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Adaptive Reuse of Ankara CerModern Art Gallery Evaluation of Structural System

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Abstract

The buildings in Türkiye reflecting the impact of industrialization originating from Europe in the 18th century and later are considered industrial heritage today. These buildings that are worth preserving are brought back to the city by the phenomenon of adaptive reuse. However, among important issues to be discussed are seismic loads which bear a great risk for industrial heritage building. Adaptive reuse of such structure focus on the building the design, repair and retrofit of structural systems. While also establishing the link between the old identities of the structures and the present one. In this study, the transformation process of the CerModern building, which is a registered industrial heritage building in Ankara, into Ankara's first modern arts center was evaluated while focusing on structural system design. The CerModern building was reviewed in terms of restoration interventions. The main purpose of the study is to comparatively examine and evaluate the authentic structural system and the designed new structural system applied.

1. INTRODUCTION

Industrial buildings that once reflected and functioned in the spirit of the industrial revolution are no longer able to meet the needs of the time and are often out of use. Due to a wide range of conditions such as changing economic and industrial practices, population, and increasing operating and maintenance costs. This is mostly because the buildings are not suitable for their original use and an alternative application cannot be found (Orbaşlı, 2008).

Industrial structures that were built in Türkiye with the effect of the industrial revolution and lost their function over time can be considered industrial heritage according to their qualities. Due to their historical, technological, social, and aesthetic values, buildings including warehouses, factories, and transportation infrastructure that was constructed in association with the industrial revolution after the 18th century are referred to as 'industrial heritage buildings' (TICCIH, 2003). Industrial buildings, which were planned in the city peripheries at the time they were built, can find a place in the city centers with the urban changes over time. These structures, which reflect the spirit of the time that has lost their industrial function, can offer unique spaces for the city. It is possible to contribute to the dynamism of the city by defining new functions for industrial buildings that have lost their function.

Historic buildings, as symbols of culture and heritage, function as focal points for individual and social life. Since ancient times, people have believed that historic buildings are important and should be preserved, but it wasn't until the nineteenth century in Europe when the Arts and Crafts Movement, notes by William Morris, and John Ruskin, among other things, were used to describe a preservation action that would later influence conservation practices. Romanticism and rationalism-influenced ideologies served as the foundation for contemporary conservation in the twentieth century and are included into several

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international regulations and treaties, notably the World Heritage Convention. Additionally, cultural preservation is becoming a global issue in the twenty-first century (Orbaşlı, 2017).

Adaptive reuse refers to any building modification, improvement, or reuse to adapt a building to new circumstances or needs (Douglas, 2006). Reusing historic buildings benefits communities' social and environmental well-being while preserving the nation's past (Shen & Langston, 2010). In addition to extending a building's life and lowering pollution while using fewer resources, energy, and transportation, reuse also helps the environment (Bullen & Love, 2009). Reusing buildings extends their useful lives while preventing waste from demolition, encourages the recycling of embodied energy, and offers major social and economic advantages to society (Department of the Environment and Heritage, 2004). Historical structures are now regarded as having ecological significance in addition to local identity, cultural history, and socioeconomic qualities as people grow more environmentally concerned (Cramer & Breitling, 2007). As it consumes less energy and generates less waste, recycling is a better choice than demolition or replacement. This can also benefit society by revitalizing well-known locations (Conejos, Langston, & Smith, 2011).

Conservation practices need a thorough understanding of the structural and material features. It is necessary to know about the original and previous state of the building, the used techniques in its construction, the changes and their impacts, the events that took place and finally its current state. The intervention should be the consequence of an overview plan that focuses on the different dimensions of the architecture, the structure, the installations, and the functionality (ICOMOS, 2003).

