A survey on the efficiency and safety of the temporary cover systems in architectural conservation and restoration works

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Abstract

One of the biggest problems in architectural restoration works is to actually repair the 'structure' which is already problematic and lacking without letting it deteriorate even further. In the last few years, work of architectural restoration in Turkey is on the rise. These works, that are generally large monumental buildings with many problems, are planned to progress on a long timeline of several years. During this period to work safely, comfortably and without letting the structure deteriorate further due to external weather conditions such as rain, wind and snow on the roofing structure, outer facades and even in the foundations, temporary cover systems or, more appropriately, emergency protection systems are designed and applied. These temporary cover systems are sometimes wooden, simple steel construction or space frame systems depending on the problems, the applicability and the physical conditions. The applicability is generally decided according to the structural problems examined at the project phase. However a holistic evaluation on the necessity, design regulations, technology, cost, the effects on the conservation process, and the efficiency of these systems is not made, but only partial evaluations are. It is also obvious that this subject needs to be analyzed in comparison with the approaches, applications and techniques outside of Turkey. In this paper an analysis of the decision making process, the design phase, efficiency, technology, cost and the effects on restoration and conservation works of such temporary cover systems will be presented.
Keywords: temporary cover, temporary roofing, architectural restoration, work safety.

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1 Introduction

The 4th article of 'The Venice Charter' under the heading of 'Conservation' says 'It is essential to the conservation of monuments that they be maintained on a permanent basis' [1]. This statement generally perceived as 'continuous maintenance', but naturally also includes the emergency measures taken in order to keep the building up before an extensive intervention is applied. For this reason 'The Charter for Conservation of Architectural Heritage in Turkey' prepared in 2013 by ICOMOS Turkey [2] under the heading of 'Intervention Techniques' defines emergency measures as 'preventive measures taken in order to prevent further damages to the building and to the surrounding by the building during the process of examination and final restoration conservative decisions are made'.

In this context, the fact that new information surfaced during the process of restoration works may affect the original restoration decisions necessitates the continuum of emergency measures even during the application process. The measures taken in order to uphold the load bearing structure in the beginning of the works later on extends the protecting the 'exposed building' and conserving and containing it until the end of interventions. These measures become inevitable in order to conserve and restore the original materials.

The traditional approach in Turkey to renovate the degraded historic material and the restoration works with interventions mainly based on renovation and reconstruction continued until the 1990s is evolving to the main understanding based on conserving the original material and the use of scientific techniques in order to achieve it. The preventive measures taken in order to conserve the original materials become prominent in the framework. These measures should be guided by emergency plans that are formed for the protection of architectural heritage against the natural disasters [3–5]. The world and especially the Middle East is full of examples that verify this [6].

In Istanbul the restoration works that take place in the last decade bring us two main steps and their sub-headings:

1. Emergency measure
   a. Old measures (systems of support and temporary covers made after an old earthquake or fire)
   b. Current measures taken with the initiation of restoration works (produced as results of the examinations of the damages made before the initiation of restoration works)

2. The temporary cover structures of the application phase (the cover structures made in order to protect the exposed building and the workers as well facilitating and elongating the possible work time)
   a. Structures sitting on the building
   b. Structures that are independent constructions from the building
   c. Mixed systems.

2 The problems of conservation in the restoration works of monumental buildings in Istanbul

2.1 The increase of restoration works in the last decade and the current situation in Istanbul

The city of Istanbul has been a capital for the Roman, Byzantine and Ottoman Empires, and is the economic and trade center of modern day Turkey. The increase of political stability as well as the economic development of Turkey in the last decade has naturally influenced Istanbul as well. The city of Istanbul is currently in an important process of urban development and transformation. In the process of urban development, the city borders continue to grow creating new centers. In the process of urban transformation especially concentrated on the historical centers, there is an attempt to revitalize these historic areas. The historic peninsula of Istanbul, a UNESCO world heritage site that was degraded and devalued in the 1980s and 1990s, began to re-increase in value. The admittance of historic peninsula as a world heritage site, the increase of investments in the cultural and the tourism sector in Istanbul and the event of Istanbul being the Cultural Capital of Europe in 2010 were important foundations of this re-increase in value. The restoration and reuse of the degraded historic buildings other than the most important examples, creation of new income areas in the historic districts and the creation of the old public spirit surrounding these restored historic buildings was also an important part of 'Ottoman revivalism' policy of the current government of Turkey.

