



kerpic'2019

Earthen Heritage
New Technology, Management
7th International Conference

5-7 September 2019
Köyceğiz, Muğla, Turkey



VOLUME

I

Proceedings for the
Seventh International Conference
Kerpiç'19
Earthen Heritage, New Technology, Management

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Themes of The Conference:

Proposed Main Theme Earthen Architecture: Lessons from Past to Future Proposed topics: All studies on movable and immovable cultural assets and tangible and intangible earthen heritage as:

- Historical, Architectural and Archaeological researches
 - Studies on Information and documentation Systems
 - Traditional construction techniques
 - Evaluation of experimental methods and tests
 - Structural behavior - static, dynamic and numerical analysis methods
 - Researches on principles and methods of conservation
- Protection against environmental effects and disasters, evaluation of risk
 - Preservative conservation in museum
 - Intervention, restoration and prevention techniques
 - Heritage site planning and management
 - Case studies
- Cultural heritage education, skill development and communication by innovative systems
 - Sustainability in building materials
 - Sustainable architecture

DEAR COLLEAGUES;

7. International Conference www.kerp-pic.org/2019 will take place at Köyceğiz, Muğla/Turkey, will follow the www.kerp-pic.org/2005 “Living in Earthen cities” at Istanbul Technical University; www.kerp-pic.org/2008 “Learning from earthen architecture in climate change” at Cyprus International University, TRNC; www.kerp-pic.org/2013 “New Generation Earthen Architecture: Learning from Heritage” Istanbul Aydin University, www.kerp-pic.org/2015 “Built Environment on Silk road” Istanbul Aydin University, Istanbul; www.kerp-pic.org/2016 “Cultural landscape, rebuilding after decay”, Istanbul Aydin University, Istanbul; www.kerp-pic.org/2018 “Back to earthen architecture: industrialized, injected, rammed, stabilized”, Hasan Kalyoncu University, Gaziantep.

Over thirty years, Kerpiç-network is carrying researches on durability, seismic response and production techniques on earthen construction material. Durability researches are based on gypsum & lime stabilization of earth, called “alker”; seismic response researches are based on horizontal energy dissipating surfaces in the load bearing walls and production techniques are based on shotcrete and compacting production of earthen walls. www.kerp-pic.org, info@kerpic.org We are pleased to announce the Call for the 7. international conference on kerpiç’19 “Earthen Heritage, New Technology, Management” and the workshop on production: 5,6,7 September 2019 Organized by Kerpic Akademi and Kerpic Network.

The conference scope will focus on using earth for housing, “Earthen Heritage, New Technology, Management”, The study will range from the graduate programs, together with the academics and professionals to exchange results and experience. It will be an opportunity to understand the strategy and the advances how to use the contemporary construction technology, using earth-based material.

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VOLUME

I

Structural Analysis and Protection Problems Of The Traditional Adobe Houses in Central Anatolia



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ABSTRACT

The buildings that are made by traditional methods in rural areas; have different features depending on local materials, economic opportunities, people's needs, climate and social life. Due to the geographical characteristics of each region, local building materials are varied and are preferred in building construction with its quick availability and economy. Beside these features, kerpic (adobe) and soil material are healthy building materials, which have been used in building construction since the first settlements of history in Anatolia.

Bilecik province, Gölpazarı, Tongurlar Village has been an important settlement since prehistoric times; which bears kerpic (adobe) architecture characteristics. The whole settlement, which has the traces of the Ottoman period, was constructed by kerpic (adobe) building material, determined by the analysis and survey studies. The kerpic material was used with masonry technique or wooden carcass filling system. Depending on the climatic conditions of the region and the properties of the kerpic (adobe) material; the occupancy of the buildings, the projections (cumba) and the balconies are specialized. However; with the change of modern living conditions, the vernacular architecture has begun to deteriorate with the uncontrolled and inaccurate interventions. With the increase of immigration to cities, the rural architecture has been lost.

In this study, the structural analysis of the rural architectural buildings in Gölpazarı were examined and the protection problems were determined. In order to ensure the sustainability of the kerpic (adobe) buildings, a conservation model has been tried to be introduced through a building, which has been restored.

Keywords: Rural architecture, Conservation, Sustainability, Adobe houses

1 ADOBE BUILDINGS

Earth is an ancient construction material that has been used with people's housing activities [7]. It has been used as a structural material and is also used as a plaster material. It is preferred especially in rural areas because it is easy to supply and economical.

