A Model on Newstereotomics of the Contemporary Masonry Buildings

Öznem Şahali

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the Degree of

Doctor of Philosophy
in
Architecture

Eastern Mediterranean University
June 2015
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Serhan Çiftçioğlu
Acting Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Doctor of Philosophy in Architecture.

Prof. Dr. Özgür Dinçyürek
Chair, Department of Architecture

We certify that we have read this thesis and that in our opinion; it is fully adequate in scope and quality as a thesis for the degree of Doctor of Philosophy in Architecture.

Prof. Dr. Yonca Hürol
Supervisor

Examining Committee

1. Prof. Dr. Gülser Çelebi
2. Prof. Dr. Füsun Demirel
3. Assoc.Prof. Dr. Müjdem Vural
4. Assoc. Prof. Dr. Kağan Günçe
5. Prof. Dr. Yonca Hürol

ABSTRACT

Today's conditions and masonry building examples are showing that even the buildings which are made closer to traditional and conventional techniques, have something different than the earlier examples. So this brought the idea of questioning the validity of types of masonry structures from architectural point of view. In this thesis, the problem introduced here is elements of contemporary masonry structure are not classified for contemporary masonry and they show undefined ontological differences even among themselves. In this thesis the aim is to demonstrate what kind of structural elements has on the masonry wall in the contemporary masonry buildings and categorize them according to their ontological group of structures. The reason of this change and variations also questioned according to earthquake resistancy if it played a determining role for this change.

In this context, the tectonics theory is extensively related with building's structure, use of material, detail, and experiences through materialization and the construction of the buildings. Thus, theory of tectonics was regarded as a kind of evaluation theory for contemporary masonry buildings. Diversity of approaches on theory of tectonics, play an important role to form the basic core of the study. As a result, in this thesis, certain approaches are emphasized to define the framework of the study. Accordingly, based on Semper's theory, Frampton's tectonic and stereotomic approach is considered as an evaluation theory. It covers heavy masses (eg.masonry wall) and light elements (linear elements (frames) or openings) in the masonry building. One of the methods of this research is to identify tectonics of contemporary masonries by using the science of ontology to create a model for reading those kinds of buildings. New structural principles will be discovered by applying this model. Departing from the theories which are comprehensively identified in the thesis, a model is created to evaluate the ontological structure category of the building according to its structural elements.

This chosen study is limited with the natural materials as adobe, stone, brick, according to scale; small-scale buildings in which the height is not more than 12 m (from single storey up to 6 storey). Then 8 examples from the 21st century's contemporary masonry structures were selected for each material (eight stone, eight brick and eight adobes). The selected structures attract attention with their advanced masonry construction technologies and won at least one architectural competition. Then Ahmet Igdirligil's stone houses were tested with the field study. As a result newstereotomics of the masonry systems is proven.

This thesis provides an introduction to those aspects of building that can help architects and students become more aware of the ontological concerns in the building process and understand how these concerns affect their design decisions.

Keywords: contemporary masonry, tectonics, ontology of structure

ÖZ

Bugünün koşullarında, yığma bina örnekleri ve geleneksele (eski yapim tekniklerine) yakın olan yığma bina örneklerinde bile geleneksel örneklerden farklı birşeyler bulunduğunu göstermektedir. Bu da mimari bakış açısından yığma yapıların çeşitlerinin geçerliliğini sorgulama fikrini doğurmuştur. Bu tezde gösterilen problem, yenilenen yığma stürüktür elemanlarının, çağdaş yığma olarak sınıflandırılmadığı gibi kendi aralarındada ontolojik farklılıklar göstermeleridir. Bu tezin amacı, çağdaş yığma binaların yığma duvarlarında ne çeşit yapısal elemanların bulunduklarını göstermek ve onları ontolojik yapı gruplarına gore mimari bakış açısı ile kategorize etmektir. Bu değişimin nedeni ve farklılıklar depreme karşı dayanıklılık bağlamında sorgulanmış ve depreme karşı dayanıklılığın bu değişimde kararlaştırıcı rölü olup olmadığı tartışılmıştır.

Tektonik teorisi binanın yapısı , malzeme, detay kullanımı ve deneyimlerin nesnelleşmeleri yoluyla derinden ilgilidir. Bu bağlamda, tektonik teorisi çağdaş yığma yapılar için bir nevi değerlendirme teorisi olarak ele alınmıştır. Tektonik teorisi üzerine yaklaşımların çeşitliliği, çalışmanın temel çekirdeğini oluşturmak üzere önemli bir rol oynamaktadır. Sonuç olarak, bu tezde, bu çalışmanın çerçevesini belirlemek için belirli yaklaşımlar vurgulanmıştır. Dolayısı ile, Semper'in teorisi temel alındığında, Frampton'un tektonik ve stereotomik yaklaşımı değerlendirme teorisi olarak düşünülmüştür. Yığma yapılardaki ağır kütle (ör. Yığma duvar) ve (doğrusal elemanlar, çerçeveler veya açıklıklar) hafif elemanları içermektedir. Bu tarz binaları incelemede kullanılmak üzere bir okuma model yaratmak amacıyla ontoloji bilimini kullanarak çağdaş yığmaların tektoniklerini

belirlemek bu araştırmanın metodlarından bir tanesidir. Yeni çağdaş yığma prensipleri bu ontolojik okuma modelini uygulayarak keşfedilecektir.

Bu seçilen çalışma, kerpiç, taş ve tuğla olmak uzere doğal malzemeler ve küçük ölçekli binalar olarak kısıtlanmıştır(–yüksekliği 12 metreden fazla değildir. 1 kattan 6 kata kadar). Daha sonra, her bir malzeme için 21. Yüzyılın çağdaş yığma yapılarından 8 örnek seçilmiştir (8 taş, 8 tuğla ve 8 kerpiç). Seçilen yapılar ileri yığma inşaat teknolojileri ile dikkati çekmekte ve en az bir mimari yarışma kazanmışlardır. Daha sonra, Ahmet Iğdırlıgil'in Yalkavak, Bodrumdaki taş evleri saha çalışması ile test edilmişlerdir. Sonuç olarak, kapsamlı olarak belirlenen teorilerden yola çıkarak, yapısal elemanlara göre binanın ontolojik yapısal kategorisini değerlendirmek amacıyla oluşturulan ontolojik okuma modeli ile 4 temel çesit çağdaş yığma stürüktür sistemi ortaya çıkarılmıştır. Bununla birlikte, çağdaş yığma sistemlerinin yeni stereotomikleri kanıtlanmıştır.

Bu tez, mimarlar ve öğrencilerin bina tasarımı sırasında ontolojik konulardan daha fazla haberdar olmaları ve bu konuların tasarım kararlarını nasıl etkilediğini anlamalarına yardım eden, binanın bahsedilen yönlerine bir giriş sağlamaktadır.

Anahtar Kelimeler: çağdaş yığma, tektonik, stürüktür ontolojisi

TO MY LITTLE STAR MEHMET ☆

ACKNOWLEDGEMENT

I am greatly thankful to my supervisor Prof. Dr. Yonca Hürol and mentor for her insight, contributions, and invaluable guidance throughout my research. Without her encouragement, I would not have explored so deeply the study. I also would like to thank to my monitoring jury member Prof. Dr. Hıfsiye Pulhan and jury members Assoc. Prof. Dr. Müjdem Vural and Assoc. Prof. Dr. Kağan Günçe for their valuable comments. I appreciate their invaluable advices. I'd also like to thank two of my external jury members Prof. Dr. Prof. Dr. Gülser Çelebi and Prof. Dr. Füsun Demirel. I would also like to acknowledge Prof. Dr. Özgür Dinçyürek who is the Chair of the Department of Architecture and Assist. Prof. Dr. Ceren Boğaç who is the Vice Chair of the Department of Architecture, EMU for their kind concern about my study, trusting, and encouraging me in all sides of academic life.

Special thanks to my mum, dad and my husband for their patience, support, and endless encouragement whenever I needed. They have strongly encouraged and lend a hand me to succeed during my difficult times. Other special thanks to my whole family who were always with me and motivated me during the process of thesis. I also extend thanks to my beloved son, Mehmet Kovancı. His cherfullness took all my stress always. His existence keeps me motivated, positive and let me to finish my thesis. I appreciate the help of my special friends Begüm Dörter, Gökhan Varol, Bedia Tekbıyık Tekin, Nilay Bilsel, Halleh Nejad Riahi, Kamyar Arab, Cemaliye Eken, Sertac Ilter, Kamiar Yazdani, Assist. Prof .Dr. Kamil Güley and all faculty members.

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Chapter 1

INTRODUCTION

In architecture studies not only evaluating building from structural, functional or aesthetical dimensions but also decomposition of each part of buildings and evaluating separately are important. Thus, recent research about each element of building stands out more than the other aspects. The prevalent studies are dominant in separating the building into smaller sections in order to find the reason for usage of each section. The importance of forming and shaping of the buildings and their construction techniques has increased and this drew the attention of architects. For this reason, these aspects can be seen in architects' research agenda. When these sections are considered separately, the material and technique that were used for each part (in other words the foundations, walls, roof, and structural system of buildings) provide examples in architecture and cultural history. The research of these sections/parts creates important data in architecture. In this context, the problem introduced here is the elements of contemporary masonry structure which were not classified before from architectural point of view. These elements show undefined ontological differences even among themselves. (In this thesis, contemporary masonry system covers the mixed structures which have different structural elements than traditional masonry structure. On the other hand, traditional masonry system covers the conventional system in which the structure has not got any other additional elements.) Because of needs, necessities and progress of the change in communal value systems vary in time; construction elements undergo change in time as well. Thus tectonic theory can be taken as a kind of evaluation theory for buildings since it is largely related to the structure of building, the use of material, details, and experiences through materialization and the making of the buildings (Hartoonian, 1994). In this context, tectonics in architectural studies is related to expression of details, materials and structural systems and the relationship between them. Hartoonian (1994) who is one of the writers about tectonics also described tectonics as indicated above. Additionally, Frampton (1995) supports this idea and states that "*theory of tectonics can be an alternative theory for architecture.*"

On the other hand, discussions about 'Tectonics' take place in the theory and history of architecture. Thus, main approaches are found from classic period to 21st century. Chronologically these are Heidegger, Vitrivius, Alberti, Palladio, Semper, Bötticher, Sekler, and Frampton, who had explained the meaning of tectonics differently.

In this context, wide range of opinions plays an important role in the dissemination of theory of architecture. Due to this problem there should be a careful investigation of the concepts and references. Environment, fundamental concepts and references will be investigated in regards of tectonic and their re-interpretation will be inevitable. The concept of "tectonic" which generally highlights architectural product and the content needs to be discussed ontologically through an analysis of transformation of the mental product to a 'real, existing object' until it occurs.

As a result, based on Semper's theory, Framton's tectonic and stereotomic taxonomy is considered as evaluation theory.

1.1 The Purpose of the Study and Objectives

Social and cultural developments caused people to reside in different type of constructions and architecture, while these developments had emerged from simple constructions and advanced to more complex ones. By the time, human beings started to improve their talent for construction in which they had started by putting basic structures such as stones, bricks or timber pieces together and by shaping the constructions with their hands. They have become more sensitive towards the places that they created. Desire to get more benefit from environment and need for larger places creates some other problems; such as the open plan system brought about the requirements for new cover systems in building systems. Nowadays the architect's duty is to design appropriate structures and develop different spacing concepts.

In order to shape structures, problems need to be solved at concept level and most importantly the problems should be identified as "construction of structure". That's why structure and relation of structural elements are important. Thus tectonic theory can cover to solve both problems as mentioned above.

In this context, 19th century theorist and architect Gottfried Semper's developed his "Four Elements of Architecture" (1851). In this book, he divided the building into separate architectural elements such as heartwork, earthwork, framework, and enclosing membrane. He explained that, these elements are derived from instincts or needs of human beings. He technically related each element to applied arts and claimed that these elements are transformed in time since the antique cultures (Mallgrave, 1989). In this explanation, Semper mentioned the necessity and the importance of construction and drew attention to relationships between form, material and technique then emphasized that art is following them. In the following chapter this distinction will be examined more deeply.

On the other hand, Frampton’s studies (1992; 1995; 1996) affected and led to the organization of conferences about tectonic. Recently tectonic theories had been analyzed and interpreted by Nesbitt (1965), Mallgrave (1983; 1989), Hermann (1984), Ulguray (1999), Beim (1999) , Alkaya (2002), Zhao (2006), Guncu (2007), Yang (2009), Liu (2010), Yang (2011), Ozdemir(2014) .

However, the studies mentioned above, are not directly related to contemporary masonry structures or any kind of visual or technical properties of the masonry systems. Thus readability and questioning of 21st century contemporary masonry structure buildings and ontological varieties of them are not covered. In this context change and transformation of tectonic properties came up as an issue that needs to be observed and investigated.

It is a known fact that technological developments have an impact on everyday life so formal properties and aesthetic quality also changed accordingly. In turn, this change becomes reflected to architectural design, designers thought in time, architectural forms, materials and techniques.

In contemporary masonry buildings, even though it seems like there is repetition in natural materials and structure technology that were used, in fact it is not the case, thus every single one of the architectural element differentiates. It is not fair to indicate that, there are limited distinctions in literature of architecture. For example in ‘Architectural Dictionary’ Hasol explains masonry structures under two sections;

in the first one; tying stone or bricks with mortar, putting them together one on the other and binding them as load-bearing. The second one is explained as, using overlap method (no nails are used) with timber and trunk (Hasol, 1998). As a consequence of this the idea of questioning the validity of types of masonry structures comes to light. Today's conditions and building examples show us that, although some buildings are made of more conventional techniques, there is still something different than the old times. In this case, is it possible to explain them under these two categories of Hasol? In order to find the right answer, it is required to find what the differences are and in which way they reach this building type.

Since the last quarter of the 20th century, criticism on Modernism and questioning of 'the presence' became the basic problematic topic. Existence (to be-being), the concepts of the individuality and the continued emphasis of individuality in our actions by ignoring the natural environment creates intolerable problem of global warming. In this context, Habitat II set forth that development in the name of "ecology" should be taken into account in all fields, as well as in the field of architecture. This has caused the new parameters to be defined in architecture and today there is a tendency towards traditional stone, brick, and adobe structures which are regarded as natural materials (more ecological). On the other hand, during 1973, the energy crisis and the fossil fuel based energy were causing ecological problems and in this context, new discourses on global size, started to be important factors that have shaped architecture after 1980. Energy conservation and energy efficiency were beginning to come to the fore especially in European countries that were plainly out of energy. This has caused an explosion in the research, that aim to reduce the energy consumption of existing methods and can renew itself, preventing pollution of the environment and evaluation of alternative energy sources which are abundant in the nature (Utkutuğ, 1999).

To solve the growing demand for environmental control, new technologies can be counted among the issues being discussed. People are starting to question the relationship between nature and technology. In this context, the social requirements vary with technological developments. This process has continued from industrial revolution till today and showed ontological differences between structure systems.

When the contemporary masonry is considered, the differentiation between them can be seen. The contemporary masonry buildings are more complicated than traditional ones and it is difficult to talk about their tectonic approaches, because the structure is somehow hidden. Contemporary masonry tectonics varies by using different materials and different techniques for each building. We can separate traditional and contemporary to understand the two better. However the border line between them may not always be clear. Materials and methods can be used in different ways.

Today, there is a chaos around the world. Vast of human and material sources and the lack of creative powers indicate monotone irregularity in our lives. It can be easily seen that the method and the materials are similar for most of the building types all around the world. Most of the buildings have steel or concrete frame structures. There can be many reasons for this but the most important one is the cost.

However, traditional materials (timber; stone; adobe or earth or clay (the raw material of mud-brick and baked bricks) are obviously available in human's immediate surroundings. They can be collected from nature and made ready to be used in buildings after an easy processing method.

According to observations, it can be asserted that frame is contemporary structure and generator of previously impossible construction techniques and emerge as a material that has come into its own in the 21st century (Croft, 2004). Additionally, many of the most memorable architectural masters have used it with meaningful and resonant tectonics.

On the other hand, traditional masonry structures seem that they do not have many possibilities as the frame structures. However, nowadays it is not easy to say this bluntly, because technical developments provide many opportunities to reach better living spaces with masonry structures as well. On the other hand, masonry syructures have a very significant place in the history of architecture.

The problem here is the conception. The views of structure as only the necessary or technical parameters for designing a building should be changed. The aim of this research is to take attention to the structures that play significant role when designing a building which express its tectonic qualities with the technical and visual values. In this context, contemporary masonry structures have been taken as systems to analyse the buildings with masonry walls from ontological point of view. One of the objectives of this research is to develop tectonics by using concept of ontology to categorize the structural elements that are used in the walls of the buildings in order to better understand the new methods for reading those kinds of buildings. When the topic is about the masonry buildings, it is necessary to consider the weaknesses against natural disasters like floods, earthquakes etc. However, the most destructive one is the earthquake and it directly relates to the safety of people.

Therefore, the focus of this research is the relationship of tectonic technology and changes, variations of walls between contemporary masonry buildings, which were applied in different earthquake zones.

The problem is, there is not any classification about structural elements that were used in the contemporary masonry buildings and ontological differences between them have not been defined yet from architectural point of view.

Firstly, it can be beneficial to understand the traditional masonry buildings and accordingly analyse the new techniques of contemporary masonry buildings. It is deniable that, the masonry systems are weak against earthquake forces, so this important parameter was also taken as a consideration. This will help to find the development of structural elements that were used in different earthquake zones. Finding the tectonic characteristics of the contemporary masonry is another objective of this research. By this way the different ontological groups that exist in contemporary masonry hybrid (mixed) structures can be found.

When looked at the traditional brick masonry examples below Table 1.1, the only difference is the colour. It is obvious that, this much of dynamism with surfaces, variation in brick courses and curved surfaces have not been seen. In comparison to traditional masonry, this play and manipulation of modular units become interesting when combined with the structural elements. The structure does not need to be interpreted as heavy and solid. As it seen from the Table 1.1, brick masonry can be light weight, open and airy.

Table 1.1: Differences between traditional brick masonry and contemporary brick masonry

Traditional Brick Masonry Example	Contemporary Masonry Brick Examples		
 Albi Cathedral from middle age (by Author)	 TheCurving House By JOHO Architecture (Url1)	 Brick Pattern House ByAlireza Mashhadmirza (Url1)	 Brick Wave House By Studio Gang (Url1)
	 Pope John Paul II Hall By Randic Turato (Url3)	 EcumenicalForum,Hafencity By Wandel Hoefer Lorch + Hirsch (Url1)	 Pavilion 4 By HMA Architects And Designers (Url1)

Additionally, when looked at the traditional stone masonry examples in Table 1.2, color of stone slightly changes. It is obvious that, this much of variation in stone surfaces and texture has not been seen. On the other hand, in comparison to traditional stone masonry examples, contemporary examples bigger openings arbitrarily arranged on wall surface and very dynamic formal arrangements. This might be interesting when combined with the structural elements. Again, in contrast to the traditional masonry, the buildings cannot be interpreted as heavy and solid. As it seen from the Table 1.2, stone masonry can be light weight, open and airy.

Table 1.2: Differences between traditional stone masonry and contemporary stone masonry

Traditional Masonry Stone Example	Contemporary Masonry Stone Example			
 Building from London (by Author)	 Demir Holiday Village by Turgut Cansever (by author)	 Metropolitan park by Polidura Talhouk Arquitectos (URL 1)	 Radio station by archium (URL 2)	
 Building from Turkey (by Author)	 Municipality Building By Mauricio Rocha(URL 1)	 Municipality Building By Mauricio Rocha (URL 3)	 Country House by DVA Arhitekta (URL 2)	

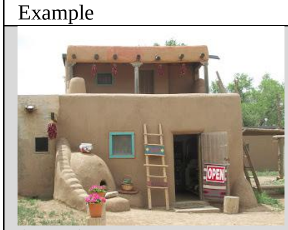
Different applications also available like stone gabion system. Thus, gabion wall technique was occurred in this category. This kind of baskets are generally used to retain dirty highways or used to stop soil erosion. However, in here, the gabions are used for building structure. Gabion walls are generally considered as gravity retaining walls or welded mesh system, that is, walls that use their own weight to resist the lateral earth pressures. Gabions are wire fabric containers, uniformly partitioned, of variable size, interconnected with other similar containers and filled with stone at the site of use, to form flexible, permeable, monolithic structures such as masonry wall. These specifications can be read from Figure 1.1 and Figure 1.2.

Figure 1.1: Villanueva's Public Library by Meza + Piñol + Ramírez + Torres, Colombia (URL 1)

Figure 1.2: Haus 9x9 by Titus Bernhard, Germany (URL 1)

The metal mesh gabion baskets and their wire connections are an important part of the structures, which gave the tectonic quality to the buildings. Because of modular usage, variations in the wire mesh density and in the size of filled stone are another value for tectonic expression.

Table 1.3: Differences between traditional adobe masonry and contemporary adobe masonry

Traditional Masonry Adobe Example	Contemporary Masonry Adobe Example		
 (URL5)	 NK'Mip Desert Cultural Center byHBBH Architects (URL 36)	 Teacher housing by Diebedo Francis Kere (URL 58)	 The Kendle Designs residence (Rael, 2009)
	 Hause Rauch by Martin Rauch (URL60)	 The school of visual arts by Mauricio Rocha (Rael, 2009)	 Lupin research park by Malik Architecture (URL 59)

Same as other categories (brick and stone), different applications are available in adobe category as well. For example: starting from Neolithic periods; the way of doing and using adobe started to change and different applications of earth structures emerged, such as rammed earth construction. First example of rammed earth structure is the Great Wall of China. Nevertheless, today's examples show different attitudes than the traditional ones as it is shown in Table 1.3.

However, these applications also are not the same as the 20^{th} century examples. Especially during the last decade of the 20^{th} century, new techniques became very popular. This is experienced mainly in New Zealand, Australia, and Mexico.

Rammed earth technique, achieved with compressing a mixture of earth which containing sand inside. The percentage of sand and clay is important. When used together with a special kind of formwork and pressure techniques, it gives the shape to the wall. At the end, formwork is taken out and solid earth wall is achieved as it seen in Figure 1.3.

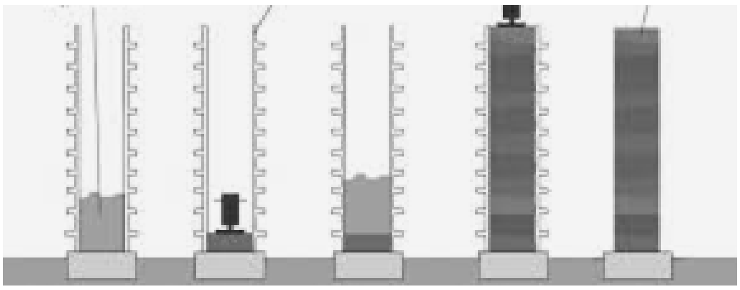


Figure 1.3: Construction method of the rammed earth wall (URL 5)

As a result, Table 1.1, Table 1.2 and Table 1.3 were showing that, there is a gap between the traditional masonry structures and contemporary masonry structures. According to the observations mentioned above, in this thesis, it is aimed to find out;

- What kind of structural elements were used on the masonry wall in the category of contemporary masonry buildings. (This can be understood by finding out what the differences are in contemporary masonry structures than in traditional masonry structures.)
- How many different ontological structure varieties there are in case of masonry wall.
- What the roles of the earthquake zones are and does earthquake resistance play a determining role for this change?

These listed questions will be investigated through stone, brick and adobe buildings which are made by contemporary masonry.

Due to diverse interpretations of researches from architecture even from different disciplines as anthropologist, historians, phenomonolist etc. numerous approaches exist in the field of architecture about tectonics. Thus, in this thesis certain approaches are emphisized to define the framework of the study. Accordingly, Semper’s and Frampton’s approaches streotomy and tectonic elements form the basic core of the study. It covers heavy and light elements in the masonry building. These are all done for understanding the determinants of the changes in the masonry buildings in terms of technical and aesthetical solutions (visual consideration).

Additionally geographical information is vital in the development of this thesis. It mainly signifies the earthquake zones of the cases. From this point of view the differences between systems of the contemporary masonries also checked. By this way, the importance of the earthquake on masonries cannot be ignored.

1.2 Hypothesis

The reason why this study was carried out is to see the different trends that are faced in today's structural practice on masonry: On one side, the trend in which the wall is independent from construction process can be seen (In other words this technique reduces architecture to scenography). On the other side, the surface architecture which pushes new material/combination, structure system and potential of techniques based on new wall forms can be found.

In this context, this problematic field has three contradictions;

- architecture is seen as a product of mind or a technical product;
- conversely, architecture is seen as a kind of fine arts product
- Last but not the least, architecture is seen solely as functionally important.

It can be stated that these three aspects should not be viewed as separate from each other; in fact they should be regarded in equal weights (there should be a good balance among these three views).

It is essential to remember that, one of the main research questions that the study focuses on to find out is that how many different ontological structure varieties are there regarding the masonry wall.

Thus, according to the concept of tectonics the hypothesis of this thesis relies on, after the ontology of the structure system are defined in this study new stereotomics theory is constituted, if the following findings are determined;

- Tectonic elements are used in contemporary masonry structures

- Masonry structural elements other than elements of traditional masonry are used
- Traditional and contemporary effects exist simultaneously
- Visual and technical qualities are present simultaneously.

1.3 Methodology and Limits of the Study

Research methodologies include a documentary research, analysis and a field study with interviews and observations. Throughout the study, different data collection methods such as personal observation, site visits and measuring, interview methods have been used for examine the original values of contemporary masonry buildings. The most original aspects of this research and its methodology are also hidden within this study. Therefore, the study includes five main parts: The first one is theoretical foundations about tectonic theory, second one is theoretical foundations about the traditional masonry and the third one is analysis of the structural elements in traditional masonry. The research method and the structure of the thesis, after a certain phase of the theoretical reading and analysis, start to overlap with each other. Thus, the creation of a model out of theory and as a fourth part the analysis of the contemporary masonry building examples (in order to classify ontological groups,) started to feed each other and hence shape too. In this context, the research process started to be developed between the theory of tectonics and existing masonry examples in the field of architecture. The fifth part is a field study on Ahmet Igdirligil stone masonry buildings.

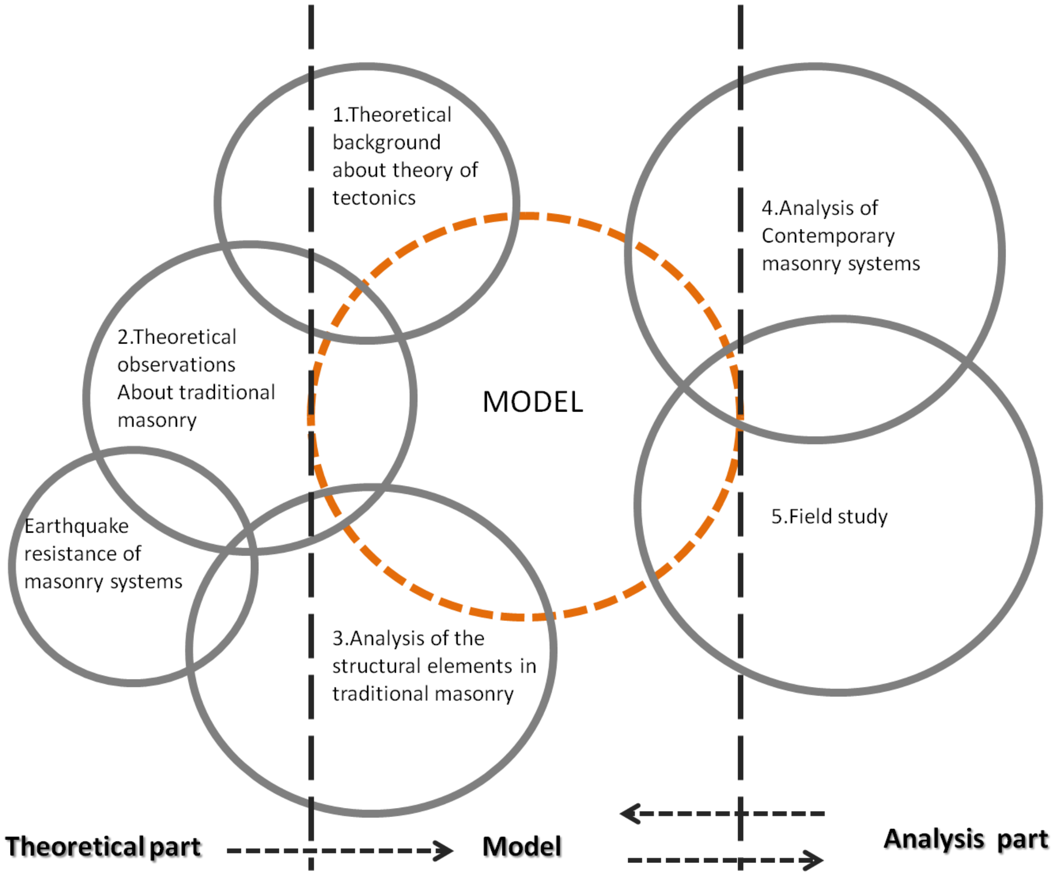


Figure 1.4: Method and ontologic reading model development

The model and the way of creating model and the methodology of the research are explained in detail in Chapter 5. In this context, brief summary provided in Figure 1.4.

The model has been developed as a result of deep investigations on literature studies about theory of tectonics and masonry systems. When model was being developed according to these foundation theories, the importance of earthquake is taken into account. In the scope of the model, evaluation tables are generated. By using these tables, selected contemporary masonry buildings were evaluated. As a result of study different structural groups are found. Additionally in the fifth step where these findings will be tested more deeply, Architect Ahmet Igdirligil's stone masonry buildings are chosen as a field study and ontologic reading model has been used for these buildings.

All the tables prepared by the author and visual data of the contemporary masonry examples were collected from internet sources. However for the field study all the photographs taken by author. The plan and sections of Ahmet Igdirligil's stone houses are obtained by Ahmet Igdirligil.

This chosen study is limited with the analysis of contemporary masonry buildings in the context of tectonics. In this sense the limitations of this study are identified in four areas: natural material (as adobe, stone, brick), small-scale of buildings, functional dimension of buildings and the building which won architectural competition.

- According to material; stone, brick and adobe categories are created
- According to scale; small-scale buildings in which the height is not more than 12 m (from single storey up to 6 storey)
- According to function divided in two as public buildings (office/work spaces,school,library,gathering places) and private buildings (house type, apartment type);

Then 8 examples from the 21st century's contemporary masonry structures were selected for each material (eight stone, eight brick and eight adobe). These draw attention with their advanced masonry construction technologies and won at least one architectural competition in the category of adobe, brick or stone. Apart from these examples, more than 40 contemporary masonry examples have been evaluated throughout the research; however there is no any other different systems found. Thus they are excluded from the thesis.

This type of study encourages the architects to reconsider architecture in alternative ways and promotes them to expand their perspectives. Not only this thesis would be helpful for architecture students to follow masonry structure construction techniques and structures but also help to acquire the skills needed to analyse architectural products within architectural theories.

This study does not analyse all parameters of tectonics in the context of cultural value, symbolic meaning, functionality etc., rather gathers the analysis into three specific matters of the buildings as material, detail and structural system. On top of these, this study questions the buildings' aesthetic and technical quality. Therefore, the focus of the analysis is solely on the physical building rather than the architect's intentions when designing building.

1.4 Structure of Thesis

This thesis composed of 7 main chapters. The organization of this thesis is as follows:

Chapter 1 introduces the background of this study. Introduction part includes topic of the study, purpose, importance, hypothesis, method and limitations of the study.

Chapter 2 presents existing definitions and categorization of tectonics and also includes literature survey. Tectonic concept is put forward in relation with ontology and theories. Following that, the synthesis of a wall in theory of tectonics and stereotomics, then the importance and originality of the thesis will be presented in this way.

In Chapter 3, tectonics will be explained according to the concepts of tradition and contemporary. Thus this chapter is separated into three section as; the concept of tradition and contemporary in the view of tectonic; changes in traditional tectonics; and changes in contemporary tectonics. Thus, the differences between them will be examined and explained through architectural examples in chronological order.

Chapter 4 includes four sections in order to explain the traditional masonries in the view of tectonic. Firstly, the evolution of traditional masonries is touched, then structural elements of traditional masonries are discussed and tectonic values are presented. In regards with section two, in the third section, masonry structures are separated in terms of the material differences as stone, adobe, brick and the tectonic effects on traditional buildings are discussed. Last but not the least, in the fourth section, earthquake problem of masonry structure is taken into account as an important parameter to discuss general applications in the views of building codes.

Chapter 5 provides the hypothesis of study and the method used is explained in detail. Regarding this, classification of contemporary masonry by their materials' and the changes of structural elements are tectonically evaluated. Thus, provided dissolutions with 'analysis model' literature information has been explained.

Parallel to the analysis in Chapter 5, the main objective of Chapter 6 Architect Ahmet Iğdırlıgil's stone houses in Yalıkavak Bodrum was chosen for analysis from the tectonic point of view based on concepts of ontology. This is done by applying the model that was created in Chapter 5.

Finally, in Chapter 7 the general conclusion and recommendations in relation to what research can be carried out about the subject, in the future, are included.

Chapter 2

DEFINING THE SCOPE OF TECTONICS

This chapter is separated into four sections in order to explain the tectonic theory. First, the meaning of tectonics according to theoreticians' definitions and theories in relation with ontology are described. Following that, the synthesis of a wall in theory of tectonics and stereotomics are explained. Then to display the importance and originality of the thesis, studies about tectonics will be presented.

2.1The Question of Signification: The Term Tectonics and It's Relatives

The definition of tectonics is very wide in architectural theory. Thus, the variation in definition can be divided into three main parts as; terms as tectonics and architectonics; tectonics and the terms: techne, technique, technology; tectonics and the systems; structure, construction.

2.1.1 The Term Tectonics and Architectonics

The roots of term 'tectonics' comes from the word 'tekton' which generally refers to the maker, builder, carpenter in the language of Ancient Greek. In the European art cannon, it is equal with painters, artist almost poet; an act of poetic, possesses more than the means of ordinary, simple carpenter (Hartoonian, 1994; Frampton, 1995). Thus, over the time, the term was started to be used in more general as 'the constructive arts' which means the expression of technical and artistic point of view in architecture and the term calls for an interdisciplinary approach (Frampton, 1995).

In modern language, the term ‘tecton’ became to be used interchangeably with the term ‘architecton’ which means master builder.

Thus, in architecture the term architectonic also shares the same meaning with tectonics as it mentioned above. In addition to this, architectonic also include the use of mechanical and electrical systems as a part of design. Thus, architectonic both express themselves and their designs in terms of the purpose behind the functionality. Pompidou Center (Figure 2.1) in Paris is one of the examples that totally express its architectonic value by showing mechanical and electrical systems in a purposeful manner in its design (Friedman, 1989).

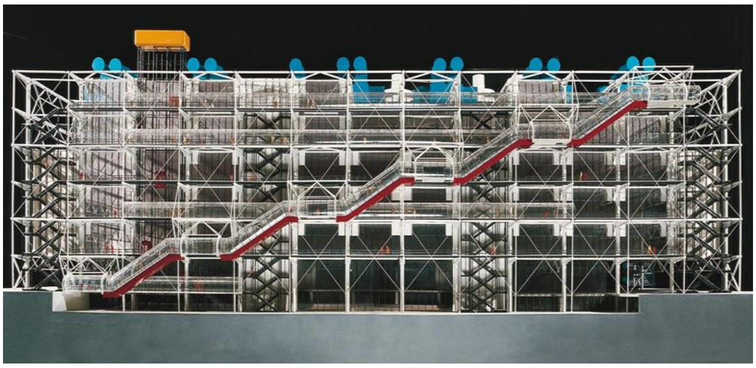


Figure 2.1: Structure system with mechanical purposes represents the architectonic value of Pompidou Center (URL 29).

As a result, both terms; tectonics and architectonic share the same root which comes from Greek. Tectonic comes from the word *‘tecton’* which means carpenter or builder as mentioned above. The only difference between tectonic and architectonic is the use of the prefix *‘archi’*. This is also indicates ‘the presence of a master builder who creates constructional art in a more modern sense and both terms exist in the theory of architecture for centuries (Friedman, 1989).

However, it is needed to mention that, the term ‘tectonics’ is being used for another area which is one of the branches of science of geology. In distinction from the architectural term, in geology the word ‘tectonics’ is used for the geological process and movements of earth. It can be briefly described as, the area of geology which deals with the formation of mountains, erosion, earthquakes or volcanoes which are created by movements of the tectonic plates. This thesis does not cover this definition of tectonics.

2.1.2 Tectonics and the Terms: Techne, Technique, Technology

Additionally, it is possible to find the relation of technology in connection to architectural writings on architectural tectonics. In order to understand the meaning of the tectonics in wider terms, the concept of tectonics should be discussed with the terms *techne, technique,* and *technology*.

According to, Porphyrios who was the theorist about architecture, in Greek the word *techne* was used for both *‘art and craft’* (Porphyrios, Papadakes, 1982; Ballantyne, 2002). According to him, Greeks did not separate craftsmen from artists and named them as *technites* because the term *techne* expresses the man’s knowledge, intelligences and abilities which involve music, sculpture, poetry, agriculture, medicine etc. and it’s reflections on construction (Ballantyne, 2002). Additionally, he stated that the term *techne* in general was used as opposite with nature. Furthermore, he explained with an example that a man with the organized knowledge transform raw material into some other things, after a series of processes and in the end, he can produce totally different thing which is not natural any more (Porphyrios, Papadakes, 1982).

Another important philosopher Martin Heidegger refers to the man-made build environment, with the concept of 'being in the world', and he discussed 'dwelling poetically' in his essay; '*The Origin of Work of Art'*. He explained the meaning of techne authentically. According to him, techne signifies *'a mode of knowing'* rather than *'an action of making'* (Heidegger, 1971; Norberg-Schulz, 1976). Thus, he evaluated the term dwelling as building. In German, the term building means 'to stay in a place', different to that of Greek meaning of building, so the term building is signifying the dwell. That is why, according to him, *'building is not an art or technique of construction but dwelling'*. These discussions are about the art of building. He argues that the nature of the building lets to dwell rather than to construct because dwell gathers the four matters into one which is the building. In here, the fourfold are the earth, the sky, divinities and mortals which he defines as four primary beings. In addition, he discusses the existence of Greek temple in case of symbolic meaning by emphasizing the meaning of being alive, death and importance of god with respect to the environmental context of the temple. Thus, he described the work as not as representational and that the work should show the 'truth' (Heidegger, 1971; Norberg-Schulz, 1976). With this explanation, it can be said that, he signifies techne as making something appear and be evaluated as 'the poetic revealing of things' (Heidegger, 1971; Hartoonian, 1994). Thus, he considered the essence of architectural tectonics to be originated from techne. In '*Being and Time'*, he used a more specific definition for world which is based on earth, sky and divinities. With this categorization, he defined the world ontically that the means of 'totality of the things' and 'being of these things' from the ontology 'wherein a human being is living' (Norberg-schulz, 1976). In his essay '*Poetry, Language, Thought*' he discussed art, space and the spatiality and explained spatiality as ‘freeing of places for human dwelling’. Here he saw the buildings as ‘a kind of object between earth and sky and humans as a kind of connector to earth and sky (Heidegger, 1971; Hofstadter, 1971).

Christian Norberg-Schulz (1976) also discussed Heidegger’s definition about techne in his essay, ‘the phenomenon of place’. He follows the same thoughts with Heidegger while explaining that with using a phenomenological approach which the ontological purpose of the buildings is to create site as a place and reveal the meaning of building. For him, building should represent its own identity with all properties of its surrounding (Norberg-schulz, 1976). Thus, the term techne means a kind of *“poetic arrangement of a place through plastic forms rather than the scientific abstraction of a space”* (Norberg-schulz, 1976).

In 17th century the word techne was replaced by the word technique which links to using technical elements of an art or a craft. According to Giedion, building technique is not a tool for solving the problem of form, but is just the source for considering architectural spatial form (Giedion, 1967). In other words, art was started to be thought separately from technology. Technique is closer to the technology only because by the help of the techniques, technology can be improved and art is expressing this techniques or technology visually.

In addition to Heidegger’s (1971), Giedion’s (1967) and Norberg-Schulz’s (1976) definitions, another theorist Gevork Hartoonian (1994) explains the term technology as a corresponding term for techne in Greek, which means art of making. In the classical period, the term technology was not known in the same sense of today. According to him, in classical period Vitruvius and Palladio were used techne for explain '*logos of making'* which gave emphasis '*ontological bond between art and science'*. Then, in 17th century dilemma between Galileo and Cartesian legacies were created inspiration for the epistemological break with the classical taught. Hartoonian (1994) explained this break point as *"the absence of structural utility as a theme in the architectural discourse of classicism was caused by an ontological relationship between meaning and work".* As a result of this break point three main changes were occurred as '*concept of beauty', 'new understanding classical order'* and '*concept of fabrication'*. With this way, the process of building became a determining factor of cultural values of the final product. As a result these were caused to break up the classical taught in between 'style and construction' in wider sense 'art and science' (which was the ancient meaning of techne).

In the 18th century the ontological relationship between art and technique are disappeared and the concept of technology emerged as based on technique (Hartoonian, 1994). For that reason, architecture and engineering were started to be separate two disciplines (Hartoonian, 1994).

On the other hand, Kenneth Frampton (1995) also followed Heidegger's definition and he stated that:

> "...techne reveals the ontological status of a thing through the disclosure of its epistemic value."

By explaining that, he pointed out that the term techne contains 'the meaning of revealing' which he generalized as both knowing and making (Frampton, 1995).

In addition to above discussions, both the terms technique and technology are originated from same root of techne. However the definition of technique and technology were explained differently in architectural critics. It can be summarized as they agree that techne is poetic revelation of construction based on Greeks. On the other hand, in modern sense, technology means the structural utilization of construction based on scientific and objective analysis.

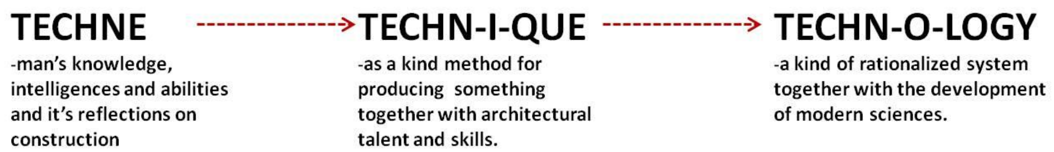


Figure 2.2: Terminological relationship between Techne, Technique and Technology.

In architecture, the term technique could be explained as a kind method for producing something with architectural talent and skills. On the other hand, the term technology indicates a kind of rationalized system in which the development of modern sciences occurs (Angelil, 1989). However, when modern materials and construction methods were developed in 19th century and another term was required to explain phenomena of technological construction for cover all these changes in architectural theory. While technology in architecture refers to a rational system, the term techne does not cover a system; techne refers to the poetic revealing of all fields of art and craft with knowledge. However, technology does not give the meaning of poetic knowledge. In this context, the term tectonics is used to express higher-level means of construction because it refers to the 'art of construction' (Frampton, 1995; Kim, 2010).

As a result, it can be said that the term tectonics is used to explain how an architect make use of elements such as details, structures, materials on walls, roofs, and floors to create an overall design of the structure. In general, the concept of tectonics is used to explain the quality of building. It is usually described 'how the structural elements, materials are brought together and constructed. Frampton's (1995) definition about the concept of tectonics can be given as an example to support this idea as he stated that;

> "When a structural concept has found its implementation through construction the visual result will affect it through certain expressive qualities which clearly have something to do with the play of forces and corresponding arrangement of parts in the building yet cannot be described in terms of construction and structure alone. For these qualities which are expressive of a relation of form to force, the term tectonic should be reserved (Frampton: 1995)."

From this quote, it can be concluded that, tectonics is involved with the structure; it is not limited to the question of how structure is made; the purpose of use also is the questioned. In other words, tectonics involves explaining the expression of the structure's nature and its role in space making.

2.1.3 Tectonics and the Systems: Structure, Construction

One of the 20th Century theorists Eduad Sekler (1965) in the essay, structure, *construction, and tectonics,* he regarded these terms strongly related. He evaluated the term tectonics which is gathering the meanings of structure and construction together. According to him, structure is a kind of abstract concept which arranges the forces. In other words, it is a kind of system or principle based on play of forces. On the other hand, he defined the term construction as more rationalized system or principle based on selection of materials, material properties and the way that are doing, coming together. Thus, he asserted that neither structure nor construction alone can give the full meaning of "*certain expressive qualities together with the arrangement of forces (Sekler, 1965; Frampton, 1995; Kim, 2010)*".

Thus, he asserts that the term tectonics includes both meaning of structure and construction and he insisted the concept of tectonics is more than the meaning of *'technically structural qualities',* it is considered as '*representational forms'*, (which aesthetical values of structure), as well.

Hartoonian (1994) and Frampton (1995) are also influenced from Sekler's definition of tectonic. Hartoonian concerning tectonics as an advanced level of construction and define as 'the logos of making'. His tectonics respond to structural forces and this is expressing itself with ornamentation. In here, ornamentation is the aesthetic way of structural elements or considering visual qualities of structures to made them visible. It is helping to express the structures more visually (Hartoonian, 1994).

On the other hand Frampton's concept of tectonics regards structure, material and its poetic way of relations. Referring to Gottfried Semper and his understanding of tectonics, Kenneth Frampton's (1995) theory of 'Tectonic Culture', contains a reference to 'tectonics' as tectonic construction. Tectonics is discussed as both the poetics of construction, and as a specific mode of construction: the tectonic frame. Following the theory of Semper and by discussing it as part of cultural practice as a means of its representation, Frampton focuses also on the aspect of its aesthetic expression.

