The Adoption and Refinement of Reinforced Concrete Construction
In Early 20th Century Korea

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Abstract
This study examines the advances that reinforced concrete structures have gone through from the introduction of concrete to Korea in the early 20th century to the development of composite action between reinforcement and cement. At the earliest stage, concrete was used exclusively for foundations and ground floors and was later used as the floor system in multiple story construction with steel beams and corrugated steel plates. As an example of this progression, in the Chosen Hotel which was completed in 1914, steel bars were used for the reinforcing materials in the concrete floors and steel beams were covered with concrete for fire-proofing. This led to the use of prefabricated Kahn type reinforced concrete girders in the construction of the Chosen Government-General in 1918. In the late 1920’s, the introduction of stirrups and bent-up reinforcement using the Hennebique method in construction enabled the integration of columns, floors and girders into a composite action structure. For instance, at this time, the application of this method was adopted in public buildings including the main office building of the train station and government buildings in Gyeongseong.

Keywords: Korean modern architecture; concrete slab; Kahn Bar; Hennebique Beam; reinforced concrete structure

1. Introduction
The introduction of new construction materials such as timber, brick, steel and cement through the ports open to the world made it possible to adopt Western style architecture in Korea. Of these materials, concrete has had the most impact on subsequent developments in Korean architecture. The first use of concrete was for the foundation and roof structures in the English Consulate Building built in 1891, although in this particular instance, it was used solely as a non-structural material.

After 1824, when the manufacture of Portland cement began in England, concrete was first used as a structural material for floor slabs with more than one story in conjunction with cast iron columns and steel beams. However, lessons learned from structural failures due to fire initiated the use of concrete as a fireproofing material, first for beams and then for larger girders. This, in turn, led to reinforced concrete with the full composite action of floors and girders.

The reinforced concrete architecture which started in the West in the middle of the 19th century was developed in East Asian countries in the early 20th century, especially in Japan which had experienced frequent disasters from earthquakes. During those times, buildings using unreinforced concrete and reinforced concrete appeared widely in Korea as well. These advances have continued to the present time.

Accordingly, this study attempts to identify the historical development of reinforced concrete construction in Korea from its introduction up to the present, by chronicling the use of construction methods including respectively, unreinforced concrete floors, combined steel beams and concrete floors, and composite reinforced concrete slabs, beams and columns.

The study of the progressive refinement in reinforced concrete construction techniques appearing at each stage of the modernization of architecture is significant for two primary reasons: first, as milestones in the advancement of Korean modern architecture and secondly, for the aspects of historical research and restoration technologies for the continuous preservation of the extant structures in (reinforced) concrete construction.

2. Concrete Floor Structure with Steel Beams
1) Concrete Placement with Brick Arches
Brick buildings are generally constructed with wood floors. Wood floors are built with the placement of
large beams on the brick walls and large spaces consist of long and short span beams and internal columns. The weight of the floor is basically supported by the brick wall. Similar to a wood structure, the first concrete floor structures were placed over brick arches or steel plates between beams while long and short span wood beams were replaced with steel beams.

Examples of upper floors supported with the use of brick arches can be seen from ancient times. Also, these examples can be found in crypts installed under altars in religious architecture built in modern times in Korea as they can be traced back to the water supply and sewage facilities in Roman times. A representative example can be seen in Myeongdong Catholic Church built in 1898, where the ceiling of a crypt used for its small sanctuary is built with brick arches and its upper section, which is finished with granite plate stone or soil compaction as shown in Fig.1.

Before the placement of brick arches, steel beams are installed at about 1.5m spacing and concrete is placed after the piling of arches in 1/2 brick (0.5B) between beams. In order to prevent the horizontal thrust of the arches from affecting beams, steel beams are connected with bolts from 1.2 to 1.8cm in diameter.

