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Utilization of Visual Object Information for Civil Engineering BIM Implementation in Construction Lifecycle Stages

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Abstract. Recently, in civil engineering projects, diverse efforts for applying BIM technology have been tried in construction sites. However, the BIM technology for the civil engineering projects is still focusing on the visualization of changing status on the 3D shapes based on the existing 4D CAD. Besides, the BIM has many difficulties in applying to practical business of construction because the reprocessing procedures of BIM models are demanded in a real construction works. Therefore, to solve these issues, this study suggests the development methods and improvements of active BIM provides an environment that the project managers can operate systematically the construction life cycle information under the dynamic analysis environment of construction data by a BIM system.

Keywords: BIM, 4D CAD, Visual Object Information

1. Introduction

Recently in the construction industry, efforts have been made to realize building information modeling (BIM) by developing BIM processes of practical business, controlling/running wide-ranging visual objects and offering information models for business support. As civil engineering BIM operates on the basis of conventional 4D CAD, most of the construction information is focused on visual implementation for examining slight changes in 3D images according to a schedule. This is simply a three-dimensional implementation of conventional numerical or planar drawing information. Hence, so a separate reprocessing procedure is needed to convert this visualized information into data that is directly applicable to practical business of construction projects.

To address this issue, this paper provides an improved operation system of visual information that may be utilized as practical business information throughout the entire construction lifecycle as opposed to a two-dimensional decision-making environment that utilizes conventional visual information alone. For this reason, this paper seeks to develop an active BIM implementation system by applying information obtained through controlled procedures within the system to construction sites as a practical business information model for schedule management and safety management rather than offering mere visual object-based information. It also suggests further improvements of the system.

2. Civil engineering BIM operation system in the construction lifecycle

2.1. Civil engineering BIM operation in the planning phase

The planning phase is the stage in which the feasibility of project execution is assessed, where reviews of the validity of structure allocation and structural alternatives, three-dimensional bird's eye views, and the

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overall schedule sequence simulation may be undertaken. All of this data is assembled using approximate 3D modeling of civil engineering structure shapes, which can be done through adequate object control of the virtual settings.

In reviewing structural alternatives, the entire shape is taken into account as a single model instead of evaluating the alternatives of individual members by detailed modeling. For this reason, realistic alternative assessments are rarely done. Instead, harmony with the surroundings by means of overall changes in the structural shape model and environmental feasibility are examined.

2.2. Civil engineering BIM operation in the design phase

In the design phase, structural shapes are specifically categorized based on the visual information examined in the planning phase. They reflect the design information required in the construction phase. For this purpose, detailed modeling is carried out so that the 3D model of structural shapes contains shapes such as reinforcement placement and temporary facilities.

In this process, design BIM can visually examine object interruptions to review the actual constructability and utilize detailed models to detect errors in the quantity estimation, the 2D drawing extractions, the design, and the overall schedule so that any design and construction errors that may arise during the construction phase can be visually examined in advance.

2.3. Civil engineering BIM operation in the construction phase

The construction phase is carried out on the basis of 4D CAD, which can simulate 3D model shapes according to the schedule. Here, schedule simulations for visualized objects can be performed to examine the overall progress of schedules as well as the structural shapes at a given point in time. This provides a limited simulation operation environment that ensures integrated schedule management through linkage with field progress management information as well as the resource/cost information reflected in the schedule. Construction sites reflect various construction management systems and assess/analyze the information obtained for applications of practical business. Thus, optimal information in consideration of these aspects should be offered.

2.4. Civil engineering BIM operation in the maintenance phase

In the maintenance phase, simulation models are used to leverage information utilized after the completion of the construction project, thereby expanding the shared use cycle of the structures. Information on drawings (3D) as well as the schedule, cost, resources, specifications and maintenance is provided in the form of VR object-based electronic manuals that provide all of the information that users need on a real-time basis. In addition, the locations of the sensors are synchronized to those of 3D members to send a warning regarding parts that exceed crucial instrumental data values and to track measured spot models.

3. Problems with the conventional civil engineering BIM system

3.1. 3D Object-centric fragmentary decision making

Civil engineering BIM consists of a 4D CAD-oriented BIM operational environment which is, however, based on 3D objects. Digital mockups (DMU) are also developed through virtual prototyping of the structures to verify constructability based on interruption checks or to provide information on only the three-dimensional visual conditions of the images. Therefore, this information is rarely applied to construction management processes of practical business.