2.2 Theories of Tectonics

Starting from classical period to nowadays "tectonics" takes place in the history of architectural theory. As it is mentioned above, the terminological meaning gave information about how the concept of tectonics includes various branches subjected to it such as aesthetics as artistic point of view to static, structural, mechanical as functional point of view etc. It can be said that, the theory of tectonics is an interdisciplinary approach in the field of architecture. It is obvious that, this interdisiplinarity make the theory more complex. There is no definite explanation, so it is open to interpretations. That is why, each architect, researcher or philosopher who made contributions and evaluations about the concept of tectonics interpreted the theory with various opinions. Consequently, in this section, the main theories of tectonics will be presented from classical period to 21st century. That is why this section is divided into 3 main groups (according to the centuries) as follows;

1. There is no evidence that in classical period the term tectonics was used in an explanation but it can be evaluated as one of the categories as classical tectonics. However, it is obvious that, the start of the tectonic tradition coincides with the beginning of the master builder era. Thus, this first group consists from Vitruvius, Alberti and Palladio who were in search of developing building culture together with materials and techniques.
2. The second group consists of architectural theorists such as Gottfried Semper (1803-1879) and Karl Bötticher (1806-1889) from 19th century. In that period both Semper and Bötticher were key theorists that developing tectonic theory as an architectural movement.
3. The third group consists from Eduard Sekler (1965) and Kenneth Frampton (1995) from 20th century. Both of them gave contributions to the concept of tectonics on architectural writings by re-interpreting tectonics. Thus, they were selected to see differences and similarities between them.

According to Vitruvius architecture is based on three facts: Strength (firmitias), utility (utulitas) and aesthetic (venustas) (Kruft, Kruft, 1994). Strength does not only include construction type, but also static properties, in relation with construction and material too. Vitruvius who made researches on classical Greek period architecture defines places of worship as transformation of cottages formed with mythological philosophy, but in reality built as the need of carrying weight object column was transformed to structural system's stylist representative element. Correspondingly, Vitruvius' approach had identified the ontological relation of typology and logos of making (Hartoonian, 1994; Kruft, Kruft 1994).

In one of the books of the readers of Vitruvius, Renaissance theorist Leon Battista Alberti's book called 'De re Aedificatoria', it is expressed that a building has a structure and its decoration. In Renaissance period, the decoration was one of the important facts and it was independent from the structure. Therefore, in this period's buildings, there is wide difference between structure and its appearance. This was a breakthrough in the ontological relation between the structure and appearance (Hartoonian, 1994).

On the other side, Palladio approaches the subject more rationally and defends that classical period architectural products are based on causality and built according to appropriate proportions and these proportions need to come from nature and proportions of human body. Therefore, he underlines that new architectural forms need to be built for meaningful reasons rather than for artistic elements. He draws attention to re-establishment of ontological relation.

Because of contradictions between modern world and 19th century's European democracy whose products are based on historical forms, Semper researched about meaning of architecture and architectural design element. He found out that if people directed themselves to their cultures they could reach to future design elements. In 1851, in his book called ‘Four elements of architecture’ he used primitive hut as a model and he identified architecture as being related to applied art in relation to four elements: Earthwork, the heart work, the framework, and the enclosing membrane (Frampton, 1995). According to Semper, these basic structural elements are general necessities for a space to build and a place to live. Thus, it is possible to see these in each local architect’s basic structure of architecture and in construction elements of structures. It can be said that, according to him every architectural structure includes tectonic and stereotomic techniques. Thus, the structure and material’s relationship creates his tectonics. Therefore, material effect on space comes ahead of structural expression and the form. Here, basic and lightweight structure is the tectonic and stereotomic is the heavy construction.

Tectonic and stereotomic parts of buildings vary in different places of the world, in different cultures, in different climates, traditions and materials. So, architectural object/product is related with both ‘time’ and ‘space’ (Frampton, 1995). Briefly, the concept of stereotomic corresponds to the use of heavy construction and tectonic corresponds to the use of light structure and these can be used together.

Karl Bötticher (1806-1889) suggested two main elements of tectonics as kernform=basic/core form (the structural core of the building) and kunstform=symbolic/art form (the explanation of the structural form through ornaments). In other words, structural form indicates that each part of structure should be necessary for mechanical purposes and statical functionality. On the other hand, the art form indicates meaningful representation; a kind of characteristic in which the way the structure becomes visible. According to him, both of them are essential parts of tectonics. For example; Bötticher, in his essay ‘Die Tektonik der

Dellen'(1843-1852) explained concept of 'tectonic' as a detailed system which combines Greek worship elements and ontology (kerform) of structure in Gothic architecture. In representative decoration of Greek architecture construction (kunstform) of decoration requirements stand out and are emphasized. In order to associate structure and ornament with ontology and representation, he suggested a third architectural tectonic (Hartoonian, 1994; Frampton, 1995). Unlike Semper, Bötticher's division on core form and art form is more related to the form of the building rather than material, detail or construction.

In 'structure, construction and tectonics', one of the 20th century theorists Eduard Sekler's study carried out in 1965, building is divided into two as 'tectonic' character and 'atectonic' character building. Visual result of trick between construction and structure needs to bring an aesthetic expression together to provide a tectonic expression. Tectonic expression covers rhythmically repeating structural elements or two different elements (repeating each other) but in order to present the tectonic expression these repeating elements should be combined with details. It can be defined, as 'atectonic' when there is not coherence in structure's visual expression of load- bearing and its appearance (Hartoonian, 1994; Frampton, 1995).

At the beginning of 1990's Frampton, one of the theorist who brought up 'tectonic' concept once more in his architectural expressions, gives reference to difference of 'symbolic' and 'technique' sides of construction and draws attention to the difference between 'representative' and 'ontological' sides. Frampton's 'tectonic form' is an open structure that shows all the logic of construction and is defined as a form/shape that comes out from the details, which reflects load transfer through structural elements (Jameson, 1997). In this case, 'tectonic form' is a tool to expose a building's core (ontology), thus it can be regarded as a way of expression.

Frampton defines 'tectonic' as an art of connection and draws attention to the difference between 'tectonic' and 'atectonic' concepts. According to Frampton 'atectonic' means that a construction is with hidden tectonic elements. In general, 'tectonic' concept means construction but he defines this concept as poetic construction. He accepts structure as a construction action and as a 'tectonic' activity that is not scenographic. In here scenographic means being equal with representation or symbolic use of material, detail etc. without any functionality. According to him, structure is an ontologic and an existing object, if it represents itself with all its manners (Frampton, 1996).

On the other hand, when evaluating this, it is obvious that Frampton was influenced by Semper's taxonomy, which underlined that there are two basic techniques of structure art (Frampton, 1995):

- Tectonics of frame: Light system and form created of linear elements to frame a spatial matrix.
- Stereotomics of earthwork: The elements heavy as mass and size wise elements one on the other repetitively.

According to these main theories and definitions on 'concept of tectonics' it can be said that, it is a kind of theory that tries to balance the two arguments of architecture- firstly by rejecting the thought of architecture being a product of free art and secondly rejecting the thought of having only technical or structural quality. Both arguments should be considered equally. In addition to these, expression, the poetic way of building also should be expressed. In other words aesthetic values, visual considerations and the technical considerations can be followed in similar ways to reach the ontological quality in the buildings.

The concept of architectural tectonics sees the buildings as architectural edifices and the architects who have skill to produce tectonic architecture are very limited, and they are regarded as talented (Frampton, 1995).

According to Giedion (1967);

> “ In the field of tectonics, the use of modern technology means considering how to use new techniques, new materials and new building methods to produce structural harmony, thus allowing architecture to produce a new spatial form, being established on an inseparable relationship between architecture and site context, producing an interaction between people, nature and culture. In the end, architecture can take its place in history as a messenger of civilization (Giedion, 1967; Frampton, 1992).”

In this section, main theories are presented as they were encountered during the research in the field of tectonic. Since the classical period, “tectonic” can be found in the history of architectural theory. Architects and researchers interpret it differently as it was mentioned before. To sum up, these theories are used extensively throughout literature on tectonic but the definitions given in the literature hints that there is a lack of consensus and true understanding of their full meaning. The results of this part are shown in Table 2.1.

Table 2.1: Tectonic theories according to centuries

Classical Period			19th Century		20th Century	
Vitrivius	**Alberti**	**Palladio**	**G.Semper**	**K.Bötticer**	**G.Sekler**	**K.Frampton**
			(1803-1879)	**(1806-1889)**	**(1965)**	**(1990)**
Firmitas Utilitas Venustas	Structure Decoration	Science Techne (art)	Stereotomics Tectonics	Kernform Kunstform	Tectonic Atectonic	Ontology Representation
According to Vitruvius, architecture is based on three basic factors: Strength (firmitas), usefulness (utilitas) and aesthetics (venustas). Strength does not only contain static properties' it also contains construction techniques or style and relation between construction and materials. Vitruvius underlines nature of material in choosing, and usage of material in order to provide high quality, strong buildings (Kruft, Kruft, 1994:30).	According to Leon Battista Alberti, a building's core consists from building's structure with it's decoration. However, in Renaissance decoration was not an important fact. In addition, it is independent from the structure. Therefore, in the buildings of this period there is an obvious difference between structure and appearance (Hartoonian, 1994)	According to Palladio, integration of mind (or science) with art ("techne") will make a harmonious object with logos of making (Hartoonian, 1994:12). Therefore, "techne" with this content is based on the combination of the purpose of architectural object with the construction technique. It finds a definition as classic architectural column order or wall style. In other words, these architectural elements instead of a shape, which comes out from a construction, are based on nature and similarity with human body proportions or the proportions, which are designated by relations.	Tectonics of Frame: A light system and linear elements framing a spatial matrix in order to formed a building (Frampton, 1995:16) Stereotomic of Earthwork: masonry Repetition of heavy system elements, mass, and volume comes consecutively (Frampton, 1995:16).	Kunstform (Symbolic art form) that is understood as the representational language of Kernform (Core form/structural members). Basic loadbering system. He defines the concept of "tectonics" quite simply as the activity of forming a building, as a detailed system, which combines all elements of Greek temple (Bötticher 1874:32)	According to Sekler, the imbalance of carrier and loads in visual expression can be defined as "atectonic". The point in "atectonic" is the hidden tectonic elements in construction. He insists on structural order and building methods can be understood independently. Structural rhythm and constructional details should give "tectonic" expression to the	Frampton defines "tectonic form" as a form, which shows a building's constructional logic (Frampton, 1995:34). An open structure and a form, which comes out from details, that reflects load transfer in this case forms a "tectonic form", which can be thought as a tool, which shows or expresses a building's real core ontology. Representational characteristic must address the function: the element must represent the role it plays in the structural whole of a building (Frampton,1995:21).if it is not scenography emerged.
In Renaissance period ontological relation among human, tool and nature was pointed. According to this in classical period, columns, beams, and walls are not only shaped for the purpose of carrying load, but they were shaped on the base on similarity between nature and human body (Porphyrios, Papadakes, 1982:51).			From these divisions through the centuries, the only common result is that; if one of these items is ignored tectonics cannot be achieved			

2.2.1 Technical, Visual and Being Ontological

Discussions of aesthetics date back to Plato and Aristotle, both whom believed in the objective value of beauty. Both of them introduced the aesthetics as certain objects which have objective properties. These properties provide it to be perceived as beautiful. Additionally, Immanuel Kant in his essay “The Critique of Judgment” stated that *“the judgment of beauty as disinterested, necessary objective, in which humans take pleasure in something because it is viewed to be beautiful, not vice versa”.* It is obvious that there is not a measurement that proves the aesthetic value. That is why, he sees that the collective understanding of harmony gives people the reason and ability to make judgments of beauty (Mallgrave,1989; Masiero,1999).

In the light of Semperian thought, the primitive construction is an ongoing process, besides the period that the stylistic concept dominated, ‘each architectural forms emerged based on these construction methods and has turn to the art form’ was the main thought. He argued that, primitive principles of structural elements started to be developed with the idea of settlement which the buildings started to be connected to earth in parallel with natural conditions. Later, the aesthetical values of the new order and production tools were constantly added increasingly to the tradition of construction. And he adds; the basic elements of the buildings such as the structural elements, walls and roof beams have been converted into "art form" (Wagner, 1988).

On the other hand, in 19th century, based on the discussion about abstract concepts such as “style” and “beauty” Germans needed to give more definite meaning to them. Thus the term tectonic was introduced as the product of these discussions (Masiero, 1999).

Additionally, Schwarzer (1993) summarized Bötticher's concept of tectonics in his article *"Ontology and Representation in Karl Bötticher's Theory of Tectonics" as "a harmony between building and human culture brought about by the mediation of artistic ornament."* it can be said that, here the art-form serves as a vital link between a building and its visitor.

Through tectonics the architect may make visible, in a strong statement, that it intensifies experience of reality which is the artist's domain – in this case the experience of forces related to forms in a building. Thus structure, the intangible concept, is realized through construction and given visual expression through tectonics (Mallgrave, 1989).

Additionally "building construction artistically considered," is the simple phrase Frampton uses to describe the term "tectonic" in the most general sense.

As it was mentioned before, it might not be easy to give one clear definition for the concept of tectonics. The way of understanding the tectonics passes through testing many examples and considering various definitions of tectonics theory. In general, it can be explained as the interrelations between the parts and whole structure. In this sense, it can be related to the elements or materials that come together side by side, overlapping, interlocking based on the idea of structure. On the other hand, it should not be thought of only as a kind of object and it is possible that it has a phenomenological dimension as well. For example it can be felt by touching or a kind of feeling that reminds us something which we have experienced before. Sometimes, it can also be a kind of sense of seeing. For instance; a play of light in the buildings or hearing a sound can provide a tectonic expression. There can also be a unique element on building that is not solved previously. The way that some special detailing which is different than the others or two contrasting elements are used can be evaluated as tectonically. In the light of Semperian thought, it can be said that, the term ‘Tactile’ was always associated with the concept of tectonics. In general, the word of tactile expresses something that was learnt or felt by the sense of touch (URL 7). In the field of architecture, tactile is used to explain how materials affect the user’s experience through senses. Thus it is not necessary to touch any kind of object for testing what it feels like. As provided in “Experiencing Architecture” by Rasmussen (1964);

> “We build an enormous library of tactile memories. We remember touching materials like stone and brick at a very young age, and cognitively store the feeling of these things in our minds. We can tell by the visual texture of an object how it’s going to feel when we touch it. Therefore, there may be a difference in how we experience a wall made of concrete, which we would perceive as cold and rugged compared to a wall made of wood, which we would perceive as warm and somewhat smooth. These perceptions are extended to include weight and hardness as well, which also have bearing on how we experience materials (Rasmussen, 1964)”.

The implementation of the tactile senses in architecture has purposeful uses because it indicates the tectonical aesthetics. According to above statements, it can be said that, depending on how the architects interpret the concept of tectonic, they are also considered tectonic aesthetics as well.

Additionally, Pallassma’s (1995) definition of the concept of tectonic occurred by considering haptic senses. The term haptic also comes from Greek, which means “to come into contact with”. This describes our senses and perceptions which are associated with material and physical structure. This kind of design can also be called haptic architecture. Some misuses the word to describe anything that has texture. However, the sense of touch implied in the word tactile is not synonymous with the physical structure of a substance implied in the word texture.

Widely, the term *ontology* was used in literature on artificial intelligence, which emerged from philosophy. The origin of word comes from the *'ontos'* in Greek language which means *'being'* and *'logos'* meaning *'word'*. In 19th century, ontology was introduced by German philosophers in the study of existence of matter in the field of natural sciences (Sowa, 2002). Regarding this, Heidegger shares the similar ideas thus he provided the definition of world *'totality of things'* as *ontically* and *'being of these things'* as *ontologically*. Bunge (1977) also understands ontology as "the furniture of the world"-a method with which the world can be orderly organized.

On the other hand, another phenomenologist Peirce (1955) understands ontology "the science of being" which provides a materialistic understanding of particular things by relating them or separating them from other things. Peirce's (1955) phenomenology, which is seen as the "science of appearances," can be useful in order to describe the concept of "ontology" as well as to describe the concept of tectonic as a method (Atakara, Hürol, 2007).

In conclusion, it can be said that, wall is the most important existing object in the architectural environment and the concept of ontology investigates such existing things. Since the wall is an existing element and directly affects people, it can be regarded as the first architectural element to be questioned according to concept of ontology.

2.3 Synthesis of Wall in Theory of Tectonics and Stereotomics

Tectonics and stereotomics can be taken as two contrasting terms. However, both of them come from Semper's material approach and his attempt to connect with technical arts. He defines tectonics as molding the material with all artistic skill revealed by cosmic order. It can be clearly seen in the following statement of him:

> “Tectonics deals with the product of human artistic skill, not with its utilitarian aspect but solely with that part that reveals a conscious attempt by the artisan to express cosmic laws and cosmic order when molding the material (Herrmann, 1984)”.

According to him all artistic skills deal with material. Thus, he formulated his own concept of tectonics on the basis of artistic skill, where he improved the material approach by contrasting tectonics with stereotomics. Thus, he concentrated onto the four basic technical skills; 1.Ceramics (later metalwork), 2.Masonry, 3.Timberwork and 4.Weaving. Then, he categorized them under tectonic or stereotomic. Accordingly, timberwork and carpentry were categorized as tectonic part of building. On the other hand, stereotomics parts focus more on solid, massive materiality which is masonry techniques.

The dictionary definition of stereotomy is “the science or art of cutting solids into certain figures or sections, as arches, especially the art of stonecutting” (URL 7; URL 8). It can be said that, it is a kind of knowledge that indicates the quality of a stone. The roots of the word come from Greek as; *stereos* which means solid, and *tomia* which means - to cut. Thus, Frampton (1995) also explained it as ‘the art or technique of cutting solids’. Despite, its dictionary definition and word meaning of stereotomy which emphasize the significance of the cutting technique of solids, in Semper’s definition, the concept of stereotomy is considered as massive solid, heavy materiality on structures which is masonry rather than stonecutting.

To support this idea one of the theorist Cornelis (1978) state that;

> “...with stereotomic Semper meant, above all, a constructive method of assembling mass in such a manner that the total plasticity was moulded in one undivided dynamic unity... (Cornelis, 1978)”

Additionally, Anderson (1980) summarized Semper's term Tektonik as; "*constructs of articulated elements (elastic skeletal structures, e.g., timber or metal frames)"* and the term Stereotomie as *"comparatively inert assemblies (intractile masses, e.g., masonry walls)."*

On the other hand, Platz (1984), improve Semper's tectonics and stereotomics by applying contemporary materials, included iron and steel in *Tektonik* as membered structures and concrete in *Stereotomie* as wall structures (Frampton, 1995).

Semper's taxonomy, *tektonik* and *stereotomie* are not only based on the properties of the materials related to two technical skills of carpentry and masonry but are also derived from the components of Semper's four elements that comprise a building. According to Semper, the four elements that composed ancient architecture were the hearth (the sacred focus), the mound (the earthen platform), the roof on columns (supporting system), and finally the enclosure as a textile hanging (Mallgrave, 1989).

Due to improvements on materials and changes through structures, Frampton reinterpret the concept of tectonics and stereotomics on the basis of Semper's taxonomy. This can be understood from his statement as follows;

> "…the tectonics of the frame, indicates lightweight, linear components are assembled so as to encompass a spatial matrix, the stereotomics of the earthwork, wherein mass and volume are conjointly formed through the repetitious pilling up of heavyweight elements (Frampton, 1995)".

In this way, he applied tectonics to the modern constructional situation by focusing on the issue of the spatial matrix of the structural frame, while he expanded stereotomics in terms of the constructional process by describing "the repetitious pilling up" of load-bearing masonry (Frampton, 1995).

Semper relates the tectonic wall as a combined type, that is, “the frame with the corresponding filling,” however Frampton, in modern sense, referred it as the framework and the lightweight enclosing the membrane, respectively (Frampton, 1995). Although Semper’s theory on original tectonics was based on carpentry as the frame or the support, the spatially enclosing function was more important than the structurally supporting one in Semper’s tectonic wall. As Semper considered the intrinsic function of the wall as a spatial enclosure by stressing that in all Germanic languages, the word *Wand* (wall) has the same root and basic meaning as *Gewand* (dress), the tectonic wall of Semper is spatially and materially focused. For Semper, structure was veiled by material dressing and needed to provide itself as the frame or the support of the enclosing membrane (Mallgrave, 1989).

Frampton also asserted that this “tectonic/stereotomic distinction was reinforced in German by that language’s differentiation between two classes of wall: the *die Wand*, indicating a screen-like partition such as the type we find in wattle and daub infill construction, and *die Mauer*, signifying massive fortification (Frampton, 1995).” Although Frampton stressed the importance of the structure by taking into account “the structural unit as the irreducible essence of architectural form” in his tectonic theory, he appeared to say that the screen like infilling was also an essential part of the tectonic wall (Frampton, 1990).

2.4. Studies in the Concept of Tectonics

Vittorio Gregotti (1983) argued that a column should not first and foremost be understood as a support, but as a representation of the body. The choice of structure and construction was therefore not only the domain of the engineer. Gregotti understood the detail in architecture as the point from which the bodily experience of architecture should be created.

Likewise, Marco Frascari (1984) argued for the importance of the joint. He called his essay the-tell-the-tale-detail thereby pointing to the role of the detail (formal as well as structural) as the conveyer of meaning in architecture. Frascari was concerned with the impact of the industrial production to the detail.

In Kenneth Frampton's book, 'Studies in Tectonic Culture: The Poetics of Construction in 19th and 20th Century Architecture' (Frampton, 1995), architecture's tectonic and poetic tactile dimension is mentioned. In this context Frampton, from the samples he investigated, he had identified change of roles in constructions that formed architecture and situations after observing a group of architects and their works. These architects were different in designing concept language such as Auguste Perret, Frank Lloyd Wright, Mies van der Rohe, Louis Kahn, Jorn Utzon, Carlo Scarpa and he showed that every single one of these architects were affected from tectonic idea so it can be said that there are architects who are aware of this concept. As a result of this he found out tectonic architecture comes from Vernacular architecture's basic structure elements.

On the other hand, Hartoonian's book 'Ontology of Construction: On Nihilizm of Technology in Theories of Modern Architecture' (1994) notes an important change in the relationship between design and construction. This chance occurred when techne was shifted with technology. Additionally, the theme 'Montage' was very important for him and he stated that this is the way of creating 'art of construction'. It can be said that his notion of montage emphasizes fragmentation like parts and whole. The tectonic for him became the ‘joint’ but the ‘dis-joint’ also was very important for montage.

More to the above studies, international conference was held under the name of ‘Tectonics Making Meaning’ in Eindhoven University of technology in 2007. In this conference it was aimed to discover the relations between the various disciplines of the building industry in the context of a growing tectonic culture. It widened the culture of tectonic potential in architectural product improvement and combined tectonic together with the fields of technology, sustainability and adaptability.

Furthermore, many researchers also gave the valuable contribution to this subject with their master or PhD thesis.

In Ulguray’s (1999) master degree study called ‘Minimalism tectonic in Contemporary Architecture’, she has observed mostly minimal of forms, processing of material and articulating minimalism tectonic.

In Alkaya’s study in 2002 called ‘Tectonic Analysis of Buildings: Case from Ankara’ masters degree, 20th century Turkish architecture’s buildings belonging to different periods were analyzed by the same method of Kenneth Frampton’s tectonic culture book architectural form.

Beim (2004) in her thesis “Tectonic Visions in architecture– Investigations into practices and theories of building construction. Six case studies from the 20th century” from 1999 and in the publication “Tectonic Visions in Architecture” from

2004 developed and elaborated the thesis. Beim argued that architects had a continuing ability to create tectonics in the new context and demonstrated this through the works of six architects who were inspired by the industrial materials, technology and principles.

Zhao (2006), the author of “The Tectonic Trip through Traditional Dwellings”, tried to relate the dwelling with tectonic theory by considering the importance of how construction makes the meaning of architecture because he believed that “architects who are concerned about construction and the essence of architecture would abundantly give full play to the value of the dwellings”. In the end he made a comparative analysis between modern and traditional dwellings by examining the quality reflected from the material, construction and detail of the dwellings, consequently bringing new thinking for today's designs.

Güncü (2007) in her PhD thesis, under the name of ‘An Analysis of Building Enclosure's Tectonic Arrangement Change in High Rise Buildings’, with a tectonic analysis model she proofed 19th century theorist Semper’s theory of cladding is valid for 20th century architecture in case of highrise buildings.

In the thesis of Yang (2009), “Studies in Tectonic Culture and Technology of Modern Masonry Architecture in Wuhan”, former concession of Wuhan in China was taken as a field study through discussions on the effects of constructing process of masonry building on architecture forms by focusing on the modern masonry architecture based on tectonics theory. Following the analyses of typical cases of masonry buildings in Wuhan region; it was concluded that the buildings’ art patterns and the mechanical nature of structures shown were through tectonic logic.

Furthermore, existing masonries were studied. The author proposed new ways to protect masonry buildings and tried to bring attention to the construction rules and its expression characteristics on masonry buildings.

Liu (2010) in “Studies in Tectonic of Windows in Contemporary” brought attention to the evolution of windows. Liu found their lack of knowledge on the aesthetic, psychology and cultural values and stated that it was problematic. In this study, Liu tried to explore the concept and rules of the windows in contemporary by using the tectonics as a kind of method. Thus, Liu studied the windows in structural, material, constructional, and technological point of view to propose a theory and adapted the changes of time to the window design by looking at both in building scale and in urban scale.

Yang (2011) in “Tectonic Logic and Artistic Expression of Concrete Material In contemporary Architecture Design” had shown the impressions of concrete material and tried to explore the tectonic logic and artistic expression on cases by considering the ontological and representational uses of materials on buildings. By supporting the idea that tectonics is sort of a link, connecting the function, space, form, and aesthetic with the construction of materials, the study states that only the material can be related to the aesthetic values and establish the artistic representation. Because concrete, the most used material in comprehensive way in contemporary times, was regarded as an innovative material; the Tectonic logic of concrete architecture was introduced from structure, skin and the appearance point of view by analyzing the theories of concrete applications, followed by examining characters of concrete material in contemporary architecture design with artistic expression.

In the master thesis of Ozdemir (2014) under the name 'Architectonic Analysis of Energy Efficient Buildings' she proposed architectonic reading format for energy efficient buildings. For visual expression the Sekler's theory of tectonic and atectonic was considered and for architectonic features of buildings (form and surface of buildings) Frampton's theory of tectonic, scenographic and technologic factors were considered while creating this reading format. The buildings which have different architectonic features are analyzed through the proposed method. As a result the validity of theorists' approaches in present structures is evaluated.

It is fair to propose that the concept of tectonic is very wide in architectural theory. Moreover, these researches show how valuable tectonics is and how different approaches are made in the field of architecture. It is clear that tectonics can be a kind of evaluation theory for architecture. However these studies also show that there is no contribution about contemporary masonry buildings in the views of architectural tectonics.

As it mentioned before, this chapter is formed of four parts which Figure 2.50 shows.

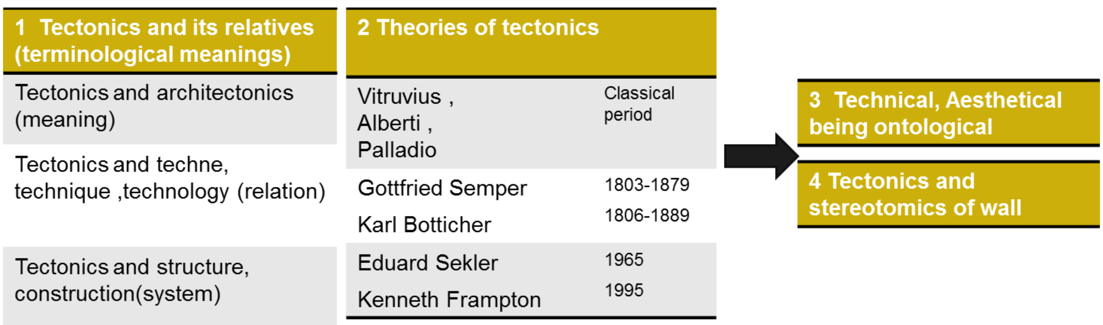


Figure 2.3: Graphical summary of the Chapter 2.

In order to apply the concept of tectonics as an evaluation theory to find the ontological differences between masonry structures, this study has categorized existing explanation of tectonics within the architectural theory. According to observations and discussions in Chapter 2 about tectonics, the conclusion is that the concept of tectonics is closely related to the following common conditions.

- Although each of them implies different meanings through the history, techne, technique, tectonics and technology always have strong relationship. It can be asserted that, because technology is one of the important factors, most of the writers about tectonic theory like Semper (1851), Frampton (1995), and Beim (2004) focus on technology and tried to explain their own tectonics in modern sense.
- Based on ‘poetic structure’, ‘art of construction’, ‘poetic component of technical matters’ it is shown that, almost each definitions about tectonic have two sides; one is art, artistic and aesthetic and the second is technique and technical. The combination of the artistic side and the technical side is considered as an important parameter. Both of them were regarded as necessary for achieving ontologically valid tectonics.
- The most influential Figures among these theorists are Semper and Frampton. In Semper’s (1851) and Frampton’s (1995), building structure was divided into specific elements as tectonic elements and stereotomic elements. Additionally, this division occurred according to material properties and art. Thus, this tectonic definition comprehensively was taken as an important parameter. Unlike others, these specifications play big role for achieving ontology.
- Briefly, ontology can be clarified as a kind of phenomenological method that associates two different worlds; the material world and the spiritual world. In

other words, it can be evaluated as the common method of aesthetic world and materiality. In addition to this, ontology can be evaluated as the things that are used in balance with technical and aesthetical solutions in the building. For instance; the structure, materials and details should express themselves, in a correct way or in a reasonable way in the building. Thus, these kinds of buildings can be regarded as ontological buildings. This point of view will be an important viewpoint for this study. As a result, necessity is important according to technical issues, uniqueness (differences from its relatives, differences from traditional or at the same time using two different thighs together as traditional and contemporary) and aesthetic use of the things will be considered for this study. These also work as evaluation criteria for this thesis.

- Accordingly, does the structure have an idea behind? Does it have technical and aesthetical reason which can be used for solving all sorts of problems, such as structural, climatic, or topographic etc. If, the answer is yes, then the problem is solved ontologically. Such a building should have reasonable and beneficial idea behind which is essential for statically, functionally and should respond to environmental issues etc. Otherwise, scenography will emerge as just representational approach or make –up.

Finally, based on Semper‘s tectonics, Frampton is one of the important theorist who made contribution to enlarge and adapt the Semper's tectonics to the contemporary architecture. Accordingly, it might be meaningful to analyze ontological differences between contemporary masonry structures through these categories.

Chapter 3

HISTORY OF ARCHITECTURE IN TERMS OF STEREOTOMICS AND TECTONICS

In this chapter, tectonics will be explained according to the concepts of tradition and contemporary. This chapter is separated into three section as; the concept of tradition and contemporary in the view of tectonic; changes in traditional tectonics; and changes in contemporary tectonics. Moreover, the differences between them will be examined and explained through architectural examples in chronological order.

3.1 The Concept of Tradition and Contemporary in the View of Tectonics

The beginning of the tectonic tradition was started with the beginning of the era of the master builder as it is mentioned Chapter 2. This era began around 8000 BC because people started to settle in cities rather than living as nomads (Mainstone, 2001). Before that time each person had built their own shelter. With a more settled society, housing was needed to be improved because the constructions were expected to be more durable and the building technique became more complex. An artisan class of building experts was developed. Tectonics is inherent to the name of the profession architect, which is a contraction of the Greek word *archi* which means master and *tect* which means builder and is related to the word tectonic (Frampton, 1995).

As a result, masons, later architects learnt about building structures and materials with try and error methods. In this sense, success or failure of the buildings, structure and material ability, durability or weakness have been experienced. Structural knowledge and material ability on buildings was improved step by step and these new explanations or experiences transferred from generations to generations of architects since the times of master builder (Erol, 1997). As a consequence of this way of transferring knowledge through time filtered faults and wrongs the process helped to develop a building culture and in this way tradition of tectonics was allowed to settle.

Mainstone (2001) stated that;

> "In the master builder era the architect worked with architecture and materials hands-on on the building site; a position in which he was in charge of every aspect of the architectural process" (Mainstone, 2001).

As it is seen in Figure 3.1 and Figure 3.2, these are the results of a close understanding of the structural limits of the materials that affected all parameters of building expressions (Mainstone, 2001).

Figure 3.1: Gothic cathedral (URL 4)

Figure 3.2: Islamic Mosque (URL 4)

Until the 17th century, there was not much of a problem about tradition of tectonics because all of them were following the classical orders that were shaped in classical period. In the beginning of 17th century with the legacy of Galileo, 'ontological relationship between meaning (style) and work (construction) changed because of structural utility was lost and classical thought collapsed after the emergence of "*the positivistic concept of beauty, new understanding classical order and concept of fabrication (Hartoonian, 1994)"*

At the end of the 17th century, changes about academics and schools caused separation of the two disciplines, leading to architecture and engineering. It is important to mention that, this is the breaking point for tradition of classical period (Hartoonian, 1994). The first example of this break is the Brunelleschi's dome of Doumo in Italy. With this example, separation of design and construction was achieved. In the light of this division, 18th century's improvement on mechanical sciences and industrial achievements and 19th century's modernist thoughts followed this breaking point. However, over the time, architectural status was changed and caused a reduction in the quality of products. This problematic breaking of schools constituted design knowledge, structure knowledge or artistic knowledge education and this separation is still in existence.

It is necessary to remember that Hartoonian (1994) and Frampton (1995) also believed that if the tectonic can be an alternative theory for architecture, then this dilemma will somehow be over.

Additionally, Collins (1960) drew attention to the distinction between architecture and engineering from the educational point of view in his essay 'Tectonics'. He saw that with this kind of separation, each branch became weaker than the earlier periods. Consequently, imagination and creativity had been reduced in both areas. He strictly recommended that not only architecture schools should add engineering courses; engineering schools should also make an important attempt to add more architectural courses to their programs. However, these courses should be interdisciplinary which consist of balanced information from both areas. He insisted that each branch, architecture and engineering, would reach new but common terminological identity. In this context, he suggested the term ‘tectonics’ is the right solution since the tectonics is the intersection of both branches.

After all, it is possible to make a distinction between traditional and modern in order to understand them better. The term ‘Modern’ covers industrial age that means modernity begins around 1750’s and continues until nowadays. ‘Traditional’ on the other hand, covers everything before a time, when everything was utilized from natural/local material, and conventional masonry construction methods were produced.

Nevertheless, differences between traditional and modern times are not only construction methods or materials. Societies, their organizations, life standards and expectations, had also been changed. This reflects itself on the needs and requirements, which effect functions and solutions of them, forms and design concepts. Therefore, structure systems also changed a lot to give respond to the epochal change. These results created different kind of architectural languages.

As a result, in contrast to the load-bearing walls, frame systems allowed considerable percentage of the wall to be used as opening by reducing wall width and depth. With this categorization, it becomes possible to discuss the ontological differences between; traditional tectonics and contemporary tectonics of structures.

It can be said that, the wall is an important parameter for buildings because from architectural point of view it has two major roles as; the most effective way to represent the structural quality and the readability of the evolution of wall through the theory of architecture.

3.2 Changes in Traditional Tectonics

From architectural point of view, since this thesis is studying structural elements from ontological point of view, wall can be the right element both architecturally and ontologically. Thus, above section 3.1 shows how the relation between the related concepts and explanations of wall occurs. Because walls are vertical dividing and load carrying elements, they enclose and define a space. In traditional masonry buildings, almost each wall work as a load-bearing structural element. These were built by the use blocks of building materials on top of each other to form a single load-bearing wall (Erol, 1997). In the Figure 3 how the load is distributed to the the masonry wall can be seen.

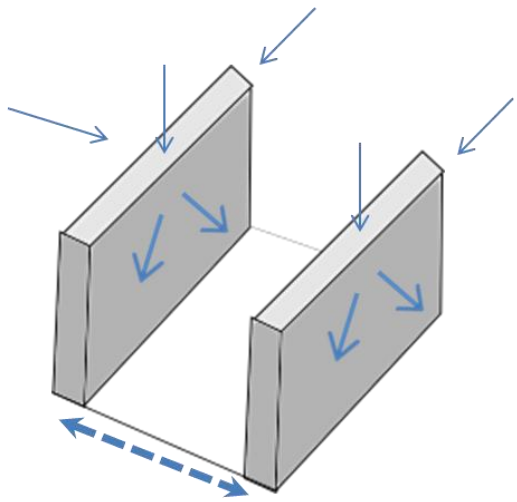


Figure 3.3: Load Bearing Solid Wall and load distribution (Drawn by author)

On the flip side of the coin, in the modern era, most of the buildings are made with skeletal structures. This is achieved by building elements into a framework in order to carry the loads. This emptiness creates advantages for the building and it can be used for space or with the use of lighter building materials for separating functions. In the following sections this is studied in more detail.

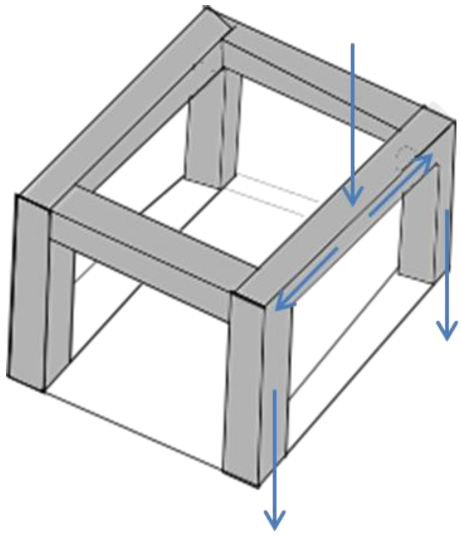


Figure 3.4: Lightweight frame system and load distribution. (Drawn by author)

In traditional buildings, tectonic approaches are very clear. Especially the traditional masonry tectonics is usually a result of the arrangement of; cross walls, buttresses, thick walls, strong corners, small openings. The main tectonic characteristics for adobe occurred by the use of smooth surfaces, for brick units in modular pattern arrangement and for stone occurred with heavy textured surface form.

In order to light the traditional tectonics, Monadnock building (Figure 3.5) can be given as an example. Traditional masonry construction techniques were used in the 16-story Monadnock's building in Chicago by Root and Burnham, 1889.

Figure 3.5: Monadnock building

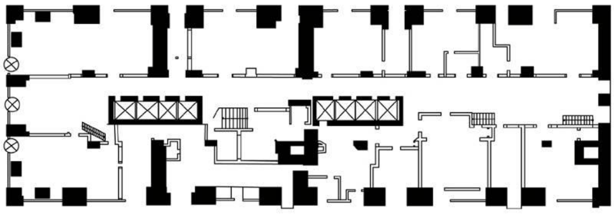


Figure 3.6: Monadnock building's ground floors shows its thick walls (URL 4)

It is obvious that traditional masonry systems are not providing opportunities as much as frame systems. In contrast to frame systems, masonry systems have some problems because of the heavyweight of the structure, such as not allowing wider spans in between spaces or lack of providing sufficient natural light to the interiors because of the limits of the openings on wall surfaces etc. These limitations and problems can be seen from the Figure 3.5 and Figure 3.6 of Monadnock building. After the inventions of the frame systems, the architects preferred to use frame systems instead of masonry system. Especially in the commercial buildings frame systems have two important advantages; maximum economy, utilization of maximum light in their designs (Elliott, 1992).

In this case, Monadnock building can be given as last example for this period of traditional masonry system. It has extremely thick walls on ground levels, 180cm thick on the basement floor. It can be seen from the Figure 3.6 that the thick walls limit the natural light to enter into the building. Because of this problem, in upper floors, cantilever system and iron window frame was used. With this way, bigger glass area was opened and more open appearance of established (Elliott, 1992). However, this building still belongs to traditional tectonics. It possesses all the values of its stereotomics with the heavy mass, thick walls, strong corners and small windows.

After Industrial Revolution iron's process as a structural element caused an important role in changing the tectonic character. Iron came out as fence and rail for the first time in 17th century, later on it was used as connector for timber truss' junctions on roofs and supporter in masonry systems (Strike, 1991). Steel is used for bridges, greenhouses, and factory buildings as first structural examples. Later, steel was used both in columns and in beams, providing wide spans for structural frames. Joseph Paxton's Crystal Palace is one of the important examples that show this change (Figure 3.7). The Crystal Palace was built in 1851 in London for the Great Exhibition which was made of cast iron and a glass structure. For instance; according to traditional masonry technique, walls have space definer and load- bearing function, however in Crystal Palace, they dissociated from load-bearing function and turned into a structure shell that limits the space.

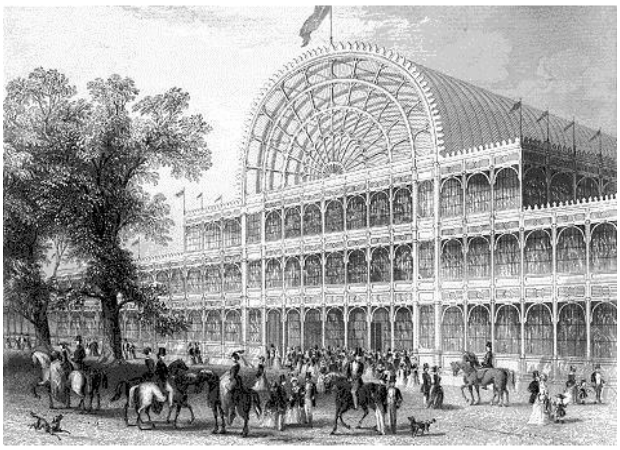


Figure 3.7: Crystal Palace with cast iron frame and glass surfaces (Merin, 2013)

Besides this dissociation, indispensable structure materials of traditional structure technology (like stone, brick and adobe masonry), the usage of new materials and the standard prepared glass curtain walls changed the tectonic character.

Since the middle of 19th century with progress of steel frames, the wall that had load bearing properties in construction technology started to turn into a partition wall for spaces and identifying facade. However, because of weakness of steel elements against fire, the thought of covering with non-combustible materials, steel load-bearing elements have taken place in the walls. First steel framed buildings were built especially between 1870 and 1900 (Rolf, 2013). This turned America's architecture to new world's symbol of prosperity, prestige and power. As a result of 1871 fire in Chicago, fire-resistant construction techniques quickly started to develop (Strike, 1991). Here, two different systems have been developed; instead of thick, load-bearing masonry walls and foundation, skeleton that consist of steel beams and columns were started to be used by covering them with traditional masonry walls. This was characterized with traditional masonry and called 'cage' system. Second system is the skeleton or frame system without masonry walls. At this point, it is worth to mentioning Chicago school of architecture. Chicago's architecture is well-known throughout the world and one style is referred to as the Chicago School. The style is also known as Commercial style. In the history of architecture, the Chicago School was a school of architects active in Chicago at the turn of the 20th century. They were among the first to promote the new technologies of steel-frame construction in commercial buildings, and developed a spatial aesthetic which co-evolved with, and then came to influence, parallel developments in European Modernism. A "Second Chicago School" later emerged in the 1940s and 1970s which pioneered new building technologies and structural systems such as the tube-frame structure (Billington, 1985; Rolf, 2013). Therefore, traditional construction technique which had thick walls and the wall thickness increased in proportion to the height of the building in order to carry the structure weight (e.g. Monadnock building) was started to be abandoned and new system started to used.

Some of the high building examples are presented in Figure 3.8 which they used new construction method (steel frame with non-load-bearing walls) between the years 1880-1920 in Chicago and New York.

Reliance Building (1894), by D. Burnham (Rolf, 2013)

WainwrightBuilding (1890), by L. Sulivan (Rolf, 2013)

Flatiron Building (1902), by D. Burnham (Rolf, 2013)

Figure 3.8: First examples of highrise buildings with frame systems

Later, similar approach is pointed out, by pioneer as Walter Gropius, Mies Van Der Rohe. Mies was interested in technical content and new materials of industrialization that brought rationalism. In 1924, in his article “Industrialized Building Construction” implied that traditional construction methods were inadequate to respond to day's conditions (Conrads, 1991). He underlined that in addition to the use of industrial product, its assembly techniques (in Hartoonian’s words ‘montage’) needed to be developed and promoted.

Correspondingly, towards the middle of 20th century Mies Van der Rohe's 860 Lake Shore Drive Building's outside of the steel skeleton system is covered with concrete and used industrially produced metal plane and I profile for protection against fire (Frampton, 1995).

In the beginning of 20th century, the manifestos', like Poelzig (1906) and Scheerbart's (1914) content in architecture mainly gave emphasis to the industrial based production and new tectonic character, although it has not disregarded the artistic dimension of architecture. However, this emphasis was not for the creativity of the traditional type (traditional tectonic) or reinterpretation of the rules. It completely revealed the way of life of industrial society's ideology in accordance with new products and material processes. It is emphasized that only in this way; the development can be achieved and it can become meaningful.

For example; in 1906, Poelzig in his manifest, "Fermentation in Architecture", mentioned that "in order to re-use the structures from older times answering the needs of contemporary life we forget that they definitely need to have a modern adaptation. Another reality that has been ignored is whichever appropriate material is applied privileges of structure techniques or professional adaptation will not be embellishing... (Conrads, 1991) ". And he emphasized that it is not possible to escape from past but with contemporary technique, potential architecture can be sustainable. He mentions that correct material technique can reflect the contemporary spirit with iron-steel, cement and glass.

Additionally, Scheerbart (1914) mentioned in his manifest "Glass Architecture" that from tectonic content of new materials "Iron construction provides to give walls any form wanted. It is not obligatory for wall to be vertical... If glass architecture would take place of brick architecture, earth could change a lot. Earth could be like surrounded with diamond and enameled jewelleries... (Conrads, 1991) ”.

However, instead of load- bearing construction, modern structures benefited material that can span large distances with steel. Using traditional materials like stone, terracotta and brick caused surfaces to gain solid and heavy expression. In this context, it can be said that they did not completely isolate themselves from the traditional tectonics or more deeply stereotomic of the buildings. However these attempts lead to the scenographic applications which represent the masonry wall only visually.

To support this idea Sert (1953) in his essay *“windows and walls”*, described these changes as:

> ‘‘The epochal change, when masonry construction replaced by frame system, walls transformed from bearing walls to non-bearing walls, partitions or screens (Leatherbarrow, Mostafavi, 2005)”.

