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Changing and Development of the Construction Technology During the Westernisation Period in Ottoman Architecture

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ABSTRACT: Since the first quarter of the 18th century in the Ottoman State, an opening towards European westernization began and this westernization phenomenon turned into a renewal movement rooted in the structure of the state and society at the time of the Tanzimat (a time of political reforms during the sultanate of Abdulmecid, r.1839-61). The symbolic appearance of the change was that Istanbul was to gain the image of a western capital. But a change rooted in the contradictory urban and architectural structure with the traditional city fabric of wooden buildings. So while construction types that the Tanzimat reforms felt the need for, the design molds of European architecture together with the principles of shaping modern building materials and production technologies began to be constructed. The reason for this is that the Ottoman State had not needed to join the internal dynamics and conservative structure of state and social structure during the "Enlightenment Movement" and later the "Industrial Revolution" that European countries lived through but remained tied to western industry. In this tie construction materials like modern brick, steel and cement that European industry produced and construction technologies that were formed by these materials influenced the formation of Ottoman architecture of the historical development period after the first years of the 19th century.

INTRODUCTION

All the techniques, methods and practices applied to construct a building came into being for construction technology. The general montage of the construction technology is gathered under two main headings, "solid block" and "framework." The solid block system is a construction technique in which the walls that gain the character of being the carrying wall through the placing in a clear design of small-dimensioned materials are brought together. As for the framework system it is a construction technique that ensures that the loads that affect the building are carried by independent horizontal and vertical bearing. As for the historical development process of construction technology, it is separated into two periods prior to and after the Industrial Revolution when important changes were experienced from the point of view of both construction materials and construction techniques.

1 PRIOR TO THE INDUSTRIAL PERIOD, OTTOMAN ARCHITECTURE BUILDING PRODUCTION TECHNOLOGIES

The passage of time from the prehistoric period to the period of high culture together with social and cultural changes created within society in the architecture field it brought a separation of "monumental" and "civil" The monumental buildings while more mixed than civil architecture in the pre-Industrial Revolution period and of necessity much more expertly done were con-

structed using more permanent construction technology. Monumental buildings in Ottoman architecture were built with four different bearing wall types and the solid block of masonry type.

Rough stone (rubble) wall: The rough stone walling in which horasan (mortar made of brick dust and lime) and rough stone were used together. The stones are put together in rows, and the differences in heights among them were straightened out with smaller stones or wide joints.

Cut stonewalls with adjacent joints: The wall has two faces. The stone blocks that have been cut straight on the inner and outer facades are put together in an adjoining smooth form that doesn't permit the mortar to be seen, and between the two facades the rough stone has been filled in a disorganized way. In addition the external façade in which adjoining joints of the cut stone, and the inner façade were mounted in rough stone are found in buildings.

Brick wall: The wall in which brick and horasan were used together is one technique. This technique did not spread in Ottoman architecture.

Alternating technique wall: The wall is made of orderly stone and brick rows. The putting together is of different types such as brick and hewn stone or rough stone and brick alternating. A row of stone, two rows of brick with a row of stone, three rows of brick alternating was the one most applied. In the walls that had two faces the inner façade was in the technique in which rough stone was put together. It would be filled in a disorganized way with rough stone and brick dust between the faces.

While stone gained importance in the construction of monumental buildings prior to the Industrial Period, Ottoman architecture remained with brick material in second place, and benefited from metal as a tie and assisting element.

