REVIEW OF INTERFACING CIM-BASED BIM MODEL AND THE STRUCTURAL ANALYSIS MODEL

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Abstract - The CIM-based digital construction system aims to change the construction works from digital data-based construction works into digital information-based construction works. This study set situations involving construction errors, structural cracks and other changes in the stage of the construction and maintenance of piers which is part of a bridge under the CIM-based digital construction system conception, and examined changes in the work flow by linking the BIM model and the structural analysis model.

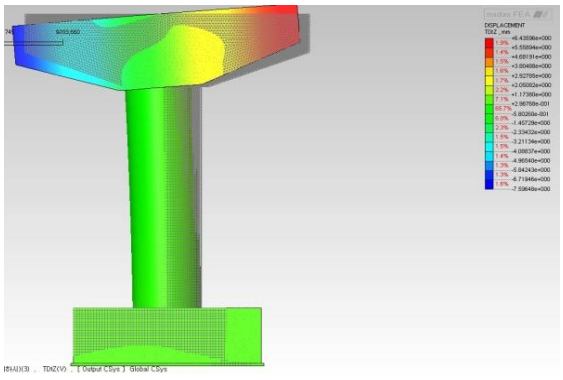
Index Terms - CIM-based BIM model, Structural Analysis Model, Interfacing

I. INTRODUCTION

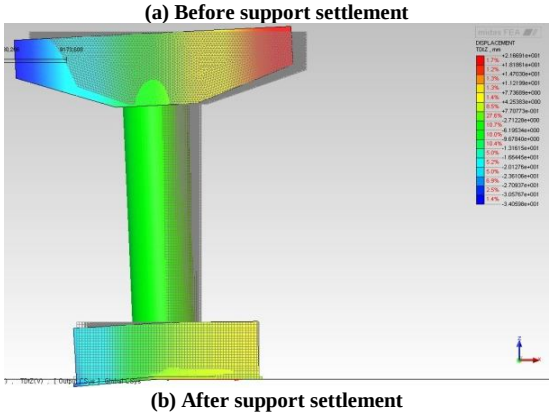
Various studies were conducted to positively link the rapidly developing computer technology to the construction environment. CIM(Construction Information Management) was defined to be used to gather, configure and manage accurate data and information related to road facilities to allow the data and information to be used by all road facility-related entities for diverse purposes such as project planning, environment assessment, surveying, design, construction, maintenance, asset management and risk management.(1) In response to such changes, in 2013, U.S. Federal Highway Administration required Transport Bureaus of all state government to positively adopt this paradigm. (2) In recent years, BIM is being positively used in the design and construction of buildings, and BIM is being partially used for major public facilities. BIM has 3D-model attributes and thus can successfully implement the review of details, processes, design and constructability. However, BIM-based information system alone is insufficient to construct the digital construction system (CIM) for construction works. For this reason, BIM contains 3D-shape information and attribute information only, making it impossible to reflect the actual environment of structures (engineering environment). Studies are required concerning the construction of digital construction systems but they are very insufficient. In 2016, a conceptual CIM model was presented.(3) In connection with the CIM-based digital construction system, this study set possible risk situations in the stages of the construction and maintenance of bridge piers, interfaced the BIM model of piers and the structural analysis model logics to verify the work flow changes, and offered the conceptual CIM method as a specific implementation method.

II. SUBJECT

Before the construction of the CIM system, the workflow must be improved. The key features of the CIM system, BIM and 3D structure analysis, were examined for their linkage, and the CIM-based workflow changes were verified. To examine the linkage of the changed workflow with the BIM and 3D structure analysis features in the construction execution stage, the following construction execution scenarios were examined. The scenarios assumed that in the construction execution stage, the field undergoes a change due to a 3cm support settlement in an area of the pier. Figure 1 presents the results of the structural analysis that was before and after the settlement. The coping's maximum displacement is serious.



(a) Before support settlement

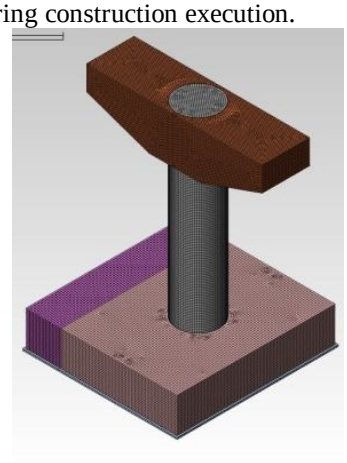


(b) After support settlement

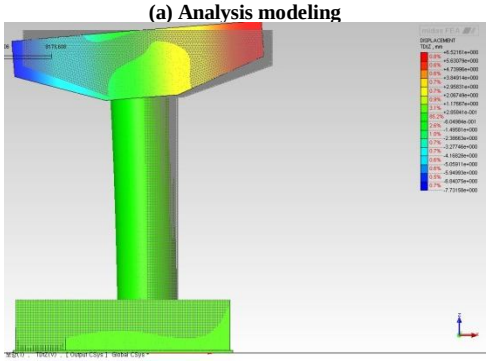
Figure 1. Structural analysis (vertical deflection) of a construction error (3cm support settlement)

