Remedial interventions for structural problems caused by fire in a historical building

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ABSTRACT: The aim of this paper is to introduce a set of intervention types suitable for historical buildings that have faced with fire. Conservation decisions taken for Mithatpasa Highschool for Industrial Training in Izmir and their applications are discussed. This neo-classical building, which is one of the unique examples of Ottoman modernization in the late 19th century in Izmir suffered from fire on March 31st 1997. It was constructed as an educational institution in 1891 and continued its original function until fire. The local authority ordered an urgent restoration of the building to utilize it again for education, starting from October 1997. Decisions taken in the project had to provide both the structural strengthening in the process of remedial interventions and the preservation of the original features of the building. This paper presents the evaluations about the documentation studies, progressed decisions and the results of the applications in relation to the structural problems.

1 INTRODUCTION

The superstructure of Izmir Mithatpasa High School Building was completely demolished after the fire it had undergone on March 31st, 1997. The absence of the roofing necessitated an urgent restoration work (Figure 1). The local office of the government, which was in charge of the building, asked Izmir Institute of Technology Faculty of Architecture to prepare the restoration project and to provide consultation during the following application phase. (Project Coordinator: Prof.Dr. Ahmet EYÜCE, Team Responsible of the Project: Assoc.Prof.Dr. Basak IPEKOGLU, Dr. Mine HAMAMCIOGLU) Yapi Merkezi, a construction firm experienced in restoration work, carried out the applications. The analysis of the structural system and the detailing of structural aspects of the project were carried out with the technical support of the Chamber of Civil Engineers in Izmir (Civil engineers in charge of the work: Muzaffer TUNÇAG and Necati UZAKGÖREN). Central Laboratories for Restoration and Conservation in Istanbul carried out the analysis of materials (Material Scientists in charge of the work: Prof.Dr. Ahmet ERSEN and Assist.Prof.Dr. Ahmet GÜLEÇ). Since the budget of the restoration phase was very limited, all types of project and consultation was provided without any financial payment.

Figure 1 : The building after the fire.

Figure 2 : Front view of the building.

The building was designed in Neoclassical style at the end of 19th century and has been used for the training of industrial craftsmen since 1891 (Figure 2). It is rectangular in plan extending on the north-south direction. The ground and first floors are organized around a central courtyard. There are also partial basement and mezzanine floors. The basement is situated beneath the east, south and west units of the building, excluding the courtyard, arcades and the north units. The mezzanine, which is between the ground and the first floor, is only placed at the east and south arms. There is a monumental staircase neighboring the rectangular courtyard at its north, while arcades surround the other three sides.

The aim of this paper is to analyze the characteristics of the historic structure, to identify its damages, to present the way of managing the restoration process, and to introduce related intervention decisions and applications in the building. The methodology developed for this case will help managing the emergency restoration applications to be carried out in buildings that have undergone fire. The way to the urgent and correct decisions for solving the structural problems of such historic buildings will be illuminated.

2 CONSTRUCTION TECHNIQUE AND MATERIAL CHARACTERISTICS

The construction technique of the building will be analyzed under the headings of floor, wall and roof systems. The materials used in the construction of these systems and their necessary finishings will also be mentioned.

The analysis results of the floor systems are as follows: The ground and first floors are in jack arch system. “I” beams are placed perpendicular to the walls with combined constructions in closed spatial units. However, binding beams with rectangular sections are placed perpendicular to the combined walls at the arcade of the first floor. The distance between each binding beam is shorter than that between the two combined walls running parallel to each other. Series of “I” beams parallel to the combined walls connect the binding beams to each other. “I” beams are connected to each other with perpendicular and diagonal metal strips mounted on them (Figure 5). It is known that jack arch systems are composed of tiny brick vaults constructed between “I” beam series. Generally, bricks are positioned so that their longitudinal axes point out the center of the vault profile. In this building, however, the short axes of bricks run along the radii of the profile. Timber beams, positioned over “I” beams perpendicularly, are used to mount the timber covering. On the other hand, the interior surfaces of the jack arches making up the ceilings are plastered with lime-straw composition, and then the surface is treated with lime or plastic whitewash. At the roof level, there is no floor system suitable for regular circulation, but timber trusses are hidden behind the timber ceiling covering. These trusses are connected to each other by diagonal elements at their bottom. Variation of the floor system is observed above the monumental staircase. Here, “I” beams are utilized at the roof floor. The left over pieces of these “I” beams indicate that they are imported from Belgium. A similar roof floor is observed above the central spatial unit of the south arm.

