Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi 26(1): 18-26 (2010)

Erciyes University Journal of the Institute of Science and Technology
Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi
http://fbe.erciyes.edu.tr
ISSN 1012-2354
Cilt (Volume) 26, Sayı (Issue) 1, Mart/March-2010

Depreme dayanıklı tasarım için Türkiye'de yığma yapıların yeniden canlandırılması

Saadet Toker[1], Aslı Er Akan[2], Semra Arslan Selçuk[3]
[1]*The University of Texas at San Antonia, Wyoming, USA*
[2]*Department of Architecture, Süleyman Demirel University, TR- 32260 Isparta, Turkey*
[3]*Department of Architecture, Süleyman Demirel University, TR- 32260 Isparta, Turkey*

Anahtar Kelimeler
Deprem Dayanımı
Yığma Yapı
Konut
Tuğla Üretimi

ÖZET

Türkiye'deki hızlı ekonomik büyüme ani nüfus artışına ve bununla beraber konut ihtiyacının artmasına sebep olmuştur. Bu nedenle ülkenin büyük bir bölümünde geleneksel konutlar yok olmaya başlamış ve binalar betonarme karkasa dönüşmüştür. Yaşam koşullarındaki ve teknolojideki değişimler geleneksel konutların modernizmin bir gereği olarak algılanan betonarme apartmanlara dönüşmesine sebep olmuştur. Sonuç olarak kentler ve köyler yerel özelliklerini yavaş yavaş kaybetmiştir. 1940'lardan beri bilinmekte olan güçlendirilmiş yığma yapı Türkiye'de kısıtlamalardan ve bu sistemin potansiyellerinin bilinmemesinden dolayı kullanılmamıştır. Bu çalışma yığma yapı sistemlerinin Türkiye'deki güçlü geçmişini ve tuğla endüstrisindeki gelişimi düşünerek deprem bölgelerinde güçlendirilmiş yığma yapıların potansiyelini inceleyip açığa çıkarmayı planlamaktadır. Dolayısıyla bu çalışmada ilk olarak yığma yapıların depremdeki performansları ve tuğla endüstrisi incelenmiştir. Çalışmanın amacı Türk yapı sektörüne yığma yapı sisteminin avantajlarını göstermek ve tuğlanın kullanımını canlandırmak amacıyla tuğla üretim kapasitesinin altını çizmektir.

Revival of masonry buildings in turkey for earthquake resistant design

Keywords
Earthquake Resistant
Masonry
Residential Buildings
Brick Production

ABSTRACT

Rapid economic growth in Turkey has given rise to a large city population with the need of housing. For this reason in the most parts of the country, the traditional building techniques has started to be disappeared; and the buildings turned out to have reinforced concrete structural frame. Alteration in living conditions and technological developments led to a sudden shift from traditional masonry houses to reinforced concrete apartment blocks, which were believed to represent modernism. As a consequence, towns and villages started to lose their own characteristics. The reinforced masonry construction has been known since 1940s. But, it is not applied in Turkey due to some reasons, limitations and unconsciousness about the potential of the system. Regarding the strong background of masonry in Turkey and the developments in brick and clay industry, this study explores the potential for reinforced masonry construction systems in earthquake prone areas. Starting with the seismic performance of both the plain and reinforced masonry, the study explores the brick industry in Turkey in order to assess its potential. The objectives are to demonstrate the advantages of the widely used system to those who deal with Turkish construction industry and to underline the production capacity of the material to revive its utilization.