2) Concrete Placement with Corrugated Steel Plate

The fireproofing structure is made with concrete and corrugated steel plates used to replace brick arches. The connection of steel beams with bolts is the same technique as used in brick arches even with flat plates substituted for arch steel plates. Steel plates, especially with deeper folds than ordinary plates, were used for flat corrugated steel plates.

In addition, the floor construction was of high strength or light weight concrete with fireproof functions, i.e. brick powder or coal concrete. Concrete could not be used for the entire floor unless the distance between beams was short, because this weakens the overall strength of concrete and makes the thickness larger.

An example of the first use of concrete with corrugated steel plates, according to records currently available, is the Seokjojeon (Historic Relic No. 124) in Deoksugung Palace. Although many repair constructions have been carried out on Seokjojeon, its original construction commenced in 1900 and was completed in 1910. During these repair constructions, a concrete floor structure with steel beams was discovered. Girders of 2I-350×150×12×24mm and joist beams of 1-125×75×5.5×9.5mm were used with the placement of corrugated steel plates of 3.6mm thickness and concrete of 13cm thickness was applied.

The former Belgian Consulate Building (Historic Relic No. 254), on which construction commenced in 1903 and was completed in 1905, consisted of 1 underground floor and 2 ground floors. According to design drawings and photo albums prepared in October 1978, beam support stones were arranged at a spacing of about 90cm with 1 beams on the first floor, while bricks are piled inside with the attachment and placement of cement mortar. Unlike the first floor structural system, the second floor is installed with wooden joists of 60×350mm at a spacing of 450mm.

Fig.1. Brick Arches of a Crypt in Myeongdong Catholic Church

Fig.2. Floor Structure of the Sugar Refinery in Bewlay Moss (Theory of Modern Architecture, 1976)

Fig.3. Details of the Floor Structure of Seokjojeon in Deoksugung Palace

Fig.4. Figure Steel Beams and Corrugated Steel Plates Exposed during the Dismantlement and Repair Construction for the Eastern Building of Seokjojeon in Deoksugung Palace in 2010
In the main building of Chosen Bank\(^7\) (Historic Relic No. 280), which started construction in November 1907 and was completed in January 1912, wide span girders are placed between brick walls and columns and angle joints are made with joist beams between girders according to "Construction Reports for Chosen Bank"\(^8\) published at the completion of construction and "Repair Reports for the Main Building of the Bank of Korea"\(^9\) published in 1989. Girders of I-300×150×8mm and joist beams of I-150×100×6mm were used and corrugated steel plates were placed between joist beams with the concrete applied at a thickness of 12cm. This is an advance from strips with a one inch (2.54cm) width and 1/16 inch (0.16cm) thickness are inserted at 9 inch (22.86cm) spacing on the concrete floor. This is an advance from the existing concrete floor structure type with no reinforcing bar, and seems to have originated from the increased need for fireproofing functions of the floor in addition to the floor reinforcement necessitated by girders and joist beams at a wider span. Another feature is that steel beams are covered with concrete in a thickness of 2 inches to prevent them from being exposed directly to fire\(^11\).

This is a more advanced floor structure than those in the previous examples, which enables us to foresee the use of reinforcing bars thereafter as the reinforcement material for concrete and the further development of reinforced concrete structures for improved fireproofing performance.

3. Composite Action Construction of Reinforced Concrete Floors and Beams

Reinforced concrete was first used in the construction of foundations. The reinforced concrete foundation is said to have been selected at the time of the establishment of the Busan Custom Service Building in 1909, as the site had risks of sinking due to its ground having been weakened from reclamations\(^12\). Anyeong Bridge (12.5m) in Naju is the oldest bridge to have been built as a T-type bridge among those still existing, and it is said to have been built with reinforced concrete in 1910\(^13\).

