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INVESTIGATION OF STRUCTURAL PROBLEMS AND DETERMINATIONS RESULTING FROM RESTORATION APPLICATIONS

Mehmet Can Balcı^{1*}, İsmail İnce², Mehmet Ergün Hatır³

^{1*}Batman University, Faculty of Engineering and Architecture, Department of Civil Engineering,
Batman, Turkey.

ORCID Code: 0000-0003-3737-2556

²Konya Technical University, Faculty of Engineering and Natural Sciences, Department of Geological Engineering, Konya,
Turkey.

ORCID Code: 0000-0002-6692-7584

³Necmettin Erbakan University, Faculty of Fine Arts and Architecture, Department of Interior Architecture and
Environmental Design, Konya, Turkey.

ORCID Code: 0000-0003-0460-0583

ABSTRACT

In monuments, which are the common heritage of humanity, deteriorations and structural problems that occur over time threaten the aesthetic and architectural values of the buildings. In order to overcome these threats, restoration plans to be developed specifically for monuments are vital for the preservation of buildings for future generations. However, in restoration projects that are not developed specifically for the building, the deterioration process in monuments may accelerate compared to the initial situation. This study examined the structural defects and types of deterioration at Kızılören Küçükhan, where restoration planning specific to the monument was not carried out. According to the in-situ examinations, the deterioration process of the monument was accelerated by the use of restoration stones whose petrographic, textural and index-strength properties were not compatible with the original building stones of the monument. In addition, after the restoration, the monument developed cracks due to consolidation and increased building load. In addition to these problems in the structure, the impacts of the deterioration processes have increased due to the lack of occupancy of the monument. This study points to the importance of planning restoration implementations specifically for the monument.

Key words: Building stone, Deterioration, Structural problem, Kızılören Küçükhan, Konya.

INTRODUCTION

In restoration works, it is extremely crucial to determine the types of destruction and to develop suitable solutions. For this purpose, the engineering properties of the original stones of the monument should be determined and practices such as patch repair, consolidation and filling should be planned for the existing blocks. The replacement of missing stones should be carried out by taking stones from the

antique quarry of the original rock. In cases where the antique quarry cannot be identified or production is not possible, rocks with the closest properties (texture, petrography, mineralogical content and index-strength etc.) to the original blocks should be preferred. When this situation is ignored, the building stones chosen for integration may diminish the authenticity value of the historic building. In addition, restoration blocks with different engineering properties compared to the original building stones may affect the wetting-drying and freeze-thawing processes as they will lead to differences in moisture absorption (Hatır et al. 2022). This may trigger the development of many types of deterioration such as flaking, cracking and differential erosion in original building stones. In this study, the problems that developed in the monument after the construction of Kiziloren Kucukhan (Figure 1), located 40 km west of Konya city center, with stone blocks that were not suitable for the structure were investigated.

DESCRIPTION OF THE KIZILÖREN KÜÇÜKHAN CARAVANSERAI

Caravanserais, which were built to provide the necessities of caravans in a safe manner and for the accommodation function, are important architectural works belonging to the Anatolian Seljuk period. Kiziloren Kucukhan, located on the Konya-Beyşehir road, is remarkable with plan scheme and facade design. The monument is accessed through the crown door on the north facade. This door has a pointed arch on the outside and a barrel arch on the inside. Inside the building, there are three jambs connected to each other with tunnel-vaulted arches. These jambs divide the interior into two levels and the levels are covered with a tunnel vault. Built in the 13th century, the monument is currently not in service.



Figure 1. View of Kiziloren Kucukhan

MATERIAL AND METHOD

In this study, the deterioration observed on the monument was observed in-situ. The deterioration was identified according to the definitions in ICOMOS-ICSC (2008). In addition, samples were prepared to determine index properties (ISRM, 2007) and strength properties (TS EN-1926, 2007; ASTM D5873, 2014) in accordance with the relevant standards. The index (porosity, dry density and P-wave velocity) and strength properties (Uniaxial compressive strength and Schmidt hammer rebound value) of the original and restoration stones were then determined in the laboratory.

