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Full Length Research Paper

Structural patterns identified through a historical analysis of Anatolian stone constructions

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This paper derives structural patterns through the analysis of ancient Anatolian structural configurations built up by stone. Related archaeological sources indicate that ancient Anatolian constructions incorporating only stone as the principal building material are infrequent. Almost all of the walls of the dwellings and monumental structures were composite. They were constructed by combinations of stone, timber and mud-brick. These combinations followed some timeless patterns which are based upon the principles of reinforcement and counter-balance. These patterns guided the physical configuration of structures. Non-composite stone constructions have been arranged in a variety of ways following the same structural principles which also inform the formation of composite structures. It is also seen that combinations of stone and brick follow the same structural principles and this system should also be outlined in order to grasp a more complete idea of the underlying structural patterns. The objective of this paper is presenting a general framework for architectural students and professionals for conceiving a set of chronologically detached constructions within a common structural vocabulary. When these seemingly unrelated examples of stone constructions are reviewed from this viewpoint, one may infer a historical contingency through which traditional building materials have been interrelated. At first examples are analyzed with respect to their underlying structural principles, and then through inductive method and synthesis, general patterns are proposed. The outcome is the identification of the structural patterns of stone in Anatolia, which are traceable and comparable across different architectural cultures and traditions.

Key words: Architecture, structure, pattern, tradition, stone, Anatolia.

INTRODUCTION

Anatolia is a conceptual and physical bridge between three continents of the Old World: Europe, Asia and Africa. The oldest evidences for human settlements are discovered in this land, which is frequently refereed as the cradle of civilizations (Kostof, 1985). Throughout history, Anatolia has been the stage of many conflicts amongst different political powers. These geographical, social and political factors shaping the history of peninsula also enriched its built environment. The peninsula is dominated by the Anatolian plateau which is framed on the north and south by mountain chains running parallel to the coastline of the Mediterranean and Black Sea (Lloyd, 1967). Great variety of the building practices has also been stimulated by the rich variety of geographical characteristics observed in distinctively different territories of Anatolia. From the perspectives of architectural history and archaeology, this land has been a fertile source of historical evidence (Frankfort, 1996).

Timber, mud-brick and stone structures, which have been the most basic constituents of architecture, are found in the historical settlements of Anatolia within rich variety of structural configurations. Current archaeological knowledge, which goes back till the Neolithic Age Anatolian architecture, furnishes us with a wide range of comparable examples. Even a quick glance at the formal features of seemingly unrelated temporal periods suggests a profound continuity between the building practices throughout Anatolia (Akurgal, 1995). By the analysis of the key structural configurations provided by archaeological examples, this contingency should be allowed to speak for itself.

Architectural history has two major sources of knowledge (Allison, 2001). The first one is the textual sources which give literal information about the culture, life styles and physical space of a certain civilization. The second one is the material sources which consist of the physical remains of a historical culture. Architectural historiography necessitates the matching of these two sorts of information according to a consistent methodology. However, this process may become harder in some situations because related with the nature of the historical period or material being analyzed; the accessibility of these sources may change.

For this paper the material evidence is the main point of focus because of the nature of the historical evidence limited by the scope. The investigation of the construction technique by stone refers to those historical examples which may be classified as “monumental” and “vernacular.” While conventional methodology in architectural historiography has accentuated an election or canon of “monumental” examples that make up a representative picture of architectural history, contemporary development in the discipline also focus on the conventionally-overlooked spaces related with the “vernacular” environments. The connotations and significance of “vernacular” architecture for cultural history has been widely discussed through several publications (Asquith and Vellinga, 2006). Moreover “vernacular” spaces are being analyzed in terms of their success in environmental integration (Bucci and Mollo, 2010). “Vernacular” architecture stands for those buildings which are quantitatively most common in a given culture (Conway and Roenisch, 1994). Thus it represents the built environment which is excluded by the grand state-run projects with a monumental scale, for instance public buildings like temples, palaces etc.

This theoretical shift in architectural historiography is significant for the architectural research in Anatolia since the “vernacular” environments constitute a considerable percentage of the historical built environment. In spite of the introduction of reinforced concrete as the dominant building material, in some regions of Turkey, Anatolian vernacular architecture still continues to be produced by local materials. These vernacular built environments have become the principle bridge for exploring the continuities between the past and the present.

When the historical background of the traditional materials like stone in domestic architecture is taken into consideration, it may be understood that material sources acquire greater significance because many ancient structures are hardly matched with consistent textual sources. Since usually there is no substantial literal information about these spaces, they are generally assessed by the analysis of the physical evidence and oral sources along with ongoing customs and traditions. Therefore when speaking of the relevant subject of this article, it can be claimed that the most significant source of information is the material evidence provided by archaeological studies.

In parallel, Frampton (2002) claims that in architectural historiography one must turn to “a material base,” and “architecture must of necessity be embodied in the structural and constructional form.” In this discussion Frampton focuses on “the structural unit as the irreducible essence of architectural form.” In this respect, the structural unit embodies the timeless principle underlying the construction. The focal point of the structural unit is the “joint,” which stands for the interfaces of load transfer and material differentiation throughout a structural configuration. The material differentiation can be realized through alternating materials or through variations of the same material in terms of size and quality. While this paper focuses on the latter and explores differentiation of stone throughout a structural system, my forthcoming papers will handle alternations of mud-brick, stone and timber in a variety of ancient and vernacular examples.

