Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 14 (1992)

Artikel: New conctruction system of high rise RC buildings

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DOI: https://doi.org/10.5169/seals-13824

New Construction System of High Rise RC Buildings

Nouveau système de construction de gratte-ciel en béton armé

Neues Methode zur Errichtung von Stahlbeton-Hochhäusern

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SUMMARY
The current labour shortages on sites can provide a good opportunity to reform the construction industry's labor-intensive nature. This could be accomplished by focusing on technological advances for construction production processes, thus completely reforming and modernizing the construction industry. The authors have developed the new concept of high rise building construction systems and it has been used to great effect at construction sites suffering from labour shortages.

RÉSUMÉ
Le manque de main d'oeuvre que nous connaissons actuellement sur les chantiers de construction peut être une excellente occasion pour réformer la nature gourmande en heures de travail de ce secteur d'activité. Pour atteindre ce but, il faudrait intégrer les progrès technologigues faits par les procédés de mise en oeuvre, opérant ainsi une réforme et une modernisation complète de la construction. industrielle. Les auteurs ont développé un nouveau systéme de construction de gratte-ciel, qui a été utilisé de manière très efficace sur les chantiers souffrant d'un manque de main d'oeuvre.

ZUSAMMENFASSUNG
Der gegenwärtige Arbeitskräftemangel auf der Baustelle kann als guter Anlaß zu einer Umstrukturierung der bisher arbeitsintensiven Arbeitsweise im Bauwesen dienen. Eine solche Umstrukturierung oder Modernisierung wäre zu erreichen durch die Einbeziehung technologischer Neuerungen in den Produktionsprozeß auf der Baustelle. In diesem Sinne haben die Verfasser ein neues Konstruktionssystem zur Anwendung bei der Errichtung von Hochhäusern entwickelt, das sich bereits auf verschiedenen von Arbeitskräftemangel geplagten Baustellen hervorragend bewährt hat.

1. INTRODUCTION

For the past few years, construction industry has been benefiting from the steady growth of other industries in Japan, and a number of high-rise RC buildings are currently being carried out or planned. However, looking at the situation that existed in many construction sites, it can be said that the construction industry is struggling to keep up with the rapidly increasing number of orders it is receiving. The main reason for this struggle is the shortage of labor that is a result of the labor-intensive nature of construction work. Although this is an old problem in the construction industry, no solution has ever been found.
The authers are of the opinion that construction site labor shortages can provide a good opportunity to reform the industry's labor-intensive nature. It has been proposed that the current shortage of labor at construction sites is not just a transitory problem but a way to help the construction industry veer away from labor-intensiveness. This could be accomplished by focusing on technological advances for the construction production processes, thus completely reforming and modernizing the construction industry.

2. THE CONCEPT OF THE INTEGRATED CONSTRUCTION SYSTEM

We have developed a new concept of high rise building construction system and named it the concept of integrated construction system. It has been used to great effect at construction sites suffering from labor shortages.
Fig.1 illustrates the basic concept about the concept of the integrated construction system. The construction work method eventually adopted at the construction site should allow for the best balance posible among quality, the construction term, economy, and safety. This sort of study is carried out in conventional and industrialized methods. However, regarding the concept of integrated construction system, subsystems for the construction of each section are selected from among the available methods, regardless of standard conventional and industrialized procedures. Thus, a greater range of selection is possible.
The advantage of the conventional methods is that all contructors, construction planners and managers, and design supervisors engaged in construction have shared a common tradition and experience with them ever since concrete developed. Structually, the conventional methods have no trouble with joints, because there are few jointings of successive concrete pour within the form-work, and homogeneous