The initial introduction of reinforced concrete construction was by civil engineers in Japan, who are said to have attempted the use of reinforced concrete construction with separate columns, girders, floors and walls according to their traditional techniques for wooden structures. They carried out their traditional techniques for wooden structures such that they finished columns first, placed girders and floors separately, or constructed floor girders first. Among the examples of those times are Warehouse D and G for the Kobe Branch of Tokyo Warehouse (with the completion of construction in June 1910)\(^14\). Floors and girders are separately constructed as well in the previous example of a concrete cover for steel beams at the Chosen Hotel. It might have been difficult for architects whose accumulated experiences were based on the fireproof floor, to deal with the unification of girders and floors and with the concrete placement on steel plates between steel beams.

As civil engineers followed the traditional method of building wood structures in their initial attempt to build reinforced concrete structures, architects adapted masonry construction techniques for their reinforced concrete architecture. Some examples can be found in buildings designed by Oto Endo. Endo completed the Head Office of Yokohama Jeonggeum Bank as a stone construction under Tsunami\(^15\) (1859-1916) before the use of reinforced concrete.

Although the roof of Echizen Western Dress Shop, which was completed in 1909, was the first use of reinforced concrete floor girders by Endo, composite action concrete placement was seemingly not used considering the parallel use of two types of bar placements. The Hennebique type is used in beams and the Maunier type is used in slabs\(^16\).

Fig.6. Presumed Detail of Floor Structure for the Chosen Hotel
(Prepared by the Author)
The Hennebique type of reinforced concrete originates from the patent (1982) by the Frenchman, Francois Hennebique (1843-1921), and can be characterized by the use of stirrups and bent-up reinforcing. The introduction of these techniques can be said to have enabled the main construction in a composite way of floor concrete and girders. Okura Civil Engineering Group completed the Tsukiji Naval Coinage Materials Warehouse (begun in July 1910, completed in March 1911) as No. 1 construction and Kokubu Locomotive Shed (begun in December 1910, completed in September 1911) as No. 2 construction for the introduction of reinforced concrete in the Hennebique type\(^1\). The reinforced concrete structure is said to have been applied to the water purification plant and slow filtration plant in 1908 when the 'First Water Purification of Ddukdo Water Source' (Tangible Municipal Heritage of Culture No. 72) was completed in Korea. The water purification plant was constructed on reinforced concrete floors with flat steel joined to rectangular columns, whereas the slow filtration plant was built on horizontal arch girders (of 300mm width) with a 5.5m distance between columns in concrete with no reinforcing bars and vertical girders (150×470mm in width and height) with a 4m distance between columns in the reinforced concrete. The reinforced concrete was applied only to vertical girders with the placement of two rectangular steel bars of 20×20mm\(^9\). Considering the fact that the Construction Office of Takjibu at that time took charge of construction for these facilities, it is assumed that the composite action construction for girders and columns in reinforced concrete could not have been accomplished. The present appearance is assumed to have resulted from many changes in the expanded construction for Gyeongseong Waterworks in March 1932.

The construction presumed to be the first to use reinforced concrete floor girders in Korea is the 'Main Building of Chosen Government-General' which was demolished in 1995. The construction of this building commenced in June 1916 and was completed in October 1926. The reinforced concrete girders were seemingly constructed in a composite way with floors during the construction for the upper structures in September 1918. Although the main bars were thick in diameter in the case of placement bars, the capacity of steel bars from the volume of girders was remarkably small because the quality of steel bars was relatively poor. Based on bar placement diagrams for girders at that time, stirrups were not used, unlike those in 'Seoul Station' (Historic Relic No. 284, the Main Building of the former Gyeongseong Station) and the bent-up bars in the Kahn type\(^9\) were replaced with thin thorn steel cores attached to the middle of angled steel bars as the main bar\(^2\) as shown in Fig.7, and 8.