Related archaeological sources indicate that ancient Anatolian constructions incorporating only stone as the principal building material are infrequent. Almost all of the walls of the dwellings and monumental structures were composite. They were constructed by a combination of stone, timber and mud-brick. In spite of this factual evidence the material evidence of non-composite stone constructions should be analyzed. This paper involves this comprehensive analysis in order to conceive how irregular units of stone are arranged in a variety of ways following the same principles of reinforcement and counter-balance that also informs the formation of composite structures. For instance it is seen that combinations of stone and brick follow the same structural principles and this system is also briefly outlined in order to capture a more complete idea of the patterns.

Persisting structural patterns which are expressed as “technical continuities” are becoming significant points of theoretical focus in studies of historical built environments. Anatolia, where the physical traces of several civilizations are juxtaposed, has become a fruitful ground for such analysis undertaken by archaeological studies (Varkivanç, 2009). This viewpoint should also be developed in the discipline of architectural history in order to unfold historical continuities in the built environment of Anatolia. The aim of this paper is contributing to the study of “technical continuities” represented by enduring structural patterns and thus reinforcing similar studies on the Anatolian architectural tradition by enriching the theoretical grounds according to which physical evidence can be interpreted.

MATERIALS AND METHODS

For realizing this analysis, this paper refers to two groups of sources. The first group is constituted by archaeological reports, analysis obtained through previous studies and personal observations of the author. These references give information about

Figure 1. Section-axonometric drawing, retaining wall with built-in stairs in the rural settlements of the Taurus Mountains, southwestern Turkey [Construction date: mid 20th century / documented in 2009 / drawing by Kavas (2012)].

Figure 2. Troy, layer II fortress tower, northwestern Turkey (Construction date: c. 2 500 – 2 200 B.C. / reference: Troja und Illion, I 44, Figure 7 in Naumann, p. 64, Figure 38).

the structures discovered in many ancient sites of Anatolia, such as Troy, Cerablus, Boğazköy, Perge, Aspendos, Side etc. In order to arrive at general patterns, the structural features given by the above-mentioned archaeological studies should be compared by the enduring architectural traditions of Anatolia. Then another group of relevant sources for this article is the set of research undertaken in the field of vernacular architecture in Anatolia. The traditional rural dwellings of several different geographical regions of Anatolia, has become an important reference. In addition some monumental structures are also analyzed in terms of the common and recurring structural patterns underlying their constructions.

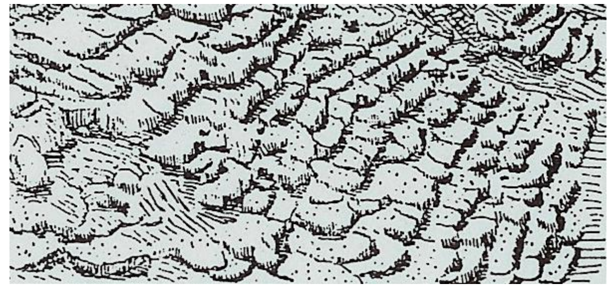

Figure 3. Troy, layer II fortress tower, northwestern Turkey (Construction date: c. 2 500 – 2 200 B.C. / reference: Troja und Illion, Figure 11 in Naumann, p. 64, Figure 37).

This paper also investigates the methods which may be devised to expand and broaden architectural history's field of inquiry into the use of traditional materials in vernacular environments. In so doing, underlying patterns of structural configuration, which have endured through ages, may be identified. The method will be unpacking several archeological representations of the fragmentary material evidence in order to compare them with contemporary examples and to decipher the patterns of continuity. In parallel, the available evidence reveals the surfacing of similar approaches to the treatment and allocation of materials in coping with ever existing structural problems.

While assessing the structural problems and solutions, this paper refers to Gottfried Semper's "division of the built form into two separate material procedures or cultures of building": the frame, and the compressive mass (Frampton, 2002). The constructional mode of "the frame" is associated with the traditional building material of timber and implies a configuration in which "members of varying lengths are conjoined to encompass a spatial field." The other mode, namely "the compressive mass," is associated with the traditional building materials such as stone, mud-brick and brick and implies "the piling up of identical units. Although exceptions that do not conform to neither of these extremities may be encountered, the fundamental contrast set by these categories defines an interpretive framework against which examples might be assessed, related and classified.

A brief assessment of the traditional Anatolian materials and techniques of construction indicates that constructions incorporating only stone as the building material are infrequent. As Naumann (1991) argues, almost all of the walls of the dwellings and monumental structures are constructed with a combination of materials and techniques. This indicates how native people adopted building practices to the available indigenous materials and economized the consumption by reinforcing one with another. This analysis of the materials departs from constructions only by stone. In this way, one can understand how irregular units of stone are arranged in accordance with the same principles of reinforcement and counter-balance underlying composite structures.

Structural treatment of inclined surfaces

Constructing sloppy surfaces for serving different functions has been a common structural problem throughout architectural history. One dimension of this inquiry has been the treatment of the sloppy terrain in order to create flat land for habitation. This has been a fundamental constructional operation traditionally undertaken throughout several regions of Anatolia (Figure 1). This requirement has stimulated the construction of retaining walls which were further articulated in order to connect several levels of the corrugated topography.