Stone that had been the most preferred in Istanbul for centuries was taken from mines near the region and because it could be worked easily, they became "küfeki" (lime stone), "od taşı" (volcanic tuff stone) and "kum" (sandstone) (Erguvanlı, 1989). The Ottoman brick used in constructing arches, vaults and alterneting technique wall structures are flat brick 24 × 24 / 28 × 28 / 30 × 30 cm dimensions and 3 / 3.5 / 4 / 4.5 cm thick, see Fig. 1, (Arseven 1965). Just as happened from the point of view of texture and color among the traditional kilns that produced them, changes were seen in dimensions too. In the solid block of masonry bearing walls in order to bind the stone or the brick material a strong mortar called "Horasan" was used as mortar. Within the mortar sand, lime, brick-tile pieces and dust along with a fiber-equipped and protein source occurred as added substances. In order to bind the stones in the massive walls metal elements known as metal clamp and tenon were used. From the second half of the 16th century in the masonry wall in place of the wooden lines that appeared was the iron element given the name "tie-rod" and later leaving it to the equipment system that was known as "collar beam" it created forms of metal use in the period architecture (Tanyeli 1990).

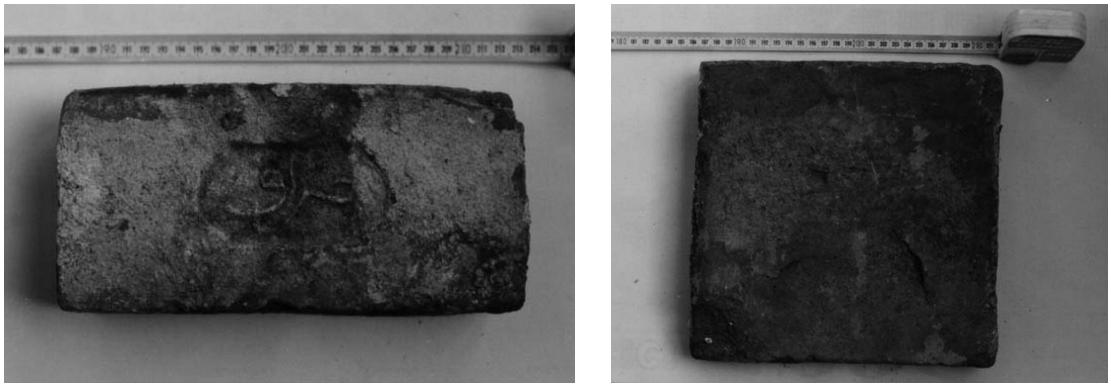

Figure 1-2 : Traditional Otoman brick 24 × 24 × 3.5 cm. Modern brick 23.5 × 11.7 × 6.5 cm (U.Yergün).

Within the borders of the Ottoman Empire wooden frame construction technique was used in civil architectural samples in a broad area that stretched from Central Anatolia to the Balkans. Up to the end of the 17th century wooden elements known as "hımış (half timbered)" were tied laterally, horizontally and diagonally to each other the building technique thus created was widely used (Eldem 1987). Among the wooden structures as fill material either adobe brick or

brick was used. While the brick would be put down in a form that would create a design or while the brick dust was made smooth in time the facades began to be plastered. From the first years of the 18th century the inner and outer faces of the wooden structure was enclosed with a "bağdadi" technique (Eldem 1987). Bağdadi is made by striking a lime plaster on the hairline on the half-batten at a thickness of nearly 1-2 cm. still which has been driven horizontally at nearly 1-2 cm. intervals into the wooden props. Over time while in the interior of the buildings bağdadi continued to be applied, the exterior walls were covered with wooden planks.

2 AFTER THE INDUSTRIAL PERIOD, THE BUILDING PRODUCTION TECHNOLOGICAL DEVELOPMENT PROCESS IN OTTOMAN ARCHITECTURE

Since the end of the 17th century following the "French Revolution" and after the "Period of Enlightenment" the European countries remained face to face with changes rooted in social structure. This change resulted in the "Industrial Revolution" that began at the end of the 18th century and the first ten years of the 19th century in England (Benevolo 1981). Together with the Industrial Revolution the methods that provided changing forms for substances, innovations related to methods, form of production and techniques and taking advantage of steam power and machinery, the period of production would be easy to check and it brought about the establishment of big and modern works that would supply the possibility of a more profitable work sector. As a result the Industrial Revolution is known for a series of changes that symbolize the passage from an economy that relied on agriculture and handicrafts to the modern industrial and manufacturing economy.