The following descriptions are written in 'How to Assemble Steel Bars to Girders'\(^\text{21}\) with "Cautions on Reinforced Concrete Constructions in the Kahn Type" which was published at the time of construction. "The gradient of steel bars in the Kahn type, which is smaller than about 2 inches at a distance between the bottom of the girder frame and the center of steel bars, shall be bent at 45 degrees or at an angle described in the detail drawings, and the concrete placement shall be decided after reviews to see if both ends are sufficiently supported by columns, girders or walls when steel bars are arranged. If any connecting bars are applied to the upper section, they shall be accurately assembled and bent to the nearest point to the finished floor as shown in drawings as much as possible to gain the maximum durability… When wooden or steel pieces are inserted into concrete, they shall be settled down a little on the upper side from the floor bottom as they are bent with a slope from steel bars on girders after major steel bars are aligned."

We can see an example of reinforced concrete floor girders specifically in the flat roof floor in the left wing of 'Seoul Station', the construction of which began on 1 June 1922 and was completed on 30 September 1925, among the existing examples of modern architecture. The girder length is 13.5m with distances between girders of 2-4m, while girders in the long span are installed in a relatively tight manner in one direction. Considering the size of girders, their width and height is 460×850mm and main bars consist of round steel bars of 25mm diameter with stirrups of 9mm diameter aligned at a 200mm distance. Peculiarly, 10 of the main bars are aligned in 2 steps only on the bottom of the girders\(^2\).

'Seoul City Hall Building' (office building of the former Gyeongseong Department, Registered Cultural Heritage No. 52), the construction of which
commenced in March 1924 and was completed in September 1926), shows a structural design of reinforced concrete very similar to the present design. Gyeongseong also adopted the strong reinforced concrete structure following the Great Kanto Earthquake in August 1923. Considering the layout of steel bars used at the time of new construction, vertical stirrups and bent-up steel bars were used for shear reinforcement in the Hennebique type. Steel bars were additionally aligned with the upper joints of columns. However, these connecting steel bars were unable to deliver loads sufficiently as they were only connected from the top of columns on the lower floor to the bottom of columns on the upper floor.

4. Composite Action in Reinforced Concrete Construction

Reinforced concrete is a combination of steel and concrete, which can be characterized by the composite action of characteristics in materials or installations. Forces such as bending moments of the floor can be delivered to girders and then to columns as the reinforced concrete is continuous throughout all the structural members. In order for reinforced concrete to act as a single material, rather than two separate construction materials, the composite action of reinforced concrete must be achieved in the placement of steel bars or concrete.

The placement of steel bars in the reinforced concrete started with the adoption of the T-type beam two way beam slab. With this configuration, beams were able to run in two directions instead of one and the distribution of stress became more complicated. If a concentrated load is applied at any given point on the beams, the floor adjacent to the compressed fibers of a beam acts as the compression flange of the beam thereby increasing the strength of the beam and this area supporting the compression is increased when the bending deformation occurs due to the applied load as the physical movement of beam and slab occurs together in a uniform way after the concrete cures.

Regarding this matter, Misao Ushio reported "Regarding the Neutral Axis on Beams in the Reinforced Concrete and T-type Beam Sections" in No. 2 of Volume 1 (p. 23, 25 July 1922) in 'Chosen and Architecture', the organizational journal of the Chosen Architecture Association. Joist beams secure the strength in a perimeter beam, although we can see two way beams in the main building of the Defense Security Command, which was completed in 1932. Besides, there exist 31 cases of reinforced concrete buildings at this time as of December 2008, which have been designated as the cultural heritage of modern architecture. (Table 1.)

The time for the introduction of reinforced concrete floor girders and columns in a uniform way with floors was related to the time of introduction of moldings (temporary form works, shaping form works). Moldings made from supports with blocking plates cannot be skipped when any spherical body is made...
with the influx of concrete. They are equivalent to casts when any cast-iron product is made. When cast at the site, strength, workability and constructability is required. Steel moldings were used in the construction of the "Gawasaki Factory of Asano Cement" (completed in 1916) in Japan dating from 1914. Although these steel moldings lacked an engineering method that would enable them to be distributed widely, moldings with blocking plates in a wooden floor frame were used in the "Koyama Factory of Fuji Spinnery" in