Industrial buildings are ideal structures for art spaces because they generally have structural features such as high ceilings, wide spaces, large windows, wide roof openings, skylights, and fewer decorations for functional purposes. In the process of transforming the CerModern industrial building, which was examined in the study, into an art center in Ankara, such characteristic features of industrial buildings have been effective. It is an important issue to take the current earthquake regulation as a basis in adaptive reuse applications for industrial buildings built with the structural knowledge of the years they were produced. CerModern stands out in the context of industrial structure with its historical value as well as having a mixed structural system as it was built between late 1800s early 1900s and put into service. This building, which was built as a locomotive technical maintenance hangar, consists of four authentic units and an additional building built in the context of adaptive reuse. For a building to be adaptive reuse in Türkiye, which is an earthquake zone, it is essential to take precautions according to earthquakes or other types of structural damage. It is also of great importance that these structural measures to be taken are designed by the architectural setup. In the research, information about the surveying drawings and authentic structural design of the CerModern art center building was obtained. The structural features of the building, the applied structural interventions, the protection limits of the building, the structural performance problems, and the extent to which these problems can be eliminated have been investigated in detail.

2. CERMODERN ART CENTER HISTORY AND DESCRIPTION

CerModern Art Center was built in Ankara the capital of Türkiye as train maintenance hangars during the nationalization of the railways 1892 or 1926 according to two different sources. According to the architect Semra Uygur, the railways were built in 1926-27, the first years of the Republic of Türkiye, and a cer workshop were built during this period. Later, 3 hangar buildings were added in accordance with the original structure. A second view is that the cer workshops were built in 1892 before the Türkiye Republic. These repair workshops are a result of the construction of the first railway line in Ankara, which was built by the Germans in 1892 as part of the Anatolia-Baghdad Line during the Ottoman Period (Sezer, 2013). It is known that the building remained inert and in a very devastating state for a long time before the restoration. In 2010, the surveying and restoration projects were prepared by the Uygur Architecture Office, the adaptive reuse project of the building was completed, and the building was put into use as a modern art museum (Figure 1).

Figure 1. *Post-restoration view of CerModern from the courtyard (Cemal Emden, 2010)*

Cer Workshops is in the Sıhhiye district of Ankara, between Kızılay and Ulus. This region is an important area with its architectural characteristic and urban regional planning. The Atatürk Cultural Center Zone where the Cer Workshops are located allows these workshops to expand over a large area of land and surrounded by buildings with similar functions. The Atatürk Cultural Center Zone is a large area where projects, contemporary art and sports activities are organized. Todays, the Cer Workshops are in the surroundings of the Presidential Symphony Orchestra Building, the Ankara Court House and the Ankara Opera and Ballet House.

The architectural features of the Cer Workshops are as follows. The building consists of 4 different masses with masonry wall system and long span. The masses are single storey and have high ceilings. The masses have a steel truss roof type. Structures have large windows and roof skylights to make maximum use of sunlight.

3. AUTHENTIC FEATURES AND ADAPTIVE REUSE DECISIONS

The authentic plan scheme of the CerModern building consists of three hangar structures with similar dimensions (1,2,3) and a longer workshop structure (4) that is thought to have been added to them later (Figure 2). There is no historical information about the workshops, offices, and warehouses that were found to be built in the following years and were considered unqualified addition in terms of restoration.

