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Visualisation and evaluation of structural characteristics and problems of a Classical Ottoman bath

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Abstract

Visual documentation has been accepted as an important phase of architectural heritage conservation. Visualisation of structural characteristics and their problems, however, has gained importance in the last decade. In this study, structural characteristics are used to comprehend the characteristics of construction techniques and materials of building components. Structural failures such as loss of a structural element and cracks, and material deterioration such as loss of material and deposit are the main problems observed. Visualisation of structural characteristics and their related problems has been the basis of the methodology in this study. It is also considered important to underline the necessity of the design of a special visualisation technique peculiar to the characteristics of the monument under study.

1 Introduction

This paper is based on a study [1] which suggests a visualisation technique for Anatolian monuments exhibiting composite usage of material in their construction. This above-mentioned study has taken into consideration the studies of researchers such as Fitzner [2], Dorsey [3] and Tavukçuoğlu–Saltuk [4]. These scholars have concentrated on the visualisation of material deterioration in historical masonry structures built with cut stone. In case of these studies, it is possible and meaningful to illustrate the problems of each cut stone making up the walls of the monument. However, it becomes harder to visualise

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material deterioration types individually in the case of composite usage of materials in the construction of walls. Therefore, a special visualisation technique has been designed that deals with the material groups composing different building elements [1].

Within this frame; a Classical Ottoman bath [5] in Seferihisar, İzmir is studied in this paper. The monument, which repeats the traditional construction technique and material usage in its region, presents composite usage of material. Walls out of rubble stone, brick and mortar put together in a random order are peculiar to this region [6]. The historical 'horasan' plastering applied in the bath is also an important value of the building. The visualisation techniques for these compositions of structural materials and covering ones have been searched. An analytical presentation of material groups and single materials involved in the construction of each building component has been chosen. First, structural characteristics and problems were marked on the measured drawings at the site. Further basic measurements necessary for this marking were taken. Abstraction techniques of the graphic discipline were referred, while developing appropriate illustration techniques. The visual documents or 'maps' produced at the end of this site work were revised in the office. Then, the results of the analysis of the structural aspects have been derived within the limits of the discipline of architecture. In short, the calibration of the above-mentioned visualisation technique for the special conditions of the Ottoman bath subjected to study has provided accuracy and ease in the structural evaluations.

2 Identification of the bath

The bath is located within a partially renewed residential settlement which is at the center of the district of Seferihisar in İzmir. Although its inscription panel has not been found, it presents the characteristics of the Anatolian baths belonging to the period of the 16th century [7]. This bath is a classical Ottoman bath with its definite mass order, transversal plan scheme and sequences of domes and vaults composing the superstructure (Figure 1, 2). It has the classical planning characteristics peculiar to the Anatolian baths with the spatial components of a dressing hall, a tepidarium and a caldarium. Its axial plan scheme develops from north towards south with the order of dressing hall, tepidarium and caldarium. This plan scheme ends with a water tank located in the south juxtaposing the caldarium. Arched niches, marble basins and stone benches in the caldarium, WC pan and praying niche in the tepidarium, chimney of the furnace and well in the courtyard are the original architectural elements of the bath.

3 Visualisation techniques

Since building materials comprise structural elements, characteristics of structural system are directly related to the characteristics of the building

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materials. Therefore, the problem has been defined as the formulation of a special visualisation technique in which the characteristics and the problems of construction technique are analyzed and asserted together with the characteristics and problems of the building materials. The development of this visualisation technique has necessitated the definition of five phases: observation, documentation, definition, classification and visualisation. In the first place, the historic structure was observed in detail at the site and was documented with hand draftings and photographs. Subsequently, the data collected were revised at the studio, each was defined and then they were classified systematically. Lastly, at the visualisation phase, it was aimed to transform the obtained data onto the drawings of 1:100 scale. Within this context, visual representations, which provide the expression of each datum with graphic description peculiar to itself, are designed. Here, it becomes important to form a co-relation between the structural characteristics and their visual representations. In order to achieve this, a colouring technique was not prefered. Instead, a technique composed of black-white hatching was used to create different visual styles and to provide the ease of copying the drawings.