Uskudar, Kadikoy and especially the historic peninsula of Istanbul being the most important historic centers do not have free areas big enough for major investments of new constructions. In order to re-evaluate and re-increase the value of these centers the major investments that can be made are to invest in substructure to turn these points into transport hubs or to invest in the reuse and restoration of the existing buildings. Currently a budget of approximately $500,000,000.00/year is dedicated on the restoration and conservation of architectural heritage under state property in Istanbul through The Ministry of Culture, The General Directorate of Foundations, the Governship of Istanbul, The Municipality of Istanbul and the local municipalities of Istanbul.

2.2 The density of architectural heritage buildings in Istanbul

The city of Istanbul that has been an imperial capital for almost 16 centuries is now known to have housed commercial civilizations for at least 9000 years in the light of the new archaeological excavations. Istanbul, an important historic, economic, commercial and political center thanks to its geopolitically important location, houses more than 16,000 certified architectural heritage buildings [7]. Many of these belonging to the Ottoman era, are constructed by the imperial dynasty and the royal court. These numbers show that there is a very large density of heritage and monumental architecture in Istanbul.

2.3 The decision-making and application process in the works of restoration in Istanbul

The restoration works on this vast amount of architectural heritage stock especially increased in the last decade parallel to the public investments continues in the framework of certain laws and charters. Every step in the restoration process even if funded and administered by different public institutions, the final examination and approval of each step is made by the Department of Protection of Monuments. The main scheme of restoration works in Turkey is like stated in Table 1.

Table 1: The scheme of restoration process.

The restoration process	Time required
Decision making phase	User dependent
The project phase (may include temporary cover and support structures in emergency situations)	6 months–4 years
The auction phase	6 months–1 year
The application phase (includes the temporary cover and support structures in emergency situations)	2–3 years
Remaking of projects and extra funding auction phase	0–3 years

2.3.1 The decision making phase

This phase includes the property owner or the institution with the permission to use it, may decide for the need of re-functioning, re-use or restoration of the building depending on its condition. This need is created due damages caused in time or by natural disasters, or with the change of needs of the user in time and begins the restoration process. If the building is severely damaged by a disaster or a sudden collapse, the Department of Protection of Monuments may intervene to force the owner to begin the process of restoration.

2.3.2 The project phase

This is the phase where the necessary projects are prepared or get prepared by the new or the existing user. This is the phase where the building survey in the current situation, the reconstitution projects depending on historical research, the restoration projects with the foreseen interventions and the re-functioning conditions are implemented and the relevant engineering projects are prepared and eventually admitted by the Department of Protection of Monuments. If the building is severely damaged in an emergency situation a supporting structure and a temporary cover system may be installed with permission from the Department of Monuments. The time required in this phase is very flexible and therefore an immediate construction of these emergency measures is necessary in order to prevent further degradation of the building in these special occasions.

2.3.3 The auction phase

The auction phase consists of the preparation of technical guidelines and the approximate costs, along with the search of funds to cover this cost. In this phase

a contract is made with a firm or an institution to actually realize the work with the specific funding and guidelines.

2.3.4 The application phase

This is the phase where the restoration projects are realized according to the technical specifications agreed in the auction phase. According to the damages and the interventions in the building, a temporary cover and supporting systems may be designed and installed.

2.3.5 Remaking of projects and extra funding auction phase

This is the phase where the restoration projects are edited with the addition of new or changed interventions in the light of the new information uncovered in the application phase. In general these projects are prepared in the application phase, but these new interventions may require the need of extra funding in some cases. The creation of the new funding for these new interventions is included in this phase. Currently this is the situation encountered in many cases in Istanbul, and with so many works going on it is not very easy to find the extra funds. In the phase where the restoration projects are edited, the related parts of the building are left untouched for the time that the decision of intervention is finalized. This waiting period creates a very delicate and vulnerable situation for the exposed building which generally necessitates installation of temporary cover and supporting systems.