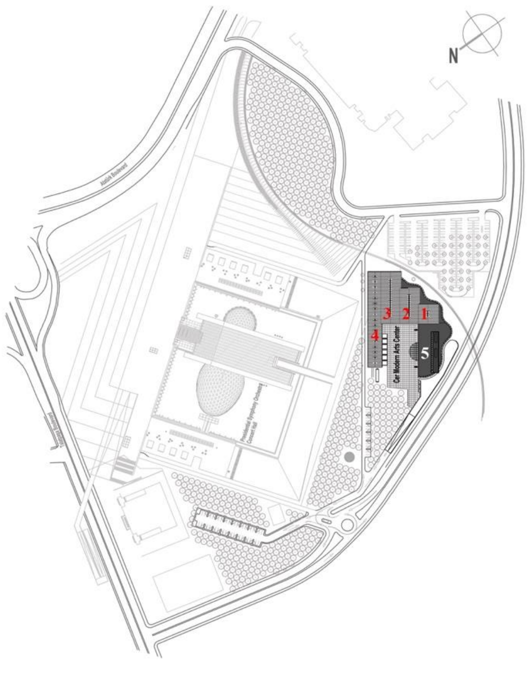

Figure 2. *CerModern site plan (Uygur Architecture Archive, 2019)*

The original structural system consists of reinforced concrete columns, steel roof trusses, dressed stone and masonry brick walls. In this way, a mixed structural system in which the masonry construction technique, the framed system, and the steel truss system are used together has been obtained. Originally there were two types of roof trusses.

3.1. AUTHENTIC STRUCTURAL SYSTEM FEATURES

The original structural system consisted of masonry, steel, and reinforced concrete units. The facade walls and interior walls were built using dressed stone, and the cross-section of the walls is 50 cm thick. Columns were 80 x 80 cm in square section and made of reinforced concrete. A monitor roof was used. The plan consists of three same sized rectangular units (1,2,3-hangar) and one longer (4-workshop). Facades vary in range of 12,40 meters to 93,40 meters as the longest one. There is no basement or penthouse in the single-storey building.

It is thought that the walls were used for filling between the columns rather than as structural in the vertical direction, but it is obvious that these masonry units give lateral support to the frame system which consisting of columns.

The hangar roof trusses (1,2,3) have similar features and dimensions, and the height of the truss beams is at safe level according to the span. In the fourth workshop (4), which is stated to have been built later, the truss opening is less, but the heights are close to the truss in other hangar roofs. Due to architectural concerns, it is thought that this provided continuity and order in the view by keeping the heights of the gable walls close to each other. There is not much change in the design of trusses except for the difference in truss spans (Figure 3). Triangle truss type was used with bolt connection. Although it is not known exactly when the building functions ended, it is known that it was in a devastated state and the roof trusses were largely corroded before it was restored (Figure 4).

