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Improved productivity using a modified table formwork system for high-rise building in Korea

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Abstract

Recently, construction of high-rise buildings in Korea has increased. However, the traditional formwork has disadvantages, such as low productivity, labour intensiveness, and long cycle times. Formwork is one of the largest cost components of a concrete building's structure, and is a factor with significant impact on construction duration. This paper proposes a modified table formwork system (MTFS) that can improve construction productivity, reduce labour requirements, accelerate construction schedules, and significantly reduce construction costs. A case study was performed to verify the validity of the MTFS by comparing schedules and costs of the MTFS with those of the traditional formwork system (TFS).

Keywords: Construction; Formwork system; High-rise building

1. Introduction

Construction investment is generally 3–10% of a nation's gross domestic product (GDP) [1,2], and construction investment in Korea is 15% of the GDP [3]. Therefore, productivity improvement in the construction industry is more influential in improving GDP than it is in any other industry [1].

Although construction companies have placed a high priority on productivity to enhance their profits and ensure competitiveness since Korea's economic crisis in 1997, the productivity of construction work in Korea is half that of other OECD countries [4]. The prevalent reason is that those who work in the Korean construction industry are not informed on the value of time and modern systems and techniques [5]. Conversely, high-rise residential building construction has recently been booming in Korea, and Koreans are showing increasing interest in such buildings, probably because the shift of population to the city centre has created demand. To respond to this need, construction companies must make more effort to improve productivity in high-rise building construction.

The various factors of construction productivity improvement are divided into headquarter-type factors and site-type factors. Headquarter-type factors include elements such as planning, scheduling, and estimating, and site-type factors include elements such as materials, labour, and methods [6]. Among these site-type factors, construction method is a significant one, having impact on construction productivity [7]. Furthermore, O'Connor and Davis [8] suggests that innovative methods are required to enhance construction productivity during

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field operation, methods that might be applied to areas such as the sequencing of field work, temporary construction material/systems, hand tools, construction equipment, constructor-optional assembly, temporary facilities directly supportive of field methods, and post-bid constructor preferences.

Among possible innovative methods, modification of the formwork system of high-rise buildings is worth considering, for two reasons. Firstly, its efficiencies accelerate the construction schedule, and reduce costs during construction, enabling early occupation of the structure, and improving related jobsite productivity [9]. In addition, formwork is one of the largest single cost components of a concrete building's structural frame [10], and one of the factors that has an impact on construction duration [11]. It may constitute 35–60% of the total cost of a concrete building's structural frame [12]. Secondly, although the traditional formwork system (TFS) is now the most widely used in building construction in Korea, its use involves problems such as labour intensiveness and long cycle periods of up to 10 days per floor. For example, the structural frame construction period for a 40-floor residential building in Korea is about 14 months, while in the US the same building takes about 7 months—a difference of about 7 months [5].

This paper introduces the modified table formwork system (MTFS) as a solution to the low productivity of the TFS used in high-rise building construction. The main objective of this paper, therefore, is to propose MTFS as a way of improving productivity, accelerating construction schedules safely, and delivering significant savings in construction costs. The feasibility of MTFS in terms of both time and cost saving is presented through a case study.

2. Improved productivity of formwork system

This study examines a residential building with five basement floors and 40 above-ground floors constructed in Seoul, Korea. However, the building could not be completed within the estimated duration and cost because the work for improving the bearing capacity was not included in the original construction plan. Improving the bearing capacity was found to be necessary after tests of the bearing capacity of the soil had been conducted following excavation works.

This factor extended the schedule and cost, since the site conditions had changed [13,14]. However, residential building units are normally pre-sold before construction commences, and the cost of units is based on the status of construction in Korea. Therefore, if the residential buildings are not completed by the scheduled date, the developer and the contractors will face claims from the tenants. And if the construction costs are not met, construction cannot be completed within the targeted cost.

To solve this problem, the productivity of the formwork, which influences the total construction duration and cost, had to be improved. The traditional form system—planned to be applied for slabs and beams—was selected for review to improve productivity. The flying form system, which is imported, and has been used recently in some high-rise buildings for accelerating construction schedules, was considered, but it was excluded from a solution because it was so expensive that it could increase construction costs [15]. Therefore, modification of the formwork system was begun while parts of the framework were being processed in the substructure, because the original construction duration and cost were estimated on the basis of the TFS. This modification was focused on deceasing the labour and using the equipment—such as auto-climbing system (ACS) formwork—considering the total process of formwork, including the form assembling, stripping and moving/lifting [5].

3. Modification table formwork system

The MTFS consists of a deck form, including a joint filler strip, a stripping deck with a small hydraulic forklift, and a lifting deck.

The deck forms (Fig. 1) are assembled into units, called decks, for forming concrete slabs and beams, and into joint filler strips for minimum interference between reinforcing bar works and formworks. After the concrete has been placed and cured sufficiently, the deck forms are removed unit by unit, and moved to upper floors in the building where they are reassembled for reuse. The deck form consists of various structural components, such as plywood decking, joists (rectangular pipe), stringers (combination of rectangular pipe

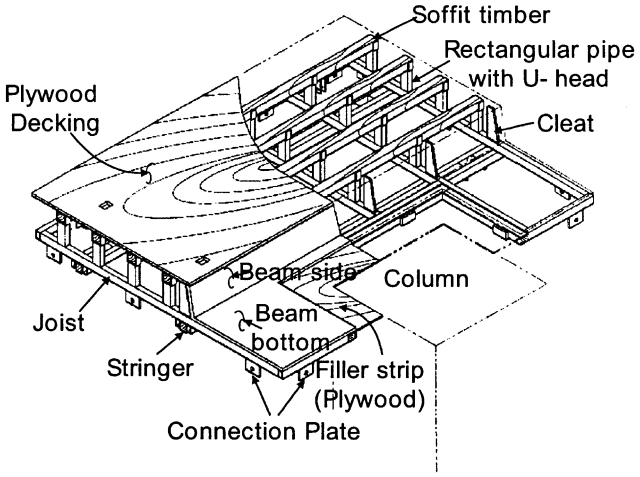

Fig. 1. Deck form.