Measured drawings and visualisation phase have been carried out by utilizing the present day technology: A PC, a CAD software (AutoCAD version 2000) and a printer have been used. At first, drawing units for the description of the drawing area and units of length are specified under the heading of format in the pull-down menu. Then, layers are created under the same heading according to the lines particular to each structural groups. This provides the possibility to define different colours, line types and line thicknesses. Commands such as line, arc and circle, which are under the heading of draw in the pull-down menu, are used to prepare the measured drawings with the help of hand draftings and measurements obtained during the site work. For the visualisation of structural techniques and problems, the command of hatch under the same heading is employed on the measured drawings. When selected, a dialogue box of quick boundry hatch appears on the screen. Predifined type which presents a series of different types of pattern is selected. A pattern is chosen and applied on the drawings by pressing the button of pick points and by adjusting the scale and angle. The whole operation is completed by saving all data. This process is repeated for the rest of the definitions that are waiting for being visualized.

At the begining, the scope was determined to evaluate the construction technique, building materials and problems together within the same presentation models in order to clarify the relations between structural characteristics and their problems. However, data in quantity made it harder to express each of them in a comprehensible way. Thus, different classification tables and presentation models are designed individually for both structural characteristics and their problems. Only the superstructure and vertical structural elements are included in this study because the floor system could not be observed.

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3.1. Visualisation technique of construction technique and material usage

At the first place, building materials are classified into two groups: materials used in the construction of structural elements and materials used in the covering of structural elements (Table 1). Materials used in the construction of structural elements are not handled individually; instead, they are described together with the construction technique of the material group they form. This is due to the fact that various types of materials are put together to comprise a structural element. In such an expression, the order of materials forming the material group becomes important within the composition. Therefore, the quantity of materials used in the composition are taken into consideration. The materials are put in order from the maximum quantity towards the minimum quantity. If the material group includes mortar, this is pointed out at the end of the sequence. Apart from this, a single material may comprise a structural element. This is only specific to timber beams. Since the timber refers to a structural element, it is not described with a new term; instead, it is indicated at the end of the classification with the name of the structural element it forms (beam with timber material). In the classification of materials used in the covering of structural elements, the position of covering materials throughout the building is taken into consideration and an order is followed from the top towards the bottom of the building. Another important criterion in this classification is the authenticity of the covering materials. Alterations in the covering materials are emphasized with the term of "intervention" at the end of the classification. This indicates that they are not original materials. After the classification of materials describing the structural characteristics, visualisation work is realised so as to transform all data onto the drawings prepared in 1:100 scale. Visual representations, which symbolize all data described in the classification table, are designed one by one. For the material group which is composed of re-used cut stone, rubble stone and brick put together with mortar in a regular order, a hatching style giving the effect of this order is used. The material group which is composed of rubble stone, re-used cut stone and brick put together with mortar in a much random order is differentiated from the former one by a hatching style composed of dots of all sizes giving the expression of a random order. Hatching styles for the other data are developed and then are employed on the measured drawings (Figure 7, 9).

3.2. Visualisation technique of structural failures and material deterioration

Problems observed throughout the historic structure are classified as structural failures and material deterioration. They are evaluated with the same aforementioned method consisting of observation, documentation, definition, classification and visualisation. Problems that are observed at the general layout of a material group (re-used cut stone, rubble stone, brick and mortar) composing a structural element (wall) are considered. In the classification table (Table 2), terminology of each problem is identified at first, then they are classified systematically according to their quantities and then they are described. In the definitions, structural failures and deterioration types observed are made clear.