* *Sorumlu yazar (Corresponding author) e-posta:* aslierakan@mmf.sdu.edu.tr

Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi 26(1): 18-26 (2010)

1. INTRODUCTION

With effect from the very early years after the proclamation of Turkish Republic, traditional housing units started to change in Turkey. These housing units could be seen as the reflections of the way of life of Turkish people due to their suitable layouts to accommodate two or three generations of the same family together. There was a sofa, generally used as the living room that also served as a passage to all the rooms around. The garden, or the court, depending on the climatic conditions of the region, is the other characteristic of the traditional Turkish houses. Since the buildings are of two or three storeys, the construction is masonry in general, the material of which is brick, stone or adobe. However, there started to be great changes especially after the 1950s, when Turkey faced with a new problem: rapid urbanization. These changes were obvious almost in every characteristic of residential buildings such as dimensions, location on the construction area, plan configuration, and structural system. The plans turned out to be the western "three rooms and a living room", which is nothing more than the arrangement of rooms along a corridor. This also brought the adjacent apartment blocks replacing the separate housing units. Another important change in this aspect is the sudden shift to reinforced concrete from traditional materials such as adobe, brick and wood.

There are several reasons for these serious changes, some of which could be listed as alterations in social and economic conditions, technological developments, lack of town planning policies and great increase in population. The enormous increase in population gave the start for unhealthy urbanization in 1950s. Another important effect is the radical alteration in the rural-urban balance, which is a result of sudden movement of migrants from towns to cities. This is mostly due to the deprivation of opportunities for health, education and cultural facilities that the rural areas generally suffer. It is undeniable that the urban areas become attractive in these aspects. And in parallel, the developments in technology that eased the agricultural facilities, which was one of the main ways of life in rural areas, led to the migration of many people to urban areas for employment. This was the beginning of the alert for accommodation problems. After 1950s, around 250.000 residences have been built in each year. This is the evidence of the great increase in population and the unhealthy urbanization. Other than this very rapid formation, the restrictions due to Town Planning Codes and Turkish Earthquake Codes might seem to be the causes of unhealthy development of the built environment. Because of these rules and regulations, architects have had to stay within the limits and as a result, every product has become to be evident from the very beginning (Toker, 2004, Bilgin, 2005, Bilgin 2005). In order to depict the effects of these limitations and the results of unconscious attempts, the building typologies of some small-scale cities in earthquake prone areas, such as Kirikkale, Cankiri, Corum, Duzce, Bolu and Kastamonu, are investigated in this study (Figure 1).

The field survey depicts that although these cities are located in earthquake region, the residential building stock is mainly composed of multi-storey reinforced concrete apartment buildings. The safety of reinforced concrete apartment blocks is still in question since the recent earthquakes showed their poor performances. The enormous mass of these buildings led to the death of about 80,000 people in the earthquakes that happened in Turkey over the last century. In fact, low-rise buildings that are constructed of lightweight materials are more effective to keep people away from the devastating effects of earthquakes. Nevertheless, since the monetary benefit -rather than the safety of buildings- is of utmost importance, construction of multi-storey reinforced concrete buildings are still going on and the buildings do not reflect any features of the local architecture, which were dominant once (Figure 2).

On the other hand, masonry buildings are still in service especially in rural areas of Turkey. In certain parts of the country, most of the built environment constitutes of plain masonry structures the type of which depends on the availability of the materials, technical knowledge, traditional practices and workmanship. Stone and adobe are the oldest materials used in masonry buildings in Turkey. Brick masonry has been used for residential and public buildings in urban areas since the second half of the 19^{th} century. Despite the fact that masonry is commonly used in Turkey, it has not been considered to be appropriate for construction of buildings in earthquake prone areas until the very recent times. The specifications and codes do not permit the construction of plain masonry structures in disaster areas. This study aims to assess utilization of masonry for construction of residential buildings in earthquake prone areas in Turkey. It is very well known that Turkey frequently suffers from earthquakes and the seismic performance of buildings is considered to be more important because of the recent earthquakes. Because of this, the paper depicts the seismic performances of plain and reinforced masonry systems. After the information is given about brick industry in order to assess the production capacity, the potential of masonry structures is re-evaluated to propose the application of its reinforced version to evoke traditions and to utilize local resources.

