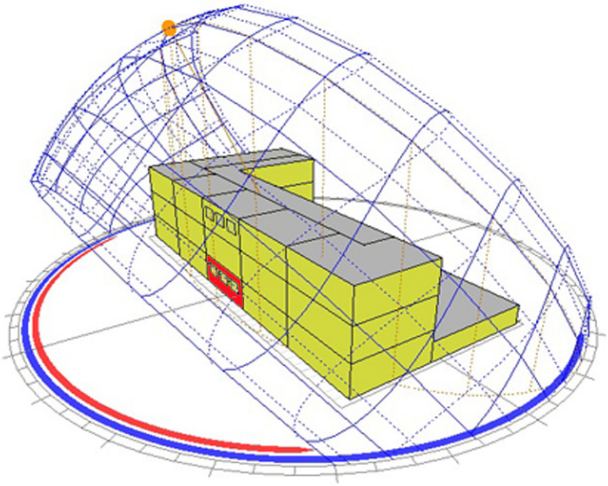


Figure 167. *Ataturk Annual Sun Path (ECOTECT Solar Tool)*

Figure 168. *Basement Classroom*

Figure 169. *Basement Corridor Glazing*

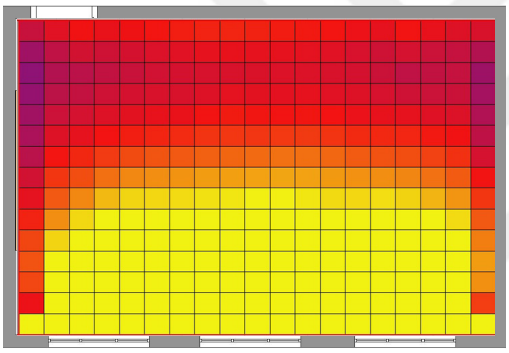


Figure 170. *Basement Classroom 21 December Illuminance*

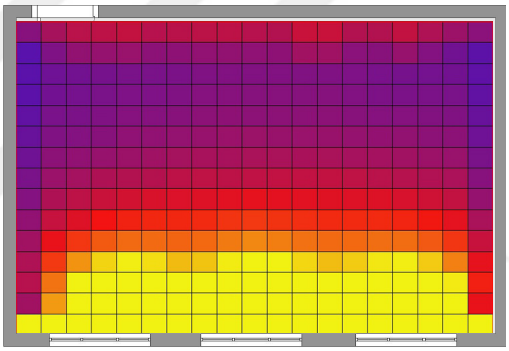
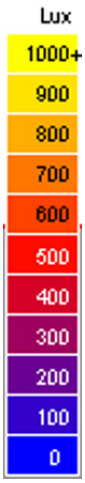


Figure 171. *Basement Classroom 21 May Illuminance*



Both schools' daylight was measured on the desk height level because that is the level the students need daylight on most of the time. Almost every classroom in Ataturk has a facade oriented to south. The solar gain from south glazing was observed to cause overheating and needs to be resized. The winter lux values are higher than summer. This is because the solar rays do not hit the windows directly in summer. In both cases the illuminance is suitable for classroom in terms of lux values, but the distribution is an issue again. Daylight does not reach until the north side of the classroom although the width is only 5 meters. The desks closer to the south facade has glare problems because the lux values go above 1000 lux.

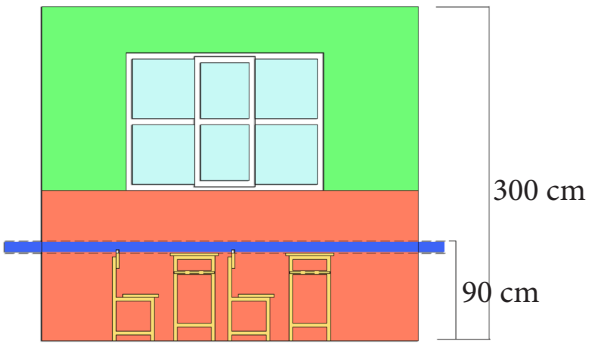


Figure 172. *Classroom, indicating the height of analysis grid*

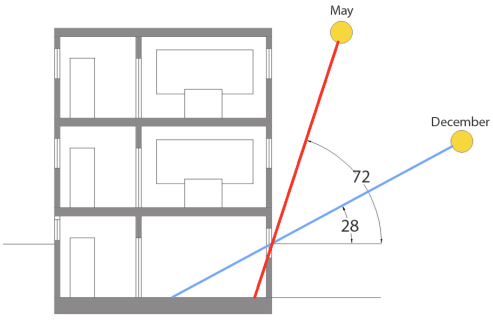


Figure 173. *Section indicating solar rays*

Conclusion

- Glazing sizes should carefully be designed to suit both thermal and daylight conditions
- Daylight should be distributed evenly throughout the classroom.
- The glazing on south should be avoided in summer and winter. If south glazing is inevitable, summer sun should be obstructed once the heating months (October-April) are over.
- If the classroom envelope is shaded, roof light will be proposed.

DESIGN

DESIGN BRIEF

Location: New Mardin City
Site Description
Zoning of Spaces

PRIMARY SCHOOL

Design Proposal
Modular System
Spatial Organization

PRIMARY TEACHING UNIT

Design Proposal
Classroom
Eyvan
Revak
Layout Variations

ANALYTICAL WORK

Daylight Analysis
- Background
- Daylight Simulations

Thermal Simulation Study
- Occupancy
- Internal Gains
- Materials
- Winter & Summer Conditions
- Layout Variation Simulations

CONCLUSION

Figure 174. *Aerial View of New Mardin*

DESIGN BRIEF

For the design stage of the project, the site was moved to the new city of Mardin which is located on north west of old Mardin City. The city has settles on a grid system over the years. Because the building code allows maximum 6 floors for buildings, the builders have been taking full advantage of it. The parameters needed in order to build a sustainable city in such climate have been ignored for the sake of fitting large densities in the city. More and more people move to new Mardin in order to benefit the job opportunities of a modernized city.

The site is located on the north border of the city where the newest settlements are. The area is under constant developments with very few buildings. The architectural aim of the project is to shape and inspire the upcoming developments around the site by building a sustainable building which is respective to its environmental and social aspects. The inspiration is the research that has been done so far in the dissertation, particularly the vernacular architecture of Mardin.

Location- New Mardin City

Most buildings in the new city are 6 floors or less due to the building code. The climate is similar to the old city except for the wind availability .The temperatures in the old city is usually 2-3 degrees less due to the wind that emerges from the slope of the city.
The grid system which is blindly followed from the western world, separates the buildings, the pedestrians and the car roads distinctly. This kind of settlement is not necessarily ideal for the hot-dry climate of Mardin. The high rise buildings stands detached on the designated blocks, with certain distance from the other buildings. This creates a great deal of envelope exposure to the sun and eventually overheating.

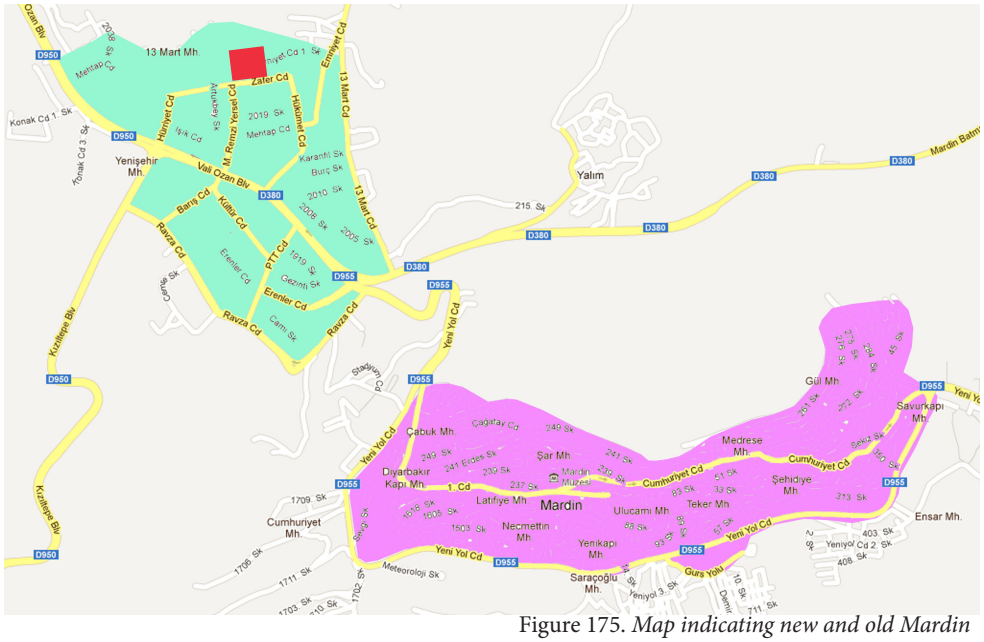


Figure 175. *Map indicating new and old Mardin*

Figure 176. *Urban texture of old Mardin*

Figure 177. *Urban texture of new Mardin*

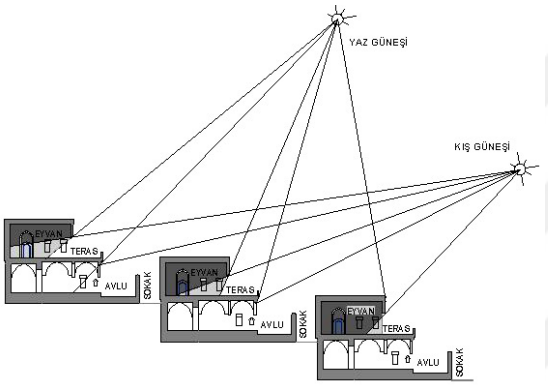


Figure 178. *Solar exposure of vernacular Mardin houses*

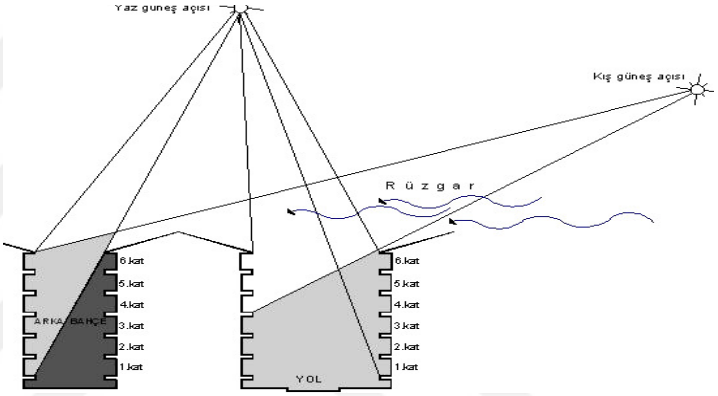


Figure 179. *Solar exposure of new Mardin houses (Karagulle ,2009)*

Unlike old Mardin, the new city texture arose from the aim to allow cars travel in and around the city. Therefore the wide roads built for this purpose increase the heat capacity of these spaces. The glazing of the store windows on the street level is another factor that heats up the city a few more degrees compared to the vernacular examples. The correct example for this climate is in the vernacular example where narrow streets have minimum glazing on the street level.

Despite the rare hills around the city, it is quite flat as opposed to the old Mardin city. Therefore the buildings require a certain distance from each other in order to provide daylight and wind to all the floors. But this is not the case in the new city. The plots were divided without the consciousness of this environmental strategy. The wind availability in old Mardin creates the dynamics of transitional spaces. The high rise buildings in new Mardin obstructs the wind and sun light to reach all the units (Figure 179)

The view of southern plains in the old city is a very pleasant and important aspect of the old city. The buildings are oriented to south for the view, and despite the environmental disadvantages the glazing ratio was maximised. When it comes to the view at the new city buildings, it is not as pleasant. Because most buildings are high rise, they either have a view to the neighbour buildings or to empty ,soon to be constructed plots.

Figure 180. *New Mardin streets*

Figure 181. *New Mardin aerial view*

Figure 182. *View from a New Mardin house*

Main aspect of the spatial organization in vernacular architecture is the transition between the public and private. The climate characteristics and social background requires a sense of privacy. Therefore a open and semi-open transitional spaces are very crucial elements of vernacular settlement. On the other hand in the new city the buildings mostly consist of closed spaces. There are no open or semi-open spaces in the buildings except for the balcony which is mainly there for the view. A recent study shows that 90% of a building in new city consists of closed spaces. Because of this case, the summers are overheated and conventional cooling is a necessity for comfortable conditions.

The common building form in the new city is the closed rectangular box. This form and the compact internal layout is good for storing the heat. However the buildings are placed with wide distances in between which increase the heat loss rate of the building. The construction is concrete skeleton filled with hollow ceramic blocks. The roofs tilted roof are built without insulation which tempts the immediate heat gain and heat loss. Recently the buildings are externally insulated for more comfortable winter conditions. This increases the discomfort the occupants are having in summer due to the overheating.

Design Parameters to Follow in the New City Mardin

- Placing the building so that every floor receives unobstructed daylight and is exposed to the wind.
- For a classroom view is very important. Because the views around the city is not desirable daylight can be provided from the roof while the view windows could face inside the school premises.
- The climate requires the transition between the closed and open spaces. The open and semi-open spaces should be brought back from the vernacular architecture. A school can benefit from the use of these spaces in terms of ventilation, circulation and seasonal teaching spaces.

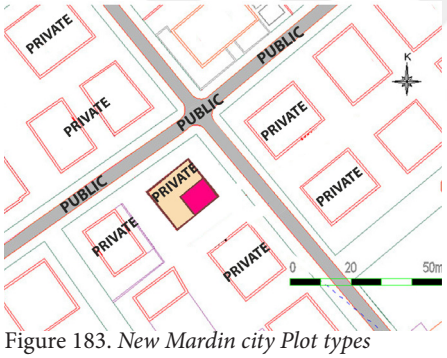


Figure 183. *New Mardin city Plot types*

- The construction technique should be improved to fit the climate.
- Both summer and winter thermal conditions should be considered during the design stage.
- Less floors perform better in order to benefit from the cooling of the ground

A new type of flexibility should be proposed in order to put together the compactness of the contemporary buildings for winter, and openness of the courtyard buildings of vernacular architecture for summer.

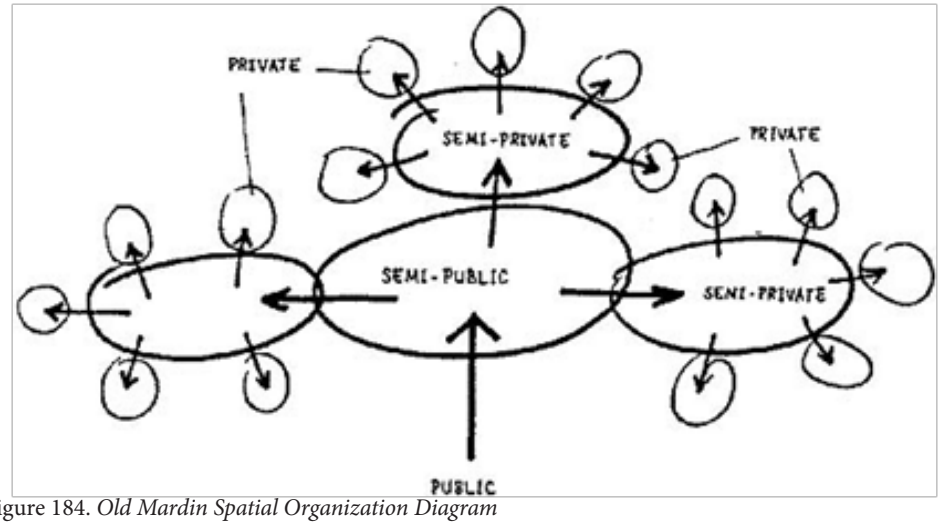


Figure 184. *Old Mardin Spatial Organization Diagram*

Figure 185. *Proposed site*

Site Description

The site that is chosen in the new city Mardin is located outskirts of the city where recent buildings are being constructed. There is an existing primary & secondary school on the site which is a corner plot of a road intersection. The site is 80 meters wide and 120 meters long. The prevailing wind is South and Southwest, and the site is almost a north-south orientation.

The primary school children are taught in the same building with secondary school in Turkey. Although the spatial organization of the school will include both of them, the *focus* of this project is *Primary School Classroom.* There is an existing school building on the site. The building is five storeys with a lot of open spaces around. Following the case study thermal analysis, the proposed design is aimed to be single storey. The one storey school complex will be distributed over the site. The second parameter for the proposed design is that it will be underground. The thermal studies concluded that ground coupling is an advantage for summer and winter conditions. The only disadvantage would be not having a view to the surroundings. Because the settlement around the site is not the most pleasant view, the problem is eliminated.

Design of the site plan layout benefits from the parameters of vernacular architecture.

- The first step is to determine the spaces needed for a typical primary & secondary school. These spaces will be categorized under separate zones where children could circulate around according to the needs.
- Second step is the modular system where the closed, open and semi-open spaces of a specific zone is layout out on a grid system. (Refer to Chapter 2, Modular System)
- The third step is to determine the necessary connections between zones in order to create an education town environment for the students. Primary school is the place where children spend the majority of their time for five years. In addition to the lessons learned inside the classroom, school environment is another strong element which shape a child's character. School buildings are small scales cities for children to get education, have meals, play during breaks, socialize and be creative. Therefore another perspective to a school's spatial organization would be the investigation that has been done about the vernacular city, old Mardin. The crucial elements to consider are,

  - Narrow streets with minimum glazing in order to create shaded pathways so that the circulation around the city is thermally comfortable in summer and winter
  - Dense settlement with introverted courtyard buildings where open and semi-open spaces are small scale. These spaces are easier to shade in summer and open to solar exposure in winter.
  - The intersections, arched walkways cutting out buildings, transitional spaces connecting separate buildings are ideal spaces for small scale communal areas.

Zoning of Spaces

The Layout of a school is initiated with the zoning of spaces. Some school examples in Turkey the spaces are zones purely according to the function. Certain rooms only function as classroom whereas the art room has specific dimensions. But many other public schools are built with rooms that are similar dimensions, and later these spaces have different functions over the years. Zoning of the proposed design will be separated according to the internal gains and age range .The sense of circulation and change of space is crucial for a student so that he or she can learn the perception of home and city inside the school building by communicating different age range students in between zones. The zoning is prepared including the required closed spaces for a primary and secondary school.