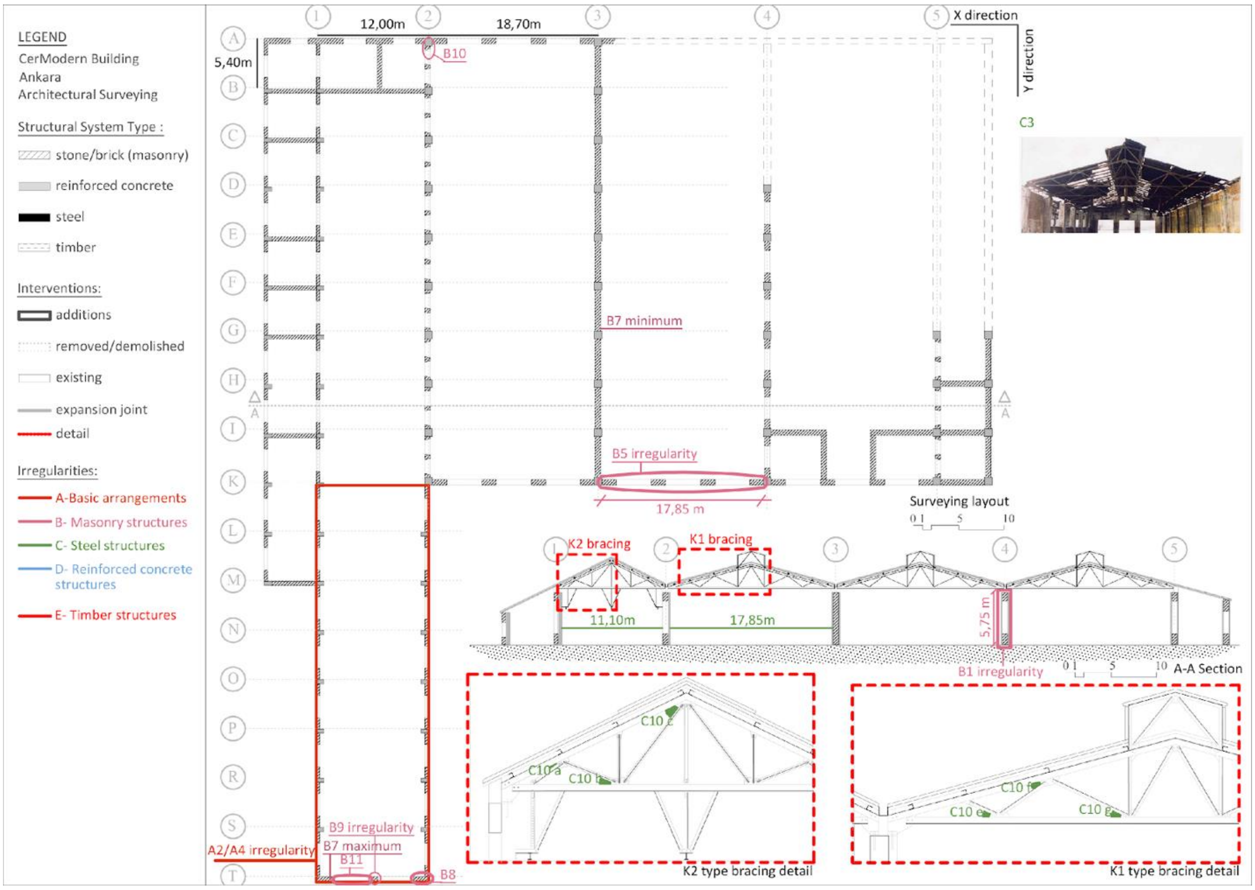

__Figure 3.__ Architectural surveying before architectural restoration, drawings of CerModern

Figure 4. *The pre-restoration state of Hangar 1-2 (Uygur Architecture Archive, 2019)*

Although the building complex is made up of rectangular units with a partially symmetrical plan geometry of hangars, the long and narrow part (4), which seems to have been added as a period annex workshop space, has negatively affected this symmetrical layout. At the same time, this addition also caused horizontal irregularity in the layout. When the distribution of the structural members is examined, it has been determined that the distributions in two directions, x and y directions, are balanced and homogeneous. The axles of the structural system are also parallel and perpendicular to each other in both directions. In the design of the structural system, an expansion joint could not be determined. However, since it is assumed that the steel system connections partially work as sliding support and as a kind of expansion joint, these connections are evaluated within the scope of an expansion joint with sliding support. In addition, it can be said that there is no need for an expansion joint since the structure is an isostatic system.

The negative aspects of masonry members can be listed as follows. The load-bearing wall heights are 5,75 meters, this value is above 3 meters, which is the highest value determined in the regulation (TEBC, 2018) and design principles. When the walls between the reinforced concrete columns are measured, it is understood that the maximum unsupported length of the load-bearing walls is 17,5 meters, and it remains above the required maximum value. This is a negative situation in terms of wall stability. The values obtained by dividing the total length of the load-bearing walls in one direction excluding the voids by the gross floor area were found to be 0.036 for the x-direction and 0.059 for the y-direction. This value, which is accepted as an important criterion against lateral loads, is well below the lower limit of 0.25. However, this negativity can be ignored since the building is not purely masonry and the main structural system consists of reinforced concrete columns and a steel truss system. It can be said that some of the walls were demolished during the period of inactivity of the building, possibly because of the failure to comply with the above-mentioned wall stability principles and because of neglect.

The fact that the building is single-storey does not pose a problem in terms of the number of floors allowed in masonry structures. On the other hand, the fact that the wall heights are above the limit values and there is no horizontal beam is seen as a negative design and construction technique. However, the reinforced concrete columns of the framed system between the masonry units are evaluated positively in terms of supporting the walls. The fact that there is no partial basement in the building was also evaluated positively. Another positive feature, the thickness of the wall sections does not fall below 50 cm, which is the smallest value determined by the earthquake regulation, even on the inner walls where it is the lowest.