Figure 1: Kırıkkale, Çankırı, Çorum, Düzce, Bolu and Kastamonu in Earthquake Zones of Turkey

2. MASONRY CONSTRUCTION MATERIALS IN THE EXISTING BUILDING STOCKS OF TURKEY

Although it has been replaced by framed structures, which are generally of reinforced concrete and steel, masonry construction system has come back on the scene in the recent decades due to many advantages it provides, such as availability, ease in construction, appearance, textural warmth, and etc. Modern masonry construction consists of bricks, concrete masonry units, and stones; all are bonded to each other by means of mortar. Today, the design of masonry construction system is based upon structural analysis methods of the 20th century, as in the case contemporary structural materials (Sinha, 2002). Load bearing masonry systems are used especially for construction of low-rise housing units. In modern masonry construction, a major evaluation took place with the introduction of steel reinforcement. Plain masonry structures are forbidden in earthquake prone areas in some countries because of the poor tensile strength of mortar joints that leads to poor seismic performance. Reinforced masonry is used to overcome this problem and strengthen the weakness due to joints in between the units. Panarese W.C. et.al. state that reinforced masonry contains reinforcing steel so placed and embedded that the masonry and steel act together to resist forces. Reinforced masonry is used especially where the compressive, flexural, and shear loads are higher than they could be resisted by plain masonry (Panarese, Kosmatka, Randall, 1991). In many countries, the codes oblige reinforcement for masonry construction in disaster areas, where recurring hurricanes, winds or earthquakes are in question.

The architectural history literature depicts that adobe is one of the oldest and crucial building materials in antiquity. In Turkey, it was widely used in regions where timber and stone were inadequate or unavailable in terms of natural resources. Adobe stems from clay and sand mixture with a stabilizing agent. The quality of adobe is determined by the amount of clay contained. In old times, straw was used for reinforcing the adobe. Today it is evident that cement and plaster has replaced the straw. When compared to the other building materials, it is seen that adobe is natural, healthy, and cheaper. It also requires less energy and is easy to produce. Because of these characteristics, adobe is seen as a way out for people of low income in Turkey, where an important portion of the residential units were produced by individual efforts rather than by the supervision of the government during the rapid urbanization period. This could also be related to the fact that adobe is so a well-known constructional material that even today it is possible to see many examples of adobe housing units in the villages of Turkey (Figure 3). Furthermore, depending on soil types and climatic conditions, adobe construction can achieve both strength and durability. One of the major defects of adobe as a constructional material lies in its inability to show adequate resistance to earthquake forces (Wasti and Gülkan, 1980).

The second material used in masonry constructions is brick. In Turkey brick is standardized for dimensional and technical properties according to TST EN 771-1 (Specification for Masonry Units) and TS 704 and TS 705 (Solid Bricks and Vertically Perforated Bricks). Bricks produced in Turkey are divided into six categories such as; hand moulded brick, fabricated brick, press brick, hollow brick, iso-brick, and fired brick.

Concrete masonry unit is the contemporary alternative for masonry construction systems. Concrete block is made from a mixture of Portland cement and aggregates. The units are often used when masonry is to form a load-bearing wall or an interior partition between spaces. They are produced in the desired shapes and then cured under pressure in the manufacturing plant. In other words, they are available in wide range of types, sizes, shapes, and surface textures, and are used for a variety of

Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi 26(1): 18-26 (2010)

purposes. And, since the material has come on the scene in the 19th century, it is treated as a contemporary material. Not only the standards have been established for its physical properties such as solid content, strength, density, water absorption capacity, moisture content and linear shrinkage potential, but also production techniques were improved to provide the blocks with greater strength and lighter weight (Beall, 2000).

Figure 2: Typical Reinforced Concrete Apartment Buildings from Duzce, Cankiri, Corum

Figure 3: Examples of Adobe Units and Houses in Turkey (Sansarak Village, Sindelhoyuk)

2.1 Seismic Behaviour of Masonry Buildings

The incapability of masonry to resist bending and shear developed in earthquakes, limited the use of masonry constructions in earthquake prone areas. The poor performance of masonry observed just after the earthquakes as stated by Bruneau, is a proof of the need for seismic resistant design requirements (Bruneau, 1995).