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There are three types of structural failures: complete loss of a structural element - timber clamps, partial loss of the timber beam, and cracks on the walls and the timber beam. Material deterioration is evaluated under the headings of loss of material and deposit. Loss of stone and brick in the composition of the masonry bond, loss of plaster material by flaking and detaching from the wall, granulation in stone, brick and mortar, and holes in the timber beam are the types of loss of material. Plant formations such as bush and grass on the mortar of the masonry bond and tiles, microbiological patinas in the form of green, yellow and black stains on the surfaces of interior walls, and discoloration of the timber beam due to rain water and sun light comprise the deposits. Hatching styles for each data are designed and then are applied on the measured drawings (Figure 8, 10).

4 Evaluation

Structural characteristics and their problems, which have been analyzed through the visualisation techniques designed as the graphic expression of the present condition of the historic structure of the bath, will be evaluated in this section.

4.1. Structural characteristics

Structural characteristics will be handled by regarding the construction technique and material usage of a material group comprising a structural element. In such an evaluation, an order from the top to the bottom of the whole structure will be followed. Construction technique and material usage of superstructure and vertical structural elements (walls) will be evaluated in the given order.

Superstructure: Domes and vaults composing the superstructure were constructed with brick and historic horasan mortar, and plastered with historic horasan plaster. However, a layer of cement plaster was applied onto this original layer of horasan plaster, which is an intervention applied by the owner of the monument. The dome of the dressing hall has the diameter of 727cm. It rises from an octagonal drum set on walls at the exterior and a circular moulding at the interior. The exterior drum, with its height of 120cm, was constructed with rubble stone, brick and mortar. Each eight corners have a re-used cut stone inserted into the course of the drum. Starting from the below level of these stones, there is the course of brick and mortar surrounding this drum. It is assumed that there lies a timber beam framing the drum behind this course, which resembles the structural characteristics of masonry walls. The dome of the dressing hall is supported by the moulding with a height of 17cm, four lobed squinches at the corners and four segmental pointed arches in each walls between these squinches. The superstructure of tepidarium and caldarium is characterized by domes and panelled vaults. The transition from the cubic volume to the hemispherical domes are provided by pendentives. All of the domes are supported by segmental pointed arches, and mouldings with the height of 14cm. Only the central dome of the caldarium stands on an exterior drum. Water tank neighbouring the caldarium has the superstructure of a barrel vault.

Walls: Thickness of the interior walls is 70cm and of the exterior walls is 75cm approximately. Construction technique of these walls are formulated with a composition of different materials working together. Masonry system composed of re-used cut stone, rubble stone, brick and mortar describes the construction technique of the walls. The wall of the east elevation, which provides entrance into the bath, differentiates from the other walls with its more regular course composed of re-used cut stones each of which are framed by two or three courses of brick and mortar. The rest of the exterior walls exhibit a much more random course system consisting of rubble stone, re-used cut stone, brick and mortar. Re-used cut stone joins this random course at the corners in order to reinforce the corners of the building. Important feature of this masonry system mentioned above is that timber beams run along inside the walls at the heights of 150cm and 270cm. These timber beams have the cross-section dimensions of 20×20cm. They are situated inside the outer part of the exterior walls and are covered with two or three courses of brick and mortar so as to be protected against the atmospheric conditions. Traces of timber clamps are established in the north wall. These clamps attach the timber beam to the wall by extending along inside the wall with a right angle with the beam and the wall. While all of the exterior walls remain unplastered, all the interior walls are plastered with historic horasan plaster. This original plaster layer is observed to be thick up to the height of approximately 100cm but the upper part of this level remains thinner.

Although the floor system could not be observed, floor above masonry pillars is thought to comprise the floor system of tepidarium and caldarium. The floor system resting on the pillars is originally composed of marble slabs at the ground surface. The floors of the dressing hall and the water tank are now covered with concrete.

4.2. Structural failures and material deterioration

Problems of the historic structure are classified into two groups: structural failures and material deterioration. Loss, partial loss and crack comprise the structural failures. Loss descirbes that a structural element has got lost totally. This problem is observed at the timber clamps that provide the connection of timber beam with the north wall. Partial loss points out the loss of a piece of a structural element. This has been seen on the timber beam of the north wall. Cracks observed on the walls are not very deep cracks and they do not exeed the width of 2cm. Cracks on the timber beam in the north wall are the results of the cycles of wetting and drying. Rain water is the stimulus.

