Title:	**Reform Measures of Korea's High-rise Buildings Construction Period**
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Subject:	Construction
Keywords:	Construction Project Management
Publication Date:	2004
Original Publication:	CTBUH 2004 Seoul Conference
Paper Type:	1. Book chapter/Part chapter 2. Journal paper 3. **Conference proceeding** 4. Unpublished conference paper 5. Magazine article 6. Unpublished

Reform Measures of Korea's High-rise Buildings Construction Period

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Abstract

The construction of high-rise buildings in Korea started in the early 1980s. However, considering the fact that the buildings practically appeared in the late 1990s to be sold for the purpose of residence, their history is quite short. Despite this, significant advancement has been achieved in construction technologies such as RC frame work and steel frame work. On the other hand, the time of finish work is still long compared to cases in other countries. It takes 14 to 18 months after the completion of frame work and it causes the delay of the overall construction period. The reasons for the delayed construction period are the lack of construction management technologies, and the wet floor heating panel work which is amid the progress of work and cut off from other works. Therefore, this study presents measures to overcome these adverse conditions and minimize time lags in order to reduce the construction period of high-rise buildings in Korea.

Keywords: high-rise building , Construction Management, time Lag

1. Introduction

Large amounts of financial resources, manpower, materials and equipment are needed when it comes to constructing high-rise buildings due to their gigantic sizes. These skyscrapers are usually located on limited sites in downtown areas with heavy traffic. Such conditions eventually reduce construction efficiency due to the rise in vertical load, wind load and vertical hoisting height. Therefore, in order for the construction of high-rise buildings to be successful, it is necessary to develop management technologies and key construction technologies or to acquire such technologies through others such as consultants.

In the construction of high-rise buildings, the repeated pattern is that one progress ends and the next progress follows. Therefore, the overall construction period is determined by the arrangement and management of construction cycles depending on the order of works and work zoning in each discipline. While Korea's key construction technologies are advanced, there is relatively much room for development for its management technologies which are deficient in many aspects and consequently the construction period is prolonged. For instance, in developed countries the steel frame work, through appropriate management of projects, is completed at the rate of 5 to 8 days per floor and the finish work in America usually ends 2 to 8 months after the completion of the skeleton work. In Korea, on the other hand, the RC frame work and finish work which need management technologies still consumes lots of construction period. It is, therefore, necessary to analyze the reasons for long construction periods of the RC frame work and finish work and find possible solutions. In this study, cases of high-rise buildings in Korea and other countries are compared and progress schedules of Korea's representative residential skyscrapers are analyzed to find the causes in detail for the prolonged construction periods and present measures to solve them.

The study proceeds as seen in Chart 1 below.

Analysis of high-rise buildings of home and abroad

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Comparison of construction periods of high-rise buildings

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Analysis of reasons for prolonged construction periods

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Possible solutions and expected results

< Chart 1. Process of Study>

2. Comparison of Construction Period of High- rise Buildings and Analysis of Reasons for Prolonged

3.Construction Period

When overall construction periods of high-rise buildings are compared, 10 to 14 days per floor were taken in America in constructing steel frame buildings. Regarding the construction period of Korea' s high-rise buildings, it took about 20.5 days per floor

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when the Korea World Trade Center, a steel frame building, was built, but the per-floor construction period of the Tower Palace III, a steel-frame residential building, was 14.7 days, 5.8 days less per floor than that of the Korea World Trade Center.

Table 1 Comparison of Construction Period of High-rise Buildings [1)]