2.4 Situations that the supports systems are needed and installed

A supporting system is necessary in historical buildings that have severe structural damage or where there is going to be a major intervention on the vertical or horizontal load bearing elements such as columns, domes, load bearing walls, slabs, joists or beams. The common cases encountered in Istanbul that require support systems may be listed as follows:

- Buildings with severely damaged load bearing elements due to disasters.
- The removal of reinforced concrete slabs that were installed as a part of an earlier restoration causing structural damage to the building due to new load distribution and placement of original elements instead.
- Buildings severely damaged due to being neglected and abandoned for a long period.
- Conservation of original and delicate decorative elements during structural interventions.

2.5 Situations when the temporary cover systems are needed and installed

In situations when support systems are installed, if the elements supported are not protected from the external weather conditions a temporary cover system is installed as well. Other than these situations if a long intervention is going to take place on the facades and on the roofing a temporary cover is installed as well in order to preserve the building from weather conditions and to prevent water from getting inside the structure. An example is a typical intervention that is applied in

structure of classical Ottoman period (15th and 16th century). The wooden horizontal runner beams that are placed in the walls and under the roofing in the original construction are deteriorated and usually turned to dust are in the need of replacement. There is no obvious need of installation of support systems if there are no cracks, but a temporary cover is installed since this is a very long intervention made to the exposed structure of the building and it needs to be protected from water and weather conditions such as rain and snow. A similar example is the removal of seams made with concrete in the last century restorations on the masonry buildings of Ottoman era. The removal of these concrete editions and the repair of the damage made by them take a long time and sometimes create openings on the façade that may let water get inside the walls. In this situation as well a temporary cover is needed whilst a supporting system is not.

3 Temporary cover structures, their technology, construction techniques, time, process, cost and effectiveness in the restoration works of monumental buildings in Istanbul

Currently in Istanbul restoration works on many buildings of different periods, with different structural properties and damages are going on. All these restoration works are going through the process explained before and temporary cover structures are installed in majority of them either in the project or application phase. There is an important decision making process in the installation of temporary cover structures and a few important steps to it. The first step is the answer to the question of whether there is a need for one or not. The answer is decided according to the damages in the structure, the interventions proposed to be performed on them and the time of interventions. In the case of natural disasters such a measure is needed to be taken, and this question is directly answered in the decision-making phase and begun in the project phase. In other cases the answer is decided by making a comparison between the cost and benefits of construction of such a system, based on the construction technology of the system, the cost and time it takes to construct as well as the ease of work it will bring and how much a damage it will prevent from further deterioration. These should all be considered comparing different structure materials and covering materials for this temporary cover system.

3.1 Comparison of temporary cover structures based on their structure material

3.1.1 Timber

A timber temporary cover structure is the most commonly used example. The material used is low-quality pinewood and firwood. These are the most easily accessible, light and low cost scaffold construction materials in Istanbul and therefore are the preferable choice for temporary constructions. These are the most generally used materials for supporting and scaffolding system in restoration works as well, which makes accessibility and integration of the cover systems with

the scaffolding very easy. This material is easily constructed and deconstructed. It is much cheaper in comparison with other alternatives. A less qualified workforce with no additional equipment is needed in order to install, but the installation may take a longer time. The scaffolding and the temporary cover structure is light which makes taking support from the building itself possible. There is always the flexibility to adjust to the situations like length changes in the construction site. Since the cover structure is integrated to the scaffolding the cover is close to the building, which decreases the area needed to be closed with cover material on the top and on the sides. The distance between vertical supporting elements should not exceed 4–5 m as the cross-sections of the materials are not very big. There is no need to build a foundation under the scaffolding since the materials are both light and densely installed. The timber can be re-used in another work after being dismantled with only around 10–20% being wasted. These elements must be covered with fire retardant coating for the work safety. An example for such a construction used is the National Education Administration Building in Istanbul, which was burned in a fire. There was also the need of an urgent supporting system and therefore the timber construction was the most efficient system to be implemented as shown in Fig. 1.