Adobe, which is widely used in building construction in Anatolia, is a building material where clay soil and water are mixed and poured into molds and dried. The use of fibers in adobe is seen in many buildings in Anatolia [9]. The first adobe buildings in Anatolia were constructed in Çayönü Diyarbakır which dated to 8500 BC. It provides thermal insulation and the most convenient climatic conditions and makes the most advantage of solar energy [1]; that emit heat energy and maintains heating when the source is cut. Because it is a porous material, it traps moisture and provides the moisture balance of the structure; thus providing natural climatic comfort [5]. Its production is easy and production costs are low [1].

With modern architecture, the adobe has been removed over time; it has been seen as a primitive material compared to new building materials in today's industrial age. Whereas it is more ecological, environmentally sensitive and energy saving material from production phase to usage phase; compared to contemporary building materials. Nowadays it has gained importance again with these features.

The adobe provides an advantage in building construction with its fast and easy production. It is poured into molds by human hand, no pressure is applied to compress and is expected to dry in sunlight. Although it is an ecological material, it has low pressure resistant and it is weak to moisture; when it is used as a structural element that should be paid attention to these features [7]. In the construction of the masonry system, it is necessary to plastering in order to protect the structure against external conditions. In order to increase the strength of the adobe material and prevent dusting, admixtures such as tow, straw, gypsum and sometimes cement are added to the adobe blocks depending on the local conditions [1]. It is seen that it is used with wooden skeleton, bearing system, as flooring material, as well as a finishing element on the walls and ceilings like adobe plaster. In order to be resistant to rain water, the adobe used in exterior plaster must be made with clay earth or additive.

2 BİLECİK, GÖLPAZARI DISTRICT AND ADOBE HOUSES

Bilecik province, Gölpazarı district where is on the way of Bilecik - Sakarya and Bilecik - Bolu (Taraklı), is the subject of this study. Because of its location, has been used as an active market area for a long time; also, still have transportation density. The residential area of the district and villages has been preserved substantially and today it is in danger of consciously and unconsciously demolition activities.

Karağaç Tumulus, Yassı Tumulus and Arıcaklar Tumulus in Gölpazarı are belong to the Copper, Hittite, Phrygian and Lydian civilizations. This area was the settlement of the Bithynia Empire from the 3rd century BC. Osman Bey took the Golpazarı Harmankaya Tekfurluğu from the Byzantine Empire and started to expand the Ottoman Empire on these lands.

"Göl" (lake) name of the district depends on the plain which located in the south was a lake before Ottomans. In this period there was a marketplace around the lake and the settlement was more intense and frequented. It is named also Nefs-i Göl, Akcaoba, Akcaova then Ottoman period, it was finally named Gölpazarı [4]. In the 17-18th century, timber was supplied from Bilecik and its environs in order to build warships at Gemlik shipyard [11].

There are 48 villages in Gölpazarı. Kasımlar, Büyükbelen, Aktaşlar, Tongurlar, and Keskin villages also 7 more villages were examined in this study. In these villages, people did fruit growing and the houses were built with adobe.

In the district, the site plan was arranged parallel to the main roads and the houses are directly related to the roads. The topography rising from the district center to the villages; the building settlement planned in organic formations with their gardens due to topography. It is noteworthy that the narrow facades of the houses are directed towards the north in order to protect the adobe buildings to rain and to provide climatic comfort for the householders (Figure 1). In the villages, houses are clustered along the road and access to the houses is provided through the gardens. In the village settlements, mosques are usually located in the center of the village and schools, which built with also adobe, in a large garden. The gardens of the schools are used as gathering areas of the villages.

The adobe houses in Central Anatolia and in Gölpa-zarı, are generally designed with square and rectangular plan. The entrances of the houses reached through the gardens are generally arranged

on the southwest and west sides. In the gardens, some barns arranged adjacent to the houses (Figure 2). The barns which was also built with adobe is not used due to the decrease in animal husbandry. It is noteworthy that, the parcels of the houses were not surrounded by a continuous garden wall; there are wooden or wire fences around the houses, some parcels are only limited by roads.



Figure 1. Büyükbelen Village site plan.