PROJECT NAME	Total floor Area (m2)	Number of Floor		Structural Format	Construction Period					Cycle per Floor
		Base-ment	Ground Floor		Overall Construction Period (months)	Earth work (months)	Skeleton Work		Finish Work after Skeleton (months)	(Day /Floor)
							Construction period (months)	(Day/ Floor)		
USA										
Cadil/Fair, Chicago	126,158	B6	62	R.C	27	5	19	8.3	3	11.9
Trump Tower	81,369	B2	70	RC	37	7	17.5	7.29	12.5	15.4
Republic Bank, Houston	136,317	B4	56	S.R.C	21	8	11	5.5	2	10.5
Dravo Tower, Pittsberg	159,880	B2	56	S.R.C	22	6	14	7.24	2	11.4
U.S Steel	272,647	B3	64	S.R.C	30	12	13	5.82	5	13.4
Korea										
Korea World Trade Center	107,708	B2	55	S.R.C	39	9	16	8.42	14	20.5
63 Building	160,084	B3	60	S.R.C	63	25	20	9.52	18	30.1
Kolon Tripolis	321,731	B3	37	S.R.C	38	5.5	17	12.8	14.5	28.5
Tower Palace Ⅰ	457,780	B5	66	S.R.C	38	6	18	7.61	14	15.8
Tower Palace Ⅱ	296,650	B6	55	S.R.C	39	6	16	7.38	17	19.2
Tower Palace Ⅲ	223,146	B6	69	S.R.C	37	4	16	6.4	17	14.8
Galleria Palace	265,796	B5	46	R.C	42	6	22	12.94	14	24.7
Acrovista	258,304	B6	37	R.C	42	10	21	14.6	13	29.3
Trump World I	78,666	B5	41	R.C	39	8	21	13.7	11	25.4

Table 1 above compares several countries in the number of days taken in each construction phase. In the civil work, its construction periods vary depending on site conditions such as groundwater levels, but in a