Up to the 19th century while it seemed there was a partial change in the materials used in building construction along with the Industrial Revolution in following the advances in technology, changes rooted in the construction center appeared.

2.1 The use of new building types and quantities of traditional construction techniques

At the end of the 16th century when the Ottoman State had reached its widest limits, its military power couldn't participate in the developments in the field and technology that occurred in European countries up to the 18th century and as a result of this it began to face defeat and the continuous loss of land. In the results and prospect of the advancement of the European countries it became the beginning of a new period in the Ottoman State to get to know the West and the wish to understand the reason for this. In the first quarter of the 18th century one of the important results of the change that the Westernization process began with the "Tulip Period" appeared in the architectural field. The reflection of this change was the waterside mansions, kiosks and pavilions that were constructed at Sadabad and later on the shores of the Golden Horn and Bosphorus. In organizing a landscape influenced by the gardens of the French palace, together with being decorated with western type motifs, it seems the traditional in architectural deigns and manufacture of these buildings did not change.

In this process its effects began to appear at the end of the 18th century in the urban fabric of architectural change that remained circumscribed by people in the imperial government and its surroundings. As a result of the removal of the traditional army (Janissary Corps.) the wish to establish a new army that would take into account the military organization structure of the western nations brought together new structural types given the new necessities. These buildings that were known as "barracks" were the first building type taking its model from European architecture in the Istanbul urban fabric and are the first big buildings with massive structures and western types that exceeded two stories aside from the monumental buildings that existed on Istanbul's silhouette. In the barracks built during the period up to the Tanzimat when modern construction technologies began to be added to Ottoman architectural traditional construction technologies being used. The first modern military buildings, the Humbaracılar (1792) and the Selimiye (1802) barracks, used European architectural fundamentals on one side, on the other side they were constructed using wooden construction technology. In order to provide security against fire in these barracks, the renewal of traditional masonry construction techniques

achieved a new dimension during this technological process. In the barracks of the period that were constructed in order to be able to meet the needs of the modern army, the carrying walls were an alternating technique mix of stone-brick so the floors were of wooden beams (Yergün, 2002). In this period the Topçu Numune (1804), Tophane-i Amire Arabacılar (1823), Maltepe (1826), Davutpaşa (1826) ve Rami (1828) barracks were built.

In the first years of the 19th century the Ottoman sultanate abandoned conservative construction and Topkapı Palace through the influence of the phenomenon of westernization. In this period the Beşiktaş (1809), Beylerbeyi (1829-first construction-) and Çırağan (1839-first construction-) palaces were built. In these buildings in place of Topkapı Palace with its scattered settlement that had developed over time and out of necessity, the places took the palaces in the western countries. But aside from the form and elements sourced in the west used extensively in the massive structure and facades, from the point of view of the plan montage and the construction technology, the characteristics that were reflected in the Turkish House were not abandoned (Yergün 2002).

2.2 The use of modern brick in vertical bearers

Brick in parallel with the technological developments that occurred during the Industrial Revolution period was beginning to be manufactured by machine in the industrial atmosphere.

Fabrication in manufacturing increased the physical characteristics and mechanical endurance, and compact, intense and standard bricks each of which carried the same characteristics were taken in hand. Because the modern brick is easy, economic and quality production and practical use it became a construction material that was preferred to stone, also to wood because of its being fire resistant. The standardization of the bricks produced by industrial methods at 6 – 8 / 10 – 12 / 21 – 23 cm made them easy to use, see Fig. 2. In this process in which the vertical bearers are mixed with modern brick, in the horizontal bearers from the technology of the era when wood was the most convenient material that could meet tensile and compressive force.

