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Impact of transparency in the design of protective structures for conservation of archaeological remains

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ABSTRACT

Protective structures are advantageous to extend the life of exposed remains and to display objects of cultural significance. A considerable number of shelters and enclosures have been constructed of transparent materials to enhance the display function. This study aims to examine the utilization of transparency in design of protective structures in terms of advantages and disadvantages. To fulfill this aim, a group of protective structures, which were completely transparent or with transparent façades, such as the Roman Villa at Piazza Armerina, Sicily (Italy), the Fishbourne Roman Palace at West Sussex (England), the Roman Bath at Badenweiler (Germany), the Cathedral ruins at Hamar (Norway) and the Terrace Houses 2 at Ephesus (Turkey) were investigated in terms of their effect on preservation and display of remains. The selected examples illustrated that greenhouse effect, condensation, loss of transparency and excessive lighting are the problems to be considered in the design process. As a result, transparent materials used in protective structures should be selected carefully according to their thermo-physical properties such as solar, thermal and light transmission in order to reduce the negative effects of overheating and condensation.

1. Research aims

Protective structures are constructed as a preventive measure to extend the life of exposed archaeological remains. A considerable number of protective structures have been constructed of transparent materials to enhance the presentation of remains. This research aims to examine the protective structures constructed of transparent materials in order to evaluate the issues related with conservation and presentation of archaeological heritage. A further aim is to contribute the design process of following protective structures by increasing the knowledge about the earlier experiences with transparency.

2. Introduction

Archaeological remains are sensitive to effects of atmospheric events during and after excavations. Taking measures for maintenance and permanent conservation and protection of the archaeological remains is necessary [1]. In the past, removal of the architectural features and decorations to be preserved and displayed in museums was a common procedure. In the following years, Charter for the Protection and Management of the Archaeological Heritage (1990) has emphasized that objective of archaeological heritage management should preserve the remains in situ providing long-term conservation [2]. In this context, protective shelters and enclosures are built to minimize the environmental factors and lengthen the life of remains. Shelters are in the form of roof having one or more sides open. Although they prevent direct rain and sun, they do not prevent wind, wind driven rain and invasion of animals. Unlike shelters, enclosures have all sides covered, which provide more controlled environment.

Protective structures not only extend life of exposed remains, they also offer the advantages of displaying the remains in situ. Remains protected under protective structures are composed of valuable objects of immovable heritage such as remains of stone, brick or mud brick structures and their associated features like mosaics, plasters and wall paintings. Size of the protected remains may vary from a single object to a monumental structure or an excavation site. In relation to this variation, protective structures range from simple pitched open shelters to enclosed high tech designs. Among them, a considerable number of protective structures in the appearance of a glasshouse have been constructed of transparent materials such as glass, plexiglass, fibreglass and polycarbonate sheets. However, transparency may result in some problems in terms of both conservation and presentation.

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Construction of a protective structure over archaeological remains has been applied as a conservation method since early 19th century in Europe. Although construction of protective structures has been practiced for a long time, research concerning this subject has been emerging only since the last decades of the 20th century. In addition to descriptive studies about the protective structures, different approaches to the issue of design methodology and evaluation of the performance have been previously considered [3–7]. In this study, the concept of transparency and its effects on conservation and presentation of the remains are investigated on a group of selected protective structures which have the complete building enveloped or the facades in transparent materials. The selected cases vary with climatic zones ranging from warm to cold. They were constructed to protect the Roman Villa at Piazza Armerina, Sicily (Italy), the Fishbourne Roman Palace at West Sussex (England), the Roman Bath at Badenweiler (Germany), Cathedral Ruins at Hamar (Norway) and the Terrace Houses 2 at Ephesus, (Turkey) were investigated. Among them, Terrace Houses 2 and Fishbourne Roman Palace were selected due to their transparent façades and the rest were selected due to their complete transparent building enclosure.

3. Protective structures and design principles

Protective structures have an effect on the remains and the historical setting both visually and physically. Therefore, decision to construct a protective structure should be part of a management plan which aims to preserve the values of the site. Other options for protection such as reburial or consolidation should be considered before construction [6]. To avoid excessive intervention, their construction should be limited to sites with rich artistic and decorative features. If a protective structure is necessary, its design and construction requires integrated planning stages for establishing the conservation, design and construction principles. The design problem is not only related with constructing a new structure in the archaeological setting but also providing long-term physical conservation of the remains, as well as, retaining values of the site. Technical investigations for understanding the cultural significance and physical condition of the site is critical for development of design principles that are based on documentation studies and understanding the threats and factors contributing to deterioration. The principles that are developed with a comprehensive viewpoint can be investigated under the issues of protection, construction, maintenance, visual impact and display.