mere comparison of the numbers in the table, constructing 2 to 3 basements in Korea in the 1980s took over 9 months and then the time in the 2000s was cut to 4.5 to 6 months for building 5 to 6 basements which is similar to the time taken in America due to the advancement of equipment and construction technologies. Concerning the steel frame work, it took 5 to 8 days per floor in America. In Korea it took more than 8 days in the 1980s and the time was reduced to 6.4 days per floor when the Tower Palace III was built, which is almost the same as the time spent in America.

However, Korea is far behind America in the construction period of the RC frame work and finish work.

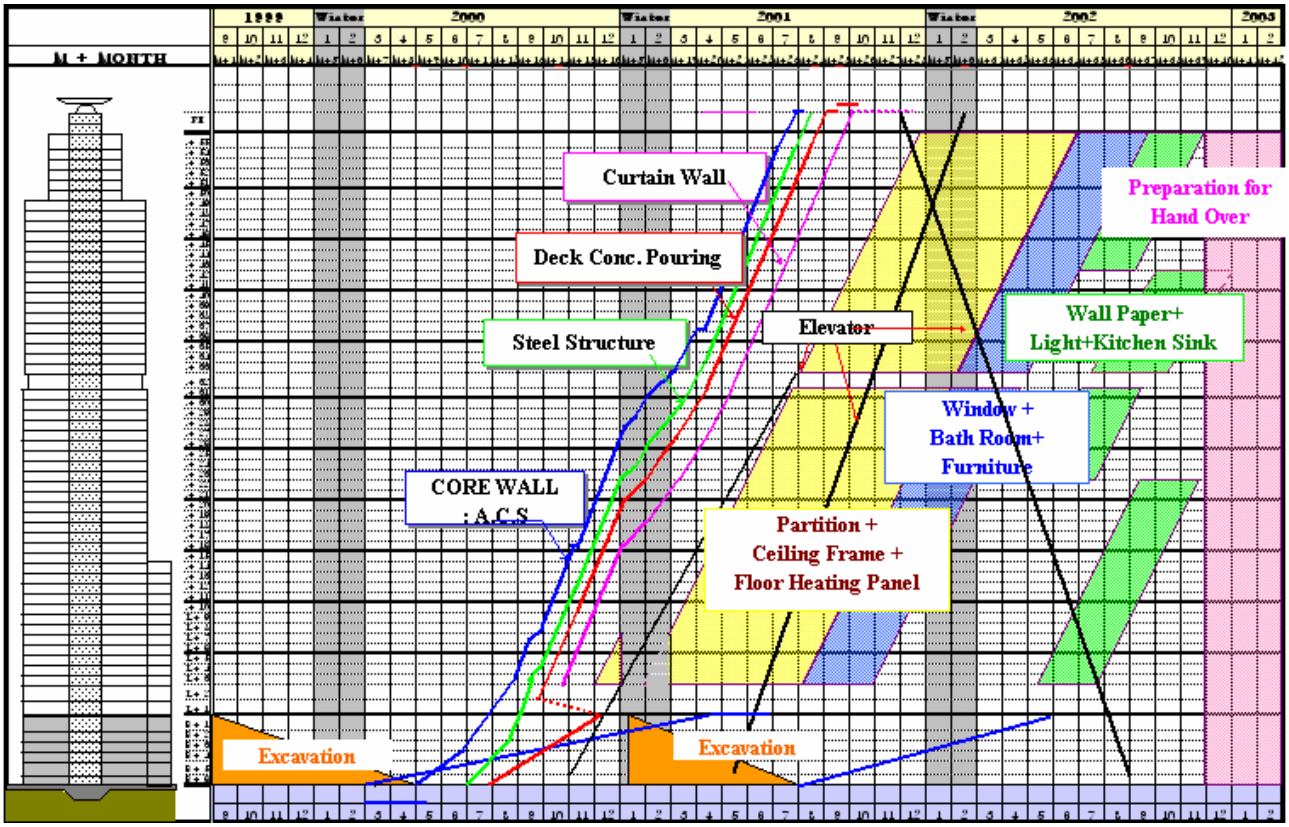
As seen in the above table, the periods of the RC frame work and finish work are longer in Korea than in America. The characteristics of these works are that they need a lot of manpower, there are good chances of delay of works due to interferences of related progresses with each other and they affect the construction period depending on the sub-contractors' cooperation and consideration of Constructability in the design stage. When relevant disciplines such as the RC frame work or finish work and management points increase, the construction period also increases due to difficulty in managing the construction.