The beginning of the use of modern brick in Ottoman architecture is in the "Tanzimat" period. The Tanzimat (1839) is the turning point in Ottoman modernization. Reform movements up to this period remained circumscribed in the scientific and educational fields and were directed entirely at developing the military strength of the Ottoman. As for the Tanzimat it included the laws that were seen as modernizing society and renewing the state's administrative and legal structure. The symbolic outlook of the renewal movements was to create a westernized capital image for Istanbul. But the diversion that the traditional urban fabric made up of wooden buildings needed requires a rooted change in urban and architectural construction. To be able to ensure the passage to modern masonry construction technology new mixed models and legal changes were taken. The first steps taken to apply these together while the new construction types were using modern masonry construction technology that belonged to the administration, education, health and the public sectors that the modern state and society found necessary to build were dismissed through the decision on construction.

In this period the Russian Embassy Building (1838) built by the Russian government using modern brick won great approval among the people as much as in the state administration with the attractive possibilities such as fire-proof, economic and quick production and long life. For this reason the Italian born Swiss architect Gaspare Trajano Fossati who built the structure was given the job of building the Bab-ı Serasker-i Hospital (1841), see Photo. 3, that was the first building in Ottoman architecture constructed using modern building technology and materials (Yergün 2002). When this building was found to be successful the construction of the Darülfünun and the Hazine-i Evrak that belonged to the state administration as well as a police station in the Eminönü district was assigned to Fossati (Ergin 1938).

Following Fossati who put his stamp on Tanzimat period architecture, foreign architects like William James Smith, Giuseppe Fossati, Bourgeois and Giovanni Battista Barborini together with Sarkis Balyan of the palace architectural Balyan family, individuals who were educated in Europe, were appointed to achieve a very heavy building program. In this period Bâbıâli Building (1844), Mecidiye Barracks (1847), Tophane-i Âmire Hospital (1847), Darülmaarif

Building (1850), Telgrafhane-i Âmire Building (1855), Gümüşsuyu Barracks (1857), Mekteb-i Harbiye-i Şahane Building (1862), Kuleli Suvari Barracks (1863), Harbiye Nezareti Building (1864), II. Darülfünun Building (1865), Bahriye Nezareti Building (1865) were built.

The transition process to Western style architecture that begins with the public sector buildings and the modern masonry construction technology continued with the palaces, pavilions and kiosks one after the other for the sultans of the period themselves and family individuals (Yergün, 2002). In this period the Dolmabahçe Palace (1842), Tophane Pavilion (1847), Ihlamur Pavilion (1849), Adile Sultan Pavilion (1853), Beykoz Pavilion (1855), Çifte Palaces (1856), Küçüksu Pavilion (1856), Mecidiye Kiosk (~1856), Beylerbeyi Palace (1861), Kalender Pavilion (1862), Çırağan Palace (1863), Fer'iye Palaces (~1863), Kağıthane Pavilion (~1866), Ayazağa Pavilions (1866), Büyük Mabeyn (1866), Malta Kiosk (1866), Çadır Kiosk (1871), Adile Sultan Palace (1876), Maslak Pavilions (~1861) ve Çit Pavilion (~1861) were built. The most important building made up to this time in Ottoman architecture and these buildings that created the potential for investment changed completely the face of the Istanbul urban fabric. Sultan Abdulmecid and later Sultan Abdulaziz in place of foreign architects preferred to use Garabet Amira, Nigagos and Sarkis Balyan of the innovative individuals who were educated in Europe.

Grand Vizier Mustafa Resit Pasa who prepared the Tanzimat decree had a waterside mansion built for himself at Baltalimanı on the Bosphorus in 1847 to Gaspare Trajano Fossati who had been given the job of applying the heavy construction program of the Tanzimat period, see Fig. 4, (Can 1993). Not only was it a high-ranking house for example the use of modern masonry technology in Ottoman civil architecture began with this building. Because most of the state officials following this building in various regions of the city had these modern houses of the period constructed for themselves (Yergün 2002).

