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Concept Design of Disasters Information Integration System for Super High-rise Buildings based on BIM/GIS

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Abstract: *This paper is intended to introduce the objective of the study. The ultimate objective of the study is to provide an integrated disasters information system to respond for rapid restoration assistance and reduction in damage due to disasters occurred in super high-rise buildings. To do this, it is planned to develop a disaster integration information system, measurement/analysis/response solution interlinked interface system, and scenario-based systematic response tools. This paper describes the performance goals of the proposed system, user requirements, and conceptual designs as an initial step of the development.*

Keywords: *disaster, high-rise building, BIM/GIS, emergency communication service, information integration system*

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I. Introduction

Since the 2000s, the number of super high-rise buildings of more than 200m height has increased rapidly around the world. Korea has also constructed a number of super high-rise buildings around metropolis. It is highly difficult for super high-rise buildings to establish a strategy of rapid evacuation and response to disasters since it takes more than one hour to evacuate all residents during disaster due to a long vertical distance of evacuation travel. Thus, various studies are needed to ensure human life safety during disaster occurrence in super high-rise buildings due to the high risk of human life safety.

Currently, a disaster management system used in super high-rise buildings in Korea is a part of subsystems in a facility management system. However, development disaster systems perform minimum communications such as notification of individual disaster occurrence signals to other facilities. Thus, individual response strategy is operated rather than integrated and interlinked operation according to disaster occurrence or evacuation progress. Furthermore, few systems for complex disaster management such as earthquakes and fire have been developed, and detailed standards on response method in case of emergency situations are not established in most individual facilities in the disaster management system but depend on know-how of companies that developed the system.

This study is now underway since Dec. 2016 and this paper explains the development strategy of the disaster information integration system using building information modeling and geographic information system (BIM/GIS). Table 1 shows annual goals and detailed contents in the study.

Table 1. Annual goals and detailed contents in the study on the development of the disaster response information integration system

Category	Goal	Contents
1st Phase	▪Design of server functions in the open-type platform for disaster information integration management	▪ Design of server functions in the open-type integration information platform for response to disasters ▪ Design of database functions used in the disaster integration information platform ▪ Design of data structure suitable for the disaster integration information platform ▪ Design of MR utilization technologies such as mobile-based AR and VR ▪ Implementation of information service (dashboard) for support of disaster management
2ndPhase	▪Implementation of server functions in the open-type platform	▪ Implementation of visualization functions of BIM/GIS-based analysis results ▪ Implementation of monitoring and visualization functions of BIM/GIS-based measurement information ▪ Implementation of management functions of BIM/GIS-based ultra high-rise facility information ▪ Development of automation rule sets in response to situations based on scenarios ▪ Implementation of MR utilization technologies such as mobile-based AR

Category	Goal	Contents
		and VR ▪ Development of emergency information service technology
3rdPhase	▪Construction and demonstration of testbed of the disaster response integration information system	▪Demonstration of technology through construction of actual-size testbed and operation tests ▪ Development of systematic and automatic response technology for each disaster type based on scenario ▪ Stabilization and advancement of the open-type disaster integration information platform

II. State of the art and development principle

2.1 BIM/GIS technology in Korea

In recent years, BIM-based facility management system has been developed in Korea. BIM can manage various pieces of information occurred during the building life cycle. The interest in three-dimensional (3D) indoor space information in GIS has been changed to BIM technology in Korea. This is because much attention has been paid BIM technology as a solution to solve problems of high-cost modeling process and the lack of interlinked indoor and outdoor information [1]. The KICT developed a technology that can utilize outdoor and indoor space information linkage through BIM/GIS data linkage construction for open source-based platform technology, facility maintenance and operation [2]. Moreover, the development of utilization applications has been done as the interest in the utilization of BIM/GIS technology has been expanded due to an increase in service demand utilizing indoor space information[3].V-World, which is an open platform and provided freely by the Ministry of Land, Infrastructure and Transport, has been operated since 2012. It provides 3D space information and 3D national infrastructure information [4].

2.2 Technology of disaster management system in super high-rise buildings in Korea

The special act on disaster management of super high-rise and underground-linked complex buildings has been enacted in Korea (2012). Thus, investments and technical developments in construction and management areas of disaster management systems for super high-rise buildings have been actively underway. Particularly, studies on structural health monitoring of super high-rise buildings using measurement technology and precision structure analysis technology have also been underway actively[5]. However, monitoring technology using measurement data has been utilized mainly to investigate the safety of major structural members in buildings or evaluate the damage during external load applied at the time of disasters rather than comprehensive information management of disasters. Furthermore, fire-related studies in Korea have been limited to specific areas such as fire-resistant structure and fire-fighting equipment in general buildings rather than super high-rise buildings. A fire management system in super high-rise buildings has remained in the setup phase of component technology concept yet.

2.3 Determination of development principle

The current disaster related technologies have been developed and operated based on one-to-one individual response strategy in accordance with individual related laws mainly. These technologies mainly play a role in detecting and alarming events of disasters via measuring sensors. However, it is highly difficult to respond to complex disasters or disasters in super high-rise buildings appropriately. That is, it is inevitable to respond to complex disasters according to individual judgments or manuals of responding parties (residents, building managers and interested persons etc.).