High-rise buildings constructed abroad are typically office buildings for which the finish work is simple, but in Korea most of the latest high-rise buildings are for residence. Especially Korea's residential buildings have many partitions among households and rooms and are equipped with kitchen ware, built-in furniture and home electric appliances. As a consequence, the reality of constructing many residential high-rise buildings is one of the reasons that increase the construction period in Korea.

Korea's construction system which separates the design and construction makes the participation of construction experts in the design phase difficult, so the constructability consideration in design is not easy and shop drawings are drawn up by construction

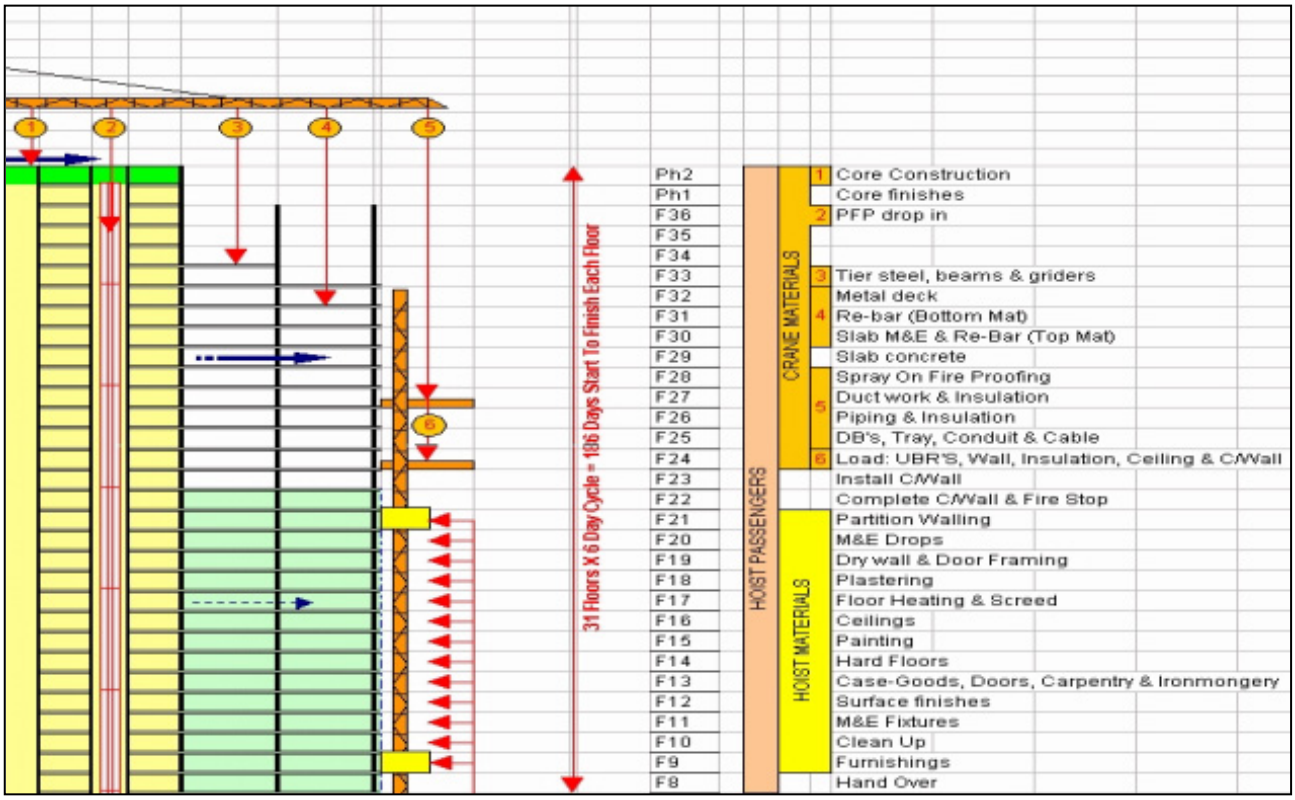
1) HanmiParsons Technical Data Collection of High-rise Buildings

engineers to reflect site conditions in many cases and consequently there are frequent design changes.
Deficient systematization of sub-contractors hampers their specialization and cooperation among relevant companies. It causes the discontinuity of works and eventually increases the construction period because the subdivision of work zoning and grouping of similar disciplines are difficult.
The floor heating panel work, one of Korea's traditional floor finish, is a wet work , so it can not be carried out in parallel with other disciplines for a certain period of time. Also, it has many progresses such as the laying of floor heating pipes on heat insulating layers, water pressure tests of the pipes, construction of heat accumulation layers, plaster work and floor paper work and as a result it consumes a long construction period.



<Chart 2> Progress Schedule of Korea's Residential Super-high rise Buildings

Chart 2 which was actually applied in the construction of a residential building of 55 stories and 6 basements in Seoul, is a typical progress chart showing the progress status of steel frame residential buildings which are commonly built these days in Korea. The chart shows that the steel frame work took about 8 days per floor which is similar to cases in other countries, but there was the 17-month period for the finish work after the frame work completion, a big period difference compared to foreign cases. According to the analysis of the reasons for the delay in the construction period of the above progress chart, the finish work started 3 months after the completion of the skeleton work and the time of partition, ceiling frame and floor heating panel works was 6 months. Also, there were additional 2.5 months from the start and end of installing the windows, 2.5 months of the final finish work including the wall papering and 3 more months of the preparation for hand over. Besides, since the start of the partition work was postponed due to the delay in the making of water-stopping floors after the completion of the frame work and each sub-contractor did not carry out its work in sequence, the construction period increased. In order to construct this residential building, the wet floor heating panel method was adopted. This makes the work continuity impossible and moreover, since each household was equipped with kitchenware, built-in furniture and some home electric appliances, there was an increase in the construction period. Due to the long period of the finish work, some disciplines were already completed one year ahead of its completion. The disciplines which ended earlier needed finish touches and had to be checked for damage. That is why the preparation for hand over took 3 months.