The ratios of the lengths of the spaces in the load-bearing walls to the lengths of the filled walls are variable. As there are walls that do not contain any gaps, there are also hangar entrances designed as large spaces for wagons to enter, and these walls are above the appropriate void ratios in the masonry structure design. On the same walls the door and window gaps were measured as 4 meters, remaining above the value allowed by the regulations 3 meters. On the other facade walls, where the gap ratios and gap lengths were found to be within appropriate limits, it was determined that the filled wall lengths between the gaps did not reach sufficient values. There are no vertical beams on both sides of the gaps to eliminate the negative effects of the gap.

It was stated that serious corrosion and material loss were detected in the steel members due to the long-term inactivity of the structure before the restoration, besides, there is naturally no precaution against fire in the members. It is understood that the collapsed and fatigue structural system members have adversely affected the continuity of the structural system. In the authentic truss design, it has been determined that the weld and rough bolt joints are not used together. In terms of truss beams and axle spacings, the ratio of axle spacing to truss beam opening is above the required ratio of 1/3 to 1/4 for both truss beam types. The ratio between the height of the truss beam and the span of the truss is by the limits determined in the design principles. According to these ratios, the truss design receives engineering services. The presence of horizontal wind and stability joints on the roof is positive for safety. Considering the angles between the web members, it has been determined as a positive feature that it is generally designed to stay at 30 degrees and above. Apart from this, the presence of masonry walls between the columns on which the steel trusses sit was determined as an important plus in terms of resistance to lateral loads.

The determinations regarding the columns, which are reinforced concrete members, are as follows. The fact that the building is a single-storey, the lack of a frame system, the continuity of the members caused by the collapsed elements, and the long-term exposure of the members to the external weather conditions are adverse conditions. The member dimensions providing the values determined by the earthquake regulation and the optimal axis arrangement are the features that can be considered positive.

Considering the period in which the building was designed, it can be said that it is a special example in which newly developed structural systems such as steel and reinforced concrete were used intensively. Although the traditional masonry system was used as a part of the structural system, it is understood that the main structural system was provided with reinforced concrete and steel members. Due to the knowledge available, it is thought that the walls between the reinforced concrete columns could have been integrated into the design by chance. The reinforced concrete and steel mixed structural system applied in the building was not designed within the earthquake regulation. For this reason, it is thought that they were designed with computational methods within the certain scientific knowledge, as they are newly developing systems.

3.2. NEW AND RESTORED STRUCTURAL SYSTEM FEATURES

During the restoration, to ensure integrity in the hangar 1,2,3 and workshop (4) space all interior walls except the exterior masonry walls and the walls between the workshop-hangar sections were removed. However, in this case the lateral stability integrity of the frames has disappeared and the risk of not being able to meet the lateral loads such as earthquakes has emerged. As a solution to this problem, steel I beams and steel braces in some parts were added between all reinforced concrete columns (Figure 5). Interventions were made to the masonry walls where needed for protection.

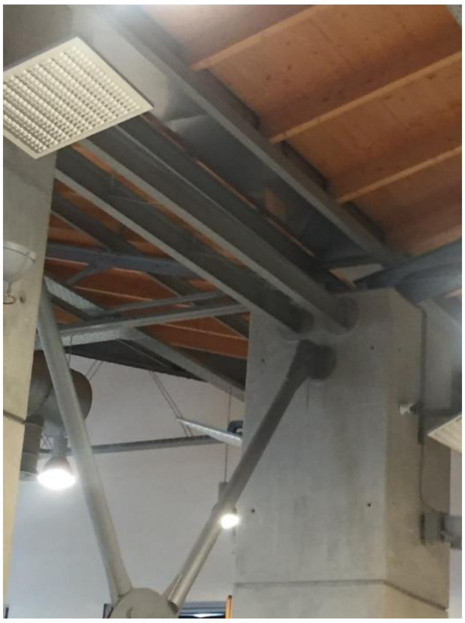

Figure 5. *Added steel I beam and braces*

The horizontal and vertical beams on the masonry walls were not arranged in accordance with the original during the restoration. These walls were used as partitions between columns rather than vertical supports, but it is a fact that they limit the horizontal displacement of the frames.