Figure 4. Perge stadion, view of the vaulted structure providing inclined surface for the functional requirements of the building (Construction date: Roman period, c. 2nd – 3rd century B.C./ photograph by Kavas (2012).

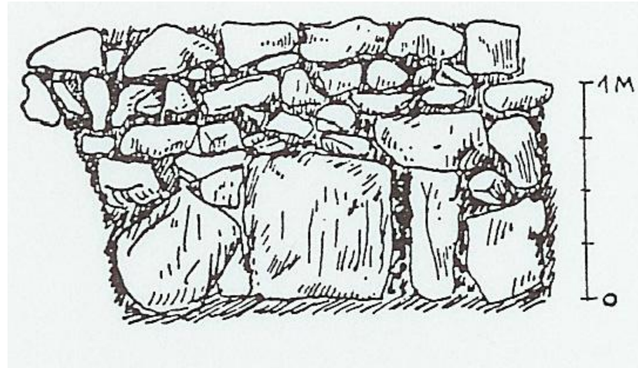

Figure 6. Cerablus, Broken stone masonry, Carchemish II, southeastern Turkey (Construction date: c. 13th century B.C. / reference: Carchemish II Figure 55 in Naumann, p. 70, Figure 46).

Figure 5. Perge Stadion, view of the vaulted structure providing inclined surface for the functional requirements of the building (Construction date: Roman period, c. 2nd – 3rd century B.C./ photograph by Kavas (2012).

The appearance of steeper wall surfaces suggests a development of craftsmanship in masonry techniques. Craftsmanship displayed by these defensive structures are also reflected by the vernacular architectural traditions of Anatolia, especially in the reigons of Mediterranean and Black Sea, where stone is abundant (Aran, 2000).

Rubble stone masonry in the Taurus Mountains (Southwestern Turkey) indicates how the topography is reshaped according to the human requirements. The texture of these modest retaining walls is in fact products of a deep-seated tradition (Figure 1).

This configuration represents a further articulation of the wall surface according to human needs. Figure 1 exhibits the functioning of the outer surfaces of the walls as stairs. Each step is a stone unit embedded in the masonry. The configuration not only shows the economical and practical use of resources but also conveys the idea of historical continuity in mastering of the stone construction techniques.

The defensive structures of Troy exhibit wall surfaces inclined towards outside (Naumann, 1991: 58). This quality explicitly indicates the wall's resistance against lateral forces of soil pressure (Akarca, 1998) (Figure 2).

As shown in Figure 1, variations of the incline may transform the wall surface into a ramp. Naumann states that in Troy, especially in the layers 1 and 11, the loosely arranged broken stone masonry necessitated an exaggerated inclination, so that the wall surface might be used as a ramp (Figure 3).

As techniques of corbelling developed in history, inclined surfaces have become the outcomes of vaulted structures which span different spaces beneath them (Figure 5). The stadion of Perge, in the province of Antalya in southwestern Anatolia, illustrates how inclined surfaces were constructed in order to fulfill the function of the building. Secondary stone elements were fixed upon the inclined structure so as to provide seats for the spectators. Figures 4 and 5 indicate the current situation of the Stadion of Perge.

Structural combinations of irregular stone units

As it is clearly seen through the above-mentioned examples of the retaining walls, craftsmanship becomes more critical when masonry is composed of imprecisely and irregularly shaped units (Figures 2 and 6). In order to cope with these problems, the rarely found precise units are used in characteristic configurations. For instance, material evidence obtained from different historical periods (Figure 17) indicates the general practice of constructing thick foundation walls which have outer shells of precisely cut large stone units filled with imprecise rubble stone. Walls made up of cut stone are constructed by the use of imprecise rubble stone and gravel (Figures 6 and 12). The constituent stone units are compressed and interlocked into a loose web of masonry. When these examples are reconsidered together they affirm the continuous tradition of interlocking irregular units of stone into each other in order to structure a stable whole. In Cerablus we observe that the larger units are placed at the bottom (Figure 6) (Naumann, 1991).

Thermi I give a further articulation of this structural pattern. In Thermi I, especially in the lower courses, long and unexpectedlylight pieces of volcanic stones are seen (Figure 7). Whereas, on the higher section of the wall, limestone is used (Naumann, 1991: 71). These long units are used with the same purpose of timber lintels in the later examples. The wall configuration in Thermi I (Figure 7) reflects the reinforcement of the interlocked web of stones through horizontal leveling layers. This

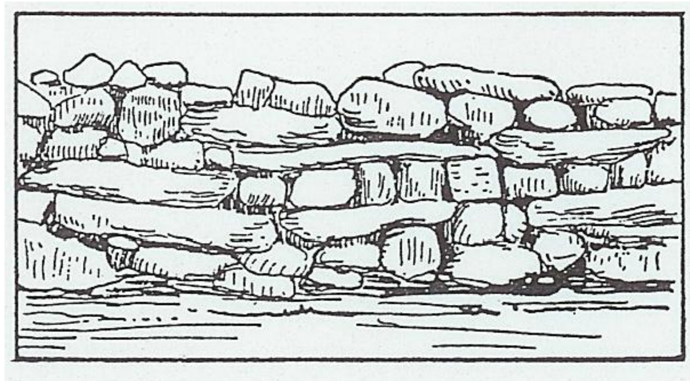

Figure 7. Settlement V wall, Thermi I, northeastern Greece (construction date: early Bronze Age, c. 2800 B.C. / reference: (E 6/7) (Thermi, plate III, 4, Naumann, p. 64, Figure 40).