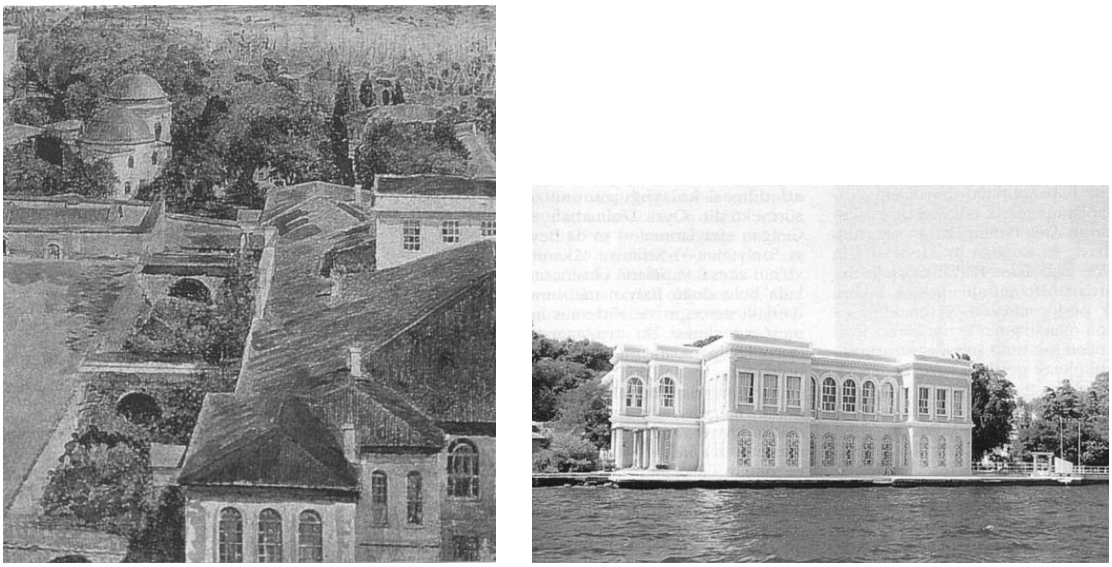

Figure 3-4 : A picture of the Bab-ı Seraskeri Hospital signed by Fossatti (C.Can archives). The Reşit Paşa Waterside Mansion (1847), one of the first examples constructed with modern brick (U. Yergün).

2.3 Use of jack arch (metal beams) in horizontal bearers

Since the mid 19th century in connection with the development in industrial metal technology together with mass steel production an important change happened in western architectural building production technology. While in this technology the vertical bearers as happened previously were mounted using the solid block of masonry technique with modern brick material, the horizontal carriers were constructed in the building technique known by the name of "jack arch". In jack arches mounted while the steel beam was used with the passing of the tight steel beam on one side of the opening that it was to pass through and with the closing between them done in flat vault form, the above spaces were covered. In the structure of the flattened vaults

between the steel beams tile materials were used together with what seems to have been brick or openings, see Fig. 5. As the horizontal bearer the use of steel beams in place of wood provided an increase in the opening between the bearer walls that the building structure totally protected against fire.

Coming to the last quarter of the 19th century, new material and production technology began to be used in Ottoman architecture. Within the Istanbul urban fabric the German Embassy Building (1874) and the German Hospital constructed by the German government are two sample buildings using this new building technology as first examples and following them, the Avrupa Passage (1874), Çiçek Passage (1874) and Akaretler Row-Houses (1875), see Photo. 6, were constructed (Yergün, 2002).

During the time in which this building production technology from the last quarter of the 19th century up to the first quarter of the 20th century when reinforced concrete construction technology had begun to be used, because civil architecture examples were produced from material that was completely fire proof it was preferred in the construction of every building type immediately. But when this production technology spread, the role of measures offered by the government with economic incentives and taken through legal arrangements was big.