The walls of the building may be classified into three according to their construction systems: The walls with combined constructions, timber skeleton inner walls and masonry walls with stone. The walls with combined constructions are composed of two interrelated systems – the inner timber skeleton system and the outer masonry system (Figure 3). After the construction of the skeleton system, the stone and brickwork is realized both to provide the infill of the skeleton and to compose the masonry outer skin. This composite system is observed at interior and exterior walls and on ground, mezzanine and first floor levels. It is used to establish a series of frames one inside the other. The first frame makes the outer skin of the building; the second makes the face between the closed spatial units and the arcade; and the third goes around the central courtyard. The two long sides of the inner frame running along the north-south direction are continued so as to meet the outer frame. The material used in construction is generally rubble stone, brick and mortar. Brick and mortar are preferred only at the inner frame of the first floor. The thickness of the combined walls is 75 cm. at the places facing the exterior, and 60 cm. at the interiors. The width of the timber skeleton is approximately 15 cm. The timber skeleton always faces the interior space at the exterior walls. Metal elements were used to connect the timber skeleton system to the masonry neighboring it, and to connect the elements of the skeleton to each other. These timber elements are upper chord, post, diagonal and bottom chord.

The second group of walls is the timber skeleton inner walls. They are located at ground, mezzanine and first floors. Their perpendicular positioning against combined walls provide support to the frame system and help the organization of the unit spaces. Their timber skeleton systems are connected to those combined walls by the metal elements described in the above. At the eastern spatial units of the first floor, the skeleton system is covered with lath at its two surfaces, and then plastered. The total thickness is about 15 cm. This is a traditional technique known as “wood-lath”. At ground floor, and southern and western spaces of the first floor, brick infill is preferred. Here, the total thickness is about 20 cm.

The third group of walls is masonry stone walls. They are only observed at basement level. Rubble stones are put together with mortar. The exterior walls get thicker as approached from the ceiling level to the base plane (75-100 cm. of width). The interior walls are around 60 cm.

All of the three groups of walls are plastered and washed. Excluding the north elevation, which is covered with cut stone; east, south and west elevations are plastered and whitewashed. Lime plaster is used at wall surfaces facing with exterior weathering conditions. The surfaces facing the interior are plastered with a mixture of lime and straw. Besides lime-based whitewash, plastic and oil paint finishing material are observed on the wall surfaces. Similarly, additional tiles are observed at the following positions: On the walls of the laboratory at the first

floor neighbouring the eastern staircase at its north; walls of the toilets; the eastern, southern and western porticoes, and the wall pieces used to fill in the arches bordering the north side of the courtyard on the ground floor.

Figure 3 : The walls with combined constructions

Timber trusses and tile covering were used in the construction of the roof system. Unfortunately, the roof was thoroughly ruined during the fire. Only some traces of the structural elements could be observed. The examination of the tile pieces that were left over has proved that they were imported from France.

3 DAMAGES IN THE HISTORIC STRUCTURE

The primary cause of damage in the building was the fire. However, sea and sewer water used while extinguishing the fire ruined the historic structure as well. These damages were listed in the below:

