

Construction Period Analysis of Composite Method Using Hollow-PC Column

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Abstract—Recently, as the problems such as lack of construction personnel and reduction of construction duration due to the increasing labor cost and aging labor personnel, the researches on the PC method have been reactivated. However, the purpose of most of these researches is to develop and structurally interpret the PC method, and there are not that many researches conducted from the perspective of the construction management. Accordingly, this research examines the composite method using hollow-PC column (hereinafter referred to as “HPC composite method”) from the perspective of the construction management, and the purpose is to analyze the construction period of the HPC composite method. The differences per method are analyzed through the specific comparison of the construction procedures as well as the in-depth interview with the expert, and the construction period of the HPC composite method is analyzed based on the analyzed differences. It seems that the construction in the HPC composite method, the construction period seems to vary depending on the column segment status. It seems that the construction period can be more effectively shortened through increasing the number of segmented columns. However, since the construction period relating to work types other than the PC method is not considered in this research, it is necessary to analyze the construction period relating to the overall construction process in the future.

Keywords—joint; hollow precast concrete column; head splice sleeve; PC composite method; half-PC slab method

I. INTRODUCTION

A. Study Background and Purpose

In Korea, as the precast concrete method (hereinafter referred to as “PC method”) has been indicating problems such as lack of construction personnel and reduction of construction duration due to the increasing labor cost and aging labor personnel, the related researches have been reactivated [1]. In comparison to the preexisting reinforced concrete (hereinafter referred to as “RC method”), the PC method not only indicates difficulties in securing the

integrity of the joint between the members, but also is vulnerable to the lateral force. In addition, due to the member transport cost as well as the lifting equipment use, it is difficult to reduce the construction cost [2]. Currently, a number of new methods are being developed to supplement such problems. The composite method using hollow precast concrete column (hereinafter referred to as “HPC composite method”) is a method developed to supplement the weaknesses of the preexisting PC method. Some of the precedent researches on the HPC composite method are: a research on compressive behavior of HPC column [3], a research on structural performance of beam-column joint using HPC column [2], a research on structural performance of head splice sleeve [4], a research on performance evaluation through head splice sleeve-applied column [5], and a research on seismic performance of HPC column [6].

However, the purpose of most of the preexisting researches is to structurally interpret the member, and there are not that many researches conducted from the perspective of the construction management. Accordingly, this research examines the HPC composite method from the perspective of the construction management, and the purpose is to analyze the construction period of the HPC composite method. It is expected that the analysis of the construction period of the HPC composite method can be used as the reference data for applying the HPC composite method to the actual field in the future.

B. Study Scope and Method

In this research, the HPC composite method currently being developed is selected as the research subject, and the purpose is to analyze the construction period of the HPC composite method. The application scope of the HPC composite method is limited to warehouse facilities such as distribution centers, and the half-PC slab method which serves as the basis for the PC composite method is selected as the comparison subject.

To described the research method, initially, the 12 copies of data such as design drawing and construction plan are

analyzed, and the specifics of the HPS composite method-based joint are constructed. In addition, the construction procedures between the half-PC slab method and the HPC composite method are compared, and the differences per construction are analyzed through the in-depth interview conducted with the PC method expert. Based on the result acquired through analyzing the differences, the construction period is analyzed through setting up a hypothesis that the HPC composite method is applied to the case to which the half-PC slab method is applied.

II. ANALYSIS OF CONSTRUCTION PROCEDURES OF HPC COMPOSITE METHOD

A. Development of HPC Composite Method

The HPC composite method is a structural system which applies the strengths of the RC/PC methods. The HPC column and head splice are used to enhance the joint-related construction performance and integrity. The HPC column is a composite HPC column composed of hollow precast concrete and cast-in-place [2]. The HPC column is manufactured through placing the rebar into the specially manufactured mold and using the centrifugal force. The rotation creates an empty space within the column, and, therefore, the PC serves as the mold. Through placing the concrete into the empty space, the integrity of the HPC column and half-PC beam can be enhanced.