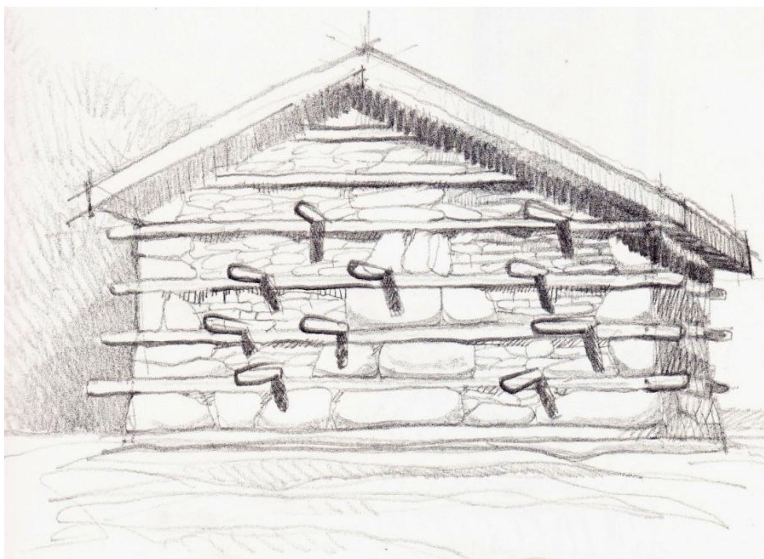

Figure 8. Rural dwelling in Selge, southwestern Turkey (Construction date: early 20th century / site analysis and drawing by Kavas (2012).

pattern is a variation of the logical relationship between the large / precise units and small / irregular units. When the archaeological data is reviewed it is inferred that a course generally made up of longer units form a leveling layer (Figures 7, 8, 9, 10, 11 and 12). This is a reflection of the structural necessity for making regular leveling in certain intervals.

This structural pattern has continuously underlied the traditional built environment. The traditional dwelling in Selge (Figure 8) displays how large and monolithic stone units are placed with regular intervals. They extend horizontally in order to form leveling in certain intervals. The spaces left between them are filled with smaller units with less strength. Timber lintels are additional elements of this system. The structural pattern of leveling courses of stone is based upon the same principle that underlies stone masonry with timber lintels. In this system timber lintels in longitudinal and lateral directions are introduced in order to form a web of reinforcement within stone masonry. This system is used in cases where stone units are not capable of forming a self-consistent structural system. Masonry in a rural dwelling in Selge reflects the system of longitudinal and lateral reinforcement in masonry (Figure 8). Here structural weakness of the masonry composed of irregular units is compensated with a timber reinforcement web. This stands for a basic articulation where stone is reinforced by a secondary material to overcome structural problems.

Turning back to the main problem of this paper, that is masonry without timber reinforcement, it can be realized that some ancient examples produced outside Anatolia also reflect similar structural principles of leveling courses (Figure 9). Masonry in Delos juxtaposes irregular units with leveling.

In the Acropolis of Sifnos (Figure 10) leveling courses and all other components of the structural configuration are clearly exposed. In the stage wall of the theater of Perge (Figure 11) it is seen that the principle of leveling is adopted to masonry with regular stone units. The clear-cut units on the exterior faces of the wall are indeed outer shells and the interior sections of the wall are filled with rubble stone. This principle is also exhibited in İsa Bey Mosque in Selçuk (western Anatolia) (14th century). In Perge there

Figure 9. Stone masonry in Delos, southeastern Greece (Construction date: c. 4th century B.C. / Kavas (2012).

Figure 11. Theater of Perge, stage wall, southwestern Turkey (Construction date: Roman period, c. 2nd – 3rd century B.C. / photograph by Kavas (2012).

Figure 10. Acropolis wall, ancient Sifnos, southeastern Greece (Construction date: c. 4th century B.C. / Kavas (2012).

is a regular rhythm of stone courses representing the principle of leveling.

A similar masonry structure is encountered in the Seljuk Caravanserai called "Sadettin Han" in Konya – Aksaray road (Belke and Restle, 1984) (Figure 12). Here leveling courses are constructed by the use of "spolia" transferred from the ancient monuments nearby. Masonry of Sadettin Han indicates the principle of leveling integrated with the multicultural historical depth of Anatolia.

The traditional dwelling in Banaz (mid-western Turkey) (Figure 13) displays a variation of the structural pattern in Thermi I (Figure 7). Mortar is not used in this example. Horizontal rows of larger stone units work as leveling in certain intervals. It can be observed that they are placed more frequently at the corners, which are the critical structural zones of a masonry wall. The reinforcement of the corners and use of leveling through horizontally placed units and filling the in-between space with more imprecise units are strategies developed for the economization of resources and achievement of the highest level of stability in the given context (Özgüner, 1970).