Figure 1: National Education Administration Building.

3.1.2 Standard steel profile

The temporary cover systems constructed with standard steel profiles can be used together with both steel and timber scaffolding systems. Even though it is not very frequently encountered in restoration construction sites, still is a very easily accessible material to use. It is more expensive than timber, but the construction time needed is less. Steel is still a flexible and adjustable material in the construction site even if not as easy as timber. A more qualified workforce and some additional equipment is needed in order to construct it. Since the steel is a heavier material than timber, if there are supports placed on the building, there is a need to pay attention to punching shear on the support points. It is risky without

the proper calculation and the construction of a pillow under the supports to lean the cover structure on the building. The system has a big advantage that it is possible to cover any distance with making the proper calculations and ordering the standard profiles needed in the design. Even though there is not a need for a heavy foundation system, still the feet of the structure should be fixed at the ground and sometimes little foot foundations need to be constructed(not necessarily reinforced concrete foundations, they can be just wide metal plates fixed on the ground). These steel materials can be dismantled to be reused with only 5% of waste. These steel materials exposed to weather conditions must be painted with anti-corrosive materials. An example of such a use is the Madrasa of Semsipasha in Istanbul, Fig. 2. The choice here was standard steel profile for the temporary cover structure, because on one side of the building there was too narrow a space for timber scaffolding or otherwise and the distance needed to be covered without supports was ranging between 9–18 m.

Figure 2: Semsipasha Madrasa.

3.1.3 Space frame system (steel or aluminium)

Even though the elements of space frame systems are generally steel similar to standard profiles, they must be considered in a different category. The standard profiles are produced industrially and are easily accessible, but the elements of space frame systems are ordered and produced according to the results attained from the design and calculations. Since the production is based on ordering, the unit cost is higher than traditional steel material. However it is easier to cover larger openings with less material which will bring the total cost down, possibly even less than the alternatives. The materials are produced on demand and therefore are not flexible or adjustable in the construction site and therefore precision is very important. The system is made of elements plugged into each other, but the workforce needs to be very qualified for the construction. The system cannot be integrated with the scaffolding. The system is put on fewer feet, which

are large pillars put on large single foundations. The large single foundations on the feet are necessary to create weight and stability. Since this system is not flexible and is not integrated with scaffolding. The area needed to be covered in order to protect the building from external weather conditions is larger. The materials are each plugged into each other and therefore they can be dismantled without any waste, but the process may be as long as the construction time. These materials are painted with anti-corrosive materials when they are produced. It is also possible to create such a system from aluminium as well, which is much lighter material, bringing the total weight almost to a quarter of steel construction, the high cost of aluminium does not make it feasible. An example for this type of construction is made in Chora Museum as shown in Fig. 3. There is a very severe structural damage in the Museum and it is not possible to have any support on the building which does not make timber construction possible and also it is not possible to bring even mobile cranes to the construction site, which makes it almost impossible if not too risky to place standard steel profile trusses to cover a 30 m x 30 m area. The solution was to create a space frame system.

Figure 3: Chora Museum.

Table 2: Comparison of temporary cover structures.

	Timber	Standard steel profile	Space frame system
Accessibility	Very easy	Easy	On demand
Unit cost	Low	Medium	High
Construction time	Long	Short	Very short
Qualified workforce	Low	Medium	Very qualified
Scaffolding integration	Easy	Medium	Not possible
Re-usability	10–20% waste	5% waste	No waste
Foundation	No need	Simple fixed support	Heavy single foundation
Work security measure	Fire retardant	Anti-corrosive paint	Anti-corrosive paint