In the architectural restoration works, due to the serious corrosion of the roof trusses and their cover, steel frame connections, truss type, and connection members were completely removed and rebuilt following the authentic roof. Although the roof truss beams were found to be positive in terms of dimensions and proportions, the decision to completely replace the problematic trusses caused by corrosion and renew them in the authentic state was implemented (Figure 6-7-8).

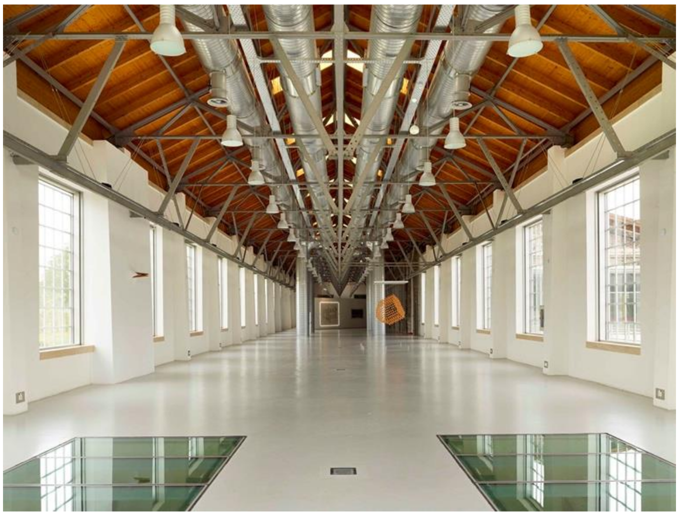

Figure 6. *Post-restoration view of the hangar structure (Cemal Emden, 2010)*

Since they have been open to environmental factors for a long time and the cross-section dimensions of the members were not considered sufficient, it was decided to retrofit the reinforced concrete columns by jacketing method and their cross-sections have been increased to 120 cm x 120 cm.