3 TRADITIONAL ADOBE HOUSES

3.1 Architectural Features of Adobe Houses

The village houses are important living and gathering places. The entrances of the buildings, which are constructed as single or double storeys, are provided from the west or south facades. There are semi-open porch spaces, which called "hayat", on the southern facades of the houses have stone pavement. People make summer and winter food preparations by "imece" (together), the cauldrons are boiled in the garden to make products such as molasses and tomato paste, and people come together in the evenings around a fire. With these features, gardens are open spaces used as living spaces of houses.

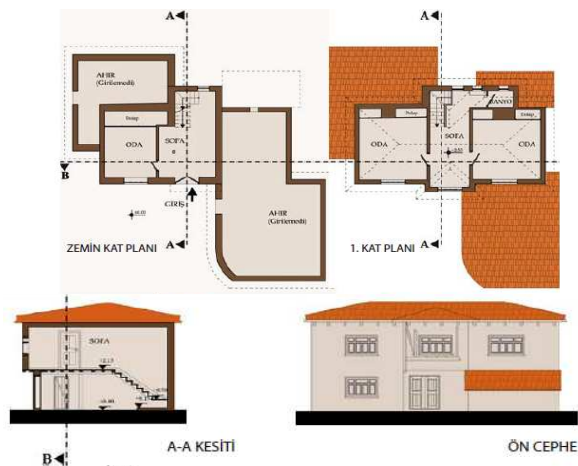


Figure 2. A house planning from Tongurlar village

The adobe houses in Gölpaazarı have sofas where are directly related to the gardens. Some rooms are organized adjacent to the barn walls so that they get warm (Figure 2). In these houses the sofas were planned on the edge; in the single buildings the plan type with the middle sofas is widely used (Figure 3). In the downstairs sofas, there are usually kitchen niches to serve in the garden, and staircase leads to the upper hall (Figure 2 and 3).

Service spaces are usually located on the ground floors. In some houses there is a guest room in this floor. On the upper floors, the bedrooms open to the hall (sofa) and there are cupboard niches inside the rooms as traditional (Figure 3). In the middle sofa plan type, the sofas carried out and the projection of the sofas become an eave on the entrance doors (Figure 3). In the plans, symmetrical order was created according to the sofas and reflected also to the facade. The main entrance door and the sofas on the first floors are emphasized with a bay window or balcony. In the houses which planned with the barns on the ground floor, have irregular facade organization in this level floors, besides that first floors have symmetrical order (Figure 2). The windows of the rooms are usually arranged on the east and west facades; it is avoided that planning a window on the north facades, the northern facade of the buildings is generally deaf.

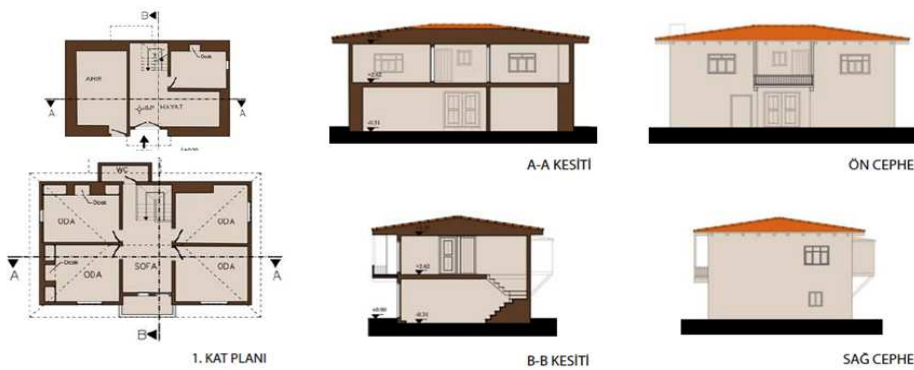


Figure 3. A house planning from Aktaşlar village

3.2 Construction Techniques and Materials

Adobe was used in three different structural systems. The first one is the load bearing system which consists of adobe blocks with adobe mortar, the second one is the wooden carcass with adobe block filling system and the other one is the mixed system. In addition to these systems, in the center of Gölpaazarı there are houses which have completely wooden skeleton with bagdadi slat and adobe plastered.