The mortar-filled splice sleeve (hereinafter referred to as “splice sleeve”) is frequently used for the PC method-based joint. The head splice sleeve is a mortar-filled connection, and its adhesion is increased through mounting the head on the embedded bar [4]. The preexisting splice sleeve lacks constructability and economic feasibility due to its excessive cross section. However, the head splice sleeve indicates high constructability and economic feasibility since its cross section is optimized through increasing its adhesion. Figure 1 and Figure 2 show the HPC column as well as the cross section of the head splice sleeve.

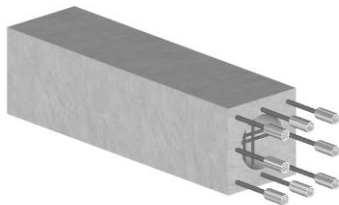


Figure 1. Hollow-PC column

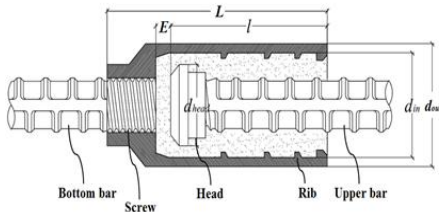


Figure 2. Head splice sleeve

B. Specifics of HPC Composite Method-based Joint

The HPC composite method uses the HPC column and head splice sleeve to create a joint in between the columns, and the process is quite different from that of the half-PC slab method. Table 1 shows the specifics of the joint created in between the columns through the HPC composite method. Initially, the half-PC beam and half-PC slab are installed on the HPC column. Starting from the hollow section of the HPC column, the topping concrete is placed into the beam and slab. After the concrete curing is complete, the upper column is jointed with the lower column. The column joint process is conducted in the following order: head splice sleeve combination, leveling and perpendicularity adjustment, column support fixation and placement of non-shrinkage mortar into sleeve. After the column joint process is complete, the mold is assembled in between the columns, and the concrete is placed into the hollow section until the height reaches 1/2 the upper column.

TABLE I. SPECIFICS OF JOINT IN BETWEEN COLUMNS

Column & Column	Specific Joint Procedures
	<ol style="list-style-type: none"> 1. Monolithic Placement of Topping Concrete into Hollow Section of Column 2. Joint Process between Upper/Lower Hollow PC Columns(Head Splice Sleeve Combination) 3. Leveling & Perpendicularity Adjustment 4. Column Support Fixation 5. Placement of Non-shrinkage Mortar into Sleeve
	<ol style="list-style-type: none"> 1. Assembly of Mold in between Columns 2. Placement of Concrete into Hollow Section of Upper HPC Column

C. Analysis on the Difference of HPC Composite Method

(1) Comparison of Construction Procedures: The construction procedures between the HPC composite method and half-PC slab method are compared to analyze the differences. Table 2 shows the comparison of the construction procedures between the HPC composite method and half-PC slab method. In the HPC composite method, “assembly of mold in between columns” and “placement of non-shrinkage mortar into sleeve” are differently ordered in comparison to those ordered in the half-PC slab method, and “settlement of lower beam bar in hollow section” and “placement of concrete into hollow section of HPC column” are additionally included.