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<Chart 3 >: Example of Construction Cycle and Hoisting Plan

Chart 3 is a plan of progress of Korean residential buildings prepared by a foreign CM manager when he participated in the construction of a steel frame building of 37 stories and 3 basements in the suburbs of Seoul. The construction period of the frame work and finish work was 186 days with 6 days taken for each floor of 31 typical floors. The continuity of works was possible due to short time lags among disciplines and the number of progress cycles was reduced due to the integration of similar disciplines. In the chart, there were 21 progress cycles after the slab concrete pouring until the hand-over, and if the finish work is calculated by a 6-day cycle per floor, it is expected to be 121 days. The 121-day time of the finish work which is similar to foreign cases demonstrates that the construction time of Korean residential buildings can also decrease to the level of foreign cases. Since hoisting loads have a great impact on the maintenance of each discipline's progress cycle, efforts were made to reduce the hoisting loads by placing materials with tower cranes on designated places. However, when this progress cycle plan prepared by a foreign CM manager was actually applied, the finish work period after the completion of frame work was 14.5 months which is similar to those of other projects. This means that reduction in the construction period of Korean high-rise buildings might be difficult to make without breakthroughs in construction methods and development of management technologies.

4. Reasons for Delay of Construction Period

There are various reasons which cause the delay of the construction period and each item of the reasons works in complexity, interrelated with others. The following are the 7 major reasons.

1) Lack of experience
Since there are only a few cases of constructing high-rise buildings in Korea, the concept of project management is not widely recognized in the country. Also, each progress is loosely connected with others and it causes a great deal of lost time in the performance of relevant works because major decisions to be made and design documents to be reviewed in advance were done or changed amid the construction.

2) Separation of construction and design
In Korea, construction companys are prohibited to design, so construction engineers can hardly participate in the design phase and most designers do not have sufficient experience in construction. Consequently, the constructability consideration in design is not easy and the construction period ends up in frequent delay. Moreover, integrated design management is difficult since most design companies are small and are engaged in a separate area such as architectural, mechanical, electric and fire fighting.

3) Problems in application of Fast track method
In order to achieve the construction period saving, Fast track method should be proceeded by a well-experienced designer, while forecasting the later design. However, since most designers do not have enough experience, their designs are often not suitable for site conditions.

4) Lack of specialization in construction management
In the construction of high-rise buildings, the frame work is performed according to a certain cycle, so its process is easily checked and clearly managed. In Korea, key construction technologies such as ACS (Auto Climbing Form) were also adopted and there is little difference in frame work methods and construction periods compared to cases in Europe or America. Regarding the time of finish work, it varies a lot depending on the project management such as constructability consideration of design documents, adjustment of order of disciplines, cooperation of each discipline with others, appropriate input of workers and methods to group relevant works. The general construction management of the finish work is deficient, and it causes the construction period to increase.

5) Problems due to wet work method
The wet floor heating panel work hinders the continuous work process of back-to-back disciplines and the work itself consumes a lot of time.

6) Scarcity of competitive sub-contractors
If the bidding system which chooses sub-contractors who offer low prices is used, it can lead to selection of companies with deficient technologies. In this case, defective works can be made due to the input of low-quality workers and lack of cooperation among relevant disciplines. It will eventually prolong the construction period.
7) Lack of preparation in advance
In Korea, there are not many cases of constructing high-rise buildings and most of them were carried out before the strict construction performance plans were made. It consequently caused conflicts among disciplines and prevented sub-contractors from forming smooth relations with each other.

5. Measures to Reduce Construction Period

1) Adoption of general project management concept
There should be a separate team for the overall management of the high-rise building project in order to make sure that it will adopt and carry out the general project management ranging from decision making to design management to project schedule management. Regarding the progress management, there is a tendency that only the progress management in the course of construction is considered. However, the general management including decision making management, design management, management of sub-contractors and management of ordering materials should be implemented to promote smooth connection of back-to-back disciplines and proceed the construction progress without any time lag.
When there are delays in placing orders or making decisions, the construction period can also be delayed. Therefore, the procurement schedule should be incorporated into the project master schedule in advance to guarantee the execution of the general management and it can prevent the delay of procurement schedule from causing the delay in the construction period.

