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HISTORICAL CONSTRUCTION IN ERZURUM IN EASTERN ANATOLIA

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Abstract. *Anatolia is hosting endless variety of many vernacular houses which were built using the dominant material in the region and were formed by climatic conditions of the region according to the traditional life. In every region of Anatolia the traditional houses were differentiated by basis of these criterions. Especially the dominant material in the region is the most important factor affecting physical structure of the vernacular houses. So Anatolia's traditional dwellings are grouped in terms of material and local tradition.*

One of the groups is stone architecture combined with traditional runner or tie beam (hatıl) which is seen from Erzurum to east and North East Anatolia and South Caucasus relatives in Dagestan. The vernacular architecture was shaped with stone which is the dominant material of the region. Stone walls are conformable for rigorous climate and have high performance against the pressure. For the resolution of weakness against the tension and horizontal movements like earthquake movements, the woodwork can be seen in there. The construct of stone walls combined with timber beams is proper of this region. The system was set up with tie beams for earthquake-resistant. The usage of tie beam at these stone masonry structures under the threat of earthquake is inevitable for a traditional solution.

In the context of it, one of the important cities in east Anatolia, Erzurum is selected to research its traditional houses structure and behaviors. Thereby understanding their structural situation against any kind of disaster is tried to ascertain with this study. This historical construction is documented in Erzurum and its surrounding. The documentation is composed visual data also it is enriched taking measurements, drawings. The knowledge of the construction system is essential for restoration of these vernacular houses. Also it improves the quality of conservation work. In this study it is aimed that to quote references at conservation of these houses.

1 INTRODUCTION

Today in conservation field we discuss how we should restore as well as what we should preserve. At 21th century we can see many high technologic solutions and engineering systems for conservation of historical buildings. Without understanding the structural behavior of building this system cannot be useful also it can be more expensive application even though they have been developed and new methods have been invented day by day. So we must be analyze the building structure and evaluate its problems correctly before its restoration.

The conservation of traditional houses are seen very simple than any other monument because of its size and to be widely known. So we generally do not need the high technologic solutions for small scale housing. At this point, its structure and behaviors against t any kind of disaster must be well understood. So we can define its problems and solves truly.

In this context, we researched the historical structures of vernacular houses in Anatolia. We focused on Erzurum which is an important city of East Anatolia. Through the ages under the earthquakes, settlements in Erzurum always have destroyed and then reconstructed or renovated. This process had been a cycle for there. Associatively vernacular houses can be dated the middle of the 18th century at latest and they give us industrial and technological knowledge of period when they constructed. By using this knowledge we can provide to lengthen life of these dwellings which are existed at least 100 years.

At this study Erzurum traditional houses where East Anatolia of Turkey are researched to understanding their structural situation improves the quality of their conservation work. The documentation of the structure enriched the Anatolian vernacular architecture will quote references at restoration.

2 WORKING METHOD AND DESCRIPTION OF AREA

One of important city of East Anatolia Erzurum is selected for our study. The reason why this city selected is to see many traditional houses with their original property. this knowledge specialize Erzurum vernacular houses.

Firstly we want to introduce Erzurum. Then it is given information about the traditional houses in there. As this study's subject, predominantly the structure of these houses are told about. Trying to understand, their structure, traditional construction type and why tie beams used are discussed in this study. Especially it is focused on the tie beams that is the first thing when talking about earthquake. We profit from the archival document the traditional settlement changes after major earthquakes.

As a historical document, the official report from Erzurum state to center in September 11, 1859 bears out it. At the document it was written that while the old buildings in Erzurum were embedded to ground without openings, after earthquake people wanted to construct their houses in a new style which was uplifted from the ground, and having windows [1]. This document shows us that Erzurum traditional houses were changed with earthquakes. Firstly the scale of the houses changed. Also the construction techniques should have developed against the earthquakes. At conclusion it is evaluated the relation of the tie beams and earthquakes in Erzurum.

2.1 Erzurum

Erzurum with its 360.000 population is a city, elevated 2000 meter from sea level that has leading ski center of East Anatolia. This city is very popular with tourists thanks to its ski centers and winter sports. Mountain Palandoken is very near to the city center and it provides most entertaining activities for winter sports. The most severe climate of Turkey is seen in

this region. Springs are rainy and summers are hot and arid. Winters are so cold and snowy. The average temperature is less than 8 degree in about 220 days of a year.