There is also a more articulated structural leveling pattern unique to Anatolia. Naumann (1991: 69) states that the "hearing bone" arrangement of stone has only been documented in Anatolia. In this case indigenous stone used in the site failed when arranged in horizontal courses. The "herring bone" technique is locally devised in order to solve this structural problem. In this particular arrangement, a variation of which is also observed in Troy, the units were interlocked leading to a more resistant whole than the individual constituents (Figure 14). It is thought that the wall configurations were not intended to be seen because clay mortar is traced as a finishing layer on the wall surface (Naumann, 1991: 69). In Troy I, the technique is used in an advanced manner using stones of 20-30 cm. tied with clay mortar (Naumann, 1991: 69).

A variation of the "herring bone" theme is observed in the ground floor masonry of the traditional dwelling in Safranbolu (Figure 15). In this dwelling where the first floor is made up of a timber frame structure, the ground floor reflects the ancient masonry traditions characteristic to Anatolia.

In terms of the comparable examples available for illustrating the stone masonry techniques, the herring bone technique represents the most articulate point where structural requirements are fulfilled by the use of a single type of material.

Besides these patterns of longitudinal reinforcement, there are also structural configurations reinforcing the lateral direction of the wall. In the rural dwelling of Selge (Figure 8) this is done by timber lintels, cross ties. In a totally different historical period and context, the same principle is realized through the integration of spolia columns into the wall section in the fortifications of Antalya (Attaleia) citadel (Lanckoronski, 2005: 55) (Figure 16).

Examples given in this section illustrate that in the architectural history of Anatolia, several cultures have used similar structural principles through different contexts and materials (Kaymak, 2009: 243). The historical and spatial continuity parallels technical continuities and persistence of certain structural patterns (Varkivanç, 2009; Yilmaz, 2002). Most of these patterns, namely, use of high quality material on the surfaces, rubble stone infills, integration of irregularly sized materials and principle of leveling are exhibited by masonry in the Isa Bey Mosque in Selçuk.

Masonry combinations of stone and brick

The most basic precaution for reinforcing stone masonry through leveling is the placement of timber lintels in certain intervals. Figure 8 displays an example of this configuration where lower and higher courses are differentiated in terms of size and precision. Examples of these composite structures are quite abundant and they will be explored from the same viewpoint in another paper.

Figure 12. Sadettin Hani, Konya, central Turkey (Construction date: Anatolian-Seljuk period, early 13th century / reference: T.I.B. 4, Figure 63).

Figure 13. A traditional shepherd dwelling in Banaz, Uşak, Mid-Western Turkey (Photograph by: İbrahim Bakir, site analysis: Kavas and Bakir, 2011).

However, another variation of the structural theme of leveling is explored here in more detail. The use of stone together with brick units (Figure 18) is a characteristic architectural feature which is observed in Anatolia during the Roman and Ottoman period. When Figures 17 and 18 are reviewed together from the viewpoint of structural principles their common structural behavior can be understood. "Alternative wall" is based upon the theme of "alternation," which, for Batur (1970: 218) stands for either the use of different materials or the use of same material in different physical properties. Batur states that alternation by the use of the same material with different physical properties has been an enduring tradition going back to the Hellenistic period. This technique was used in Ancyra (Ankara, Central Anatolia) and Pamphylia (Antalya – Southwestern Anatolia) by the Romans during the 2nd century A.D (Figure 19). The technique persisted during the Byzantine (Figure 20), Seljuk (Figure 18) and Ottoman (Figure 21) periods in Anatolia (Aktuğ-Kolay, 1999).

For the architectural historians working on Ottoman architecture, "alternative wall" generally points to a certain refined technique observed in distinguished examples of the architecture produced by the Ottoman State. This technique has also been used in vernacular architecture during later centuries (Figures 22 and 23).

Batur (1970: 218) states that "we do not exactly know in which environmental conditions, amidst which stage of production and culture, and in which historical and geographical circumstances, the first examples of alteration have appeared." In spite of our lack of knowledge, for Batur the alternative wall should be a "fulfillment which must have been built after a long period of preparation and incubation," therefore it should have had an earlier use. When the wall details in Figures 20 and 21 are compared it becomes easier to identify the historical process through which the technique acquired refinement.

Although "alternation" is also possible through the change of color and texture (Batur, 1970: 138), this paper solely focuses on

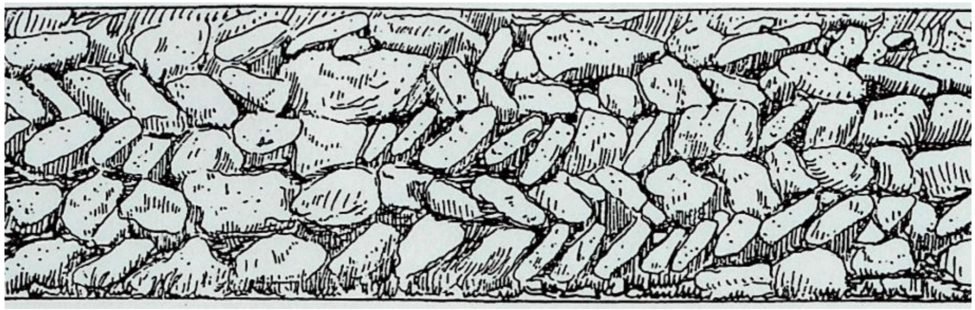

Figure 14. Troy, Wall on the layer I northwestern Turkey (Construction date: c. 3000 – 2500 B.C. / reference: Anatolian 40 in Naumann, p. 70, Figure 4).