Material deterioration is observed much more extensively than the structural failures. Types of material deterioration are evaluated under two headings: loss of material and deposits. Loss in the material group of stone, brick and mortar, disintegration of horasan plaster and granular disintegration of stone, brick and mortar are the types of loss of material. Loss in the material group of stone, brick and mortar are observed at all elevations. However, north wall is the one which

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has the highest quantity of this type of deterioration (Figure 3). Especially up to the level of 150cm, loss of stone is considerably extensive. Especially, granular disintegration in the mortar leads to the loss of mortar, which is in fact the main cause in the loss of stone. In this north wall, another material deterioration is in the form of loss in the material group of brick and mortar that covers the timber beam. This gives rise to the deterioration of timber beam and timber clamps by being exposed to weather conditions (Figure 4). Deposits form the second group of material deterioration. This type of deterioration is in the form of plant formation, microbiological patinas and discoloration. Plant formation is observed at the highest quantities especially on the superstructure and walls. North wall is the one that has this deterioration type at maximum quantities. Microbiological patinas are on the surface of the interior walls where rain water penetrates through the cracks and open light holes on the domes and vaults (Figure 5,6). Discoloration is due to wetting by rain water.

5 Conclusion

This Ottoman bath forms a continuity of the local building technology with its structural characteristics and material usage. It is especially important that the historic structure has survived up to present without any severe structural damages. This reveals the fact that construction technique and material usage were applied succesfully and rationally. Therefore, a comprehensive survey and visual analyses are required in order to understand and describe the structural charactersitics thoroughly. This study provides the visualisation of structural characteristics and their related problems. The historic structure has been asserted by a special visualisation technique since it exhibits a much more different course system than the ones composed of cut stone. The masonry system is of a composite type. Masonry walls were constructed with material groups consisting of re-used cut stone, rubble stone, brick and mortar. This course system is framed by timber beams running along inside the exterior walls. Variety in the building materials makes it difficult to visualize types of material deterioration individually and necessitates much effort for the establishment of all types of deterioration throughout the structure. Therefore, a special approach has been tried on this Ottoman bath. It has been based on a special study that was designed for the establishment of structural characteristics and their problems by evaluating the characteristics of material groups composing each structural element throughout the historic structure.

Application of this visualisation technique has exposed the structural failures of the bath as follows: It has been clarified that material deterioration plays an important role in the formation of structural failures. Loss in the course of brick and mortar, which protect timber beam against atmospheric conditions, is the primary cause of partial loss, cracks and discoloration of the timber beam in the north wall. What is more, loss of stone and mortar observed along the below level of the same wall threatens the structural stability of the wall. It is believed

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that these types of material deterioration are effective in the formation of cracks on this north wall.

In conclusion, this study, which has provided detailed information about the present situation of the bath within the frame of structural characteristics, has formed the basis for the establishment of intervention decisions.

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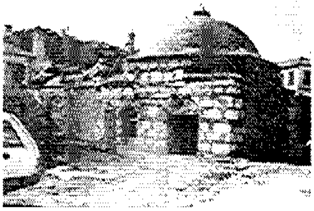

Figure 1. General view of the bath from the east elevation.

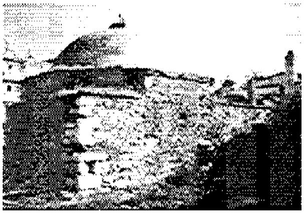

Figure 2. General view of the bath from the west elevation.

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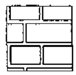
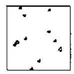
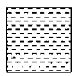
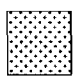
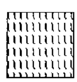
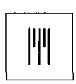
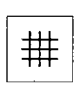
Table1. Classification and visualisation of structural materials together with their construction technique.