Masonry structures could be regarded as monolithic boxes, which constitute of shear walls in two orthogonal directions. These walls are to be connected to each other by means of floors acting as diaphragms in between. The walls and diaphragms constitute the very basic elements that resist the vertical gravity loads and horizontal seismic loads. Arranged uniformly in both directions, the walls should be sufficient in number and strength to obtain a structurally sound behaviour. The length to thickness and height to thickness ratios should be decreased since the walls are the most vulnerable elements during earthquakes and tend to topple down in the weak direction. Precise interlocking of the courses as well as horizontal bands and floors that act as rigid diaphragms would be helpful (Tomazevic, 1997 and EQTip12, 2004).

2.2 Seismic Behaviour of Reinforced Masonry Buildings

The introduction of reinforced concrete slabs, which act as rigid diaphragms, pushed the limits of masonry construction beyond its limits. Lack of resistance to bending and shear as well as insufficient ductility and energy dissipation capacity, however, limited the utilization of the system despite several advantages offered.

In the second half of the 20th century, masonry construction started to come back on the scene; but with constructional and structural design principles, which are applied for contemporary systems. This enabled to construct high-rise masonry structures with reduced wall thickness (Hendry, 2002). Klingner states that reinforced masonry structures, designed according to the provisions sustained little damage while plain masonry structures were severely damaged or even collapsed (Klingner, 2004).

Masonry can be reinforced both horizontally and vertically. The hollow core concrete blocks enable reinforcement through the wall. The blocks might be laid with or without mortar. The vertical reinforcement not only helps the structure to sustain bending instead of rocking but also prevents collapse in the weak direction. Furthermore, the steel ratio is dependant on yielding due to tension (Casabonne, 2000, and EQTip, 2004)

3. BRICK INDUSTRY IN TURKEY

Industrial activities have gained more importance in the economy of Turkey especially in the recent years. Among the several developing industrial branches, brick production has shown a sharp increase despite the negative effects of devastating earthquakes on the construction market with effect from 1999. It is encouraging to see that Turkish brick industry puts a great effort to keep up with the latest technologies and to improve product quality. Furthermore, the manufacturers pay great effort to satisfy the requirements of modern construction with over 80 different brick types and formats (Harder, 2004). The first attempts to establish tile and clay factories started in the late 1930s, but took effect in almost ten years time. Due to the strict relationship between clay and construction industry, the number of tile and clay factories has shown a sharp increase after 1950s in parallel to urbanization period. In 1955, the number of tile and clay factories was recorded to be 78 with 8136 employees (CCI and TOBB, 1958). Especially in the 1980s, which is the beginning of the construction boom with the introduction of mass housings, significant growth rates were observed in clay and tile industry afterwards. The number of factories is seen to be 358 in 2001 (Sahin, 2001), while this number is stated as 498 according to the information directed from TUKDER (Association of Brick and Tile Makers) in 2006 and report of T.R. Prime Ministry State Planning Organization (SPO). More than 300.000 people are employed in these factories, which points out an important work opportunity for the unemployed (TUKDER, 2006 and SPO: 2530.ÖİK:546, 2000).

Table 1 gives the number of brick factories in seven geographical regions of Turkey. According to the report of SPO, more than 20 % of the factories are located in the western part of the country while almost 30 % take place in the central region (Sahin, 2001 and DPT: 2773-ÖİK 703, 2008). One and probably the most important of the several possible reasons for this uneven distribution of the factories could be the local availability of the raw material.