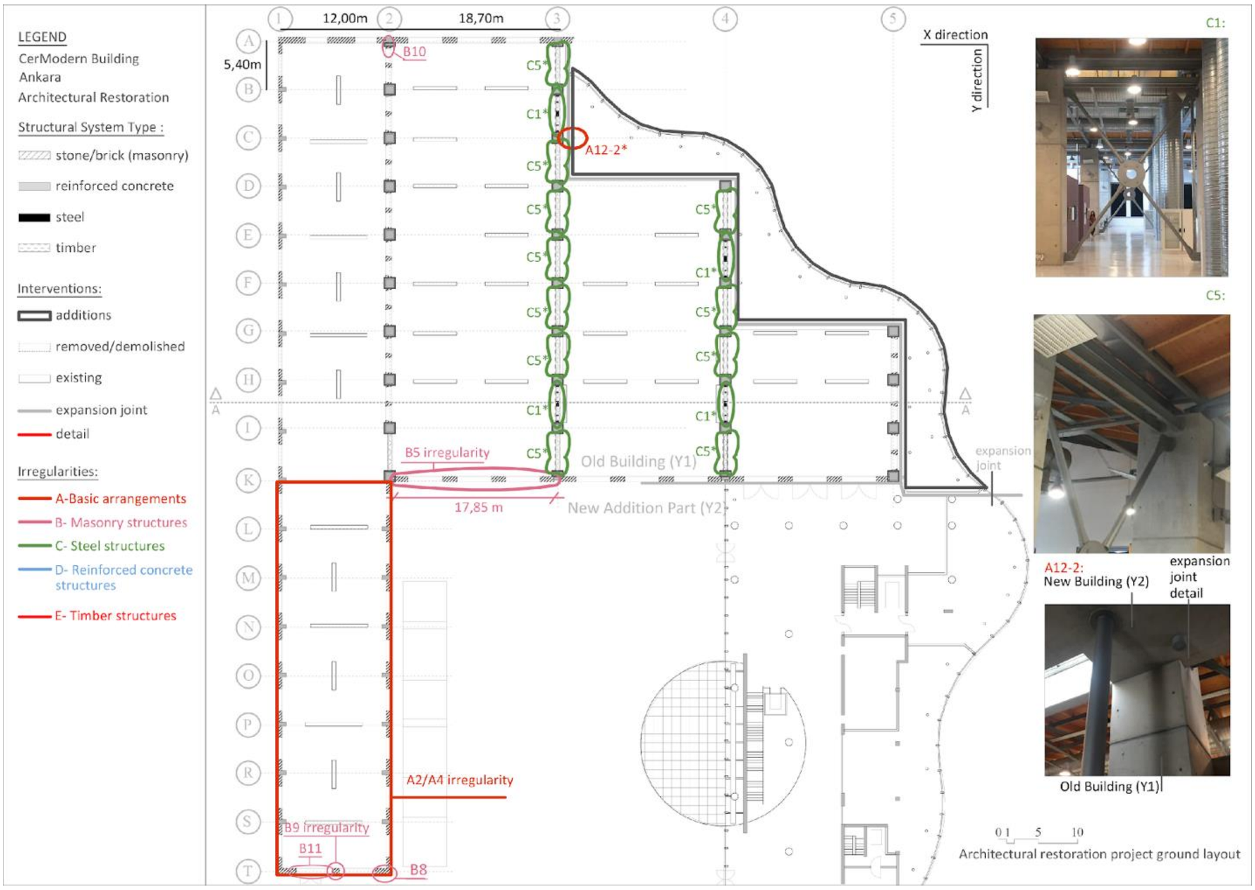

Figure 7. *Architectural restoration drawings of CerModern*

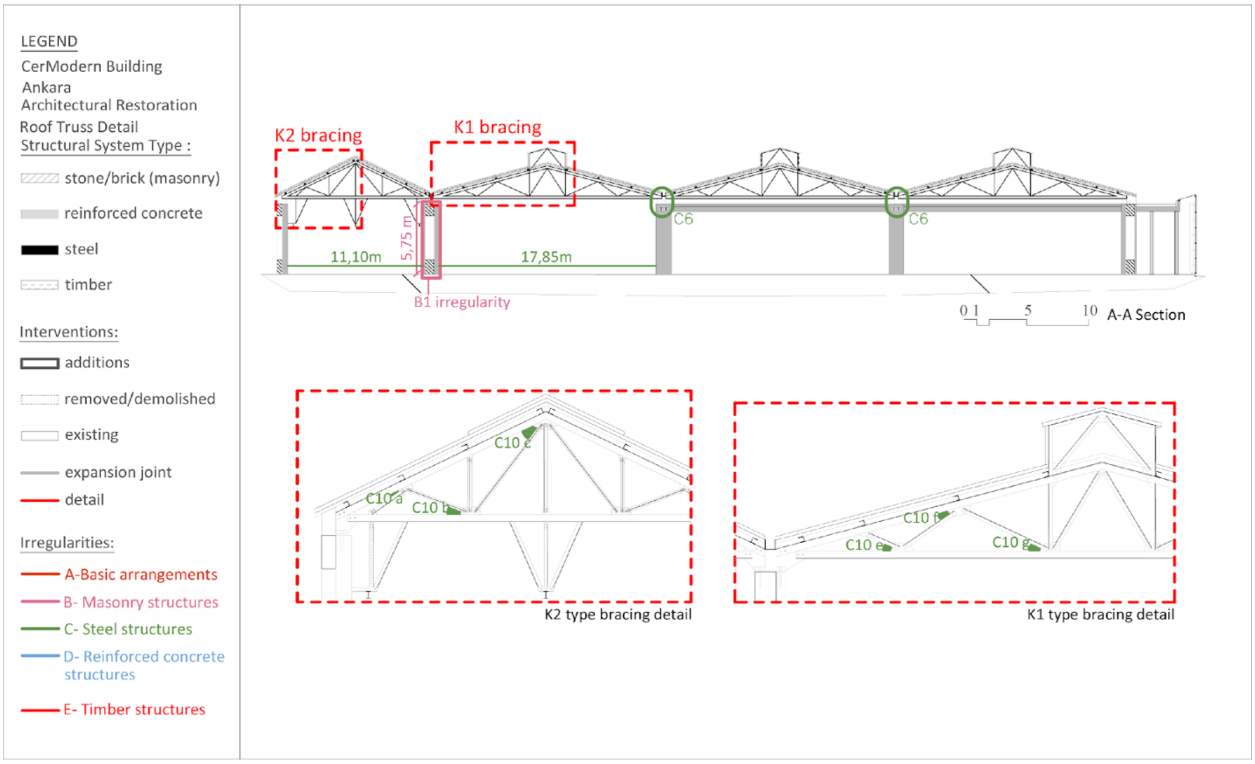

Figure 8. *Restored truss details*

During restoration, the number of floors in the authentic units of the building has been preserved, but a basement floor was added to the additional building (5) which was added to meet the requirements of the new architectural program (Figure 9). Together with the additional building, a form was obtained to define the courtyard. In the restoration, the additional block structure and the adjacent old building were separated from each other by an expansion joint. The additional block's main structural system was a reinforced concrete frame system, but steel support columns with a diameter of 20 cm were used at the cantilever of the roof and floors.

Figure 9. *An additional building block (Cemal Emden, 2010)*

4. EVALUATION AND CONCLUSION

The original CerModern building is not symmetrical in plan. The axles of the structural system are in their authentic condition, and they are parallel and perpendicular to each other in both directions. In the original structural system design, there was no provision for expansion joints and no intervention was made in this direction during the restoration. It was stated that the structure is an isostatic system, and no expansion joint was required. It was determined that an expansion joint was applied between the restoration additional building and the existing structure. Considering the torsion and pounding effects during possible earthquakes, this expansion joint has been evaluated positively.

The fact that the internal load-bearing walls have been greatly decreased has greatly removed the effect of the masonry units, which initially contributed to the lateral drift of the structural system. This situation can be considered negative in terms of post-restoration building safety. Except for the facade walls, the other masonry walls retained after the restoration are thought to have been preserved as evidence of the building's history. The original masonry wall heights have been preserved. The values obtained by dividing the total lengths of the load-bearing walls in one direction excluding the voids by the gross floor area decreased further in the last case. However, it has been determined that measures have been taken for these negativities by means of steel beams and braces.