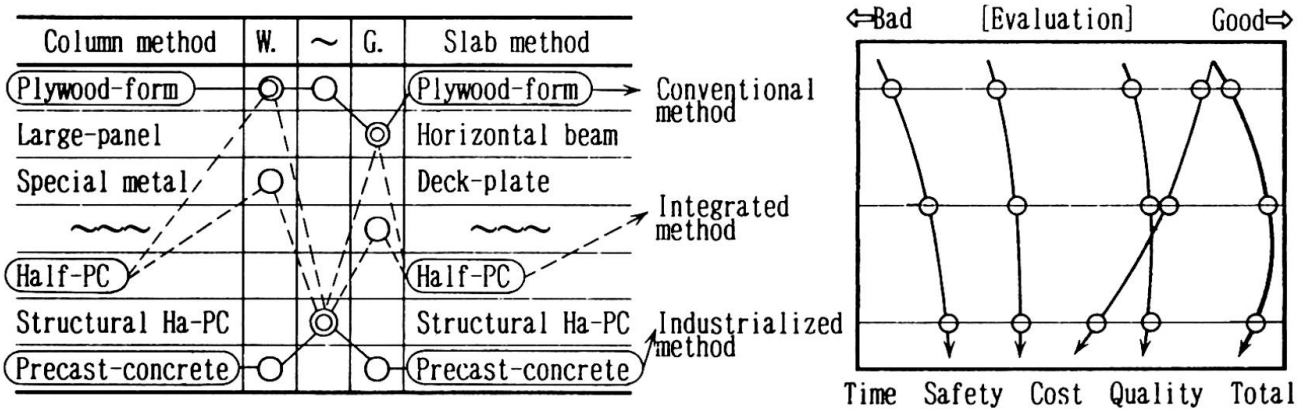


Fig. 1 The basic concept of the integrated construction system

concrete structure can be produced, and the generation of high-level local stress can be avoided, From the standpoint of concrete quality, superior construction is possible with good shielding performance against water, heat, fire, and noise. In production, the conventional methods have many useful properties, including good compliance and constructivity. The conventional methods provide more problem-free interfaces than industrialized methods do, making flexible production possible and no need for subsequent processes such as the treatment of joints. Also, the conventional methods are better in price, although it's said that in quality and speed of construction they are inferior to the industrialized methods.
With regard to precast concrete member mutual interfaces, the industrialized construction methods is based on the idea of "strictry conventions" that are simplified and standardized so as to be in common only within an individual construction methods. This makes it possible to have a closed system and is an attempt to achieve prefab effectiveness through mass production. Thus the industrialized methods have superior performance in term of quality and construction speed. But in term of price it is said to be inferior to the conventional methods. The integrated construction system adopts the open system, in which they are as "simple, flexible agreements" as possible, to make it possible to adopt a variety of methods and members for every position. Thus its goal is not to achieve the prefab effect through mass production as in the industrialized methods, but rather to achieve an organic-effect for construction work as a whole by using simple, flexible agreements to cleverly incorporate semi-finished prefabricated materials into construction plans, for the purpose of relieving the labor situation and shortening construction term.

3. APPLICATIONS

3.1 APPLICATION EXAMPLE

The concept of the integrated construction system has been applied to many high-rise buildings. The schedule of building construction and the site planning using the concept of the integrated construction system are shown in Fig.2 and Fig.3.