Additionally, Mainstone also evaluated this in a similar way and he state that:

> “The history of architecture is followed the evolution of the load-bearing walls that punctured by apertures (Mainstone, 2001).”

Until this point, trends throughout centuries and the building types arising from hanges of structural system (which is high-rise) were studied and it was shown how the traditional tectonics got affected from this change. In this point of view, it can be asserted that, this change started the high-rise buildings and desire for getting more natural light and bigger spaces etc.

3.3 Variations in Contemporary Tectonics

In the following sections, contemporary tectonics will be tried to be shown with relatively small scale buildings. First, the basic concepts, then architectural examples will be presented according to contemporary tectonics.

It is commonly known that 20th century was the beginning of new epoch in many branches as well as in architecture. Each country started to represent their first architectural approaches on architectural examples. Importantly while there was conversion in England due to inventions on building systems that consisted of prefabrication, standardization, mass production based on industrialized elements on building's construction. In the forthcoming years the technology started to utilize and improve these building systems accordingly. In Germany, in accordance with the requirements of the epoch "School of Bauhaus" (1919-1933) it was aimed to formulate a theory about basic ideas and principles for establishing new language for architecture and it was argued that architectural products were supposed to be converted in parallel with the technological development (Strike,1991).

This movement became more clear and visible in the beginnings of 20th century. In contrast to traditional masonry techniques where walls had possessed heavy and solid properties in between interior and exterior spaces, the walls became a flexible, transparent, and light curtain. Bauhaus building can be given as a first example that represents these values of the contemporary tectonics which shown in Figure 3.8. This building was designed by Walter Gropius in 1919, for educational purposes and played an iconic role on shaping 20th century's modern art and architecture. As it seen from Figure 3.8, the frame system was used with metal and glass type of industrial materials in this building (Frampton, 1992).

Figure 3.9: Bauhaus building with metal and glass facade by Walter Gropius (Merin, 2013)

After Gropius and 1920s, according to the architects who especially followed modern architectural perception, means of wall is a curtain or climate preventer. In this sense Gropius is one of the first architects who used this type of walls, and draws attention to glass walls. Most of his buildings were not common in his period (Leatherbarrow, Mostafavi, 2005).

In between 1920 and 1930, in Russia, “constructivism” was dominant. Here, machinery and industrial production were considered as an important part of architectural design and structure was used as a means of expression tool (Cernikov, 2001).

In Netherlands, architectural approaches such as De-stijl movement, principles of visual abstraction took as a basic concept (Giedon, 1967). As a result, because of new materials such as concrete, glass and iron and since the tectonics depends on the nature of these materials, new combination techniques of these materials were tried to be developed with an art form so the modern architectural form has begun. In De-stijl architecture oblique view was used and contrasted with horizontality. For example, one of the products of the De-stijl architecture is Schröder house, which was built in 1924 by Dutch architect Gerrit Rietveld. In the house, windows are located in the corner, when they are closed; they act like other windows in the house. When they are opened the corner disappears and this provides an oblique view to the outside which is shown Figure 3.9. In contrast to this system, generally we expect to see structural element like columns at the corners. This is another way of contemporary tectonics, which expresses the structural quality and opportunities together with the use of special details as well as aesthetics.

Figure 3.10: Schröder House's corner windows create oblique view (URL 41).

However, some other philosophers had put forward opposite arguments to modern era architecture (that thin, lightweight and transparent walls replaced with thick, heavy and opaque walls) (Jameson, 1997). According to them, this lightness and that much transparency do not fit into the society (URL 41). They asserted that, with these modern construction techniques the product, building, is not integrated to the cities and natural environment. As a result, post-modern era emerged and they attempted to turn back to the thick wall construction with the use of conventional techniques. They sometimes have false walls (Broadbent, 1977). This era was seen in the early twenties and Otto Wagner, Josef Hoffman, Robert Venturi are the pioneer architects of post-modernism, although, each of them interpreted architecture differently (Broadbent, 1977; Leatherbarrow, Mostafavi, 2005)

Different than the movements within the 20^{th} centuries, in order to explain the concept of contemporary tectonics, 20^{th} centuries examples are needed to be presented more deeply. The new structural principles and a new tectonic based upon utilization and expression of new technologies are shown later. Thus, we can reach that point from analyzing and classifying choices which are available in literature of architecture. To begin with, the basic concepts, then the architectural examples will be studied according to contemporary tectonics with a descriptive method on the basis of the literature surveys. It is obvious that, like Aldof Loos, Alvar Aalto, Frank Lloyd Wright, Le courbusier, Mies van der Rohe, Louis Khan, Carlo Scarpa, Frank Gehry, architects tried to establish a tectonic expression in their jobs with an innovative way of thinking. They used new structural systems or combined different systems according to the needs of functions or to different use of materials or to special detailing in their designs (Frampton, 1990).

Contemporary tectonics varied in using different materials and different techniques for each building. In the beginning of 20^{th} century, the exploration of frame system was one of the generators of structure and skin’s paradigm, which provided contemporary approach with open plan, free facade, technological possibilities, mass production and repetition of structural elements. Depending on all of this, the frame system provided a new structural model and gave new possibilities to the use of tectonic issues (Jameson, 1997).

At the very beginning of the 20th century, Adolf Loos used traditional methods and materials together with modern ideas and materials in his designs. When you look at his buildings, which are in Figure 3.10 and Figure 3.11, it is shown that pure form of the cube, arbitrary arrangement of windows with normal aesthetics without any ornamentation were the first contemporary tectonics for that day. Additionally, plan arrangement which was named “Raum Plan” also was considered as first examples of the modern era. This plan type is based on the idea of flexibility; allowing scaling of rooms different from each other and different heights of spaces. With this planning method both verticalization (plan) and horizontalization (dynamic section) occurred. It gives emphasis to the structural awareness and ability to model spaces as well.

Figure 3.11 : Pure rectangular prism and arbitrary arranged openings of Rufer House by Adolf Loos, 1922 (Ford,2003)

Figure 3.12: Mullorova Villa by Adolf Loos,1930 (Ford, 2003)

On the other hand, Le Corbusier took attention from another dimension that is the openings within wall, not directly the wall. According to him, history of the window is the same with the history of architecture. Because, up to 20th century, architectural history had followed the development of load-bearing wall with small openings or limited spans, but with the frame system, it became possible to make big spans and full facade windows with no apparent limit. Thus, with this evolution "wall-windows" appeared (Leatherbarrow, Mostafavi, 2005).

It can be said that, Le Corbusier's contemporary tectonics consist of the idea of horizontal windows, roof terrace, standardization of structural elements, common materials, details and colour. Additionally, pure simple forms are used in an abstracted way in the nature that tectonically used. This is also obviously presented in Figure 3.12 and Figure 3.13.

Figure 3.12: Villa Masoin Stein
by Le Corbusier, 1927 (Ford, 2003)

Figure 3.13: Villa Savoy
by Le Corbusier's 1929 (Ford, 2003)

The buildings have a simple geometry, not symmetrical, but consisting of a cube, simple design and plan arrangement. In contrast, the exterior walls represent both symmetry and the Golden Section values. With his own invention, the scheme of the Domino project, he always used reinforced concrete structure system (domino structure) with plastered walls. In this way, walls were totally separated from the structure and became only space-enclosing elements or skin to the buildings. As a result, walls have become completely free. This is different from the traditional solid masonry wall of stone or a brick, which is found within stereotomic techniques. The frame system has created a certain type of flexibility on form and space that was previously unknown. Consequently, Figure 3.12 and Figure 3.13 present, repetitive structural elements, double height living space, free facade, free plan and horizontal window were the results of tectonic expressions of him.

The works of Mies Van Der Rohe has the lightest structures in 1920's. For example, Barcelona Pavilion has an open plan to allow flowing in space. This gave a sense of clarity at the same time perceivable proportion. Simple planes of stone walls used together with steel cruciform columns and special doors and window frames.

Figure 3.14: Barcelona Pavilion by Mies Van Der Rohe, 1929 (Ford, 2003)

Figure 3.15: Fransworth House by Mies Van Der Rohe ,1946 (Ford, 2003)

Thus, the wall was articulated as a particular element with space flowing around it that in Figure 3.14 shows. Mostly, the building was constructed with the help of technology. He produced his unusual details with different type of materials; stone clad mass walls which remind us streotomy of the wall and steel columns next to it, as tectonic element.

After that, he used glass and steel materials a lot which carry the direct tectonic potential. Fransworth house which is shown in Figure 3.15 can be give as an example to explain. "He tried to reflect perfection but also he played and manipulated to express the tectonic of technology (Frampton, 1995)". Consequently, Mies' use of different architectural elements together, helped him to combine tectonic meaning with abstract form (Frampton, 1995).

Another example is from the 1950's. Louis Khan created a new tectonics as a kind of division of form. Every building was separated into pieces, but when looked at them from far away, they were seen as in unity.

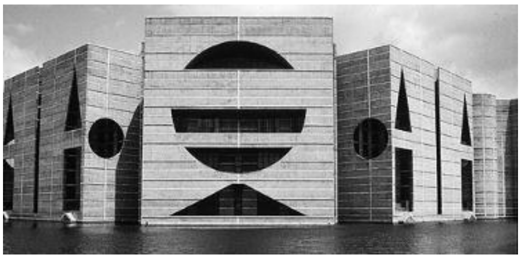


Figure 3.16: Exeter library by Louis Khan (Ford, 2003)


Figure 3.17: Dakka Parlement Building (Ford, 2003)

When looked at the structure system, it has a main structure and has some sub-structures. There is double order or triple order of the structural frame. Interior spaces are big and inside walls have big openings which are used as an artistic way with the combination of light effects that is controlling both light and creating shadow effects inside which is seen Figure 3.18. This double order of structural frame, has allowed creating walls accordingly. For example, it is seen from the Figure 3.16 from exterior and Figure 3.18 from interior, that behind the walls, there are other walls for heating, cooling and insulation purposes. Interior space also gave the impression of outdoor space because of the surface's texture of materials tectonics in Figure 3.17 and Figure 3.18. Walls look like heavy and acting like stereotomic masonry walls but they are actually not as understood from big openings and light effects as it seen Figure 3.18. This is also another result of the combination of tectonic expression with the idea of double order of the structural frame.

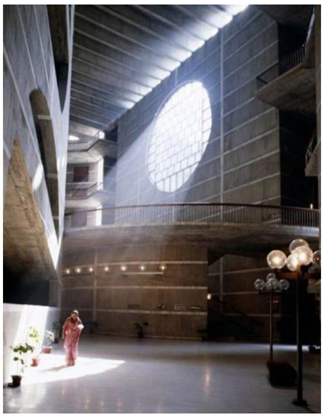


Figure 3.18: Interior view shows double order on structure and light effect how broke the stereotomy of the wall (Ford, 2003).

According to Frampton, Carlo Scarpa's manner to express the technical dimensions of the process and at the same time sensitivity throughout the aesthetic use of joints, unique presentation of detailing and combination of different materials were actually spoken by the desire to highlight the structural function of the architecture (Frampton, 1995).

Figure 3.19: Brion-Vega Cemetery by Carlo Scarpa, 1970 (Ford, 1998)

In Figure 3.19 was also showing this sensitivity through material and different representation of details on surface. Thus, all these unique use of design showing the structural possibilities as well.

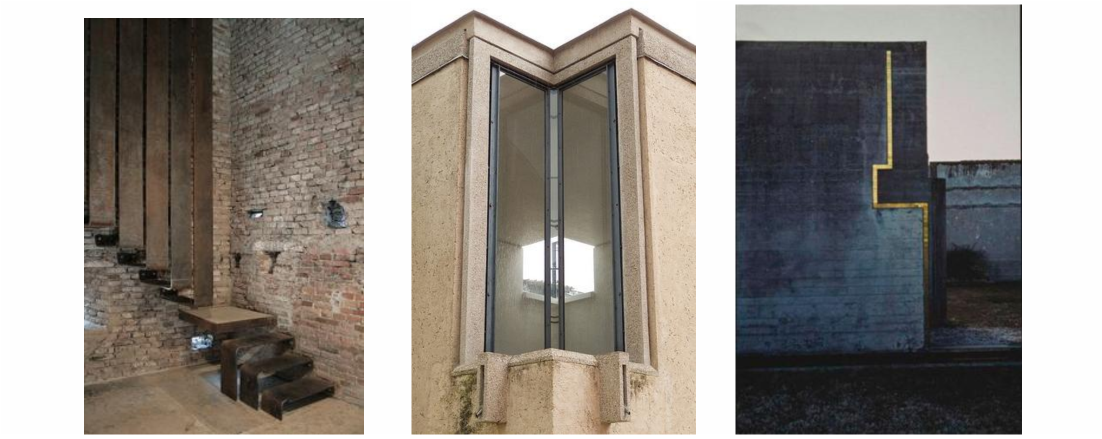


Figure 3.20: Castelvecchio Museum stairs and opening details by Carlo Scarpa, 1970 (Ford, 1998)

Figure 3.20 shows the Castelvecchio Museum stairs where the importance of the use of different materials together such as iron stair with stone wall can be seen. Combination of these two materials is achieved by a special joint so they did not touch each other. It can be evaluated that the stone masonry wall is streotomy and the steel stairs as tectonic elements. Additionally, openings’ details and the way that play windows as lighting element are also very unusual **(**Özturk, Gürel, 2009).

Figure 3.21 : Guggenheim Museum, Bilbao by Frank Gehry,1997 (URL 4)

Figure 3.22 : Walt Disney Concert Hall by Frank Gehry, 2003 (URL 4)

Unlike Scarpa, Frank Gehry’s architecture creates another type of tectonics. It can be said that he is trying to destroy unity and the sense of pure forms. The compositions of the building, use of structure or material selection are not readable but at the same time building have a tectonic look. However it is not possible to evaluate it as stereotomic. It seems that each piece is independent from each other, although the uniqueness and contrast with its environment creates tectonic individually.

This relationship between structure and form has its roots to the oldest traditions of European architecture, and since the beginning of the nineteenth century has been defined with the term tectonic, the theme is linked to the possibilities of seeing architecture as a representation of a precise structural conception.

As it mentioned before, this chapter is formed of four parts which Figure 3.23 shows graphically.

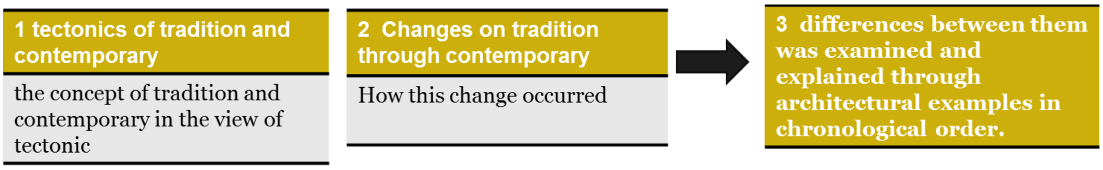


Figure 3.23: Graphical summary of the Chapter 3

As a result of this chapter, tectonic and stereotomic reading the buildings from tectonical point of view were done and the effects of architectural movements were studied in this chapter.

It can be concluded that, necessity of daylight, consideration of climate in the office buildings and open size gradually increased which was apparent first in Chicago frame buildings with the invention of the frame systems. This caused change in the traditional role of the ‘wall’ because load-bearing solid walls were turned into an infill wall and they lost their structural function. It means ‘heavy, load-bearing, solid wall’ with small openings replaced by thin, punctured walls or even “wall windows” which is totally glass (Leatherbarrow, Mostafavi, 2005).

This gave new visual and formal characteristics to the buildings. For example; in traditional masonry wall systems, proportion and dimension of each element was important like the opening size ratio to wall width, surface, or wall height ratio to wall thickness, distance between each wall, distance between each opening and their distances to the wall corners etc. These are much rationalized, well-known parameters for masonry structures. However, in today's architecture we can see that contemporary masonry building have big challenge about these parameters of masonry structures mentioned above.

Chapter 4

TRADITIONAL MASONRY STRUCTURES

This chapter is separated into four sections in order to explain the traditional masonries in the view of tectonic. Firstly, the evolution of traditional structures; from Cave, Tent, to Masonry is touched, then structural elements in traditional (unreinforced) masonry buildings are discussed (as wall, roof/slab and buttresses) and tectonic values are presented. In regards with section two, in the third section, masonry structures are separated in terms of the material differences as importance of material on masonry structures (as stone, adobe, and brick) and the tectonic effects on traditional buildings are discussed. Last but not the least, in the fourth section, earthquake problem of masonry structure is taken into account as an important parameter to discuss general applications in the views of building codes (as importance of earthquake resistance in masonry buildings).

4.1 The Evolution of Traditional Structures; Cave, Tent, Masonry

First architectural elements, primitive materials and constructional techniques are based on human-nature relationship. For instance, human being's first building action to build a small shelter appeared due to the instinct of protecting itself from negative natural conditions and wild animals. One of the basic instincts of human being is accommodation. In the old ages, people were using natural creations to accommodate such as caves, when caves were limited and were not enough they started to build shelters from natural materials which they could find around such as stone and tree. In Figure 4.1 it can be seen that first examples of shelters that are also placed in architecture theory (Benjamin, 1984).

Figure 4.1: First examples of shelters that made of tree (URL40)

Doubtless, whichever material was more around the people they improved construction techniques relying on those materials. For example in primitive ages people covered the branches and bamboo sticks with animal posts. In Figure 4.2, it can be seen that these examples of primitive huts.

Figure 4.2: First examples of primitive huts that covered with animal post (URL40)

In Architecture the word 'structure' which supports building to stand stable also known as supporter, comes from Latin language meaning 'to build' in Latin 'stuere' derived from 'structura' (Benjamin, 1984; Kuban, 1998). According to Kuban form is a set which keeps the material straight and this set has a structural frame which makes set to stand up. Therefore, this structural frame or the system, which keeps the form straight, is that system's structure (Kuban, 1998).

Hasol expresses structure as “load-bearing part of structure”. Load- bearing system transfers the weight to the ground, and at the same time, it is an element, which covers and focuses the mass. In other words, structure is a kind of system that creates balance between its cover and its load-bearing part of building (Hasol, 1998). Structure systems generally have two important parameter, one is material second is geometry.

Structure, affects the form of building from the beginnings of a construction. For example, because of structure’s obligatory shape, bamboo huts were planned as circular. After the start of agriculture, accommodation started to take place by the rivers and fields and this created the idea of using bamboo as first construction material as they were in high amounts around these areas (Weston,2008).

Figure 4.3: Bamboo Hut located near the river (Weston, 2008)

Human beings formed the structure by using natural materials and hand-made products. While first accommodation places were caves, in time the accommodation places were evolved into tents and humans started to improve places with stone, adobe or brick blocks (Benjamin, 1984). These were the first architectural structures that were created and this transformation can be seen from the Figure 4.4.

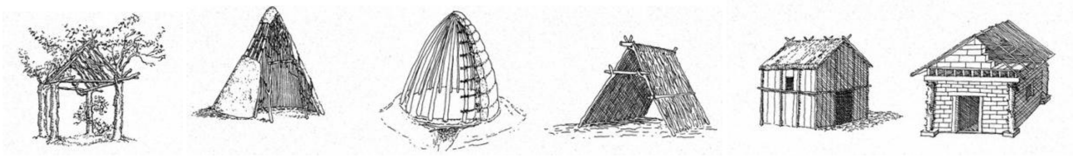


Figure 4.4: Transformation of Primitive Huts (Crowe, 1995)

For example, ancient people found the earth and shaped it with hands or cooked it to strengthen the earth, which produced brick material or quarried stone. These are all again provided from nature. So, pre-historic people left their shelters or caves and started building more comfortable and strong buildings, leading to masonry building structures.

It can be given as an example that there were lots of stones in Egypt and it was the main material of ancient Egyptians' constructions (Weston, 2008). We can give pyramids as one of the example from that region and ancient times (Figure 4.5). On the other hand, Figure 4.6 shows that, there was not enough stone in Mesopotamia thus they were using adobe as their construction material as it was done in Çatalhöyük.


Figure 4.5: Pyramids that is made of stone


Figure 4.6: Çatalhöyük that is made of adobe (URL 1)

Later first fried brick produced in Mesopotamia artificially. However, the quality of first examples of brick was weak. This is the reason that, Romans made buildings with brick more economically but they covered the surfaces with plaster or thin stones to gave more rich look (Arun, 2005). In this way, masonry construction techniques and architecture was developed by plastering however building's structure material and covered material (with stone) lost their ontological relationship.

With the industrial revolution, architectural values and sensitivity through natural materials changed; desire to design buildings with the new technological and industrial materials start. As a result steel, glass or concrete buildings emerged almost in every countries of Europe. This has positive sides as improvement, better living spaces, higher quality of life standard, possibilities on new materials, structures etc. On the other hand, negative sides such as loss of cultural values, sensitivity, solutions not fitting to societies and people not satisfying somehow from the products which lost their localities etc. It is necessary to remember that one of the theoretician Semper (1851) took attention to cultural values. Thus he also pointed out that cultural values are an important parameter for architectural quality and that was the uniqueness of the structures. Thus, the solution may be to turn back again. In this context, this can be interpreted as; every culture when they turn to their values, their localities, quality will be available again.

In this manner, it is obvious that, structure is not completely different from construction methods and materials. It is not possible to provide needed structure from every material. It is also not possible to provide same type of structure from different materials. For example, a structure made with concrete or steel is not possible to be made of earth. In other words, we can say construction of building structures can follow the needs of societies, cultural structure, technical potentials, form of a place and material.

Human beings improved themselves over time. They put the stones and cooked adobe one on the other, stick them with mixture of mortar including soil, water and different type of materials, build up walls. Then, they improved on cover system to create space. Previously used straight ceiling formed covers were not enough for large spaces but with arch and dome, it was possible to create large spaces (Ozer, 2006). Structures developed parallel to new materials and technological progresses. In this part, the reality of the buildings built in the past, in other words, structure of traditional built construction elements from pre-history to the future progress has been observed. In a space, for transferring weight with vertical elements to the foundation, there is a need for structural elements (Benjamin, 1984).

4.2 Structural Elements in Traditional (Unreinforced) Masonry Buildings in the Views of Tectonics

Traditional masonry structure is the structure which uses potential of natural materials before contemporary materials and techniques (concrete, steel and etc.). It includes the time from the first example of architecture to the beginning of contemporary structure systems, usage of steel in constructions and RC frame systems.

As it was mentioned before, traditional masonry building construction system consists of adobe, stone, timber and brick materials. They carry their own weight and create walls as the structural elements. In this system, walls have two architectural functions; firstly their load-bearing property and secondly is to separate spaces from each other (Arun, 2005). At this point, it can be said that the walls themselves can be evaluated as ontologically valid tectonic. Traditional masonry systems are made with the combination of vertical load- bearing elements, walls, and cover element which is the roof. These elements were formed due to the possibilities or limits of natural building materials. The structure, which keeps a straight form, consists of a combination of structural elements, which comes together according to certain rules. For example; in traditional masonry buildings, these elements' dimensions are created according to the amount of load they can carry, span they can pass through and the material type they are made up of. Thus, structural elements' dimensions and geometry give the building's dimension and form. Before static calculations and analysis period, the people who were actually building the structures directed to geometric forms that could be perceived easily (Cowan, Smith, 1988). These specifications about any type of masonry structures gave the tectonic quality to the masonry buildings. This is because; each rule was generated according to structural requirements and functional necessities.

When a structural design is based on geometry, it is possible to say that geometrically perfect ones create the strongest structure. The reason why arches and domes are round is due to the perfectness of the circular form. During the renaissance period, geometric structural design rules were the ones that were applied in Rome. The buildings that built in these periods with the geometrical orders come until today. Therefore, geometry was the main aesthetic and structural rule since 18th century. According to Cowan, the reason why classical structures seem nice to people is because of their geometric proportions (Cowan, Smith, 1988). It is good to remember that Alberti's emphasis on proportions, pure geometric forms and its tectonic relations.

In addition to these, according to Gestalt's psychology, mind simplifies the visual environment to perceive. In other words, if a composition is simple and regular, then it becomes easier for it to be perceived and to be understood (Ching, 1996). Ancient people who had limited opportunities either because of intuitive or topological obligatory, chosen to use basic geometrical forms while they were making their buildings. For example; the simplest formed accommodation was made out of bamboos and they were round in form. This form is also a result of the concept of structure.

4.2.1 Wall

In pre-historical ages, walls were made with big stones, without mortar and they were standing still with their own weight. Later on, smaller stones were preferred and double-sided walls were filled with soil and pebbles. In Mesopotamia material was adobe so in order to make strong walls, thicknesses varied between 3 meters to 12 meters. These walls were generally blind walls, without openings. In Egypt, small-scale building's walls were made with adobe; they used stone only for the sides of the openings. Big- scale building's walls were made of stone with mortar. When they made wall with bricks, they supported it with timber tie beam or thick walls were made double sided and the space between the bricks was filled with blocking (Ünsal, 1967). These heavy, thick and solid properties of masonry walls are the stereotomics of the traditional masonry.

In masonry structures, walls were shaped according to three architectural functions; first basic function is load-bearing structural element, second; is used to separate spaces from each other and limit the spaces and third; with the openings, getting the day light to the interior spaces for better living conditions (Arun,2005).

1. From the structural point of view, walls formed by the loads that were coming from roof, later on helped wall to take a form for structural and

decorative function. In order to transfer loads which come from roofs to the sides of openings (door, window etc), lintels or arches were being used.

2. In order to provide uniform load distribution on walls, it is necessary to consider two important parameters; one that the stone or brick bound lines should not be continuous vertically although it is necessary to create straight horizontal lines for creating evenly distribution of the load. The structural necessities gave the wall surface texture as it seen in Figure 4.7, at the same time expressing tectonic quality.

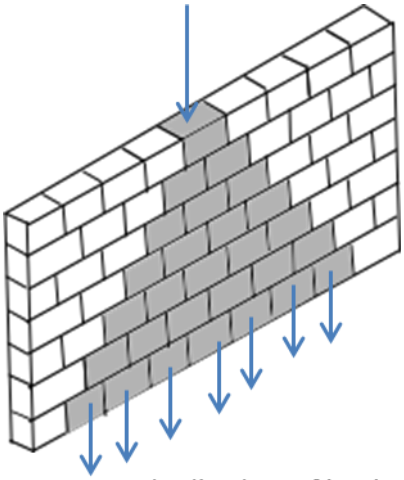


Figure 4.7: Load distribution on masonry wall (by author)

3. For providing horizontal straight lines on the walls tie stones generally used. These tie stones generally are big stones or timber that joints the two sides of the walls. As it is seen Figure 4.8, they were using specific distances on the wall.

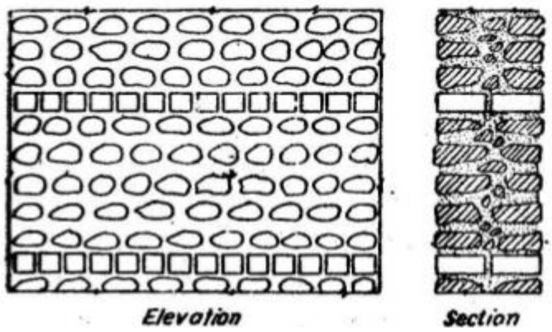


Figure 4.8: Providing horizontal straight lines on the wall

4. Additionally, masonry walls were supported with horizontal ties or tie beams generally. These tie beams should have been the same thickness with the wall. The reason for using horizontal tie is for increasing the wall strength against the additional loads such as earthquakes, storms, etc. These can be classified into 3 different categories according to the materials as stone horizontal ties Figure 4.9, brick horizontal ties Figure 4.10 and timber horizontal ties Figure 4.11.

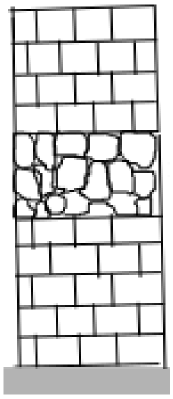


Figure 4.9: Masonry wall with horizontal stone ties (by author)

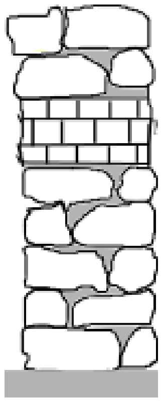


Figure 4.10: Masonry wall with horizontal brick ties (by author)

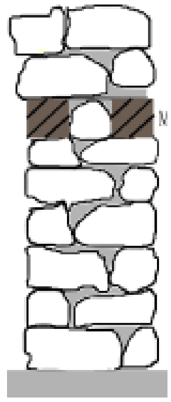


Figure 4.11: Masonry wall with horizontal timber ties (by author)

As it was seen from the Figure 4.12 Ottoman architecture has brick and stone layers, which are red and white. And Figure 4.13 shows the stone wall and timber tie elements on wall surface. These have tectonic effects on the facade.

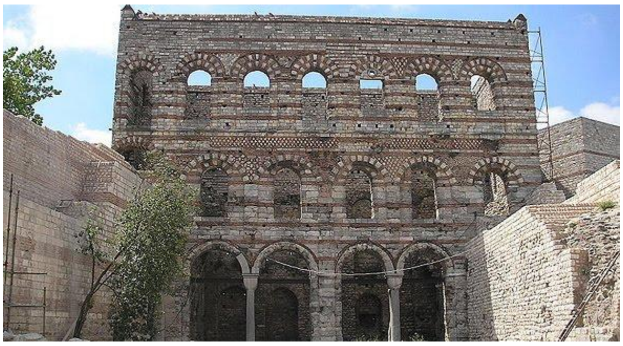


Figure 4.12: Brick and stone layers on wall (Tekfur Palace) (URL 4)

Figure 4.13: Stone masonry with timber horizontal ties (by Author)

5. On the masonry buildings, corners also are playing very important structural role. Generally, the stones or bricks at the corners should be interlocked between each other's and should be bigger than the rest of the wall.

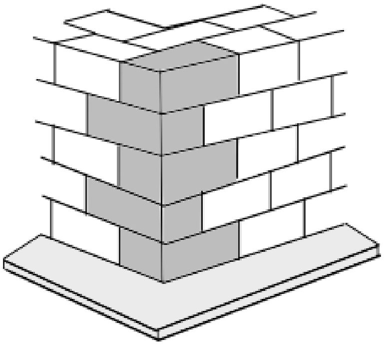


Figure 4.14: The way of interlocked corners (by author)

Corner stone's or any kinds of opening sides were reasonably square or roughly squared to obtain increased strength and stability at these points. In contrast to the brick and stone, adobe buildings have curve corners.

Figure 4.15: Examples of stone and brick building which have interlocked corners (by author)

Figure 4.15 is representing a structurally essential technique visually. Thus, the texture creates tectonic effects to the building. The changes in size and color of stone are expressed both aesthetically and structurally. This is same for brick masonry as well.

Figure 4.16: Examples of adobe building which have curve corners (URL 5)

On the other hand, in contrast to the brick's and stones' sharp corners, adobe buildings have curved; smooth corners as it seen Figure 4.16 are also another tectonic effect for adobe buildings.

4.2.2. Roof and Slabs

Roofs and slabs are horizontal elements that cover the spaces. At the time, when material and technical information was not sufficient, buildings were limited with small spans because of the top cover of building was played bigger roles. Usually, the roofs and slabs were made with using horizontal timber elements/beams so timber length brought the limitation in this manner. Therefore it can be said that it is directly effecting the plan arrangement. These linear, lightweight timber elements are the tectonic part of the traditional masonry building. When there was a need for wider spans, spaces have been obtained by using timber trusses, arches, vaults and domes. Additionally, in traditional buildings usually flat roofs were used.


Figure 4.17: Timber roof and slab in masonry building (Kucukerman, 1991)

Rhythmic use of timber elements and its combination with masonry wall is shown structurally and aesthetically. This is a picture from both the inside and outside of the building because roof rafters extended outside through passing masonry wall. This effect, aesthetically gave character to the building and shows different material usage and technical reasons directly.


Figure 4.18: Timber roof and slab in adobe masonry building (URL 5)

Additionally, the use of timber for the roof or slab shows the contrast combination of the wall stereotomic, which is heavy and solid while presenting lightweight linear elements of the tectonics. By this way, they gave tectonic effect to the buildings.

4.2.3. Buttresses

Buttress, is an opposite construction support system to prevent the wall bending towards outside (Sözen, Tanyeli, 1992). In masonry systems, when the walls are not strong enough to carry the weight coming from the roof, buttresses have been used in order to prevent walls from opening.

In traditional structures, the different type of buttresses can be seen due to load situations. One of the main buttresses is perpendicular to the wall surface and the buttresses are equally bonded into rectangular shape. The second of the main buttresses is bonded increasingly in triangular shape. Buttresses strengthened the building for horizontal forces (Ozer, 2006).

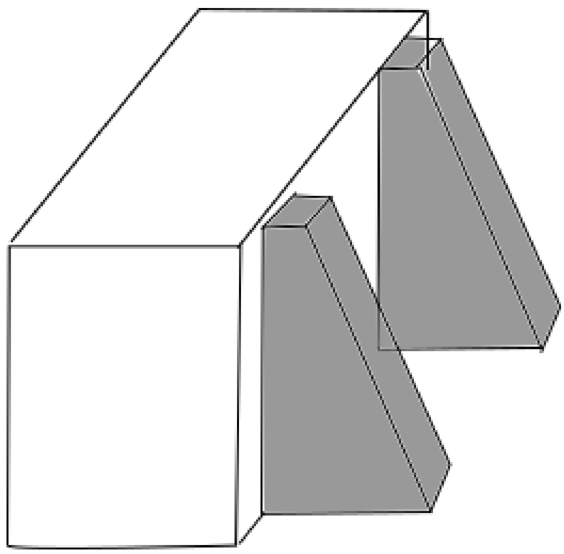


Figure 4.19: Triangular Buttresses (by author)

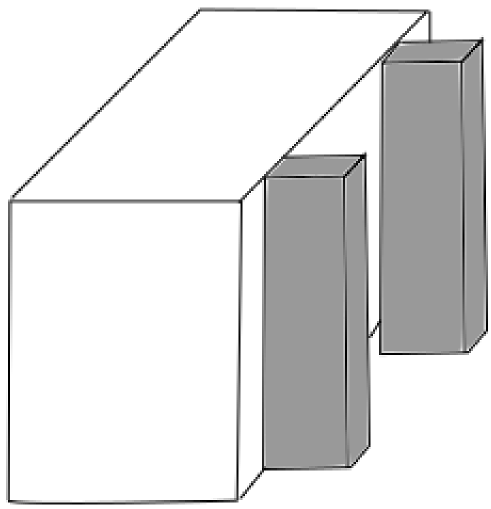


Figure 4.20: Rectangular Buttresses (by author)

Besides the technical use of buttresses, which increases the strength of the wall, they repeat rhythmically on the building surface. This gave building an aesthetic effect while totally meeting with technical requirements.

Figure 4.21: Flying buttresses of the Gothic Architecture (URL 4)

The reason behind the use of structural elements both for aesthetics and techniques is to create tectonic value. Gothic cathedrals with the flying buttresses' can be given as the best tectonic example which is shown in Figure 4.21.

4.3 Importance of Material on Masonry Structures

Semper (1851) stated that;

> *"*Every work of art should reflect in its appearance the material as physical matter, in this way we may speak of ... a brick style, stone style, earth style... and so forth (Weston, 2008)*"*.

According to above quotation, it is obvious that, the material's abilities and effect on the appearance of the building is important. In other words, if material has structural ability, it should not be used only for decoration. The structure and materials that are used in the building and the effect on us should be parallel to each other in order to give a kind of tectonic expression, both technically and aesthetically. This not only gave emphasis to the tectonic values but also the true expression and the right use of materials gave emphasis to ontologically valid tectonic form. In this manner, significance of material in masonry system needs to be considered tectonically. Types of materials affect the structures and this creates different ontological groups. That is why the materials used in structures are very important for structural system's improvement (Unay, 2002).

4.3.1 Traditional Stone Masonry Building Technology and Tectonics

Through the centuries, people have been using stone for buildings as a structural material, from building scale to urban scale. Mainly, we can find the examples from Egypt, Italy or Mesopotamia.

Stone is a material which can be found in the nature or taken out from stone quarries has a homogeneous structure and is a resistant material to natural conditions (Türkçü, 2000). Due to properties of the stone, structures are able to resist compression but are weak in tension. Thus, this property makes it as one of the important for masonry structural material. Additionally it is often used for arch, dome and vault because of easy access. Usually, the resistance of structures made of stone can be obtained by common reaction of stone and stuffing combination (Unay, 2002).

Figure 4.22: Traditional stone building (by author)

As it seen from the Figure 4.22, the building consists of simple rectangular prism which is symmetrical. It has small size openings on the facade which are far from each other and the corners. The importance of the corner's can be seen from stones as bigger than others. The rough texture and solid walls is reflecting wall stereotomics.

Another example of stone structures is the one of the city of Turkey, Mardin. In this city, stone buildings have been used for many centuries. As it seen from the Figure 4.23 in the city scale the tectonic values can be easily read. It is obvious that traditional stone arches were important structural elements for openings and gave identity to the buildings. It has harmonious relationship with its environment and achieving tectonic value with this way.

Figure 4.23: City of Mardin as a composition of stone masonry buildings (URL 4)

On the other hand, from the building scale, the Castel Hedingham (Figure 4.24) can be given as an example of stone masonry. The castle was made for military purposes in England during 12th century. The building is made of stone masonry system. The building height is 9.5 meter which consists of 4 storeys. The wall thickness varies between 3 to 3.5 meter in ground floor as it seen from Figure 4.25 (section) and

Figure 4.26 (plan). For this reason, when it is looked at, walls show the authentic senses to the people with the whole feeling of heavy, solid surface due to thicknesses while representing all manners of stone as a rough surface.

Figure 4.24: Castel Hedingham, London (URL 33)

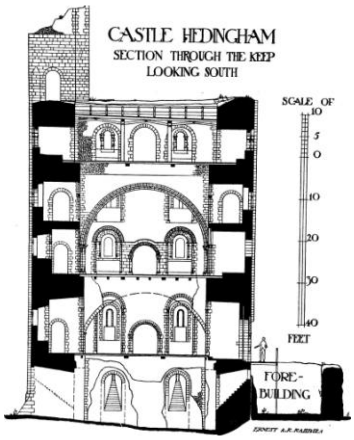


Figure 4.25: Section of castle (URL 33)

Additionally the walls are supported by thin buttresses which are repeated rhythmically on the wall surfaces. In between these buttresses, openings are placed on the wall less in number and small in size. The arrangements of the windows are almost the same on each elevation except second floor which is doubled according to functional necessities. Main hall spanned by a massive and semi-circular arch (Figure 4.25). Arch structurally divides the space into two equal sides (Figure 4.26) (plan). From the traditional tectonic point of view, the ontology of the building is achieved by using it both technically and visually.

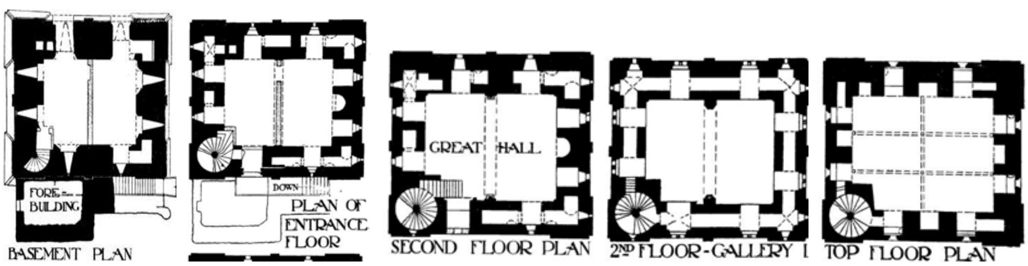


Figure 4.26: Floor plans of castle represent the heavy walls stereotomics and wall like room (URL 33).

4.3.2 Traditional Brick Building Technology and Tectonics

Another masonry product is brickwork, which is put on top of each other and tied with mortar to build up brick walls. Brick is mixture of hardpan and clay, partly include kaolin or soil and when it is necessary mixed with water, sand, grained brick or tile dust, ash as additional materials. Then it would own to form it as structural material (Türkçü, 2000). It is known that it was first used in Mesopotamia and started to be used more professionally by Romans afterwards. In Italy, almost each building that belongs to Roman period has shown that brick masonry uses stone or marble cladding. The advantages are that it has good thermal insulation, it is not affected from environmental factors, it is more durable and strong as a building material, it is easy to construct, it is easy to repair and it has aesthetic look. These advantages caused brickwork to spread easily. Other European countries like Germany, Spain, and England also effected from this movement between 19th and 20th century. Therefore, brick masonry buildings commonly occupy important place in their histories.

Bricks in primitive examples made of sun dried adobe. However, this type of produced bricks are not resistant to rain that is why it is ovened in 1000°C and have increased the resistance. Bricks as main material represent the first prefabricated elements (Crochi, 1998)

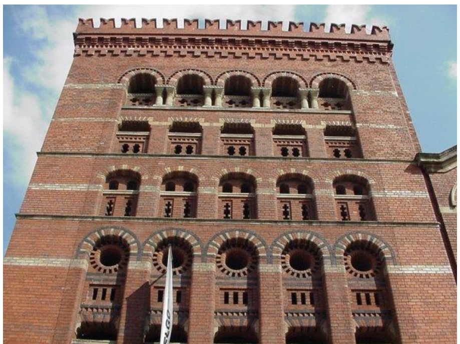


Figure 4.27: 19th Century brick building from London (URL 34)

The brickwork of this building (Figure 4.27) is both structural and highly decorative. It is obvious that it follows the design principles stimulated by the period. Due to inventions on industrial area, bricks were created by using machines. Thus, it would be possible to made bricks of different colours. It is possible to find the uses of brick masonry at city scale as well (Weston, 2008).

When compared with stone and adobe, brick is the most rich in sense of texture possibilities; this is of course achieved by bond type. With this method, ontologically valid tectonic expression occurs. Since the brick is a modular material the wall thicknesses depends on one brick's thickness but this can be increased by bonding double or triple brick layers together. The necessary and common wall thickness is between 20 cm - 30 cm. This bonding type and modularization gave visual effect to the building as well. It can play a big role on aesthetical point of view. Previously, brick was an essential part of the masonry system, in modern times it has been used together with frame systems. In these days, it turns to be non-load bearing material with frame systems.

15th century building Tattershall Castle can be given as an example (Figure 4.29). It can be said that this building is typical traditional brick masonry building which represents many values such as; horizontal ties, thick walls, small openings and symmetrical plan arrangement. The building height is 30.5 meter which consists of 5 storeys. From the technical point of view, the walls are made from red and white brick. Wall thicknesses, varies from 40cm to 150 cm according to height proportionally Figure 4.28 (plan).

Figure 4.28: Plan of Tattershall Castel shows thick walls (URL 34)

This is the reason that, when you look at the building, walls give authentic senses to the people with the whole feeling of heavy, solid surface due to thicknesses. This can be read through plans that the wall thicknesses even created space in it, like a room (Figure 4.28). This is also another tectonic expression for all traditional masonry buildings.


Figure 4.29: Tattershall Castel, London, 15th Century (URL 34)

In Figure 4.29 shows that horizontal white brick line in various places on wall surface represents structural necessity and gave aesthetic to the building. Technically it was used for increasing the strength of the wall as traditional horizontal tie. The use of different colours to express this structural identity, gave the building an aesthetical proportion. This is used for other structural elements such as arches which cover the openings from the sides. From the traditional tectonic point of view, the ontology of the building is achieved by using it both technically and aesthetically.

4.3.3 Traditional Adobe Building Technology and Tectonics

Adobe used as a hand-made structure material. Adobe with hardpan as main material was used with bamboo and wattle dried under the sun and adobe walls are created. Below Figure 4.30 shows the process of doing adobe/mud brick. Sand and pebbles in mixture need cement and lime to combine. However, adobe has this combination in itself because of clay. In order to increase material resistance, some additional materials are used in adobe mixture latterly.

Figure 4.30: Sun dried adobe (URL 5)

Through the centuries, people have been using adobe to build buildings in many scales and places. Mainly we can find the examples from England, West American villages or Mesopotamia.

Adobe masonry is well-known for its successful responds to changes to climatic conditions. It has tectonic outlook, which shows various colors of earth in haptic senses. Having curved, smooth corners are also another tectonic effect for adobe buildings. The use of timber for the roof rafters adds to tectonic identity because they usually extend outside through the adobe wall. Additionally buttresses, which support the building mass, were also applied repetitively surrounding the exterior walls with its tectonic expression.

Adobe is a natural building material, which consists of sand, clay, water, wooden sticks, straw, and dung. It can be said that it is the first building material experienced in many centuries because of advantages of being naturalist essence without having toxic material inside, low cost, fire proof, sound proof and provide good thermal conditions in almost all regions of the world. Adobe can be use in different ways like rammed earth, mud-brick and compressed earth block.

One of the valuable and historic examples of adobe masonry buildings is the Great Mosque of Djenne in Mali, Africa. The building started to be built in 13th century but the main part was built in 1907 (Figure 4.31). Comparing to the other adobe masonry structures it is the biggest adobe structure in building scale so it is the most famous landmark in Africa. In 1998, it was listed as one of the World Heritage Site by UNESCO (URL 11).

Figure 4.31: Great Mosque of Djenne in Mali, Africa (URL5)

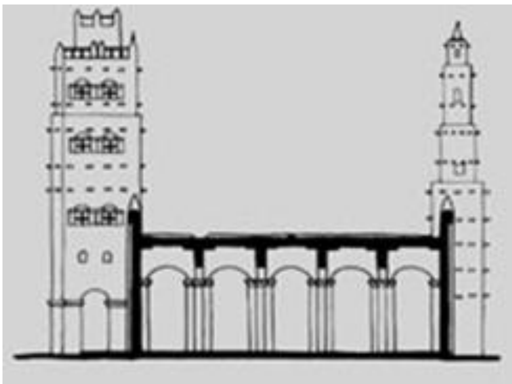


Figure 4.32: Section of the building (URL 5)

From the technical point of view, the walls are made from sun-dried mud bricks, where wall thicknesses vary between 40cm and 60 cm according to height proportionally (Figure 4.32). Because of this, when you look at the building, walls gave the authentic senses to the people with the whole feeling of heavy, solid surface due to thicknesses but with the smooth, curved edges people feel contrasted (Minke, 2006).