3.2.1 Adobe buildings with load bearing system

In this structural system, adobe blocks put (almaşık) side by side and one on top of the other (Figure 4). In some of these buildings, stone masonry walls were built to the plinth wall and adobe blocks were raised on them. The dimensions of the adobe blocks used in barn and warehouse differ; it is seen that the blocks were not poured on molds in similar dimensions. The outer wall thickness of the buildings is composed of 2 rows of adobe blocks and is approximately 50-60 cm. in depth; while the interior walls are about 30 cm. thickness. All wall surfaces were plastered with adobe plaster. Because of the weather conditions, plasters of some buildings has been lost and deformations have occurred between the blocks (Figure 4).

In the barns, roof structure was made in order to wooden truss because of the large opening. The woods were not chipped and like as logs. The ceilings are not covered, the roof construction can be seen from the inside. In these buildings, a regular wooden rafter is not used and wooden boards are placed on it. This and the other building types have alaturca roof tiles (Figure 5).



Figure 4. A house with load bearing system



Figure 5. A barn with load bearing system

In order to protect the buildings from rain, the eaves are carried out and the lower surface of the eaves are not covered. The roof construction can be seen from under the eaves, some of the eaves have wooden forehead. There is no rain pipe system on the roofs, which are designed as hipped or gable roofs, and the woods used on the roof is not planed and only simply shaved.

In the two-storey houses, the floor beams are placed in short direction on the masonry walls. The length of the wooden beams generally does not exceed 4 m.; as a result the space measurements were determined. The wooden floor beams were placed on horizontal beams which were placed along the walls and were connected to each other on the outer body walls to strengthen. The bottom of the wooden floor beams was covered with wooden ceiling boards in the houses; it is seen that the wooden flooring is not exposed in the barn structures and warehouse spaces (Figure 5). The floor covering of the first floors of the houses is made of wood and the ground floors are made of stone pavement so as not to be affected by water.

On the windows and doors, wooden lintels were used. On the arched windows were constructed in a similar way to brick arched windows; by using molds, the adobe blocks were placed in an upright direction of the arch, the molds were removed and then window openings were formed (Figure 4).

3.2.2 *Wooden framework with adobe filling system*

In this system, which is called "Hımış", adobe blocks were filled between the wooden framework. The buildings were built with stone masonry to plinth wall level, from this part, wooden carcass system was established. The door and window openings were formed by wooden vertical and horizontal supportings. On the walls wooden vertical supports were connected to each other by timber diagonal and horizontal brackets (Figure 6). The adobe blocks were prepared to fit one in the spaces between the brackets; the blocks were filled diagonally or horizontally between the wooden carcass (Figure 6a and 6b). In both systems, the building facades were plastered with adobe plaster (Figure 4 and 6).

In this structural system, the woods were carved but not grated. The floor was arranged in the short direction of the spaces as *kagir* system. In the roof level the same system was made, the eaves were extended outwards and covered with tiles. No flat-roofed housing was found in the region due to climatic factors. On the wooden floor beams timber flooring was applied. The ceilings are completely covered with wood; flooring or beam systems are not seen. The floors of ground levels have stone pavement.



Figure 6a. *Wooden framework with diagonal..* **Figure 6b.** *..with horizontal adobe block fillings*

3.2.3 Mixed structural system

In this system, buildings were constructed in a similar way to the load bearing system; wooden beams are used to distribute loads between the floors, wooden pillars were used as structural support at the corners of walls and wooden frames on the window and door edges (Figure 7). The wooden beams on the walls connected to each other and reinforce the structure against compressive and tensile strength. In this system, the buildings were placed on a stone foundation and the floor and roof constructions were solved like wooden carcass structures.

According to the results of physical, chemical and mechanical tests that performed in the laboratory condition, on the adobe blocks, adobe plaster and wall mortar samples which were taken from houses of the villages. According to the results of the tests it is determined the clay soil and straw were used in samples. It was found that 4 mm soil material granulometry was used to increase the strength of adobe blocks and filler mortar, while in thin granulometry soil was used in plaster mortar (the material passing through the sieve was less than 2 mm). The rate of clay was found approximately 67-80% in adobe blocks, 56-58% in plasters and 10% to 5% ratio straw [3].



Figure 7. *Mixed structural system*

Energy efficiency and comfort level analyzes have also been conducted on approximately 50 houses in the region. As a result the houses have provided appropriate values for energy efficiency.

4 CONSERVATION PROBLEMS OF ADOBE HOUSES

Adobe is affected by rainwater and temperature differences, because of that adobe material must be protected against to climatic conditions. Therefore, regular maintenance of the adobe buildings is important. However, there are conservation problems due to migration from rural areas to urban areas and the benefits of adobe and earth are not known sufficiently.