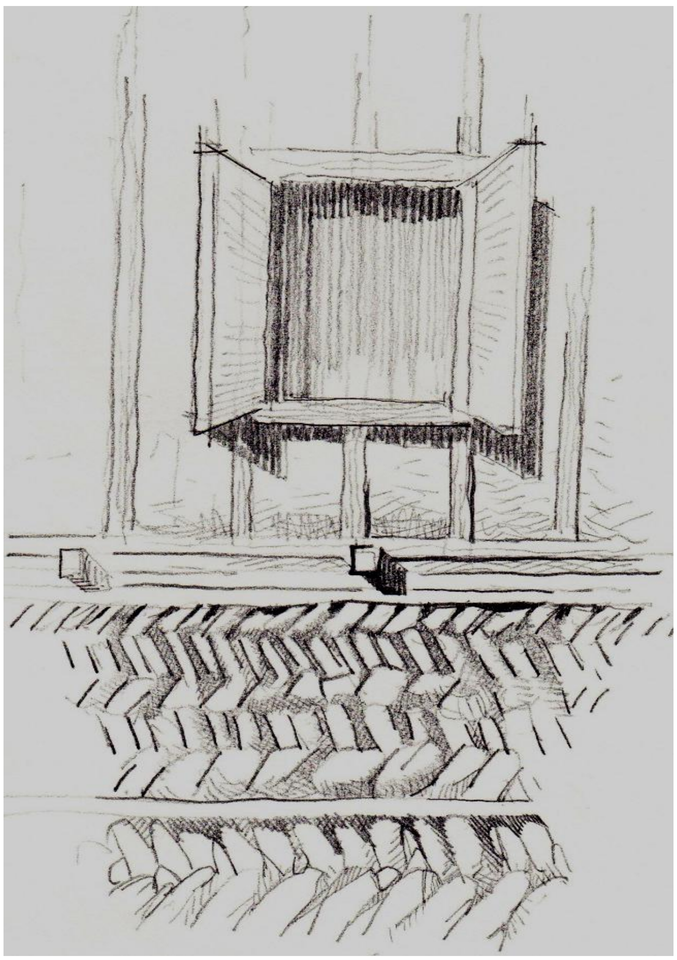

Figure 15. “Herring bone” technique observed in the ground floor of a traditional dwelling with a timber frame second floor, Safranbolu, northwestern Turkey (Construction date: Late Ottoman period, 19th century / drawing by Kavas (2012).

the structural dimension of the issue and explores the Ottoman alternative walls in order to understand their common underlying principles and historical continuities with the ancient examples. In this respect “alternative” wall stands for common structural principles and varied solutions to the same problem.

RESULTS

From the viewpoint of the definition of “alternative wall”, itcan be claimed that the examples given in this paper so far illustrates the earlier kinds of “alternative wall” because they exemplify the use of the same material in different physical properties within the same wall structure. Therefore, the examples covered so far are kinds of “alternative walls” employing “alternating” properties of the same material according to structural and functional necessities. Their underlying structural principles based upon alternation unite these different wall structures disseminated into different regions of Anatolia in different historical periods.

By using the above-mentioned archaeological examples as evidentiary basis, this paper discerns structural patterns that identify otherwise unmarked affinities between different construction systems. The following patterns will help us to organize the already presented corpus of archaeological evidence around a coherent interpretive framework based upon timeless structural principles. The identification of the following structural patterns of stone in Anatolia displays common principles traceable and comparable across different architectural cultures and traditions.

Structural pattern 1: Composite structure (Figures 1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22 and 23). This pattern underlies the constructional system which is composite in terms of the variety of constituent materials or variety of the same material by size, quality etc. It represents the strategy of complementation/ compensation due to the shortage of structurally efficient and high quality building material.

Structural pattern 2: Interlocking and counter-balancing (Figures 1, 2, 3, 4, 5, 6, 7, 8, 13, 14 and 15). This pattern underlies the practical use of the mechanisms of interlocking and counter-balancing between the irregular units of the otherwise unusable material. Through the resultant structural configuration the system achieves a structurally-consistent and resistant entity.

Figure 16. (Left) a general view of the spolia columns vertically integrated to masonry. (Right) spolia columns with changing diameters integrated to the fortifications of the citadel of Antalya (Attaleia), southwestern Turkey (Construction date: Anatolian-Seljuk period, early 13th century / photograph by Kavas (2012).