Figure 4.33: Horizontal timber elements, repeated openings and buttresses on adobe wall (URL 5)

Horizontal timber elements are also used for two technical reasons which are shown in Figure 4.33. Firstly, they were used for increasing the strength of the wall against cracks, which happens due to changes in humidity or natural disasters. Secondly, these timber elements serve as a step for repairing the building. Additionally the walls are supported by buttresses which repeat rhythmically on the wall surface. In between these buttresses, size openings are placed on the wall less in number and small in size. This is also another consideration for technical limits of adobe masonry structures (Rael, 2009).

From the aesthetical point of view, the building representing itself as growing from the earth which look like an object sitting aesthetically on the site. It is evident that, it emphasizes the authenticity of close environment structures while fulfilling all the demands of tradition. From the traditional tectonic point of view, the ontology of the building is achieved by using it both technically and aesthetically.


Figure 4.34: Adobe example from Burkina Faso (URL 5)


Figure 4.35: One of the Adobe Mosque in Ghana (URL 5)

As it seen Figure 4.34 and 4.35, it is possible to find other typical examples in different regions like Mali, Burkina Faso, Cameroon, and Ghana. Hassan Fathy‘s New Gourna Village, is one of the well-known example of adobe. It was built between 1946 and 1952 in Egypt and the symbolically meaningful use of adobe with traditional arches and domes (Rael, 2009; URL 5; URL11).

Another example of adobe structures is one of the village of Mexico, Taos Pueblo. In this village, the buildings have been used for more than ten centuries.


Figure 4.36: Adobe village Taos Pueblo in Mexico (URL 11)

This village has a significant place in architecture because it is one of the adobe examples in the urban scale which is why it is listed on both world heritage site by UNESCO and a national historic landmark (URL11, URL 35).

Technically, the buildings made from adobe masonry structure, usually are buildings with two storey located on top of each other, it can be seen from the Figure 4.36. There are thick walls with timber supported roofs. The orientation of the buildings is according to environmental conditions and climatic issues. These qualities of buildings can be seen from the Figure 4.37.

Figure 4.37: Dwellings of Taos Pueblo in Mexico (URL 11)

4.4 Importance of Earthquake Resistance in Masonry Buildings

The earthquake occurs with a sudden, rapid movement of the ground. This movement creates seismic load which can also be defined as a dynamic load (Ozer, 2006). When seismic waves in ground reach the buildings, they create vibrations and the buildings create a reaction against these vibrations. Stability of masonry structures to vertical loads and horizontal earthquake loads depends on geometry, connection between walls, durability of materials and masonry blocks (adobe, stone, brick). In this context, when it has been evaluated from structural point of view, masonry structures stand against the external loads with walls, buttresses, arches, vaults, domes and element like lintels (Ozer 2006). These structural elements should respond to tension, compression, and shear, bending and twisting forces. It can be said that, the structural elements' geometrical forms and their material properties play a determine role in this response. Their load-bearing capacity shape accordingly and they can only respond one or all of the forcing powers above (Ozer 2006).

Stone and brick walls carry compression well. Their resistance to tension or bending type of forces is very low. Depending on these properties of structural tools, different types of structural systems were developed. For example, all elements in structures with arches or domes can be forced with compression. Due to this technique, stone and brick found a very wide area in the structures for thousands of years until today (Büyükyıldırım, 1999). Adobe is weaker than brick and stone in case of earthquake loads.

Masonry walls have been used by locking stone or brick units to each other by using tenon, ferrule (zivana) or mortar. To increase the homogeneity of masonry walls mortar was as a chemical connector. Additionally timber tie beams were used for physical connection for distributing weight equally to the base. Thus, more resistant masonry buildings created were against earthquake.

Structural elements' dimensions and proportions are directly related to their structural duty. That is why; they have visual determining role for perceiving dimension and measuring the space. Proportions of masonry walls reflect the importance of these elements in structural systems and reflect the properties of materials they are made of. It is obvious that, the strength of the historic buildings is based on structure’s geometry and material properties. For example, the structural rules, which were created by Romans, still exist. Every single one of them has certain geometry. They can be identified by certain proportions and geometric construction rules (Büyükyıldırım, 1999).

Additionally, with some institutional research facilities like Pontificia Universidad Catolica del Peru and the University of Technology in Sydney, Australia have been trying to improve the earthquake resistance of masonry buildings. Additionally, through the building codes of the countries, the improvements in the safe use of masonry structures are still ongoing. Here, it can be said that building codes of different countries lack a consensus. For example; Pakistan, India, Peru and Mexico have separate building codes for masonry structures, which contain practical information, requirements for material to increase the building resistance, such as adding bamboo, timber and cane into the wall (Coburn et al. 1995, Blondet et al. 2002; Hürol, Yüceer, Şahali, 2014). It is obvious that in these regions, most of the building types are built with masonry structures and by local people. This has a cultural value for them. That is why the countries’ building codes try to teach and encourage the people to use new techniques in a more appropriate and safe way.
Table 4.1 shows the basic principles for strengthening masonry buildings against earthquake.

Table 4.1: Ongoing research for improving quality of masonry structures (prepared based on EERI, IAEE, 2000) (Rael, 2009; URL 6)

Cross-Walls In Wall Intersections And Buttresses Buttresses and cross-walls are provided at critical locations to increase the overall stability and strength of a building. Buttresses act as restraints, preventing the inward or outward collapse of walls. Buttresses and cross-walls must be used in addition to wall reinforcement to ensure adequate seismic safety	
Horizontal or Vertical Tie-Beams in Long Walls Tie-beams (also known as a crown beams, collar beams, bond beams, ring beams, or seismic bands) are one of the most important earthquake-resistant provisions for load-bearing masonry construction. They make building to behave like a box because they tie the walls to each other. They should be continuous, strong and tie the top of the wall. The width also must be same as the wall thickness.	
Long Walls With Timber, Bamboo, Cane Vertical And Horizontal Reinforcement During the earthquakes tensile stress attract the wall so cracks appear and the wall starts to be broken. To prevent this, vertical and horizontal seismic reinforcement must be placed at critical locations. The reinforcement must be continuous and can be either inside the wall or attached to the wall surface.	
Steel bar or Steel mesh Reinforcement (Chicken Wire) The use of external welded wire mesh has been used as a reinforcement system that could be applied both to new and existing masonry construction. The mesh is placed in horizontal and vertical strips, simulating beams and columns, and it is covered with cement and sand mortar.	

In this context, it can be said that, without adding extra industrialized materials to the masonry walls, they try to use as much natural materials as possible. With this way, they are not changing the traditional meaning of wall streotomy. Thus, proposing to use buttresses on exterior side of wall or using horizontal and vertical ties from natural materials keeps traditional tectonics available.

On the other hand, some of the countries building codes need engineering calculations or requesting the use masonry in such a way that it becomes similar with the frame system. The building codes of New Zealand, America, and Republic of

Cyprus are in this category. Addition to table 4.1, there are some other important key rules for increasing the earthquake resistance of masonry buildings (Dowling et al. 2005; Blondet et al. 2011). Building codes has been developed for masonry buildings according to experimental studies and research. It is possible to list the common requirements of building codes (for earthquakes) which are commonly mentioned for masonry buildings in architectural context as follows (Blondet: 2005; Brzev: 2007);

1. Form of the building should be regular. It should not have too much solid void, preferably symmetrical form (Blondet, 2005; Brzev, 2007).

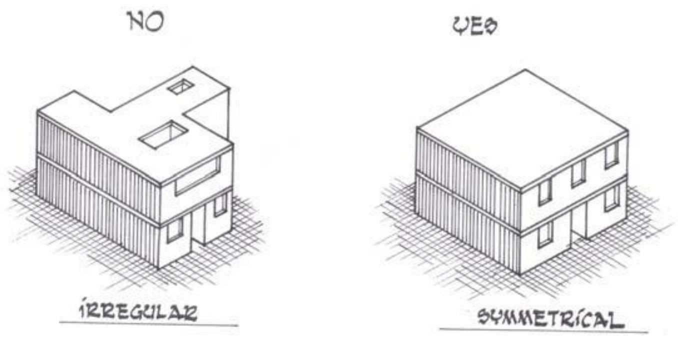


Figure 4.38: Irregular and regular building form (Brzev, 2007)

2. The building length to with ratio should be balanced. The building length should not exceed more than 4 times the width (Blondet, 2005; Brzev: 2007).

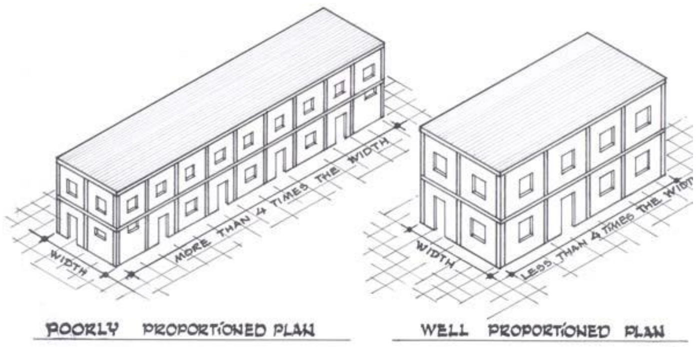


Figure 4.39: Building ratio (Brzev, 2007)

3. According to plan arrangement, walls should be parallel to each other (Figure 3.40) and should be continuous from bottom until top of the building (Figure 3.41).

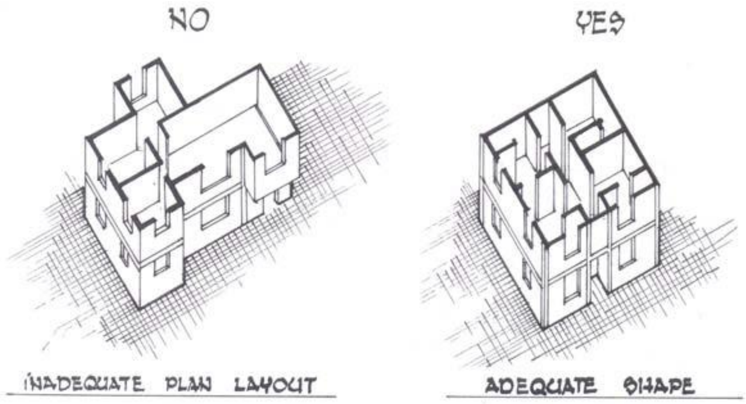


Figure 4.40: Irregular and regular wall arrangement (Brzev, 2007)

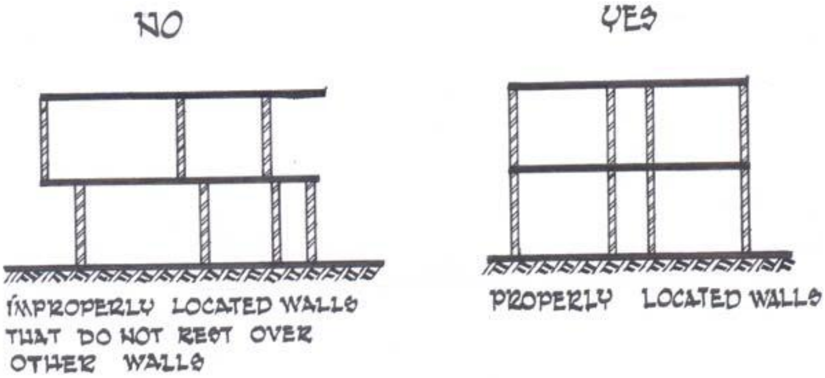


Figure 4.41: Continuous walls up to building height (Brzev, 2007)

4. The position of the openings should be placed on same axis both horizontally and vertically. It needs to have equal distances from corners and the size and place of openings should be determined proportionally. If the opening sizes/ area more than 1.5 m2, it is required to have vertical ties at both sides of openings.

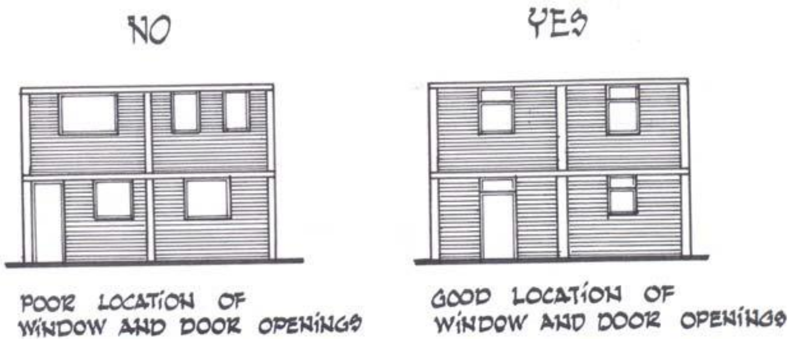


Figure 4.42: Opening arrangements on the wall surface (Brzev, 2007)

5. Horizontal ties should exist in each floor level or it should be repeated in every 3 meters.

6. Vertical ties should be placed in every 4 meters. Additionally they should be in the wall intersections and wall ends.

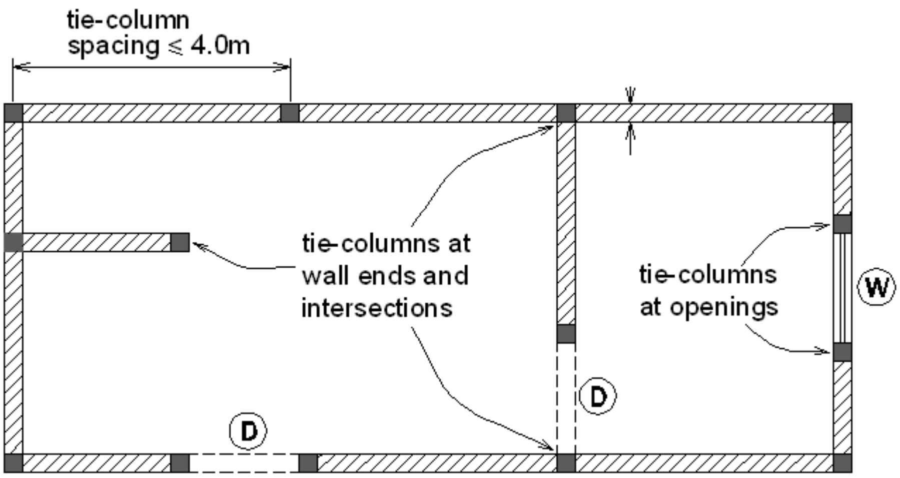


Figure 4.43: The placement of vertical ties in the plan (Brzev, 2007)

7. Since the earthquake performance depends on the shear resistance of masonry walls, it is necessary to have a sufficient number of walls in each direction of the building to avoid twisting problem during an earthquake.

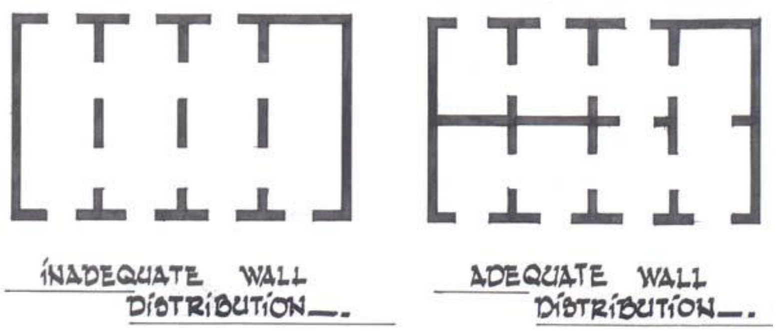


Figure 4.44: Distribution of wall in plan (Brzev, 2007)

8. Building height is also important. Each storey should not exceed 3 m height and the total building height can vary depending on each country (from low (1 storey) to medium rise (4 storey).
9. Additionally, the application of plastering and the use of reinforced concrete continuous foundations are very important.
10. Use of light roof system and not having big rooms are also important parameters to consider.
11. The weight determines the earthquake load thus the building should be as light as possible.

It is important to note that, over the last 30 years, these rules have been practiced in Italy, Slovenia, Serbia, Mexico, Chili, Peru, Iran, Indonesia, China etc. (URL 6, EERI/ IAEE: 2000). When looked at their earthquake zones, majority of them are located at high seismic risk zones. Although, the experiences and observations show that buildings which were built according to these rules were affected from earthquakes, they have sustained without collapse (URL 6; EERI/ IAEE, 2000).

Turkish buildings codes (2007) can be given as one of the examples that follow similar approach. Here, the building code specifies the structure under a separate heading as masonry and gives sub-headings for materials, such as brick, adobe and stone. The requirements for all of these materials are almost the same for brick and stone, where adobe is under strict requirements. Figure 4.42 shows the basic regulations for the masonry structures in six steps. (Ministry of Public Works and Settlement Government of the Republic of Turkey, 2007).

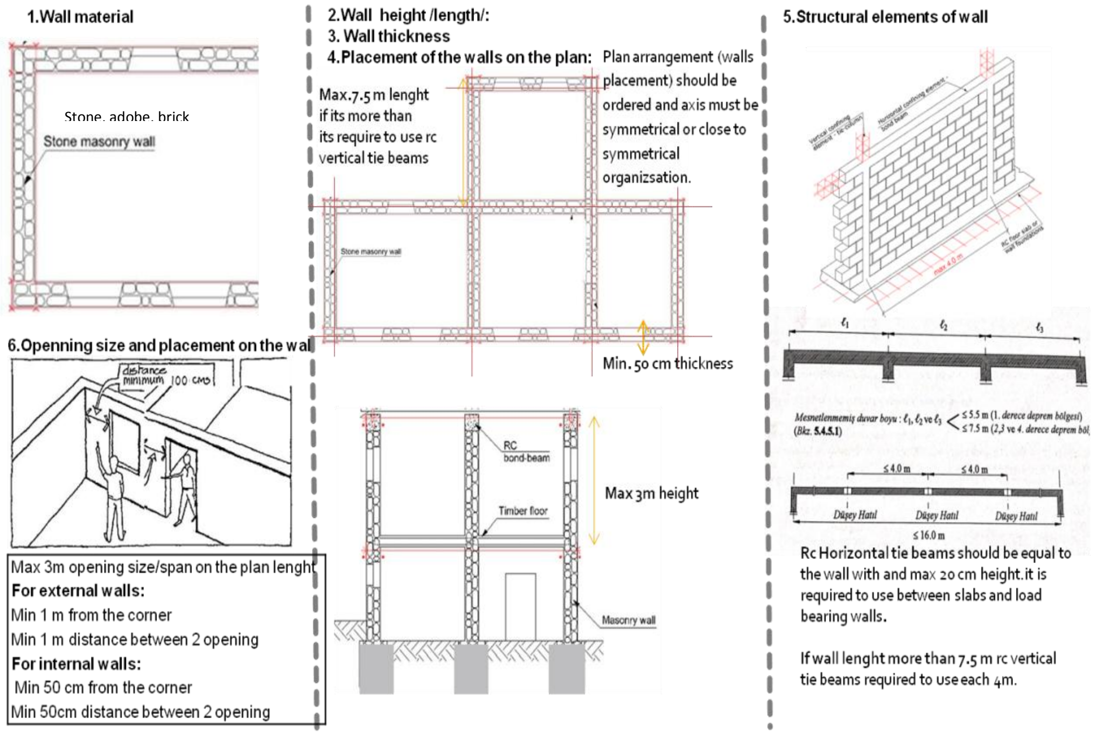


Figure 4.45: General six important rules from Turkish building code 2007
(By Author)

According to 2007 building code of Turkey, material properties are important. Therefore, they are divided into 3 as stone, brick and adobe masonry. In this research the field study will be selected from stone masonry thus stone masonry building code requirements can be summarized as follows;

1. Wall thickness will be specified at 50 cm,

2. Wall length will be limited to 7.5 m. maximum. If it is more than 7.5 m, it is required to use reinforced concrete vertical tie beams in every 4 meters.
3. Horizontal tie beams should be placed on top of the walls. It's depth should be equal with wall thickness and depth should not be more than 20 cm.
4. Wall height will be specified at maximum 3 meters for each storey and maximum 2 storey building.
5. Plan arrangement should be ordered and axis should be symmetrical or close to the symmetrical organization.
6. Opening length in plan should not exceed the %40 of the wall length. Placement of the openings on exterior walls should be specified as minimum 1 meter away from corners and each opening should have minimum 1 meter distance in between. On internal walls, openings should be minimum 50 cm away from corners and each opening should have minimum 50 cm distance in between.

These differences between the building codes are expected because of the differences of the earthquake zones of different countries and their economical conditions. However, the Earth can be categorized into seismic zones and some basic, fundamental principles can be put, then each country can follow and improve their own building code, based on these principles. Earthquake Engineering and Research Institute and International Association for Earthquake Engineering established an online web site under the name of "World Housing Encyclopaedia" for sharing data and findings to improve it globally. On the other hand, Blondet

(2005) with *Construction and Maintenance of Masonry Houses- for Masons and Craftsmen* and Brzev (2007) with the book of *Earthquake- Resistance Confined Masonry Construction* and Fodi & Bodi, (2011) proposed basic rules and key factors, which are universally easy to apply to corresponding earthquake zones.

As a result of this chapter;

1. Structural elements of traditional masonries were defined in architectural point of view. 2. Traditional buildings were analyzed from tectonical point of view and 3.According to earthquake problems of masonries, building code requirements were defined in general. Accordingly, 3 main different building codes found that;

- Pakistan, India, Peru and Mexico have separate building codes for masonry structures, which contain practical information, requirements for material to increase the building resistance, such as adding bamboo, timber and cane into the wall.
- Like New Zealand, America, and Republic of Cyprus building codes need engineering calculations.
- On the other hand Turkey and Iran request the use of masonry in such a way that it becomes similar with the frame system.
- As it was mentioned before, this chapter is formed of four parts which are shown in Figure 4.46.

1 the evolution of traditional masonries	2 structural elements of traditional masonries	3 Importance of material on masonry structures	4 Importance of earthquake on masonry structures
From caves to tent and first masonry examples	Wall Roof and slabs Buttresses tectonic values are presented	Stone Adobe Brick the tectonic effects on traditional buildings are discussed	earthquake problem of masonry structure is taken an important parameter to discuss general applications in the light of building codes.

Figure 4.46: Summary of Chapter 4

Chapter 5

ANALYSIS OF CONTEMPORARY MASONRY BUILDINGS

The theory of “tectonic” with the synthesis of existing theories in literature of architecture and transition between traditional tectonics and contemporary tectonics was displayed in chapter 2 and chapter 3, and then the characteristics of traditional masonry were presented in chapter 4. Therefore, in this chapter, the contemporary masonry architecture will be examined in relation to tectonics to find out how many ontological groups exist in contemporary masonry and develop a model. In this regard, awarded buildings from 21st century were analyzed to represent tectonic characteristics of contemporary architecture.

5.1 Creation of the Ontological Structure Category of the Buildings According to Its Stereotomic and Tectonic Elements Model

In this thesis, Semper and Frampton’s theories are used more intensively than the others because of the clarity of their concepts on masonry structure. According to the findings in Chapter 2, four basic components are defined as evaluation theory as shown in Table 5.1.

Table 5.1: The defined basic components of tectonic theory for evaluation

<table>
<tr><td>1. Tectonics and technology relationship</td><td rowspan="3">4. Togetherness of technical and visual consideration of tectonics</td><td rowspan="3">Achievement of ontologically valid structure</td></tr>
<tr><td>2.Tectonics and structure construction relationship</td></tr>
<tr><td>3.Tectonic and Stereotomics</td></tr>
</table>

Stereotomic elements indicate the masonry wall and show what kind of elements are inside the wall, within the scope of the traditional masonry. On the other hand, tectonic elements include the secondary structural elements that indicate the masonry structure to be lightweight, linear elements or with light, open and airy effects. It shows what kind of elements are inside the wall, outside the scope of the traditional masonry.

According to these theories, it is seen that first Semper categorized tectonic and stereotomic elements in 19th century. Later, Malgrave and Frampton got inspired from this separation of the structural elements and whenever they talked about masonry buildings, they always referenced him and evaluated buildings according to this categorization. If talked about masonry, the most powerful theory that differentiates tectonics and stereotomics is needed to be considered. It is the 21st century and this thesis asserts that a new stereotomics exists. This does not mean that Semperian theory does not exist anymore. However, according to the needs of people and demands of modern life such as living in a green and a sustainable world to delay and/or prevent the full effects of global warming, the use of natural materials and techniques are increasing. Experiences on natural disasters, like storms, earthquakes, flooding caused the buildings to be designed more durable and strongly.

Therefore, people started to use different elements on the masonry walls and this has caused changes in the meaning of the stereotomic.

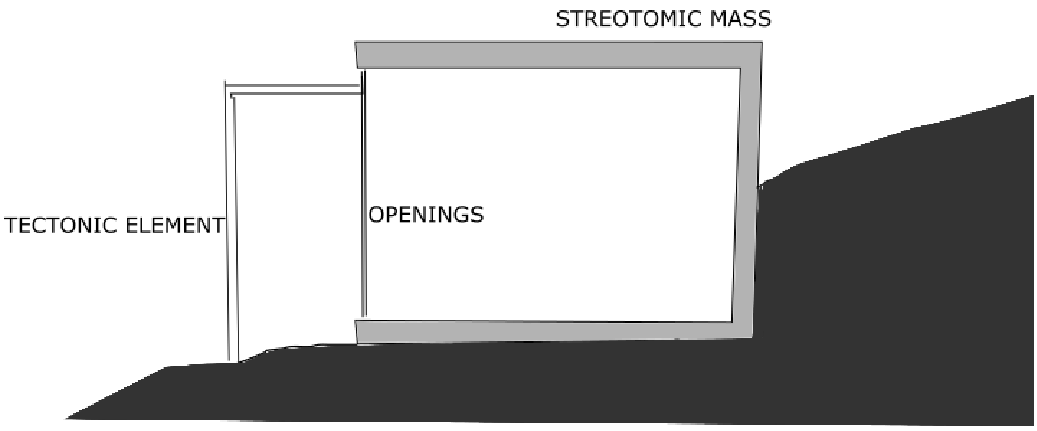


Figure 5.1: 1-Stereotomic mass, 2- Tectonic element, 3-Openings (By Author)

For example Figure 5.1 shows that the walls and floors have stereotomic qualities by retaining the earth. The stereotomic mass is the primary structural element and indicates solid wall, heavyweight look and heaviness. It can be brick, adobe, stone masonry or concrete. It can be evaluated as architecture and earth.

The tectonic structure becomes the secondary element in the structural system which indicates lightweight frame or membrane, linear elements, lightness and openness. It can be bamboo, timber, and steel. It can be evaluated as architecture and air.

The glasses, windows, and doors, in brief openings, form the tertiary structure where they act as threshold between spaces and stereotomic and tectonic structures.

The structural elements that are used in the structure can be divided into four main categories as; wall stereotomics with timber elements, wall stereotomics with reinforced concrete elements, wall stereotomics with steel elements and tectonic elements. The architectural elements, which are categorized as stereotomic elements and tectonic elements are;

1. Wall stereotomics with timber elements indicate heavy, massive and solid wall with timber elements. In other words, masonry buildings were built using only timber horizontal tie beams as an additional structural element on wall. The use of cross wall technique or interlocking walls to increase the stability of building is also considered in that category. Additionally, masonry buildings with buttresses are included in this category. This category is closer to the traditional masonry structure systems because the wall properties show traditional masonry tectonics and stereotomics. Streotomy with timber arm of model is shown in Figure 5.2.

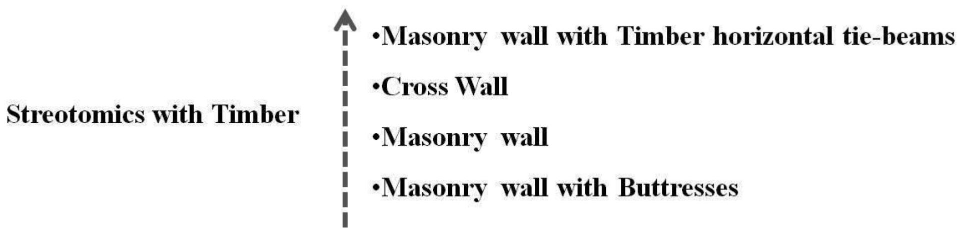


Figure 5.2: Wall stereotomy with timber elements

2. Wall stereotomics with reinforced concrete elements: Basically, the wall can have reinforced concrete horizontal tie beam or vertical tie beam or the both (masonry wall with reinforced concrete horizontal and vertical tie beam together). It can be a cavity wall as well or can be totally based on reinforced concrete frame with load bearing masonry infill wall. The use of reinforced concrete shear wall with load bearing masonry infill wall is also considered in this category. All of these can be combined

with reinforced concrete frame system at the end. Streotomy with reinforced concrete arm of model is shown in Figure 5.3.

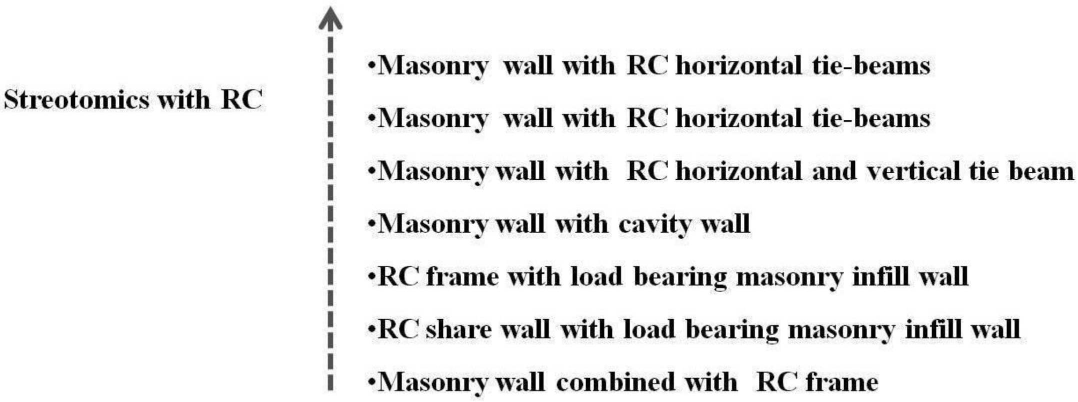


Figure 5.3: Wall stereotomy with reinforce concrete elements

3. Wall stereotomics with steel elements; basically, the wall can have masonry wall with steel vertical tie beam or horizontal tie beam or both (masonry wall with steel horizontal and vertical tie beam together). The main structure can be steel frame with load bearing masonry infill wall. Apart from these, gabion wall technique which is a steel mesh frame filling-up with stone masonry technique should also be considered in this category. Streotomy with steel elements arm of model is shown in Figure 5.4.

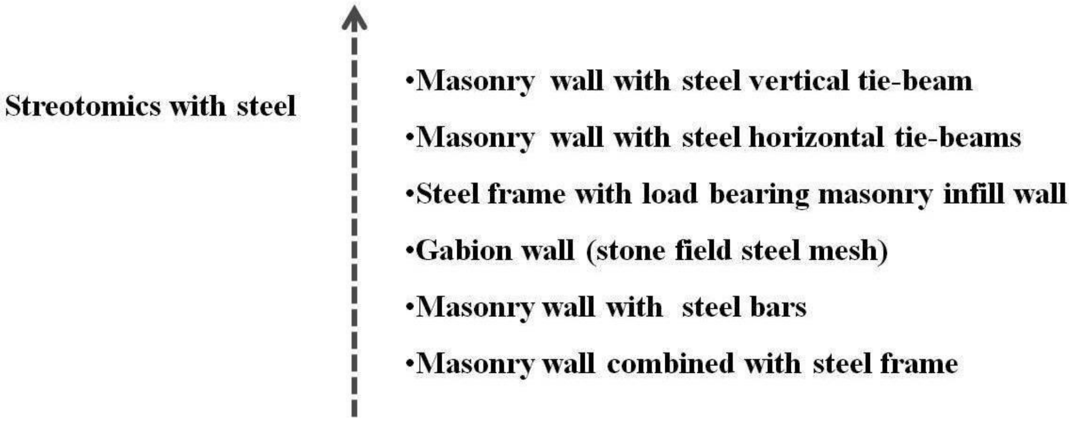


Figure 5.4: Wall stereotomy with steel elements

4. Tectonic elements are consisted of masonry walls with large openings, corner openings, openings close to each other and close to corners; a wall having full height openings more than 3m. These elements allow us to create lighter weight structures as well as lighter weight in appearance. If openings are arranged irregularly on masonry walls or different sizes of openings are located on different places on same the wall, this also gives the contemporary and light effect similar to traditional elements. Additionally, masonry buildings with large spans, like glass walls /glass surface (longer than 3m) or glass walls with special shutter details, steel, Timber, Bamboo frame without masonry wall (there can be non-load-bearing infill), masonry building with truss roofs, masonry building with cantilevers (timber, rc and steel), masonry building with steel, timber, bamboo roof/ slab, different brick, adobe, stone pattern and texture are also considered under this category. Tectonic elements arm of model is shown in Figure 5.5.

Tectonic Elements

- **Masonry walls with large openings, corner openings,**
- **Openings close to each other and close to corners**
- **Full height openings**
- **Masonry walls with irregularly arranged openings (Different size of openings located on different places on same wall)**
- **Masonry building with large spans**
- **Glass walls /glass surface (longer than 3m) /special shutter detail**
- **Steel, Timber, Bamboo frame without masonry wall(there can be non-load-bearing infill)**
- **Masonry building with truss roofs**
- **Masonry building with cantilevers timber, rc and steel**
- **Masonry building with Steel, Timber, Bamboo roof/ slab**
- **Different brick, adobe, stone pattern, texture**

Figure 5.5: Tectonic elements of building (By Author)

By the combination of the arms as 1.Wall stereotomy with timber elements (Figure 5.2), 2.Wall stereotomy with rc elements (Figure 5.3), 3.Wall stereotomy with steel elements (Figure 5.4) and 4.Tectonic elements of building (Figure 5.5), the type of masonry structures reading model was created as in Figure 5.6.

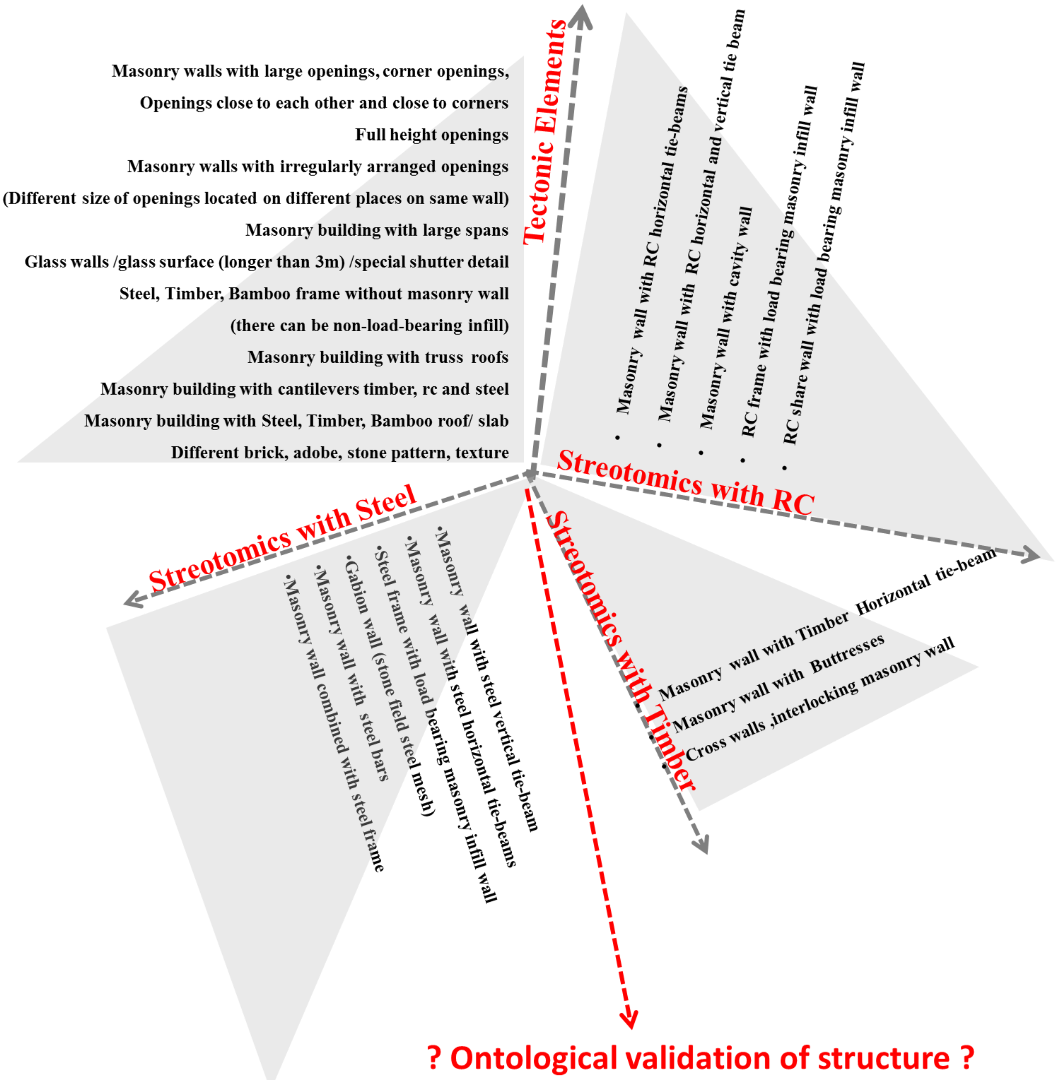


Figure 5.6: Tectonic reading model according to structural elements of masonry structures.

In order to test the ontological validation of the structures another reading model is created which questions the types of masonry structures if both visual and technical aspects and traditional contemporary effects are considered simultaneously in the buildings.

In the second part of the model ontological qualities of these elements are evaluated according to technical values and visual consideration. Rather than the purpose of usage, any kind of element should be supported technically and visually together, in order to evaluate the effects of ontology on the tectonic design.

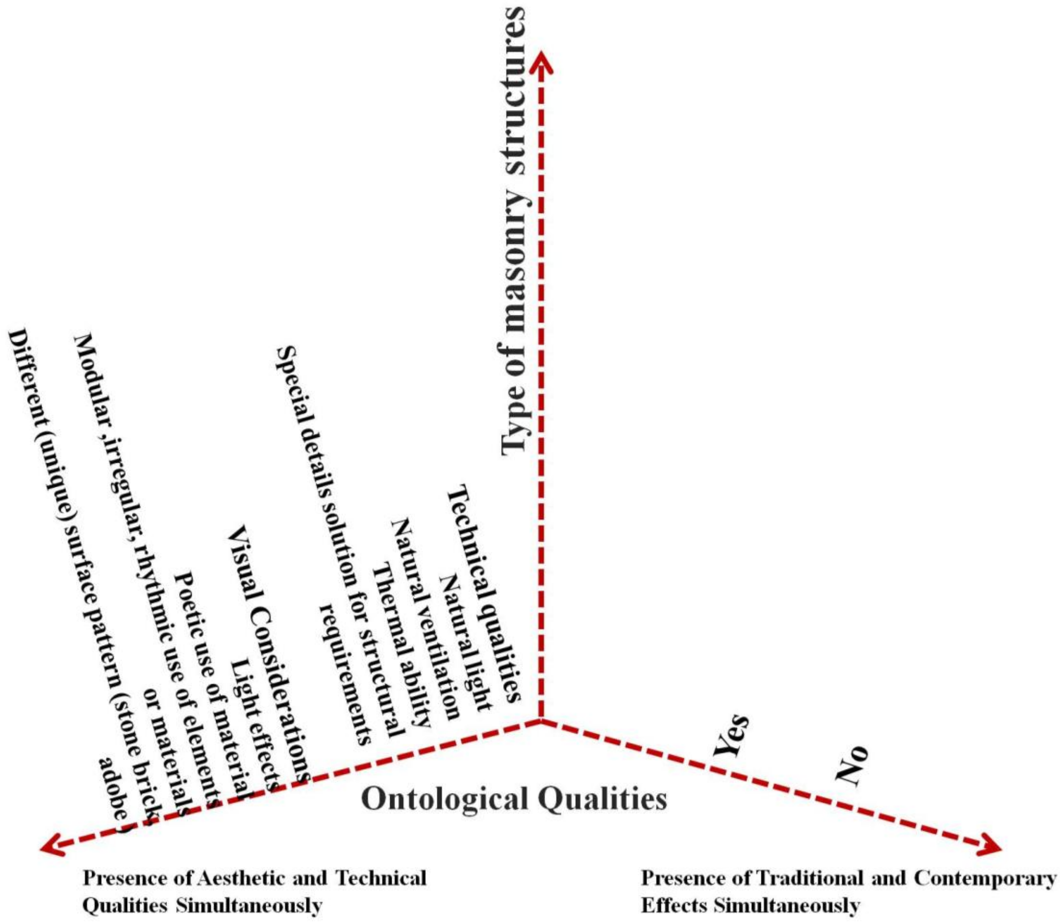


Figure 5.7: Ontological validation reading model

Departing from the theories, that were defined in chapter 2, a model is created to define the structural elements based on stereotomic and tectonic values (Figure5.6). Then, in order to evaluate the ontological structure category of the building second model was created; that is ontological validation reading model (Figure 5.7) and merged with each other. Figure 5.8 shows the ontological structure category of the building according to its stereotomic and tectonic elements model's structure in a graphical way.

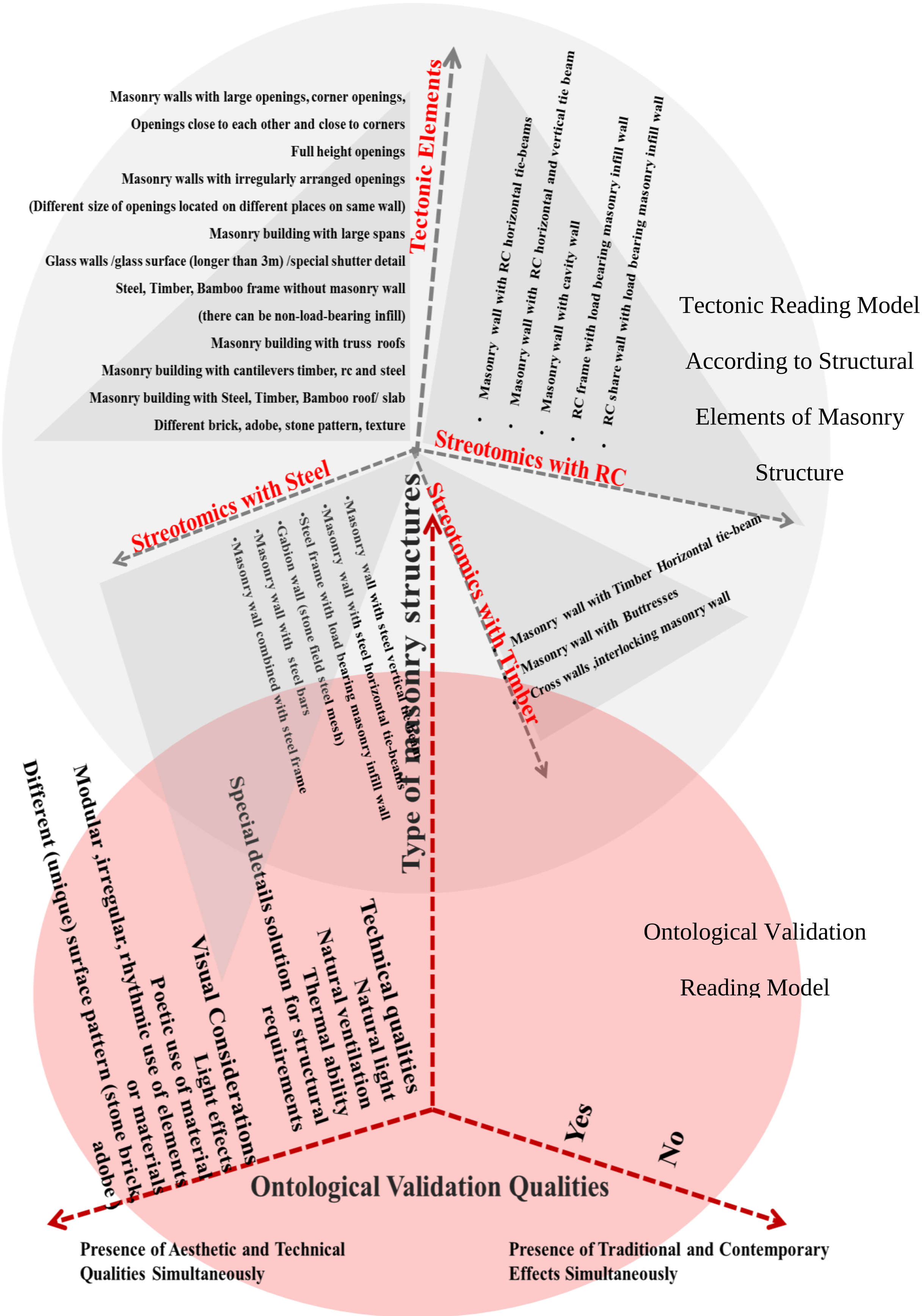


Figure 5.8: Ontological structure of the building according to its stereotomic and tectonic elements model (By Author)

5.2 Preparation of the Assessment Table

Only small-scale buildings which are in the category of contemporary masonry buildings were selected. Initially, an assessment chart was formed according to the materials and only stone, brick, adobe masonry buildings were selected as it can be seen in Table 5.2. This is because, these three are more analogous than timber or other experimental materials as building materials, such as straw bale or sandbag which are not considered in this category to be analysed in this thesis.

Table 5.2: Material categories (By Author)

A	Material Category	Stone	Brick	Adobe

Then, eight buildings for each category (stone, brick, and adobe) from the 21st century, award winning buildings chosen by a jury in their categories, were selected. They all have at least one of their walls as a load-bearing wall. As a result, a total of 24 buildings were analysed as can be seen in Table 5.3.