4. RE-EVALUATING THE POTENTIAL OF MASONRY IN TURKEY

Despite the several advantages that masonry provides, the incapability of the materials limited its utilization in the recent decades in Turkey, where the seismic performance of buildings has become more important than ever. It is a well-known fact that materials of masonry construction are strong in compression. However, during an earthquake, the forces to be resisted are not only compressive forces. There are shear forces and bending moments as well. The distribution of shear forces in an earthquake could be seen in the Figure 4. As the figure depicts, the maximum load is seen to be on the top of the structure; nevertheless, since the forces would be summed from top to the bottom, it could easily be understood that the maximum shear force would be at the bottom level. Under these circumstances, it is clear that the amount of shear forces to be resisted by a building is also dependent on the height of the building. The higher the building, the more are the shear forces. This case clearly demonstrates why plain masonry is allowed only for the construction of low-rise buildings in Turkey.

Under these circumstances, the urgent need for construction of multi-storey residential buildings in urbanization period might be seen as the explanation for abandoning masonry in a very short time although the construction technique has a strong background in Turkey. However, it might not be reasonable to reject masonry completely when the rich potential of the country in terms of materials and construction is considered. In Turkey, especially in cities with more than 500.000 populations, it is unavoidable that high-rise buildings are required. However, it medium-scale and small-scale cities, where the buildings are about 5-8 storeys in height, utilization of masonry should be reassessed. Reinforced concrete and steel might seem to replace masonry thoroughly since they are the very materials of the last century. On the other hand, it is a fact that an important portion of reinforced concrete buildings either collapsed or was severely damaged in the recent earthquakes despite the very well known capacity of the construction material. On the contrary, steel structures are seen to behave stronger in earthquakes. This brings the question up in minds whether the properties of steel could be passed over to masonry structures or not. If masonry is reinforced by means of steel, then it might be possible to overcome the problems about resisting shear forces and bending moments.

Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi 26(1): 18-26 (2010)

On the other hand, it is a well-known fact that the western region is much more developed than the rest of the country, which points out the direct proportion between construction and clay industry. According to Sahin, the other reasons could be listed as the climate, which is a dependant factor on the production of clays and tiles, ease of transportation, distance from industrial zones, and the rate of urbanization (Sahin, 2001). The western and central parts of Turkey step forward when all these considerations are in question. The eastern and southeastern regions are undoubtedly far behind in these aspects.

Parallel to the establishment of production units, a sharp increase has been observed in the quantity of bricks as well. In 1955, 101.999.670 units of brick were produced in 78 factories (Sahin, 2001). This number is seen to be 5.250.000.000 units in 2004 (Harder, 2004) and 7.353.100.000 units in 2006 (SPO: 2530.ÖİK:546, 2000). Based on the report of SPO, Table 2 gives the importation and exportation of bricks and tiles in Turkey.

Table 1: List of Brick Companies According to Regions (DPT: 2773-ÖİK 703, 2008, pp.265)

Marmara Region		**Central Anatolian Region**		**Eastern and South-eastern Anatolian Region**	
Istanbul	1	Afyon	22	Mardin	2
Tekirdag	14	Ankara	13	Batman	6
Edirne	3	Polatli	5	Urfa	1
Izmit	7	Corum	35	Diyarbakir	11
Canakkale	2	Osmancik	12	Bingol	1
Balikesir	2	Eskisehir	6	Erbaa	18
Black Sea Region		Kutahya	7	Turhal	8
Duzce	1	Konya	13	Erzincan	2
Kavak	5	Aksaray	2	Elazig	5
Trabzon	1	Yozgat	14	Maras	3
Boyabat	25	Avanos	8	Malatya	2
Bartin	3	Amasya	6	Tunceli	1
Tosya	9	Bilecik	2	Igdir	1
Cankiri	2	**Aegean Region**		Erzurum	1
Mediterranean Region		İzmir	8	Adiyaman	1
Antakya	4	Turgutlu	50	Agri	1
Adana	5	Salihli	31	Sivas	3
Mersin	4	Akhisar	1	Antep/Islahiye	2
Antalya	3	Aydin	6		
Burdur	7	Ortaklar	6		
		Denizli	1		
		Usak/Banaz	2		
		Mugla	3		

Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi 26(1): 18-26 (2010)

Table 2: Importation and Exportation of Brick and Tile in Turkey (SPO: 2530.OIK:546, 2000)

Importation of Brick and Tile in Turkey					
	1995	**1996**	**1997**	**1998**	**1999**
Brick (Tone)	14	3	67	219	265
Tile (Tone)	100	28	2	5	6
Brick (US$)	69.288	108.026	36.076	125.643	213.227
Tile (US$)	704.722	35.671	32.790	25.949	7.807
Exportation of Brick and Tile in Turkey					
	1995	**1996**	**1997**	**1998**	**1999**
Brick (Tone)	4240	7031	522	489	409
Tile (Tone)	6901	230	782	1483	1.128
Brick (US$)	254.009	685.251	486.500	460.248	294.847
Tile (US$)	590.572	642.948	521.466	624.214	721.773

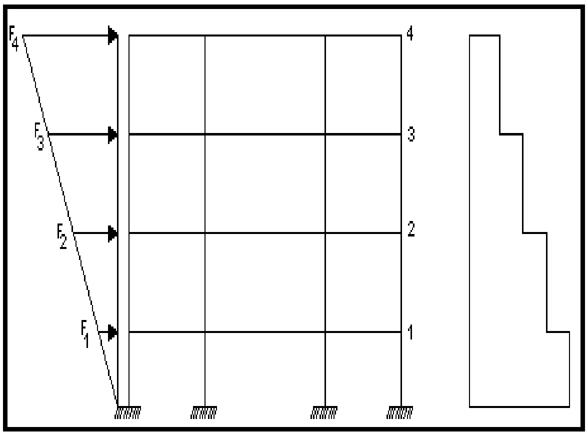

Figure 4: Distribution of Earthquake Load

It is possible to handle utilization of steel as the means for reinforcing the masonry structures in two aspects. The first of these is the construction of new buildings in earthquake prone areas regarding the codes and regulations. The buildings could be constructed of masonry that is reinforced by means of steel in the load bearing members. The second is the strengthening of existing buildings. It is a fact that reliability of existing buildings becomes susceptible with the introduction of each and every earthquake code. In other words, every building built before the last revision of earthquake codes should be seen to be vulnerable to earthquakes. However, this should not mean to demolish all the buildings and to rebuild them up. After performing careful inspections and necessary calculations, most of these buildings could be reinforced. This would consume less energy, time and money. Strengthening might also address to post disaster precautions, which also cover rehabilitation of the damaged buildings.

5. CONCLUSIONS

The researches carried out just after the earthquakes depicted that the most important reason why the buildings were severely damaged or collapsed is inadequate or unconscious structural design. The most critical hazard was observed in the buildings of medium height, which are 5-8 storeys. Therefore, there should be new building solutions for earthquake prone areas, which means almost the entire country. Besides structural safety, one other concern should be the characterization of the built environment, which should be the reflections of environmental, geographical, social, economical and cultural values. Under these circumstances, masonry buildings step forward with their strong background in the traditional heritage of Turkey.

Afore mentioned, plain masonry structures may not display a sound performance against earthquakes. On the other hand, there are some other materials as structural steel, with proven resistance against earthquakes. Therefore, it might be possible to reinforce masonry by means of steel since there is an important market for masonry construction materials. Among them all, brick steps forward as the pioneer.

Masonry structures of stone or brick were the most important means for construction before the country fell into the chaos of urbanization. When urbanization came into light with all of its problems, a sudden shift from traditional materials to reinforced concrete and steel was observed. From this point of view, it might seem to be ironic to try to utilize the earthquake resistance of steel to revive masonry. Now, reinforcing masonry by means of steel might be the only means to evoke masonry once again. This method might be the most appropriate way for both freshening the traditions and keeping pace with the innovations of the age.