Figure 1: Turkey map (Yandex, 2014)

The history of Erzurum traces back to 4000 B.C. Excavations in the city show that such civilizations like Urartians, Kimers, Scytihans, Meds, Persians, Parts, Romans, Byzantines, Sasanians, Arabians, Seljukians, Mongols, Ilkhanits and Safavits dwelt on this area. Erzurum became the capital city of East Anatolia under the rule of Seljuq Dynasty. Many times the title of Erzurum was changed under the rule of different dynasties. Through the ages the city has been become very important caravan station on the main east-west trade route. There are historical artifacts that belong to people mentioned above. Many of those historical artifacts come until today without any destruction [2].

Figure 2; Twin Minarets Madrasa and back of it; Palandöken Mountains which are famous for winter sports

The vernacular settlements are surrounded the castle which is historical ruin that belongs to Byzantium 5th century A.D. Another the most important historical place is Twin Minarets Madrasa (Çifte Minareli Medrese) whose construction traces back to the 13th century. Also near this madrasa many traditional houses are existed. The other neighborhood of the city we can see many historical houses.

Figure 3: An old photograph of Erzurum Castle in 19th and traditional houses in 19th century [4].

According to 2010 data of Erzurum Cultural Heritage Preservation Board there are 91 traditional houses in the list included 340 properties. Mostly remaining structures are dated to late 1850s. The number and date of the houses are related to massive earthquakes damaged the city and its surroundings through the century [4].

2.2 Classification of Anatolia vernacular settlements and the importance of Erzurum

Anatolia's civil architectural heritage was grouped taking different criteria into several times. Especially the vernacular houses were tried to gather into a group according to materials and regions. Despite being in the same classification, we can see the many differences at houses. In the context of study these differences are determined as traditional techniques on wooden material. In the circumstances of classification the wooden material as the determining factor at traditional dwellings are into 2 groups.

- Usage of wood as a constructor of system
- Usage of wooden as a secondary (regularity) part of building

Accordingly the timber frame and timber log systems are in the first group. In the second group there are three systems. These are mixed system; first floor masonry the upper floor timber frame, masonry system with timber construction (and wholly masonry system where the timber was seen only as building element). At this classification the usages of the timber not only as constructor, but also as a structural member retrofit the masonry system. It is defined that the usage of wooden material at masonry construction system perhaps is a requirement besides a necessity.

Also Prof. Dr. Doğan Kuban classified the Anatolia's traditional dwellings. There are seven groups in terms of material and local tradition according to his study One of the groups is stone architecture combined with traditional runner or tie beam (hatıl) which is seen from Erzurum to east and North East Anatolia and South Caucasus Relatives in Dagestan. As can be seen Erzurum is important example of this classification. Most authentic examples are existed in there[3].

3 ERZURUM EVLERİ

Erzurum Traditional Houses have two storeys generally. At ground floor there are stables, storage and cellar. To access to first floor are by a wooden stairs. If having more than one storey, the main living space is located upstairs. At this storey there are a sofa and many rooms which are opened to sofa. The kitchen/tandır house generally is located at ground storey or in the garden. It is a simple mechanism used to cook meal and heat from the prehistoric period to today. It is a common space of traditional houses in Eastern Anatolia. The most important factors leading to the continuity of the tandir culture are the climate, which is effective all over Eastern Anatolia, regional ones, economic situations and also customs [4].

Figure 4: the tandir space and its special roof that is called kirlangıç (İnan, 2012)

Erzurum Traditional Houses are classified according to position of the sofa as a result of research of Turkish Houses. But in this paper we focus on the structure of the houses not their plan decisions. And the construction techniques are studied.