| Item | Name | Former Use | Location | Year | Area (m²) | Structure | BF/ GF | Remarks |
|------|------|------------|----------|------|-----------|-----------|-------|---------|
| Monument | 49 | Modern History Center | Business | 24-2, Dongdaemun-dong 2-ga, Jung-gu, Seoul | 1920- | 1,380 | RC | 0/3 | Busan Branch of the Former Orient Colonization Company Completed in Sep. 1929(*) Repair history is arranged. |
| Historic Relic | 284 | Seoul Station | Sales | 122, Bongnae-dong 2-ga, Jung-gu, Seoul | 1925 | 8,574 | Stone, Concrete | ½ | Partial RC |
| Registered | 52 | Seoul City Hall Building | Business | 1-31, Taepyeong-ro, Jung-gu, Seoul | 1936 | 6,783 | RC, Stone | ¼ | Steel frame and reinforced concrete structure is applied. Under repair as of September 2010 |
| Registered | 237 | Former Supreme Court Building | Business | 37, Seosomun-dong, Jung-gu, Seoul | 1928 | 6,164 | RC | 1/3 | 13,433m² as of now, change of use to an art gallery |
| Registered | 1 | Building of Korea Electric Power Corporation in Namdaemun-ro | Business | 5, Namdaemun-ro 2-ga, Jung-gu, Seoul | 1928 | 5,957 | RC | 1/5 | |
| Historic Relic | 278 | Former Main Building of Seoul National Univ. | Education | 1-130, Dongdaemun-dong, Jongno-gu, Seoul | 1931 | 1,626 | RC, Masonry | 1/3 | Changed to offices |
| Tangible | 49 | Daegu Branch of Korea Industrial Bank | Business | 33, Pojeong-dong, Jung-gu, Daegu | 1931 | 1,971 | RC | ½ | Undergoing change to a museum |
| Registered | 375 | Main Building of Defense Security Command | Medical | 165, Seogyeong-dong, Jongno-gu, Seoul | 1932 | 9/3 | RC | Annex medical center for former Gyoseongseo Medical College |
| Registered | 329 | Central Busan Branch of Korea Electric Power Corporation | Business | 23-1, Toseong-dong 1-ga, Seo-gu, Busan | 1935 | 2,667 | RC | Ⅳ | Building for former Namseong Electric Ind. |
| Registered | 76 | Pajun Jangdan-myoneon Office | Business | 515, Dongjak-gu, Jung-dong, Seoul | 1933 | 216 | RC | 0/1 | Listed |
| Registered | 11 | Former National Assembly Building in Taepyeong-ro | Business | 60-1, Taepyeong-ro 1-ga, Jung-gu, Seoul | 1935 | 5,676 | RC | 0/3 | Top 9th floor |
| Registered | 17 | Main building and others in Gwangju Seokjojeon Elementary School | Education | 14-1, Seokyo-dong, Gwangju | 1935 | 2,203 | RC | 0/2 | Gymnasium (1930), Annex Center (1943) |
| Monument | 51 | Busan Weather Center | Business | 9-305, Dongdaemun-dong 1-ga, Jung-gu, Seoul | 1936 | 644 | RC | Ⅳ | Repair history is arranged. |
| Registered | 22 | Building of Cheolwon Labor Political Party | Cultural gathering | 1-2 and others, Gangjeong-gu, Cheongwon, Gwangju | 1936 | 1,884 | RC | 0/3 | 1946, Repair history is arranged. |
| Historic Relic | 281 | Main Building of Jungang High School | Education | 1, Gye-dong, Jongno-gu, Seoul | 1937 | 2,409 | RC | 0/2 | |