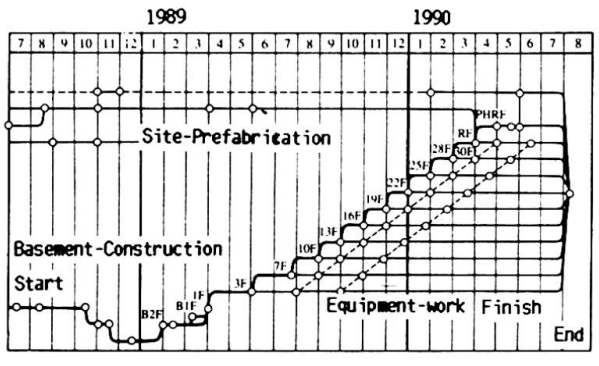


Fig. 2 The schedule of building construction

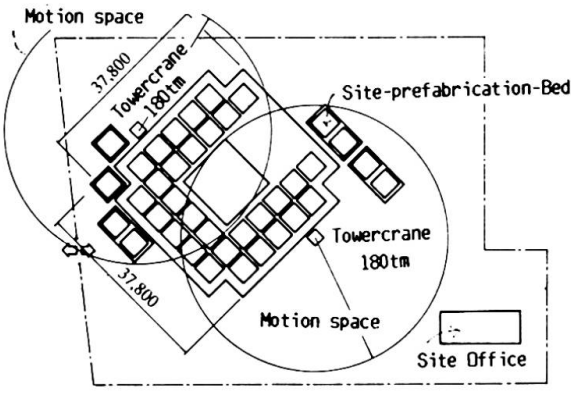


Fig. 3 The site planning

This building is designed for the construction of a multiple-dwelling house 30 stories of reinforced concrete structure. The blocking construct area method as shown in Fig.4 and the separated horizontal-and-vertical construction method is adopted.

3.2 ONE ACTUAL EXAMPLE

The basic plan of "SST" is shown in Fig.5. The case of SST is given as one actual example of the concept of the integrated construction system and it has been developed for the construction of super high-rise RC multi-dwelling buildings. A construction planning of a high-quality and super high-rise RC apartment take such general conditions into consideration as a large volume of materials, long lifting distance, shortage of labor, job repetition, high-techniques required and facilities held. Then, the appropriate quantity of labor, materials, equipment, work term, etc. is decided for the whole system and the subsystems. Finally, SST that optimizes the entire body is created as shown in Fig.6. No particular methods is specified for each part of the building, but rather the conventional method, the half-precast concrete method and full-precast concrete method are all a vailable. The method for each part in selected, simulated, and determined from among them based on the size of the building, construction-terms, the building's location, and while seeking to optimize the construction work as a whole.

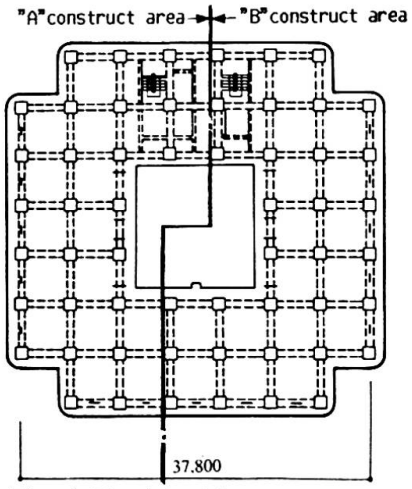


Fig.4 The blocking area

Recently the shortage of skilled workers at construction sites has become a major contraint, and at many sites, SST is done at the pase of one foor every six to eight days under a plan using a specific formwork method for columns, a specialized formwork method or half precast concrete method for girders, the precast concrete method for walls, stairs and valconies and the large half precast concrete method for slabs.