ZONE 1 - Administration
1. Entrance
2. Ceremony / Meeting Space
3. Gymnasium

ZONE 2 - Primary School
4. Private Tutoring Rooms
5. Teaching Units
6. Teachers Lounge
7. Art / Music Room

ZONE 3 - Secondary School
4. Private Tutoring Rooms
5. Teaching Units
6. Teachers Lounge
8.Science Lab

ZONE 4 - Public
9. Cafeteria / Canteen
10. Library
11.Computer Lab

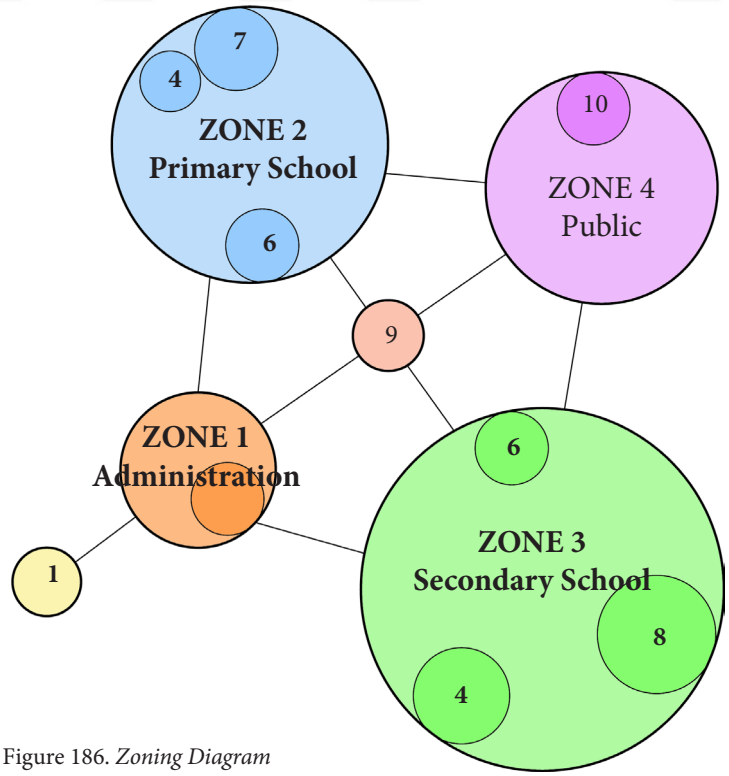


Figure 186. *Zoning Diagram*

Once the four zones are created with the age and occupancy parameters, the spaces inside these zones would be determined by student activities. These spaces will be created by a modular system which brings together several units designed according to the student activity. The type of activities to create these units include, sitting down or light activity during the scheduled classes, break time activities such as standing or running and finally the ceremonies where the national anthem and oath. (Figure 3) Therefore the design process could be divided into three different scales of units in order to show the development more clearly.

Figure 187. *Seated students*

SMALL SCALE
Teaching & Private Tutoring Units

Spaces: Classroom & Eyvan & Revak

Activity: A classroom activity would vary from seated to standing, sedentary work (1 - 1.2 met)

Occupancy : 25 students per classroom

Figure 188. *Students playing in break-time*

MEDIUM SCALE
Primary School Zone

Spaces: Teaching units & Teachers Lounge & Art and Music Room

Activity: The break time activity in the open - semi-open spaces vary between standing to sport activities. (1.2 - 6 met)

Occupancy : 450 students

Figure 189. *Students during daily ceremony*

LARGE SCALE
Primary & Secondary School

Spaces: ZONE 1 & 2 & 3 & 4

Activity: The ceremony activity in the open - semi-open spaces vary between standing to sport activities. (1.2 - 6 met)

Occupancy : 1000 students

The first and main focus of the dissertation is the teaching units where students spend most of their school time. Once this unit is determined the spatial relationships between these units would be solved in order to form the primary school zone. And finally the school complex idea will emerge putting together all the units.

PRIMARY SCHOOL ZONE

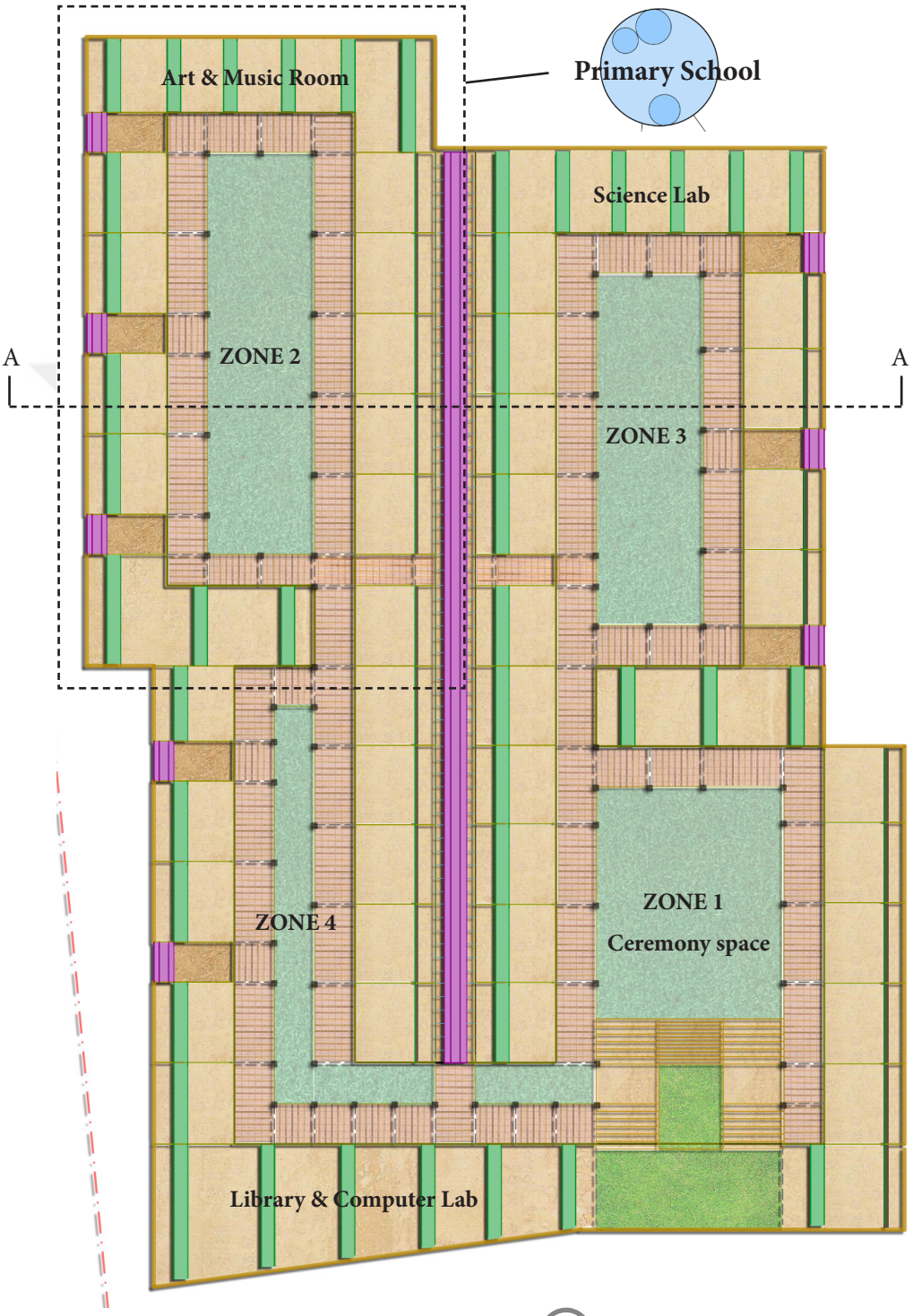


Figure 190. *Proposed Site Plan for School Complex*

Modular System

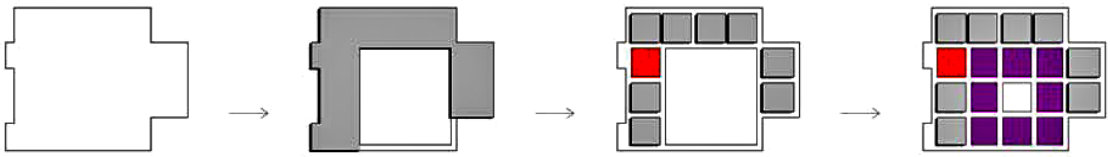


Figure 191. *Steps of Modular System*

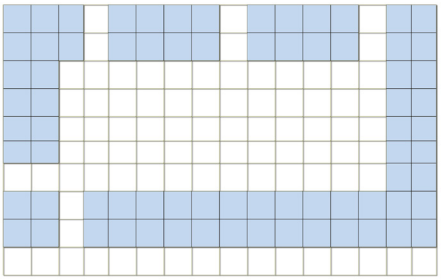


Figure 192. *Closed Spaces (Classrooms)*

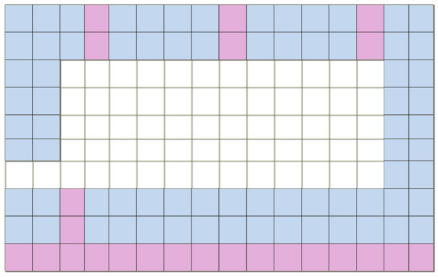


Figure 193. *Semi-open Spaces (Eyvan)*

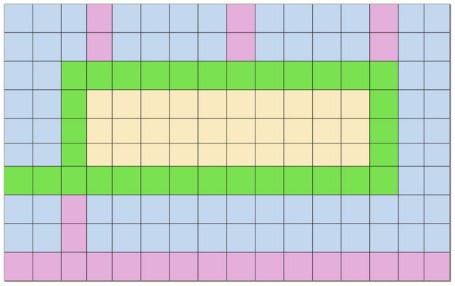


Figure 194. *Semi-open Spaces (Revak)*

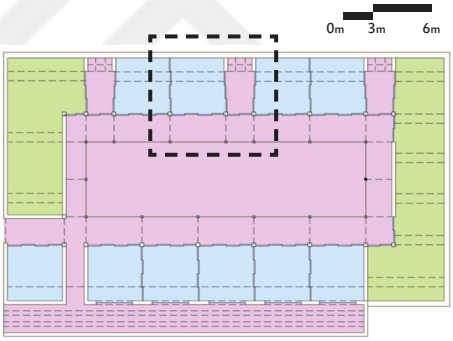


Figure 195. *Primary School Floorplan*

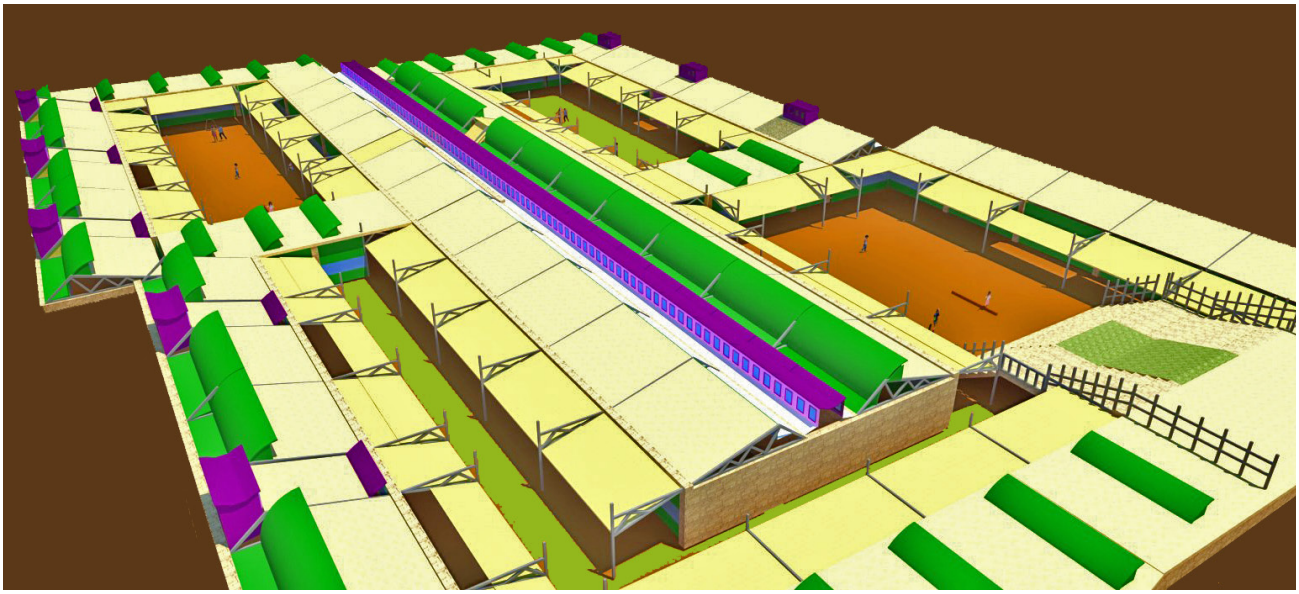


Figure 196. *Aerial view of the School Complex (Source: V-Ray)*

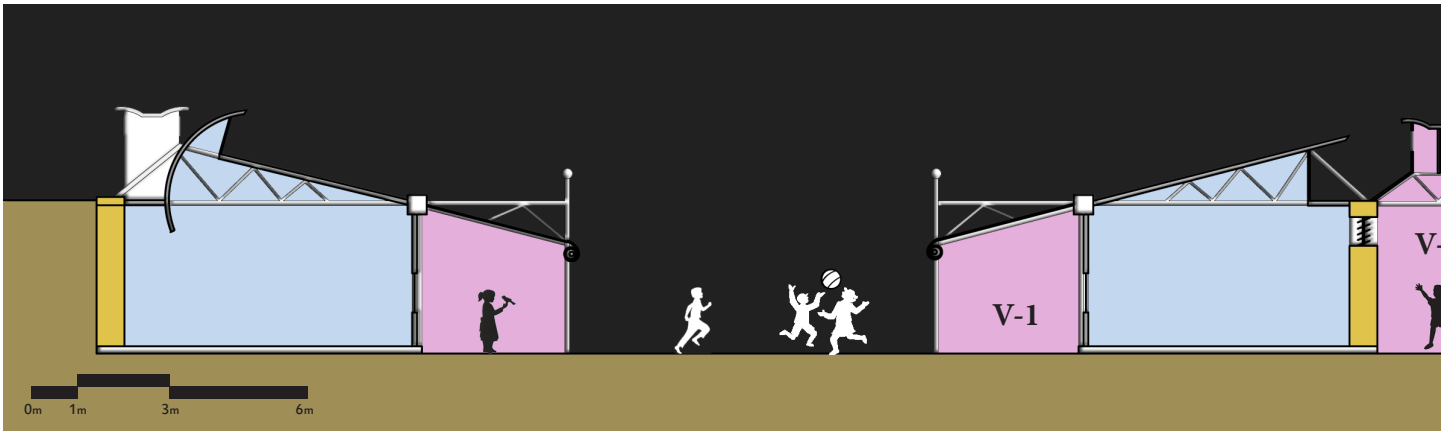
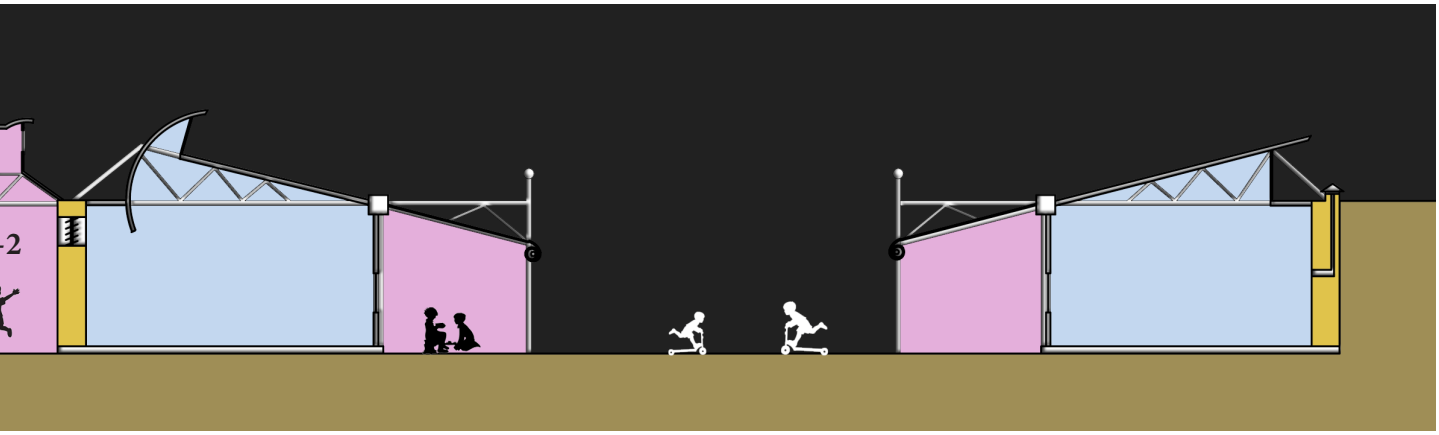


Figure 197. *Site Section A-A*

Spatial Organization

Chapter 2 discussed how building forms are created. The starting point is to organize the spaces on the site by using the modular system. (Figure 191) 1/4 of the site is divided into 3x3m grid system. First the closed spaces (classrooms) are laid out on the parameters. For the units where north facade is ground coupled, one eyvan space is created for two classrooms to share. The opposite orientation classrooms are coupled by a long eyvan instead of ground. Therefore the north side consists of classrooms and eyvans side by side, whereas south side classrooms are adjacent to each other by coupling with a long eyvan on southern facade. Classrooms provide ventilation from these spaces, and they also serve as secondary classroom or activity areas. The last step of the modular system is to lay out covered revak spaces for shaded circulation.

Figure 198. *View to the courtyard from revak corridors (V-1)*



Once the primary school zone is created, other zones are similary laid out in order to design the school complex. (Figure.190) The school consists of 4 courtyards for each zone. A typical couryard is 8 meters wide which was refered to Gazipasa courtyard dimensions. This dimension proved to work well by letting good amount of sunshine for winter. For summer small scale courtyards are ideal.