| Registered | 19 | Former Daejeon Branch of Korea Industrial Bank | Business | 92-1, Jung-dong, Gwangju, Daejeon | 1937 | 1,291 | RC | ½ | Shop (glass shop) |
| Historic Relic | 465 | Gyeonggyo of Seoul | Residence | 108-1, Pyeong-dong, Jung-gu, Seoul | 1938 | 945 | RC, Stone | Ⅴ | Medical facilities |
| Registered | 2 | Former Gyeonggi High School | Business | 2, Hwa-dong, Jung-gu, Seoul | 1938 | 7,479 | RC | 0/3 | Changed to a library |
| Registerd | 81 | Western Building of Seokjojeon in Deoksugung Palace | Cultural gathering | 5-1, Jeong-dong, Jung-gu, Seoul | 1938 | 3,403 | RC | 1/3 | Museum |
| Registered | 238 | Former American Cultural Center | Business | 63-1, Eulji-ro 1-ga, Jung-gu, Seoul | 1938 | 4,290 | RC | Ⅳ | Changed to offices |
| Registered | 269 | Car Inspection Shed in Cheonryangni Station | Factory & Warehouse | 587-1 and others, Jeonjung-gu 2-dong, Donghae-sun, Seoul | 1938 | 5,796 | RC | 0/1 | |
| Registered | 13 | Main Building of Seoul Industrial High School in Dongdaemun-dong | Education | 390-5, Dongdaemun-gu, Seoul | 1939 | 4,239 | RC | 0/3 | |
| Registered | 402 | Former Annex Building of Shinan Daily | Business | 1-28, Gyerim-dong, Jung-gu, Seoul | 1930- | 2,000 | RC | Ⅳ | Expanded construction to 3rd and 4th floor in 1975 |
| Registered | 12 | Former Seoul Industrial College in Goungseung-dong | Education | 172, Gongneung-dong, Nowon-gu, Seoul | 1942 | 10,193 | RC | 1/3 | Used as Dasan Center and Creativity Study Center |
| Registered | 149 | Former Tongyeong County Office | Business | 28, Dongcheon-dong, Tongyeong-si, Gyeongnam | 1943 | 1,175 | RC | 0/2 | Changed to a music center and local facility |
| Registered | 20 | Daejeon Branch of Chosun Bank | Business | 51-3, Dong-gu, Daejeon | 1951 | 1,171 | RC | 0/2 | Bank |
| Registered | 155 | Former Jeju Provincial Office | Business | 1176-1, Ido 2-dong, Jeju City | 1952 | 1,490 | RC | 0/2 | |
| Registered | 166 | Former Taebaek Registry Office | Business | 69B, Jangseong-dong, Taebaek-si, Gangwon | 1956 | 1,171 | RC | 0/2 | Under repair as of 2010 |
| Registered | 230 | Seoul Hyehwa-dong Catholic Church | Cultural gathering | 58-2, Hyehwa-dong, Jongno-gu, Seoul | 1960 | 3,132 | RC | Ⅴ | |
| Registered | 92 | Former Auditorium of the National Assembly in Uiwang-gu | Business | San 1-5, Seokgwan-dong, Seongbuk-gu, Seoul | 1962 | 466 | RC | 0/2 | Conference room 1972 (234m²) |
| Registered | 107 | Chuncheon Cultural Center | Business | 107, Okechon-dong, Chuncheon-si, Gangwon | 1964 | 544 | RC | ½ | 1959 |
1917 (completed in 1924), which was designed based on hints from those moldings, were good regarding the feasibility of construction, and were registered as the company's new design for practical use[25].