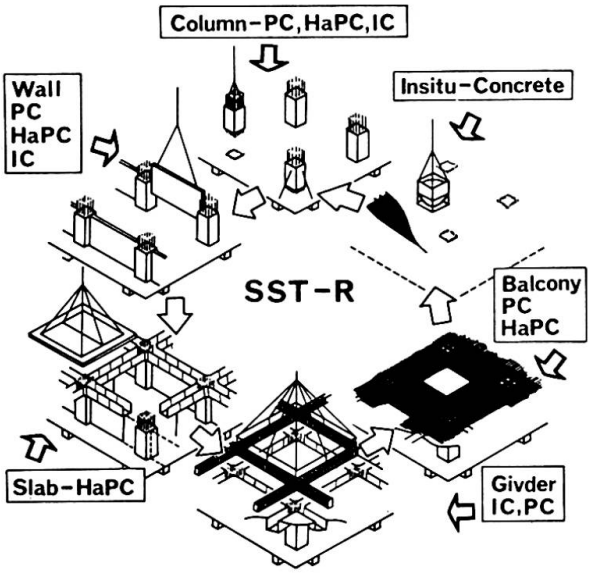


Fig.5 The basic plan of SST

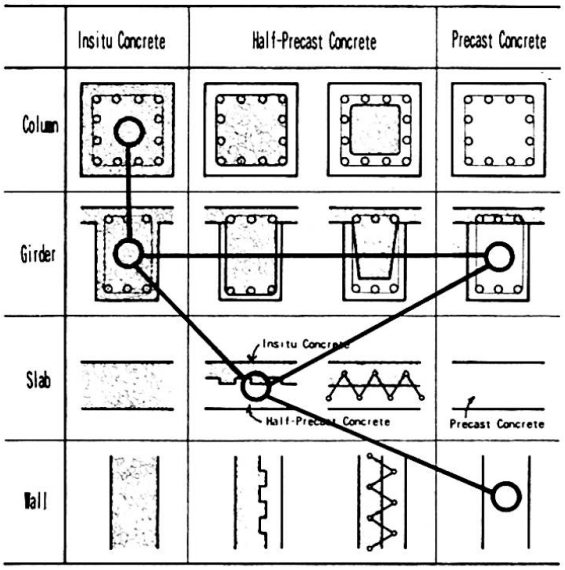


Fig.6 The selected methods of SST for application example construction

3.3 WORK SCHEDULING

When one cycle of detailed work is planned to improve the operation rate of workers, cranes, forming materials, temporary facilities, etc, the work scheduling is effective to plan repetitive work. Work repetition brings improves learning

and productivity, stabilizes quality and favorrably influences work safty.
In order to realize a high production on the high-rise building construction, not only repetitive work but also a fixed members of workers and standardizing crew size is required. The multi-activity-chart method is applied to work scheduling of application example construction in which seven work teams repeat their work at the same cycle in two blocks simultaneously, as shown Table 1. Multi-activity-chart is a timetable which indicates each work team's schedule, and who, when, where, and what they do. In this table, the holizontal axis shows each work teams and the vertical axis shows workdays.

Team	Crane		Carpenter	R-Bar Placer		Mecanician	PC-Labor
Number	1	1	9	5	3	2	4
Days 1 st	Scaffolds SD. ALW Delivering	PC-Girders Setting PC-Slabs Setting	Columns Form Erection Girders Panels Stripping	Columns Re-Bar Pre-fab.	Girders Re-Bar Pre-fab.	Columns Re-Bar Jointting Girders Re-Bar Jointting	Half-Slabs Pre-fab.
2 nd	Columns Concrete Pouring	Columns Re-Bar Erection PC-Balcony PCCorridor Shoring	Girders Panels Erection				
3 rd	PC-Slabs Setting Girders Re-Bar Erection	Slabs Re-Bar Erection	Slabs Supporting	Columns Re-Bar Erection		Inspection	
4 th	PC-Walls Setting PC-Stairs Setting	Slabs Concrete Pouring	Columns Form Stripping Columns Form Reforming	Slabs Re-Bar Erection Girders Re-Bar Erection	Girders PC Re-Bar Erection	Columns Re-Bar Jointting	

Table 1. The multi-activity-chart method applied to work scheduling of application example construction

4. CONCLUSION

The concept of the integrated construction system is now popular in Japan and SST has been applied to many high-rise buildings in a relatively short time. The concept of the integrated construction system makes it possible to complete construction work satisfactorily and successfuly in shorter periods and thereby to save manpower and conserve materials. The effects of the concept of the integrated construction system on the economy of the construction work were examined on site as follows:

1)The labor productivity ratio of the integrated construction system to the conventional method was 2 to 1.

The comparison of the amount of labor beween the actual amount of labor invested on site in which the integrated construction system was used, and the trial-calculated amount of labor planed to be invested using conventional methods is shown in Fig.7.