Table 5.3: Selected examples according to material categories (By Author)

A	Material Category		Stone	Brick	Adobe
B	First 15 Years of The 21st Century (2000-2015)	1	Mauricio Rocha *Campamento De Edificios Públicos*	Anagram Architect *South Asian Human Rights Documentation Centre*	Anna Heringer, Eike Roswag *Hand-Made School*
		2	Han Tumertekin *B2 House*	Monica Ponce De Leon And Nader Tehrani *Tongxian Gate House*	Bc Architects And Members Of The Local Community *African Children Library*
		3	RDR Arquitectos *Buenos Mares House*	Taka *House1+House2*	Diébédo Francis Kéré *Primary School*
		4	Beijing Studio Atelier Teamminus *Jianamani Visitor Centre*	Bangkok Project Studio *Kantana Film And Animation Institute*	Rudanko + Kankkunen *The Sra Pou Vocational School*
		5	Archium *Radio Broadcasting Station*	CM Architecture *Noxx Apartment*	Mauricio Rocha *School Of Plastic Arts*
		6	Herzog De Mouron *Dominus Winery*	Azl Architects *Brick House*	Dust *Tucson Mountain Retreat*
		7	StantonWilliamArch *Sport Complex*	Azl Architects *Z53 Social Housing Complex*	HBBH Architects *Nk'mip Desert Cultural Centre*
		8	Maison Edouard François *The Building That Grows*	Dominikus Stark Achitekten *Education Center*	Peter Sassenoth And Rodolf Reitermann *The Chapel Of Reconciliation*

It is significant to remind that masonry buildings are the topic the earthquake resistance of the buildings is needed to be considered. Because of this, the location and the earthquake zones' of the buildings are taken as important parameters when evaluating contemporary masonry buildings. In this evaluation, the building codes were not considered deeply region by region. However, selected building's location was marked on the world seismic hazard map to show the earthquake zone of that region. In this way, evaluation was made stronger and if there were any changes according to zones it was seen in a clear way. Accordingly, World Seismic Hazard map will be used to find the earthquake zones of the cases (buildings) which are shown in Figure 5.9. According to the World Seismic Hazard map, the world is divided into four main earthquake zones. In Figure 5.9 these four zones, are classified as low risk (marked as blue), middle risk (marked as yellow), high risk (marked as pink) and very high risk (marked as red) earthquake areas. In the analysis tables each building's earthquake zones will marked on this map.

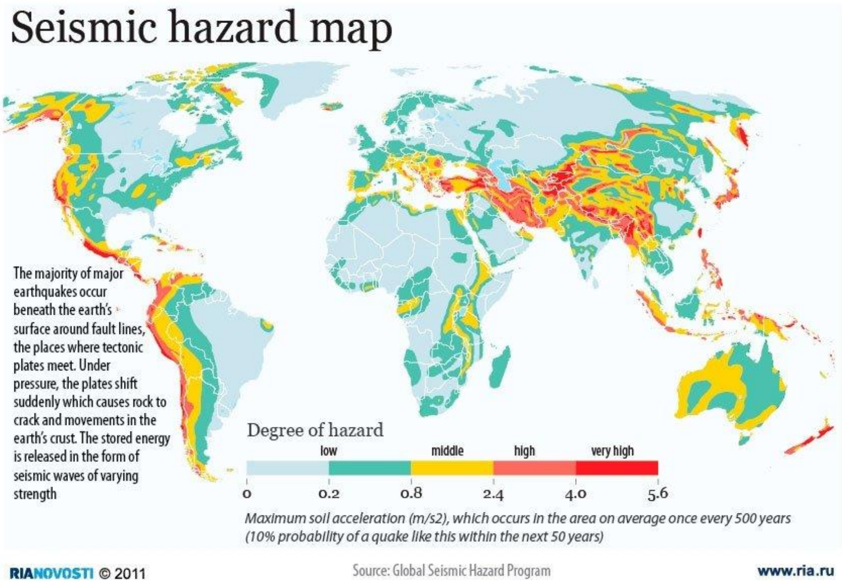
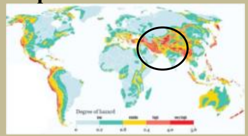


Figure 5.9: World seismic hazard map (URL 21)

As a result, criteria of the ontological structure category of the building according to its stereotomic and tectonic elements model were transferred to table for the analysis of the selected buildings so Table 5.4 was created as an assessment table. Table 5.4 also contains visual data of the buildings like plans, section photos and wall details. It also shows their earthquake zones according to locations. In other words, ontology model is put into the Table 5.4 for analysis. Thus, the analysis of buildings also contains their tectonic qualities as seen in Table 5.4.

Table 5.4: Assessment table and evaluation criteria which are transferred from the tectonic and ontological reading models.

Category Stone Brick Adobe	**Name of the architect** **Name of the building**	**World Seismic Hazard Map** 			**Location:** **Earthquake zone: low-middle-high- very high** **Year:** **Function:** **Award:**	
Plan		**Wall Detail**	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements**	**Wall Stereotomics with <u>STEEL</u> Elements**	**Tectonic Elements**
			Masonry wall with Timber horizontal tie-beams Cross Wall Courtyard Masonry wall Masonry wall with Buttresses	Masonry wall with RC horizontal tie-beams Masonry wall with RC horizontal tie-beams Masonry wall with RC horizontal and vertical tie beam Masonry wall with cavity wall RC frame with load bearing masonry infill wall RC share wall with load bearing masonry infill wall Masonry wall combined with RC frame	Masonry wall with steel vertical tie-beam Masonry wall with steel horizontal tie-beams Steel frame with load bearing masonry infill wall Gabion wall (stone field steel mesh) Masonry wall with steel bars Masonry wall combined with steel frame	Masonry walls with large openings, corner openings, Openings close to each other and close to corners Full height openings Masonry walls with irregularly arranged openings (Different size of openings located on different places on same wall) Masonry building with large spans Glass walls /glass surface (longer than 3m) /special shutter detail Steel, Timber, Bamboo frame without masonry wall(there can be non-load-bearing infill) Masonry building with truss roofs Masonry building with cantilevers timber, rc and steel Masonry building with Steel, Timber, Bamboo roof/ slab Different brick, adobe, stone pattern, texture
Section			**Technical Consideration**		Natural light , Natural ventilation ,Thermal ability, Special details for structural requirements	
Photo			**Visual Consideration**		Light effects, Poetic use of material, Modular ,irregular, rhythmic use of elements or materials , Different (unique) surface pattern (stone brick, adobe)	
Effects of ontology on tectonic design	Plan arrangement or type, ontological category of structure (for ex: masonry wall with frame structure), Ontological category Stereotomic /tectonic ,Contemporary / traditional uses together					

5.3 Tectonics of the Works of Contemporary Masonry Awarded Buildings

In times when static analysis was not known yet, structural design of buildings were made in accordance with geometric rules. Structural elements relationship with each other, rather than mathematical calculations were determined based on the basic rules of geometry. For example; wall thickness over time has found its place entirely experimentally by using try and error method. Architects, to design a building, did not need to know complex engineering calculations. As in geometry, in the same kind of structures under loads of different structural effects can occur. Capacities of different materials, cross-sections and its construction details/elements, similar to geometrical structure can lead to different structural effects. This is the reason why it has generated different ontological groups. Therefore the materials used in buildings, are important for the accuracy of structural system (Unay, 2002).

Although these issues exist and the contemporary debates about the notions of tectonics emerge out of the study, in what other ways the tectonics might be approached or involved in designing a wall was seen.

In general, use of details, structures and materials play a significant role to our immediate experience of architecture. One could claim that architectural skill and knowledge is most visible in the structure, materials, and detailing of a building.

We usually get in close physical contact with this small scale of the buildings. We can touch the materials and analyze the design, thus these three items provide us with valuable information about the architectural scheme as a whole. Hence, tectonics is conceived as both the structure’s identity, as well as its aesthetic representation; it is the material basis, as well as its ideal expression and perception that matters in tectonics. In this section, 24 awarded buildings are chosen to represent tectonic characteristics in contemporary masonry architecture.

In this study these buildings take into account the following points;

1. Got inspired from local architecture and respond to the needs of today’s in order to create a contemporary architecture. Such as use of masonry structure system, that consists of natural materials and big openings.
2. Tried to keep natural environment unharmed, such as topography and emphasize the environment.
3. Gave importance to the climatic conditions so the positions of the buildings/ walls are according to the sun, wind direction to take the most benefit from the natural sources.

Referring to Gottfried Semper and his understanding of tectonics, Kenneth Frampton’s (1995) theory of ‘Tectonic Culture’, contains a reference to ‘tectonics as tectonic construction. Tectonics is referred as both the poetics of construction and as a specific mode of construction: the tectonic frame. Following the theory of Semper, and by discussing it as a part of cultural practice and as a means of its representation, Frampton focused on the aspect of its aesthetic expression. In this thesis it was attempted to relate tectonic construction to use of materials and structures by focusing on its structural identity.

Finally, it should be noted that, tectonics is regarded as the ontology of construction (Porphyrios, 1982). As the first philosophy for buildings, tectonics is the visible part of construction. This is the reason why a building also represents the poetics of construction. The ontology of the poetics above of construction is based on the technical experience, and can be approached through skills (Semper, 1989).

Between Table 5.5 and 5.28 the analysis of the 24 case studies are shown.

Table 5.5: Campamento de Edificios Públicos's analysis of stone masonry wall from ontological point of view

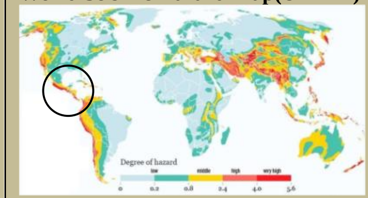
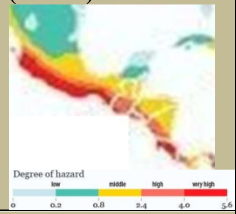
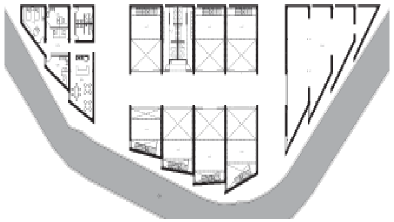
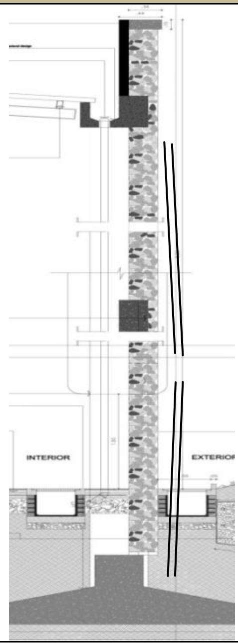
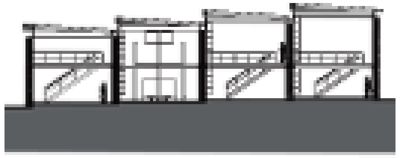
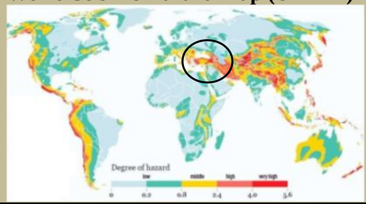
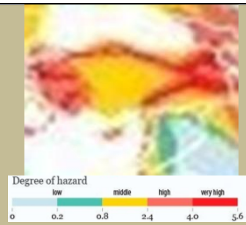
Category Stone 1 ■ Brick Adobe	**Mauricio Rocha** **Campamento de Edificios Públicos's** analysis of stone masonry wall from ontological point of view	**World Seismic Hazard Map(URL 21)**  	(URL 21)  	**Location:** Mexico **Earthquake Zone:** High-Very High **Year:** 2004 **Function:** Building is located in rural area serving as art studio.		
Plan (URL 22)		**Wall Detail** (URL 22)	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements**	**Wall Stereotomics with <u>STEEL</u> Elements** (URL 22)	**Tectonic Elements**
		 			-Stone masonry wall with vertical and cross type steel tie beams.	-Steel frame -Full height and full length openings horizontally and vertically -Corner windows
Section (URL 22)			**Technical Consideration** (URL 22)	On the skin of the self-supporting walls made of local stone, a light, independent metal structure is raised, with columns and roofs made of C-section steel joists and metal sheeting. This provides to have horizontal and vertical full height openings for ventilation and natural light. 		
Photo (URL 22)			Visual Consideration (URL 22)	The massive stone wall is used together with lightweight steel frame which rise up from tone blocks. The upper windows stretch to the edge of the building and are modulated in openings to become vertical windows. This helps to get natural light to inside and break the massiveness of the stone walls in an aesthetical way.		
Effects of ontology on tectonic design	The plan arrangement consists from triangle. The building has double structure like the skin of the self-supporting walls made of local basalt stone, a light, independent metal structure is raised, with columns and roofs made of C-section steel joists and metal sheeting. Stone walls play an important role on the project as they are part of the structure and work together with steel frames. The building is located in high seismic zone so masonry wall combined with steel frame. There is two-structure system, which is used together. This creates a new way of ontological category of structure.					

Table 5.6: B2 House’s analysis of stone masonry wall from ontological point of view

<table>
<tr>
<td>Category
Stone 2 ■
Brick
Adobe</td>
<td>HAN TUMERTEKIN
B2 House’s analysis of stone masonry wall from ontological point of view</td>
<td>World Seismic Hazard Map (URL 21)
</td>
<td>(URL21)</td>
<td colspan="2">Location: Turkey
Earthquake Zone: Middle-High
Year: 2001
Function: The house is located at rural area

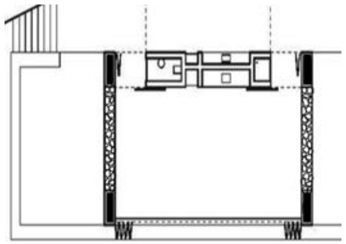
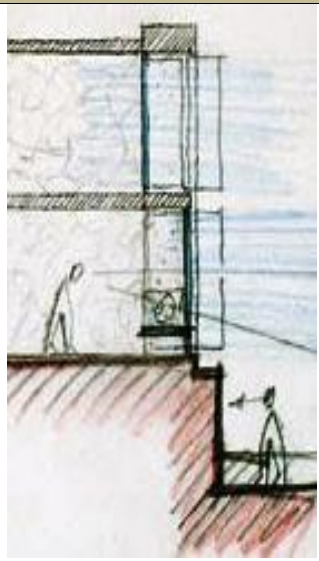
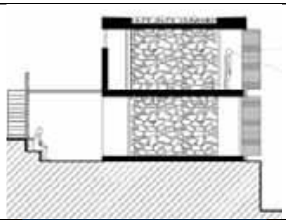
2004 Aga Khan Awards for Architecture</td>
</tr>
<tr>
<td rowspan="2">Plan
(URL 24)</td>
<td rowspan="2"></td>
<td>Wall Detail (URL 25)</td>
<td>Wall Stereotomics with <u>TIMBER</u> Elements</td>
<td>Wall Stereotomics with <u>RC</u> Elements (URL 25)</td>
<td>Wall Stereotomics with <u>STEEL</u> Elements</td>
<td>Tectonic Elements</td>
</tr>
<tr>
<td rowspan="3"></td>
<td></td>
<td>-Stone masonry with rc shear wall system</td>
<td></td>
<td>-Timber shutters
-large openings
-corner openings
-large spans</td>
</tr>
<tr>
<td>Section
(URL 24)</td>
<td></td>
<td>Technical Consideration
(URL24; URL 25)</td>
<td colspan="3">Rigid monolithic structural box with shear walls. Structural elements are able to resist seismic forces more than masonry stone walls. In this project stone wall has no structural function but have a thermal ability to moderate the temperature in the building.</td>
</tr>
<tr>
<td>Photo
(URL 24)</td>
<td></td>
<td>Visual Consideration
(URL24; URL 25)</td>
<td colspan="3">The stone walls refer to the built environment and are visually coherent with the village. On the other hand, material usage as steel framed wooden shutters, concrete and stone wall together, gave the richness. Because of combination of traditional and contemporary materials.</td>
</tr>
<tr>
<td>Effects of ontology on tectonic design</td>
<td colspan="6">Plan arrangement consists of pure rectangle .The appearance of the building is not a direct expression of its structure. The shared walls come out from the stone masonry and frame it. Thus the stone walls lose their structural functions because sheare walls are the main structure. This building is located in high risk earthquake zone so stone non structural walls with rc shear wall used together. This different unusual combination creates ontological category.</td>
</tr>
</table>

Table 5.7: Buenos Mares House’s analysis of stone masonry wall from ontological point of view

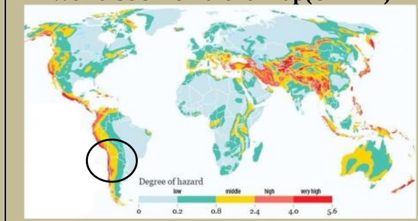
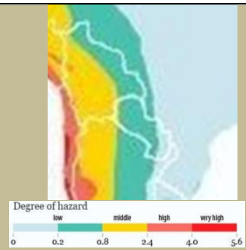
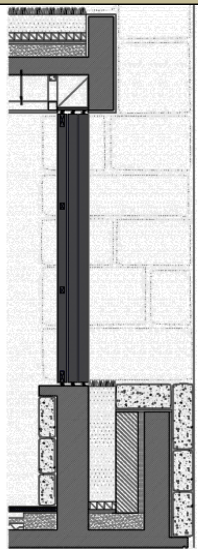
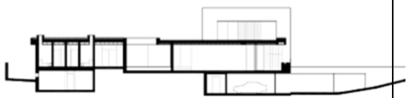
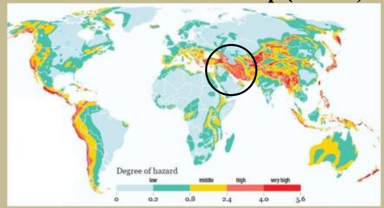
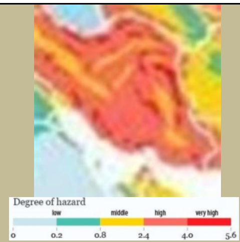
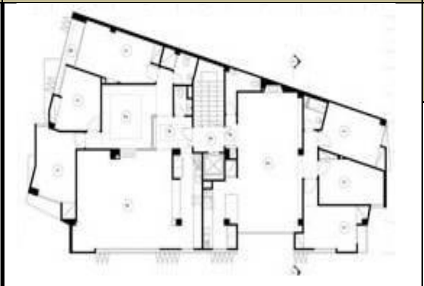
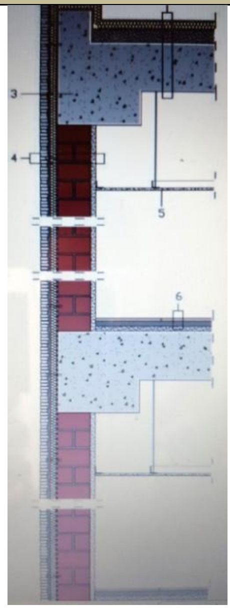
Category Stone 3 Brick Adobe	**RDR Arquitectos** **Buenos Mares House** analysis of stone masonry wall from ontological point of view	**World Seismic Hazard Map(URL 21)** 	(URL21)		**Location:** Argentina **Earthquake Zone:** Middle-High **Year:**2009 **Function:** Building is located at the Seaside and serves as a residential building.	
Plan (URL 26)		**Wall Detail(URL 26)**	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements (URL 26)**	**Wall Stereotomics with <u>STEEL</u> Elements**	**Tectonic Elements**
				-Stone masonry with rc frame system (slabs works as a bond beam top of the independent stone masonry wall)		-Timber shutters -large openings -corner openings -large spans
Section (URL 26)			**Technical Consideration** (URL26;URL 27)	The large sliding windows turn the house into a great exterior, shaded space during the summer. Opening size and numbers are more than the ones of traditional. It was a necessity for better light and ventilation. Walls itself provides a comfortable indoor climate		
Photo (URL27)			Visual Consideration (URL26;URL 27)	A series of stonewall, separated by courtyards and covered by a large slab. Openings punctuate the texture, and develop abstract geometric relations while remaining loyal to the structural logic.		
Effects of ontology on tectonic design	The plan arrangement consists of rectangular prisms there is no symmetry in the plan. Independent stone walls connecting with frame system. These are evidences of contemporary techniques which are used aesthetically and technically for creating ontology. Once the traditional masonry stone buildings are investigated, it can be said that independent walls and big openings are not independent. Structure was solved according to today’s needs. Designed with both technical and aesthetical reasons. The building is located in high seismic zone so masonry wall with RC horizontal beams combined with rc frame. There is a unique structure made in a new way so ontological category of structure is created.					

Table 5.8: Apartment No 1’s analysis of stone masonry wall from ontological point of view

<table>
<tr>
<td>Category
Stone 4 ■
Brick
Adobe</td>
<td>ABCT - ARCHITECTURE BY COLLECTIVE TERRAIN

Apartment No 1’s analysis of stone masonry wall from ontological point of view</td>
<td>World Seismic Hazard Map (URL21)
</td>
<td colspan="2"> (URL21)</td>
<td colspan="2">Location: Iran
Earthquake zone: Very High
Year: 2010
Function: Building is located in a city and serves as a residential building.

2013 Aga Khan Award For Architecture</td>
</tr>
<tr>
<td rowspan="2">Plan

(URL 28)</td>
<td rowspan="2"></td>
<td>Wall Detail (URL 28)</td>
<td>Wall Stereotomics with <u>TIMBER</u> Elements</td>
<td>Wall Stereotomics with <u>RC</u> Elements (URL 28; URL 29)</td>
<td>Wall Stereotomics with <u>STEEL</u> Elements</td>
<td>Tectonic Elements</td>
</tr>
<tr>
<td rowspan="3"></td>
<td></td>
<td>-Stone masonry walls with RC frame system(slabs works as a bond beam top of the stone masonry wall)</td>
<td></td>
<td>-Timber shutters

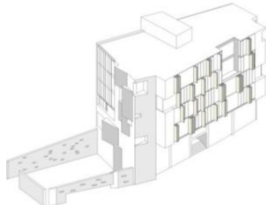
-Triangular openings</td>
</tr>
<tr>
<td>Section
(URL 28)</td>
<td></td>
<td>Technical Consideration
(URL28;URL 29)</td>
<td colspan="3">Large windows are covered by wooden shutters, which help to control the light and heat inside the units, and provide privacy for the residents. Windows, which are not covered by shutters, are small in size, consistent with traditional characteristics of the tradition. Small windows are shielded by triangular stone protrusions, allow residents to regulate light and temperature levels. Walls are pushed forward from the axis of structural wall to form triangular openings.</td>
</tr>
<tr>
<td>Photo
(URL 28)</td>
<td></td>
<td>Visual Consideration
(URL28;URL 29)</td>
<td colspan="3">The masonry stone walls play an important role on the project as they are part of the structure and re-interpret the traditional brick wall. The triangular prisms are added to the mass in different sizes and locations which gives dynamism to the exterior façade. Massive stone façade and totally glass façade creates contrast.</td>
</tr>
<tr>
<td>Effects of ontology on tectonic design</td>
<td colspan="6">Form of the building and plan arrangement consists of a triangular prism. According to traditional stone wall thicknesses, here wall thickness was reduced. Walls are supported by evidences of contemporary techniques which are used aesthetically and technically for reaching ontology. The building is located in very high seismic zone so masonry wall with RC horizontal tie-beams are combined with rc frame. This creates another ontological category of structure.</td>
</tr>
</table>

Table 5.9: Jianamani Visitor Centre’s analysis of stone masonry wall from ontological point of view

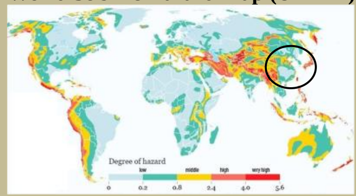
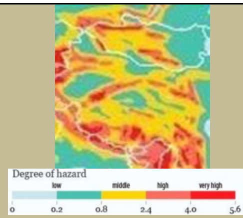
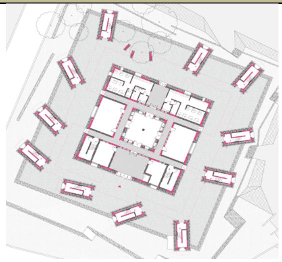
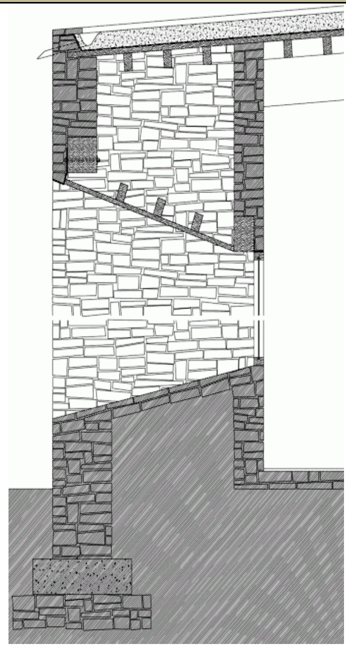
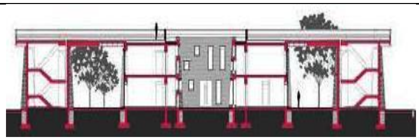
Category Stone 5 Brick Adobe	**BEIJING STUDIO ATELIER TEAMMINUS** **Jianamani Visitor Centre’s** analysis of stone masonry wall from ontological point of view	**World Seismic Hazard Map (URL 21)** 	(URL 21)		**Location:** China **Earthquake zone:** Middle-High **Year:** 2014 **Function:** Building serves as visitor centre for an ancient Buddhist memorial in Tibet 2014 World Architecture Festival In Singapore	
Plan (URL 31)		**Wall Detail** (URL 31)	**Wall Stereotomics with TIMBER Elements** (URL 31; URL30)	**Wall Stereotomics with RC Elements**	**Wall Stereotomics with STEEL Elements**	**Tectonic Elements**
			-Stone masonry walls with horizontal timber tie beams -Buttresses -Courtyard			-The rooftop decks were constructed from timber -Timber slabs and roof -Full height openings
Section (URL 31)			**Technical Consideration** (URL30;URL 31)	The 50 cm thick walls at both sides of the openings work as buttresses, increasing the overall structural stability and reducing the interior span as well. Beams for bigger spans are made from several small logs bonded together.		
Photo (URL 31)	 		**Visual Consideration** (URL30;URL 31)	The stone walls refer to the built environment and help in forming a visually coherent building with the village.		
Effects of ontology on tectonic design	Plan arrangement consists of a square building with a courtyard at the centre. 11 observation decks surround the courtyard and they are like traditional buildings. Nevertheless, thicknesses of the walls are reduced when walls get higher. Walls worked as buttresses and started to become independent blocks with the full height of openings. These are evidences of contemporary techniques which are used aesthetically and technically for reaching ontology.					

Table 5.10: Radio Broadcasting Station’s analysis of stone masonry wall from ontological point of view

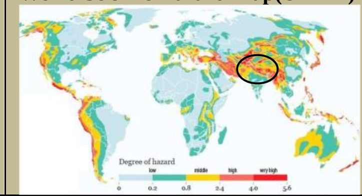
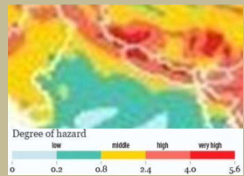
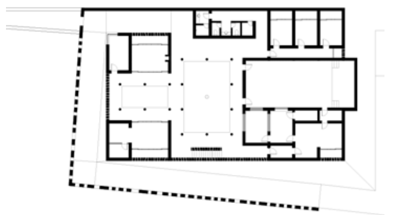
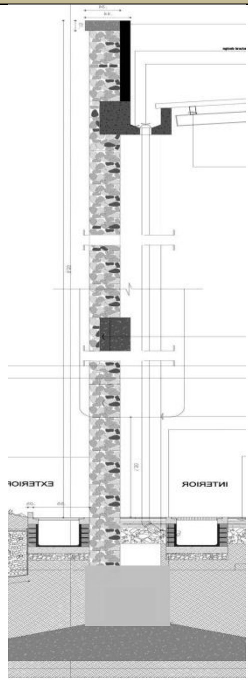
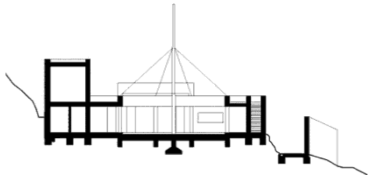
Category Stone 6 ■ Brick Adobe	**ARCHIUM** **Radio Broadcasting Station’s** analysis of stone masonry wall from ontological point of view	**World Seismic Hazard Map(URL21)** 	(URL 21)		**Location:** Nepal **Earthquake zone:** Middle **Year:**2013 **Function:** Building is located in rural area serving as a radio station building and office.	
Plan (URL 38)		**Wall Detail** (URL 35)	**Wall Stereotomics with TIMBER Elements**	**Wall Stereotomics with RC Elements** (URL34;URL 38; ULR 39)	**Wall Stereotomics with STEEL Elements**	**Tectonic Elements**
				-Stone masonry walls with vertical Rc tie beams -rc colonnaded courtyard		-courtyard covered with a tensile system -full height openings -Corner openings -Irregular openings
Section (URL 38)			**Technical Consideration** (URL34;URL 38; ULR 39)	Thick stone walls are used in order to protect the building from the winds of the area. But the walls are cut straight and form a protected corridor. Inside the stone wall is a more modern glass wall for the inner space. While conveying a strange and soothing atmosphere tall walls are punctuated by small glazed openings. Rooms and broadcasting facilities are organized around courtyards that allow natural light to reach glazed walls and windows. Stone slab is supported by rc columns.		
Photo (URL 38)			**Visual Consideration** (URL34;URL 38; ULR 39)	The masonry stone walls play an important role on the buildings tectonic expression, as they are part of the technical solution. Aesthetically coherent with the natural landscape it has a natural quality that makes the building unique in the rocky area. Besides the stone wall, glass wall is used for the inner space. The modern line breaks the heaviness and solidity of the traditional stone wall. It helps the building to find the balance between traditional and contemporary, while conveying a strange and soothing atmosphere.		
Effects of ontology on tectonic design	Rectangular plan arrangement was used. The building is located middle earthquake zone. Based on site conditions and the environmental conditions traditional stone masonry was re-organized by contemporary methods. The modern lines deconstruct the thickness of the traditional materials and help the building to find the balance between traditional and contemporary. Small courtyard in between the separated walls open up a space seemingly destined to be confined by a softening wind and full light exposure, making a gap to establish its relationship with nature. The building is located in middle seismic zone. Masonry wall consist of unique use of stone with rc vertical tie-elements. This way of doing creates ontological category of structure.					

Table 5.11: Dominus Winery’s analysis of stone masonry wall from ontological point of view

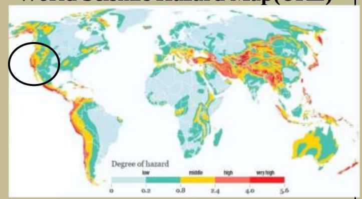
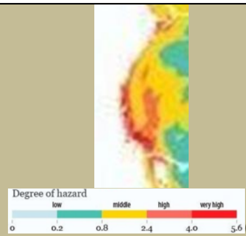
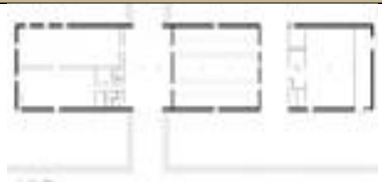
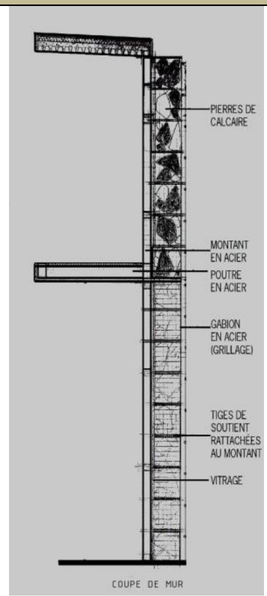
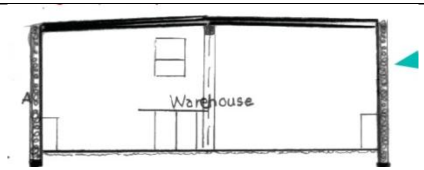
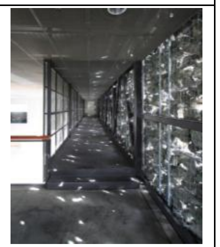
Category Stone 7 Brick Adobe	**Herzog de Meuron** **Dominus Winery’s** analysis of stone masonry wall from ontological point of view	**World Seismic Hazard Map(URL)** 	 (URL 21)		**Location:** California **Earthquake zone:** Middle- High **Year:** 2001 **Function:** Building is located in rural area serves as a factory. 2007 Civic Trust Award Pritzker and Stirling Prize-winning	
Plan (URL 42)		**Wall Detail (URL 42)**	**Wall Stereotomics with TIMBER Elements**	**Wall Stereotomics with RC Elements**	**Wall Stereotomics with STEEL Elements (URL 42)**	**Tectonic Elements**
					-stone masonry gabion walls (stone field steel mesh) -Steel frame system	-Large spans - Truss roofs
Section (URL 42)			**Technical Consideration** (URL42)	The gabion stone wall has the thermal ability, ecological integration of the building with its surrounding environment. This kind of baskets are generally used to retain dirty highways or used to stop soil erosion, it designates ‘*gabion*’ but here, the gabions are used for two technical reasons. One, to moderate the excessive temperatures of the Valley, second to get natural light to interior spaces.		
Photo (URL 42)			**Visual Consideration** (URL 42)	The use of gabion wall is aesthetically coherent with the natural landscape. It has a natural quality. Light filters through different size of stones in the gabion wall and creates poetic environment inside. They have both an aesthetic and technical choice. Light emerges through the gabion walls so it gives building aesthetic look. 		
Effects of ontology on tectonic design	The plan arrangement is pure rectangle. The outside wall is traditional and massive, blind wall without openings however the different density of stones creates varying degrees of transparency with all modern values. At the base of the walls, an intermediated gabion is added to prevent rattlesnakes from nesting among the rocks. Steel meshes act as the wrapping for this huge mass of stone. The walls are more like skin than like the traditional masonry. There is a structural expression in the building. Therefore, use of structure is very ontological. According to spatial needs of building, structure differs. For instance, from one place to another the load bearing wall system (gabion wall) is replaced by steel frame system according to needs of the complex.					

Table 5.12: The Building that Grows' analysis of stone masonry wall from ontological point of view

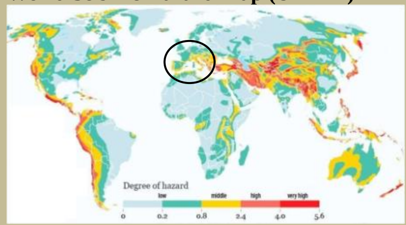
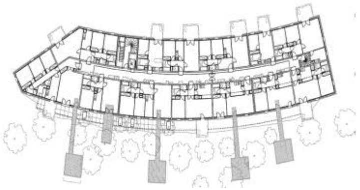
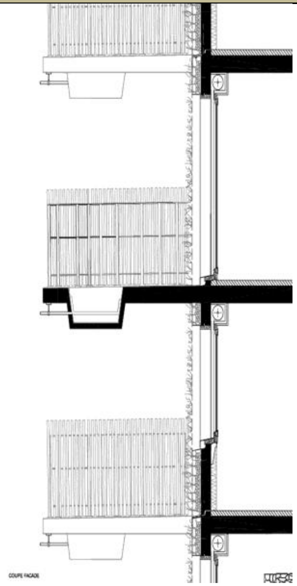
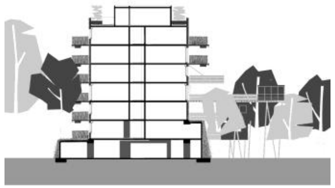
Category	MAISON EDOUARD FRANÇOIS	World Seismic Hazard Map (URL 21)				
Stone 8 Brick Adobe	**The Building that Grows'** analysis of stone masonry wall from ontological point of view		 (URL 21)		**Location:** France **Earthquake zone:** Low **Year:** 2000 **Function:** Building is located in city serves as residential housing. 2008 Sustainable Habitat Award	
Plan (URL 43)		**Wall Detail** (URL 43) 	**Wall Stereotomics with TIMBER Elements**	**Wall Stereotomics with RC Elements**	**Wall Stereotomics with STEEL Elements** (URL 43)	**Tectonic Elements**
					-stone masonry gabion walls Gabion wall (stone field steel mesh) with prefabricated concrete panels -Rc frame system	- timber cantilever balconies
Section (URL 43)			**Technical Consideration** (URL43)	The walls and cantilevers are used for better living spaces, also due to a technical choice. The use of stone masonry gabion wall helps to reduce the use of energy sources because the wall technique moderate inside temperature of the building. Secondly it is used to get natural light to interior spaces.		
Photo (URL 43)			**Visual Consideration** (URL 43)	The building façade is made of modular gabion of wire-mesh which of locally quarried stone of different size and shape. This allows taking natural light during the day and reflecting the artificial light during the night to the outside. This gave building an aesthetic look both inside and outside. Various types of balconies tectonically exploded from the stone surface.		
Effects of ontology on tectonic design	The gabions are used for both technical and aesthetical reasons. Steel meshes act as the wrapping for this huge mass of stone and provide varying degrees of transparency. The different density of stones is more like a skin than like the traditional masonry. Timber panel or Rc cantilever balconies are punctured from the gabion walls. Additionally, some of them are supported by steel columns and connected to the flats by timber pathways. Plan arrangement consists of curve. The building is located in low seismic zone so the masonry wall consists of steel mesh and is combined with rc frame. This way of doing creates ontological category of structure.					

Table 5.13: South Asian Human Rights Documentation Centre's Analysis of Brick Masonry Wall from Ontological Point Of View

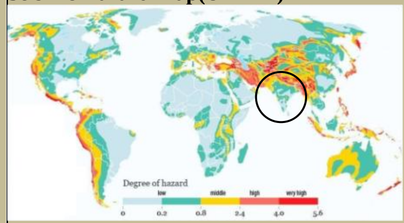
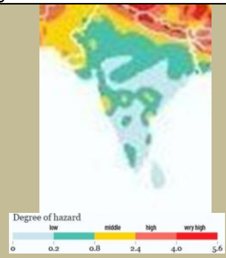
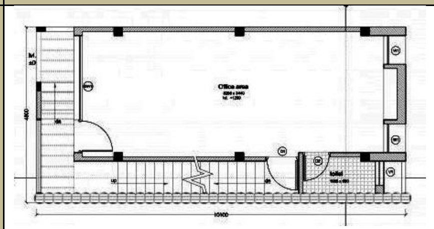
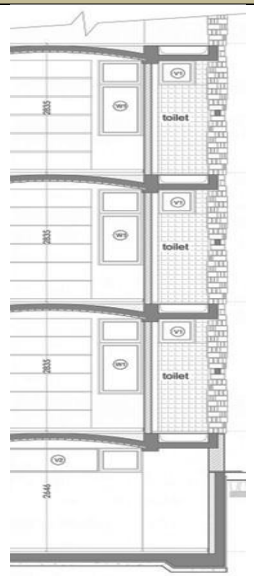
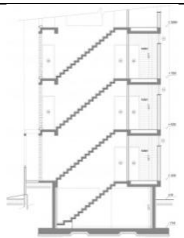
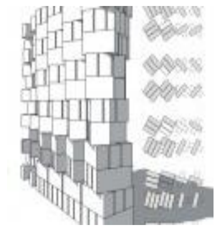
Category **Stone** **Brick 1** **Adobe**	**ANAGRAM ARCHITECT** **SOUTH ASIAN HUMAN RIGHTS DOCUMENTATION CENTRE'S analysis of brick masonry wall from ontological point of view**	**Seismic Hazard Map(URL 21)** 	 **(URL21)**	**Location:** India **Earthquake zone:** Low **Year:** 2005 **Function:** The building is located in the city, serving as a office Won second prize in brick category Aga Khan Awards for Architecture		
Plan (URL 44)		**Wall Detail (URL 44)**	**Wall Stereotomics with TIMBER Elements**	**Wall Stereotomics with RC Elements (URL44;URL 45)**	**Wall Stereotomics with STEEL Elements (URL44;URL 45)**	**Tectonic Elements**
				-Masonry wall with RC horizontal tie-beams -Combined Rc frame	-Masonry walls with steel vertical tie-beams	-Steel framed glass surface -different brick pattern
Section (URL 44)			**Technical Consideration (URL44;URL 45)**	Bricks are technically used in an angular way, layer by layer, and the wall became a kind of punctured. Thus, it gets fresh air and light to the office building. It became acoustic barrier for the building to keep the unwanted noise out. 		
Photo (URL 44)	 		**Visual Consideration (URL44;URL 45)**	Different types of bricks are turned each time and created a wavy shape for the wall. It can be asserted that unique architectural effects can be achieved by simple bricks and dictate more complex patterns. Structures and openings are unusually poetic. During the day, the light is filtered to inside and at nights the light is reflected outside in a poetic way.		
Effects of ontology on tectonic design	Plan arrangement consists of pure rectangle. There is the use of material and techniques form contrasting elements as one side is completely transparent glass wall surface, other side is heavy brick masonry wall. Still it does not fit with the traditional idea because of wavy look and gaps between the brick bond stereotomy meaning of wall broken. New-stereotomics exist in a sense that is more lightweight. The building is located in low-middle earthquake zone with the use of masonry brick wall. Masonry wall consist of steel vertical/ rc horizontal tie beams and this masonry unit connected with rc frame system. This triple combination creates ontological category.					

Table 5.14: House1+House2’s Analysis of Brick Masonry Wall from Ontological Point Of View

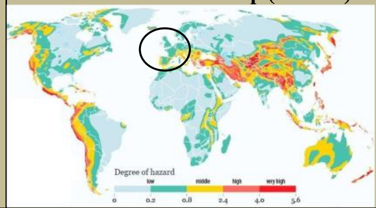
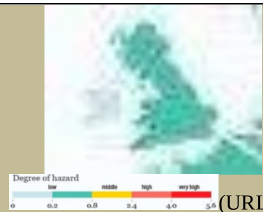
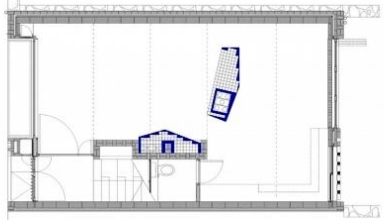
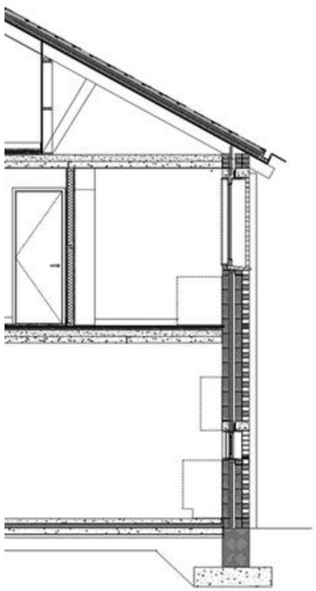
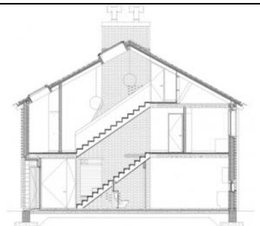
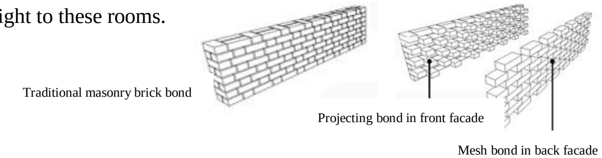
Category	TAKA	World Seismic Hazard Map (URL 21)				
Category Stone Brick 2 Adobe	**TAKA** **HOUSE1+HOUSE2’S** s analysis of brick masonry wall from ontological point of view	**World Seismic Hazard Map** (URL 21) 	(URL21)		**Location:** Ireland **Earthquake zone:** Low **Year:** 2009 **Function:** The building is located in a rural area and serves as a residential building. Won Progressive Architecture Awards 2010	
Plan (URL46)		**Wall Detail** (URL46)	**Wall stereotomics with TIMBER Elements**	**Wall Stereotomics with RC Elements (URL46))**	**Wall Stereotomics with STEEL Elements**	**Tectonic Elements**
				-Masonry wall filled with RC cavity wall and RC horizontal ties		-Different brick pattern -Full floor height windows -Corner openings -Walls with large openings
Section (URL46)			**Technical Consideration (URL46)**	Masonry brick wall with cavity creates better insulation and sound absorption with the use of high strength brick. At the back of the house; the corresponding bricks have been removed, providing ventilation and light to these rooms. 		
Photo (URL46)			**Visual Consideration (URL46)**	If ties did not support the brick wall, this kind of brick pattern could not be achieved. Aesthetically new brick texture gave poetic meaning to the building thus tectonic expression and wall stereotomics are shown. An expressive pattern is created in the front façade by offsetting the bricks used to create the typical bond, so they project from the front facade. The result is a regular arrangement of light and shadows those changes throughout the day.		
Effects of ontology on tectonic design	Plan arrangement consists of pure rectangle. The building located in low seismic zone and masonry wall consists of Rc cavity wall in the middle. This way of doing creates ontological category of structure. When looked at the building from outside it can easily be perceived that the use of different size and direction of the bricks helps to make different types of brick texture, the openings close to the corners and close to each others, and the size also more than half of the wall surface. The bricks are bonded to form brick masonry wall however differently from traditional way only one layer of brick was used for building facades. Wall became thin and provided a modern look to the building. While doing this, the structure is not hidden. Even the horizontal tie beams are seen from outside.					