Definition	***Hatching***
Materials used in the construction of structural elements	
Course composed of re-used cut stone, rubble stone, brick and mortar	
Course composed of rubble stone, re-used cut stone, brick and mortar	
Course composed of brick and mortar	
Beam composed of timber	
Materials used in the covering of structural elements	
Covering with horasan plaster	
Covering with tile	
Covering with marble	
Covering with cement plaster – *intervention*	
Covering with concrete – *intervention*	

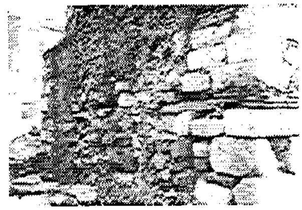


Figure 3. View from the north wall illustrating structural and material problems.

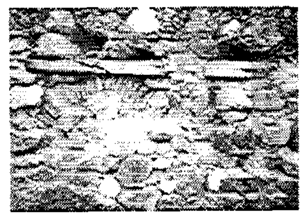


Figure 4. A detail from the north wall illustrating material deterioration.

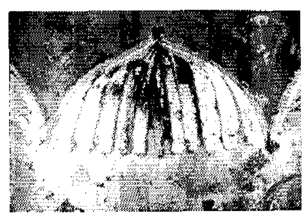


Figure 5. Deposit on the plaster layer of the squinch in form of microbiological patinas.

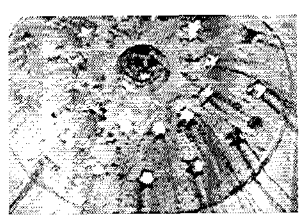


Figure 6. Deposit on the interior surface of the dome of the caldarium.

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Table 2. Classification and visualization of structural failures and material deterioration.

Deterioration Types	***Definition***	***Hatching***
Structural failures		
Loss	It is observed at the timber elements that clamp the timber beams to the masonry walls. These clamping elements are completely lost.	
Partial loss	It defines the loss of a piece of a structural element. It is observed at the timber beam of the north wall.	
Crack	It defines the crack whose width is less than 2cm. It is observed on structural elements like walls and timber beam.	
Material deterioration		
Loss of material		
Loss	It defines the loss of stone, brick and mortar in the composition of the masonry bond. They detach from the bond.	
Disintegration	It is the loss of plaster material by flaking.	
Granular disintegration	It defines the condition of granulation in the materials of stone, brick and mortar.	
Holes	They are observed at the timber beams. The stimuli are insects.	
Deposit		
Plant formation	It defines the formations such as bush and grass on the mortar of the masonry bond and tiles.	
Microbiological formation	It describes microbiological formation in form of green, yellow and black stains on the surfaces of interior walls.	
Discoloration	It describes the formation of grey and black stains on the timber beam. The stimuli are rain water and sun light.	

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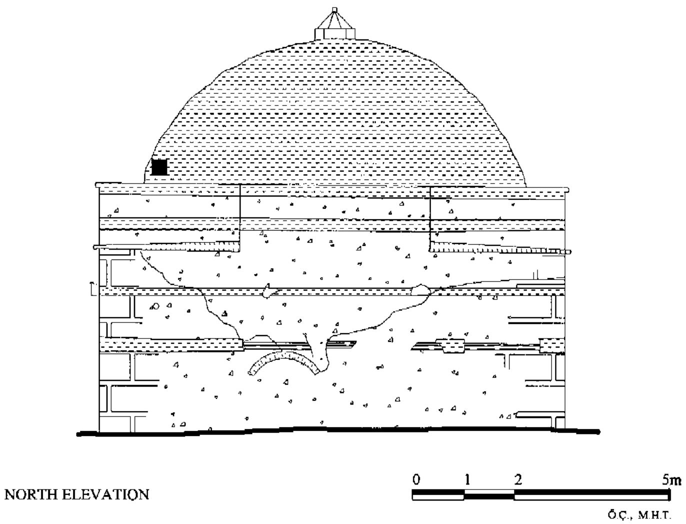

Figure 7. Visualisation of construction techniques and material of the north wall.