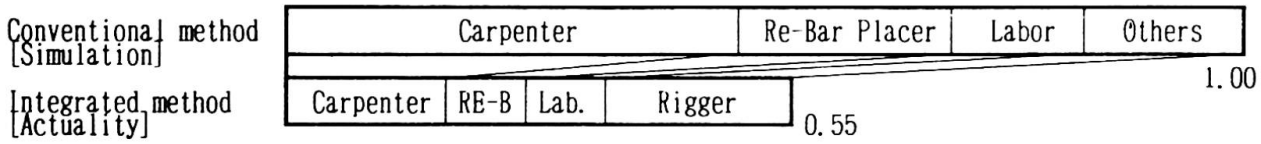


Fig. 7 The comparison of the amount of labor

This diagram shows only the quantity of labor expended, but it is clear that its quality is reduced along with its quantity, as fewer skilled workers and more unskilled workers are employed.

2)The construction period required for the integrated construction system was approximately half as long as that for the conventional method.

The comparison of the construction speed beween the actual amount of the construction speed on site in which the integrated construction system was used, and the trial-calculated amount of construction speed planed to be invested using conventional methods is shown in Fig.8.

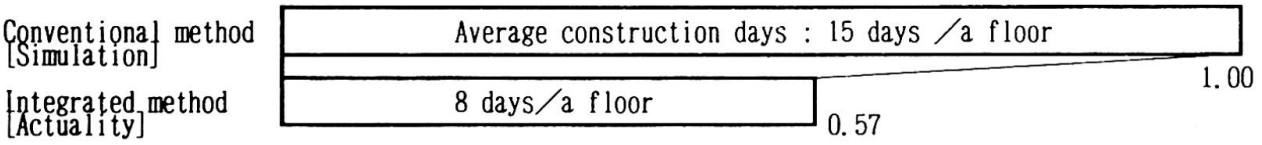
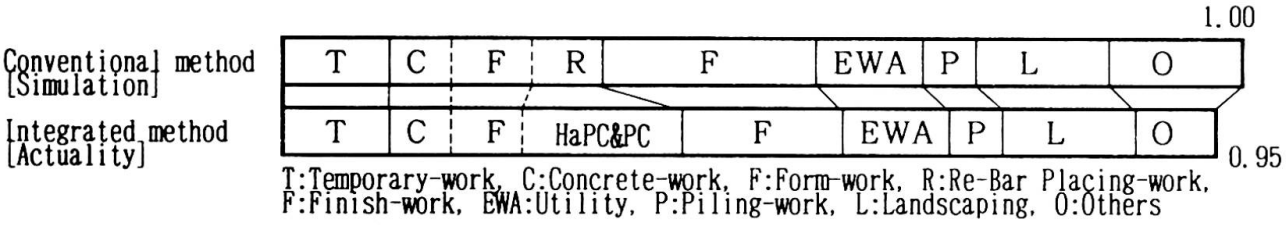


Fig. 8 The comparison of the construction speed

3)No different expenses are seen between the integrated construction system and the conventional method.

The comparison of the construction expenses beween the actual value of the construction expenses on site in which the integrated construction system was used, and the trial-calculated value of the construction expenses planed to be invested using conventional methods is shown in Fig.9.



T:Temporary-work, C:Concrete-work, F:Form-work, R:Re-Bar Placing-work, F:Finish-work, EWA:Utility, P:Piling-work, L:Landscaping, O:Others

Fig. 9 The comparison of the construction expenses

4)The integrated construction system can be of great use for labor saving and construction term shortening of high-rise buildings.

The rate of labor decrease at every construction site in which the integrated construction system was used is shown in Fig.10.

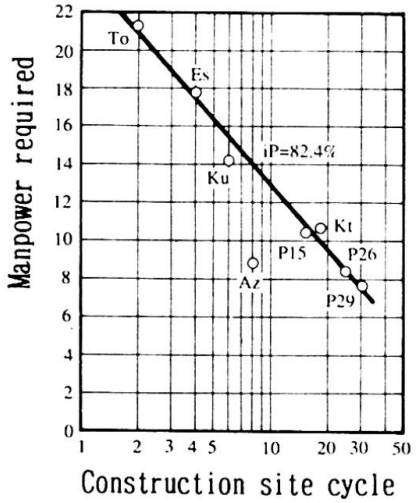


Fig. 10 The rate of labor decrease

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