Table 5.15: Tongxian Gate House’s analysis of brick masonry wall from ontological point of view

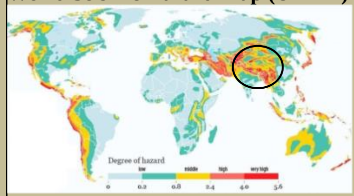
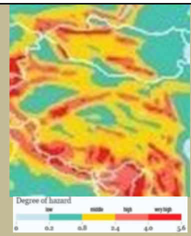
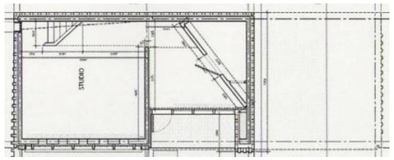
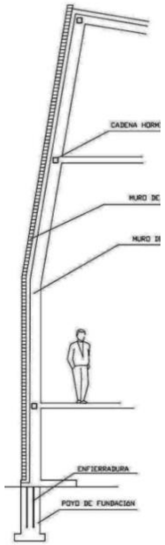
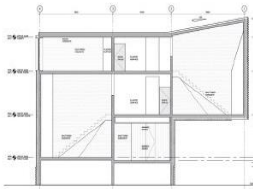
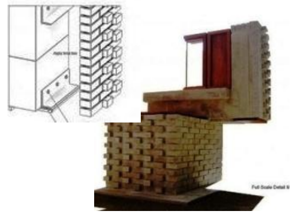
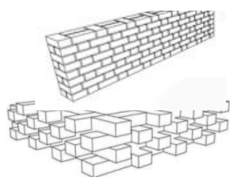
Category Stone Brick 3 ■ Adobe	**MONICA PONCE DE LEON** **AND** **NADER TEHRANI** **Tongxian Gate House’s** analysis of brick masonry wall from ontological point of view	**World Seismic Hazard Map (URL21)** 	 (URL 21)		**Location:** China **Earthquake zone:** Middle-High **Year:** 2005 **Function:** The building is located in rural area serving as an entry to the Art Center site Won Progressive Architecture Awards 2010	
Plan (URL 47)		**Wall Detail** (URL 47)	**Wall Stereotomics with TIMBER Elements**	**Wall Stereotomics with RC Elements** (URL 47)	**Wall Stereotomics with STEEL Elements**	**Tectonic Elements**
		 		-Masonry wall with RC horizontal tie-beams -Combined Rc frame		-Cantilever -Corner window -Timber framed glass surface -Large span
Section (URL 47)			**Technical Consideration** ((URL 47)	Technically the brick wall serves as a light filter because natural light and air come inside the building. Additionally brick wall and concrete block wall are used together in this work as a double skin.		
Photo (URL 47)			**Visual Consideration** (URL 47)	Aesthetically new brick texture gave poetic meaning to the building. This technique was used for the first time. In traditional brick works, generally two layered bricks were used but here only one side was used.	Traditional masonry brick bond 	
Effects of ontology on tectonic design	When looked at the building from outside it can be seen that there are different types of brick texture achieved by using different size and directions of the bricks. The brick wall openings are very close to the cornerstone side of exterior facade is fully transparent with timber frame and deep cantilevers. It can be said that this building is the test of possible interactions between brick and concrete that express the tectonic truly. The bricks are bonded as a brick masonry wall however in some parts with the help of steel joint elements just hold on the concrete block wall. This is understood from the presence of huge cantilevers without any additional supports that are something different from traditional masonry. Plan arrangement consists of pure rectangle. The building is located in middle and high seismic zone so masonry wall consists of Rc horizontal tie beam and combined with rc frame. This way of doing creates ontological category of structure.					

Table 5.16: Kantana Film and Animation Institute’s analysis of brick masonry wall from ontological point of view

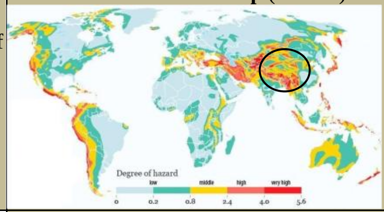
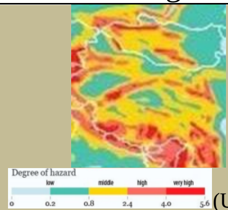
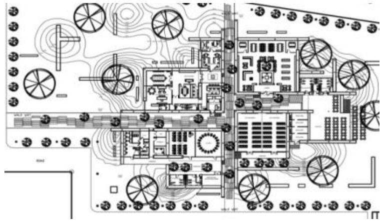
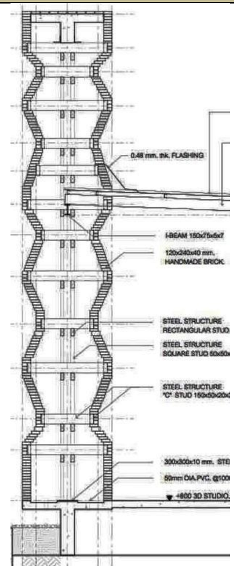
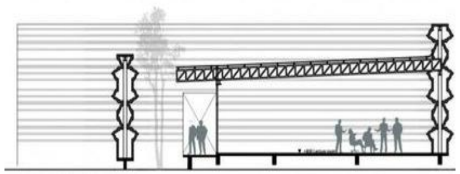
Category Stone Brick 4 Adobe	**BANGKOK PROJECT STUDIO** **Kantana Film and Animation Institute’s** analysis of brick masonry wall from ontological point of view	**World Seismic Hazard Map** (URL21) 	 (URL21)			**Location:**Thailand **Earthquake zone:** Middle-High **Year:** 2011 **Function:** School -2013 Award Cycle Aga Khan Prize -Grand Prize And Category Winner “Special Solution” In Wienerberger Brick Award -Grand Prize Winner Of The Ar+D Awards For Emerging Architecture In 2011
Plan (URL 49)		**Wall Detail** (URL49) 	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements**	**Wall Stereotomics with <u>STEEL</u> Elements** (URL48;URL 49)	**Tectonic Elements**
					-Masonry wall with steel horizontal and vertical tie-beams -Combined steel frame	-Different size of openings located on different places on the same wall (irregularly arranged openings) -Truss roofs -Different brick pattern
Section (URL49)			**Technical Consideration** (URL48;URL 49)	These trusses help to strengthen the walls and gave thickness as it was a traditional masonry building. Otherwise that long wall without any support would not be achieved. The openings in different sizes and at various places on each wall allowed circulation of the air into all spaces. With the use of handmade brick which is double the size of normal, a wavy brick wall achieved by a kind of steel truss that placed in the middle of the walls. According to function of the building big spaces are needed so big spans passed with truss roof. 		
Photo (URL49)			**Visual Consideration** (URL48;URL 49)	Wall is seen as layer by layer because of the waviness. Openings provide a play of light and shadow. These give the building aesthetic character. Window openings are created with the layout in a geometric pattern. 		
Effects of ontology on tectonic design	Building is constructed and represented by brick masonry, underlining with various sizes of complex steel structure. The idea of interlocking long walls are used here, which comes from traditional masonry technique, however the length, the height, and the wavy shape of the walls totally, represent the modern attitude. It can be said that shape, size, and thickness of the walls became a unique element for this building. Spaces that were left in between the interlocking walls are covered with steel truss roofs and combined with steel frames. The thickness, length, and height of the walls give weight to the brick masonry in contrast to irregular (non e axial) openings with various sizes and places a on the wavy walls. This breaks the traditional look of the building. Additionally the integration of steel frame and brick masonry that is a convergence of engineering and arts create an innovation with use of traditional and contemporary techniques together. Plan arrangement consists of combination of rectangular prisms with cross walls. This building is located in high seismic zone so masonry wall consist of unique use of steel horizontal and vertical tie-elements and combined with steel frame. This way of doing creates ontological category of structure.					

Table 5.17: Noxx Apartment’s analysis of brick masonry wall from ontological point of view

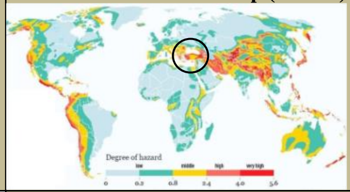
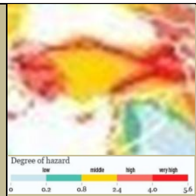
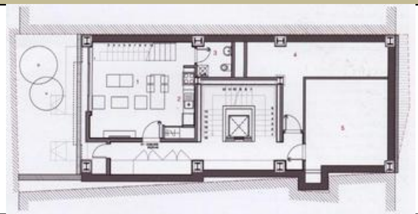
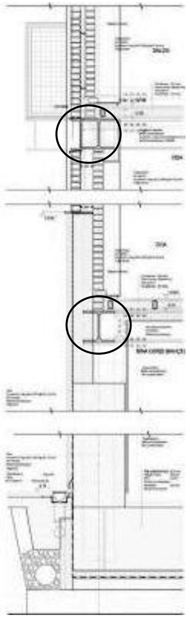
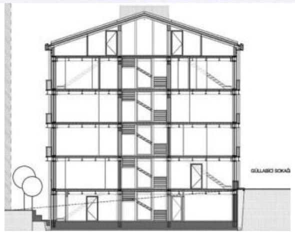
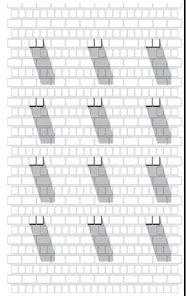
Category Stone Brick 5 Adobe	**CM ARCHITECTURE** **Noxx Apartment’s** analysis of brick masonry wall from ontological point of view	**World Seismic Hazard Map** (URL21) 	 (URL 21)		**Location:** Turkey **Earthquake zone:** High-Very High **Year:** 2013 **Function:** The building is located in city serves as residential 2014 National architectural award	
Plan (URL50)		**Wall Detail** (URL50) 	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements**	**Wall Stereotomics with <u>STEEL</u> Elements** (URL50)	**Tectonic Elements**
					-Steel frame with load bearing masonry infill wall	-Glass walls with steel frame -Different brick pattern
Section (URL50)			**Technical Consideration** (URL50;URL51)	In some parts of the wall bricks are used rhythmically in a different direction and extended outside. This is for getting natural air into the building. With this solution, walls provide a comfortable indoor climate.		
Photo (URL50)			**Visual Consideration** (URL150;URL 51)	The masonry brick walls play an important role on the buildings tectonic expression, as they are part of the technical solution. With this aesthetic use of bricks on wall, creates sensibility to shadows and lights. Re-interpretation of the traditional brick wall was blurring the boundary between structure and ornament. However, they have another function as place for birds.		
Effects of ontology on tectonic design	When looked at the building from outside, it gives two important emphasis; one is that heavy solid stereotomics of the brick wall although the brick wall is used as infill wall not the load bearing. The second is light, transparent glass wall on the other side of the building .Both of them are supported with steel frame. You can feel the building language which is blurred the boundary between traditional and contemporary. Brick as the traditional building material, and steel frame contemporary building system. Plan arrangement is rectangle. The building is located in high seismic zone so masonry wall used together with steel frame. This way of doing creates another ontological category of structure.					

Table 5.18: Brick House's analysis of brick masonry wall from ontological point of view

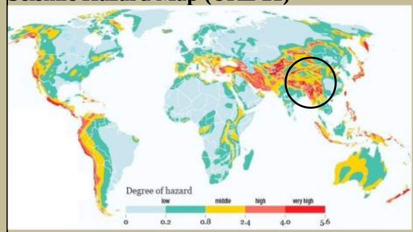
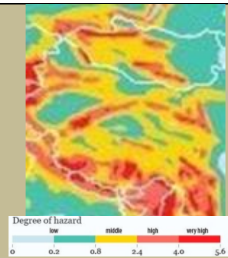
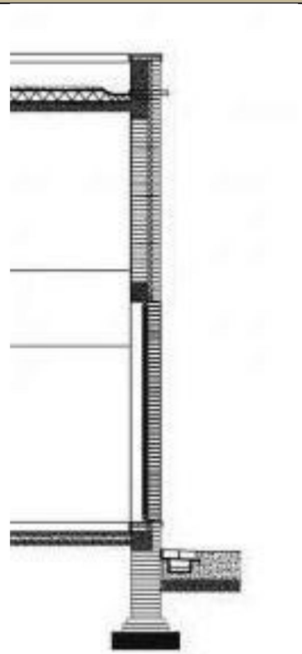
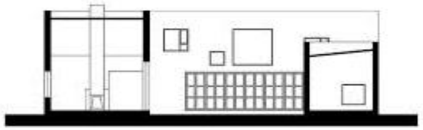
Category Stone Brick 6 Adobe	**AZL ARCHITECTS** **Brick house's** analysis of brick masonry wall from ontological point of view	**Seismic Hazard Map (URL 21)** 	 (URL 21)		**Location:** China **Earthquake zone:** Middle-High **Year:** 2008 **Function:** The building is located in rural area serves as residential Wienerberger Brick Award 2012	
Plan (URL 52)		**Wall Detail** (URL 52)	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements** (URL 52)	**Wall Stereotomics with <u>STEEL</u> Elements**	**Tectonic Elements**
				-Masonry wall with RC horizontal tie-beams -Combined Rc frame		-Different brick pattern - Walls with irregularly arranged openings (Different size of openings located on different places on same wall) -Big openings
Section (URL 52)			**Technical Consideration (URL 52)**	Whenever the brick texture is changed, the structure is also changed. Behind the texture façade glass is used for getting controlled day light. Interlocking pattern leaves perforations between bricks, and protruding bricks cast shadows along the wall.		
Photo (URL 52)			**Visual Consideration (URL52)**	The face is made of three different textures of bricks. Openings punctuate the texture, and the brickwork along the edges of these portals further develops abstract geometric relations while remaining loyal to the structural logic.		
Effects of ontology on tectonic design	It can be said that the building is a kind of synthesis of tradition and contemporary. When looked at the building it can be understood that traditional brick masonry is used but with the open places and texture of the brick indicates something different in terms of bounding bricks and structure system. Plan arrangement is rectangle. The building is located in high seismic zone so masonry wall with RC horizontal tie-beams are combined with rc frame. This way of doing creates another ontological category of structure.					

Table 5.19: Z53 Social Housing's analysis of brick masonry wall from ontological point of view

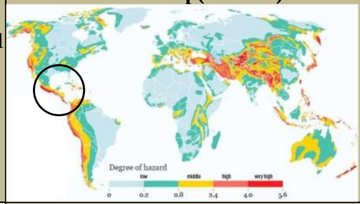
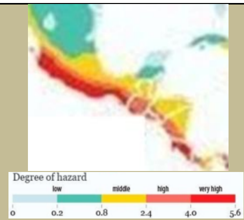
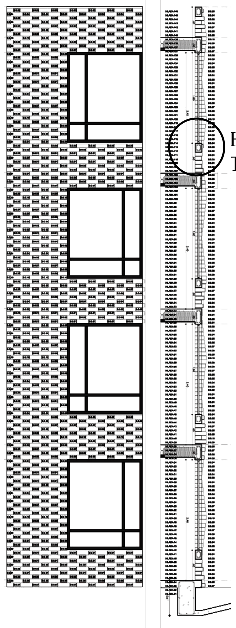
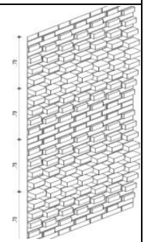
Category Stone Brick 7 Adobe	**MAP/MX + Grupo Nodus** **Z53 Social Housing's** analysis of brick masonry wall from ontological point of view	**Seismic Hazard Map(URL 21)**  	 (URL 21)		**Location:**Mexico **Earthquake zone:** Middle- Very High **Year:** 2012 **Function:** residential Wienerberger Brick Award 2012	
Plan (URL 12)		**Wall Detail**(URL 12)	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements**	**Wall Stereotomics with <u>STEEL</u> Elements**	**Tectonic Elements**
		 		-Masonry wall with RC horizontal tie-beams -Combined Rc frame (URL 12, URL 1 URL 3)	-Masonry walls with steel vertical tie-beams (URL 12, URL 1,URL 3)	-Steel framed glass surface -different brick pattern
Section (URL 12)			**Technical Consideration (URL18;URL 19)**	Mass of the walls of the structure keeps the internal climate stable. Therefore, it is logical that the brick is used as a façade for the mass of the building. Different bonded brick work form a shading element for openings. They help to control the sun light during the different times of the day; reflecting sun inside or rejecting and reflecting outside according to the sun. (URL 12, URL 1, URL 3)		
Photo (URL 12)			**Visual Consideration (URL18;URL 19)**	The masonry brick walls play an important role on the project as they are part of the structure and re-interpret the traditional brick wall, blurring the boundary between structure and ornament, creating walls that are sensible to shadows and lights. (URL 12, URL 1, URL 3)		
Effects of ontology on tectonic design	When looked at the building from outside the balance and solid/ void relationship between solid wall and openings can be felt. Sizes and numbers of openings are more than traditional ones. It was a necessity for better light and ventilation. It is the difference from the tradition. The highest architectural quality is the double-meaning of its appearance; it's new and old simultaneously. Plan arrangement is of rectangle shape. This building is located in a very high seismic zone so masonry wall with RC horizontal tie-beams combined with rc frame. There is a unique structure made in a new way so in this way another ontological category of structure is created.					

Table 5.20: Education Centre’s analysis of brick masonry wall from ontological point of view

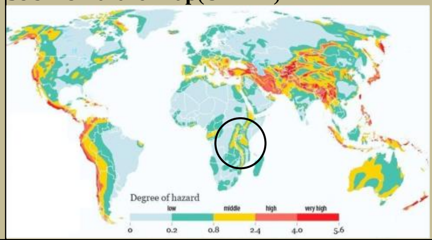
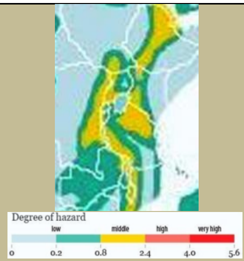
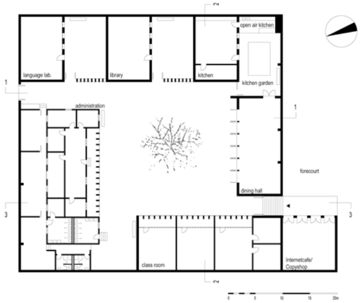
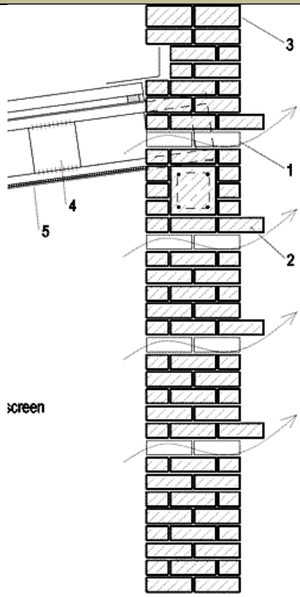
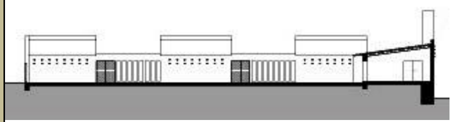
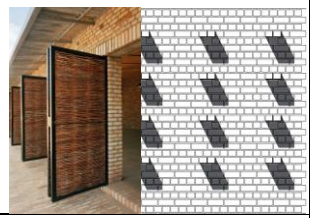
Category Stone Brick 8 ■ Adobe	DOMINIKUS STARK ARCHITEKTEN **Education Centre’s** analysis of brick masonry wall from ontological point of view	**Seismic Hazard Map**(URL 21) 	 (URL 21)		**Location:**Rwanda Central Africa **Earthquake zone:** Middle- Low **Year:** 2010 **Function:** school Architectural Review's emerging architecture 2013	
Plan (URL 53)		**Wall Detail** (URL 53) 	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements** (URL 53)	**Wall Stereotomics with <u>STEEL</u> Elements**	**Tectonic Elements**
				-Masonry wall with RC horizontal tie-beams -Combined Rc frame		-Steel framed glass surface -different brick pattern -big spans -special shutter detail -truss roof
Section (URL 53)			**Technical Consideration** (URL 53)	Walls provide a comfortable indoor climate. Gaps in the brickwork facilitate natural ventilation. In some parts of the wall rhythmical bricks are used in a different direction and they are extended outside. This is for getting natural air into the building. Therefore, walls provide a comfortable indoor climate.		
Photo (URL 53)			**Visual Consideration** ((URL 53)	The masonry brick walls play an important role on the project as they are part of the structure and re-interpret the traditional brick wall, blurring the boundary between structure and ornament. Doors produce by local cane lacework which creating		
Effects of ontology on tectonic design	The bricks are used in an innovative way and are double-layered. When looked at the building from outside you can feel the buildings' language of colour and form of courtyard refers to the local architecture. Clay, the traditional building material, manually processed to form fired clay bricks, has been used for the whole complex. The building is located in low seismic zone so masonry wall with RC horizontal tie-beams combined with rc frame. In here, masonrystructure syetem made in a new way so in this way of doing creates another ontological category of structure.					

Table 5.21: Hand-Made School's analysis of adobe masonry wall from ontological point of view

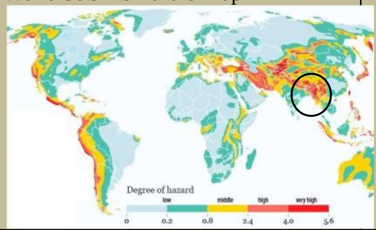
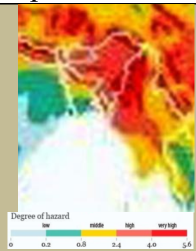
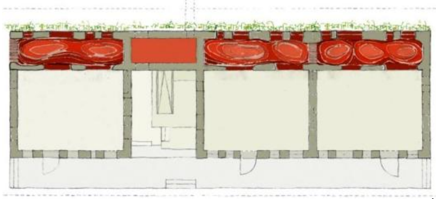
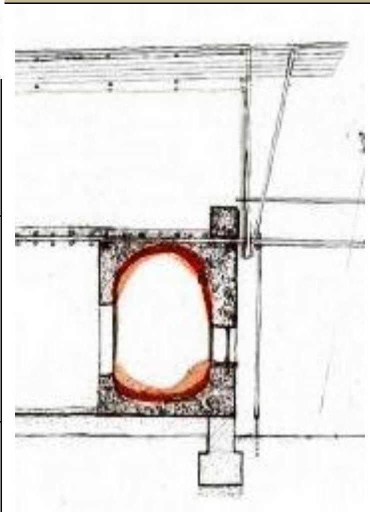
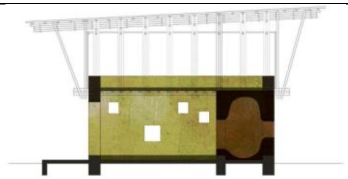
Category Stone Brick Adobe 1	**ANNA HERİNGER, EİKE ROSWAG** **Hand-Made School's** analysis of adobe masonry wall from ontological point of view	World Seismic Hazard Map 	 (URL21)			**Location:** Bangladesh **Earthquake zone**: High-Very High **Year**: 2005 **Function**: building is located in rural area serves as a school 2007 Award Cycle Aga Khan Prize
Plan (URL 15)		**Wall Detail** (URL 16) 	**Wall Stereotomics with <u>TIMBER</u> Elements**(URL 15)	**Wall Stereotomics with <u>RC</u> Elements**	**Wall Stereotomics with <u>STEEL</u> Elements**	**Tectonic Elements**
			-masonry mud walls reinforced with rammed straw			-Bamboo walls -Bamboo trusses - Openings close to each other and close to corners -Masonry walls with irregularly arranged openings (Different size of openings located on different places on same wall) -Colorful bamboo doors
Section (URL 15)			**Technical Consideration** (URL15;URL16; Lim,2007)	Second floor and the roof are made of lightweight bamboo frame. The roof is extended outside for protecting mud walls from rain and sun. This is achieved by using special joint detail that is bamboo truss with knot fix. 		
Photo (URL 16)			**Visual Consideration** (URL15;URL16; Lim,2007)	Rhythmical placement of the bamboo trusses and the organic curved spaces within the mud walls give particular tectonic characteristic to this building.  		
Effects of ontology on tectonic design	Challenge of using local materials to explore a new building dynamics is in the design of mud-wall construction. The aesthetic use of bamboo trusses on the first floor and the change of materials due to the change in structure, give an ontological meaning to the building. Materials and details play an important role in giving character to the spaces which have different functions. Plan arrangement consists of pure rectangle.					

Table 5.22: African Children Library’s analysis of adobe masonry wall from ontological point of view

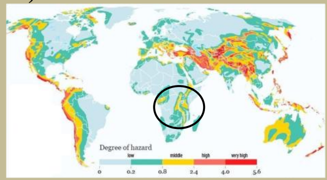
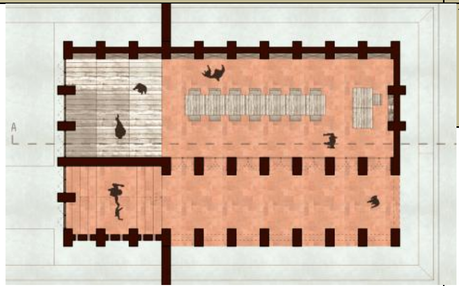
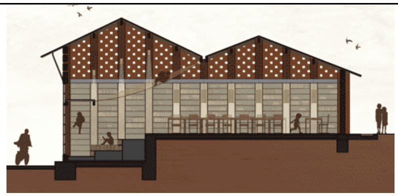
Category Stone Brick Adobe 2 ■	**BC ARCHITECTS AND MEMBERS OF THE LOCAL COMMUNITY** **AFRICAN CHILDREN LIBRARY’s** analysis of adobe masonry wall from ontological point of view	**World Seismic Hazard Map**(URL 21) 	 (URL21)		**Location:** Africa **Earthquake zone:** Low- Middle **Year:**2012 **Function:** Building is located in rural area serves as a library.	
Plan (URL17)		**Wall Detail** (URL17) 	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements** (URL17)	**Wall Stereotomics with <u>STEEL</u> Elements**	**Tectonic Elements**
				-Load bearing mud walls (compressed earth blocks)with rc horizontal and vertical tie beams (reinforced concrete structure has inside the compressed earth blocks columns .There are work as buttresses)		-Openings are close to each other and close to the corners -Masonry walls are with irregularly arranged openings (openings located on different places on same wall) -Timber beams are tied to the rc tie beams with knot -Large Span
Section (URL17)			**Technical Consideration** (URL17)	The mud brick pattern and multiple openings of full heights help to get natural light and cross ventilation. Rhythmically extended walls work as buttresses. The timber roof is covered with metal sheets and extended to protect mud walls from rain and sun. The façade is perforated according to the rhythm of the Compressed Earth Blocks (CEB). This helps to play with natural light as well.		
Photo (URL17)			**Visual Consideration** (URL17)	The brick pattern and multiple varying full-height openings contribute to the sensorial stimulation. Transparent openings between the columns create the interaction between inside and outside. Fully opened, these doors make the library open up towards the outside. Thus, it is connected with the environment visually.		
Effects of ontology on tectonic design	The aesthetic use of timber roof for the traditional architectural practices was reinterpreted to meet modern requirements for this educational space. There is a contrast between heaviness of the masonry walls and fully transparent openings. Structural system of closely spaced columns at 1m30 intervals, also act as buttresses for the high walls of the building. This rhythmic repetition of columns is a recognizable feature of the building from outside and inside. The building is located in middle earthquake zone so plan arrangement consists of pure rectangle.					

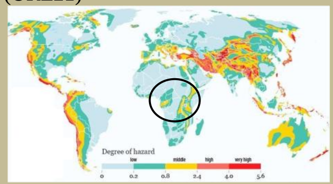
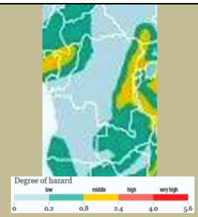
Table 5.23: Primary School’s analysis of adobe masonry wall from ontological point of view

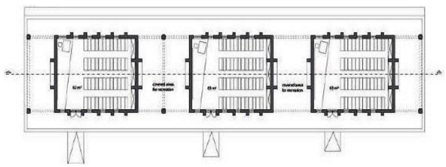
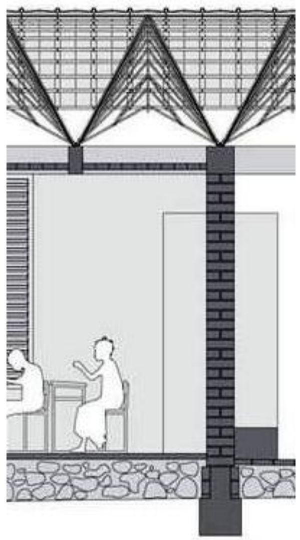
<table>
<tr>
<td>Category

Stone

Brick

Adobe 3</td>
<td>DİÉBÉDO FRANCİS KÉRÉ

PRIMARY SCHOOL’s analysis of adobe masonry wall from ontological point of view</td>
<td>World Seismic Hazard Map (URL21)
</td>
<td colspan="2">(URL21)</td>
<td colspan="2">Location: Burkina Faso(West Africa)
Earthquake zone: Low
Year: 2001
Function: building is located in rural area serves as a school

Aga Khan Award for Architecture 2004
Global Award for Sustainable Architecture 2009</td>
</tr>
<tr>
<td rowspan="2">Plan
(URL 19)</td>
<td rowspan="2"></td>
<td>Wall Detail (URL 19)</td>
<td>Wall Stereotomics with <u>TIMBER</u> Elements</td>
<td>Wall Stereotomics with <u>RC</u> Elements (URL18;URL 19))</td>
<td>Wall Stereotomics with <u>STEEL</u> Elements</td>
<td>Tectonic Elements</td>
</tr>
<tr>
<td rowspan="3"></td>
<td></td>
<td>-Load bearing mud walls (compressed earth blocks)with rc horizontal tie beams

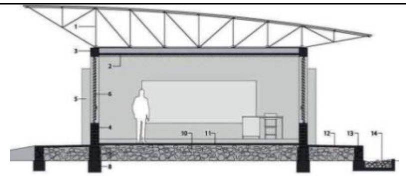
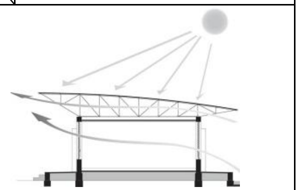
- compressed earth blocks columns .There are work as buttresses</td>
<td></td>
<td>-Openings are close to each other and close to the corners
-Colorful, special detailed wooden shutters.
-Steel truss roof
-Full height opening</td>
</tr>
<tr>
<td>Section
(URL 19)</td>
<td></td>
<td>Technical Consideration (URL18; URL 19)</td>
<td colspan="3">Walls have ability to absorb heat during the day. Walls also act as a storage unit for cooling while special roof construction ensures ventilation and creates cooling and shadow. Buttresses are supporting the walls.</td>
</tr>
<tr>
<td>Photo
(URL 19)</td>
<td></td>
<td>Visual Consideration (URL18; URL 19)</td>
<td colspan="3">Combination of lightweight roof and heavy masonry walls create a contrast. Walls are extended rhythmically and give visual and proportional characteristics to the building.</td>
</tr>
<tr>
<td>Effects of ontology on tectonic design</td>
<td colspan="6">The basic principle is to place the rooms on a raised foundation and to cover them with a wide overlapping roof that would afford protection to the clay walls. The classrooms themselves are designed as simple rectangular modules. This building is located in the middle earthquake zone so load bearing mud walls are used together with rc horizontal tie beams. The buttresses (reinforcing wall elements) lend a play of light and shadow to the walls. They also give a dimensional quality to them. At the same time the reinforcements are beneficial components and work as buttresses that create cooling areas of shadow and also act as acoustic buffers absorbing sound between the classrooms. Ontology of structure is achieved by this way.</td>
</tr>
</table>

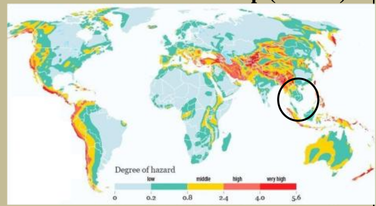
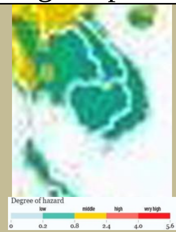
Table 5.24: The Sra Pou Vocational School‘s analysis of adobe masonry wall from ontological point of view

<table>
<tr>
<td>**Category**

Stone

Brick

Adobe 4</td>
<td>**RUDANKO + KANKKUNEN**

The Sra Pou vocational school ‘s analysis of adobe masonry wall from ontological point of view</td>
<td>**World Seismic Hazard Map** (URL21)
</td>
<td colspan="2">(URL21)</td>
<td colspan="2">**Location:** Cambodia
Earthquake zone: Low
Year: 2010
Function: building is located in rural area The Sra Pou vocational school serves as a business training centre and public hall.

2012 Award Cycle AGA KHAN PRIZE</td>
</tr>
<tr>
<td rowspan="2">Plan

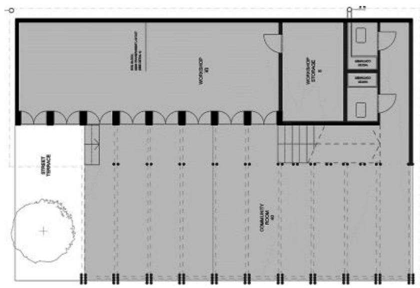
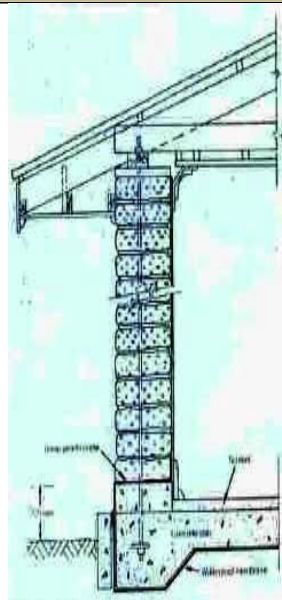
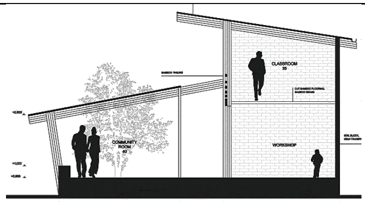
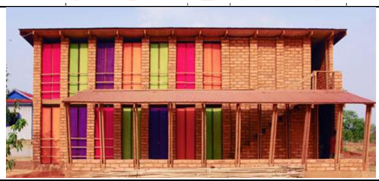
(URL 54)</td>
<td rowspan="2"></td>
<td>**Wall Detail** (URL 54)</td>
<td>**Wall Stereotomics with <u>TIMBER</u> Elements**</td>
<td>**Wall Stereotomics with <u>RC</u> Elements** (URL 54)</td>
<td>**Wall Stereotomics with <u>STEEL</u> Elements**</td>
<td>**Tectonic Elements**</td>
</tr>
<tr>
<td rowspan="3"></td>
<td></td>
<td>-Rc vertical tie beam (inside the compressed earth blocks columns. There are work as buttresses)</td>
<td>-Steel vertical reinforcement bar</td>
<td>-Openings are close to each other and to the corners
-Masonry building is with large spans
-Bamboo special shutter detail</td>
</tr>
<tr>
<td>Section
(URL 54)</td>
<td></td>
<td>**Technical Consideration**
(URL 54)</td>
<td colspan="3">Small gaps in brickwork allow soft natural light and breezes to flow through the building while colorful woven shutters open the indoor teaching areas onto a shaded terrace .Rhythmically extended walls work as buttresses. The timber roof protects the walls from environmental effects such as rain and sun.</td>
</tr>
<tr>
<td>Photo
(URL 54)</td>
<td></td>
<td>**Visual Consideration**
(URL 54)</td>
<td colspan="3">The mud brick pattern and rhythmic openings of full heights contribute to the sensorial stimulation. Openings between the columns create an interaction between inside space and outside. Fully opened, these doors make the library open up towards the adjacent square so the building is aesthetically and visually connected with environment</td>
</tr>
<tr>
<td>Effects of ontology on tectonic design</td>
<td colspan="6">The building is located low earthquake zone. Load bearing mud walls are used together with rc vertical tie beams and steel reinforcement bars to improve the stability of the walls. Ontology of the structure is achieved by these ways. Traditional architectural practices were reinterpreted to meet modern requirements for this educational space. There is a contrast between heaviness of the masonry walls and rhythmical openings with colorful shutters and totally lightweight timber frame as semi open space. Structural system of closely spaced columns at 1m30 intervals acts as buttresses for the high walls of the school. This rhythmic repetition of columns is a recognizable feature of the building, both out and inside of the building.</td>
</tr>
</table>

Table 5.25: Oaxaca School of Plastic Arts‘s analysis of adobe masonry wall from ontological point of view

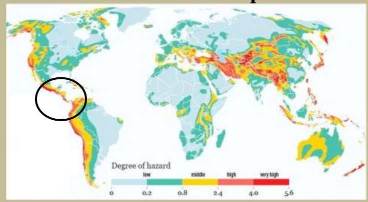
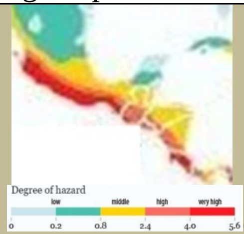
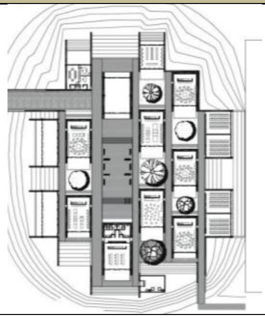
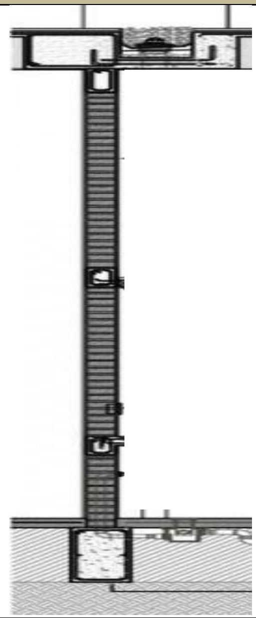
Category Stone Brick Adobe 5 ■	**MAURİCİO ROCHA** **OAXACA SCHOOL OF PLASTİC ARTS ‘s** analysis of adobe masonry wall from ontological point of view	**World Seismic Hazard Map** 	(URL21)	**Location:** Mexico **Earthquake zone:** High-Very High **Year:** 2010 **Function:** public hall 2009Adobe building awards		
Plan (URL23)		**Wall Detail** (URL 23)	**Wall Stereotomics with TIMBER Elements**	**Wall Stereotomics with RC Elements** (URL23)	**Wall Stereotomics with STEEL Elements** (URL23)	**Tectonic Elements**
				-Rc horizontal tie beam -Combined share walls	-Steel horizontal reinforcement bar	-Masonry walls are with large openings, -Full height openings -Different adobe texture
Section (URL 23)			**Technical Consideration** (URL23)	Rammed earth creates an optimal microclimate for the climatic conditions and provides acoustic insulation for the classrooms. Large openings contribute to the buildings energy efficiency and show us challenge with masonry wall. Cross ventilation, with windows on the north facade, improves the indoor lighting as well. 		
Photo (URL 23)			**Visual Consideration** (URL23)	Aesthetically, the thin horizontal layers of earth produce tonal lines and give the richness of walls. In addition, concrete beams can also be seen under the earth structure. 		
Effects of ontology on tectonic design	With the use of rc horizontal tie beams they reached the big spans and openings, in contrast to the heavy structure of wall giving lightness and modern sense to the building. On the other hand elevated space’s slabs are supported by shear walls. The building is located in very high earthquake zone so rc horizontal tie beams were used together with horizontal reinforcement bars on rammed earth walls.					

Table 5.26: Tucson Mountain Retreat's analysis of adobe (rammed earth) masonry wall from ontological point of view

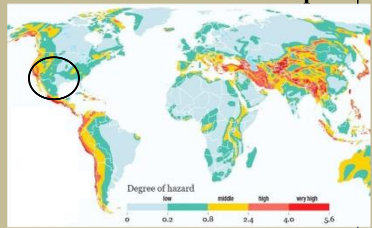
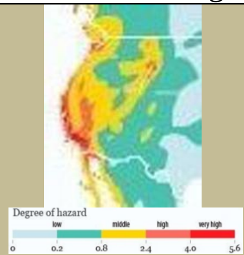
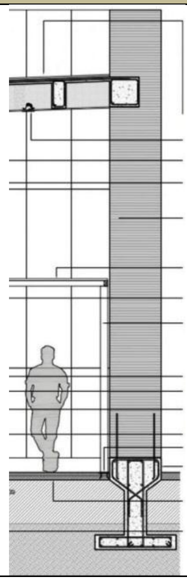
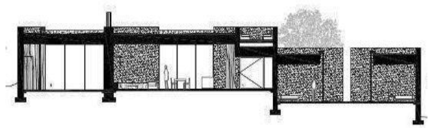
Category Stone Brick Adobe 6	**DUST** **Tucson Mountain Retreat's** analysis of adobe (rammed earth)masonry wall from ontological point of view	**World Seismic Hazard Map** 	 (URL 21)		**Location:** Arizona **Earthquake zone**:Low- Middle **Year:** 2010 **Function:** residential	
Plan (URL 55)		**Wall Detail** (URL 55) 	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements** (URL 55)	**Wall Stereotomics with <u>STEEL</u> Elements** (URL 55)	**Tectonic Elements**
				-Rammed earth masonry wall with horizontal Rc beam -combined by rc frame	-Steel horizontal reinforcement bar	-Large openings, -Openings are close to corners -Full height openings - Masonry building with large spans -Glass walls - Different adobe texture
Section (URL 55)			**Technical Consideration** (URL 55)	The masonry walls turn around the spaces. At least 3 sides of the spaces are covered with rammed earth walls. This helps to regulate the inside temperature and creates energy efficiency. With the use of rc horizontal beams the rammed earth walls are tied to each other. With this way cross ventilation is created in the desert conditions and big spans for ventilating spaces are naturally reached.		
Photo (URL 55)			**Visual Consideration** (URL 55)	The surface of the walls consists of earth lines with different colors that give the building an aesthetical effect. Big openings frame the surrounding environment vision and give lightness and modern sense to the building.		
Effects of ontology on tectonic design	The house is technically a line of four one-story buildings made of earth, concrete and steel. A monolithic structure becomes a sculptural block in the landscape. If looked at traditional buildings a fragmented plan arrangement cannot be seen. According to present needs, functions are increased, more privacy in the homes created necessity to separate spaces as service public and private areas. These features have affected to the plan. The hierarchies of the spaces are readable and different from the traditional and by this way ontology achieved. The building is located in middle seismic zone.					

Table 5.27: Nk'Mip Desert Cultural Centre analysis of adobe (rammed earth)masonry wall from ontological point of view

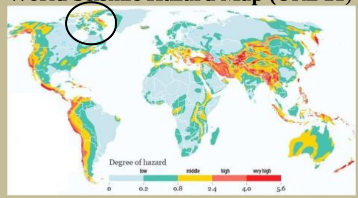
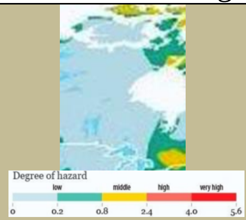
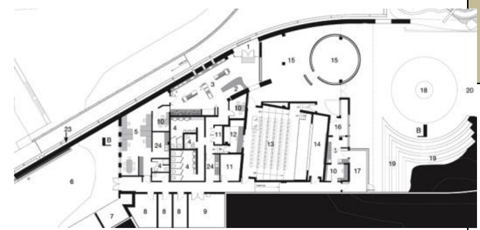
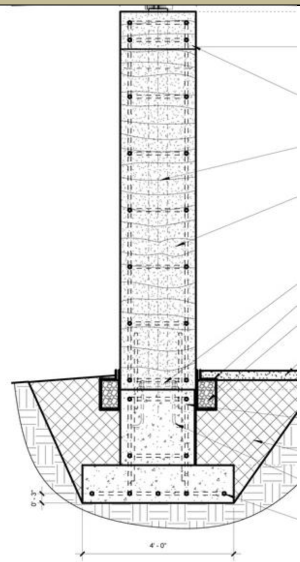
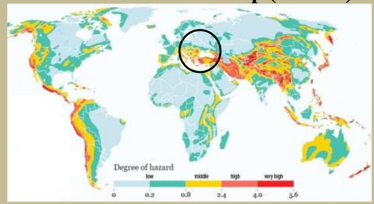
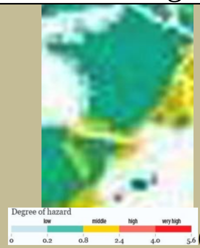
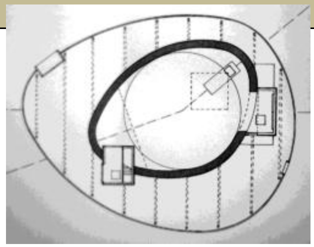
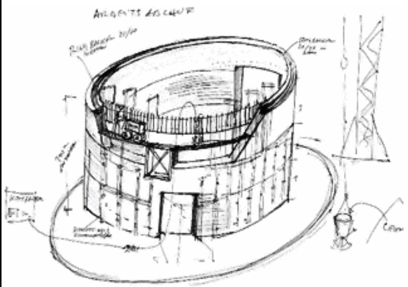
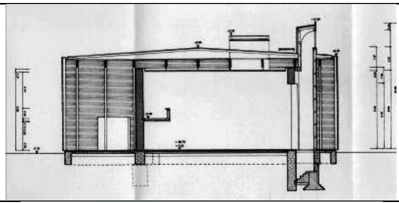
Category Stone Brick Adobe 7	HBBH ARCHİTECTS **Nk'Mip Desert Cultural Centre** analysis of adobe (rammed earth)masonry wall from ontological point of view	**World Seismic Hazard Map** (URL 21) 	 (URL 21)		**Location:** Canada **Earthquake zone:** Low **Year:** 2006 **function:** building is located in rural area serves as cultural center 2008 Governor General's Medal In Architecture	
Plan (URL 56)		**Wall Detail** (URL 56)	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements** (URL 56)	**Wall Stereotomics with <u>STEEL</u> Elements** (URL 56)	**Tectonic Elements**
				-rammed earth wall	- Steel horizontal and vertical reinforcement bar	-Large openings -Different adobe texture - irregularly arranged openings -large span
Section (URL 56)			**Technical Consideration** (URL 56)	Huge opening in the middle parts of the wall shows us a challenge with masonry wall. Wall works as a barrier in front of the main building. It reduces the direct solar exposure of the interiors.		
Photo (URL 56)			Visual Consideration (URL 56)	Aesthetically, the thin horizontal layers of earth produce tonal lines like warm and haptic senses. Big openings frame the surround environment vision and give lightness and modern sense to the building		
Effects of ontology on tectonic design	The length of the rammed earth wall is 80 meters; the longest adobe masonry wall in the world. The wall has the appearance of being as handmade and precise-its layers are irregular, and it is in the form of sharp and geometrical shape. The technique results in a physically strong, durable wall with thermal qualities heating up slowly during the day in the hot sun, and releasing its heat in the evening. Naturally rammed earth wall connects the building and its environment. The building is located in the low earthquake zone. Load bearing rammed earth is used together with steel reinforcement bars to improve the stability of the wall. Ontology of structure is achieved by these ways.					