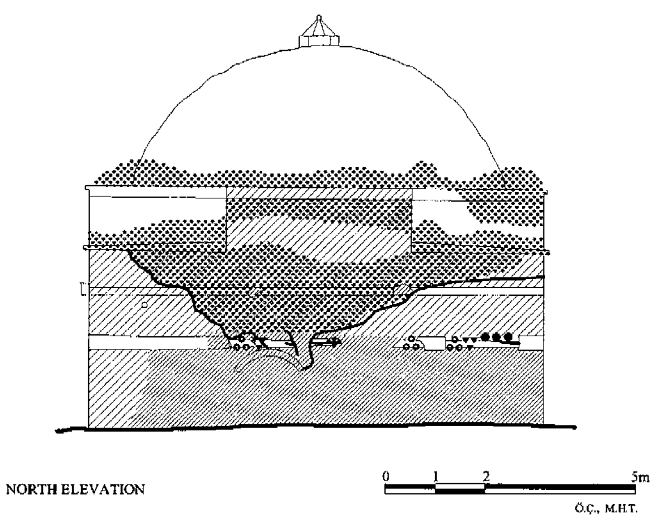

Figure 8. Visualisation of structural failures and material deterioration of the north wall.

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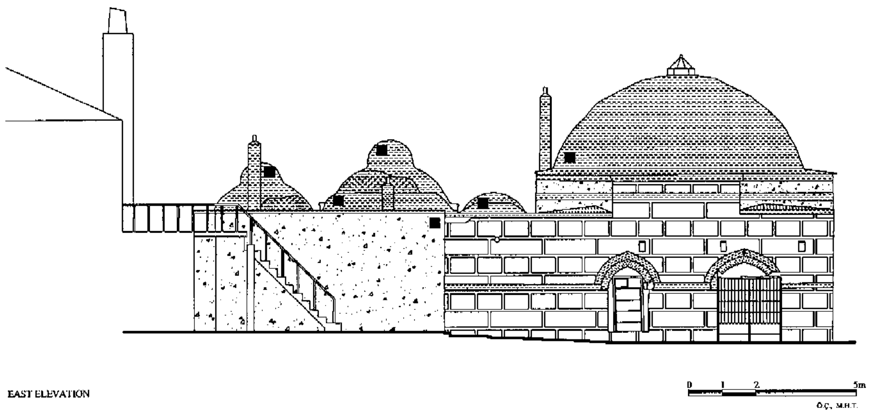

Figure 9. Visualisation of construction techniques and material of the east wall.

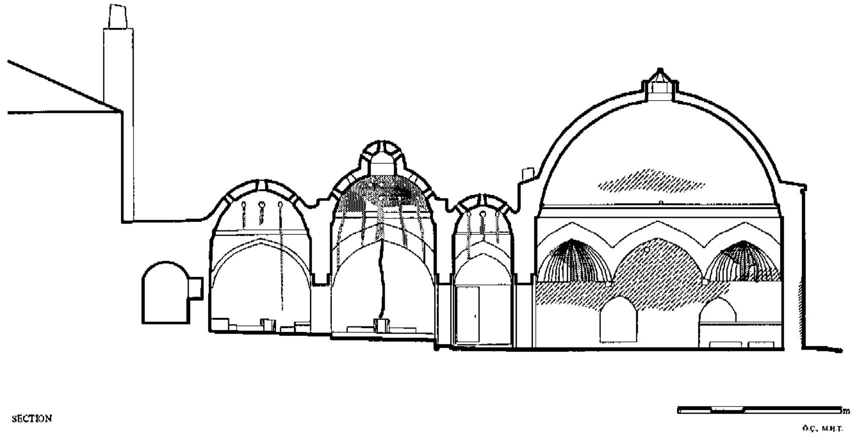

Figure 10. Visualisation of structural failures and material deterioration of the longitudinal section.