The school complex is a combination of closed, open and semi-open spaces. The main idea is to be able to adapt these spaces for school activities including lecturing. In addition to their environmental aspects, transitional spaces are placed for break-time activities or extensions to classroom spaces. The teaching units can occupy between 25-30 students. The entire school can occupy 1000 students. Now that the school complex is formed, the investigation goes back to the smallest scale, teaching unit.

Figure 199. *View through the long eyvan (V-2)*

PRIMARY TEACHING UNIT

Mardin city and the surrounding settlements are in constant growth for several years. The demand for schools is increasing greatly and the government is having difficulties meeting it. Almost all around South-east Turkey there is a large number of students compared to the number of school buildings. Therefore even though the classrooms are designed well , the density diminishes the pupils efficiency in school. 3 students occupy a 2-person desk, and the classrooms are crowded.

Apart from the density issue, the demand for teachers is also quite high. Because of the harsh climate and transportation problems, teachers do not prefer South-east assignments. One of the interesting solutions observed around the area is that one teacher is assigned for several grades. For instance in a village primary school outside of Mardin, there is only one classroom for 5 grades. The classroom layout is divided into 5 rows of desks where each row belongs to one grade. (Figure 201)

Figure 200. *Multi-grade classroom in Southeast*

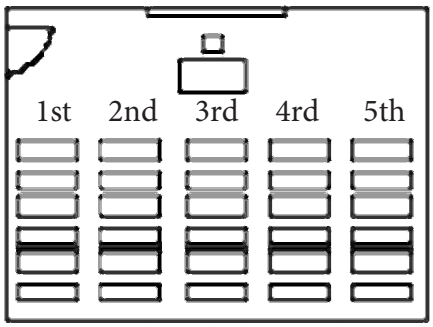


Figure 201. *Multi-grade classroom plan*

The problem of density will continue for many years as the area continues to develop. Constant growth means constant change to the social elements and the density of the area. Therefore the ideal dimensions for a classroom can never be estimated as the numbers change over the years. But a classroom that is able to adapt its dimensions to the population change would be the ideal solution.

Another issue is that the classrooms have been designed according to a fixed internal layout for several decades: a rectangular classroom where one side has the board and the teacher seat, and the rest of the seats facing to that wall. The locations of the students is fixed and difficult to modify. However recent developments in classroom design suggests a level of flexibility inside the classroom where children could modify the internal layout according to the activities. As the various classes such as science, art, grammar, require different kind of concentration, the various layouts of seating would be much more efficient for a child's learning process. One of the concepts Mark Dudek came out with is " the Home Base" teaching unit. (Background, Pg.26) The school building consists of several of these units where the spaces are not defined permanently in order to leave the choice of limitation to the teacher and the students.

The solution to the density problem lies on the flexibility of spaces. The demand for enough teachers for schools in Mardin will continue to be a problem. The most primitive solution was observed in a village classroom where students in different grades are taught by one teacher in one classroom. The teacher teaches a theory lesson to the 1st grade while letting other students do the required exercises given by the same teacher. Of course this extreme situation is not efficient, but the idea of one teacher taking care of multiple classrooms is the starting point of the design proposal.

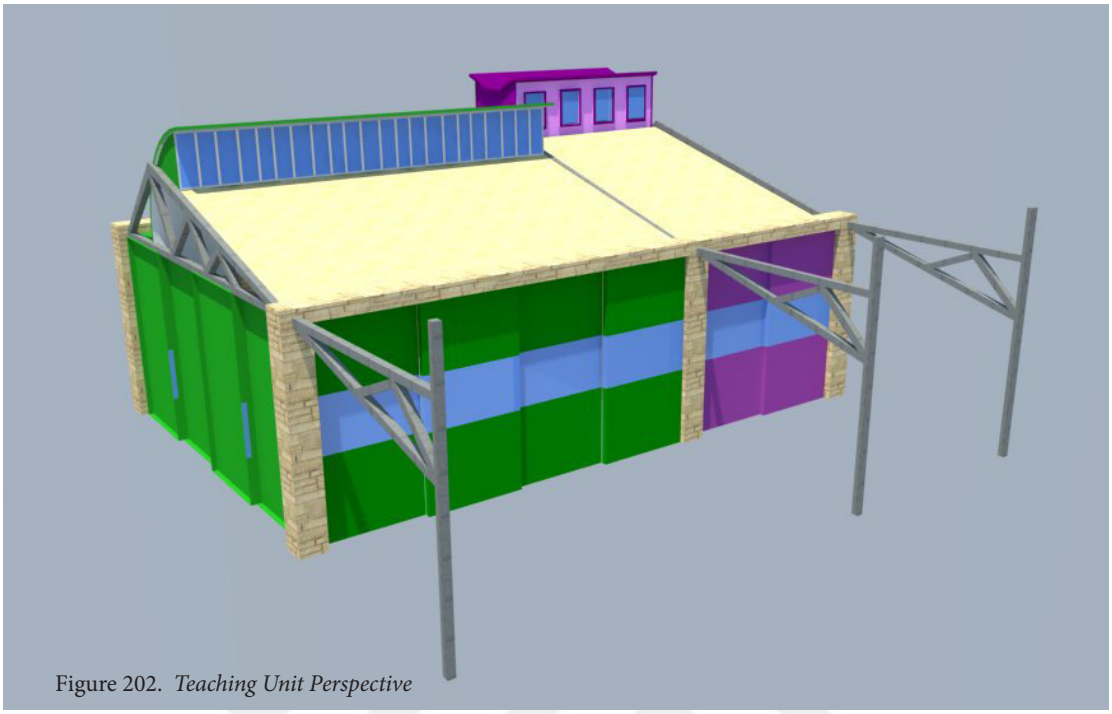


Figure 202. *Teaching Unit Perspective*

Therefore a teaching unit is created where a classroom ,eyvan and revak space is put together. The structure is fixed whereas the walls are movable so that various dimensions can be emerged depending on the activity and density of the classroom. The base case of this unit is where classroom is used for teaching, eyvan for entry and private tutoring and revak is for circulation. Revak is covered by a local fabric sheet which could be removed in winter for more exposure to the solar radiation.

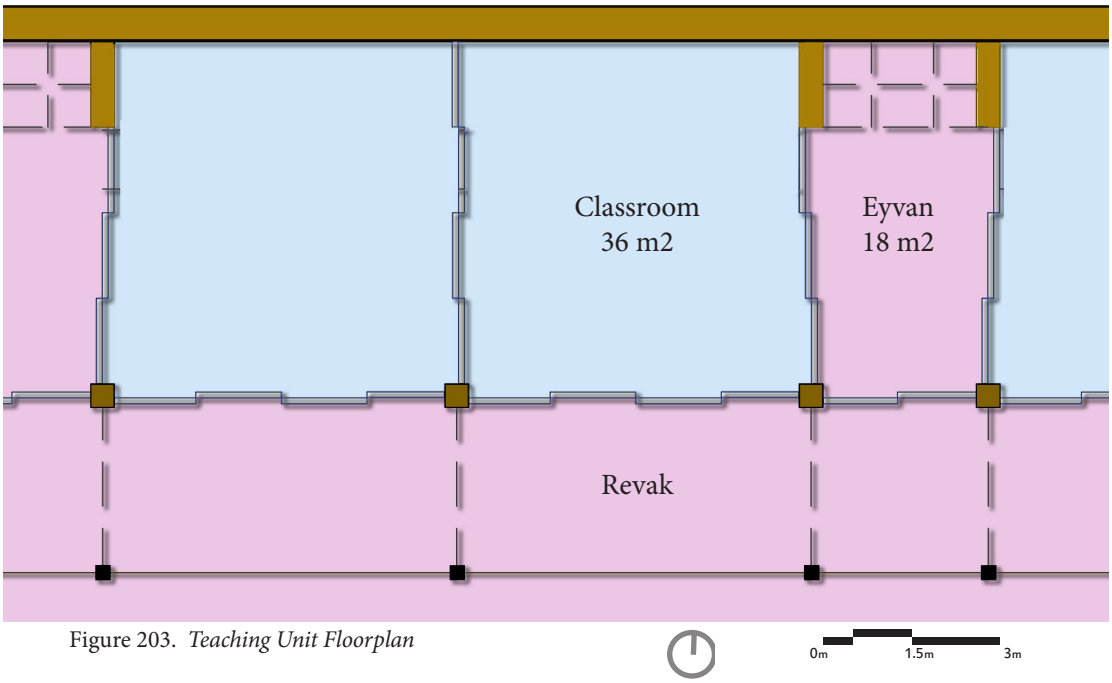


Figure 203. *Teaching Unit Floorplan*

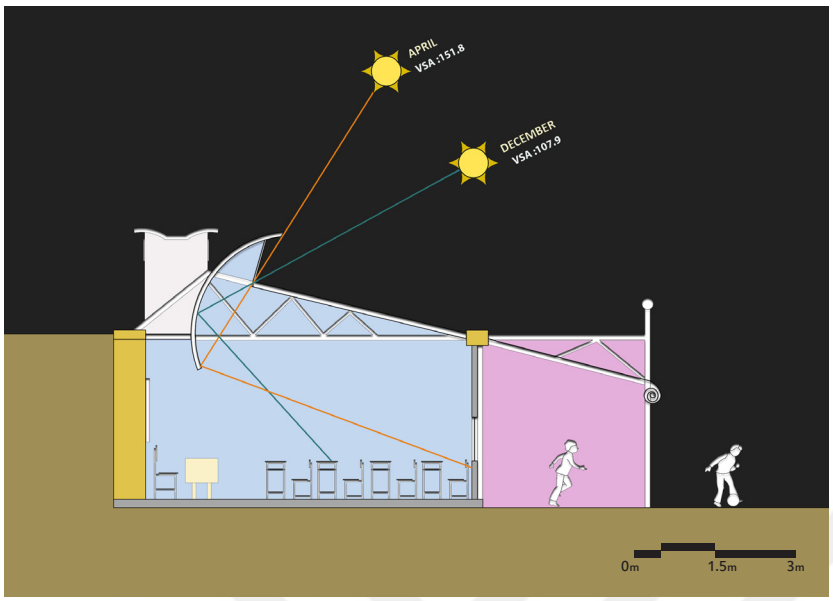


Figure 204. *Classroom Cross Section*

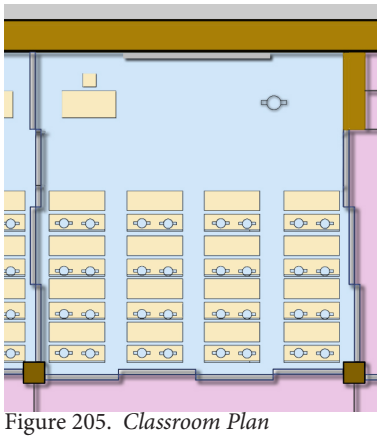


Figure 205. *Classroom Plan*

Figure 206. *Seated Students*

The focused teaching unit is located on the north east side of the site plan where the north facade is ground coupled and south facade is facing to the courtyard. Design concept is a synthesis of the solutions brought to the problem of density and adaptation to the education system. Proposed design of the teaching unit consists of three spaces:

- Classroom
- Eyvan
- Revak

Classroom

The classroom is placed on a 6 x 6 m grid covered by a slanted roof. The square form of the classrooms was brought back from the Medrese classrooms. These dimensions was preferred because the layout of the seating would be modified according to the activity and even daylight at times. It can occupy up to 30 students in the traditional fixed layout, however variations will be indicated in the upcoming sections. The 36 m2 is based on the classroom area in Ataturk Primary School. The aim is to provide students more space without actually enlarging the size of the classrooms but letting them stretch to the adjacent spaces.

The north facade is the ground coupled side where the dark side of the room is. If a traditional layout is preferred, this darker space is for board or the projector. Moving down from north to south, the classroom gets brighter for student seating. The daylight needed for student efficiency is received from the roof light (Figure 220).

All the walls except for north side is movable panels so that the classroom could be enlarged by opening to the adjacent spaces. The only fixed elements of the classroom are the columns and truss for structure , the north wall for the utility (pipes, ducts, conduit) and the roof for daylight. The south movable walls include glazing at 70cm height to provide students with a pleasant view of the courtyard.

Figure 207. *Proposed classroom interior view*

Eyvan

Eyvan is a common type of transitional spaces in Mardin vernacular architecture. (Refer to Chapter 2) The space is adjacent to the classroom space and shared by two classrooms. There are architectural and environmental reasons to place this space between the classrooms. One of the problems found in Ataturk Primary school was that students used the *corridor* for circulation and break time activities. This created student overload in every 10 minute break. In this project the circulation inside the primary school is provided by the revak which is the covered pathway. This way the multiple function of the corridor is divided into two spaces. The eyvan serves as an entry space for two classrooms where coat hangers and some seating areas are located. Because there are no dining halls, students used to eat their lunch in the classroom, but eyvan is an alternative space for lunching or other light activities during breaks.

The flexibility of the teaching units allow the spaces to be united with the help of the movable walls. If only one panel is opened, eyvan is used as private tutoring room, whereas all three panels open up to enlargen the classroom. This case would be beneficial for summer where bigger volume classrooms would reduce the temperatures.

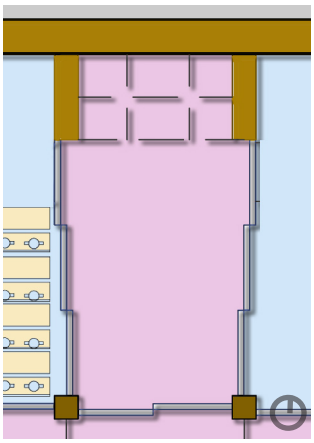


Figure 208. Eyvan Plan

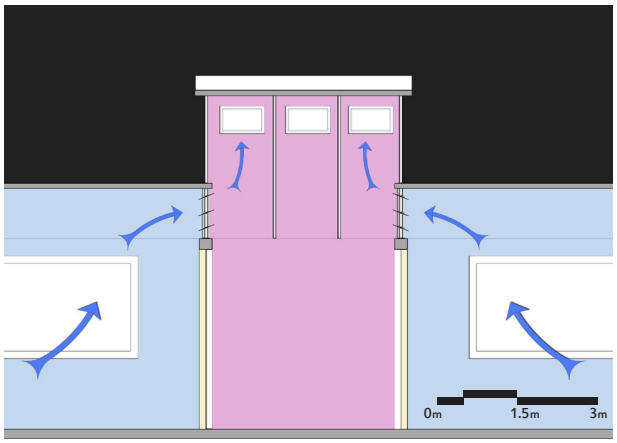


Figure 209. Eyvan Longitudinal Section

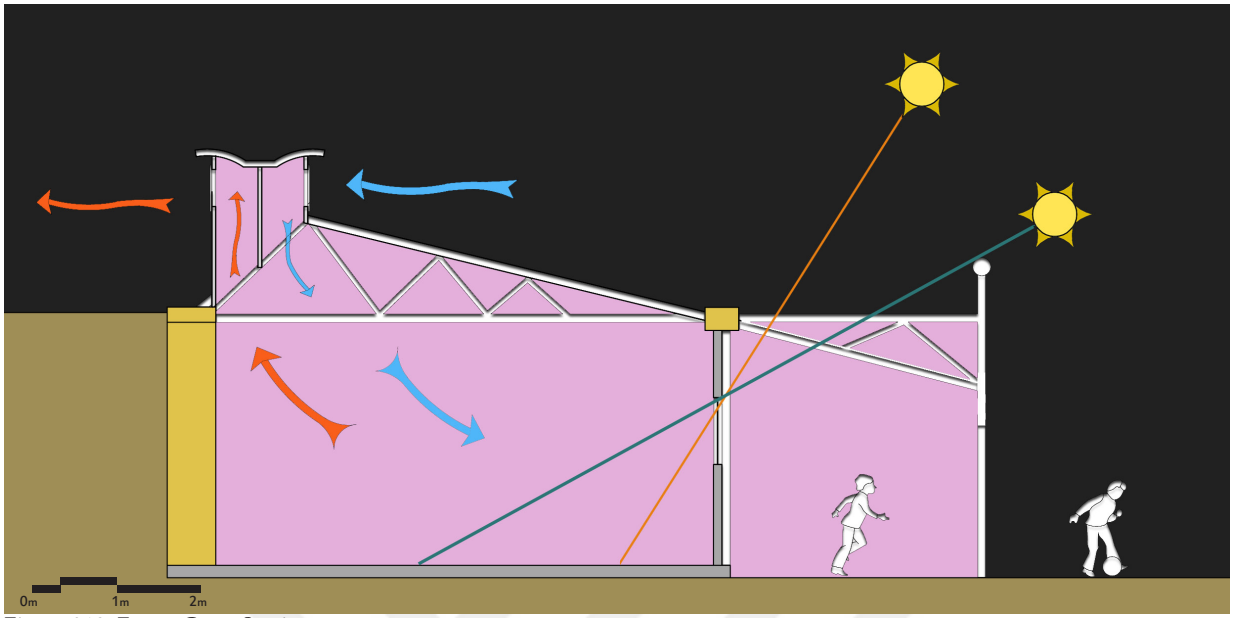


Figure 210. Eyvan Cross Section

In the vernacular Mardin houses, eyvan is a transitional space where air is cooled with the help of air chimneys. This way eyvan cools the adjacent spaces when needed. It is used as a cool living room in summers. Fresh air ventilation is highly crucial for classrooms because there is large amount of occupancy gains during the day. They need to be ventilated often, but the outdoor air temperature effects the inside temperatures in great deal. Therefore classroom vent openings to eyvan provide cooled or warmed fresh air for the students when needed.

Revak

Figure 211. Revak View

Revak is the colonnaded walkway placed on the south facade of the teaching unit. It provides the circulation around the school. Revak is covered with fabric sheets which could be removed as desired. The sheets are attachable to hinges of the metal trusses of the colonnade. When the sheets are on, south facing classroom windows are shaded. These sheet can be removed if more daylight and solar gain is desired from the south windows. This condition would be observed in winter whereas in summer the shading is preferred.

This is another transition space where the classroom can stretch to. It is observed that eyvan is a semi-open space where only one facade is open to the courtyard. Referring to the occupants experience, this space is one of the most comfortable spaces in the house. Although thermally it might not be the most comfortable space, people in Mardin enjoy being outdoors if they are covered from the strong solar exposure in summer. The movable wall panels on south facade allow the students to have this experience. Depending on the classroom activity these panels can be opened . This way the revak space is included inside the classroom and an outdoor classroom experience is created.