Table 5.28: The Chapel Of Reconciliation' analysis of adobe (rammed earth)masonry wall from ontological point of view

Category Stone Brick Adobe 8	PETER SASSENOTH AND RODOLF REITERMANN **The Chapel Of Reconciliation'** analysis of adobe (rammed earth)masonry wall from ontological point of view	**World Seismic Hazard Map** (URL 21) 	 (URL 21)		**Location**: Germany **Earthquake zone:** Low **Year:** 2000 **Function:** church	
Plan (URL 57)		**Wall Detail** (URL 57)	**Wall Stereotomics with <u>TIMBER</u> Elements**	**Wall Stereotomics with <u>RC</u> Elements** (URL 57)	**Wall Stereotomics with <u>STEEL</u> Elements**	**Tectonic Elements**
				-Rc horizontal ring beam(on top of the wall)		-Timber frame -Different adobe texture
Photo (URL 57)			**Technical Consideration** (URL 57)	This wall supports a series of timber beams that span across the inner room and cantilever 2 meters beyond the rammed earth wall. The timber planks are hung from the cantilevered ceiling spanning to the concrete base. They are spaced about 5cm apart with no thermal enclosure keeping out the surrounding environment		
Photo (URL 57)			**Visual Consideration** (URL 57)	The use of natural material such as timber frame and earth gives the emotional look to the building. It belongs its surrounding, coherent with landscape and aesthetically standing as an elliptical prism. Timber roof also lets the light to reach inside.		
Effects of ontology on tectonic design	Plan arrangement consists of elliptical shape. Using rammed earth involves a process of compressing a mixture of damp earth that has suitable proportions of sand, gravel and clay into an externally supported former that moulds the shape of a wall section creating a solid block of earth. The structure consists of an oval-shaped rammed-earth with a bond beam (horizontal tie beam) and it is surrounded by timber frame which improves the stability of the wall together. Ontology of structure achieved by these ways.					

5.4 General Evaluation of Analysis

It is obvious that these buildings which are analysed in Table 5.5 and Table 5.28 are part of contemporary masonry architecture, which represents tectonic qualities. In these buildings, materials, details, structures, natural texture, color, and light were used as part of the composition. Each of them consisted of different techniques for establishing design-possibilities and performing singularity in assemblies that are heterogeneous, both socially and materially.

It can be said that; all buildings can be evaluated as part of the architects' tendency for creating tectonics and all aspects of ontology are almost used. Additionally most of the details and structural elements that are used can represent themselves technically and aesthetically in reasonable ways.

Even in aesthetic use of materials, structures, or details, there is an idea behind the building, which is either mechanically necessary or statically useful. This analysis can be shown as an evidence for this argument. Architects reinterpreted the traditional construction methods not necessarily by using high technology but by innovative ideas of transforming the right effects of materials, structure, details etc.

It can be said that, masonry has a long history; it is one of the first building structures that was used by humans and constitutes a large number of buildings. The history of architecture is written primarily by masonry. In the long course of development, the fate of masonry is changing constantly with the advance of technology and the development of materials.

Today, it is commonly known that masonry structures are weak in respect of earthquakes. In addition, building codes played big roles to change the system because each of them are asking or developing different requirements for masonry buildings. Not only the appearance of masonry, but also the function and structural elements of masonry has changed a lot and requires reinterpretation.

It is good to remember that one of the objectives of this thesis is to find, what kind of structural elements exist in the walls of contemporary masonry buildings. Thus table 5.33 shows that, through the analysis of 24 contemporary masonry buildings, 8 different types of techniques were identified by means of structural element usage on masonry walls.

1. In 6 buildings (out of 24) horizontal and vertical ties were used together. The only difference is the materials between these buildings. 3 brick masonry buildings (Table 5.13, Table5.16, Table 5.19) and 3 adobe masonry buildings have horizontal and vertical ties together in the wall either from reinforced concrete or steel materials (Table 5.22, Table5.23, Table 5.26). This method was not found in the stone masonry category. In table 5.29 this is shown as green colour.
2. In 6 buildings (out of 24) only horizontal ties were used. The only difference is the materials between these buildings. One adobe masonry (Table 5.28), 3 brick masonry buildings (Table 5.14, Table 5.18, Table 5.20) and 2 stone masonry buildings have horizontal ties in the wall and are made from reinforced concrete (Table 5.7, Table 5.9). However, one of the stone masonry building have timber horizontal tie (Table 5.9). This method was

found in all masonry categories. This can be seen in Table 5.29 as blue colour.

3. On the other hand 2 of masonry buildings used only vertical ties. One of them is stone masonry (Table 5.10) and the other is adobe masonry building (Table 5.24). Both of them are made from reinforced concrete (In table 5.29 shown as brown colour).
4. Only one of the brick masonry used horizontal tie beam and cavity wall in it (Table 5.15). This is also made from reinforced concrete. This method was not found in the stone and adobe masonry category. This can be seen in Table 5.29 in orange colour.
5. In 3 buildings (out of 24) frame system and structurally load bearing wall like infill were used. One of them had stone masonry wall with shear wall (Table 5.6). One of them had stone masonry wall with reinforced concrete frame (Table 5.8) and one of them had brick masonry with steel frame (Table 5.17). This method was not found in the adobe masonry category (See Table 5.29 in purple colour).
6. Different from all the methods, 2 of the stone masonry buildings used the steel mesh (Table 5.11, Table 5.12). This method was not found in the adobe or stone masonry category (Shown in Table 5.33 in yellow colour).
7. In 3 adobe masonry buildings (out of 24) only reinforcement steel bars inside of the walls were used (Table 5.21, Table 5.25, Table 5.27). This is shown in Table 5.29 in white colour).
8. Different from the other methods, in one of the stone masonry, steel bracing were used in front of the walls (Table 5.5) (In table 5.29 showed as pink colour).

Table 5.29: Results of the analysis; new techniques and structural elements of contemporary masonry

	Brick categories			**Stone categories**			**Adobe categories**			Limit
	Architect	Building	Wall elements	Architect	Building	Wall elements	Architect	Building	Wall elements	
1	Anagram Architect	South Asian Human Rights Documentation Centre	Rc Horizontal tie beam + Steel vertical tie beam+ Brick masonry	Mauricio Rocha	Campamento De Edificios Públicos	Stone masonry(with steel bracing)	Anna Heringer, Eike Roswag	Hand-Made School	rammed straw-reinforced mud walls	First 15 Years Of The 21st Century (2000-2015)
2	Monica Ponce De Leon And Nader Tehrani	Tongxian Gate House	Rc Horizontal beam+ brick masonry	Han Tumertekin	B2 House	Stone masonry infill+ Rc shear wall	Bc Architects And Members Of The Local Community	African Children Library	Rc Horizontal tie beam + Steel vertical tie beam+ Adobe masonry	
3	Taka	House1+House2	Horizontal tie beam brick masonry with rc cavity	Rdr Arquitectos	Buenos Mares House	Stone masonry+ horizontal beam	Diébédo Francis Kéré	Primary School	Rc Horizontal tie beam + Steel vertical tie beam+ Adobe masonry	
4	Bangkog Project Studio	Kantana Film And Animation Institute	Steel Horizontal tie beam Steel vertical tie beam + Brick masonry	Abct-Architecture	Apartment No1	Stone masonry+ infill with rc frame	Rudanko + Kankkunen	The Sra Pou Vocational School 'S	Rc vertical tie beam +Adobe masonry wall	
5	CM Architecture	Noxx Apartment	Steel frame+ brick masonry infill	Beijing Studio Atelier Teamminus	Jianamani Visitor Centre	Timber horizontal tie beam +stone masonry wall	Mauricio Rocha	School Of Plastic Arts	Rammed earth + rc horizontal and vertical steel bars	
6	Azl Architects	Brick House	Rc Horizontal tie + brick masonry	Archium	Radio Broadcasting Station	Rc vertical tie beam +stone masonry wall	DUST	Tucson Mountain Retreat	Rammed earth masonry wall +Rc horizontal beams+ Rc vertical tie beams	
7	Map/Mx Grupo	Z53 Social Housing Complex	Rc Horizontal tie beam+ Steel vertical tie beam+ Brick masonry	Herzog De Mouron	Dominus Winery	Modular Steel mesh filled with stone	HBBH architects	Nk'Mip Desert Cultural Centre	Rammed earth wall + Steel vertical bars	
8	Dominikus Stark Achitekten	Education Center	Rc Horizontal tie beam+ brick masonry	Maison Edouard François	The Building that Grows	Modular Steel mesh filled with stone	Peter Sassenoth And Rodolf Reitermann	The Chapel Of Reconciliation	Rammed earth wall + rc horizontal ring beam on top of the wall	

5.5 Structural Elements in Contemporary (reinforced) Masonry Buildings in the Views of Tectonics (results)

In masonry structures walls have come until today with their load- bearing functions and also these walls were made up of local natural materials. In modern times, thick and blind walls creating big obstacles for designing the spaces are replaced by walls which have large openings. This gave potential to the creation of lighter and wider spaces. Thick bonded walls became thin and this is through the help of technical progress, built straight, gained importance of space concept and progress of ties transferring weight to certain points without a need of consistent load- bearings.

Violet Le Duct experienced and observed the architecture in many levels such as governmental, academic as well as social levels. Based on Violet Le Duct's theory of architecture Greek and Gothic styles were the ideal system for modern architecture (Bressani, 1989), "the ideal system" passed from using structural elements in a dynamic relation with forces. It can be said that he was the first person using iron elements in gothic cathedrals for making lighter and open space buildings. With this way, first, he passed wider spans than stone arch, more economically. Secondly, wall mass (which is wall stereotomics) was made possible to be reduced by using vertical supports which were made of iron (Taschen, 2006). If one considers the Violet Le Duct's buildings as a reinforced masonry, it means that, for more than 100 years, reinforced masonry building technology has been used as an alternative system to both traditional (unreinforced) masonry and frame systems. The term 'reinforced masonry', is known as 'modern masonry or confined masonry'. It usually means masonry structure system with additional steel or concrete elements. These reinforcing elements improve the earthquake performance of masonry wall

(Brezev, 2007). It should be noted that, the focus of this thesis is on stone, brick and adobe masonry buildings. The systems that were found mainly through analysis are; reinforcement with steel bar, reinforcement with steel or concrete horizontal / vertical tie- beams and its combination with concrete or steel frame systems, even shear walls.

Challenging the size and layout of openings, increasing wall thickness proportionally with the wall height and length, sometimes having only one floor, using a light roof system increases the earthquake resistance of masonry buildings and these altogether create tectonic of the building.

On the other hand, the ones who used steel to reinforce all types of masonry structures, steel is either combined with masonry or steel frame, caused a change in the meaning of stereotomics where heavy, mass, solid walls were replaced by more light, punctured walls. This helps to speak of new stereotomics of contemporary masonry walls.

Thus, second objective of this thesis is to find; how many different ontological structure varieties are there in case of masonry wall. Thus, based on evaluation in the section above, 4 main ontological categories are defined. In general, contemporary masonry structures can be divided into 4 basic categories as listed below:

1. Original structure strengthening with reinforcement (steel bars, canes, bamboo straw etc.)

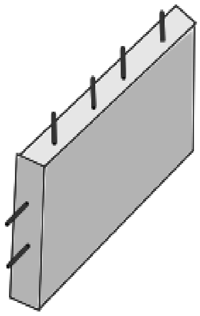


Figure 5.10: Adobe Masonry wall with steel bar reinforcement. (By Author)

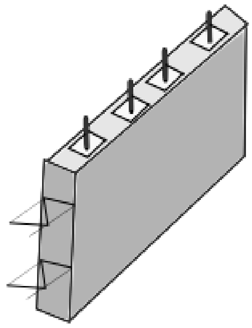


Figure 5.11: Steel bar reinforcement's placement in hollows core of brick masonry wall. (By Author)

Reinforced masonry with vertical and horizontal steel bars is being for contemporary masonry buildings in general. Vertical bars are generally placed in hollow cores of bricks (Figure 5.4) or in the middle of the adobe wall (Figure 5.3). For stone or brick masonry there is one more solution to use steel bars with cavity wall (Figure 5.5). Cavity wall is placed in the middle of stone or brick masonry walls and the reinforcement (horizontal or vertical steel bars) is placed in that. (Alcocer, Klingner, 1994; Brezev, 2007).

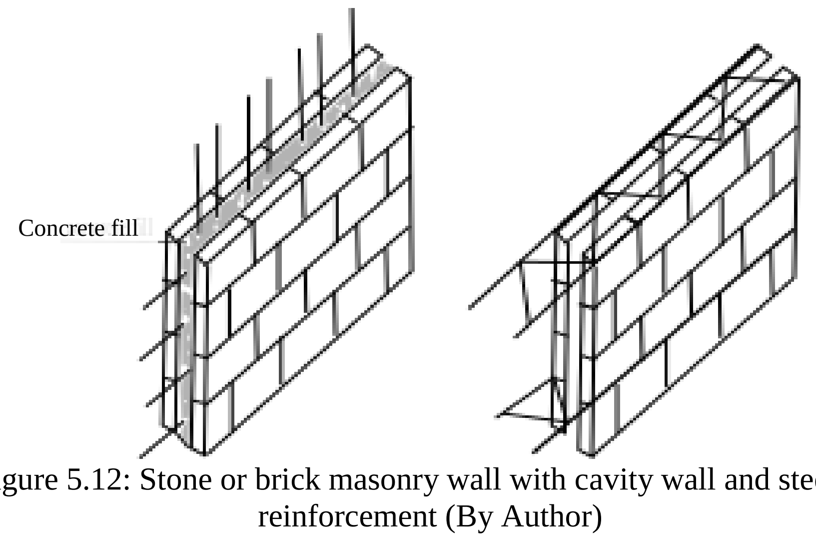


Figure 5.12: Stone or brick masonry wall with cavity wall and steel bar reinforcement (By Author)

In rare occasions however, it might be attached to the wall surface. Vertical bars are used at the corners or intersections of the walls and all sides of the openings. On the other hand, horizontal reinforcement bars are generally located at the lintel level. Vertical reinforcement bars resist the axial and bending loads; horizontal reinforcement bars resist the shear, which occur during an earthquake (Blondet: 2005).

2. Old (traditional) and new (contemporary) structure coexisting [masonry wall (old) with RC or Steel horizontal and vertical ties (new)

It can be said that, this is the system that is in between frame systems and traditional masonry systems. Masonry wall is supported with horizontal and vertical structural elements. These elements can be built either separately (only horizontally or vertically) or together to all sides of masonry wall plane (Blondet: 2005; Brezev, 2007). It is required to emphasize that these elements are not the same as beam or columns of frame systems. They are dimensionally smaller than the frame systems with less reinforcement bars inside with simple details and joints. That is why they are named as horizontal tie-beam and vertical tie-column (Blondet: 2005; Brezev, 2007). These reinforcing elements effectively improve the earthquake performance of masonry walls.

2.1. With vertical tie beams, which are embedded in masonry walls to strengthen them.

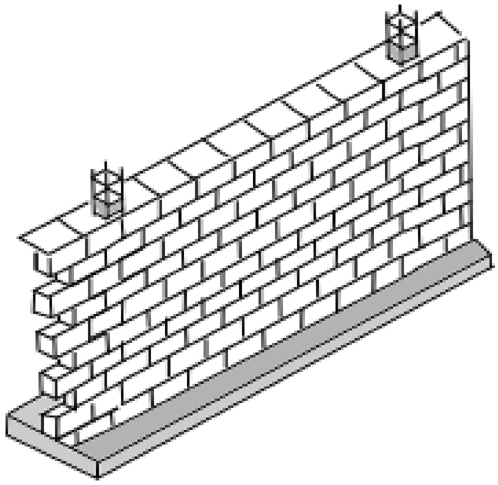


Figure 5.13: Masonry wall with vertical tie beam (By Author)

2.2. With horizontal tie beams which are embedded in masonry walls to strengthen them.

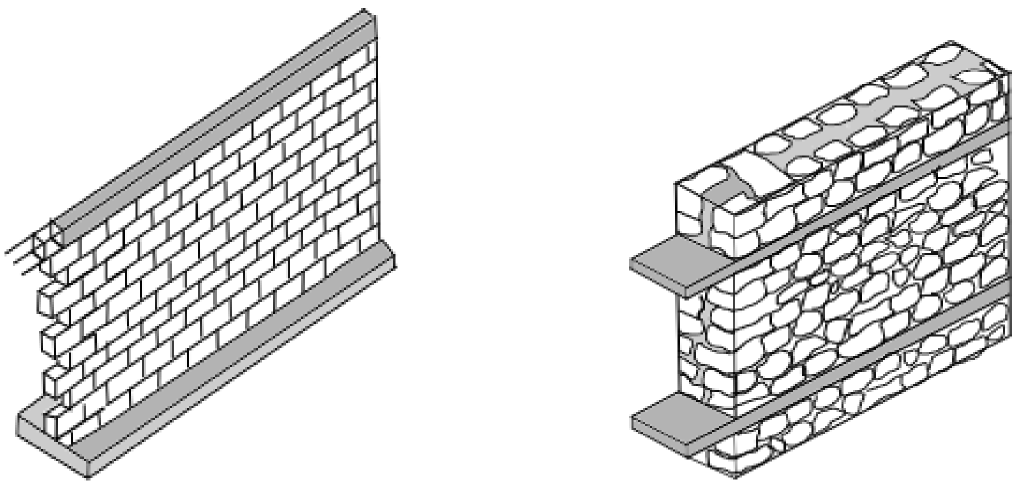


Figure 5.14: Masonry wall with horizontal tie beam (By Author)

2.3. With vertical and horizontal tie beams, which are embedded in masonry walls to strengthen them.

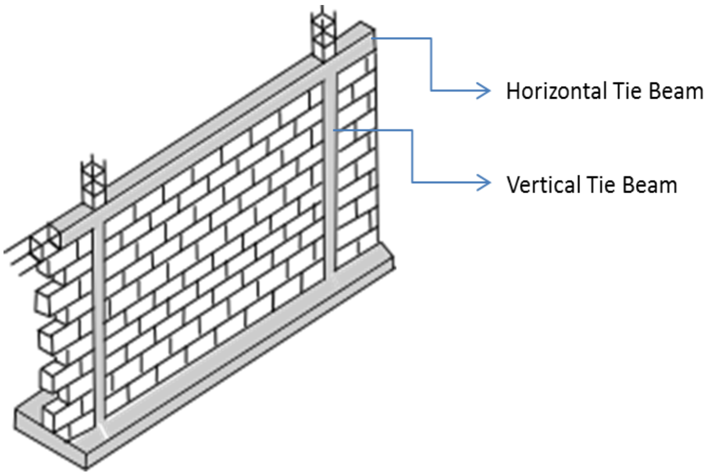


Figure 5.15: Masonry wall with vertical and horizontal tie beam (By Author)

This can be done with different materials. For example; stone or brick walls may have timber or steel or rc. ties as horizontal and vertical reinforcement.

3. Masonry wall with RC or Steel horizontal and vertical ties (new) Combined with frame system (Mixed-structure).

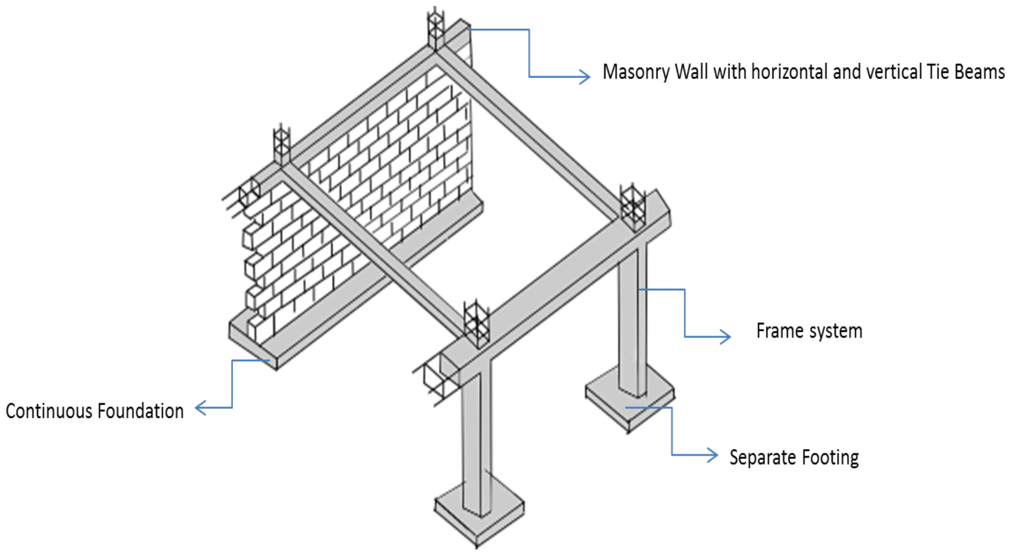


Figure 5.16: Masonry wall with vertical and horizontal tie beam combined with frame system (By Author)

4. The new structure with renewal (masonry wall with rc and steel frame system)

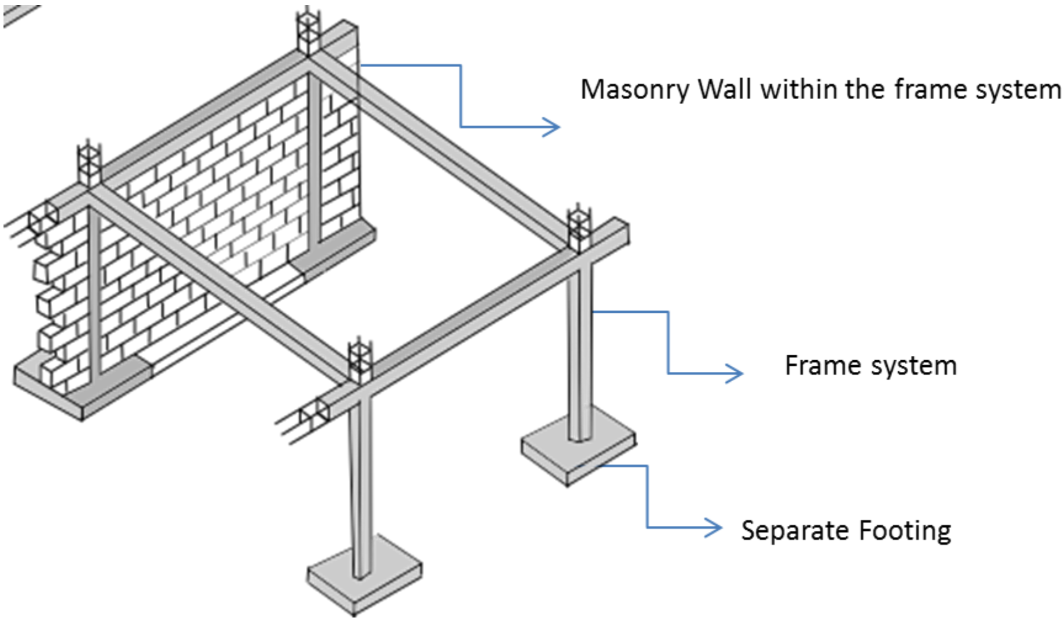


Figure 5.17: Masonry wall within frame system (By Author)

As a result of the case analysis part, the ontological structure categories of the contemporary masonry structures are defined. The gabion wall and use of steel bracing are evaluated as a technique so it is not considered as structure system, because it was used only for stone masonry. However, it should be noted that there is a thin line between these four categories. Thus, the differences between each category are shown in Table 5.29.

Table 5.30: Differences between ontological masonry structure categories (et. al. Blondet, 2005; Brezev, 2007)

	1.Original structure strengthening with reinforcement (steel bars, canes, bamboo etc.)	**2.Masonry wall (old) with RC or Steel horizontal and vertical ties (new)**	**3.Masonry wall with RC or Steel horizontal and vertical ties (new) Combined with frame system**	**4. The new structure with renewal**
Main load bearing elements	A. Masonry walls are the main load bearing elements with reinforcement.	A. Masonry walls are the main load bearing elements with horizontal tie-beams and vertical tie-columns. Bathe are significantly smaller in size than RC beams and columns.	Both reinforced masonry walls and frames are the load bearing elements.	A. Frames are the main load bearing elements that are relatively large beams, columns, B. Infill walls are also load-bearing walls.
Foundation	Continuous footing	Strip footing beneath the wall and the RC plinth band	Isolated footing beneath each column and continuous footing under masonry wall.	Isolated footing beneath each column and continuous footing under masonry wall.
Construction process	1.Wall and reinforcement being constructed together at the same time.	1. Masonry walls are constructed first. 2. Subsequently, tie-columns are cast in place. 3. Finally, tie-beams are constructed on top of the walls, simultaneously with the floor/roof slab construction.	1. Masonry walls are constructed first. 2. Subsequently, tie-columns are cast in place. 3. Finally, tie-beams are constructed on top of the walls, simultaneously with the floor/roof slab construction. 4. The rest combining with frame system	1. The frame is constructed first. 2. Walls are constructed at a later stage and are not bonded to the frame members; these walls are nonstructural, that is, non-load bearing walls.

It can be said that, masonry has a long history; it is one of the first building structure that is used by human. Masonry constitutes a large number of buildings. The history of architecture is written primarily by masonry. In the long course of development, the fate of masonry is changing constantly with the advance of technology and the development of materials. It is commonly known, today, that masonry structures are weak in respect of earthquakes. In order to find the more concrete results, according to the findings from buildings which were analysed (from Table 5.5 and Table 5.28), the buildings were arranged by respective earthquake zones in Table 5. 31. In this way the distribution of each building's stereotomic elements and tectonic elements were shown in accordance with earthquake zones (starting from low to very high risk). As a result it can be said that building codes have played big role to change the system because each of them ask or develop different requirements for masonry buildings. Not only the appearance of masonry is changed, but also the function and structural elements of masonry is changed or re-interpreted.

		MAURİCIO ROCHA School Of Plastic	ANNA HERİNGER, EİKE ROSWAG Hand-Made	ABCT ARCHI Apartment no 1	HAN TUMERTEKIN B2 House	MAURICIO ROCHA Campamento de	MAP/MX Z53 Social Housing Complex	BEIJING STUDIO ATELIER TEAMMINUS Jianamani	RDR ARCH. Buenos Mares House	AZL ARCH. Brick House	CM ARCH. Noxx Apartment	BANGKOK STUDIO Kantana Film And Animation	MONICA PONCE DE LEON &NADER TEHRANI
Traditional masonry Stereotomy with Timber	Masonry wall with Timber horizontal							X					
	Cross Wall												
	Courtyard							X					
	Interlocking Walls												
	Masonry wall with Buttresses							X					
	Masonry wall	X	X			X							
Stereotomy With Rc	Masonry wall with RC horizontal tie-beams						X		X	X			X
	Masonry wall with RC vertical tie-beams												
	Masonry wall with RC horizontal and vertical tie beam												
	Masonry wall with cavity wall												
	RC frame with load bearing masonry infill wall			X									
	RC share wall with load bearing masonry infill wall				X								
	Masonry wall combined with RC frame						X		X	X			X
Stereotomy With Steel	Masonry wall with steel vertical tie-beam						X					X	
	Masonry wall with steel horizontal tie-beams											X	
	Steel frame with load bearing masonry infill wall										X		
	Gabion wall (stone field steel mesh	X											
	Masonry wall with steel bars					X							
	Masonry wall combined with steel frame	X				X						X	
Tectonic	Masonry walls with large openings, corner openings	X	X	X	X	X			X	X			X
	Openings close to each other and close to corners	X		X		X							
	Full height openings		X	X	X	X		X					
	Masonry walls with irregularly arranged openings (Different size of openings located on different places on same wall)	X		X					X	X		X	
	Masonry building with large spans	X			X				X		X	X	X
	Glass walls /glass surface (longer than 3m) /special shutter detail				X		X		X		X		X
	Steel, Timber, Bamboo frame without masonry wall(there can be non-load-bearing infill)												
	Masonry building with steel/ truss roofs											X	
	Masonry building with cantilevers timber, rc and steel		X	X									X
	Masonry building with Steel, Timber, Bamboo roof/ slab	X				X		X					
	Different brick, adobe, stone pattern, texture						X			X	X	X	
	BUILDING'S EARTQUAKE ZONES	VERY HIGH						HIGH					

		DUST Tucson Mountain Retreat	BC ARCH. African Children Library	HERZOG DE MOURON Dominus Winery	ARCHIUM Radio Broadcasting Station	HBBH ARCH. Nk'Mip Desert Cultural Centre	PETER SASSENOTH AND RODOLF REITERMANN The Chapel Of	RUDANKO + KANKKUNEN The Sra Pou Vocational School 'S	DİÉBÉDO FRANCİS KÉRÉ Primary School	MAISON EDOUARD FRANÇOIS The Building that Grows	DOMINIKUS STARK ACHITEKTEN Education	TAKA House1+ House2	ANAGRAM ARCHITECT South Asian Human Rights Documentation
Traditional masonry Stereotomy with Timber	Masonry wall with Timber horizontal												
	Cross Wall												
	Courtyard				X								
	Interlocking Walls												
	Masonry wall with Buttresses		X										
	Masonry wall												
Stereotomy With Rc	Masonry wall with RC horizontal tie-beams	X					X		X		X	X	X
	Masonry wall with RC vertical tie-beams		X		X			X					
	Masonry wall with RC horizontal and vertical tie beam								X				
	Masonry wall with cavity wall											X	
	RC frame with load bearing masonry infill wall												
	RC share wall with load bearing masonry infill wall												
	Masonry wall combined with RC frame	X								X	X		X
Stereotomy With Steel	Masonry wall with steel vertical tie-beam										X		X
	Masonry wall with steel horizontal tie-beams												
	Steel frame with load bearing masonry infill wall												
	Gabion wall (stone field steel mesh			X						X			
	Masonry wall with steel bars	X						X					
	Masonry wall combined with steel frame			X								X	
Tectonic	Masonry walls with large openings, corner openings	X	X		X	X		X				X	
	Openings close to each other and close to corners	X							X				
	Full height openings	X	X		X				X			X	
	Masonry walls with irregularly arranged openings (Different size of openings located on different places on same wall)												
	Masonry building with large spans	X	X	X				X			X		
	Glass walls /glass surface (longer than 3m) /special shutter detail	X						X	X		X	X	X
	Steel, Timber, Bamboo frame without masonry wall(there can be non-load-bearing infill)					X							
	Masonry building with steel/ truss roofs		X	X		X	X		X				
	Masonry building with cantilevers timber, rc and steel									X			
	Masonry building with Steel, Timber, Bamboo roof/ slab			X	X								
	Different brick, adobe, stone pattern, texture	X			X	X	X				X	X	X
	BUILDING'S EARTQUAKE ZONES	MIDDLE				LOW							

Comparison of basic techniques of traditional and contemporary masonry were shown as newstereotomics exist (Table 5.32).

Table 5.32: Comparison of traditional masonry techniques with contemporary (By Author)

Traditional masonry building	**Contemporary masonry buildings**
The quality of building material is important	The quality of building material is important Different brick, adobe, stone pattern, texture
Foundation should be continuous	Foundation type can be varied
Corners cannot be empty	Openings are close to each other and close to corners evenly Corner openings exist
Rectangular small openings on same axial arrangement	Openings can be varied in any size, any shape and any place Masonry walls with large openings, corner openings, Full height openings Masonry walls with irregularly arranged openings (Different size of openings located on different places on same wall)
According to the length and load, wall thicknesses should increase for stone min.50 cm for adobe min.40 cm for brick min.20 cm	Thinner walls are possible with reinforcement, additional tie elements horizontally or/ and vertically
Masonry system is used as the singular system and generally timber roof and slab were used.	Structure system can work together with other structural systems such as steel, concrete frames. Masonry building with truss roofs Masonry building with cantilevers timber, rc and steel Masonry building with Steel, Timber, Bamboo roof/ slab

According to the hypothesis of this thesis;

- Tectonic elements are used in contemporary masonry structures; it is also shown in Table 5.31.

- Table 5.31 also shows that masonry structural elements other than elements of traditional masonry are used (only two of them made full of traditional elements which is shown in Table 5.9 and Table 5.21)
- According to observations, the ones which are reinforced with steel or rc or combined with frame systems, provide to challenge the size and layout of openings, challenge span size and the more thin perforated walls occurred. In this way both visual and technical qualities are presented with traditional and contemporary effects simultaneously.

These cause a change in the meaning of stereotomics which is heavy, mass, solid wall replaced by more light, punctured walls. This helps to speak of newstereotomics on the wall. In the Table 5.33 it is shown that these changes occur in a comparative way in between contemporary and traditional in case of earthquake resistance precautions.

Table 5.33: Comparison of traditional masonry techniques with contemporary due to ways to increase the durability of the walls for earthquake resistance. (By Author).

In traditional masonries for increasing durability of the walls for earthquake resistance the following are applied;	In contemporary masonries for increasing durability of the walls for earthquake resistance the following are applied;
-cross-walls either interior or exterior wall intersections, -buttresses in various places on wall, -timber/bamboo/vertical tie-beams in long walls, -sometimes having only one floor, -increasing wall thickness proportional to wall height and length, -using a light roof system increases the earthquake resistance of masonry buildings.	Masonry system with frame systems or even share walls, -Reinforced concrete foundations, -Reinforced rc or steel lintels over openings, -Vertical and horizontal reinforcement with steel, rc ,bamboo, cane, chicken wire, etc.,
-These were increasing the stereotomic meaning of the wall.	-These decreased the stereotomic meaning of the wall.

As a result, Figure 5.18 shows the sequence of this chapter with findings. Thus ontologic reading model was defined and tested with 24 awarded buildings. Accordingly, 8 different types of techniques were identified by means of structural usage on masonry wall. Then, 4 main ontological structure categories were defined in case of masonry building. Based on the findings the hypothesis of this thesis proved that newstereotomics occurred with the contemporary masonry.

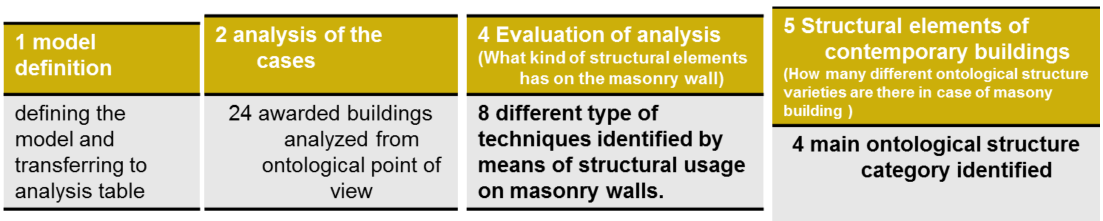


Figure 5.18: Summary of Chapter 5

Chapter 6

FIELD STUDY: AHMET IĞDIRLIGİL'S STONE HOUSES, BODRUM, TURKEY

Parallel to the analysis in Chapter 5, Architect Ahmet Iğdırlıgil's stone houses in Yalıkavak Bodrum was chosen for analysis from the tectonic point of view. There are three specific reasons in choosing these buildings.

1. There is no interpretation about the tectonics of Bodrum's contemporary stone masonry buildings in the literature of architecture.

2. These stone house projects were nominated as candidate to Aga Khan Prize 2009 Awards.

3. According to the limitations only 21st century contemporary masonry buildings are considered in this thesis, thus Iğdırlıgil's buildings are also recently done and are of latest examples of 21st century modern stone masonry buildings in Bodrum.

4. The most important reason is; according to the 2007 building code of Turkey, it is not possible to use these structures any more.

5. Bodrum in Turkey is one of the regions where original characteristics of the buildings are tried to be preserved and these characteristics have to be sustained in to future.

The stone houses in Bodrum are analyzed considering the relationship between concepts of ontology specific to the Bodrum region in Turkey. This is done by applying the model that was created in Chapter 5. The main objective of chapter 6 is to analyse Ahmet Iğdırlıgil's stone buildings from the tectonic point of view, which is an architectural theory based on concepts of ontology.

6.1 General overview and observations from Bodrum

Bodrum is a port city in Muğla Province, in the southwestern Aegean Region of Turkey. It is seen from the Figure 6.1 that it is located in a very high seismic zone.

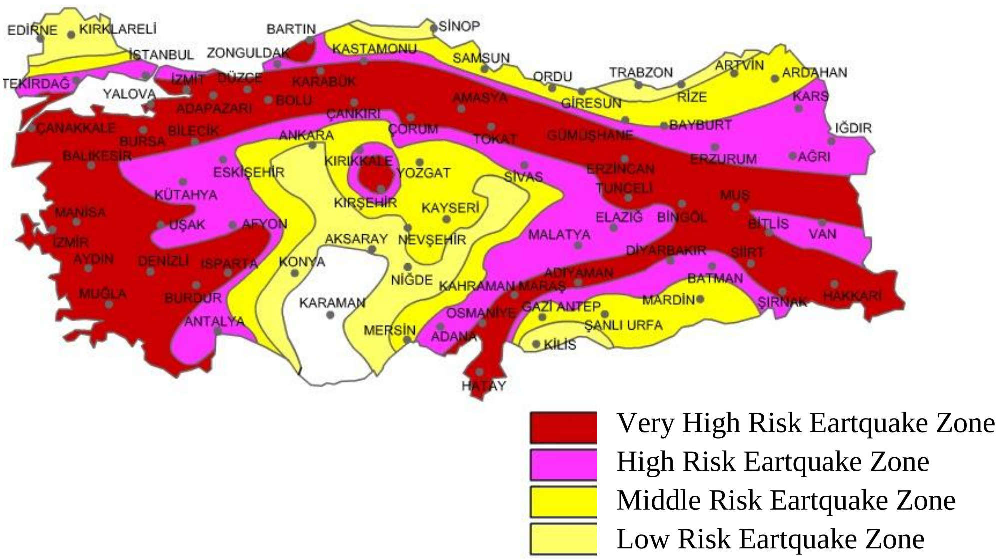


Figure 6.1: Turkey's earthquake zones (URL 20)

The traditional architecture of Bodrum is protected because of its geographical location. Lack of transportation was effective as Bodrum was a silent place till 60-

70's. In the beginning of the 70's, tourism was developed and most of the coastal cities started to be tourist destinations. As a result of these, hotels started to be more dominant in these places, different from other coastal cities. Bodrum keeps having the traditional Mediterranean architecture by developing housing instead of building big hotels.


Figure 6.2: Arial view of the city


Figure 6.3: Side view of the city

Nowadays, there are many hotels in Bodrum, but visitors prefer to stay in small scale boutique hotels which are converted from traditional houses. Local authorities encourage the architects to build as much as similar attitude with the vernacular context. But it is obvious that it has some contradictions between the regulations and built environment. Ayiran (2011) also mentioned in his research that under the name of "Architectural Continuity towards Cultural Sustainability in Bodrum", the region has ten municipalities and all of them have different building regulations, in some way or another. If the aim is to encourage architects to use "contextualist architecture" which is coherent with the vernacular architecture of Bodrum, he suggested that, there should be preservation of the main characteristics of Bodrum houses such as garden walls, courtyards, fireplaces in all regulations.

Cansever (1992) also explained the local architecture characteristics of Bodrum, as consistence of repetitive stone buildings with simple geometry. The wall surface punctured with small rectangular openings and the hearth (fireplace) (Figure 6.4). According to him, these are "the domestic architecture of the Bodrum". Additionally he took attention to the historic buildings from different periods, such as Greek and Ottoman periods. He added that all of these different periods' buildings were also made with local stone masonry system. This common characteristic can be seen on all the islands of Aegean Sea. The typical characteristics can be listed as follows;

- stone masonry buildings,
- buildings floored at two or three levels.
- having flat roofs and floor slabs both made out of timber
- small rectangular openings
- having inner gardens or courtyard with tall outside stone walls
- having the hearth(fireplace)

Figure 6.4: Some examples of traditional Bodrum architecture (by author)

As it is known, Mediterranean climate is moderate in winter and hot in summer. This consideration is almost seen in every traditional house in Bodrum. Organization of the urban settlement shows the main characteristics of the vernacular architecture of Bodrum. Basically, it can be divided into four considering climate; to get away from the heat is important in Mediterranean region so the streets are narrow to create shadow. To get benefit from the wind, street’s directions are open to the wind direction. Streets located perpendicular towards the sea for getting best benefits from the nature. None of these buildings close the view and sun of each other.

Focus of this chapter is contemporary stone masonry buildings in Bodrum. Stone buildings were the tradition of the Bodrum and the problem here is the impossibility of achieving a real stone masonry anymore according to 2007 building codes of Turkey. Analysis of the old and new techniques with stone masonry is needed in order to discuss the ontological dimension of the problem.

It is necessary to remember that, there are two extremes in this area:

i. One is principles of architectural history which is generally comparison of styles to discuss about ontology

ii. Most of the studies analysed buildings according to only spatial arrangement, space quality, form or functionality.

In the absence of such critical analysis, it is common to fail to realize that ontology is something between these two extremes and when discussing they should be together and balanced.

The aim of this study is to discuss the concept of ontology by considering contemporary technology in case of masonry structures. This concept will be clarified through examples, and for this purpose Ahmet Iğdırlıgil’s stone houses are chosen in order to discuss the ontological characteristic of buildings and compare with building codes.

As it is mentioned in pervious sections, technical necessity is important, uniqueness, difference from others, aesthetics, traditional and contemporary effects of the structural elements should be considered in order to reach the tectonic design.

Architect Turgut Cansever in 1987 designed Demir Village in that region. With this project he won the Aga Khan Award in 1992. In these buildings stone masonry structure have been used with reinforced concrete horizontal tie beams in each floor level and top of the walls. Some of the slabs and the four sides of the openings are made of exposed concrete.

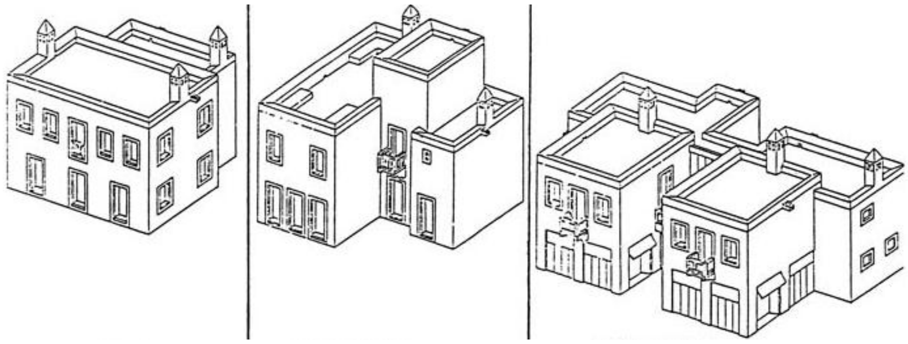


Figure 6.5: Different types of houses in Demir Village (Khosla, 1992)

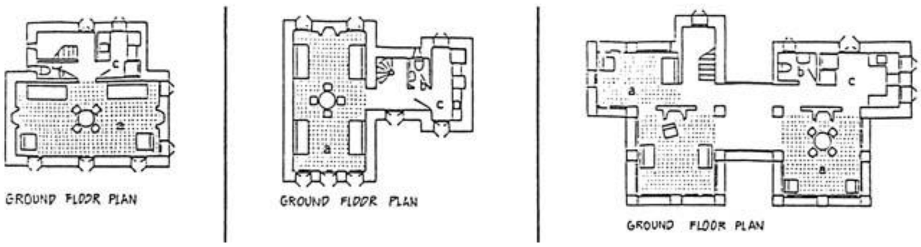


Figure 6.6: Plan arrangement of the buildings (Khosla, 1992).

Figure 6.7: View from the Demir village (Khosla, 1992).

On the other hand, the buildings have been criticized negatively by local architects and people. This was because of the presence of concrete ties placed on the stone facade. This can be seen as an aesthetic problem, but it has deep and right reasons behind it and these are symbolic and cultural values. It can be said that, the building shows its structure system in a correct way which consists of load bearing stone walls with exposed concrete tie beams. However, showing the concrete ties on stone surface decreases the possibility of having a meaningful, authentic local architecture of Bodrum, which is inadequate in comparison to traditional examples. However contemporary effects of the structural elements should be considered in order to reach the tectonic design.

6.2 Yalıkavak Stone House Settlements

According to the interview conducted with the local architect Ahmet Iğdırlıgil, due to intense urbanization and construction in Bodrum, Iğdırlıgil tried to find a solution for Bodrum with these projects and the solution was the houses located in Yalıkavak which is 15 km away from Bodrum. The area is a kind of hillside and consists of 36,000 m2 for six separated houses. Infrastructure expenses were common for all owners. However, houses were designed according to owner’s needs and budget. Also, each of them is planned independently from each other.

Figure 6.8: Arial view of the Ahmet Iğdırlıgil's stone houses

When he is explaining his concept and his philosophy of design, he states that;

> "…Dimensions were taken from traditional Bodrum houses; air circulation, climate, direction of the sun; topography and natural environment were always in my responses. Of course local architectural context and lessons from the local carpenters are very important and valuable for my designs. These considerations play big role about the decisions of building heights, space dimensions, functionality, people's needs, culture and tradition."

Also, he raised attention of how the culture and people's lifestyle play a determinant role in design. He explained with an example; "...when you look at the life style of Bodrum, for nearly 7 months we are living in outside of the house..." and it is very important for whole region. It is a special meaning for everybody to sit outside of the house, having breakfast, lunch, dinner, drinking coffee etc...

It can be said that, it is the tradition of the Mediterranean region so gardens should be incorporated into the design while you are designing the building. Also these gardens have a special name, called ‘hayat’.

From architectural point of view, the architect was inspired from local architecture and responded to the needs of today to create a contemporary architecture. That is why he used stone masonry structural system, which consists of natural material. Secondly, he tried to keep natural environment unharmed, such as topography and trees. Thirdly, the positions of the houses are according to the cool summer breeze and sun direction to take the best benefit from the sun. It can be said that natural environment has shaped the design.