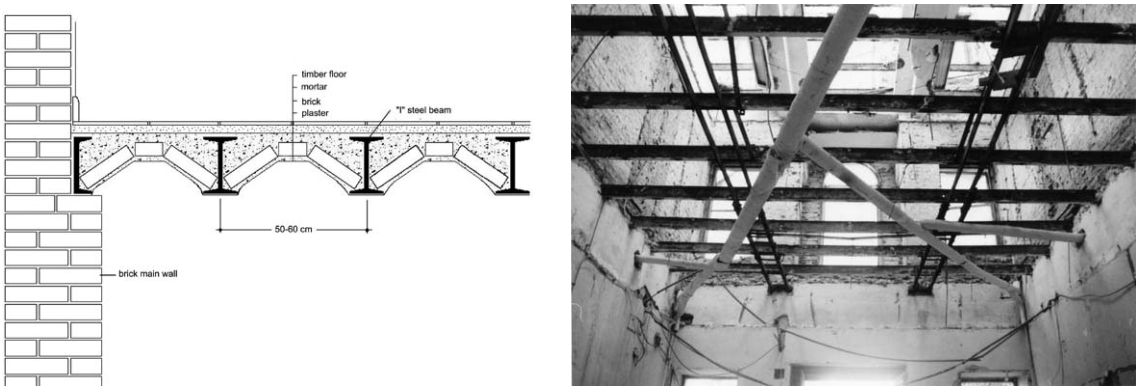

Figure 5-6 : Jack arch construction technology. Akaretler Row Houses (1874), jack arch and steel beams appearance / restoration 1998 (U. Yergün)

2.4 Use of steel framework construction technology

In the last quarter of the 19th century new openings were brought to the technologic level building production field that had been the steel industry. Steel characteristics provide important advantages ensuring that more original designs in architecture as a construction material included soundness, elasticity, lightness and workability. Buildings with steel frameworks that began to be constructed in European countries and in particular America since the 1880s put its stamp on modern architecture and from the beginning of the 20th century this production technology was began being used more widely (Benevolo 1981).

The capitalist economy required in transportation, industrial and commercial buildings and this steel framework structure that was completely open in front of completely open eyes in public buildings and those with other functions did not see acceptance especially among academic circles. So the steel structure in these multi-storeyed buildings with broad expansive ness as the period felt necessary, was hidden inside the masonry walls which are not bearing walls. Architectural designs, in spite of variety and elasticity gain the façade formations mostly remained tied to the past and just as the process came up to this period it resembled European architecture with its historical and choice styles.

In this construction technique, the vertical and horizontal bearers of metal beams are mounted in a framework structure form. In the framework structure the general weight of the building is transferred as the dot on the ground by the metal bearing elements. In the metal bearing elements, because of the forces that affect the building the bending and buckling that appear as a result of uniting the metal beams in various forms and dimensions is brought about through

separately cut in the form required by the bearer, see Fig. 7. On the spaces that are carried by the metal beams of the steel framework system is enclosed with a type of jack arch renewed according to the technology of the period. The jack arch cover mentioned here is a surface that covers the space's ceiling but is not characteristic of the bearer. On the short side of the space among the metal beams that have been placed at a distance of ~100-150 cm the brick was placed in the form of a flat vault or was created by concrete being poured in the form of the flat vault.

Ever since the first years of the 20th century in Ottoman architecture, while the steel framework construction technology was used the buildings constructed began to take place. However, different from the practices in western countries, in all buildings in which this construction technology was used including industrial, communications and commercial function buildings, the steel structure was concealed inside the masonry walls that did not have the characteristic of load bearing. In Ottoman architecture this construction technology that was preferred for the buildings that required special designs like a large mass and wide-open area from the necessity of the architectural project along side the steel structure montage, builds that were first constructed like the Haydarpaşa Train Station (1906) and the Metro Khan (1914), see Fig. 8, the project was prepared in European countries and carried out by architects who came from these countries also (Yergün 2002). But after a while we see that the steel structured Dördüncü Vakıf Khan (1916) was built by Kemaleddin Bey, the Turkish architect who had his education in Germany.