- The adobe material which is weak to climatic conditions is severely affected by the water coming from the roof and floor. The adobe buildings which constructed with load bearing system are more sensitive to wooden carcass structures. First of all, the plasters of the buildings are damaged and fall down then due to external weather conditions, the filling mortar between the blocks have been lost and deformations occur between the blocks. The moisture also gives harm to the wooden framework.
- Local people often see continuous care as a difficulty and do not want to make. Buildings that are not regularly have conservation are exposed to external weather conditions and their damage is increasing.
- Because of changing living conditions, production in rural areas is decreasing, production activities that took place in open and semi-open spaces have lost their importance; sofa, gardens, barns are not used.
- Due to the excessive consumption brought by modern life, comfort conditions change, and people do inaccurate restoration works, wrong arrangements on buildings, deteriorate the original architectural features of the buildings. Also, these arrangements are not suitable for the structural system of buildings so structural damages occur.
- Migrations are increasing in rural areas; the house holders are moved from their homes and the buildings are abandoned and damaged. Instead of the demolished buildings, concrete structures are made, and rural areas become unidentified and our adobe architecture have begun to lose.
- In addition to the migration, on the other hand, people get away from the cities due to crowded city life and rural tourism is in demand because of need natural life. This situation, which increases the interest in rural areas, has both advantages and disadvantages for the protection of these areas. Unconscious interventions caused by urban people starting to spend time in rural areas for weekend vacations cause loss of people because of their easy access as in many rural areas.
- With inheritance, new users have houses in rural areas and want to demolish them not to provide comfort conditions. Instead of the adobe houses, the buildings with reinforced concrete system are constructed, the parcels and gardens surround with high walls and alienation have began.

5 PROTECTION OF ADOBE HOUSES AND CONCLUSIONS

Adobe porous, natural, ecological material that provides heat and sound insulation. However, its benefits are not sufficiently known.

- In order to ensure its sustainability, continuous maintenance and climatic conditions should be taken.
- The house holders are unwilling to make periodic maintenance works. Because of that, it is recommended to obtain a more durable adobe on repair works with improved adobe that suitable admixtures should be used in order to ensure the long life of the adobe structures and to provide optimum conditions by the user [3].
- The use of adobe is very important in the buildings to be repaired or reconstructed. In the production of adobe material, the soil must be screened well; straw and fibers to be used as additives must be thoroughly chopped and comminuted. The adobe blocks should be compressed by hand pressure into the wooden molds and allowed to dry.
- Traditional buildings cannot provide today's comfort conditions, but rather, they will be abandoned completely; these buildings should be protected. The characteristics of rural architecture must be

examined and developed with the knowledge of today's industrial age to get more healthy and comfortable structures.

- Traditional heating systems of rural buildings are stoves and each room could not be heated in same way. In this case, a radiator system could be integrated in stoves for thermal comfort; local materials continue to be used as fuel. Hot water can also be supplied by installing a solar energy system in adobe houses.
- With reducing production activities in rural areas barns and warehouses is now nonfunctional. These spaces could be reuse with convenient arrangements.
- In order to increase the energy efficiency of the buildings to be reconstructed, it may be recommended to have water and heat insulation on the floor, roof. New adobe production can be achieved by adding water repellent additives to the plaster material and wall blocks. This will extend the time required for periodic maintenance. In order to provide thermal comfort of the houses, it is recommended to replace the windows with double glazing wooden windows instead of inappropriate PVC windows.
- Narrow sofa spaces in traditional houses can be rearranged depending on the needs of the users in the houses to be reconstructed, but the traditional architectural plan should not be changed.
- Cultural policies should be developed to preserve vernacular architecture; conservation projects should be organized and encouraged. Rural tourism should be supported.
- Reinforced concrete buildings in rural areas should be restricted and local regulations should be prepared.
- National economic policies should be developed for rural areas to reduce migration, increase the production activities and contribute to national production.
- In order to ensure the sustainability of our adobe architectural heritage, academic studies should be supported.
- Adobe is a recyclable and natural material, this should be considered as an advantage. New adobe materials can be produced by reusing the adobe soil by utilizing the construction residues of demolished or collapsed structures. The continuity of the material and architecture can be achieved by reconstruction with these materials with low production cost.

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