Protection: a protective structure should fulfill its function against deteriorative effects of atmosphere such as precipitation, wind and direct sunlight [8–11]. High and low temperatures, high relative humidity, condensation and freezing should be avoided in the protective structure. It should ensure stable relative humidity and temperature in addition to ventilation. Moreover, protective structures should prevent from invasion of flora and fauna, as well as, human beings. Protective function is not only related with weather protection but also stability of microclimate, durability of the protective structure and security of the remains.

Construction: construction over the valuable remains necessitates an accurate planning of the construction, as well as, a meticulous craftsman. Practicality of the construction, durability of the material and reparability are three main criteria of the construction design. Selection of the construction techniques and the materials is an important issue that can be related with conservation. Ideally, protective structure should have a minimum number of support points not to damage the remains [8,10,12]. It should be capable of rapid construction on-site, so as to minimize disruption of visiting and investigations of remains. In addition, when necessary, it is able to be removed without causing any damage.

Maintenance: archaeological sites are mostly located far away from centers, which may result in inevitable neglect during certain periods of the year. Use of natural ventilation and natural lighting of the site should be considered [10]. In addition, materials used for construction should enable a long life span and low maintenance requirement as much as possible [8–10]. Considering aging of the material over time, use of locally available architectural material and workmanship is important from the point of reparability and maintenance budget.

Visual impact: a protective structure can be defined as a mass intervention inserted into an archaeological setting. Design of a protective structure is related to aesthetics of proportions, color and texture of materials with reference to the particular situation of the remains in addition to landscape characteristics of the site. Moreover, physical and spatial relationship between protective structure and what it protects is important. The aesthetic impact of the structure should not take over from the remains [8,10]. Its visual impact on surrounding historic fabric and significant values of the site should be considered as well.

Display: a protective structure provides a covered space for archaeological field studies and display of remains in addition to protection. Arrangements for conservation studies and visitor circulation are necessary. Visitor damage by walking on or touching the remains should be prevented. Entrance, routing of walkways, informative panels are of great importance for the best understanding of the site [13].

Above-mentioned principles include basic concerns of shelter design, but they should be assessed within the management context of the site for developing the design criteria. None of the principles should be disregarded; however a hierarchy of "protection" is advisable [13]. If design process lacks full understanding of conservation needs in addition to current and potential threats, unexpected consequences may take place. Undesirable effects of enclosing and sheltering may trigger deterioration of resources due to windblown rain water, rising damp, condensation, insufficient ventilation, greenhouse effect, frost, fluctuations in relative humidity and temperature, high and low temperatures. After construction, evaluation of protective structure is critical to understand whether the remains can be safe and protected in the environment for long period of time. If the protective structure creates the above-mentioned deterioration factors, design needs to be improved.

4. Investigation of protective structures constructed of transparent material

Transparent material is frequently preferred in the design of protective structures. They are frequently used for façade cladding and rarely roof. The motivation of this attitude can be associated with above-mentioned design criteria concerning maintenance, construction, visual impact and display. Enclosed remains are inevitably isolated from the historical setting both physically and visually. Transparency helps to decrease this isolation by providing visual relationship between interior and exterior spaces. On the condition of complete transparent structures like Badenweiler Roman Bath in Germany and Hamar Cathedral ruins in Norway, the appearance of complete transparent structures is the structure itself and the remains inside. Therefore, it is possible to claim their visual perception can be less massive in comparison to an opaque structure in a historical setting. Besides, installation of transparent and translucent sheets can be advantageous for rapid installation and dismantling on site. Another reason for using transparent material is that it provides natural illumination for display of ruins during site visits in addition to ongoing excavation and conservation studies. Translucent material also serves this purpose; in fact, translucent roofing has been preferred for this aim at considerable

Fig. 1. Protective enclosure over the Roman Villa at Piazza Armerina at Sicily, Italy [17].

number of sites such as Neolithic Houses at Çatalhöyük, Turkey; Terrace Houses 2 at Ephesus, Turkey; Danae and Dionysos Houses at Zeugma, Turkey and Roman Villa at Piazza Armerina in Sicily, Italy.

These advantages give rise to transparency in the design of protective structures. Nevertheless some problems can be observed in terms of conservation and display in practice. When direct sunlight is not prevented transparent material allows short-waves to pass through into the protective structure. Once radiation hits the remains, it changes into long-waves, which are not able to pass through the glass and get trapped inside. Short-waves emitted by the remains cause sharp rise of temperature and damage to the remains [14]. The protective structure at Piazza Armerina can be a significant reference to conservation problems due to greenhouse effect. The light steel protective structure resting on the original walls was built in 1950 to protect and display the mosaic pavements (Fig. 1). Transparent and translucent plastic panels were used to cover the facades and roof structure. Level ceilings were installed under the translucent roof cover, to protect from heat and prevent shadows of the metal framework from falling on the mosaic [15]. The walls were constructed partly of corrugated sheeting and partly of slats of the Venetian-blind type; in some cases the wall panels, can be opened for ventilation in hot weather. However, level ceilings and plastic panels failed to control solar radiation and heat. The translucent enclosure created a kind of showcase that resulted in high temperature and relative humidity, frequent condensation [16,17]. Due to the adverse climate inside the protective enclosure it had to be removed and a new structure with opaque material is being constructed.