Severe corrosion and material loss were detected in the steel members and the unusable truss beams were renewed and completed in accordance with the original. Prevention against fire in steel members is provided by a general sprinkler system. For this reason, it has been preferred not to apply a chemical application to the element surfaces to increase the fire resistance of the steel members. The roof was renewed while preserving the original truss proportions. Horizontal wind and stability connections on the roof are positive for safety. The steel bracing and I beam members added between the reinforced concrete columns are positive in terms of ensuring the continuity of the frame. Another positive feature is the retrofit of the structural system against horizontal / earthquake loads by using steel beams and braces. As a result, the negativities that could be caused by the removal of the authentic walls between the reinforced concrete columns were eliminated by integrating steel beams and braces into the structural system.

The column cross-sections, which were 80 cm in the authentic design, were retrofit with the reinforced concrete jacketing method and arranged to be 120 cm in all directions. Since the original axis layout was formed in a proper way, it was preserved exactly during the restoration process.

As a result of the restoration interventions, authentic structural system along with the interventions that can follow the current earthquake regulations have also been applied. The most important interventions can be shown as the arrangement of steel beams and braces to increase the performance of the structure against lateral loads. It was determined that the reinforced concrete additional building, which was arranged as a restoration addition, was also designed in accordance with the current earthquake regulations.

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