Layout Variations

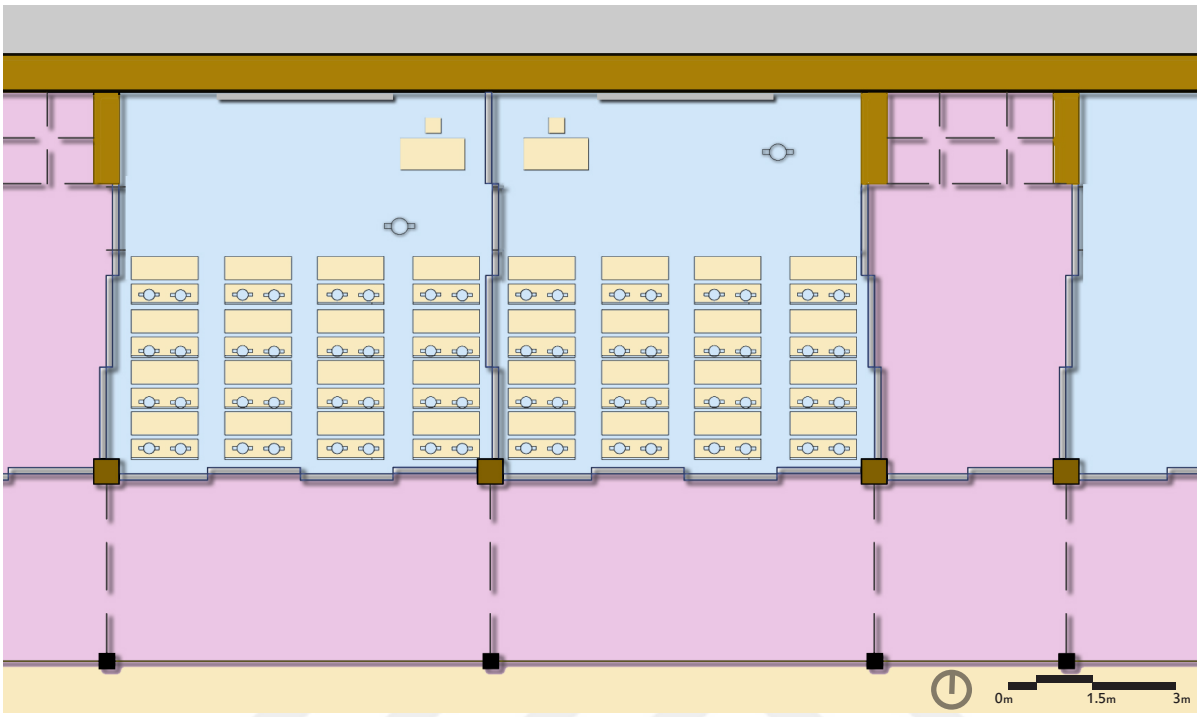


Figure 212. Traditional Layout with fixed classroom furniture

The original teaching unit allows the *traditional layout* with fixed student locations by facing the board on the northern wall dark spot. This arrangement can fit 25-30 pupils. A *cooperative layout* is established once the eyvan panels are removed. Students get to have their own workstations work group projects.

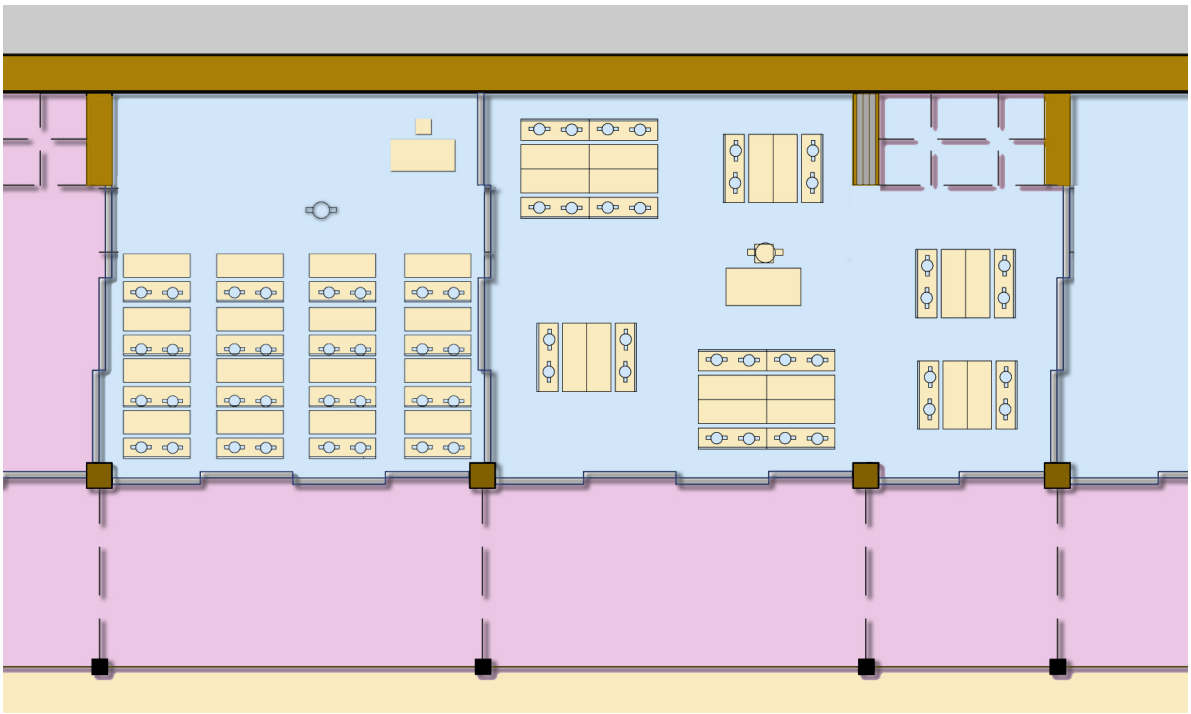


Figure 213. Cooperative Layout for group projects

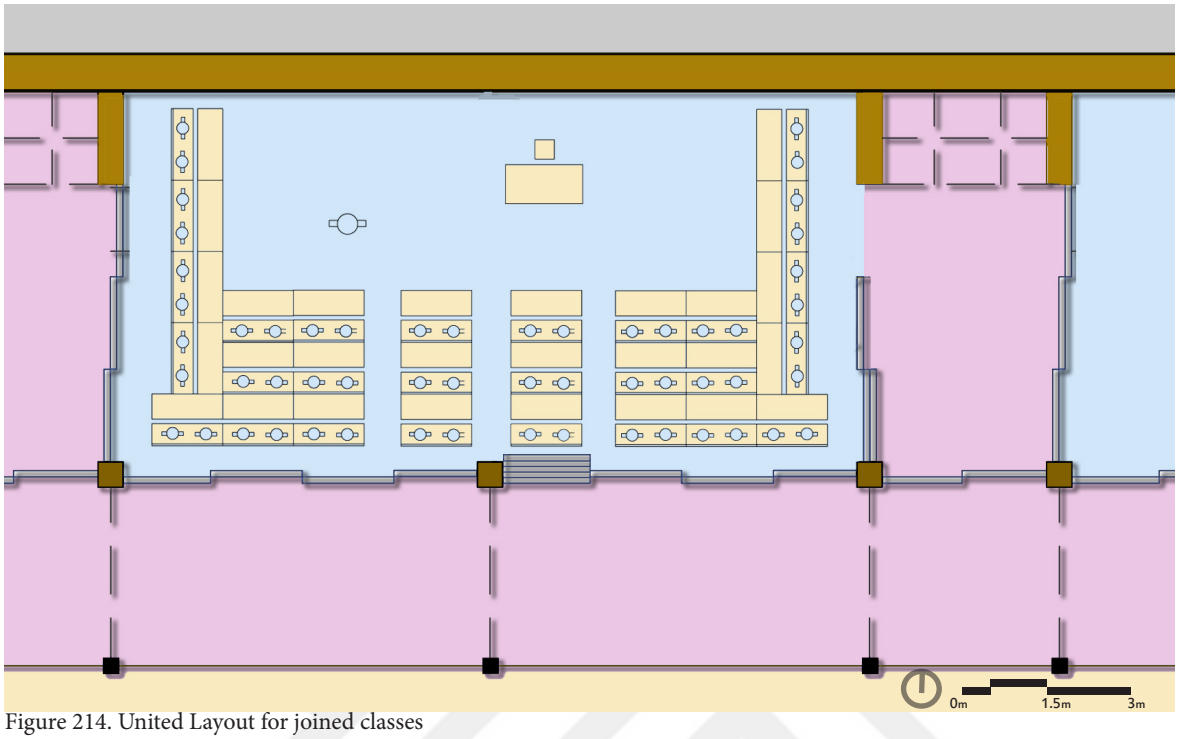


Figure 214. United Layout for joined classes

United Layout is formed if the adjacent class does not have an assigned teacher. Cases such as conferences, guest lectures or general announcements are ideal for this arrangement. *Creative layout* allows students to experience the outdoor environment during a class. Panels facing the revak are removed, additional fabric is rolled down for solar protection. This layout emphasizes the freedom and creativity of the students and the teacher.

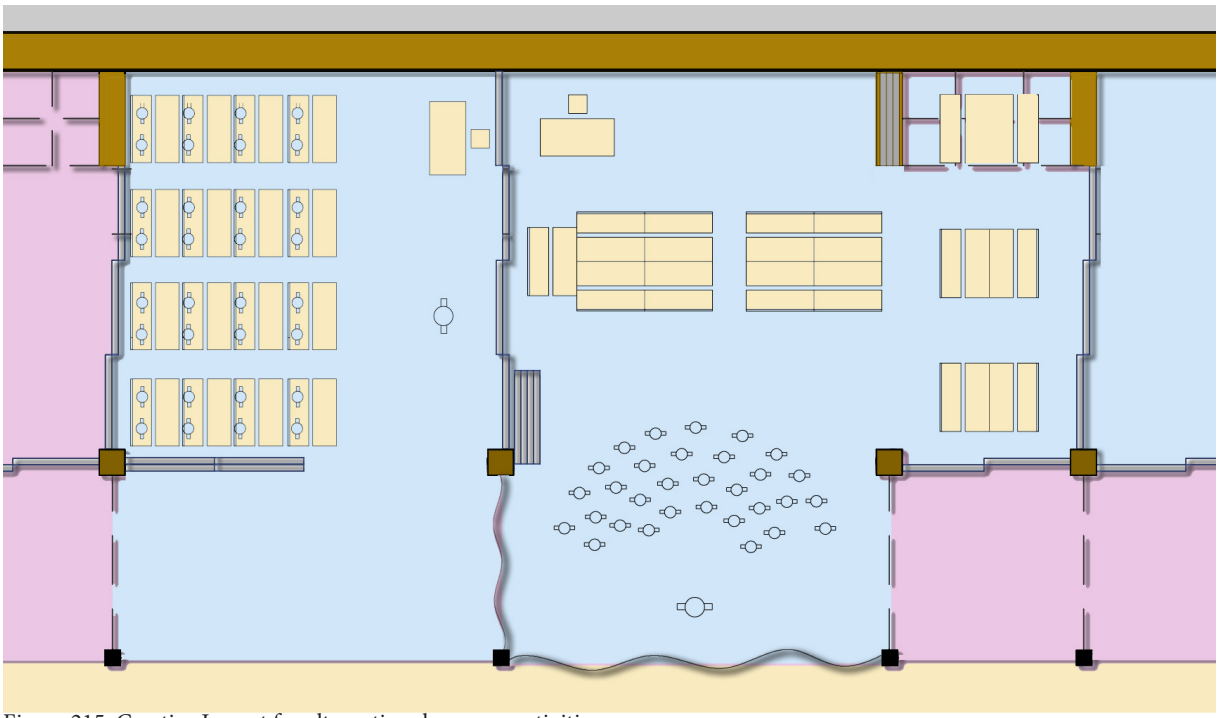


Figure 215. Creative Layout for alternative classroom activities

DAYLIGHT ANALYSIS

Background

The best school environments give and impression of liveliness, with attractive spaces and a general feeling of pleasantness which it is difficult to define. As well as the design of the spaces, well-being of teachers and pupils, lighting also plays an important role.Having a good lighting is essential to provide enough illumination for students to work on their tasks safely and comfortably. Lighting can be provided by means of daylight and electric lighting. The aim is to gain as much daylight during the day so that only the last few hours of occupation depend on electric lighting during shorter daytime hours.

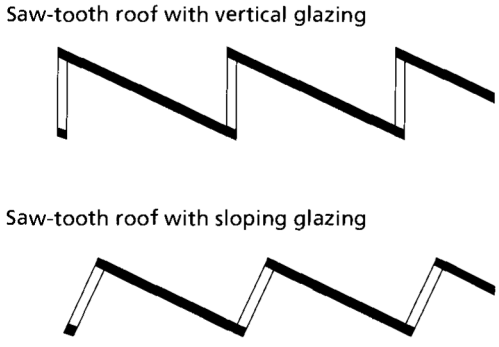
Lighting in a building has three purposes:

— to enable the occupant to work and move about in safety
— to enable tasks to be performed correctly and at an appropriate pace
— to create a pleasing appearance. (Source: CIBSE Guide A)

Classrooms also need daylighting to keep the classroom environment pleasant. This could be achieved by the design of windows. However this chapter is focused on investigating the glazing of the proposed classroom through the three purposes above. The aim is to provide good distributed, indirect daylight without glare.

The school complex is built underground which ground couples every classroom on at least one side. The north-south oriented teaching unit is ground coupled on north facade. South facade would be ideal for glazing however the adjacent revak space needs to be shaded for light and thermal transition between inside and outside. In addition to this, the light received from south would be strong enough to create glare problems inside the classroom as it was observed in Ataturk and Gazipasa daylight studies. Therefore the classrooms depend on roof lights for necessary daylight. Looking into the type of roof lights, the type of saw-tooth roof with vertical glazing is chosen but the design is modified in order to answer the design questions of,

- How to design the angle of the roof window
  1-Receive winter sun and obstruct summer sun
  2-Reflect the direct sun with reflective panels
- How to design the angle of the curve in order to reflect the sun through out the room.
- In what angle does the concave shape reflect the light?



Saw-tooth roof light

- Facing north in the northern hemisphere, is usually the best choice where solar gain would otherwise be troublesome.
- Better control of solar gain and solar glare
- Direct daylighting is unidirectional; tall machinery or storage racks can cast heavy shadows
- Large enclosed volume can lead to thermal stratification

Figure 216. Saw-tooth roof light diagrams (Source CIBSE-Guide A)

Source: Szokolay , 2008

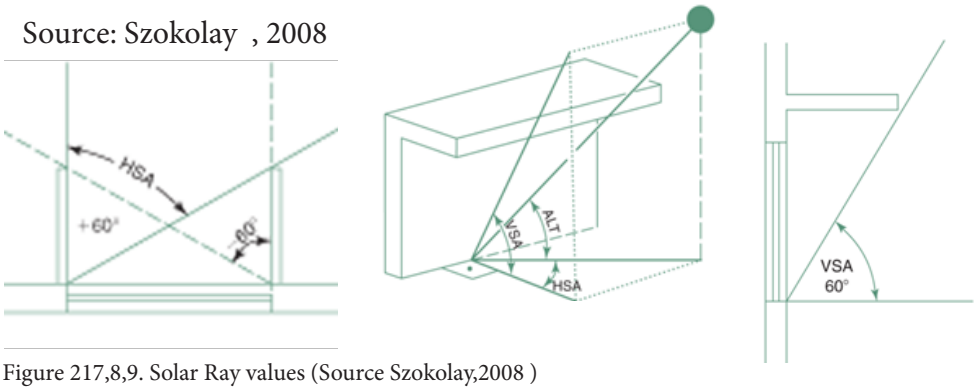


Figure 217,8,9. Solar Ray values (Source Szokolay,2008)

The resulting concave shape roof structure is designed to direct winter sun between the months of November and April so that the solar gain could help the free heat gains. Starting from May the direct light is obstructed in order to reduce overheating. The concave was created according to the Vertical shadow angle of the months when free solar heat gains are needed. April is the last angle before the top of the concave shape starts obstructing the sun.

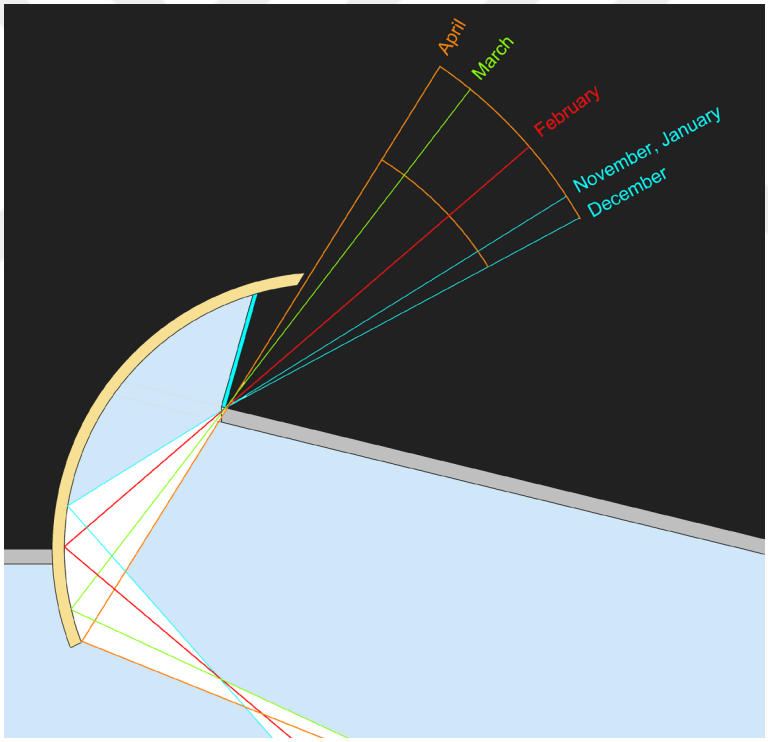


Figure 220. Solar rays hitting the Concave rooflight structure

The exact relationship between visual performance and illuminance or luminance has been the subject of many investigations . All of these studies indicate that this relationship depends upon many factors, which vary with task, individual and environment.
The SLL Code for lighting contains illuminance recommendations for many different working situations. (Source : CIBSE Guide A, 2006)

According to CIBSE Guide A , the needed illuminance for teaching spaces is 300 lux. The classroom illuminance will be measured in order to provide the required illuminance level both in summer and winter.