TABLE II. COMPARISON OF CONSTRUCTION PROCEDURES

	Half-PC Slab Method	HPC Composite Method
Basic Installation	- Marking - Anchor Location Perforation - Internal Hole Cleaning - Anchor Bolt Construction - Level Confirmation & Shim Plate Installation	- Marking - Anchor Location Perforation - Internal Hole Cleaning - Head Splice Sleeve Construction - Level Confirmation & Shim Plate Installation
Column Installation	- PC Column Erection - Leveling & Perpendicularity Adjustment - Support Fixation - Assembly of Mold in between Columns - Placement of Non-shrinkage Mortar into Sleeve	- HPC Column Erection - Leveling & Perpendicularity Adjustment - Support Fixation - Placement of Non-shrinkage Mortar into Head Splice Sleeve - Assembly of Mold in between Columns
Girder Installation	- Support Fixation after Girder Installation	- Support Fixation after Girder Installation (Settlement of Hook-shaped Lower Beam Bar in Hollow Section)
Sleeve Installation	- Slab Installation - Lower Support Fixation	- Slab Installation - Lower Support Fixation
Electric Piping & Upper Rebar Placement	- Slab-Slab Reinforcing Rebar Placement - Slab-Beam Reinforcing Rebar Placement - Upper Beam/Slab Rebar Placement	- Slab-Slab Reinforcing Rebar Placement - Slab-Beam Reinforcing Rebar Placement - Upper Beam/Slab Rebar Placement
Concrete Placement	- Half-PC Beam, Half-Slab Monolithic Placement	- Hollow Section of HPC Column, Half-PC Beam, Half-Slab Monolithic Placement

(2) Analysis of Construction Period Differences: Based on the comparison of construction procedures, the construction period differences between the methods are analyzed through the interview with the expert. Table 3 shows the analyzed construction period differences between the half-PC slab method and HPC composite method. As a result, the HPC composite method uses different member joint method, lifting work, and concrete placement, and, therefore, indicates different construction period. Since the weight of the HPC columns is light in comparison to that of the preexisting PC column, the column segment count can be decreased. The daily column-related lifting work load varies depending on the column segment, and this may shorten or extend the construction period.

TABLE III. CONSTRUCTION PERIOD DIFFERENCES PER METHOD

	Half-PC Slab Method	HPC Composite Method
Member Joint Method	Use of Preexisting Splice Sleeve	Use of Head Splice Sleeve
Lifting Work	Increased Lifting Work Load Due to Column Segment	Decreased Lifting Work Load Due to Minimized Column Segment
Concrete Placement	Monolithic Placement of Girder, Slab & Column	Addition of Hollow Section Placement

III. CONSTRUCTION PERIOD ANALYSIS OF HPC COMPOSITE METHOD

A. Analysis Method

The differences in the HPC composite method are analyzed in order to analyze the construction period of the HPC composite method. Based on the deducted differences, the construction period is analyzed through setting up a hypothesis that the HPC composite method is applied to the case to which the half-PC slab method is actually applied. Table 4 shows the outline of the case to which the half-PC slab method is applied. The PC method is applied to this building from the 1st basement floor to the 5th upper floor. The identical PC is used for all the columns and girders. More than three methods are partially and compositely applied to the slab. In particular, the segmented columns are used due to the maximum transport weight of the lifting equipment.

TABLE IV. THE CASE OF CONSTRUCTION PC METHOD

Title of the project	Seoul distribution complex development
Building site	Songpa-gu, Seoul
Principal use	Distribution center
Kind of the project	New construction
Total floor area	404,346.81m ²
Building area	84,018.92m ²
Number of stories	B2~7F
Column	PC Column
Girder	PC Girder
Slab	DECK Slab, PC Slab (DTS, RPS)

B. Construction Period Analysis of HPC Composite Method

The HPC composite method uses different member joint method, lifting work, and concrete placement, and, therefore, indicates different construction period. However, since the member joint method and concrete placement are barely different, only the lifting work is considered into the analysis of the construction period.

(1) Construction Period of Selected Case: The construction period of the selected case is analyzed through using the 1st~2nd floors and 3rd floor as the standards. This building is constructed through the use of the segmented heavy weight columns. The columns used for the 1st~2nd floors are segmented twice, and, therefore, 3 segmented columns are used as 1 column. The columns used for the 3rd floor are segmented once, and, therefore, 2 segmented columns are used as 1 column. The daily average quantity of the members assembled into this building is 15 for segmented column, 17 for girder and 20 for slab. The construction period per floor used as the standard is as shown in Table 5.