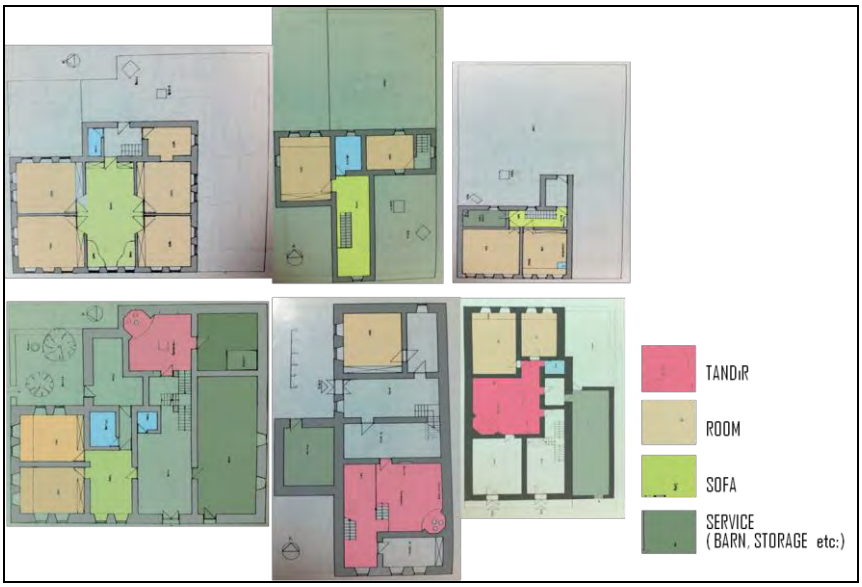

Figure 5: three example of Erzurum Houses plans **[4].**

3.1 Construction Materials

Especially the dominant material in the region is the most important factor affecting physical structure of the vernacular houses. While timber-framed buildings are sited at areas dominated by wooden material, in another region masonry structures built using indigenous stone has been seen. But it does not mean that the wood is not used any way in areas dominated by stone. On the contrary considering the advantages' of the wood according to stone, the woodwork can be seen in any traditional house. When we look at these houses in Erzurum, initially stone house is defined. Besides window and door frames many building elements and details like slab, beam and girder were made of wood. After this comment we can classify the construction materials. Accordingly to this;

- Stone; the name of stone comes from its quarry where are in the city and its surrounding. Karataş, Bozlaş and Kamber are some example of them. Generally coinage stone was used at corners of façades. If the coinage stone not used, rubble stone wall are seen.
- Wood: it is the most commonly used after stone. The runner beams (that used for connecting walls), the beams, floors, ceilings and all windows and doors are made of wood. Pine, poplar and willow are common varieties of trees. Also the reed as an auxiliary material is using for covering of the roof.
- Soil: it is main cover material of Erzurum Traditional Houses. Also the soil was used in the mortar of the walls. It was available readily from the forts around the city.
- Brick: because of the conduce soil; the bricks were made of high quality. We can see brick partition as wall. Also the first floor facades and construction of chimney the bricks were used.
- Metals: wrought iron was used as door and window hinges, nails, door knockers, window guard.

3.2 Foundations

In the scope of the study firstly we research how the substructure of Erzurum Traditional Houses constructed. But it is not enough our present knowledge on building. So we need archival sources or information from the extensive restorations of the buildings. At this point we profit from Curzon who had a comprehensive observations in Erzurum. His text relates steps of construction and more importantly gives details of building construction techniques and plan organization. According to his telling taken an area approximately 0,4 decare and dug 150 centimeters or 5 fits. After this process the woods were logged height of a room, 8-9 fits. These were arranged in two or four lines. The other woods were used for beams [1].
As understood from Curzon, it is seen that opening foundation pit in a certain level. The other archival document should be discussed here as a case. According the historical document after earthquake in 1859 the houses which embedded into more land were raised later. It means that before the earthquakes the foundation of houses built was itself. The foundation described by Curzon was of houses after earthquake.

In our observations, it is not seen wall thickening which is deal with ant level. Also there is no change at walls. For a detailed observation, research excavations during the restoration give us true expression.

3.3 Walls

At Erzurum traditional houses, the construction techniques of masonry walls are examined in this study. Stone came from its quarry in the city and its surrounding was used for bonding

wall. Generally the rubble wall as construction type is seen. Actually it is also deal with rich host or not. For qualified construction the coinage stone was used. Thereby many wall construction types are seen Erzurum vernacular houses. The type might be change ground storey and first storey or there is no change at two storeys. But the usage of tie beam is seen at every kind of wall. These beams are called hatıl. They are placed several level of the wall. This topic is detailed at 3.5 and 4.2.

Figure 6: The runner beams at the wall (İnan, 2010)

The thickness of the wall at ground floor is approximately 90-100 centimeters. It becomes 50-65 centimeters at first floor. Interior space the partition walls are made of brick and their thickness is about 20-25 centimeters.

Figure 7: the section of the wall (İnan, 2011)

3.4 Floors

Generally in Erzurum traditional houses ground floor covering is stone at courtyard and hall and wooden at rooms. At upper ceiling the wooden beams as support element pass the space. The secondary beams located on the beams more often. In the mezzanine floor the bricks were used over the secondary beams. It is seen some examples.

Figure 8: The section of mezzanine floor, it is composed of wooden beams and bricks (İnan, 2010)

The last ceiling was finished as falt roof. Layer of land fill with clay was over the wooden beams. This layer is about 30 cm. James Justinian Morier who came to Erzurum at 18th century, described the traditional houses were covered with green grass because of vegetation top of the roof.