- Dampness in the basement floor: At the basement, there has been the problem of rising damp ever since the building was constructed, because the basement level is below the level of underground water. In order to cope up with this situation, two pumps were situated at the basement. They controlled the level of ground water by pumping it off regularly. After the fire, the ground water rose 25 cm up from the basement floor because the pumps broke down.
- Dampness in the ground floor: Corrosion in I beams and coloring in the finishing material is observed in the jack-arched system of ground floor. The northern border of the monumental staircase was ruined. This part was composed of three arches supported by two columns at the centre and two others neighbouring the walls at the sides. The marble cubic blocks making up the columns were disintegrated partially with the effect of heat. Similarly, marble blocks of stairs were cracked and partially broken. Balustrades of cast iron were blackened. Embellished plasterwork under the windowsills were split off the wall surfaces.
- Loss of architectural elements at mezzanine floor: At the mezzanine level, elements of the doors located at the eastern staircase and providing link to the mezzanine units and the neighboring building at the east were completely lost.
- Severe structural damages in the first floor: At the first floor, timber elements and stone-brick filling material of the walls were partially burnt. Consequently, metal connections in the walls were damaged. Plasters have split off the wall surfaces because of the extensive amount of heat. Timber skeleton walls covered with lath and plastering, and timber floor beams and their covering were so damaged that their repair was impossible. Timber doorframes were completely lost, where as the altered iron joinery of the windows were damaged. At the north corridor, the columns and arches defining the border of the monumental staircase were severely damaged. Here, the arches were constructed with timber laths and plastered. Similarly, timber columns

were plastered and whitewashed to create the image of marble surface. Column capitals imitating Corinthian style and stone column bases were all in ruins. At this space, the embellished ceiling was completely lost together with the roof (Figure 4).

- Disintegration of the plastering on the ceilings and walls at basement, ground and mezzanine floors.
- Complete loss of the roof system that was preserved with its original material, structure and form until the fire.

Figure 4 : Columns and arches of the monumental staircase.

4 PROGRAMMING OF THE RESTORATION PROCESS

The restoration process of the building included the following phases: Urgent precautions against collapsing of the structure, design of the project phase, wreckage removal and documentation work, preparation of the project in 1/50 scale and its approval, laboratory studies, preparation of the detail drawings and the implementations.

1. Precautions: The extraordinary conditions of the historical structure necessitated some preliminary interventions before the preparation of the project. The precautions taken just after the fire were as follows: The traffic flow was taken under control on Mithatpasa Street on which the building has been situated. The flow of heavy vehicles was forbidden in the line adjacent to the north elevation. In fact, this northern wall has become completely unstable and scaffolding was erected to support it at its exterior side. At the interior, a series of timber panel frames were placed perpendicular to the exterior and middle frames of composite walls on the first floor. This was a precaution against shifting during restoration. The tops of the walls were covered with nylon sheets. Sheets of water resistible plywood were used to construct a temporary floor over the ruined first floor to take rain water under control.

2. Project Design: During this phase, the factors of time, economy and technical possibilities were taken into consideration. The local government that was in charge of the building decided to begin the implementation work as soon as possible and make the school building ready for the next education year. Consequently, the measured drawings, which were prepared by Dokuz Eylül University in 1/50 scale a few years before the fire, would be updated considering the damages of the fire (Figure 5). The documentation work would be carried out together with the removal of wreckage. The components of the building and their traces would be documented via photographs, drawings and reports. Preparation of detail drawings and compatible new materials in the laboratory would be carried out together with the implementations.

3. Wreckage Removal and Documentation: The burnt plastering on the first floor walls and thoroughly damped plastering on the mezzanine and ground floor walls were removed. After these removals, the damages in the timber elements of the combined walls were documented on the drawings of interior facades. The ruins on all of the four faces in each space were

documented via drawings and photographs. The types of damages and related intervention decisions were illustrated (Figure 6). Material samples were taken from the building.