3.2 Comparison of cover materials

3.2.1 Water-proof canvas

The textile cover material has a very wide range of quality, resistance and character. In restoration works the canvas used as the cover material is totally water-proof. It is a very cheap material and since different pieces are sawn into each other it is possible to get a piece as big as you need. These materials can be put on timber or steel structures or can be used without any structure directly by placing on the building. In the case of being covered on a structure, underneath there must be a very dense mesh of timber or steel and the canvas must be as tight as possible to prevent any sagging of the canvas which can carry water and eventually lead it to tear. Also the material is very vulnerable to wind. The more wind-resistant the material the costlier it is, and the other alternatives become much more feasible. They are usually not reusable since there is a great possibility of creating holes or tearing during the installation and dismantling. An example of use of canvas without any structure is the Cinili Mosque in Istanbul, Fig. 4. There was no visible structural damage and the only work to be done was the replacement of the lead cover of the mosque, so there was no need for an expensive system.

Figure 4: Cinili Mosque.

3.2.2 Metal deck sheets

The deck sheets are the most resistant material that is used as a temporary cover element since they are made out of metal. They can be fixed to metal or timber structures easily with screws. There is no water insulation problem where the sheets are put next to each other, but the hips and valleys of the roof structure where the sheets come perpendicular to each other create a problem. These areas are the weak points of the cover to the wind force and to the water insulation, so special attention is to be made. The cover material of metal is the heaviest option, so the structure carrying must be made accordingly. The material is totally opaque and therefore may cause the work area to be dim that may create a work safety problem. This is the most resistant element to wind force entering under the

temporary structure and these materials can be reused with ease after dismantling. An example that this type of cover material used is Semsipasha Madrasa, Fig. 2. The reason for the choice was the location of the building. The location of directly on the coast of Bosphorus and the area is very windy. The roof structure did not have any valleys or hips in the open, so there was no constructional deficiency.

3.2.3 Fibre reinforced composite materials

These waterproof elements are generally not very expensive and are even used in permanent structures as cheap decorative roofing elements. They are easily accessible and applicable. They have special elements created for the hips and valleys and therefore do not pose as much weak points as metal deck sheets. They create a rigid cover structure that can even carry snow load, but they are not as resistant as metal and may be damaged physically easier. They have even transparent elements which make working under them easier and safer. Different composite materials are present made with cellulosic fibre (easily flammable, but cheaper) or glass fibre that are made rigid in cement or resin. Therefore there is a wide range of resistance and hence costs. An example is the Siyavuspasha Madrasa shown in Fig. 5.

Figure 5: Siyavuspasha Madrasa.

4 General evaluation and conclusion

After reviewing different options, materials and criteria, we can deduce that the temporary cover system in restoration works must pass through an important decision making process. The first step is the decision of the need of an emergency measure and whether it will be constructed in the project phase or re-evaluated at the application phase. In the application phase the damages and problems of the building and the interventions that are to be made will tell us the need of a temporary cover structure.

Intangible values as well as tangible values should be taken into consideration in the decision-making progress. The architectural heritage to be restored has

historical, cultural and artistic value, therefore the cost of any damage on it is not simply based on the value to repair, but also of the intangible value that is lost. It is not acceptable that a 400 year old unique decorative element is lost or irreversibly damaged other than the production of a replica just because the cost of the temporary cover system is too expensive to build. However in another situation it is not acceptable to build a high cost temporary cover structure that will bring little help in the case where the protected elements are non-original elements which are going to be totally replaced with elements produced from original materials.

After the decision is made to build a temporary cover structure, the construction technique and materials need to be decided on several criteria. The structural problems of the building must be examined and the time required for the interventions requiring a temporary cover structure must be foreseen. Other than the cost of application of temporary cover structures, a rough calculation of the benefit it will have on the intervention costs and the tangible value of the materials protected should be made. The presence of a space around the building for having foundations, the load carrying capacity of the soil around our building, the support systems and scaffolding to be applied inside the building, whether it is possible to get support from the walls of the building or not should all be considered in the cost calculation. A general picture of the temporary cover structure has to be made with great precision taking all the criteria in consideration in order to make this system become effective, where it has a great possibility of getting astray and become very inefficient and costly.

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