RESULTS AND DISCUSSIONS

Petrographic and geomechanical properties of stones

The original rock used extensively in the construction of the monument is light-dark yellow and beige in color. When these rocks are analyzed in terms of grain size, ~55% consists of grains between 2-64 mm and ~45% consists of grains smaller than 2 mm. This rock is named as “lapilli tuff” according to Fisher’s (1966) “percentage distribution of grain sizes” classification. The restoration stone used in the monument is light-dark gray in color. ~10% of the grains in these rocks consist of grains between 2-64 mm and ~90% of the grains were smaller than 2 mm. This rock is defined as “ash tuff” according to Fisher (1966) classification. The index-strength properties of the building Stones (original and restoration) used in the monument are presented in Table 1. The dry unit weights of the original and restoration building stones were 12.30 kN/m³ and 16.72 kN/m³, respectively. The porosity of the original pyroclastic rocks was determined as 32.50% and P-wave velocity as 2.57 km/s. The porosity and P-wave velocity values of the restoration stone were 19.48% and 2.28 km/h, respectively. While the UCS value of the original building stone was 17.45 MPa, the UCS’ value of the restoration stone was calculated as 62.65 MPa.

Table 1. Indexes and strength properties of the samples

Sample	γ_d kN/m ³	n %	V _p km/s	SHR	UCS MPa
Original building stone	12.30	32.50	2.57	15.25	17.45
Restoration stone	16.72	19.48	2.28	62.65	47.10

Deterioration observed in the Monument

In Kızılören Küçükhan, low-density pyroclastic stones were utilized and marble rock (Figure 2) was preferred only in one block. However, the dry unit weights and uniaxial compressive strength of the pyroclastic rock chosen for restoration are high and the porosity is quite low. The restoration stone has a high dry unit weight and caused excessive load on the original blocks. As a result of the low uniaxial compressive strength of the original rock, it could not bear the load on it. This situation resulted in the development of cracks in the original blocks (Figure 3). In addition, the excessive loads in the areas where the restoration stone was excessive caused different settlements on the soil and large diagonal cracks occurred in the Han (Figure 4).



Figure 2. Marble block on the door



Figure 3. The crack type that develops in the monument



Figure 4. Crack development caused by restoration stones

Another major problem in the monument is the humidity associated with the capillary zone (Figure 5). The presence of moisture in the capillary zone has led to the atmospheric phenomena of freeze-thaw, wetting-drying and salt crystallization. Efflorescence type occurred as a result of the ascent of water soluble salts with capillary effect and evaporation with the sun (Figure 6).



Figure 5. Moist area observed in the structure



Figure 6. Efflorescence type

Freeze-thaw and wetting-drying processes primarily caused flaking type in building Stones (Figure 7). In the repetition of these processes, contour scaling type deterioration ranging from mm to cm scale has developed (Figure 8).



Figure 7. Flaking type



Figure 8. Contour scaling development

In addition, differential erosion due to textural differences between the matrix of the pyroclastic rocks and the phenocrysts and/or rock fragment was detected in some of the building Stones (Figure 9).



Figure 9. Differential erosion caused by matrix loss

Another problem arising from moisture in the monument is biological colonization. Biological formations that can develop rapidly under humidity, organic matter and appropriate temperature were detected at the capillary zone of the structure (Figure 10).



Figure 10. Developing biological colonization of the monument

CONCLUSION

In this study, the structural problems and deterioration developments observed in the monument as a result of the restoration implementation carried out without scientific and technical research on the monument were investigated in Kızılören Kucukhan. The different colors and textures of the restoration stones reduced the aesthetic value of the monument. In addition, the restoration blocks,

which caused extra loads on the structure due to their engineering properties, triggered consolidation in the monument and led to the development of diagonal cracks on the facades. Flaking, contour scaling and differential erosion types have widely developed in this region due to the lack of necessary measures for the elimination of water in the capillary zone of the structure during restoration works. In addition, biological colonization was observed in the capillary zone.

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