Daylight Simulations

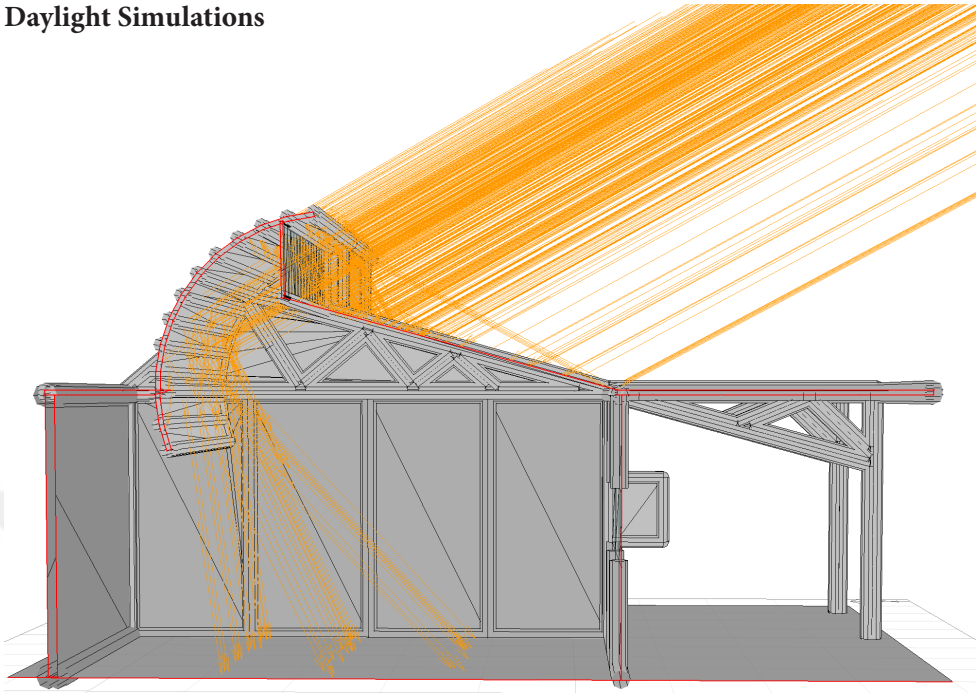


Figure 221. Solar rays hitting the Concave Structure in 21 December (Source: ECOTECT)

The testing of solar rays indicate that the sun reaches the students indirectly during winter providing them enough illuminance. The concave prevents the rays reaching the dark are located by the north wall. In summer the rays are obstructed as aimed. If additional daylight is desired, revak could be uncovered to expose the south windows.

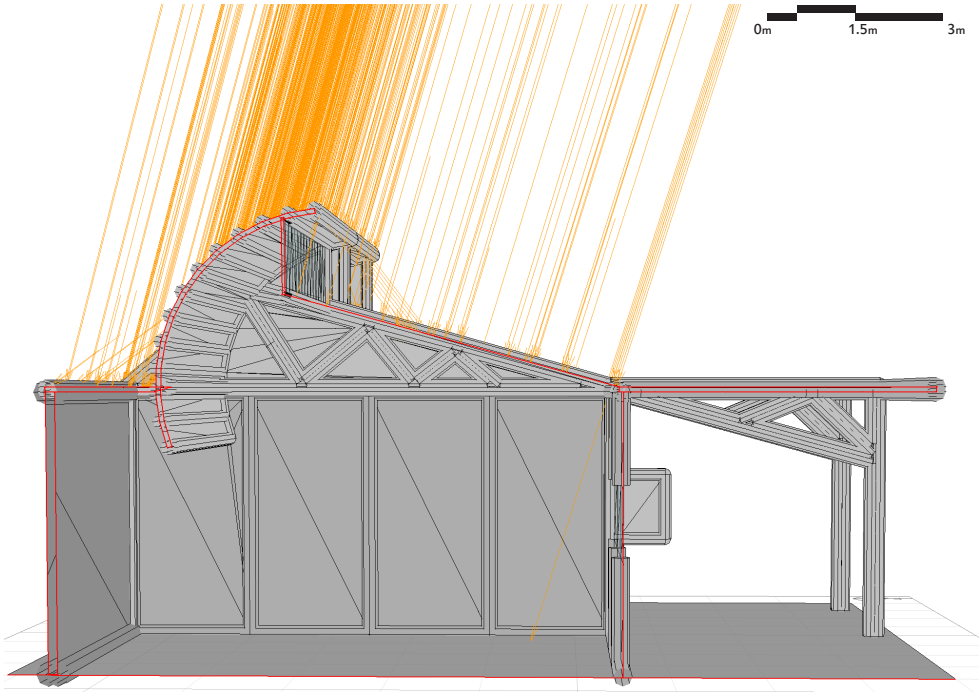


Figure 222. Solar rays hitting the Concave Structure in 21 May (Source: ECOTECT)

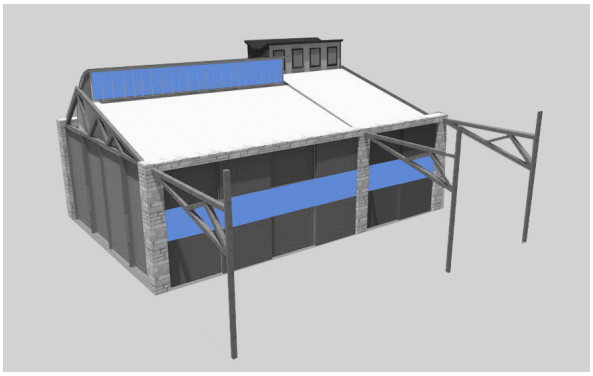


Figure 223. 3d Model highlighting Glazing

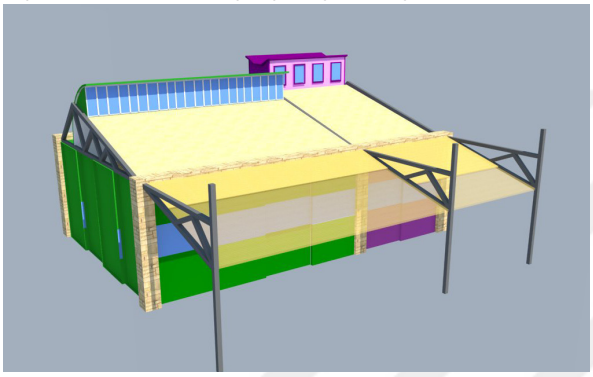


Figure 224. Teaching Unit with Revak Cover

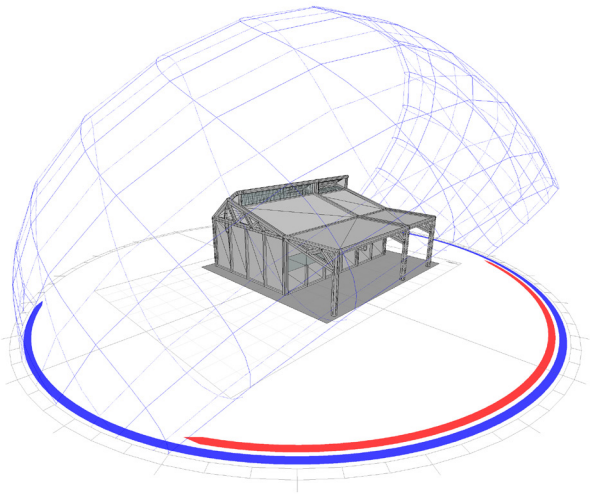


Figure 225. Annual Solar Path (Source: ECOTECT)

South Glazing : 600 cm x 80cm = 4.8 m2
Roof Light : 600 cm x 90cm = 5.4 m2
Glazing Area : 10.2 m2

Window to Floor Ratio : 28%

One of the important elements to mention about this classroom is the dark spot. The concave light distributor is located 1 meter off the north wall. The space left between the north wall and the concave structure is intended to be darker. For the traditional uses of the classroom ,where the student and teacher locations are fixed, this spot is where the teacher and the board would be located. This is because during the board and projector usage less light is preferred.

The analysis grid for the daylight simulations, was placed on top of the study desks which is 90cm high. The typical wooden desks in Turkish school are being kept for this design. They could be covered with a lighter material so that they could benefit the light distribution. According to the winter and summer results, the spaces except for the dark spot receives good amount of daylight for an efficient teaching space. Because direct sunlight is received in winter the values are around 500 lux. In summer the sun is obstructed, but the values are still around 300 lux which is the minimum value needed.

Standard maintained illuminance / lux	Characteristics of activity/interior	Representative activities/interiors
300	Continuously occupied interiors, visual tasks moderately easy, i.e. large details > 10 min. arc and/or high contrast	Libraries, sports and assembly halls, teaching spaces, lecture theatres, packing

* Maintained illuminance is defined as the average illuminance over the reference surface at the time maintenance has to be carried out by replacing lamps and/or cleaning the equipment and room surfaces

Table 11. Examples of activities/interiors appropriate for each maintained illuminance

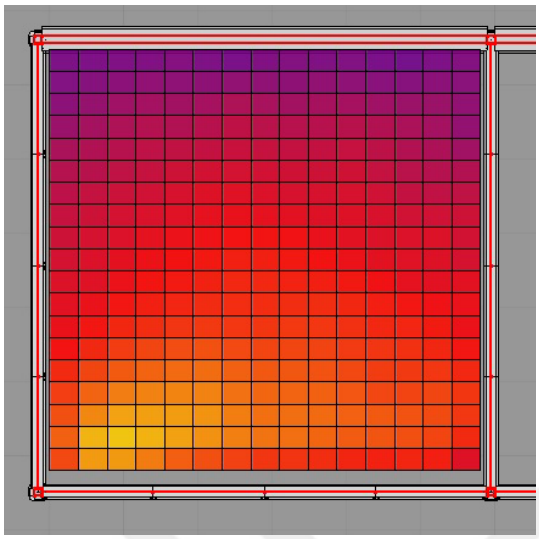


Figure 226. Interior Lux values in 21 May
(Source: Radiance)

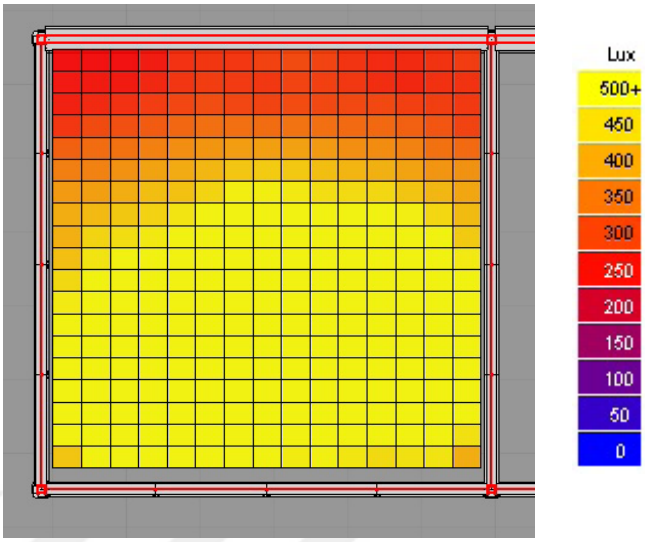


Figure 227. Interior Lux values in 21 December
(Source: Radiance)

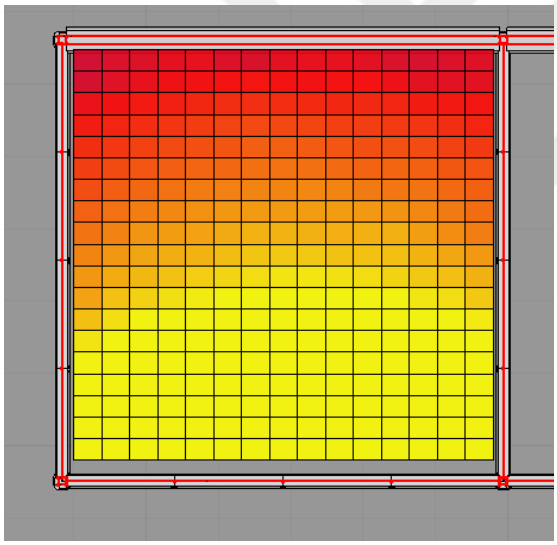


Figure 228. Interior Lux values in 21 May
(Source: Radiance) without Revak cover

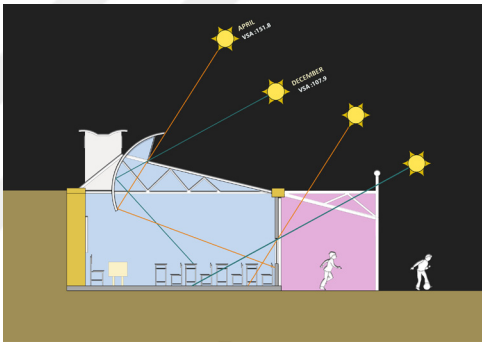


Figure 229. Classroom environmental section
without Revak cover

The south windows facing the courtyard are mainly for view purposes. The height is modified so that a child sitting down can see the view to the courtyard. (height : 70cm) The limited daylight these windows receive can be increased if the sheets covering the revak are moved or removed. The results can be compared between figure 1 and 2. The poor illuminance in summer was improved once revak is uncovered.

The concave is designed in a way to distribute the light evenly throughout the classroom. Some daylight is received from the south view windows early in the morning and late afternoon when sun is at a lower angle.

The design of the glazing will be supported with the thermal studies in the next section. Case study schools were observed to have problems with summer conditions due to the exposed glazing. The summer obstruction of the roof light and revak cover for south window shading is there to prevent the overheating in summer.

THERMAL SIMULATION STUDY

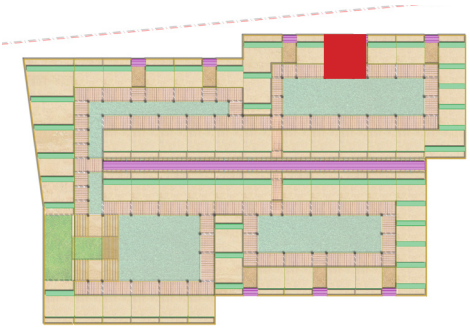


Figure 230. Site Plan highlighting the unit study

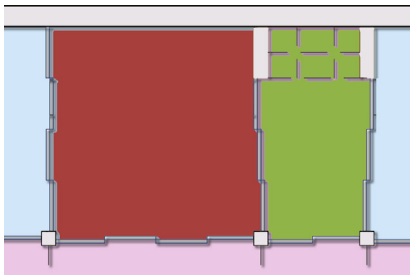


Figure 231. Teaching Unit Plan

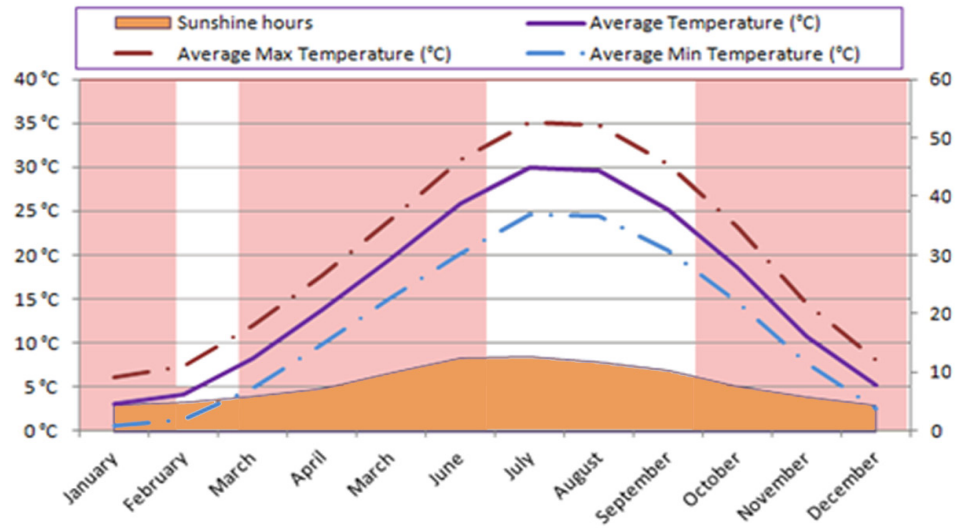
For thermal simulation studies, teaching unit in the primary school zone is chosen. The unit is ground coupled on northern facade, and receives daylight from roof light and southern facade glazing. There is an attached eyvan space on eastern side of the classroom. Eyvan is shared by two classrooms providing them with fresh air ventilation.

Occupancy

Primary school occupies children between the ages of 7-11. Most schools in Turkey has double schedule due to the density problems. Half of the school population gets education before noon whereas the other half goes to school in the afternoon. Because proposed school can fit 1000 students, there is no need to divide student schedules. School starts in mid September and goes until Early June. School closes before the peak temperatures hit Mardin but there would be summer workshops for children or adults.

Internal Gains

Simulations were performed according to 26 students. The classroom can still fit 30 people. Fresh air requirement for classroom and eyvan was calculated and used in the simulations. (Table 13) As the next step, these values were transformed into apertures.



Graph 15. Monthly average temperatures of Mardin (Source: DMI)

Building Element	Width (mm)	Conductivity (W/m C)	U-Value (W/m2 C)
External Wall Panel			0.68
paint	5	999.999	
metal	50	204	
soil	80	0.52	
insulation	30	0.026	
paint	5	999.999	
Internal Partition Panel			3
paint	5	999.999	
metal	50	204	
soil	80	0.52	
paint	0.1	999.999	
Concrete Masonry	400	0.5	1
Single Glazing Window			5.8
Ground Floor			2.3
finish	10	999.999	
precast concrete	100	0.38	
plaster	12	0.18	
Roof			1.2
finish	10	999.999	
precast concrete	250	0.38	
plaster	5	0.18	

Table 12. *Materials of the teaching unit*

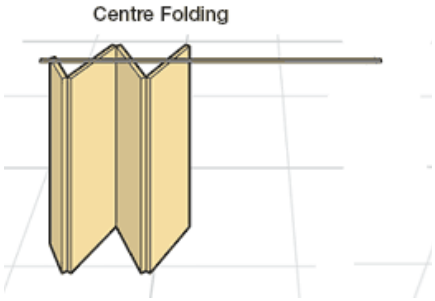


Figure 232. Movable Panels

Figure 233. Concrete Masonry Blocks

Materials

There are two types of elements in the materiality : fixed and movable. The masonry wall on the northern facade is ground coupled and fixed. The concrete roof, metal truss and the concrete columns are also fixed forming the structure of the unit. The movable panels bring flexibility to the classrooms. Moving them around, various volumes of spaces are created.