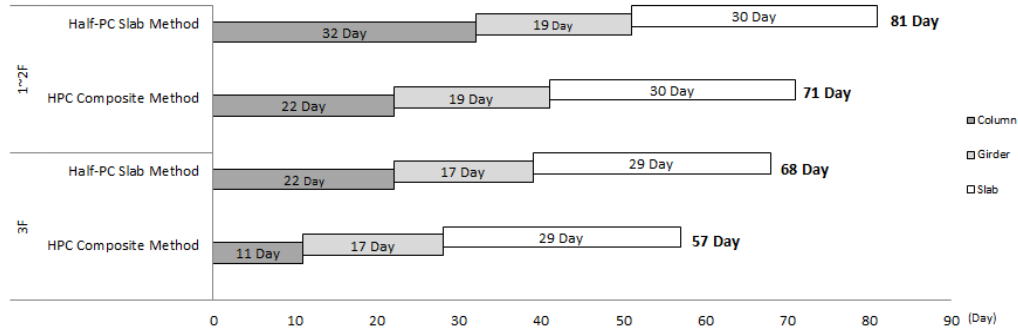


Figure 3. Construction period analysis of HPC composite method

(2) Analysis of Construction Period of HPC Composite Method : The total quantity of the segmented columns used for the 1st~2nd floors is 481. Provided that this is replaced with the HPC columns indicating a 50% hollow ratio, the total quantity of the segmented columns can be reduced to approximately 320. In addition, the daily average quantity of the segmented columns assembled into the building is 15, and the HPC composite method-based column installation period is 22 days. This shows that the installation period can be shortened by approximately 10 days. In addition, the total quantity of the segmented columns used for the 3rd floor is 320, and the installation period can be shortened by approximately 11 days. Figure 3 shows the analyzed construction period of the HPC composite method. The construction period for the 1st~2nd floors is shortened by 12.35%, and the construction period for the 3rd floor is shortened by 16.18%.

TABLE V. ANALYSIS OF CONSTRUCTION PERIOD OF SELECTED CASE

Division		Total Quantity	1Day Quantity	Period(Day)
1~2F	Segmented Column(Column)	481(160)	15(5)	32
	Girder	314	17	19
	Slab	585	20	30
	Total Construction Period			81
3F	Segmented Column(Column)	320(160)	15(7.5)	22
	Girder	580	17	17
	Slab	574	20	29
	Total Construction Period			68

IV. CONCLUSION

It is difficult to decrease the construction cost through using the preexisting PC method since the high capacity lifting equipment used for transporting the heavy weighted members increases the transport cost. Currently, a number of new methods are being developed to supplement such problem. The HPC composite method is one of the methods being developed to supplement the weakness of the preexisting PC method. However, there are not that many researches conducted from the perspective of the construction management. Accordingly, this research is conducted on the HPC composite method from the perspective of the construction management, and the purpose

is to analyze the construction period of the HPC composite method. The important results deduced from this research are as follows.

In order to analyze the differences in the HPC composite method, the construction procedures are compared and the interview is conducted with the expert. In the HPC composite method, “assembly of mold in between columns” and “placement of non-shrinkage mortar into sleeve” are differently ordered in comparison to those ordered in the half-PC slab method, and “settlement of lower beam bar in hollow section” and “placement of concrete into hollow section of HPC column” are additionally included.

In addition, the HPC composite method uses different member joint method, lifting work, and concrete placement, and, therefore, indicates different construction period. Based on the differences in the HPC composite method, the construction period is analyzed through setting up a hypothesis that the HPC composite method is applied to the case to which the half-PC slab method is actually applied. As a result, it is found that the HPC composite method decreases the column segment count, and, thereby, shortens the construction period.

In the HPC composite method, the construction period seems to vary depending on the column segment status. It seems that the construction period can be more effectively shortened through increasing the number of segmented columns. However, since the construction period relating to work types other than the PC method is not considered in this research, it is necessary to analyze the construction period relating to the overall construction process in the future.

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