Figure 9: The layer of flat roof (İnan,2010)

3.5 Tie beam (hatıl)

The runner beams are positioned aligned with the edges of the walls. While the runner beams are parallel to the wall, a perpendicular position to this alignment another timber element is used. It is known as püştüvan traditionally. This element links the runner beams and prevents separating from each other. This construct is bedded in the walls regularly. The distance between two püstüvan is approximately 1 meter. Also the tie beams placed at every one

meter level vertically. Sometimes this distance changed. At some examples it is measured 90-130 centimeters.

Figure 10: Only for Erzurum as a peculiar feature, püstüvan was extended approx. 50-70 cm. from out edge of the wall. It is used as scaffold during maintenance

The wall thickness is compared with the distance between two tie beam and püştüvan. According to this; if the wall thickness is defined as 'a', the level of tie beams generally 'a', rarely '1.3 a'. Also the linking wooden element was placed 'a' distance. It means the wall thickness would be a unit to determine the distance tie beams and püştüvans.

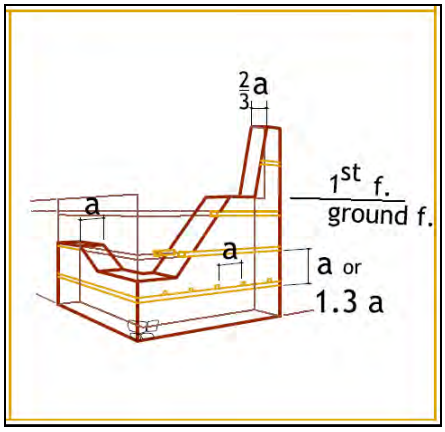

Figure 11: The diagram of proportion between wall thickness, tie beam level

The figure shows us the placement of tie beams at the wall. All levels are defined. According to this;

For ground floor

- 1; below the door
- 2; middle of the door or if there is any window, its down level
- 3; up of the door.
- 4; under the ceiling

For first floor

- 1; under the window
- 2; middle of the window
- 3; up of the door
- 4; under the roof

The level called 2 for each storey is not used a few examples. Except of number 2, all of levels are seen at every traditional house. The position of tie beams deals with the distance of them. Although the tie beams cannot continue at middle of the window, it is seen at level 2. It would be a standard for using at every 1 meter level.

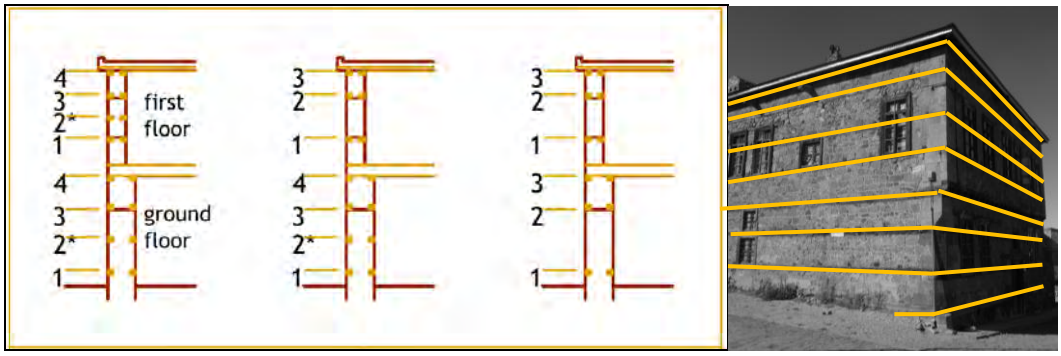

Figure 12: the schema shows the placement of the tie beam at masonry wall

Where the required the continuity of the wooden which has a limited length, the elements must be joined together. It is studied that how combine two wooden element which their fibers in the same direction. According to their position it is classified as the corner joints and plane joints.

There are two types for combining to wooden tie beams at the same plane. Generally the beams are in same alignment using joint of half lap splice. Also joint of simple lap joint is seen at examples tie beams overlapping the each other. Also in some examples there is iron retrofit around the point of combine.