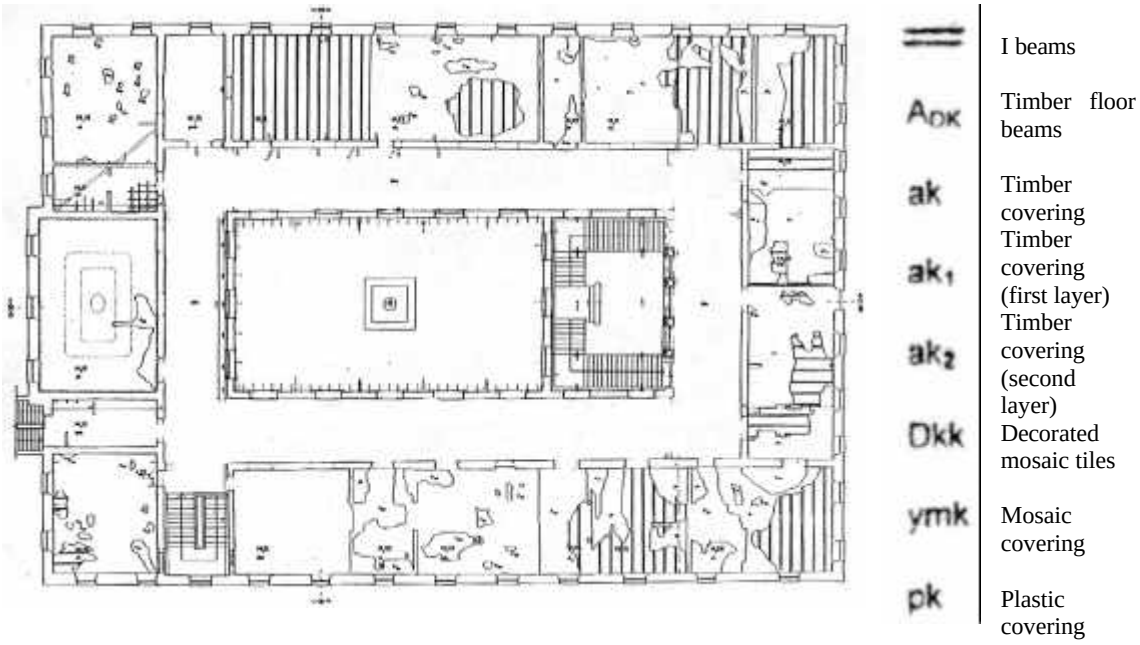

Figure 5 : First floor plan – Analysis of the damages

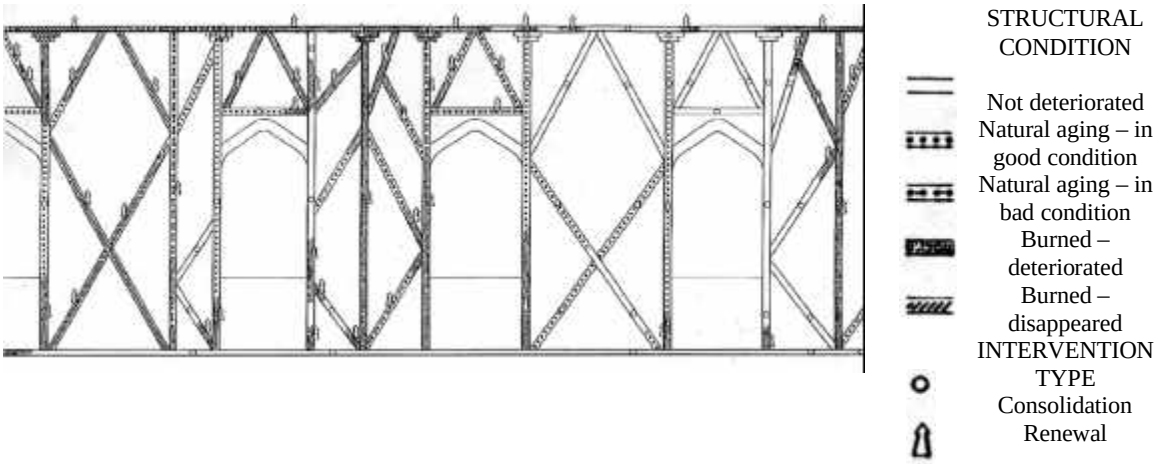

Figure 6 : Structural analysis of walls with combined constructions and intervention decisions.

