DEVELOPMENT OF ROBOTIC-CRANE BASED AUTOMATIC CONSTRUCTION SYSTEM FOR STEEL STRUCTURES OF HIGH-RISE BUILDINGS

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ABSTRACT: In this paper, we address a new technique for automatic construction of steel structure in high-rise buildings termed RCA system (Robotics & Crane based Automated Construction System). RCA system can be divided into four core systems: 1) Monitoring and control system, 2) Material assembly system, 3) Beam assembly system, 4) Construction Factory (CF) system. Through our research, we expect that this new technique will increase the construction efficiency and it will alleviate the man power shortage problem.

***Keywords**: RCA system, Construction Automation, Bolting Robot System, Construction Factory*

1. INTRODUCTION

Over the past two decades, many new technologies have been introduced in the engineering, construction, and design of buildings. However, dangerous works on construction sites are still primarily carried out by human labour. Especially, even though the erection of structural steel frames is one of the most dangerous tasks among the high-risk operations on construction sites [1], it is relied on the human experts in high-rise. In order to solve this problem, many researches have been proposed for construction automation. In the 1990s, several Japanese construction companies introduced heavy temporary structures such as Sky Factory, the SMART System, the ABCS, and the BIG Canopy system. The Sky factory [2], which is an automated weather unaffected building construction system developed by Fujita Corporation, has an umbrella unit that provided a weather-unaffected working space. The SMART (Shimizu Manufacturing system by Advanced Robotics Technology) system [3], which is an integrated automated construction system developed by Shimizu, also has a weather protection cover that can be utilized on a rainy day. The automated building construction system (ABCS) [4] and the Big Canopy [5] which are developed by Obayashi Corporation also have a Super Construction Factory (SCF) that comprised a roof, surrounding walls, and weather-proof sheets for the structure. The existing systems successfully provide a working environment unaffected by the weather. However, the costs and weights of the structures are extremely high, because the robots and the massive cranes are combined together with the structure. To solve the problem, we developed the RCA system which is an alternative automated construction system differs from the previous systems. The RCA system has the following advantages: reducing risk factors in human operation, and decreasing the construction cost.

2. RCA System

As shown in Fig. 1, RCA system consists of four core systems as follows; (1) Monitoring and control system, (2) Material assembly system, (3) Beam assembly system, (4) Construction Factory (CF) system. In the monitoring and control system, all data from the system sensors are gathered through the integrated system protocol. Then the real-time progress management (RTPM) and visualization system (RTVS), which are the sub-system of the monitoring and control system, examine the construction

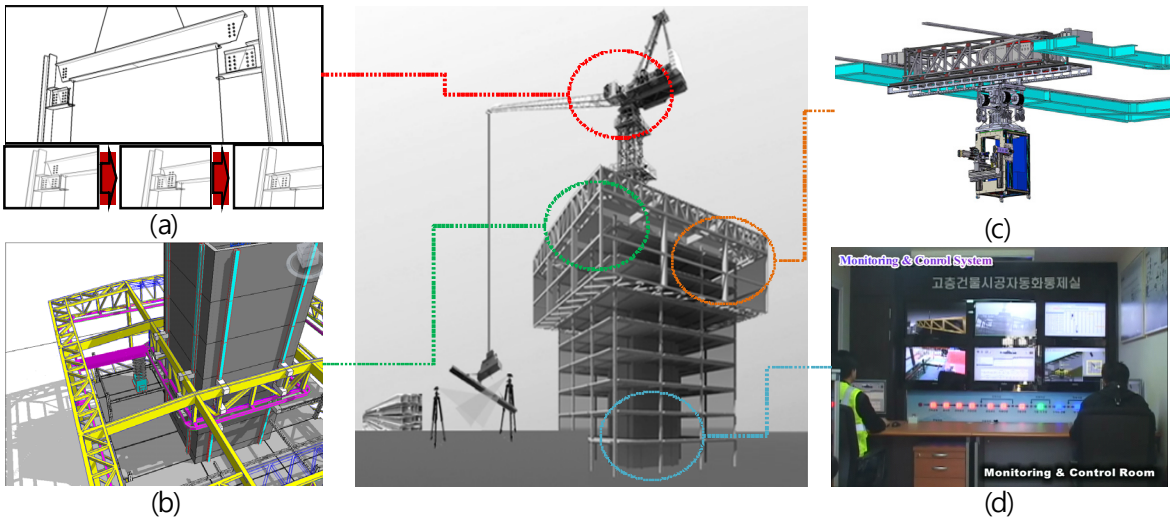

Fig. 1 Structure of RCA system: (a) Material assembly system, (b) CF system, (c) Beam assembly system, (d) Monitoring and control system

progress and display the status of the construction progress in 3D. In the material assembly system, materials and structural steel frames are transported into the CF using a tower crane installed at the core of building and then they are assembled automatically by Design for Automation (DFA). Beam assembly system transports the bolting robot system to the working space in CF and it executes the bolting process. In the CF system, the weight of the developed system is less than 500 ton, whereas that of the previous system is over 1200 ton.

7. CONCLUSION

In this paper, we introduce the robotic-crane based automatic construction system which consists of four core systems. The advantages of our system are as follows: 1) it ensures human safety, 2) the difficult and dangerous jobs are conducted by robot. However, this system is initially designed for construction of rectangular type high-rise buildings. Therefore, in order to expand the application of this system to general construction, it is needed to develop a construction automation system to overcome this technical obstacle.

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