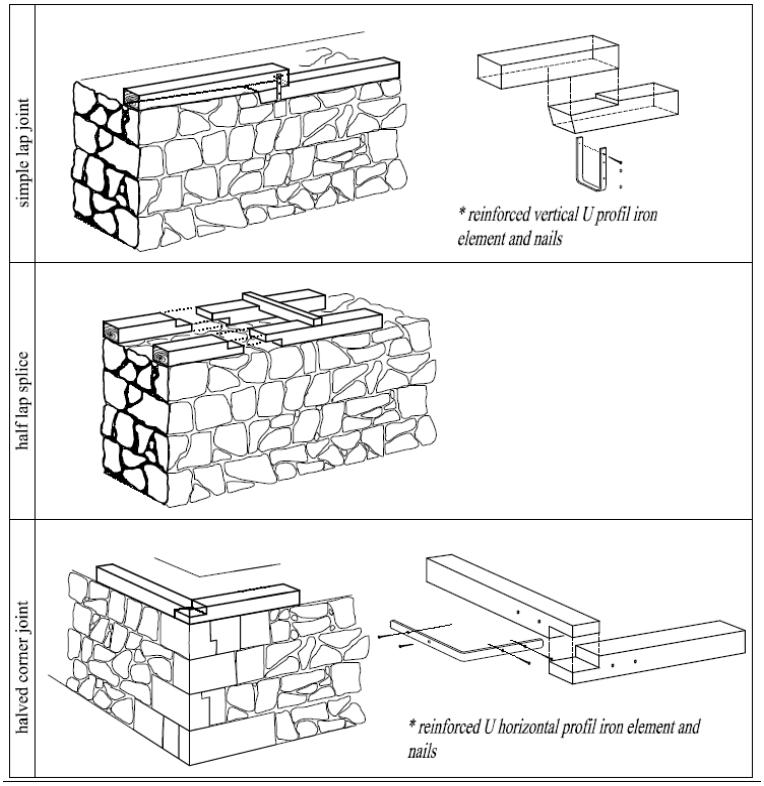

Figure 13: The classification of the joints which are used at Erzurum Traditional Houses (İnan, 2013)

Combining at corner, always same detail; halved corner joints are used. Commonly iron retrofit around the corner is seen.

4 THE TIE BEAMS FROM THE POINT OF EARTHQUAKES

4.1 Earthquakes

To understand the effect of earthquakes, the history of destruction is researched in this study. We know that the region is at the seismic belt and many times living earthquakes frequently. How the damage was in the city learned by travelers observations and archival documents. In Erzurum in 1852 a destructive earthquake was experienced. 84 houses were completely destroyed and more than 1000 houses had serious damages because of it. After seven years; June, 1859 was the date of destruction of Erzurum by earthquake again. 1462 houses completely, 1200 houses more than half of whole and 1300 houses partially were destroyed. Between 1860 and 1900 the earthquakes were lived at five times. Continually experienced earthquakes, there was a cycle of construction and destruction in the city. For this reason today a few houses dated 1850s are existed. Many of them construction date is close this century. An English traveler Harry Finnis Blosse Lynch confirms this situation. He came to Erzurum in 1893, 1898 and said that there was no old house in Erzurum and all of them renovated after earthquake [4].

Table 1: the earthquakes occurred in Erzurum at 19th century [6].

Date	severity
1850	VII
1859/01	VIII
1868	VII
1875	VIII
1890-93	IX

This shows us after earthquakes people had reconstructed damaged or destroyed houses with a new construction style. Undoubtedly they wanted their new houses to be earthquake-proof and durable. So we can understand the runner beams related with this. The choice of using runner beam (hatıl) fortifies the system against the destruction. It had been a practice for this region where has experienced very frequent and violent earthquakes through centuries.

4.2 The function of tie beams

Stone walls have high performance against the pressure. Also the fire resistance of stone walls is higher than the timber frame structures. But the masonry walls may be weak against the tension and horizontal movements like earthquake. Therefore to see the usage of timber beam as a solution at the remains from the historical settlements is not surprising. At study the construct of the stone walls with timber beams are similar at settlements are examined.

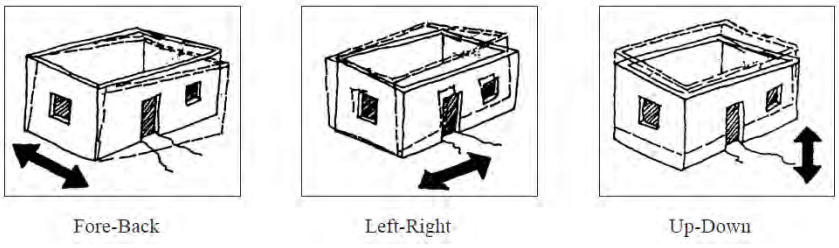

Figure 14: Ground Shaking

Typical damage observed consisted of generalized cracking of the masonry walls, especially between openings and in corners, leading to loss of the superficial plaster and sometimes

causing localized collapses in poor cornices and above window lintels. Floor collapses might have been triggered by out-of-plane deformation of walls and subsequent loss of support for the floor beams [7].