The use of moldings was mainly introduced in Korea during the construction of the Chosen Government-General. "Cautions Concerning Reinforced Concrete Construction in the Kahn Type" describes details on the construction of moldings and temporary facilities, which was issued by the Department of Civil Engineering in the Chosen Government-General. In addition, detail drawings for the reinforced concrete moldings[26] for new construction in the Western inner building of Changdeok Palace seem to have been prepared at that time as well, although it was not constructed.

5. Conclusions

The introduction of concrete slabs for multiple story buildings in the early 20th century in Korea led to the following progression, which can be identified from the historical record: the introduction of reinforced concrete floors with steel beams, steel mesh and bars, and the composite action of reinforced concrete floors, girders and columns.

Concrete floor construction with brick arches was superseded by the placement of concrete with steel beams and corrugated steel plates in the early 1900s as shown in the Seokjojeon (Historic Relic No. 124) in Deoksu Palace, while the fireproofing was subsequently improved by inserting steel bars into the concrete floor as a reinforcing material in the Chosen Hotel, the construction of which was completed in 1914.

The separation between reinforced concrete floors and girders changed into the composite action of reinforced concrete combined with floors and reinforced concrete girders with the use of bent-up bars in the Kahn type, which are the pre-fabricated materials used in the construction of the Chosen Government-General in 1918. The approach to structural design with reinforced concrete in a uniform way with columns, floors and girders, could be carried out with the placement of Hennebique type bars using vertical stirrups in addition to bent-up bars with shear reinforcement in the new construction of the main office building of the train station and government buildings in Gyeongseong in the late 1920s.

Notes

1) Korean Institute of Architects, Modern Architecture in Korea 1876-1990, p.258.
2) The first reinforced concrete structure was completed in 1903 and the architecture of reinforced concrete construction was completed in Japan starting with structures introduced in the late 1880s, and its distribution then began throughout the country. Starting with the introduction of concrete at the end of the 19th century, reinforced concrete construction was introduced for concrete floors with steel beams, civil and industrial structures in the early 20th century, and public buildings, and was distributed across the country in the middle of the 1920s in Korea.

3) Architectural Institute of Korea, Research and Investigation Reports for the Seokjojeon Building (Eastern Building) in Deoksu Palace, January 1989 / Note) Dohwa Structural Engineer Office, Report for Structure and Safety in Precision for the Seokjojeon in Deoksu Palace, December 2003.
4) Architectural Institute of Korea, rewritten in accordance with Research and Investigation Reports for the Seokjojeon Building (Eastern Building) in Deoksu Palace, January 1989.
5) Constructions for the dismantlement, transfer and restoration were carried out on 1059-13, Namhyeong-dong, Gwanak-gu as of March 1980 to August 1982 with the construction of a new building for the Head Office of the Korea Commercial Bank after it was designated as a historical relic on 12 November 1977.
6) Design drawings for the dismantlement construction of cultural heritage in Hoohyong-dong, Samsung Architect Office, October 1978 / Photo Albums of the Former Belgium Consulate Building, Samsung Architect Office, 1978-1980.
7) The modified building as part of increased construction through restoration work in January 1958 was restored near the original building in 1989, and it is now used as the Monetary and Financial Museum through remodeling in 2001.
8) For restoration of the Bank of Korea, the then Governor Choi Chang-rak requested the Chairman of the Bond and Credit Bank of Japan, Tatsuo Katsuta, to bring them into our country in 1985. There are 2 copies of design drawings for the main building of the Bank of Korea, 2 copies of the progress concerning construction of the main building of the Bank of Korea, reports for the construction of the Bank of Korea, and other materials.
9) Daerim Industrial Co., Ltd., Reports of the Repair of the Main Building of the Bank of Korea, 1989.
10) Design of the Chosen Hotel was assigned to the German architect Georg de Lalande (1872-1914), who was active in Shanghai and Tokyo among others after his graduation from Berlin Industrial University.
11) Byoung Ok, Jeon., Hoon, Yl and Tai Young, Kim (2006) A Study on the Appearance and Structural System of Concrete Slab in the Early 20th Century, Journal of the Architectural Institute of Korea, March 2006, p.180.
12) "First Overview of Architectural Business", 1909, pp.131-132. For more details, refer to Soung Won, Kang., Jung Hyun, Hwang and Jin Kyoong, Kim (2008) Introduction and Development of Reinforced Concrete for Administrative Buildings in the First Half of the 20th Century, Journal of the Architectural Institute of Korea, July 2008, p.166.
13) Ministry of Construction and Transportation, 'Research on the Status of Bridges', April 2003.
14) Study on the History of Structural Technology with the Progress of Reinforced Concrete Construction in Japan, Takeyoshi Hori, 12 December 1981, p.87.
15) He was a pioneer in Western architecture in the Meiji era as a governmental officer under the consecutive election for public office, who resigned from the Industrial University (former university of the current Tokyo University), transferred to Cornell University in the US for overseas study, and then entered the Tokyo government. As the founder of structural methods using refined steel he used steel strips and rods to make masonry construction withstand earthquakes. Tsunami had distributed masonry constructions while suggesting the official supply of bricks and timbers as he was commissioned as an advisor to the company's construction office for Takijyu. Yoon Il-ju, History of 80 Years of Western Construction in Korea, Yajeong Cultural Company, 1986, p.93.
16) Study on the History of Structural Technology with the Progress of Reinforced Concrete Construction in Japan, Takeyoshi Hori, 12 December 1981, pp.87, 95.
17) Study on the History of Structural Technology with the Progress of Reinforced Concrete Construction in Japan, Takeyoshi Hori, 12 December 1981, p.77.
18) Quoted "Repair and Reinforcing Constructions for the Water Supply Museum" by Geumsung Architect Co., Ltd., 2006 again from Soung Won, Kang., Jung Hyun, Hwang and Jin Kyoon, Kim (2008) Introduction and Development of Reinforced Concrete for Administrative Buildings in the First Half of the 20th Century, Journal of the Architectural Institute of Korea, July 2008, p.167.