2) Constructabililty consideration of design.
In order to boost the technical development of the Korean construction industries, it is necessary to find solutions to perform the design and construction simultaneously. Also, architectural, structural and electrical experts and construction engineers should participate from the schematic design phase to study the constructability of the design when it is prepared.
Constructability of core areas is a key determinant to the construction period of the frame work, so the constructability should be considered by making construction engineers participate from the structural design stage. Another key determinant to the construction period is the constructability of finish work details. Therefore, constructability of the design should be studied when it is drawn up. Also, during the construction, a shop drawing team should reside at the site and prepare a shop drawing suitable for site conditions to improve its constructability.

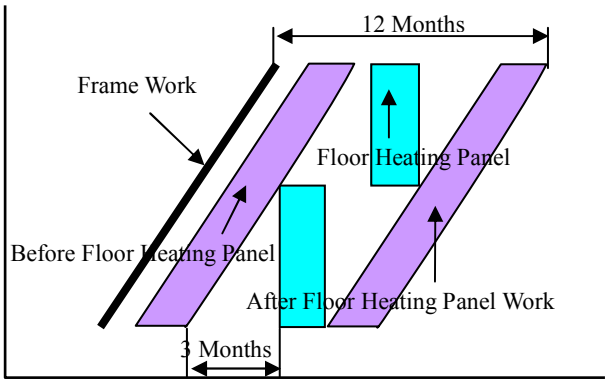
3) Enhancement of design organization
Well-experienced designers are required for the smooth performance of Fast track design method and a site design team should be well organized to take site conditions into account in the design process. Also, relevant experts should participate in each phase if necessary.

4) Acquisition of construction management technology
Construction management technologies should be acquired. They include adjustment of order of disciplines, measures to group relevant works, appropriate maintenance of work zoning and progress cycle, labor management and materials management. Without the acquisition of them, there will be no good possibilities of preparing and executing accurate construction programs and making projections.
Reduction of the construction period can be achieved if the maintenance of continuity of works is made by studying interference feasibility among disciplines in advance and controlling workers and order of works properly and the time lag of back-to-back works is minimized by subdividing work zones and integrating similar disciplines.

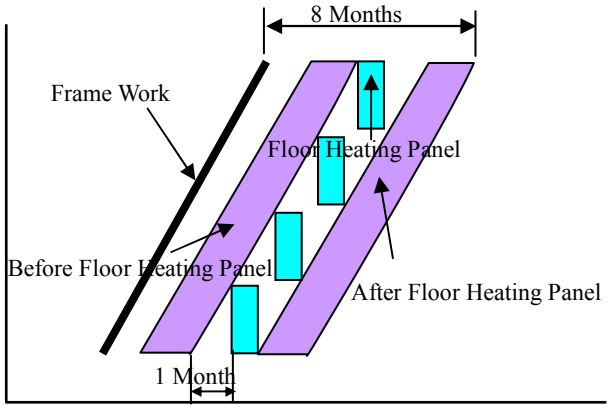
5) Dry floor heating panel work and modular coordination

Dry work method of floor heating panels should be applied and its modular coordination is required to reduce its interference with other disciplines and make the continuity of works possible.

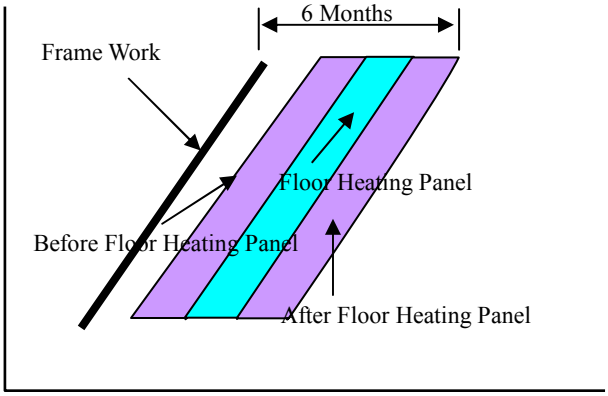
The floor heating panel work, one of the construction methods which originated from the Korean traditional way of living on the floor, is included in the construction of Korean residential buildings. Since the wet work method of floor heating panels is usually applied, there are many disciplines incorporated in it. In particular, other works usually should stop, when porous concrete for insulation is poured, floor heating pipes are arranged, their water pressure is tested, mortar is poured and cured on the floor. In addition, the work itself consumes a lot of time. Therefore, there will be no significant reduction in the progress of work without measures to improve this construction method.