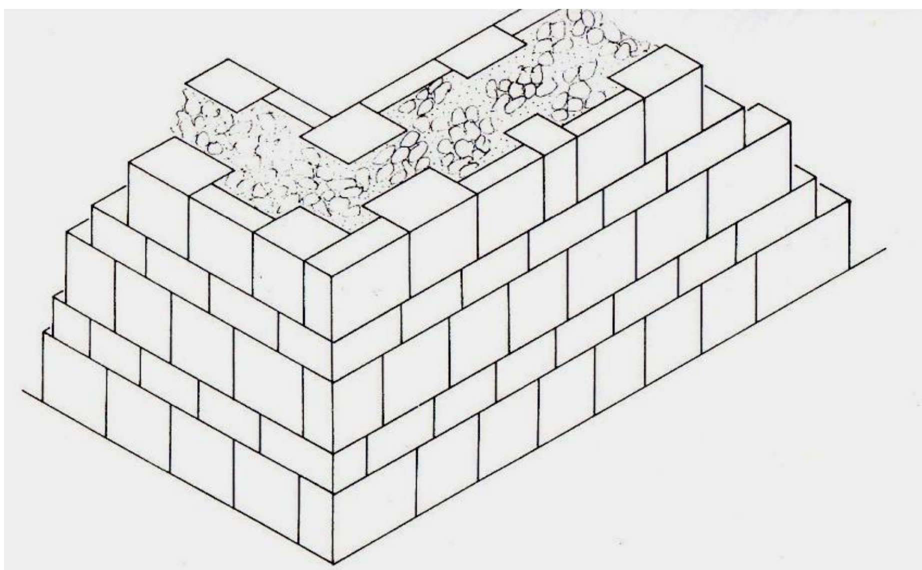

Figure 17. Isa Bey Mosque, Selçuk (Western Turkey), 14th century, section axonometrics indicating the rubble stone infill covered on two faces with clear-cut stone units with regular leveling courses (Aktuğ-Kolay, 1999: 26).

Structural pattern 3: Leveling (Figures 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 and 23). This pattern relates to the logic of leveling through courses. This configuration structures practically reproducible horizontal segments of the constructional section and coincides, in certain interstices, with the working rhythm of the builder.

Structural pattern 4: Material differentiation across leveling (Figures 8, 15, 18, 19, 20, 21, 22 and 23). This pattern represents the articulation of the constituent materials, through either material alternation or formal / physical differentiation conforming to the horizontal leveling.

Structural pattern 5: Tensile frame behavior within compressive mass (Figures 7, 8, 9, 13, 15 and 16). This pattern represents the tensile frame behavior within alternating layers of compressive masonry through lintel-like elements structuring a continuous web of

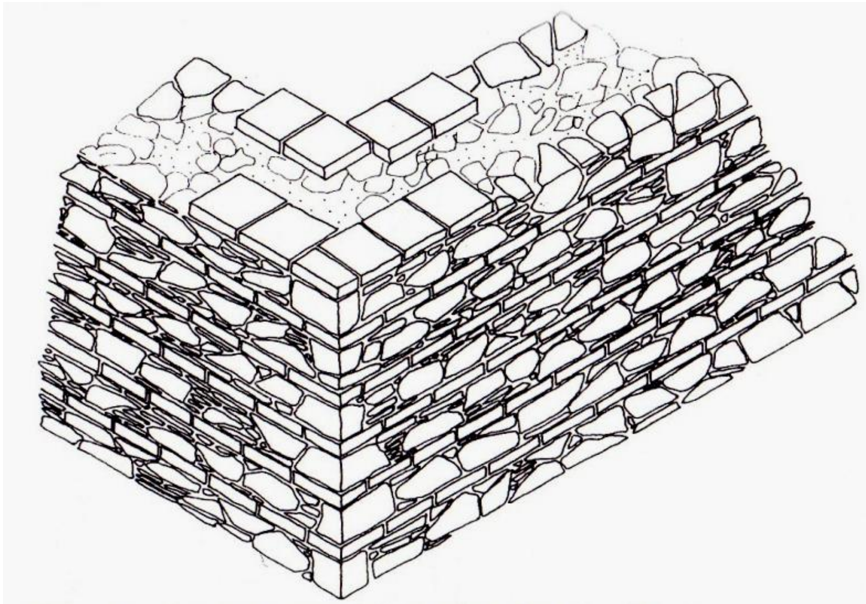

Figure 18. Section-axonometrics indicating the combination of stone and brick with regular leveling courses, tomb structure in Karahasan Mosque, Tire, Western Turkey (Construction date: 14th century / reference: Aktuğ-Kolay, 1999: 29).

Figure 19. Remains of the adjoining structures to the Aspendos Aquaduct, southwestern Turkey (Construction date: Roman period, 2nd – 3rd century B.C. / photograph by Kavas (2012).

reinforcement.

Structural pattern 6: Lateral reinforcement (Figures 8 and 16). This pattern helps to understand how reinforcement is set up against lateral forces by interconnecting the inner and outer surfaces of the wall.