4. Project and its Approval: The previous drawings were revised according to the new documentations. Plans, sections and elevations were prepared in 1/50 scale with conventional techniques. Although there was limited amount of time, the project was prepared considering all the prerequisites of restoration. Clearly, phases such as documentation, historical research, restitution studies, material and structural analysis were undertaken. The local Conservation Council approved the restoration project.

5. Laboratory studies, detail drawings and implementations: In parallel to the implementations, laboratory studies were completed and principles of material conservation were clarified. Detail drawings were prepared in 1/20, 1/10 and 1/5 scales. The restoration work was completed in seven months and the school building was made ready for the next education year.

5 INTERVENTION DECISIONS

The interventions for the restoration of the building may be grouped according the causes of decay as follows: Interventions to cope with the decay caused by the fire, interventions that are necessary to cope with the physical obsolescence as a result of aging, interventions related with unqualified formal and spatial alterations, and interventions necessary for to provide contemporary requirements of the education function. In this context the following decisions for the building parts and elements were determined.

WALLS: Historical structural system, where the main walls in the combined structural system and the partition walls in the timber skeleton system acting as a whole, exemplify the construction system of the late 19th century in the region. Besides this system reflects a historical construction technique, it provides both stability and flexibility. For these reasons, the conservation of the original construction system of the walls was decided. In combined construction technique of the walls on the upper floor, burned and deteriorated timber elements would be replaced and completed with new ones, which have same properties with old timber material, rubble stones and bricks. The timber columns in the corners of the outer walls were destroyed by fire when the roof was burning. In these parts, strengthening would be provided by iron bars and concrete material. At first, iron bars would be placed and concrete would be grouted on the sides of the remaining part of the timber columns. Metal clamps in the good condition on the timber skeleton system would be preserved, however damaged ones would be replaced with new metal clamps which would be produced according to the given detail drawings. Epoxy based resins would be used as an injection material for the joining of the new metal clamps to the wall. The part above the timber skeleton system, which was constructed from rubble stone and brick irregularly, was severely affected by fire and charred. On the other hand top chords of the timber skeleton system were partially damaged. These elements would be completed with new ones, then masonry above the timber skeleton would be removed and reinforced concrete beam would be constructed on the upper level of the walls. Concrete material would be composed of trass cement. After the completion of the inner consolidation of combined construction system of the walls, the surface would be plastered to strengthen the walls. Rough coat would be in the original composition. Instead of rendering, gypsum board would be used to provide easiness of maintenance.

Original partition walls, which were constructed of timber skeleton and covered with wood-lath and plastered, were severely burned and it was not possible to restore them. For this reason, these walls would be reconstructed of timber skeleton with the principle of the continuity of completeness in the historical construction system. They would be covered with fiber sheets for insulation and then with gypsum board. New partition walls which were designed in the restoration project would be made of gypsum board to emphasize that these are new parts belonging to the restoration phase.

On the ground floor, in the combined construction system of the walls, the decayed timber elements of the timber skeleton system would be replaced and completed with new ones in the same properties of old timber material. The decayed parts of plasters would be renewed with the original composition.

COLONNADED PARTS IN THE SPACE OF THE MONUMENTAL STAIRCASE: On the upper floor, colonnaded and arched part which formed the north side of the space which possesses the monumental staircase was completely devastated by fire. The thick timber columns together with their stone bases, capitals, original plasters and the arches constructed in wood-lath technique suffered severe damage. This part would be renewed with steel construction however the original formal features would be replicated in cast glass-fiber reinforced concrete.

On the ground floor, the marble columns composed of marble blocks of three arched openings, which provide the entrance to the space of monumental staircase from the north corridor, were affected from the high temperature during the fire. Since the thin layers were partially detached from the marble surface in the south side, the damaged parts would be

chiseled and undamaged marble would be exposed. Then these missing parts would be partially completed with the same kind of marble material.