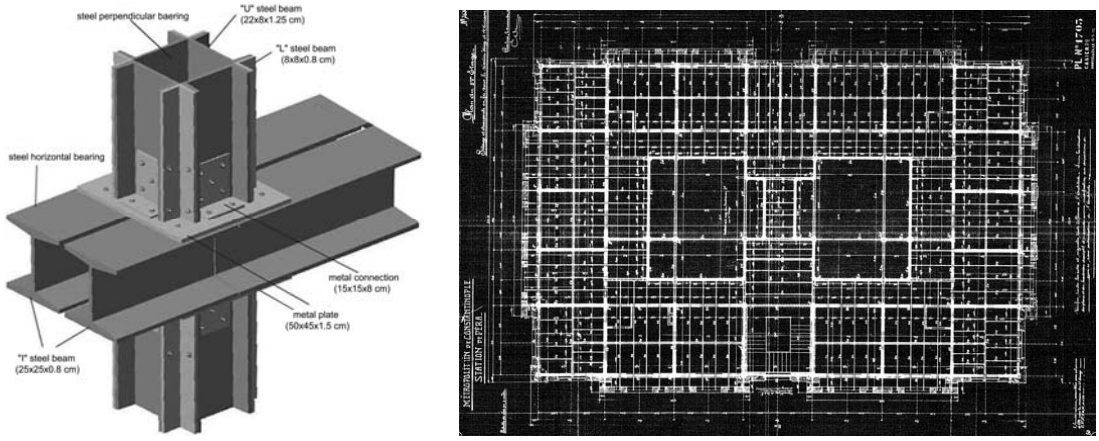

Figure 7-8 : Steel framework construction technology, vertical and horizontal bearer (U. Yergün). Floor Project, Metro Khan (1913), one of the first buildings with steel framework structure (İETT archives).

2.5 Use of iron-concrete construction technology

In the period when steel framework buildings began to occur in Ottoman architecture, a new building production technology that united steel beam with concrete began to be used in western architecture.

The first use of concrete that was one of the materials that created this construction system stretches back to the Roman period. However concrete that was not developed in later periods came on the agenda in today's understanding in the beginning of the 19th century. This development period that began by adding water to a mixture of quicklime and ash resulted in the production of the substance started by the British J. Aspolin in 1824; it was given the name "Portland Cement" and still used today. Colqent's producing a wall of concrete in 1852 began the process of using cement in the building sector (Gerçek 1979). Because concrete was weak principles were developed for strengthening it and to meet the shrinkage with some material. In 1892 French engineer F. Hennebique reinforced concrete with steel. This technique, in spite of being bearer elements for steel and concrete separately against reactions relied on the principle of both materials working together. F. Hennebique, filling concrete between sheets of iron strip,

built the Charles V Thread Fabric near Lille in 1895 with the columns and beams he produced (Ersoy 1997).

In this building technology that is a basic example of the concrete bearing system known as "iron-concrete", the horizontal and vertical bearers came into existence by uniting concrete with steel beams. Because of the forces that affect the building against bending and buckling, the section measurements of the bearer had to be separated according to the dimensions that distance necessitated and the concrete poured, see Photo. 9. While the section dimensions of the horizontal and vertical bearers united in the steel structure, they were created by pouring concrete between them. While in the steel structure the section dimension of the horizontal and vertical bearers united with the steel beams, in the iron-concrete building technology that concrete can be poured in the dimension wanted brought to the construction sector more flexible design understanding and economic solutions. The spaces were covered with concrete layers that were supported by steel girders that carried the iron-concrete framework system beams and were located on the short side of the space.