<Chart 4 >: General Work Zone Division



<Chart 5> : Smaller Work Zone Division



<Chart 6>: Adoption of Dry Floor Heating Panel Work and its Standardization

Chart 4 shows the typical construction progress and period of Korea's high-rise buildings in which about 30 households are constructed at the same time. It increases the time lag, prevents the works from continuing and eventually prolongs the construction period. In Chart 5, construction time is reduced when subdividing the work zone into 10 households because it cuts short the time lag. However, the construction time is still delayed due to the wet floor heating panel work which can not be performed with other works simultaneously. Therefore, as in Chart 6, dry floor heating panel work method should be adopted and its standardization should also be made. Currently, the use of dry floor heating panels is limited due to their high prices, but when they are widely used they can get price-competitive.

6) Systematization of sub-contractors

Without full cooperation of sub-contractors, it is difficult to reduce the construction period which is frequently determined by sub-contractors' ability such as their personnel and materials. In order to mobilize appropriate number of personnel and procure sufficient materials from sub-contractors, mutual confidence with them should be formed by systematizing sub-contractors. In this way, construction time saving is guaranteed as highly skilled personnel of sub-contractors are secured and their specialization is possible.

7) Thorough preparation of construction method statements

Temporary works and hoisting planning have a great impact on the progress of constructing high-rise buildings. Korean technologies are not capable of accurately calculating operating cycles and capacities of vertical carrying tower cranes and lifts and it affects the overall construction time and costs. Therefore, temporary work experts should plan the capacities, locations and quantities of temporary equipment along with the flow planning on the job site. They also have to closely study the location of stock yards and work flow for each material and to determine the order of hoisting, type of materials, time of hoisting, hoisting methods and time of dismantling hoisting equipment.
Efforts to reduce vertical hoisting loads by lift cars should be made. Particularly when the vertical and horizontal hoisting and movement of materials are planned, each material should be hoisted and placed as much as possible where it is used after all of the slab concrete is poured in order to reduce hoisting loads by hoists. Especially measures to use elevators early for the actual construction affect vertical hoisting very much. When temporary works are planned, it should be done with the cooperation of equipment experts and construction experts and in-depth study needs to be made on tower cranes, hoists and temporary access platforms which have significant influence on the construction period and costs. In addition, the performance of the finish work should be planned thoroughly ahead of the time it is to be performed not to mention the RC frame work, steel frame work and curtain wall work and the progress status should be fixed and added in comparison with the original construction plan.

6. Conclusion

In order to reduce the construction period of high-rise buildings in Korea, there should be a separate team which will take full responsibility for managing the construction project and it will adopt and execute the general project management ranging from decision making to design management to project schedule management. Construction engineers should participate in the design phase to assess the constructability of the design. It is also necessary to secure designers with ability to do Fast track design and to enhance the site design team. One of the weakest points in the Korean construction industries is the construction management technology such as progress management, labor management and materials management. Therefore, attempts should be made to develop and advance it to make the continuity of works possible by a certain cycle and save the time of the construction cycle. The wet floor heating panel work makes the continuity of works among back-to-back disciplines impossible and its performance itself needs a lot of time. Therefore, it should be replaced by the dry floor heating panel work method and its modular coordination will have to be made to reduce its interference with other disciplines and enable the continuity of works. Also, management of sub-contractors should be systemized in order to form mutual confidence with sub-contractors, secure their highly skilled personnel and to promote their specialization. With these efforts , professionals then should produce efficient construction programs and construction management and reduce the construction period.

Reference

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2) ① HanmiParsons Technical Data Collection of High-rise Buildings(2003)