FLOORS: The original timber trussed roof was completely lost during the fire and it would not be possible to reconstruct due to financial and time factors. It was necessary to build a new floor system, which would consolidate the existing system and provide the facility of implementation, and would be realized in a short time. It was considered that the pre-stressed concrete panels would be appropriate to provide these mentioned conditions and it was decided that the roof floor system would be constructed with these panels. However, the experts who were responsible from the structural system of the project decided to strengthen the pre-stressed concrete panels with reinforced concrete beams, which would be constructed at certain intervals. In addition, steel beams would be constructed above the south corridor.

The floors composed of jack arch system would be preserved. On the upper storey, the floors of the spaces which were covered with terrazzo and the floor of the space at the center in the south covered with figured tile which was not effected seriously would be cleaned and preserved. Burnt timber floor coverings would be removed; wire-mesh reinforced concrete floor system would be constructed in connection with both the load bearing walls and the original jack arch system.

ROOF: Instead of the burned timber-trussed roof, hipped roof would be constructed on the floor, which would be built from pre-stressed concrete slabs as in the original shape and timber material and covered with tiles. Since the fire did not affect the independent hipped timber roof of the space, which was in the center at the south, it would be preserved and repaired. The superstructure of the central courtyard was constructed from steel and covered with wired glass. In this part cracked wired glasses in the fire would be replaced with new ones. Gutters and rainwater pipes, which lead to the courtyard floor level, would be renewed.

CEILING COVERINGS: The ceiling and the roof of the space, which is at the center in the south, were not damaged by the fire. The ceiling plaster and paintings of this space would be restored. Ceiling coverings of other spaces were lost together with roof during the fire. In these spaces, pre-stressed concrete slabs would be covered with gypsum board on the ceilings. In the entrance space, since the decorated ceiling plaster and its structure were seriously devastated by water used in fire extinguishments, they would be restored considering original features. In the space, which functioned, as library the decorated ceiling covering would be restored.

FLOOR COVERINGS: On the upper floor, the figured tile coverings in the space around the central courtyard and in the space which is in the north of the east staircase and terrazzo coverings of the space in the north of the space in the southwest corner would be cleaned and preserved. On the other hand, the wire-mesh reinforced concrete floor system would be covered with linoleum. On the mezzanine and ground floors, the timber floor covering would be repaired and terrazzo coverings, which were made during the previous repairs, would not be changed. However, since ceramic tile coverings of the teachers' room were inharmonious with the original floor covering material, they would be removed and the floor would be covered with timber as in the original. The figured tile floor coverings of the courtyard and the library space would be cleaned and preserved. The obsolete fluted tile coverings belonging to previous repairs in the arcades, would be replaced with mosaic tiles. Marble floor covering in the entrance space would be cleaned and preserved. In the space where the monumental staircase was located, the marble floor covering damaged by fire, would be renewed. The monolithic marble steps were broken, cracked and seriously affected by the high temperature. These would be chiseled and covered with new marble material as in the same kind of the original marble. The staircase, which was constructed from reinforced concrete and covered with terrazzo in the east part of the building, had severe damage. For this reason it would be renewed with marble revetment.

JOINERY WORK OF THE DOORS AND WINDOWS: On the upper floor, the timber joinery of doors was completely burned. The metal joinery of windows, which were altered in previous repairs were damaged during the fire. Both would be constructed of timber in the same detail of the original ones. Jambs of the doors would be renewed with steel and the swinging would be made of laminated timber material. Burned timber thresholds on the upper floor and

damaged terrazzo thresholds on the ground floor, which belonged to the previous repairs, would be renewed with marble material.

MEASURES FOR HUMIDITY: There were two kinds of sources which caused humidity problem in the building; one was the rising damp because of the ground water and the other was the drainage system which was not in good condition. The water leaking out the drainage system penetrated to the basement floor. Using the motor pump and providing continuous air circulation would solve the problem of ground water. For this, wire blind would be added to the window frames and the windows would be continuously kept open. Old drainage system would be renewed and isolated so as to provide prevention of water.