19) It is a type developed from the patent by the American Julius Kahn in 1903, of which the most important feature is the Kahn bar to withstand shearing power. The Kahn bar is manufactured by Trussed Concrete Steel Co., Ltd. in the U.S.

20) Reports for the Actual Measurement and Dismantlement of Former Chosen Government-General Buildings (First Part), 1997, p.441.

21) "Rules for Concrete Construction in the Kahn Bar Type", Civil Engineering Department of Chosen Government-General, 1917, pp.9-11.

22) Samwoo Structure Consultant, Safety Diagnosis in Precision for Former Seoul Station, 2008.

23) Sang Sik, Kim and Seong Hoon, Jeong (2009) Reinforced Concrete Technology and the Modernization of Korean Buildings, Journal of Korea Concrete Institute, May 2009, p.56.

24) Endo used it for the first time in the school building for the department of electric works of the Tokyo Commercial High School (construction was completed in March 1916). Study on the History of Structural Technology with the Progress of Reinforced Concrete Construction in Japan, p.95.

25) Part of the Production from Shimizu Construction for 200 Years, Cheongju Construction Co., Ltd., November 2003, p.98.

26) Collections of Modern Architectural Drawings, Library of Literature Collections in the Central Institute of Korean Studies, January 2009, pp.096-097.

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2) Study on the History of Structural Technology with the Progress of Reinforced Concrete Construction in Japan, Takeyoshi Hori, Paper for the Doctorate Degree in Tokyo University, 12 December 1981.

3) Sang Hoon, Kang and Woo Gab, Shim (2003) A Study on Reinforced Concrete Elementary School Buildings of 1930's, Journal of the Architectural Institute of Korea.

4) Sang Sik, Kim and Seong Hoon, Jeong (2009) Reinforced Concrete Technology and the Modernization of Korean Buildings, Journal of Korea Concrete Institute.

5) Soung Won, Kang., Jung Hyun, Hwang and Jin Kyoon, Kim (2008) Introduction and Development of Reinforced Concrete for Administrative Buildings in the First Half of the 20th Century, Journal of the Architectural Institute of Korea.

6) 200 Years of Shimizu Construction - Part of Construction, November 2003.

7) A Study on the Development History of Architectural Technology for the Past 100Years in Korea, Korea Science Foundation, 1990.

8) History of Modern Japanese Architecture, Teijiro Muramatsu, 1976, First Edition.

9) Structural Aspects of BUILDING CONSERVATION, Paul Beckmann and Robert Bowles, ELSEVIER, 2004 (Second Edition).

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