Thus, this study set the expansion and sharing of information in real time as the technical development direction for efficient management and comprehensive response to situations during complex disasters. To do this, intuitive and prompt actions can be provided by diversifying tools of information delivery system and alarm system, by which abnormal signals are detected and risk situations are responded. Furthermore, scenarios (or rule sets) are set up to determine damage size and respond to disasters by type in consideration of accident characteristics such as accident party, location, and cause in order to facilitate appropriate judgment and actions according to risk situations. Table 2 shows the performance goals considering user requirement.

Table 2. User requirements and performance goals of the development

Required level	Current technological level	Performance goals of the development
▪Construction and utilization of integrated information for complex disaster management	▪Information management and system operation for each disaster type or individual facility	▪Information integration of disasters and construction of integrated management system
▪Utilization of high quality foundation information for analysis on disasters	▪Duplicate construction of foundation information for analysis and limitation of simplification	▪Interlinked integration of integrated information platform and specialized disaster analysis system

Required level	Current technological level	Performance goals of the development
▪Proactive technology is needed to respond to various scenarios including complex disasters	▪Scenario and actual response are not operated organically.	▪Development of technologies to respond to disasters rapidly for different situations
▪Providing intuitive information for rapid response due to the characteristics of disasters	▪Providing 2D drawing, maps, and text-based information	▪Development of technologies to assist intuitive judgment for practical control and evacuation
▪Unit technology as well as complex technology, and analysis	▪Operation of testbed at a verification level of individual unit technology	▪Aiming for actual size testbed to execute design, construction, and performance evaluation of applications and disaster integration management system of super high-rise buildings and complex facilities.

III. Conceptual system design

3.1 System architecture design

The Disasters Information Integration system was designed. It has 3-tier layers: Presentation layer, Application layer, Database and Model layer (Fig. 1).

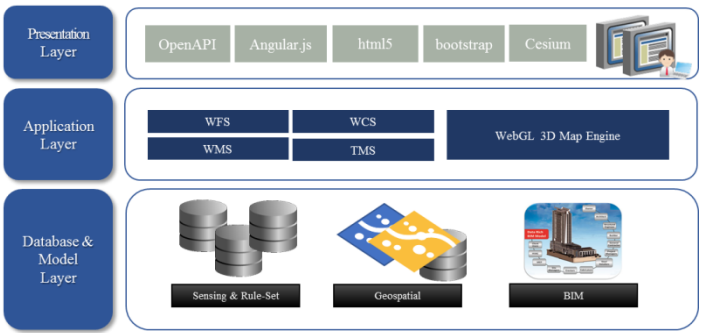

Fig. 1. System architecture design

3.2. Conceptual service flow design

The system to be developed was divided into two concepts: daily information service and emergency information service. Figure 1 shows a conceptual service flow chart of the emergency service to design information services in the disaster information integration system. The emergency information service was designed based on rule-sets information derived through analysis and simulation according to various scenarios.

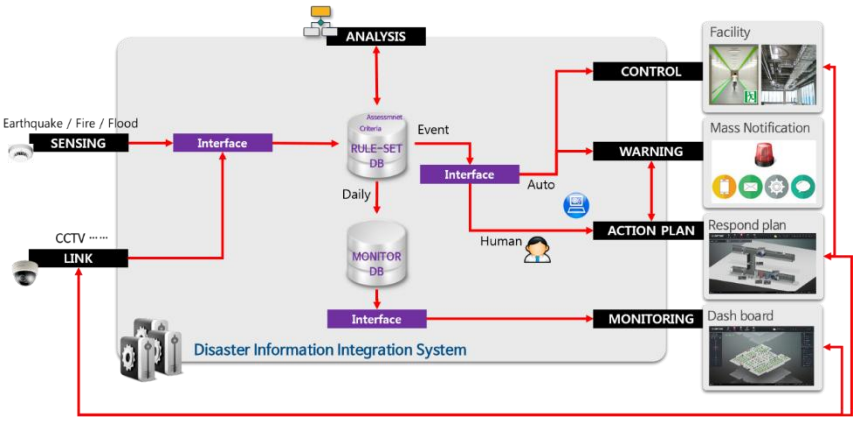

Fig. 2. Conceptual flow of emergency information service

IV. Conclusion and future work

The ultimate objective of this study is to provide an integrated information system to respond to disasters for rapid restoration assistance and reduction in damage due to disasters occurred in super high-rise buildings. Currently, it is an early phase of the development, in which performance goals of the system to be developed, user requirements, and conceptual service flow design were conducted. Now, investigations on mandatory elements are underway. The study items to be conducted in the future are as follows:

- Development of open-type disaster integration information system
- Development of systematic response system to situations based on scenarios

- Development of measurement, analysis, and response solution and interlinked interface system
- Development of intuitive disaster information service technology utilizing MR technology such as AR and VR
- Construction and demonstration of testbed of the disaster response integration information system

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