Structural pattern 7: Structural and functional inclination (Figures 1, 2, 3, 4 and 5). This pattern relates to the inclination of the wall for structural or functional reasons. Masonry may have an inclined surface in order to resist gravitational forces more successfully or it may form an inclined surface in order to house an activity on this

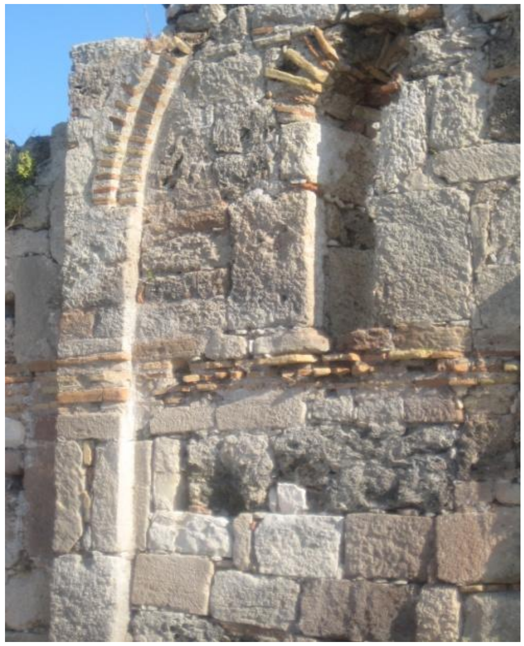

Figure 20. Byzantine Hospital in Side, southwestern Turkey (Construction date: 6^{th} century AD / photograph by Kavas (2012).

Figure 21. Yildirim Bayezid Mosque in Edirne, northwestern Turkey (Construction date: early Ottoman Period, 14^{th} century / photograph by Kavas (2012).

surface.

Structural pattern 8: Structural transparency (Figures 1, 2, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20 and 21). This pattern explains the clear revelation of the structural system of the constructional section on the architectural surfaces. Through this pattern the underlying approach towards nature may be traced because it both displays the material characteristics of the location and cultural attitude towards shaping nature according to human

Figure 22. Combination of brick and stone (alternative wall) in a dwelling wall in Bergama (Ancient Pergamon), western Turkey, (Construction date: early 20th century, photograph by Kavas (2012).

Figure 23. Garden wall, old governmental building in Bayindir, Western Turkey (Construction date: early 20th century / photograph by Kavas (2012).

requirements.

DISCUSSION

During the exploration of the historical built environment, it is possible to identify focal points whereby these proposed patterns interpenetrate in a variety of ways. Some of these are as follows.

Structural patterns 1 and 2 are founded on the same basis of material configuration; however their difference lies in the focus of accentuation: pattern 1 emphasizes the employment of differing materials while pattern 2 focuses on the behavioral features suggested by these materials (Figures 1, 2, 6, 7, 8, 13, 14, and 15).

Structural patterns 2 and 3 are based upon the same structural principle of counter-balancing. Pattern 2 gives the more abstract principle while Pattern 3 unfolds a specific solution related with this basic problem of stability (Figures 7, 8, 13, 14 and 15).

Structural patterns 3 and 4 are strongly related since the former introduces an essential structural exigency and the latter suggests a specific cultural response to the problem put forward by the former (Figures 8, 15, 18, 19, 20, 21, 22 and 23).

Structural patterns 2, 4 and 5 indicate how “material differentiation across leveling” coincides with different structural logics within the same system. Tensile frame and compressive mass are usually related through the material differentiations which emphasize the principle of counter-balance (Figures 8 and 15).

Structural patterns 3, 4 and 7 are strongly related because structural inclination of the wall surface parallels material differentiation and leveling according to structural roles within masonry composition (Figures 1 and 2).

Structural patterns 5 and 6 are interrelated in that the elements of lateral reinforcement span the lateral section of the wall by resisting tensile and compressive forces acting against the integrity of the wall. Therefore pattern 6 is a special form of pattern 5 (Figures 8 and 16).

Finally, structural patterns 1 and 8 are interrelated in that the honest expression of the constituent materials and techniques is a frequently invoiced feature of vernacular architecture (Figures 1, 2, 7, 8, 9, 10, 11 and 12).

The above-mentioned patterns may be multiplied according to the specific area of study and characters of the object being investigated. This list is a preliminary proposal for the comparison and the categorization of the traditional structural systems through a reinterpretation of the archaeological evidence.

From the proposed structural patterns it is possible to derive a general framework for conceiving a set of chronologically detached constructions within common structural criterion. When these seemingly unrelated examples of stone constructions are reviewed from this viewpoint, one may infer a historical contingency through which traditional building materials have been interrelated.

Conclusions

From this study, it can be concluded that simple structures incorporating only stone as a principle building material have remarkably common structural properties with the composite systems. Even if the stone masonry structures do not incorporate timber lintels for reinforcement, the articulation of the stone units structures leveling that function like horizontal lintels.

It is seen that the above mentioned patterns incorporate otherwise weak and perishable components into a resistant and permanent entity which clearly reflects the organizing constructive logic. In this case stone units of different characteristics are combined according to these general principles. The rhythm as well as the consecutive steps of construction is traceable through a surface observation, however a comprehensive assessment of the system requires a deeper understanding.

Given the absence of adequate information, both textual and material, for structuring a continuous historical narrative of progressive continuity, the evidence we possess rather reveals the surfacing of similar approaches to the treatment and allocation of materials in coping with ever existing structural problems. The persistence of the similar motives throughout ages suggests timelessness.

The timeless structural patterns inferred by this paper may unite different constructions irrespective of their origins against a general framework of principles applicable to all structural configurations. Hence, these patterns, which have the potential to engender related variations, provides a basic guide for the members of the architectural professions in their problems of conceiving, evaluating and classifying structural systems according to their material configurations and underlying principles.

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