Figure 9-10 : Iron-concrete construction technology. Galata Customs Building (1907), one of the first buildings constructed with iron-concrete construction technology (U.Yergün).

In Ottoman architecture the Galata Customs Building (1907), see Fig. 10, and the Merkez Rıhtım Khan (1912), see Fig. 11, were constructed using iron-concrete production technology. However, as the Silahtarağa Electric Central (1911) buildings that were constructed as steel structuralism the vertical bearers were mounted in the iron-concrete technique with the purpose of distributing the weights over a broader surface (Yergün 2002).

2.6 Use of reinforced concrete construction technology

In the iron-concrete construction technology the steel beam and concrete have the characteristic of being able to bear separately, against the bending and tensile forces of concrete that is rather high in enduring pressure while being equipped with steel, the construction technology "reinforced concrete" appeared with mounting on a form that would show only a single material characteristic. In 1877 the American, T. Hyatt published the trial results of his idea that concrete in inclined form and steel would be used for a time. In 1901 A. Perret and G. Perret achieved the first application of reinforced concrete (Ersoy 1997). Because of the forces that affect the structure with the reinforced concrete production technology against bending and buckling, the bearing element the cross section measure reinforced being able to be modeled as necessary in the size of the characteristics had to be separated their dimensions.

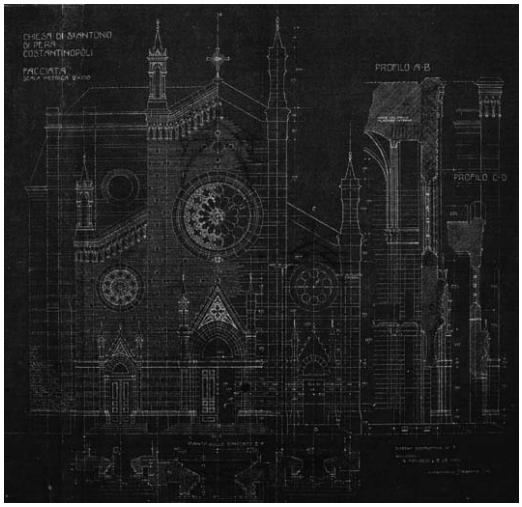

Figure 11-12 : Merkez Rıhtım Khan (1912), one of the first buildings constructed with iron-concrete construction technology (U.Yergün). Sant'Antione Church (1910), one of the first buildings constructed in reinforced concrete construction technology, entrance facade part plan and section (Can & Girardelli 1996)

Reinforced concrete became a construction technology that answered the construction necessities of the economic and modern age thanks to the characteristics of concrete and steel. For this reason ever since the first years of the 20th century it began to be used frequently especially in American and European architecture. In a short period of time the process of reinforced concrete that began in Ottoman architecture with Sant'Antoine Church (1910), see Fig. 12, and Herikzedeğan Apartments (1919) in parallel with technological developments continues still in Turkey in widespread form (Yergün 2002).

3 CONCLUSION

During the westernization process, the understanding of architecture at the same time that rapidly changing processes were seen in the field of construction technology was realized although a connection with modernization movements such as the technological advances experienced in European industry, governmental political, legal and corporate structures and society's social and cultural structures was unrecognized.

The construction technologies used in the production of buildings that were erected using western architecture as the model and the symbolism expressed through architectural values that were carried in the urban fabric, the achitecture of the westernization period and the construction technology became the indicators of the development period. In this regard the process of change and development in the construction production technology of the westernization period shows a form in the shape indicated below.

Construction Technology	Period
The use of new building types and quantities of traditional construction techniques	Early ~ 19th century
The use of modern brick in vertical bearers	~ 1840 and later
Use of jack arch (metal beams) in horizontal bearers	~ 1874 and later
Use of steel frame work construction technology	~ 1905 and later
Use of iron-concrete construction technology	~ 1907 and later
Use of reinforced concrete construction technology	~ 1910 and later

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