Also usage of tie beams is so important against vertical or horizontal ground movements like earthquakes. The seismic behavior of masonry building during an earthquake generated vibration strongly depends upon how the walls are interconnected and anchored at the floor and roof level. In the case of masonry building where the walls are not interconnected with help of timber, the individual walls tend to separate along joints or intersections.

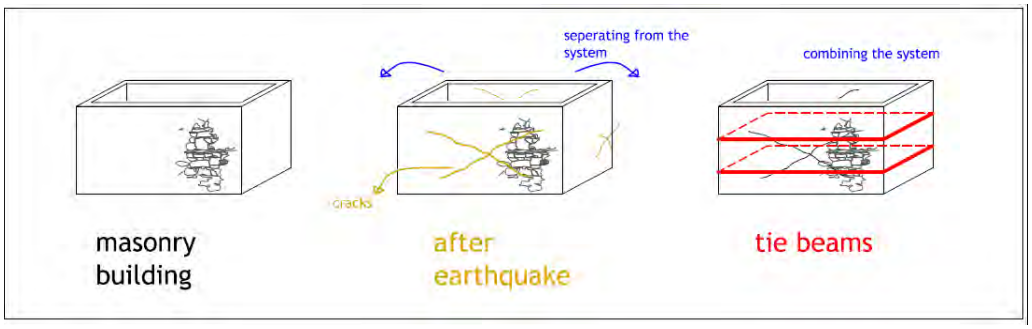

Figure 15: effect of earthquakes and situation when tie beams are used [7].

After the every earthquake the houses would be renovated or reconstructed with innovations in Erzurum. These are not only new style but also new construction techniques. The usage of iron material proves this situation. Using of iron material is related with the industry which came to Anatolia at the middle of 19 the century. With the industrial development the equipment and machinery could work with the use of stream power instead of manpower. These innovations were luxurious and its spread started from the center. So the machines could be seen in Erzurum, an important center of state at Ottoman Empire.

In every kind of wall the tie beams were used in. never usage of tie beams would not given up. Even the houses have ornaments, tie beams are used also they are applied according to decoration.

Figure 16: the tie beams are shaped according to ornaments (Inan, 2011)

5 CONCLUSIONS

In this study it is researched that the construction choices of traditional houses in Erzurum whose historic pattern destroyed by earthquakes and then reconstructed again, through the centuries. With knowing the Anatolian houses shaped by their living traditions it is taken the answer of what the material and construction techniques depend on. In this context the chosen

of material is not only deal with its dominant or not. Even if it was used as constructive material, every time another material in other words secondary material was need for curing of the construction system' weakness. Doubtlessly this situation has been true for Erzurum Traditional Houses. Moreover it was not only usage of secondary material but also changing houses form, construction type for earthquake-proof.

Previously Erzurum traditional houses were nearly buried to ground due to cold. Overtime they were raised. To increase strength of rising walls, the tie beams were formed at several levels. So that usage of tie beams would have been a permanent feature of this geography, East Anatolia. As a result of it, this region referred to stone architecture combined with traditional runner or tie beam (hatıl).

Usage of tie beams is so important against vertical or horizontal ground movements like earthquakes. The seismic behavior of masonry building is improved when walls are connected together by means of timber tie beam. In this case, vibrations of the walls are synchronized. The building behaves like a box and all the walls contribute to the resistance of building. Coinage stone at corners and iron retrofit at connection enhance the strength of masonry wall.

Under the umbrella of the conservation not only the plan type and space composition but also every structural element which lifts the building should be researched. In this context as mentioned The Nara Document on Authenticity e form and design, materials and substance, use and function, traditions and techniques, location and setting, and spirit and feeling, and other internal and external factors are conserved with the integrity of the building [5]. In the context of integrity and authenticity preserving traditional materials and traditional construction techniques are important. Therefore the knowledge of these woodwork details is essential for restoration of these building. We should not forget that this area has been affected by earthquakes through the centuries and solve the problems according this situation. The traditional houses should be conserved with their original material and construction techniques as well. Instead of high technologic solutions due to expensive application to develop the traditional solution is important. Also the documentation of the detail enriched the Anatolian vernacular civil architecture will quote references at conservation of these houses in this study.

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