The existing numerical schedule management system has been upgraded to a visual schedule management system, but the practical business provision of such information involves numerous constraints. There also remain limitations in the scope of 3D simulation information utilization in optimal progress management, resource planning and workspaces considered safety management planning and cost-optimization-based schedule planning.

3.2. Passive BIM operational environment

Conventional civil engineering BIM handles approximate decision-making information only after system operation through 3D model analysis of its virtual settings. It is also impossible for it to process optimal information for the application of practical business, meaning that the visual object information obtained should undergo a separate optimization process or an analysis/control process for manual provision of the information required by construction sites.

In this passive BIM environment, the usefulness of the BIM operational system cannot be assessed; hence, a procedure for reprocessing simple visible information is required. In this sense, it is essential to develop an algorithm that enables proactive BIM implementation on the BIM system and control 3D objects or 4D models within the system on this basis, thereby creating an environment that proactively responds to the ever-changing work processes at construction sites.

4. Utilization of visual objects for civil engineering BIM development in lifecycle phases

4.1. Utilization plans in the planning phase

The planning phase involves the development of a checklist for an alternative evaluation of individual structure shapes with the civil engineering BIM system so as to examine the structural alternatives. The system includes a process for providing optimal alternatives based on a decision-making evaluation technique to ensure optimal decision making for the 3D model and structural alternatives.

4.2. Utilization plans in the design phase

The design phase mainly utilizes 3D objects and is thus interfaced with schedule information in advance to automate mutual object interruptions. Also needed is an interruption check algorithm to verify schedule and object interruptions at the same time. In the detailed design phase, 3D modeling of individual members is carried out by schedule orders or activity units; therefore, automatic mapping with WBS code information for the schedule needs to be ensured upon modeling in order to develop a 4D simulation model that can be utilized in the construction phase. This will simplify the schedule information composition and mutual link procedures in the construction phase and help uncover schedule errors in the preliminary design phase, thereby minimizing quantitative losses during the project. Especially for an analysis of the structural alternatives, as in the planning phase, scenario assessment or Fuzzy AHP-based alternative-specific feasibility analysis procedures should be built into the system (see Figure 1 and 2).

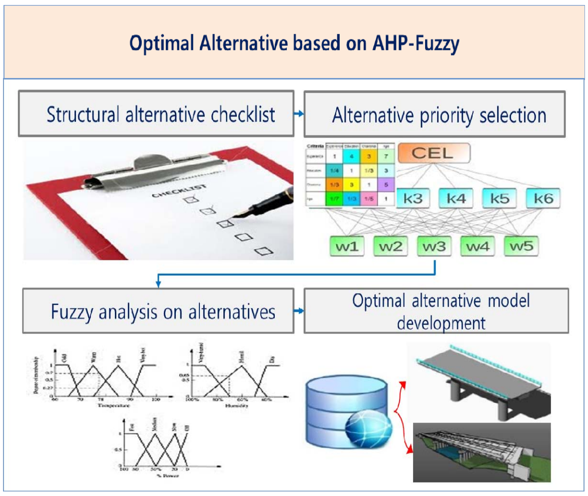

Fig. 1: Optimal alternative evaluation model.

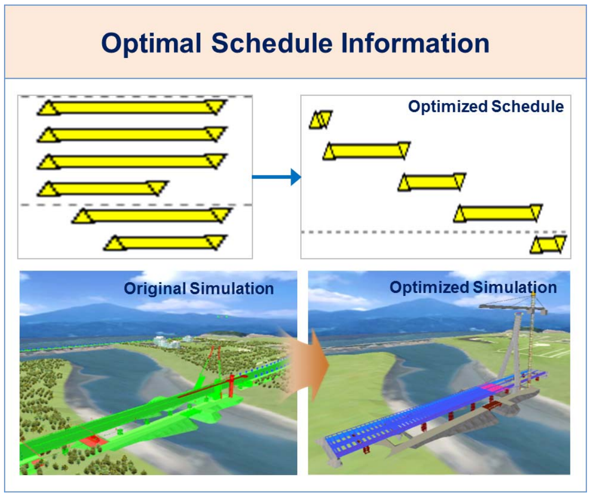

Fig. 2: Optimal schedule planning model.