Similar problem was encountered at the Fishbourne Roman Palace in England, although it is not a completely transparent enclosure. Glazed south elevation caused exposure of mosaics to direct sunlight and absence of roof insulation increased the temperature inside in addition electrical fans and ventilation triggered fluctuations of temperature and humidity [18]. The protective structure built in 1968 was modified to create a more stable environment (Fig. 2). The improvement work includes installation of external colonnade on the south, double glazing with solar reflective glass, reduction of window area and installation of roof insulation. On the other hand, damaging effects of sunlight can be prevented by a thorough design process. The Vesunna Gallo-Roman Museum at Périgueux, France with transparent facades is a successful example to keep out the sun due to wide eaves of the roof structure.

It is possible to claim that transparent or translucent roof is not efficient for conservation since it enhances solar gain as well as intercept thermal insulation [14]. The protective structure over the Roman Bath at Badenweiler, Germany in the appearance of a transparent vault is an example (Fig. 3). The glazed shell structure, which was built in 2001, designed to provide an optimum in transparency. The glass surfaces were mounted above the ground to form inlets for ventilation [19]. In addition, separations between the vaults contribute to air circulation through outlets. A solar shading system was installed on the south to avoid overheating on hot days. However, condensation on the glazed surfaces can be observed in winter when the interior surface temperature of the glass falls below dew point of the air (Fig. 4).

In the colder climate of Norway, to prevent the Hamar Cathedral from frost damage, a glass and steel structure in the form of a cathedral roof was constructed in 1998 (Fig. 5). A heat management and ventilation system was developed to protect the remains and to eradicate potential condensation problems [20]. Heaters provide direct heating of the ruins and fans supply warm air along the glass to reduce condensation risk as well. For sunny days solar protection elements were mounted under the sloping surface.

Fig. 2. Protective enclosure over the Roman Villa Fishbourne Roman Palace at West Sussex, England [22].

Fig. 3. Protective enclosure over the Roman Bath at Badenweiler, Germany [Courtesy of D. Laroche].

Fig. 4. Condensation on the glass, Badenweiler, Germany [23].

Fig. 5. Protective enclosure over the Hamar Cathedral, Norway [24].

Fig. 6. Protective enclosure over the Terrace Houses 2 at Ephesus, Turkey.

There are also some problems concerning the display of the ruins that have not been predicted in the design process. The most common problem is due to transmittance of excessive light, which may impede viewing the decorations on the floor because of blinding glare [17]. Furthermore, in the excessive light shadows of the roof and façade structure create new patterns on the floor.

In the existence of dust deposition on the transparent surface, visual connection between exterior and interior spaces may weaken. The protective structure over the Terrace Houses 2 which was built in 1999 illustrates this problem (Fig. 6). The light roof construction was covered with a translucent membrane. Facades are partially transparent on the south and east. The façade has a climatic function that allows exchange of air and optimal ventilation besides it holds sand and dust drops [21]. Although the north façade was constructed of transparent materials, dust drops caused visual and physical difficulties in the material, and eventually facade turned into translucent.

5. Conclusions

Protective structures when constructed of transparent material may result in some inappropriate conditions which were not predicted in the design process. In this study, the selected examples illustrate conservation problems. Among them the protective structure at Piazza Armerina (Italy) and Fishbourne Roman Palace at West Sussex (England) enhanced greenhouse effect and had to be modified. The Roman Bath at Badenweiler (Germany) faced condensation due to cold weather. There are also problems because of excessive lighting, which caused shades and inefficient illumination for display of decorations. In addition, transparent façade elements of Terrace Houses 2 at Ephesus (Turkey) turned into translucent due to ventilation function of façade.

The problems such as formation of greenhouse effect, condensation, loss of transparency and excessive lighting can be associated with the influence of direct solar gain and climates. Especially in warm climates such as the Mediterranean, avoidance from direct sunlight must be considered in design process. Use of solar shading elements, wide eaves double glazing have to be considered in the design process to avoid effects of direct sunlight on the remains. In cold climates, absence of thermal insulation may result in condensation. Consequently, transparent materials used in protective structures should be selected carefully according to their thermophysical properties such as solar, thermal and light transmission in order to reduce the negative effects of overheating and condensation.

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