Despite the wide spread application throughout the world, the concept of “reinforced masonry” is somehow unfamiliar to Turkish construction industry. There are several reasons for limited use of reinforced masonry construction. The first and probably the most important of these reasons is the lack of information about seismic performance of reinforced masonry structures. As long as the advantages that the system provides remain unknown, it would not be possible to see serious attempts on the topic.

It is an undeniable fact that the brick and autoclaved concrete block industry has shown a sharp increase in the recent years in Turkey. On the other hand, it is still susceptible whether the market has satisfied the demand that arose because of urbanization period or not. Production of masonry units is expected to run in parallel with the amount and speed of construction throughout the country. But, the general appearance of the built environment, which is characterized by reinforced concrete and steel, brings the questions about the sufficiency of production. Another important reason for replacement of masonry structures by reinforced concrete and steel could be the poor seismic performance of plain masonry structures. Lack of knowledge about the potential of reinforced masonry structures also affected the application negatively. This ignorance is also relevant for structural analysis, design considerations and detailing, which are among the most important determinants on seismic performance of buildings. The actors of the Turkish construction industry are not competent and experienced enough on the techniques and design aspects of reinforced masonry structures. The attention is directed towards reinforced concrete structures in particular, probably due to familiarization with the so-called “modern” materials in the recent decades.

The tendency to use reinforced concrete and steel structures in Turkey could be seen usual in some aspects. In the first place, reinforced concrete and steel structures offer multi-storey buildings, which would satisfy the urgent requirement for residential building that arose because of increasing population. Besides, the earthquake codes has been revised several times since the 1940s, which means a more detailed and experienced approach to the design of reinforced concrete structures. The fact that plain masonry is not capable of resisting earthquakes drew all the attentions to reinforced concrete and steel. Masonry, consequently, remained as a means for ornament, cladding and furniture. The variety in the production of bricks in Turkey is an evident for this type of utilization (Harder, 2004).

Contrary to the poor seismic performance of plain masonry structures, the researches carried out just after the earthquakes proved the performance of reinforced masonry structures (Klingner, 2004 and Bruneau, 1995). It is unfortunate that the potential of neither the natural resources nor the production industry are effectively utilized in Turkey despite the fact that the availability of the raw material is one of the most important criteria to assess the potential of the material. The western and central regions of Turkey are rich in this aspect. The presence of the raw material would be beneficial for the economy of the country in many aspects. The own resources of the country could be utilized and the industry could be among the most important means to provide work opportunity for the unemployed, which is another serious problem in the economic concerns of Turkey.

The obligation to comply the design of reinforced masonry structures with the provisions of reinforced concrete design practices led to the development of new brick and concrete units appropriate to embed the reinforcements (Klingner, 2004). This method could have been modified and adopted to the design practices of reinforced masonry structures in Turkey while the Earthquake Codes has been revised several times since the 1940s. Especially, the years after 1960s, which could be seen as the beginning of the sharp increase in the brick industry parallel to rapid urbanization, would have been more advantageous for application. It would have been possible to apply the same method for autoclaved concrete blocks in the more recent decades.

Today, it might not be so pretentious to claim that the relevant earthquake codes for reinforced concrete structures work properly in terms of structural design in Turkey. Nevertheless, construction details still remain in question. In other words, it could be stated that the reinforced concrete buildings that comply with the requirements of the codes might not sustain damage or collapse provided that the construction detailing are precise. If the attention for the design of reinforced concrete buildings were paid to the design of reinforced masonry structures, the seismic performance would just depend on construction details, such as the case of reinforced concrete structures. Revision of earthquake codes in such a way to involve the design considerations for reinforced masonry structures might be the first step to revive masonry construction in Turkey. Thus, reinforced masonry structures could start to be constructed in earthquake prone areas. This would provide the country with benefiting its own natural resources and existing industry.

ACKNOWLEDGMENTS
The authors thank to the employees of T.R. Prime Ministry State Planning Organization for their contributions to the study.