4.3. Utilization plans in the construction phase

In the construction phase, the BIM model built during the design phase should be utilized to create an environment that enables optimal schedule management. For this purpose, an optimization technique considering mutual tradeoffs should be deployed for optimal resource/cost input planning. It should be interfaced with a schedule so that schedule analysis results suitable for the field schedule conditions can be provided within the 4D CAD system.

In addition, a procedure for risk assessment by part of the structure and the direct application of the schedule planning results should be developed and built into the system so that users can be fed proactive feedback information encompassing schedule management, cost management, resource management and safety management. In particular, it is essential to provide a system operation environment in which the working space for resources and members is reflected on 4D simulation, schedule interruptions and space interruptions are automatically examined, and optimal schedule planning information — controlled through genetic algorithm (GA)-based schedule/space interruption optimization — is provided.

4.4. Utilization plans in the maintenance phase

In the maintenance phase, the mere provision of numerical or instrumental information through electronic manuals is not enough. It is essential to develop an algorithm that can automatically detect the location of members associated with risk via instrumentation results and recognize the pertinent spots of the parts based on 3D information in order to determine automatically what maintenance and repair/improvement information is needed and provide the information to the users. With this function built into the system, administrators can obtain real-time electronic manual information pertaining to optimal maintenance and repair/improvement via wireless tablets beyond time/space constraints without staying in a separate monitoring center and analyzing instrumental data.

5. Construction

This paper analyzed civil engineering BIM utilization in construction lifecycle phases and the associated problems suggested potential improvements in the utilization of visualized object information, whose application of practical business entail limitations, as well as a system-driven operational environment. While existing civil engineering BIM operational systems provide only visual information, this paper proposes a new civil engineering BIM operational system that analyzes, assess, and controls the visual information to provide the optimal information needed by users.

In line with the recent expansion in the use of BIM, BIM can be interfaced with construction processes, and administrators can obtain optimal BIM information processed through the system in the construction lifecycle phases. In this sense, civil engineering BIM is expected to reduce the number of operational procedures carried out by users, thus providing the groundwork for implementing a more active BIM in the field of civil engineering projects (see Figure 3).

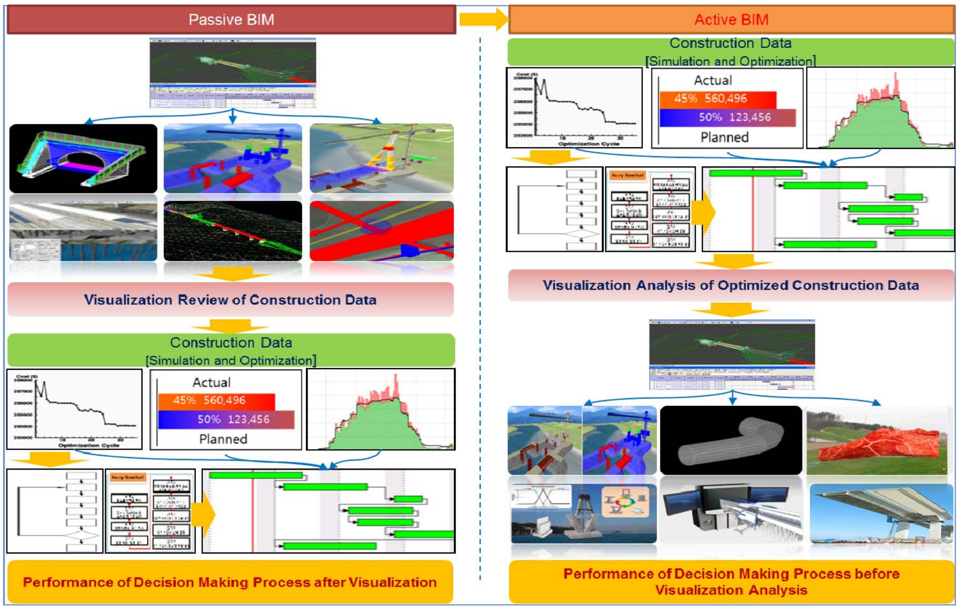

Fig. 3: Conversion of civil engineering BIM into active BIM.

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