6 THE IMPLEMENTATION OF RESTORATION PROJECT

First the structural interventions were made, and then the roof was reconstructed in its original form. The plasters damaged by the fire and the water, were renewed with competitive compositions. The joinery work of the doors and windows were constructed of timber. The decorations of ceilings were restored and the entrance elevation facing Mithatpasa Street was cleaned and partially completed. Finally, the additional buildings of poor quality on the west side of the monument were removed resulting in the re-establishment of the visual identity at this side. This area was organized as an open space with the necessary outdoor furniture.

The implementation was started with the removal of the plasters, which were not possible to preserve. According to the documentation drawings, which explain the intervention types that would be carried out in the timber skeleton system, the burned elements of the timber skeleton system were partially renewed with the new timber material in the same properties with the original material. However, mostly the original material was preserved and surface consolidation was provided with appropriate chemical composition. Metal clamps in the good condition of the timber skeleton system were preserved while the ones affected by fire were replaced with newly designed ones (Figure 7). The top level of the walls was completed with reinforced concrete beam and the system was strengthened with reinforced concrete beams and steel beams at necessary locations. Then pre-stressed concrete slabs were placed and connected to the concrete beams. Timber skeleton partition walls, which were burned, were reconstructed according to the restoration project (Figure 8).

On the upper floor, the colonnaded and arched part of monumental staircase was renewed with steel construction. This system was covered with cast glass fiber reinforced concrete material reproducing the original formal features. In this part, changes in loads during the implementation of the steel construction system caused an important problem on the marble columns at the ground floor, which were just below the new steel construction system. The surface detachment problem, which was only observed on the south surface before the implementation increased. New diagonal cracks, which were not determined before, occurred. This serious problem appeared before the placement of the pre-stressed concrete slabs over the steel construction. Necessary measures were taken at this phase of the implementation. After the determination of the problem, the structural engineers of the project developed a project, which would support the existing system. The arches were supported by the cradles included steel “false work” that could catch the arch. Then the physico-mechanical properties of the marble columns on the ground floor have been determined by experiments made in the Geology and Rock Mechanics Laboratory of the Faculty of Engineering of Dokuz Eylül University under the leadership of Prof.Dr. Necdet Türk and Geology Engineer Bahadir Yavuz. In the results of the experiments, it was determined that the marble columns lost their bearing capacity and the preservation of them could not be possible. The following decisions were taken for this part:

Figure 7 : Interventions on the walls with combined constructions.

Figure 8 : Pre-stressed concrete slabs and timber skeleton partition walls.

Figure 9 : Monumental staircase after restoration.

The space of the monumental staircase is a prestigious area, which encountered the entrance of the building. Colonnaded part in which the problem occurred was a bearing system, which transferred loads to the ground. At the same time, this part was the transparent spatial boundary providing visual connection between the entrance and monumental staircase. After the entrance to the building from the Mithatpasa Street, perception of the indoor space with its splendor was provided with this elegant bearing system. Imposing staircase, which provided vertical circulation, and the arcade, which provided horizontal circulation, were separated with this thin boundary. This arcuated system provided successfully both the architectural aesthetic and

structural stability. It was a determinative architectural element in the formation of the spatial character of the building. It would be appropriate to preserve the form, material, proportion and disposition of the system.

As a result of this opinion, the existing system was replaced with steel construction system and original formal characteristics were replicated with marble coating (Figure 9). At this phase, the experts of Yapi Merkezi, which was the implementation firm in charge, made significant contribution to the project.

The other structural restorations in the mezzanine, ground and upper floors were realized in accordance with the project. The timber-hipped roof was constructed over the concrete slabs and covered with tiles. The cracked wired glasses in the roof above the courtyard were replaced with new ones and rainwater pipes were renewed.

7 CONCLUSIONS

The development of the project and its application for the restoration of the building following the fire were realized in a short period of time. The entirely damaged roof has been the primary reason for the urgent restoration process. Decisions taken in the project had to provide both the structural strengthening in the process of structural interventions and the preservation of the original features of the building that were damaged at a great degree during the fire. The use of contemporary materials in the restoration was preferred with two thoughts in mind: the first one is to ensure that the restoration realized after the fire was discernable and the second one was to provide the building with modern comfort conditions as it would continue to serve as an educational edifice.

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