Panels exposed to the outside air are insulated whereas the partition panels are not. Normally panels walls are formed with cavities between two metal panels. In this case, the cavity was filled with soil in order to provide thermal mass. This idea comes from the vernacular construction where thick stone walls were filled with soil in order to save from material. Single glazing is used for roof light and windows. There is a solar chimney located on eyvan which helps the dynamics of eyvan cooling ventilation. Similar materials are used for roof and the chimney.

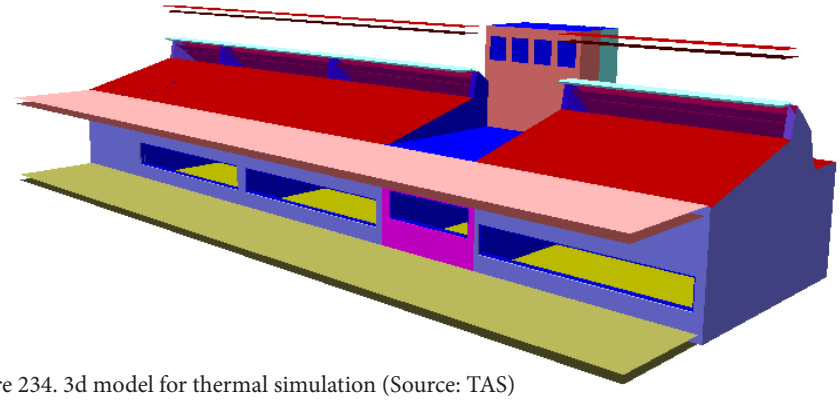
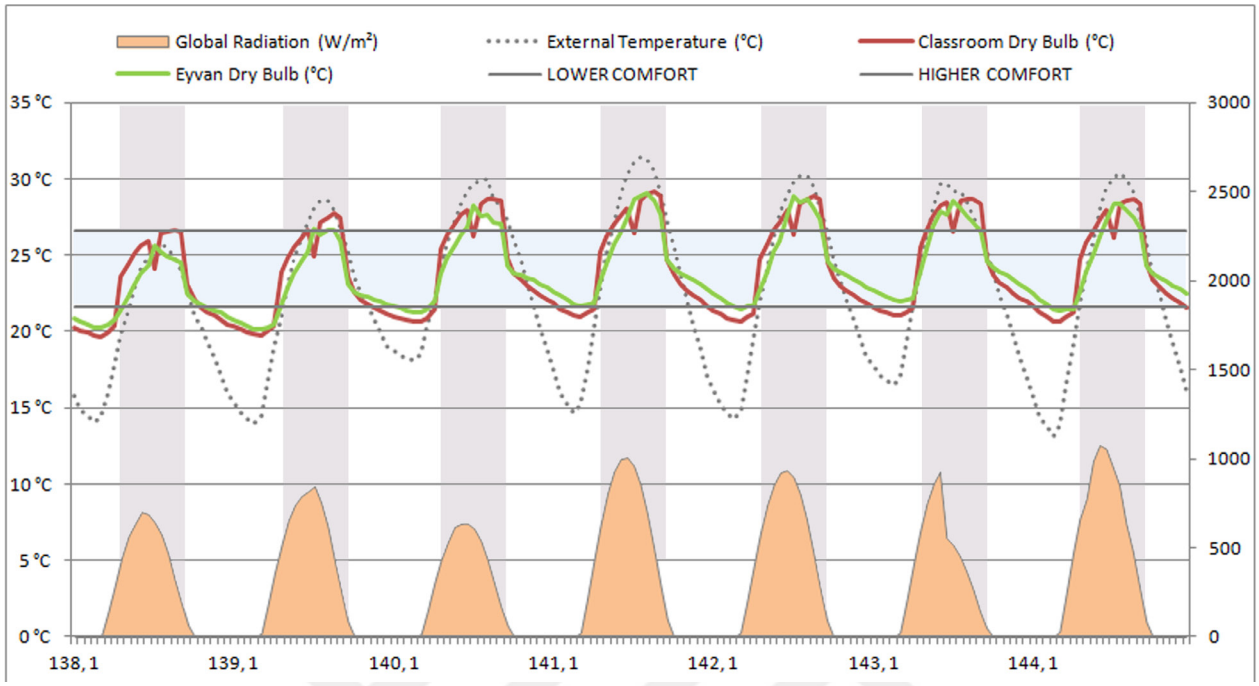


Figure 234. 3d model for thermal simulation (Source: TAS)

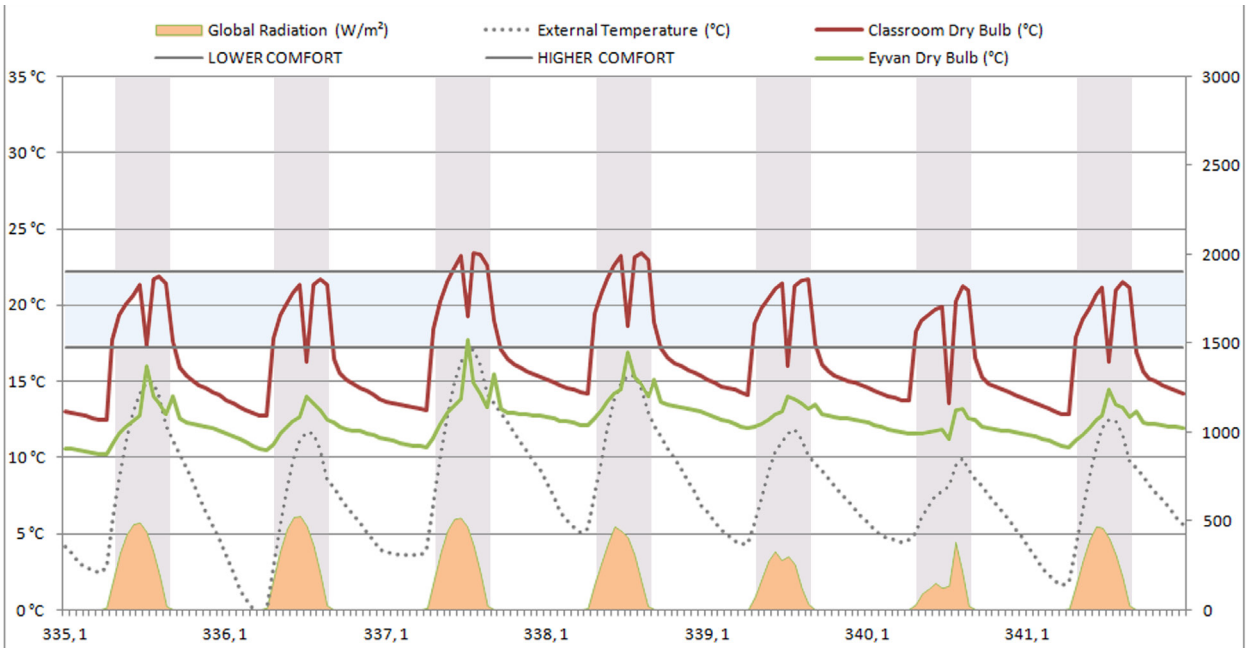
Teaching Unit	Room	Volume(m3)	Area(m2)	min air quality (10lb)	Occupancy				Lighting	
					Sensible (W)	w/m2	Latent (W)	w/m2	Lighting (W)	w/m2
	Classroom	112	36	8.035714286	1750	48.611	1125	31.25	250	6.944
	Eyvan	57	18	3.157894737	350	19.444	225	12.5	150	8.333

Table 13. *Internal Gains of Teaching Unit*



Graph 16. Typical Summer week temperatures (138 - 144) (Source : TAS)

		w/m2	
Classroom	28%	6.9	26
Eyvan	14%	8.3	26



Graph 17. Typical Winter week temperatures (335-341) (Source : TAS)

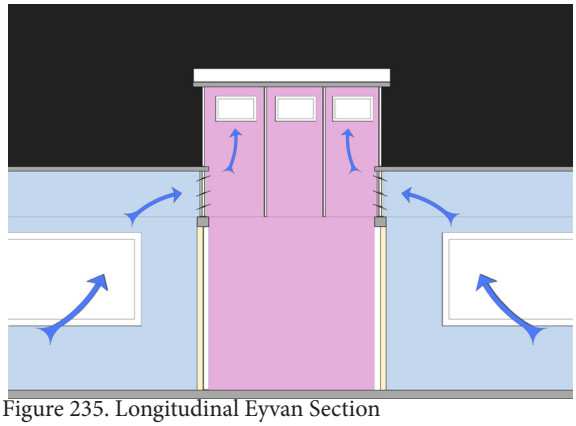


Figure 235. Longitudinal Eyvan Section

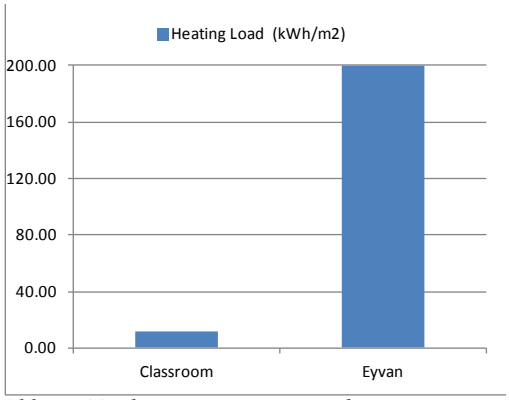
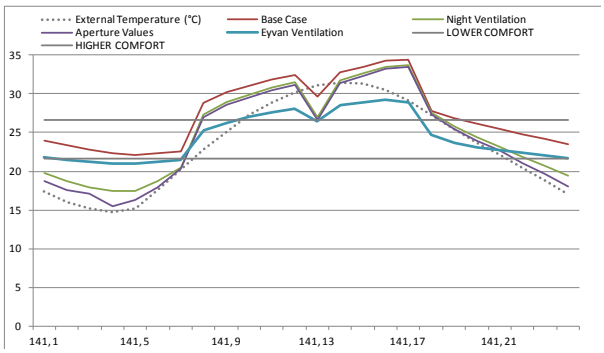


Table 14. *Teaching Unit Heating Loads*

Winter & Summer Thermal Conditions

Typical winter week simulations were based on fresh air requirement of each space. Temperatures reach the comfort band once the internal gains start with school schedule. In winter eyvan is mostly occupied during break times. Although its temperatures are indicated below comfort, the comfort zone established for eyvan is lower. Once the break time starts, the activity rate is strong enough to keep the condition comfortable.

In the later simulations 19 degrees of conventional heating was applied to the unit. Classroom heating load is 10 kWh/ m2 which saves quite a lot of energy in winter. On the other hand in order to raise eyvan temperatures to 17 degrees, 206 kWh/ m2 is needed. Eyvan need such great heating load because it does not receive direct solar radiation. In winter if the revak cover is removed, solar gain raise the temperatures. This is an option for students in case the space is used for private tutoring, or added inside the classroom. Although in the next section, flexible variations will be discussed, compact for of classroom is ideal for winter.



Graph 18. Temperatures of various parameter studies (Source : TAS)

Summer temperatures were the major thermal problems in the design. Various parameters were tested to see the improvement. Initial simulations created problems because the necessary ventilation for a classroom caused the temperatures to go above the external temperature. They started to reduce once fresh air ventilation was provided from eyvan. Eyvan temperatures are much lower because there is no occupancy gain. Therefore the air exchange cools the classroom and provide fresh air at the same time. So once the apertures were activated in the TAS model, comfort temperatures were achieved. Besides environmental strategies, the flexilibity of the unit also help the thermal conditions. Graph 2 indicates the various temperatures once the classroom layout is modified according to season, activity and density.

Layout Variation Thermal Studies

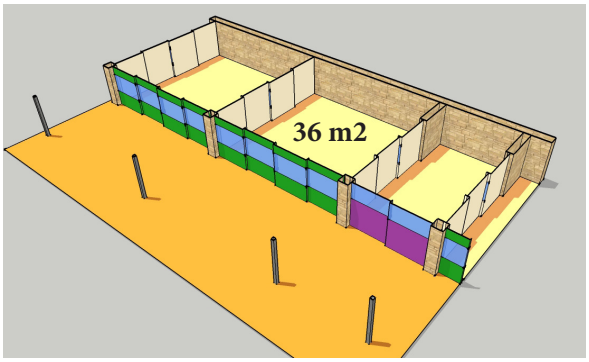


Figure 236. Scenario - 1 / Traditional Layout

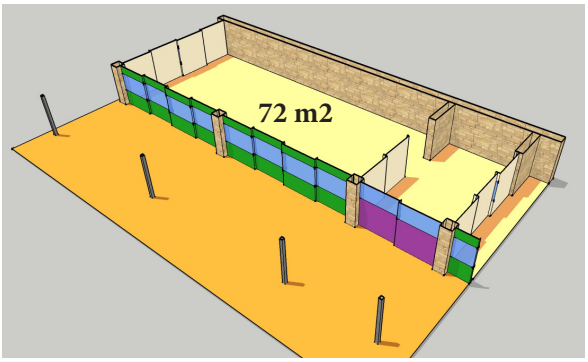


Figure 237. Scenario - 2 / United Layout

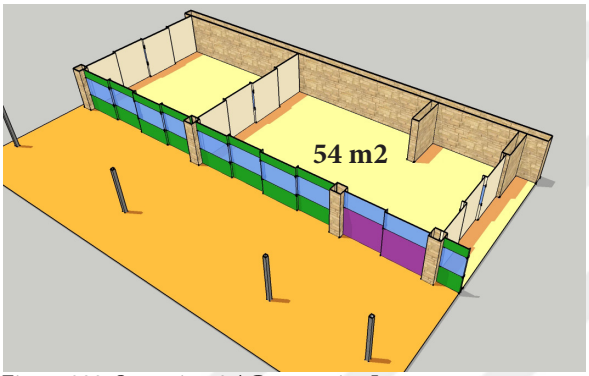


Figure 238. Scenario - 3 / Cooperative Layout

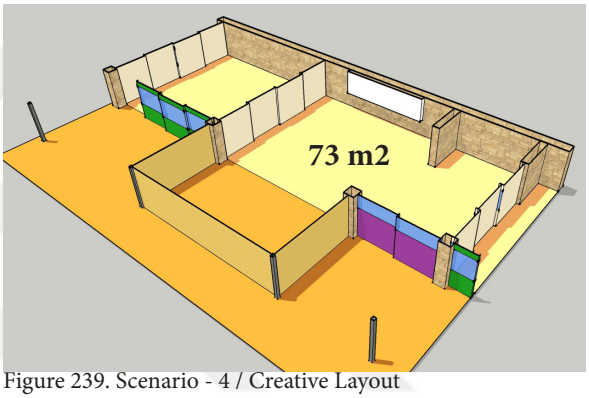
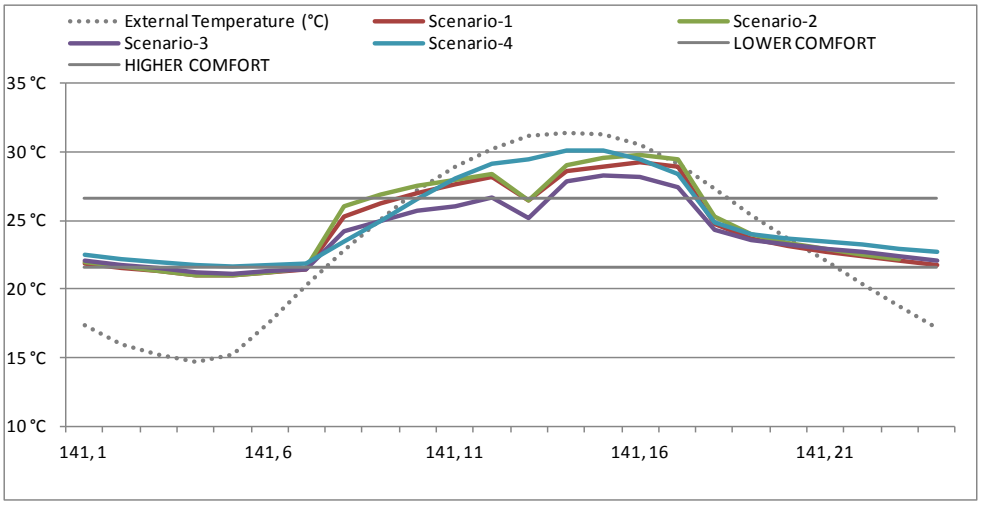


Figure 239. Scenario - 4 / Creative Layout



Graph 18. Temperatures of various parameter studies (Source : TAS)

Teaching Unit	Room	Volume(m3)	Area(m2)	min air quality (10lb)	Occupancy				Lighting	
					Sensible (W)	w/m2	Latent (W)	w/m2	Lighting (W)	w/m2
Scenario-1	*Classroom*	112	36	8.035714286	1750	48.611	1125	31.25	250	6.944
	Eyvan	57	18	3.157894737	350	19.444	225	12.5	150	8.333
Scenario-2	*Classroom*	224	72	8.035714286	3500	48.611	2250	31.25	500	6.944
	Eyvan	57	18	6.315789474	350	19.444	225	12.5	150	8.333
Scenario-3	*Classroom*	192	54	9.375	1750	32.407	1125	20.83	250	4.63
Scenario-4	*Classroom*	249	72.5	7.228915663	1750	24.138	1125	15.52	250	3.448

Table 15. *Various Layout Internal Gains*

CONCLUSION

Further investigation of thermal studies is necessary for summer conditions. In the unit the summer temperatures are sometimes outside the comfort zone. With such high internal gains classrooms in such climates need conventional would need heating.

One of the ways to improve the summer condition is to improve the dynamics of air shafts in eyvan space. Eyvan is clearly a cooler space in summer which is an advantage for the classroom ventilation. However by developing the cooling opportunities of the eyvan space, temperatures can be brought down to the comfort zone.