REFERENCES

1. Toker, S. (2004). Developing an Innovative Architectural and Structural Solution for Seismic Strengthening of Reinforced Concrete Residential Buildings, Unpublished PhD Thesis in METU, Ankara, Turkey.
2. Bilgin, I. (2005). Mass Housing Production and Architecture in Turkey, 2002, [Internet, www], Address: http://www.arkitera.com.tr/platform/konut/ihsanbilgin2.htm
3. Bilgin, I. (2005). Housing Production of Turkey in Modernization Process, 2002, [Internet, www], Address: http://www.arkitera.com.tr/platform/konut/ihsanbilgin1.htm.
4. Sinha B. P. (2002). Development and Potential of Structural Masonry, Seminário sobre Paredes de Alvenaria, P.B. Lourenço & H. Sousa (Eds.), Porto.
5. Panarese, W.C., Kosmatka, S.H., Randall, F.A. (1991).Concrete Masonry Handbook for Architects, Engineers, Builders, Portland Cement Association, Illinois.
6. Wasti S. T. and Gulkan P. (1980). Structural engineering criteria for adobe construction, Third International Symposium on Mudbrick (Adobe) Preservation, Ankara, Turkey.
7. Beall C. (2000). New Masonry Product and Materials, Progress in Structural Engineering and Materials; Vol. 2: 296-303.
8. Bruneau M. (1995). Performance of Masonry Structures During the 1994 Northridge (Los Angeles) Earthquake, Can. J. Civ. Eng. 22:378-402, Canada.
9. Tomazevic M. (1997). Seismic Design of Masonry Structures, Progress in Structural Engineering and Materials, Vol. 1: 88-95.
10. NICEE. (2004). Learning Earthquake Design and Construction, How do brick masonry houses behave during earthquakes? Earthquake Tip 12, The National Information Center of Earthquake Engineering at Indian Institute of Technology Kanpur. [Internet, www], Address: http://www.iitk.ac.in/nicee/EQTips/
11. Hendry A. W. (2002). Engineered design of masonry buildings: fifty years development in Europe, Prog. Struct. Engng Mater.; 4:291–300, University of Edinburgh, Scotland.
12. Klingner R. E. (2004). Earthquake Engineering from engineering seismology to performance-based engineering, Yousef Bozorgnia and Vitelmo V. Bertero (Editors), CRC Press, New York.
13. Casabonne C. (2000) Masonry in the Seismic Areas of the Americas, Recent Investigation and Developments, Progress in Structural Engineering and Materials, 2: 3129-327
14. NICEE. (2004). Learning Earthquake Design and Construction, Why is vertical reinforcement required in masonry buildings? Earthquake Tip 15, The National Information Center of Earthquake Engineering at Indian Institute of Technology Kanpur. [Internet, www], Address: http://www.iitk.ac.in/nicee/EQTips/
15. Harder J. (2004). The situation of the brick and tile industry in the Near East and Middle East: The Turkish brick and tile industry, KELLER HCW GmbH, Ibbenbüren-Laggenbeck Germany. [Internet, www], Address:
16. http://www.keller-hcw.de/02englisch/07presse/pressemitteil_neu/2004/11.html.
17. Chamber of Commerce and Industry of Turkey (CCI) and the Union of Chambers and Commodity Exchanges of Turkey (TOBB), 1958:19, Brick Industry in Turkey, Ankara.
18. Sahin S. (2001). A General View of Brick-Tile Industry in Turkey and A Case Study: Corum, Journal of Gazi University Faculty of Education, Vol.21: 2 19-41.
19. Feature with the president of TUKDER (Association of Brick and Tile Makers), (2006).
20. Brick, Tile and Prefabricated Construction Materials, (2000). SPO (Prime Ministry State Planning Organization): 2530. ÖİK: 546, 8th Development Plan.
21. Taş ve Toprağa Dayalı Sanayiler, Özel İhtisas Komisyonu Raporu, 9.Kalkınma Planı (2007-2013),T.C.Başbakanlık DPT: 2773-ÖİK 703, 2008, pp.26.