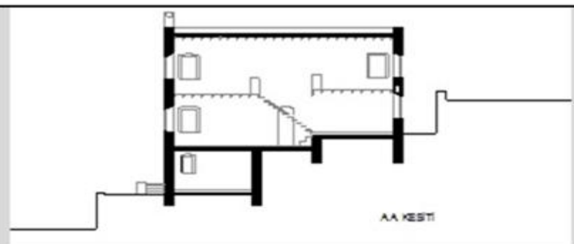
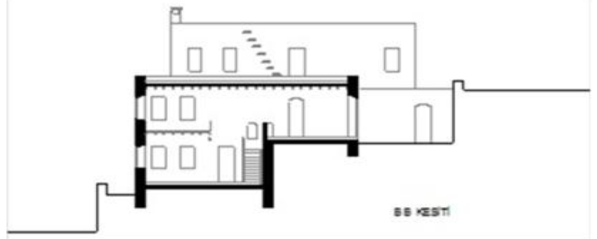
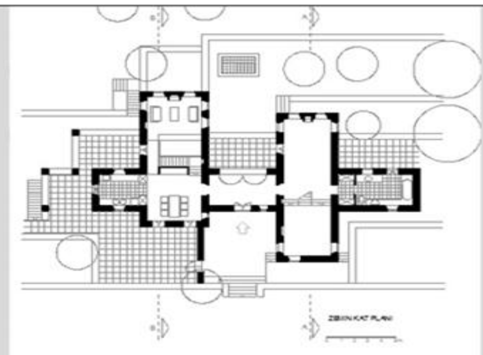
From architectural point of view, the main structure system is stone masonry system. It consists of load-bearing stone walls. However, there is reinforced concrete horizontal tie beam on top of the walls. It helps to tie them better for earthquake resistance. In traditional stone buildings, stone foundation was being used. Different from the traditional stone buildings, reinforced concrete continuous foundations were used in here. He mentioned the main problem in traditional stone houses was that the walls became segregated from each other, now they are using a kind of vertical stone in between other stones which decreases the vulnerability about any movement of the building. This stone has a special kind of flexibility because it has significant amount of iron inside. It is called ‘hellik’ stone.

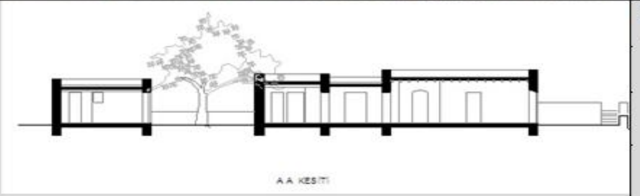
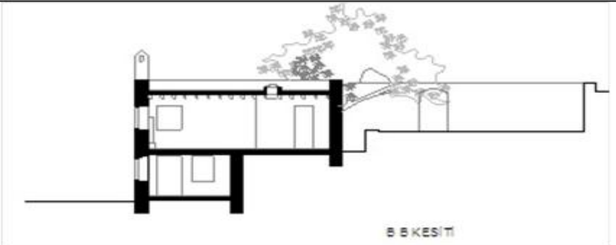
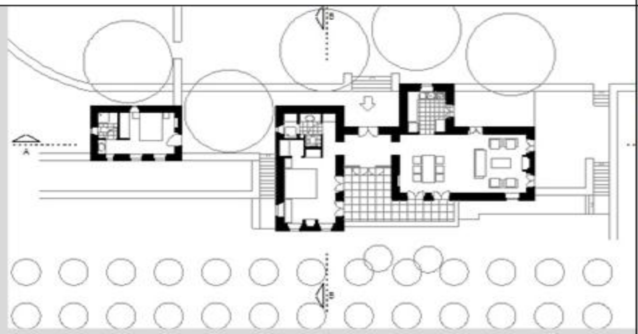
As a result, it can be said that each building was designed independently according to owners’ budget and needs. The only difference between the buildings is the size. But for the design philosophy, use of material structure system is the same for all. The storeys of the buildings and height of the spaces can vary up to 8 meters. Maximum span distances were 4m because of timber slabs and roof.

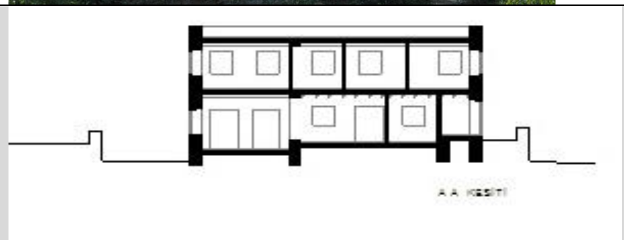
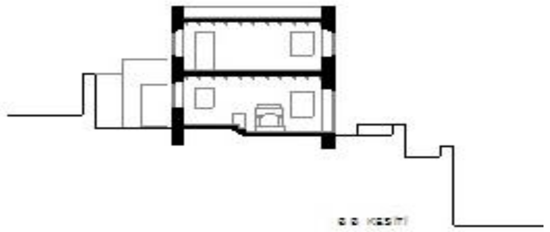
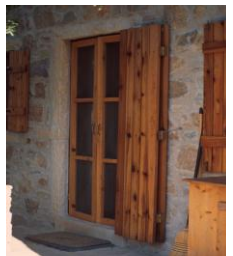
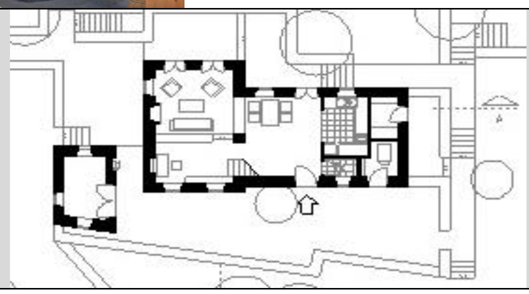
In the view of analysis, nowadays, it is impossible to build this kind of houses because of 2007 building code of Turkey. In these stone houses slabs are timber and walls are completely load bearing structural elements. There is no rc. vertical tie beam between the walls, just horizontal tie beams turning through top of the walls. Igdirligil also said that;

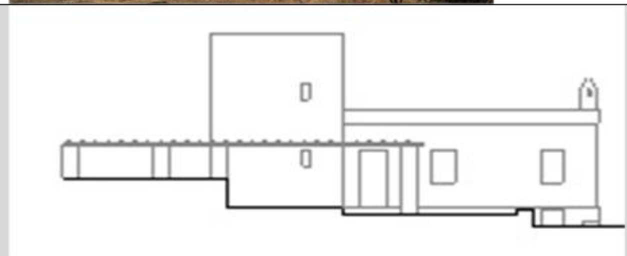
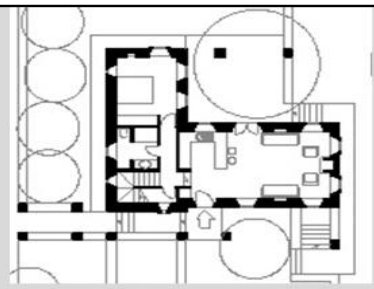
> "We can build houses which seems like stone house but structurally fitting to the regulations. The structure system needs to change to the simple frame which consists of r.c slabs and horizontal/vertical (column/beam) r.c structural elements. There are no vertical tie beams in these buildings but all walls are 50 cm max. span 4 m. "In my opinion it is against the nature of the masonry building system to have and see rc column in the middle of the stone wall. As a matter of fact, safety is important, but we experienced the earthquake up to 6 seismic intensity and just a few cracks occurred in the buildings in this region. Thus, this does not mean that masonry system should be completely changed to another system. On the contrary, with the developing technology we can reach more strengthened masonry systems, as in the world you can find more examples. These attempts of improvements on masonry buildings are more honest" (based on interview with Ahmet Igdirligil).

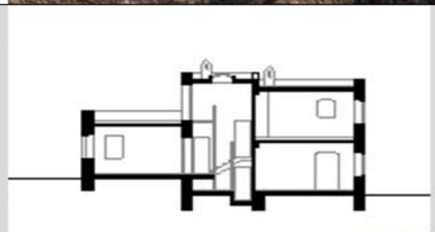
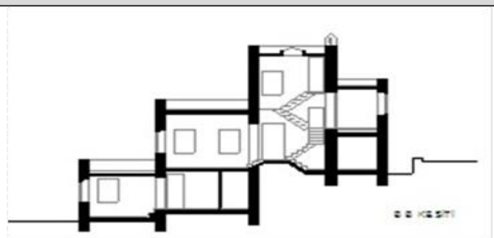
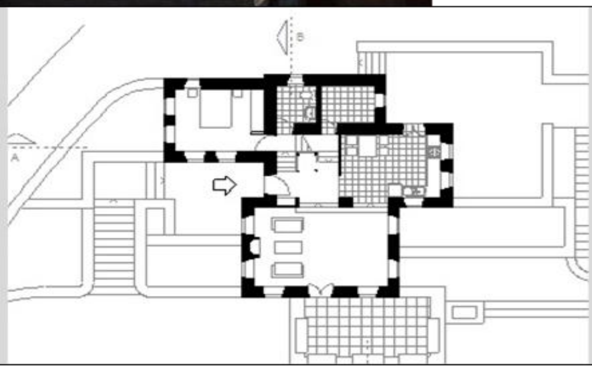
Between Table 6.1 and Table 6.6 the fields study analysis (Ahmet Igdirligil's stone houses) are shown.

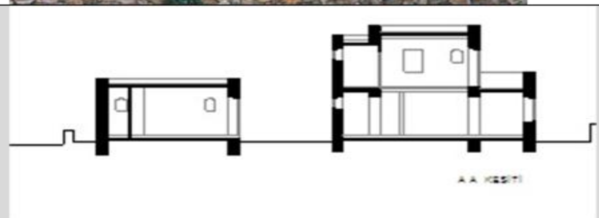
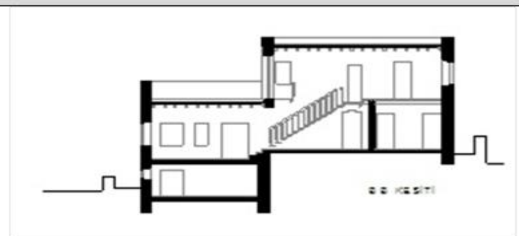
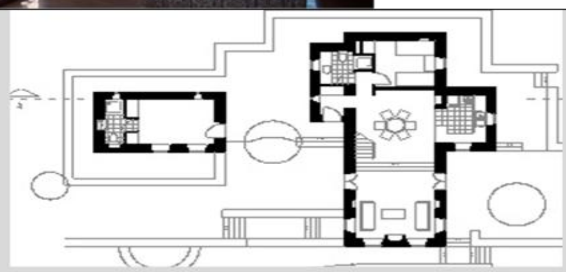
Structural elements of masonry	Technical Reasons/Solutions	TABLE 6.1:AHMET IGDIRLIGIL HOUSE	Visual Reasons/Solutions	Evaluation criteria			Building Codes/building regulations about stone masonry	The effects of ontology in the views of tectonic design approach
1.Wall material	**Stone** Unplastered natural stone gave the strong effect of continuation of the old traditional Meditarranean architecture. **Timber** Timber slabs, stairs and roof. The size of the spaces is also according to the materials avalibility. For example slabs and roof consist of timber and the dimensions of the timber is max. 4m or 5m long because of this, timber became a determined factor for spaces.		This technical solution creates simple rectangular prizm and modular units which is in repeation of the traditional Mediterranean architecture of Bodrum. Unpainted/unplastered surfaces of outside and unplastered just painted interior walls represent the nature of the material aesthetically.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	T+A		Buildings are artificial on the mountain, at the same time natural. Stone walls/prism made buildings belong to its environment. This relationship creates an ontological meaning.
2.Wall height /length	2 storey building, differs from 7 m to 8m for gave better air circulation Max.lenght of the wall 8 m(Without vertical support)		Changes of the wall height created a dynamism of form and gave emphasis to the usage of the topography. This also meets with todays requirements.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	T+A	Max 3m height Max.7.5 m lenght If it is more than this then to use rc vertical tie beams is needed.	Best advantage of the mountain used and integrated buildings into slope. It can be understood from the sections and top view that the buildings and topography relationship is very strong. This relationship creates an ontological meaning.
3.Structural elements of wall	Load bearing stone wall and reinforced concrete horizontal tie beams used in each storey		Stone walls standing as load bearing element at the same time texture gives diffirent nuance to the building. Structure shows themself as it is at the same time standing with whole aesthetices	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	T	**Rc Horizontal tie beams** should be equal to the wall with and max 20 cm height.it is required to use between slabs and load bearing walls. **İf wall lenght more than 7.5 m** rc vertical tie beams required to use each 4m.	Structurally, stone walls work as load bearing elements and carry the floor and roof. The wall and ceiling junctions are very unusual, because the horizontal tie beams are hidden, so structure is hidden somewhat. Departures from this hidden idea, these joint details are used scenographically. The architect do not show structure as it is.
4.Wall thickness	60 cm wall.This wall thickness is required for masonry structure system. on fire place max 70 cm thick wall	 Outside  Inside	Wall thicknesses gave strong effect to the structure. We can understand that the walls have a big role in the structure and representing wall streotomics with heavy mass outlook.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ 	T	Min. 50 cm	According to masonry system wall thickness is necessary and we feel strong heavy structure and the naturality. But there is no differences from the traditional wall so ontology could not be achive.
5.Openning size and placement on the wall	**Placement :** Approx.50-30 cm far away from the corners distance between the openings varied approx. 50-100 cm. **Opening size:** varied between 50-100-150 cm More than 3m glass surface in the middle of building		Big windows in middle part and dense windows show us challenge with masonry wall. They create visual connection from environment and balanced the heaviness of the stone wall with transparency. Stereotomy and tectonic of wall achived.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	T+A	Max 3m opening size/span on the plan lenght **For external walls:** Min 1 m from the corner Min 1 m distance between 2 openings **For internal walls:** Min 50 cm from the corner Min 50cm distance between 2 openings	When we look at the building from outside we can feel the balance and solid/ void relationship between solid wall and openings. Opening size and numbers are more than traditional ones. It was a necessity for better light and ventilation. It is the different from the tradition with this way ontology is achived.
6.Placement of the walls on the plan	The majority of the axis are gridal just a few of them are not continuous. But it seems like balanced.		There is not symmetry in the plan. The building has a simple geometry consisting of a rectangular prizm which creates a kind of dynamisim on the plan arrangement. Gave emphasis to the solid/ void relationship. It is effecting 3 dimensional spaces as well.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	T+A	Plan arrangement (walls placement) should be ordered and axis must be symmetrical or close to symmetrical organization.	If we look at traditional buildings we can not see that much fragmented plan arragement. According to today needs functions are increased, more privacy in the homes created necessity to seperated spaces as service public and private areas.These are effected the plan. The hierarchy of the spaces are readable and diffirent from the traditional. By this way ontology is achived.

Structural elements of masonry	Technical Reasons/Solutions	TABLE 6.2:ANN HOUNTING RESIDANCE	Visual Reasons/Solutions	Evaluation criteria			Building Codes/building regulations about stone masonry	The effects of ontology in the views of tectonic design approach
1.Wall material	**Stone** Unplastered natural stone gave the strong effect of continuation of the old traditional Mediterranean architecture. **Timber** Timber slabs, stairs and roof. The size of the spaces is also according to the materials avalibility. For example slabs and roof consist of timber and the dimensions of the timber is max. 4m or 5m long because of this, timber became a determined factor for spaces.		This tecnical solution creates simple rectangular prizm and modular units which is repeation of the traditioal mediterranean architecture of bodrum. Unpainted/unplastered surfaces of outside and unplastered just painted interior walls represents the nature of the material aesthetically.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	T+A		Buildings are artificial on the mountain, at the same time natural. Stone walls/prism made buildings belong to its environment. This relationship creates an ontological meaning.
2.Wall height /length	2 storey building, differs from 3 m to 6m for Max.lenght of the wall 10 m(Without support)		Diffiriention of the wall height created a dynamism	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	T+A	Max 3m height Max.7.5 m lenght if its more than its require to use rc vertical tie beams	Best advantage of the mountain used and integrated buildings into slope. It can be understood from the sections and top view that the buildings and topography relationship is very strong. This relationship creates an ontological meaning.
3.Structural elements of wall	Load bearing stone wall and reinforced concrete horizontal tie beams		Stone walls standing as load bering element at the same time texture gives diffrent nuance to the building.Structure shows themself as it is at the same time standing with whole aesthetics	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	T	**Rc Horizontal tie beams** should be equal to the wall with and max 20 cm height.it is required to use between slabs and load bearing walls. **İf wall lenght more than 7.5 m** rc vertical tie beams required to use each 4m.	Structurally, stone walls work as load bearing elements and carry the floor and roof. The wall and ceiling junctions are very unusual, because the horizontal tie beams are hidden, so structure is hidden somewhat. Departures from this hidden idea, these joint details are used scenographically. The architect do not show structure as it is.
4.Wall thickness	60 cm wall.this dimension is required for masonry structure system. on fire place max 70 cm thick wall	 Outside  Inside	Wall thicknesses gave strong effect about the structure.we can understan that the walls has a big role in the structure.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ 	T	Min. 50 cm	According to masonry system wall thickness is necessary and we feel strong heavy structure and the naturality. But there is no differences from the traditional wall so ontology could not be achive.
5.Openning size and placement on the wall	**Placement :** Approx.30-50 cm far away from the corners distance between the openeings varied approx. 50-100 cm **Opening size:** varied between 50-100-150 cm		Big windows and dense windows show us challenge with masonry wall. They create visual connection from environment and balanced the heaviness of the stone wall with transparency.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	T+A	Max 3m opening size/span on the plan lenght **For external walls:** Min 1 m from the corner Min 1 m distance between 2 opening **For internal walls:** Min 50 cm from the corner Min 50cm distance between 2 opening	When we look at the building from outside we can feel the balance and solid/ void relationship between solid wall and openings. Opening size and numbers are more than traditional ones. It was a necessity for better light and ventilation. It is the different from the tradition with this way ontology is achived.
6.Placement of the walls on the plan	The majority of the axis are gridal just afew of them is not continous. But it seems like balanced.		There is not a symmetry in the plan. The building has a simple geometry consisting of a rectangular prizm which creates a kind of dynamisim on the plan arrangement. Gave emphasisi to the solid/ void relation ship.	Necessity	✓		Plan arrangement (walls placement) should be ordered and axis must be symmetrical or close to symmetrical organizsation.	If we look at traditional buildings we can not see that much fragmented plan arragement. According to today needs functions are increased, more privacy in the homes created necessity to seperated spaces as service public and private areas.These are effected the plan. The hierarchy of the spaces are readable and diffrent from the traditional. By this way ontology is achived.

Structural elements of masonry	Technical Reasons/Solutions	TABLE 6.3:ERIC BULL RESIDANCE	Visual Reasons/Solutions	Evaluation criteria			Building Codes/building regulations about stone masonry	The effects of ontology ın the vıews of tectonic design approach
1.Wall material	**Stone** Unplastered natural stone gave the strong effect of continuation of the old traditional Meditarranean architecture. **Timber** Timber slabs, stairs and roof. The size of the spaces is also according to the materials avalibility. For example slabs and roof consist of timber and the dimensions of the timber is max. 4m or 5m long because of this, timber became a determined factor for spaces.		This tecnical solution creates simple rectangular prizm and modular units which is repeation of the traditioal mediterranean architecture of bodrum. Unpainted/unplastered surfaces of outside and unplastered just painted interior walls represents the nature of the material aesthetically.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	**T+A**		Buildings are artificial on the mountain, at the same time natural. Stone walls/prism made buildings belong to its environment. This relationship creates an ontological meaning.
2.Wall height /lenght	2 storey building, 7 m height Max.lenght of the wall10 m(Without support)		There is no height diffrences which is not effected aestetics.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓	**T**	Max 3m height Max.7.5 m lenght if its more than its require to use rc vertical tie beams	Best advantage of the mountain used and integrated buildings into slope. It can be understood from the sections and top view that the buildings and topography relationship is very strong. This relationship creates an ontological meaning.
3.Structural elements of wall	Load bearing stone wall and concrete horizontal tie beams		Stone walls standing as load bering element at the same time texture gives diffirent nuance to the building.Structure shows themself as it is at the same time standing with whole aesthetics	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓	**T**	**Rc Horizontal tie beams** should be equal to the wall with and max 20 cm height.it is required to use between slabs and load bearing walls. **İf wall lenght more than 7.5 m** rc vertical tie beams required to use each 4m.	Structurally, stone walls work as load bearing elements and carry the floor and roof. The wall and ceiling junctions are very unusual, because the horizontal tie beams are hidden, so structure is hidden somewhat. Departures from this hidden idea, these joint details are used scenographically. The architect do not show structure as it is.
4.Wall thickness	60 cm wall on fire place max 70 cm thick wall	 Outside	Wall thicknesses gave strong effect about the structure.we can understan that the walls has a big role in the structure.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓	**T**	Min. 50 cm	According to masonry system wall thickness is necessary and we feel strong heavy structure and the naturality. But there is no differences from the traditional wall so ontology could not be achive.
5.Openning size and placement on the wall	**Placement :** Approx. 50 cm far away from the corners distance between the openeings varied approx. 50 cm **Opening size:** varied between 50-100		They create visual connection from environment and balanced the heaviness of the stone wall with transparency at the same time its very close to the traditional building aesthetics according to size and dense	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓	**T+A**	Max 3m opening size/span on the plan lenght **For external walls:** Min 1 m from the corner Min 1 m distance between 2 opening **For internal walls:** Min 50 cm from the corner Min 50cm distance between 2 opening	When we look at the building from outside we can feel the balance and solid/ void relationship between solid wall and openings. Opening size and numbers are more than traditional ones. It was a necessity for better light and ventilation. It is the different from the tradition with this way ontology is achived.
6.Placement of the walls on the plan	The majority of the axis are gridal just afew of them is not continous. But it seems like balanced.		There is not a pure symmetry in the plan but The building has a simple geometry consisting of a rectangular prizm which is more similar to the traditional building's plan arrangement.	Necessity	✓	**T**	Plan arrangement (walls placement) should be ordered and axis must be symmetrical or close to symmetrical organizsation	If we look at traditional buildings we can see this regtangular plan arragement. These are effected the plan. The hierarchy of the spaces are readable however it is close to the only traditional building. By this way ontology is not achived.

Structural elements of masonry	Technical Reasons/Solutions	TABLE 6.4: GEORGE BASS RESIDANCE	Visual Reasons/Solutions	Evaluation criteria			Building Codes/building regulations about stone masonry	The effects of ontology in the views of tectonic design approach
1.Wall material	**Stone** Unplastered natural stone gave the strong effect of continuation of the old traditional Meditarranean architecture. **Timber** Timber slabs, stairs and roof. The size of the spaces is also according to the materials avalibility. For example slabs and roof consist of timber and the dimensions of the timber is max. 4m or 5m long because of this, timber became a determined factor for spaces.		This tecnical solution creates simple rectangular prizm and modular units which is repeation of the traditioal mediterranean architecture of bodrum.Unpainted/unplastered Natural stone gave the strong effect of continuation of the old traditional meditarranean architecture.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	**T+A**		Buildings are artificial on the mountain, at the same time natural. Stone walls/prism made buildings belong to its environment. This relationship creates an ontological meaning.
2.Wall height /lenght	2 storey building, differs from 3 m to 6m Max.lenght of the wall11 m(Without support)		Diffriention of the wall height created a dynamic moduls.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	**T+A**	Max 3m height Max.7.5 m lenght if its more than its require to use rc vertical tie beams	Best advantage of the mountain used and integrated buildings into slope. It can be understood from the sections and top view that the buildings and topography relationship is very strong. This relationship creates an ontological meaning.
3.Structural elements of wall	Load bearing stone wall and concrete horizontal tie beams		surface represents the nature of the material but structure hidden somehow inside the building we can not see	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	**T+A**	**Rc Horizontal tie beams** should be equal to the wall with and max 20 cm height.it is required to use between slabs and load bearing walls. **İf wall lenght more than 7.5 m** rc vertical tie beams required to use each 4m.	Structurally, stone walls work as load bearing elements and carry the floor and roof. The wall and ceiling junctions are very unusual,incontrast to other buildings the horizontal tie beams are seen from outside, so structure reveal in this sense.
4.Wall thickness	60 cm wall on fire place max 70 cm thick wall	 Outside  Inside	Wall thicknesses gave strong effect about the structure.we can understant that the walls has a big role in the structure.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ 	**T**	Min. 50 cm	According to masonry system wall thickness is necessary and we feel strong heavy structure and the naturality. But there is no differences from the traditional wall so ontology could not be achive.
5.Openning size and placement on the wall	**Placement :** Approx. 50 cm far away from the corners distance between the openeings varied approx. 50 cm **Opening size:** varied between 50-100		Big windows in middle part and dense windows shows us challenge with masonry wall. They create visual connection from environment and balanced the heaviness of the stone wall with transparency.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	**T+A**	Max 3m opening size/span on the plan lenght **For external walls:** Min 1 m from the corner Min 1 m distance between 2 opening **For internal walls:** Min 50 cm from the corner Min 50cm distance between 2 opening	When we look at the building from outside we can feel the balance and solid/ void relationship between solid wall and openings. Opening size and numbers are more than traditional ones. It was a necessity for better light and ventilation. It is the different from the tradition with this way ontology is achived.
6.Placement of the walls on the plan	The majority of the axis are gridal just afew of them is not continous. But it seems like balanced.		L shape plan arrangement gives refrance to the taraditional arrangement.	Necessity	✓	T	Plan arrangement (walls placement) should be ordered and axis must be symmetrical or close to symmetrical organizsation.	If we look at traditional buildings we can not see that much fragmented plan aregement. According to today needs functions are increased, more privacy in the homes created necessity to seperated spaces as service public and private areas.These are effected the plan. The hierarchy of the spaces are readable and diffrent from the traditional. By this way ontology is achived.

Structural elements of masonry	Technical Reasons/Solutions	TABLE 6.5:NETIA PIERCI RESIDANCE	Visual Reasons/Solutions	Evaluation criteria			Building Codes/building regulations about stone masonry	The effects of ontology in the views of tectonic design approach
1.Wall material	**Stone** Unplastered natural stone gave the strong effect of continuation of the old traditional Meditarranean architecture. **Timber** Timber slabs, stairs and roof. The size of the spaces is also according to the materials avalibility. For example slabs and roof consist of timber and the dimensions of the timber is max. 4m or 5m long because of this, timber became a determined factor for spaces.		This tecnical solution creates simple rectangular prizm and modular units which is repeation of the traditioal mediterranean architecture of bodrum.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	T+A		Buildings are artificial on the mountain, at the same time natural.Stone walls/prism made buildings belong to its environment.
2.Wall height /lenght	2 storey building, differs from 7 m to 8m for gave better air circulation Max.lenght of the wall 8 m(Without support)		Changes of the wall height created a dynamism of form and gave emphasis to the usage of the topography. This also meets with todays requirements.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓	T+A	Max 3m height Max.7.5 m lenght if its more than its require to use rc vertical tie beams	Used best advantage of the mountain and integrated buildings into slope. It can be understood from the sections and top view that the buildings and topography relationship is very strong. This relationship creates an ontological meaning.
3.Structural elements of wall	Load bearing stone wall and concrete horizontal tie beams		Surface represents the nature of the material but structure hidden somehow inside the building we percieve it.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	T+A	**Rc Horizontal tie beams** should be equal to the wall with and max 20 cm height.it is required to use between slabs and load bearing walls. **İf wall lenght more than 7.5 m** rc vertical tie beams required to use each 4m.	Structurally, stone walls work as load bearing elements and carry the floor and roof. The wall and ceiling junctions are very unusual, because the horizontal tie beams are hidden, so structure is hidden somewhat . Departures from this hidden idea, these joint details are used scenographically. The architect do not show structure as it is.
4.Wall thickness	60 cm wall.this dimensin is required for masonry structure system. on fire place max 70 cm thick wall	  Outside Inside	Wall thicknesses gave strong effect about the structure.we can understan that the walls has a big role in the structure.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓	T	Min. 50 cm	According to masonry system wall thickness is the necessary and strongly we are feeling heavy structure and the naturality by this way but there is no differences from the traditional wall so ontology couldnt achive
5.Openning size and placement on the wall	**Placement :** Approx.50-30 cm far away from the corners distance between the openeings varied approx. 50-100 cm **Opening size:** varied between 50-100-150 cm		Big windows and dense windows show us challenge with masonry wall. They create visual connection from environment and balanced the heaviness of the stone wall with transparency.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	T+A	Max 3m opening size/span on the plan lenght **For external walls:** Min 1 m from the corner Min 1 m distance between 2 opening **For internal walls:** Min 50 cm from the corner Min 50cm distance between 2 opening	When we look at the building from out side you can feel the balance and solid/ void relationship between solid wall and openings.Opening size and numbers are more than traditional ones.it was necessity for better light and ventilation at the same time it is the different from the tradition with this way ontology achived.
6.Placement of the walls on the plan	The majority of the axis are not gridal and walls are not continous.		There is not a symmetry in the plan. The building has a simple geometry consisting of a rectangular prizm which creates a kind of dynamisim on the plan arrangement. Gave emphasisi to the solid/ void relation ship.	Necessity	✓	T+A	Plan arrangement (walls placement) should be ordered and axis must be symmetrical or close to symmetrical organizsation.	İf we look at traditional buildings we cant see that much fragmented plan arragement. According to today needs functions are increased, more privacy in the homes created necessity to seperated spaces as service public and private areas.These effected to the plan.the hierarchy of the spaces are readable and diffirent from the traditional. By this way ontology achived.

Structural elements of masonry	Technical Reasons/Solutions	TABLE 6.6: YAKUP ICGOREN RESIDANCE	Visual Reasons/Solutions	Evaluation criteria			Building Codes/building regulations about stone masonry	The effects of ontology in the views of tectonic design approach
1.Wall material	**Stone** Unplastered natural stone gave the strong effect of continuation of the old traditional Meditarranean architecture. **Timber** Timber slabs, stairs and roof. The size of the spaces is also according to the materials avalibility. For example slabs and roof consist of timber and the dimensions of the timber is max. 4m or 5m long because of this, timber became a determined factor for spaces.		This tecnical solution creates simple rectangular prizm and modular units which is repeation of the traditioal mediterranean architecture of bodrum.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effects	✓ ✓ ✓ ✓ ✓	T+A		Buildings are artificial on the mountain, at the same time natural.Stone walls/prism made buildings belong to its environment.
2.Wall height /lenght	2 storey building, differs from 7 m to 8m for gave better air circulation Max.lenght of the wall 7 m(Without support)		Changes of the wall height created a dynamism of form and gave emphasis to the usage of the topography. This also meets with todays requirements.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	T+A	Max 3m height Max.7.5 m lenght if its more than its require to use rc vertical tie beams	Used best advantage of the mountain and integrated buildings into slope. It can be understood from the sections and top view that the buildings and topography relationship is very strong. This relationship creates an ontological meaning.
3.Structural elements of wall	Load bearing stone wall and concrete horizontal tie beams		Surface represents the nature of the material but structure hidden somehow inside the building we cannot see it directly.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓	T	**Rc Horizontal tie beams** should be equal to the wall with and max 20 cm height.it is required to use between slabs and load bearing walls. **İf wall lenght more than 7.5 m** rc vertical tie beams required to use each 4m.	With the use of rc horizontal tie beams he reached the big spans for openings ,in contrast to the heavy structures of wall gave the lightness and modern sense to the building.
4.Wall thickness	60 cm wall.this dimensin is required for masonry structure system. on fire place max 70 cm thick wall	  Outside Inside	Wall thicknesses gave strong effect about the structure.we can understan that the walls has a big role in the structure. Wall thicknesses gave strong effect about the structure.we can understan that the walls has a big role in the structure.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓	T	Min. 50 cm	According to masonry system wall thickness is the necessary and strongly we are feeling heavy structure and the naturality by this way but there is no differences from the traditional wall so ontology couldnt achive.
5.Openning size and placement on the wall	**Placement :** Approx.50-30 cm far away from the corners distance between the openeings varied approx. 50-100 cm **Opening size:** varied between 50-100-150 cm		A huge window in first floor shows us challenge with masonry wall.	Necessity Uniqueness Aesthetics Traditional & Contemporary Effefcts	✓ ✓ ✓ ✓	T+A	Max 3m opening size/span on the plan lenght **For external walls:** Min 1 m from the corner Min 1 m distance between 2 opening **For internal walls:** Min 50 cm from the corner Min 50cm distance between 2 opening	Big windows frame the surround environment vision and gave lightness and modern sense to the building. With the use of rc horizontal tie beams he reached the big spans for openings
6.Placement of the walls on the plan	The majority of the axis are gridal just afew of them is not continous. But it seems like balanced.		There is not a symmetry in the plan. The building has a simple geometry consisting of a rectangular prizm which creates a kind of dynamisim on the plan arrangement. Gave emphasisi to the solid/ void relation ship.	Necessity	✓	T+A	Plan arrangement (walls placement) should be ordered and axis must be symmetrical or close to symmetrical organizsation.	If we look at traditional buildings we cant see that much fragmented plan arragement. According to today needs functions are increased, more privacy in the homes created necessity to seperated spaces as service public and private areas.These effected to the plan.the hierarchy of the spaces are readable and diffirent from the traditional. By this way ontology achived.

According to ontological reading model of this thesis Ahmet Iğdırlıgil's stone houses are in category of old (traditional masonry wall) and new (RC horizontal ties) structure. Only reinforced concrete horizontal tie beams were used to strengthen the stone masonry wall.

Accordingly, the results which are mentioned below show that it is not possible to construct this kind of stone masonry building because of 2007 Building Code of Turkey. (These qualities can be seen from Table 6.1to Table 6.6.)

- Wall heights and lengths considered both visual and technically including both the representation of contemporary and traditional effects. According to 2007 Building Codes of Turkey in some of the long walls needed vertical RC ties.
- Structural elements of wall were used only for technical purposes; visual effect of horizontal rc tie beam did not show any of examples. Only one of the buildings represents rc horizontal tie beam on top of the building but this is also covered with stone (this part extended outside of the wall) which is shown in Table 6.4, George Bass Residance. According to 2007 Building Codes of Turkey only horizontal ties is not sufficient. There is a requirement for existence of both horizontal and vertical ties.
- Wall thicknesses all show the technical and visual effects. They represent wall streotomy visually and technically they are of sufficient thickness as in traditional. However there is no contemporary effect. According to 2007 Building Codes of Turkey wall thickness is acceptable.
- Opening size and placement on the walls both represent contemporary and traditional effects. Solid walls and voids (openings) are much denser when compared to the walls of traditional masonry and more visually representing

themselves. However the placement on the wall is regular and axial as in traditional. According to 2007 Building Codes of Turkey opening size and placement is not acceptable because most of them are close to each other and close to the corners.

- Placement of the walls on the plan is much more fragmented (asymmetric) according to the traditional thus repreats contemporary effects. According to 2007 Building Codes of Turkey Plan arrangement (walls placement) should be ordered and axis must be symmetrical or close to symmetrical organization thus the arrangement of the walls is not covering the requirements of the building code.

Chapter 7

CONCLUSION

The concept of tectonic was placed in architecture as much as architectural theory. In the previous chapters it was seen that the first known definition was done by Vitruvius. It is an undeniable fact that, industrialization and the idea of globalization had led to change the perceptions of architectures. At this point, two things are always questioned in architecture; one is that 'what architecture is' and the second is 'how can the values and qualities of architecture be defined or evaluated'. In this thesis, from the tectonic point of view, the subject was examined in the effect of ontology. The results showed that whenever the technology is changed the system was changing.

In this research tectonic theory was used with the concept of ontology and structural elements of contemporary masonry systems were categorized accordingly. That was the main objective of the thesis. Present methods and new techniques of masonry systems come out with this study.

Departing from the theories which were comprehensively identified in the thesis, an ontological reading model was created to evaluate the ontological structure category of the building according to its structural elements. New structural principles were discovered by applying this model. Additionally this ontology model is applicable for all masonry types. With this model, the differences or new systems in the future can easily be found like in this thesis.

Based on the research questions of this thesis, there is a number of structural system and constructional methods observed by the help of ontology model. A total of 4 different ontological structural categories with 8 different types of technique were identified by means of using structural element on masonry wall.

In all cases, it was tried to use the properties of building materials in order to create better buildings, larger spans, lighter and economic structures. Architecture does not use them only because of their structural or functional values. These are structure systems on their own. Architecture tries to express and communicate ideas or feelings through them by choosing and applying appropriate and effective system and methods for its own purpose. It must be pointed out again that human beings have more experience with traditional masonry structures. This is the reason that with the developing technologies, we can improve them more easily according to needs of our epoch.

In this thesis it was found out that, due to analysis in Chapter 5, based on Table 5.31, 12 buildings were located in high and very high earthquake seismic zones. It can be seen in Table 7.1.

Table 7.1: Structural elements that used in the high and very high risk earthquake zones

TABLE X: ONTOLOGICAL CATEGORY STRUCTURE OF THE BUILDING ACCORDING TO STRUCTURAL ELEMENTS

Building Name	Traditional masonry Stereotomy with Timber						Stereotomy With Rc							Stereotomy With Steel						Tectonic										
	Masonry wall with Timber horizontal tie-beams	Cross Wall	Courtyard	Interlocking Walls	Masonry wall with Buttresses	Masonry wall	Masonry wall with RC horizontal tie-beams	Masonry wall with RC vertical tie-beams	Masonry wall with RC horizontal and vertical tie beam	Masonry wall with cavity wall	RC frame with load bearing masonry infill wall	RC share wall with load bearing masonry infill wall	Masonry wall combined with RC frame	Masonry wall with steel vertical tie-beam	Masonry wall with steel horizontal tie-beams	Steel frame with load bearing masonry infill wall	Gabion wall (stone field steel mesh)	Masonry wall with steel bars	Masonry wall combined with steel frame	Masonry walls with large openings, corner openings	Openings close to each other and close to corners	Full height openings	Masonry walls with irregularly arranged openings (Different	Masonry building with large spans	Glass walls /glass surface (longer than 3m) /special shutter detail	Steel, Timber, Bamboo frame without masonry wall(there can be non-load-bearing infill)	Masonry building with steel/ truss roofs	Masonry building with cantilevers timber, rc and steel	Masonry building with Steel, Timber, Bamboo roof/ slab	Different brick, adobe, stone
MONICA PONCE DE LEON AND NADER TEHRANI Tongxian Gate House																														
BANGKOK PROJECT STUDIO Kantana Film And Animation Institute																														
CM ARCHITECTURE Noxx Apartment																														
AZL ARCHITECTS Brick House																														
RDR ARQUITECTOS Buenos Mares House																														
BEIJING STUDIO ATELIER TEAMMINUS Jianamani Visitor Centre																														
MAP /MX+GRUPONODUS Z53 Social Housing Complex							X						X	X											X					X
MAURICIO ROCHA Campamento de Edificios Públicos						X													X	X	X	X							X	
HAN TUMERTEKIN B2 House												X								X		X		X	X					
ABCT ARCHITECTURE Apartment no 1											X									X	X	X	X					X		
ANNA HERİNGER, EİKE ROSWAG Hand-Made School						X														X		X						X		
MAURİCİO ROCHA School Of Plastic Arts																	X		X	X	X		X	X					X	

According to the results of research, Table 7.1 shows ontological categories of structural elements by considering earthquake zones as follows;

- Four building have masonry wall with rc horizontal tie beam combined with rc frame. (In Figure 7.1: 1^{st} ,4^{th} ,5^{th} and 7^{th} row)
- One of the buildings has masonry wall with steel horizontal tie beam and steel vertical tie beam and combined with steel frame. (In Figure 7.1: 2^{nd} row)
- One of the example has unreinforced masonry wall without any additional elements. (In Figure 7.1: 11^{th} row)
- One of the examples has masonry wall with timber horizontal ties. (In Figure 7.1: 6^{th} row)
- One of the building has masonry wall with steel bars and combined with rc frame system. (In Figure 7.1: 12^{th} row)

- One of the examples has unreinforced masonry wall with steel (cross bracing) frame. (In Figure 7.1: 8th row)
- One of the examples was made by steel frame and masonry infill walls. (In Figure 7.1: 3th row)
- One of the examples was made by rc shear wall and masonry infill walls. (In Figure 7.1: 9th row)
- One of the examples was made by rc frames and masonry infill walls. Figure 7.1: 7th row)

From material point of view; five of them were constituted from brick masonry, five of them were constituted from stone masonry, only one was of adobe masonry, and one was of rammed earth masonry building. It can be asserted that; the brick masonry and stone masonry buildings are preferred more than adobe masonries for high earthquake risk areas.

From structural point of view, six different systems were used in different places of the world however; earthquake seismic zones are the same for all. The important point in here is that masonry and steel elements or masonry and reinforced concrete elements or both of them were used together. However, unreinforced masonry was used in the high risk earthquake areas. On the other hand, 2007 building code of Turkey considered only one type of reinforced system and only recommended one material; that is reinforced concrete for all masonry types to increase the building strength. Additionally the appropriateness of the materials was not considered.

In terms of the construction of masonry structures today, enacted in 2007, for a building to be described as earthquake resistant, the building should be constructed according to the design rules for masonry buildings as stated by the regulations which can be seen in section 5. However, the use of horizontal timber beams or slabs for masonry structures that will be built in accordance with the regulations are not concerned. It is only described that the use of horizontal timber beams is only in adobe masonry structures. Regulation describes the principles related to the regulation of horizontal beams in the adobe structure; in reality similarities with the traditional system are shown. Nevertheless, on the stone and brick masonries it is impossible to tell.

In this context, studies of Hughes under the name of “Hatil Construction in Turkey” can be given as examples. The earthquake resistance of masonry structures used to support the walls of horizontal timber beams is quite substantial effect has been shown in studies conducted on this subject (Hughes, 2000). In this study, three different models were tested on earthquake stand. Three examples are of masonry built with stone. In the first example, only timber lintels were used over the openings. However, other support elements were not used in the walls. In the second example the wall was supported by horizontal reinforced concrete beams with three different heights and corner stones were used. In the third example walls were supported by wooden beams in three different levels, yet the corner stones were used and timber lintels placed over openings. According to the result of the research the first example was seriously damaged. In the example which was supported by tie beams, partial damage was observed. Deterioration was seen in the case of the use of the horizontal timbers in the stone wall of the component. Deterioration of reinforced concrete beams used in a sample has occurred more in reinforced concrete elements themselves. These findings can be interpreted as; when compared to the reinforced concrete tie elements, timber elements have more elastic behavior (Hughes, 2000).

According to the cases that were analyzed in this thesis, reinforced concrete elements were used in the majority of examples. However, this does not mean that only this system is needed to be used. It is obvious that, developed countries like America, Australia, and European countries use calculation system for masonry buildings instead of referring, any kind of specific system like 2007 Turkey's building code. They developed their building code requirements with calculation system. According to specific calculations, if it is needed, they add additional reinforcement system to masonry buildings. The Turkish building code does not ask for a mathematical analysis for masonry structures. However, the number of storey, the height of floors, wall thickness, the use of reinforced concrete bond beams/slabs and the layout of openings are specified. Furthermore, if the length of any wall is more than 4.5 m, the building code demands the use of reinforced concrete vertical tie-beams every 4 m. This building code also suggests the use of reinforced concrete vertical tie-beams on the corners of buildings, at the intersections of walls and at both sides of all openings in order to increase the earthquake resistance of all masonry buildings (Ministry of Public Works and Settlement Government of the Republic of Turkey 2007). For example Ahmet Igdirligil's stone houses have timber slab and roof which is not appropriate for recent building code of Turkey. That quality of stone houses will not be achieved any more.

This problem occurs in northern Cyprus also because 2007 Turkey's building code is being used in northern Cyprus. The research under the name of *"Building Code Challenging the Ethics Behind Adobe Architecture in North Cyprus"* criticized also this problem from an ethical point of view. In the article authors state that; “the application of Turkish building code in the north of the island has created complications in respect of the use of adobe masonry, because this building code demands that reinforced concrete vertical tie-beams are used together with adobe masonry. They found out that the use of reinforced concrete elements together with adobe masonry caused problems in relation to the climatic response of the building as well as causing other technical and aesthetic problems” (Hurol, Yuceer, Sahali,2015). In the paper the limitations brought by building codes and the effects of these codes on the qualities of adobe masonry are studied by analysing two case studies determining which qualities of the adobe masonry were ignored whilst adhering to the requirements of the building codes, and the ethical problems behind this ignorance, is discussed with problematic examples which are created based on 2007 Turkey building codes.

Consequently, Hughes (2000) and Hurol, Yuceer, Sahali (2015) also mentioned similar problems of the 2007 building codes of Turkey and they were suggested parallel ideas with this thesis.

Depending on the research, the problems of masonry structures in case of Bodrum due to the requirements of 2007 building codes can be listed as follows:

1. The local characteristics of the buildings and the cultural values for people can be lost with the requirements of the building codes. For instance, in the case of Turgut Cansever’s project they criticize that authenticity of the traditional stone houses being lost with the use of concrete on surfaces.
2. The construction problem due to suggesting simultaneous use of modern masonry can cause masonry structure to become out of purpose.

a. They tend to look like reinforced frame structure rather than masonry. In this way, masonry wall can lose the importance on the building and it can be turned to infill wall. This means that there is no need to use masonry system because frame system can carry the building. For example in the analysis of the cases two of the buildings were located in Turkey, Han Tumertekin's B2 House (Table 5.6) and CM Architecture's Noxx Apartment (Table 5.17) and both of them used frame system as a main system and walls were turned to an infill wall.
b. Since adobe, stone and brick are sustainable building materials and they have good thermal qualities, with the use of reinforced concrete elements such as bond beams, slabs and vertical tie-beams, they can lose their thermal ability.

3. Instead of wasting time to produce masonry structure with such complex requirements, architects can prefer to use directly frame systems. This can lead to use of scenographic materials and structures. It can create problems and potentially lead to ignoring the design of buildings with masonry systems.

With a more considerate and inclusive preparation of building codes, these problems can be eliminated. In addition, the preparation of a restrictive building code, which forces architects to use certain types of building elements, without considering the general improvement of building quality, also contains problems. It is a better strategy for building codes to be more flexible to enable and facilitate different approaches to structural safety, which in turn enables better design. At least the code could be open to the use of different types of reinforced masonry rather than imposing one certain type.

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