It was concluded that the north- south orientation of the teaching unit performs well in both seasons. The next step to take in the thermal studies is to investigate the opposite units. These units north facade face to the courtyard whereas south facade is coupled with a long eyvan space. This long transitional space is coupled with two units back to back. Interesting results would be found accordingly.

Overall the design project would please the occupants who will get their first education experience. The transition between the spaces is aimed to improve student adaptivity. And by observing the adaptive possibilities of these teaching units, students and teachers would be encouraged to take advantage.

CONCLUSION

The findings of the literature review, fieldwork and case studies have concluded with the elements of proposed design. The proposed teaching unit is the execxecution of the previous findings of the research.

The context of the project is one of the most important yet unrecognized historical cities in Turkey. Mardin's topography, climate and cultural diversity cause the emergence of this unique architecture. The flexibility of the spaces are the main inspiration of the vernacular architecture. Living areas that can be turned into bedrooms are the representation of flexible life. Couches, chairs and tables seen in every eyvan, revak or courtyard, beds appearing on roof terraces in summer show the tendency to enjoy outdoor spaces. One of the main reasons why the proposed project is so into outdoor areas is that the local people favor it. Although the indoor temperature are tolerable in peak summer, people still prefer a shaded outside. If adults enjoy the experience, then for children this feeling is multiplied.

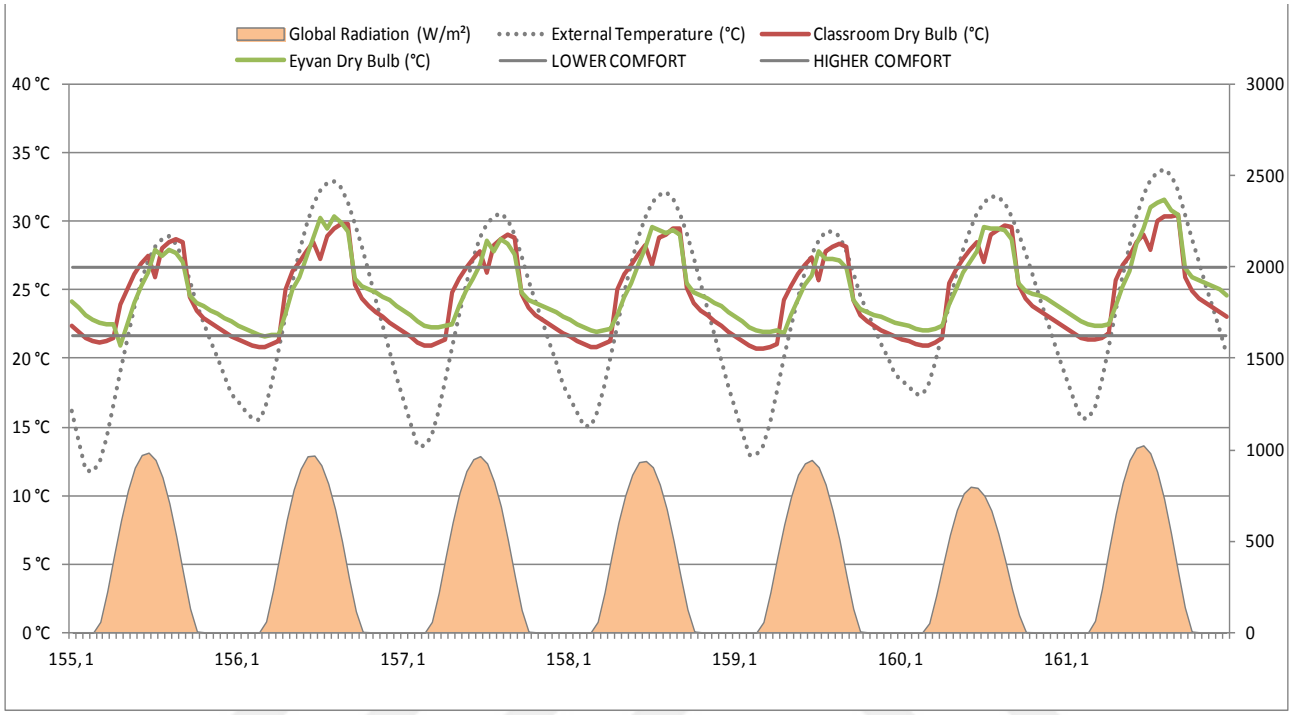
A school is a child's second home. They spend most of their youth in school buildings. Therefore the best design for a child is to let them design their own environment. Most schools in Turkey are strictly designed for education which leaves almost no space for child imagination. Outdoor is strictly seperated from indoors. This leads children to distort the functions of spaces. For example, Ataturk primary school has a large scale playground outside the building. However it was observed that children turned corridors into playgrounds. This indicate that what children need is a transition instead of separate spaces. This is why children in Gazipasa enjoy small breaks in eyvan and courtyard, whereas for longer breaks they go to the terrace. If these three spaces would equal to the area of the playground in Ataturk, but the former is used much more due to the transition.

Accordingly environmental literature has indicated that transition is also good for hot and dry climate. The transition of daylight and temperature is favored as there are major differences between the inside and outside. Eyvan and Revak shade the outdoor area so that occupants can get adapt to the temperature difference. When history of school buildings were investigated, these spaces were used widely. Although the system is completely different now, the spaces can be manipulated into the modern system. This was the intention of the proposed site plan and teaching unit.

A sustainable school building is environmentally comfortable and saves energy. But the more important element to its sustainability is of course its adaptability. It is more common for a school building to be exposed to constant changes: schedule change, season change, occupants change, system change and even the function of the building might change. If the school building is able to adapt to most changes, that means it would be sustainable.

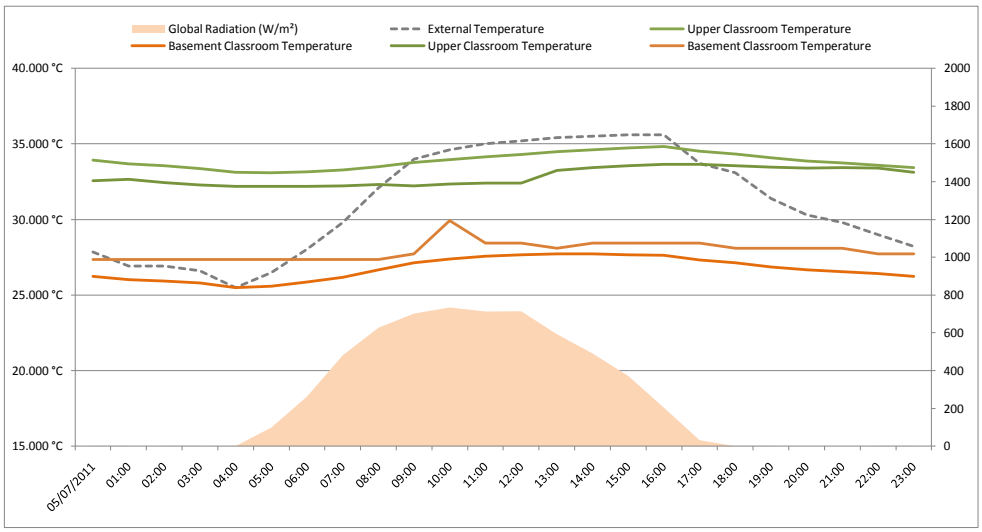
APPENDIX

APPENDIX



Graph. July Temperatures of Teaching Unit (Source : TAS)

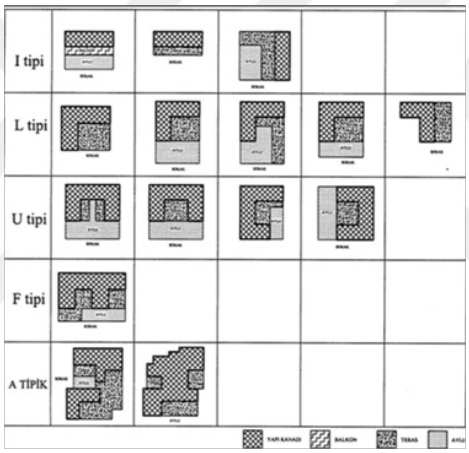
This simulation is done in order to see the performance of the unit in July when peak temperatures are observed.



Graph. Calibration of Climate information (Source : TAS)

Most rectangular living units are composed of 1,5 modules. If room entrance is on the long side, three windows are placed on the shorter side equally distanced to one another. On the other hand, if the door is located on the front façade, single or three windows are placed next to the entrance depending on the need of daylight according to the activity of the room. If the rectangular living unit is two modules, there are several alternatives depending which side of the rectangular is located on the façade. If the narrow side is on elevation, the same rules occur for single module façade. On the other hand the longer side has several alternatives as seen in FIGURE depending on the cupboard placement of the room. If the unit is composed of more than two modules, usually the shorter side of the room is the main elevation.

Inverse T shaped living units are composed of 4 modules without 'islik', 5 or 6 modules including the 'islik'. This living unit has three modules reflecting to the façade. The door is always location on the centre module while the windows are placed on two side modules with respect to single module design rules. Although the number of openings differ, in T shaped living unit the symmetry still dominates the façade.



Finally the L shaped living unit has three or four modules, having the two modules exposed. The same façade alternatives with two module rectangular living units are observed in this case.

Other closed spaces such as service or storage rooms do not reflect on main elevations. In case they are exposed, the elevation is very plain with the entrance door and ventilation openings . Due to the extreme temperature differences between day and night, window openings are highly minimized resulting from the inverted living style. Massive light colored exterior envelopes punctured by minimal openings are widely seen in Mardin vernacular architecture. This strategy moderates the temperature variations before entering the building in summer, and reduces the amount of heat loss in winter. Nevertheless more recent examples have increased window to floor ratios. Because the Southern façade of the courtyard building is open, occupants wanted to catch more views throughout the year without realizing the environmental problems this may cause.

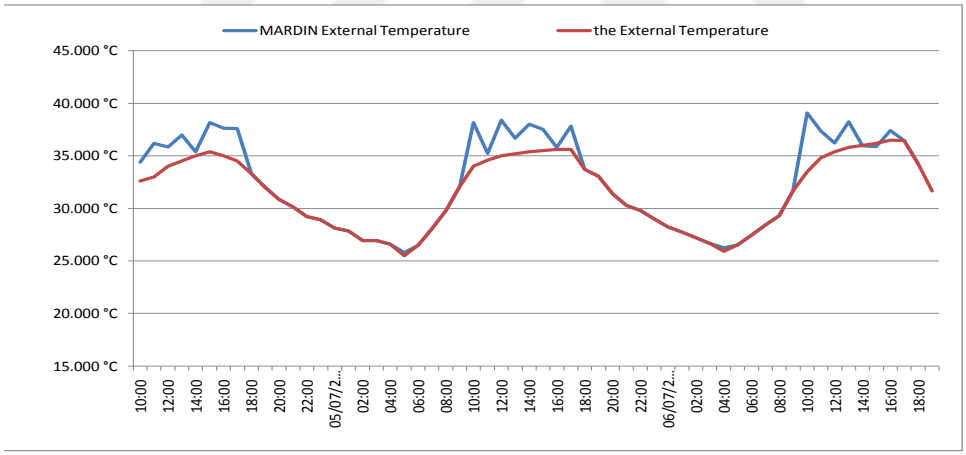
The elevations of closed spaces in a Mardin house usually have a plain look with yellow limestone blending into the landscape. This simple look is enriched with the punched openings and the dynamic facades of transitional spaces; eyvan and revak. The light and shadow created by these transitional spaces gives the elevation a sense of depth providing a more blended look to the city rather than detached housing settlement.

One of the transitional semi-open spaces, eyvan, has an arched opening looking into the courtyard. Depending on the construction technique, the shape varies from half circle to more a pointed arch. For instance if the ceiling is cavetto vault, it creates a more circular arch.

Although the opening is usually single arched, in some examples of eyvan, the opening is divided into two arches with a column in the centre. The eyvan façade is enriched with stone ornaments around the arch in most cases. The limestone used for ornaments is darker colored which is softer and easier to treat. Although the stone type is similar the color difference bring out the ornament details of eyvan elevations.

Revak is a colonnaded semi-open space providing a transition from living units into the courtyard. The space has arched façade facing into the courtyard similar to eyvan. There are two or more openings in revak with half circle or pointy arches. The most typical revak consists of two or three openings. Revak is usually located in the ground floor where the courtyard located,and first floor in some instances facing the terrace. Revak façade is an important element in the elevations. The arched openings frame the plain living unit facades in the background. This provides a nice depth to the elevations.

CALIBRATION OF CLIMATE



Because the weather station was not available for Mardin in Meteonorm, outdoor temperatures were measured during the fieldwork in order to calibrate a nearby station weather data.

DATA LOGGER SCHEDULE DURING FIELDWORK

GAZIPASA ELEMENTARY SCHOOL						
DATE	TIME	LOCATION	ACTION	PEOPLE	DOOR	WINDOWS
4-Jul	08:57am	Upper Classroom	Data Logger Placed	2	Closed	Closed
	09:05am	Ground Classroom	Data Logger Placed	2	Closed	Closed
	09:20am	Roof	Data Logger Placed	0	-	-
	09:30am	Earth Dug Room	Data Logger Placed	3	No Door	Closed
5-Jul	9:00am	Upper Classroom	Door Open	0	1 Open	Closed
	15:08pm	Upper Classroom	Door/Window Test	2	1 Open	5 Open
	15:50pm	Upper Classroom	Door/Window Test	0	Closed	Closed
	15:43pm	Ground Classroom	Door/Window Test	2	1 Open	3 Open
6-Jul	12:49pm	Upper Classroom	Children Test	2	Open	Closed
	13:00pm	Upper Classroom	Children Arrived	6	Open	Closed
	13:04pm	Upper Classroom	Children Sitting	10	Open	Closed
	13:11pm	Upper Classroom	Children Sitting	14	Open	Closed
	13:30pm	Upper Classroom	Children Sitting	18	Open	Closed
	13:40pm	Upper Classroom	Children Left	4	Open	5 Open

ATATURK ELEMENTARY SCHOOL						
DATE	TIME	LOCATION	ACTION	PEOPLE	DOOR	WINDOWS
4-Jul	10:00am	Upper Floor Classroom	Data Logger Placed	2	Open	Closed
	10:15am	Basement Classroom	Data Logger Placed	2	Closed	Closed
5-Jul	09:50am	Upper Floor Classroom	Door/Window Test	3	Open	3 Open
	10:49am	Upper Floor Classroom	Door/Window Test	3	Closed	Closed
	10:53am	Basement Classroom	Door/Window Test	3	Open	3 Open
	11:17am	Basement Classroom	Door/Window Test	3	Open	Closed
	11:23am	Basement Classroom	Spot Measurement	2	Open	Closed
	11:39am	Upper Floor Classroom	Children Test	2	Open	3 Open
	11:45 AM	Upper Floor Classroom	Children Sitting	28	Closed	2 Open
	11:52am	Upper Floor Classroom	Children Sitting	28	Open	2 Open
	12:22am	Upper Floor Classroom	Children Left Running	3	Open	2 Open
	13:00pm	Upper Floor Classroom	Leaving	0	Closed	Closed
6-Jul	11:32am	Upper Floor Classroom	Spot Measurement	2	1 Open	3 Open
	11:37am	Upper Floor Classroom	Spot Measurement Start	2	1 Open	3 Open
	12:01pm	Upper Floor Classroom	Spot Measurement Finish	2	Closed	Closed

ALTERNATIVE EDUCATIONAL SYSTEMS IN EUROPE

Reggio Emilia Approach:

The Reggio Emilia Approach is an educational philosophy focused on preschool and primary education. It was started by Loris Malaguzzi and the parents of the villages around Reggio Emilia in Italy after World War II. The destruction from the war, parents believed, necessitated a new, quick approach to teaching their children. They felt that it is in the early years of development that children form who they are as individuals. This led to creation of a program based on the principles of respect, responsibility, and community through exploration and discovery in a supportive and enriching environment based on the interests of the children through a self-guided curriculum.

- Children must have some control over the direction of their learning;
- Children must be able to learn through experiences of touching, moving, listening, seeing, and hearing;
- Children have a relationship with other children and with material items in the world that children must be allowed to explore and
- Children must have endless ways and opportunities to express themselves.

While working on projects with the child, the teacher can also expand the child's learning by collecting data such as photographs, notes, videos, and conversations that can be reviewed at a later time. The teacher needs to maintain an active, mutual participation in the activity to help ensure that the child is clearly understanding what is being "taught".

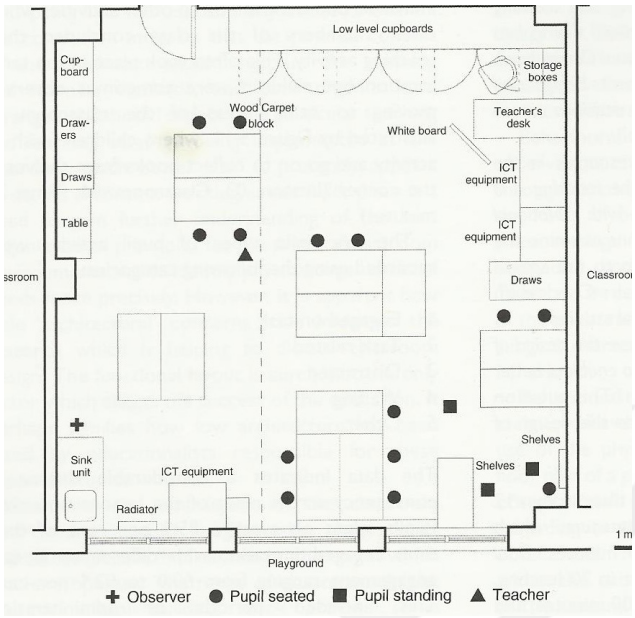
The organization of the physical environment is crucial to Reggio Emilia's early childhood program, and is often referred to as the child's "third teacher". Major aims in the planning of new spaces and the remodeling of old ones include the integration of each classroom with the rest of the school, and the school with the surrounding community. The importance of the environment lies in the belief that children can best create meaning and make sense of their world through environments which support "complex, varied, sustained, and changing relationships between people, the world of experience, ideas and the many ways of expressing ideas." It is a socio-constructivist model. That is, it is influenced by the theory of Lev Vygotsky, which states that children (and adults) co-construct their theories and knowledge through the relationships that they build with other people and the surrounding environment. This is a child who is driven by curiosity and imagination, a capable child who delights in taking responsibility for his or her own learning, a child who listens and is listened to, a child with an enormous need to love and to be loved, a child who is valued.

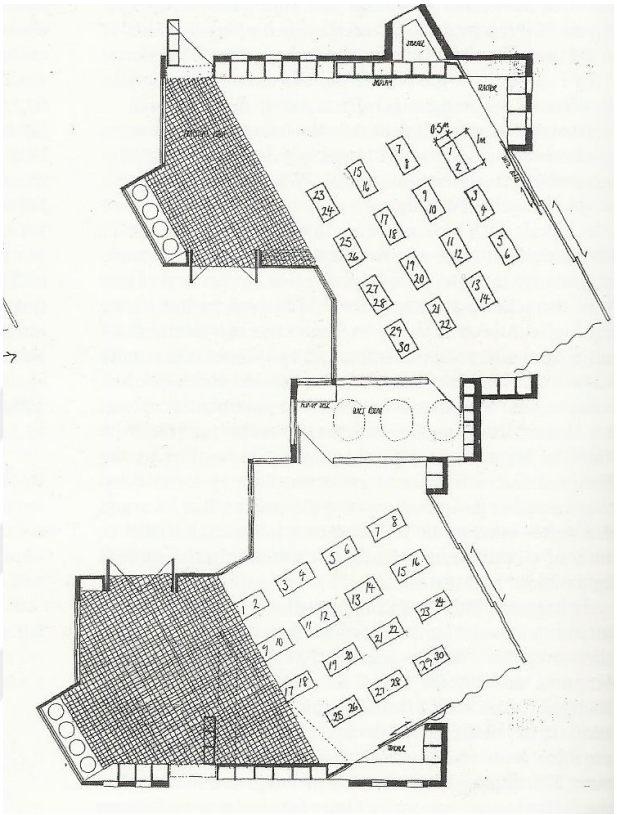
FOREST SCHOOLS:

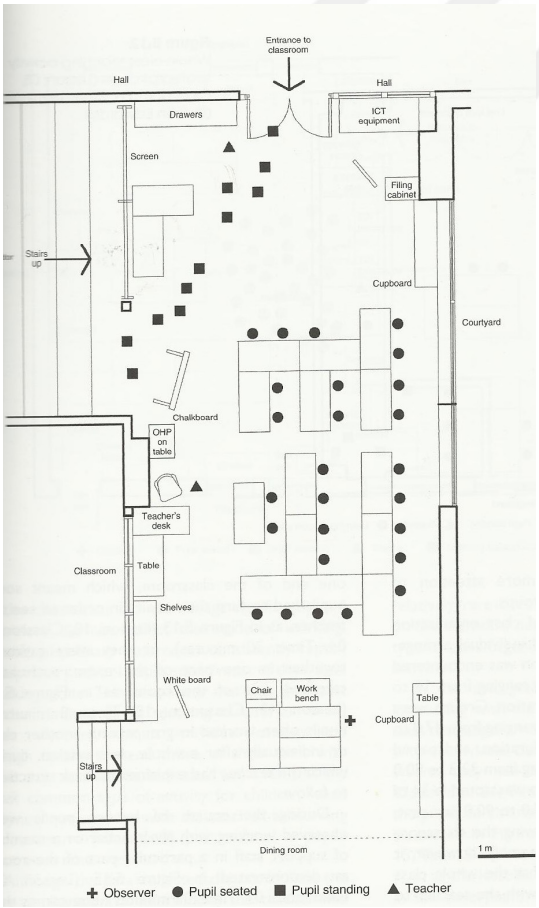
Through regular sessions in the same area of woodland, with trained Forest School Leaders, children and young people develop:

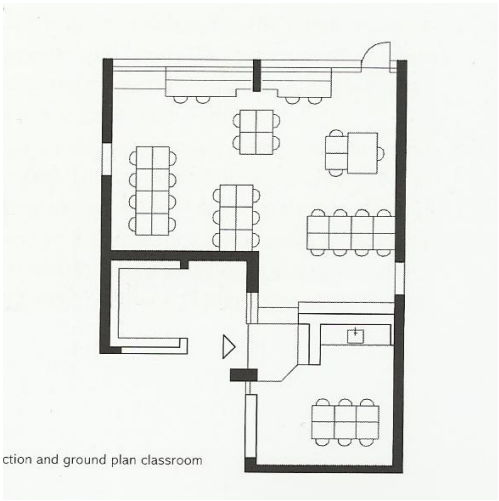
- Personal confidence and self esteem.
- Communication and social skills.
- A wider range of physical skills than developed indoors.
- A deeper understanding about their own environment.
- Increased knowledge about wider environmental issues.
- Their innate motivation and positive attitudes to learning.

CLASSROOM LAYOUT EXAMPLES FROM MARK DUDEK

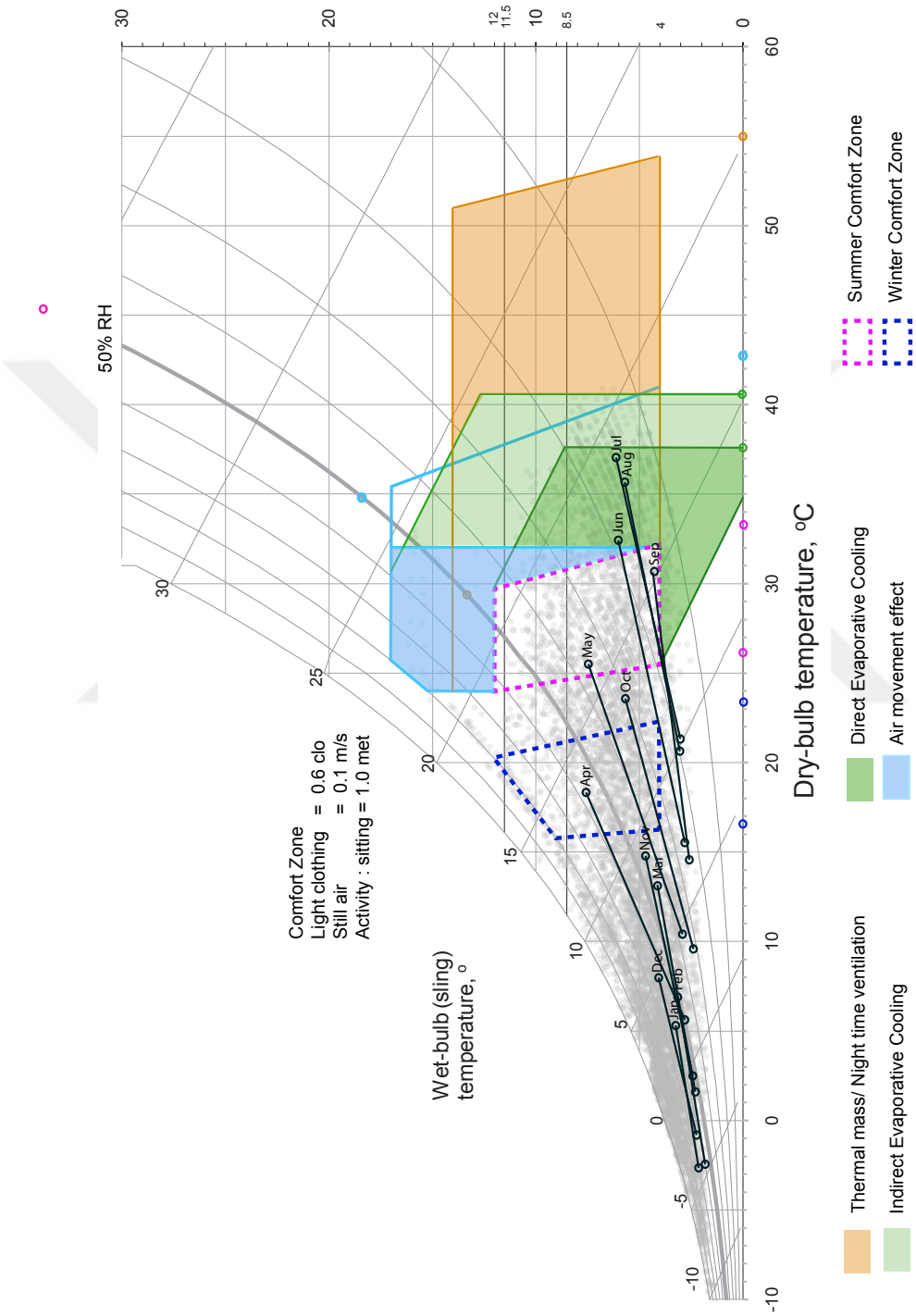




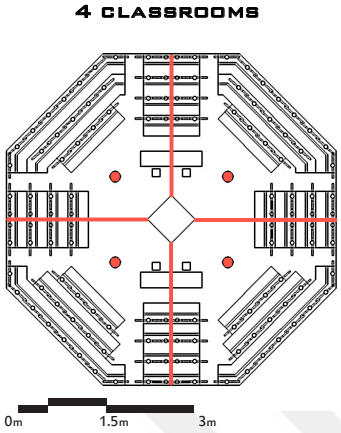


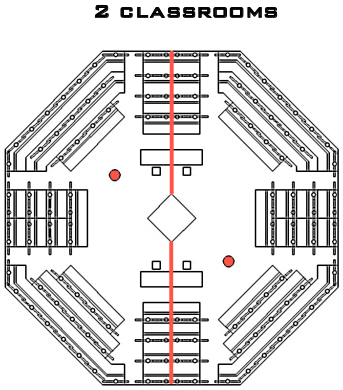


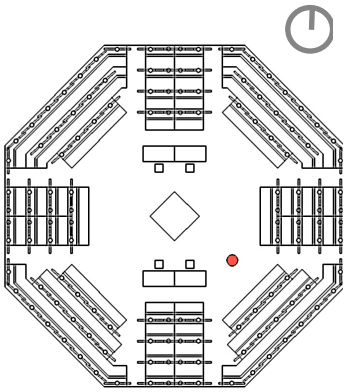
PSYCHROMETRIC CHART FOR MARDIN

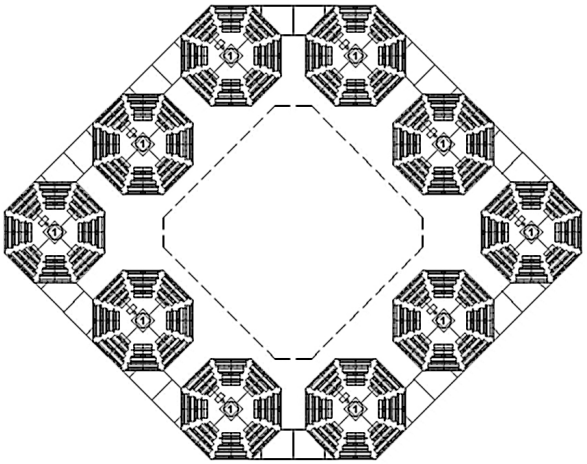


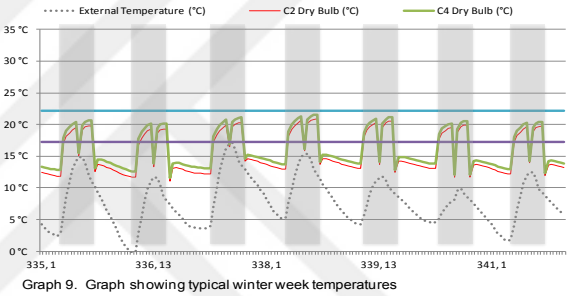
FIRST DESIGN IDEA : OCTAGONAL FLEXIBLE CLASSROOM



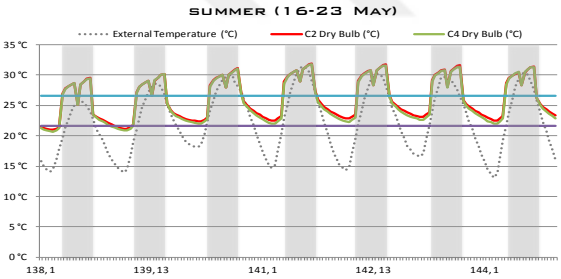




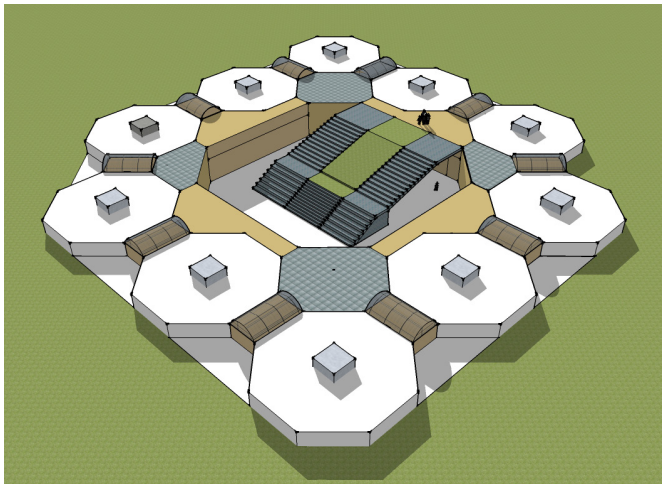


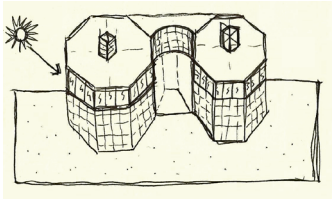


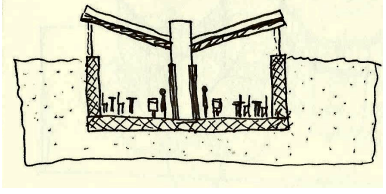
Graph 9. Graph showing typical winter week temperatures



Graph 10. Graph showing typical winter week temperatures







SOURCES & KEY REFERENCES

BOOKS

- Alioglu, E. Fusun (2000), Mardin Sehir Dokusu ve Evler, Istanbul
- Baker, N. Steemers, K (2002) Daylight Design of Buildings: A Handbook for Architects and Engineers, James & James
- Baker Nick, (2002) Natural Ventilation Strategies for Refurbishment Projects
- CIBSE GUIDE A (2006), Environmental Design, CIBSE
- CIBSE (1999) Daylighting and Window Design, CIBSE
- Dudek, Mark (2008), Schools and Kindergartens, Birkhauser, Berlin
- Dudek, Mark (2005), Children's Spaces,Architectural Press
- Dudek, Mark (2000) Architecture of Schools, Architectural Press
- Hertzberger, Herman (2008) Space and Learning, 010 Publishers, Rotterdam
- Hertzberger, Herman (1990) Architect
- Noyan, Selahattin (2008), 1950 Mardin Ilinin Monografisi, Ankara
- Noyan, Selahattin (2008), Mardin, Bir Sehir Bir Malikane Siradisi Evler, Ankara
- Noyan, Selahattin (2008), Bilinmeyen Mardin, Ankara
- Pushkin
- Szokolay, Steven (2008) Introduction to Architectural Science
- Szokolay S. , Auliciems A. (1997) Thermal Comfort
- Yannas, S. (1994). Design of Educational buildings (Primer & Examples). Environment & Energy studies Programme, AA Graduate School, London.
- Yannas, S. (1994). Solar Energy and Housing Design. (Volume: 1&2) Environment & Energy studies Programme, AA Graduate School, London.

THESIS

- Aydin, Saba Esin (2009) Analytical Approach to Mardin Vernacular Architecture in the Context of Sustainable Design, Cankaya University, 2009
- Dalkilic,Neslihan & Halifeoglu, F. Meral (2006) Mardin-Svur Geleneksel Kent Dokusu ve Evleri, Uludag Universites, Bursa
- Demiralp, Yekta (1997) Erken Donem Osmanli Medreseleri
- Gunal, Veysi (1999) Mardin'in Iktisadi Cografyasi, Harran Universitesi, Sanliurfa

- Karagulle, Can (2009) Yerel Verilerin Konut Tasarim Surecinde Degerlendirilmesi: Mardin Ornegi, Istanbul Teknik Universitesi, Istanbul

- Ozbek, Hakan (2004), Gelenekselden Tureyen Cagdas Mardin Konust Yerlesimi, Yildiz Teknik Universitesi, Istanbul

- Ozkaraduman, Togay (2007) Geleneksel Mimari Dil icin Gelistirilen Tasarim Grameri, Mardin. Yildiz Teknik Universitesi, Istanbul

- Sahin, Ertan Kerem (2008) Mardin Youth Centre as a Model for Sustainable Development, Middle East Technical University, Ankara

- Tok, Huseyin (2008) Gramer Tabanli Mimari Tasarim: Mardin'de Ilkogretim Okulu Tipolojileri, Yildiz Teknik Universitesi, Istanbul

- Tural, Mehmet Mustafa (2009) ,Mardin Geleneksel Yerlesin Dokusunun Kentsel Dis Mekan Kullanimlari Baglaminda Incelenmesi, Yildiz Teknik Universitesi, Istanbul

- Turk, Enise (2007) Mardin Ilinde Egitimin Dagilisi, Afyonkarahisar Kocahisar Universitesi, Afyon

CONFERENCE PROCEEDINGS

- Gulec, S., Canan F. and Korumaz M. (2006) Analysis of the Units Contributing Climate Comfort Conditions in Outdoor Spaces in Turkish Traditional Architecture. Proceedings of PLEA 2006

- ALİ , C., Ozer Y., (2011) Sicak Iklimlerde Bina Ici Iklimlendirme icin Geleneksel Bir Sistem, Ruzgar Bacalari

Personal Conservations

- Beliktay, Davut. (Mardin City Culture and Tourism Director) . Discussion on the school statistics and site choice for the dissertation project.

- Aslan, Nezir (City Project Architect) , Discussion on the renovation of Gazi Pasa Ilkogretim.

- Okar, Eren (Mardin Military Building Renovation Architect) Discussion on the renovation project and how to work with Mardin stone

- Ot, Mehmet (Mardin Stone Craftsman) Discussion on Mardin stone and the treatment of the facades.

Websites

- South-eastern Turkey Development Project Website
www.gap.gov.tr

- Climate Information

www.dmi.gov.tr

- Mardin Culture and Tourism Department Website

www.mardinkulturturizm.gov.tr