As such, the constructor can examine the structural reinforcement during the construction execution

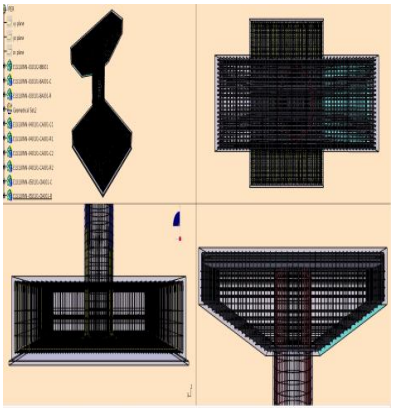
according to the changing field conditions. Thus, as illustrated in Figure 9, in the case of an additional 2m foundation-reinforced concrete construction in the error-caused area, the constructor has to decide whether to overcome the error. This situation was examined using 3D structure analysis, and as a result, the BIM model could be changed. Figure 2(a) and (b) present the reinforcement design's 3D structure analysis modeling and the resultant BIM model change to overcome the error. The grey portion of Figure 2(b) reveals that the deflection was repaired, recovering nearly the original level. This suggests that the addition of the structure analysis process in line with the changing field circumstances can change the design during construction execution.



(a) Analysis modeling



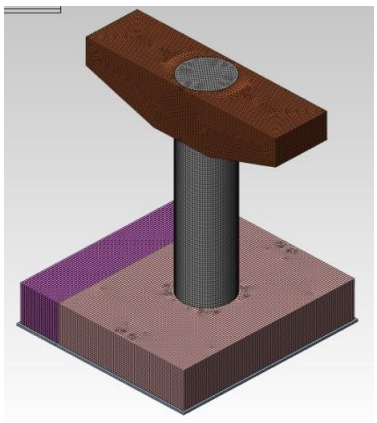
(b) Analysis results



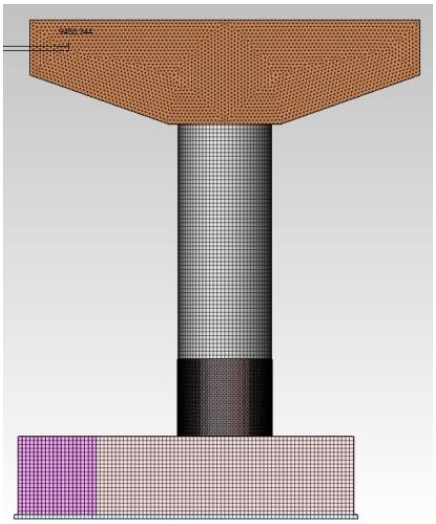
(c) Revision of BIM modeling

Figure 2. Reinforcement for the construction error, 3D structure analysis, and BIM modeling (construction execution stage)

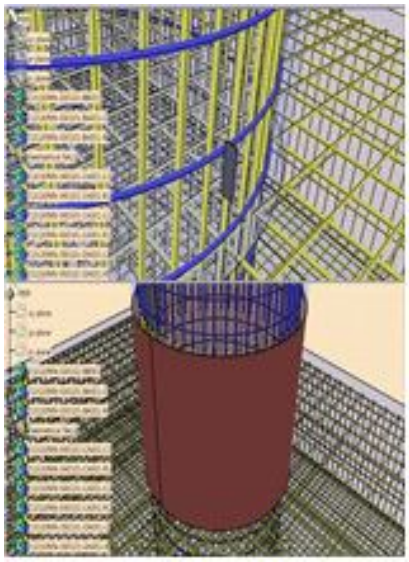
It was verified that during the maintenance stage as well, BIM modeling and 3D structure analysis were compatible and interlinked. If the workflow is changed as proposed above, the design change history can be reflected in the design and construction execution stages, and 3D structure analysis in the changed structure model is possible. Also, the corresponding reinforcement (as the above example of an additional 2m construction) output and BIM modeling and the 3D structure analysis model and construction execution results become digital information and are delivered to the maintenance stage under the CIM system. The maintenance stage adds the history of completed structures over time so that 3D structure analysis can be applied to the completed structures. Also, the damage, repair, and reinforcement measures taken according to the history can be additionally included in the structure analysis for review purposes. To verify the workflow changes, a case was examined wherein the strength was lowered by 50% due to the elasticity modulus damage caused by considerable cracks. The reinforcement involved wrapping the damaged column from the foundation concrete block with 2-m-high and 1-cm-thick steel sheets. Such steel sheet reinforcement will increase the damaged concrete's elasticity modulus and ultimate strength due to the constraint effect of steel sheets, and it was assumed in this experiment that the elasticity modulus recovered by 80%. Figure 3(a) and (b) present the 3D structure analysis models before and after the reinforcement. Figure 4 presents the structural analysis of the structure before and after being damaged. Such structural changes should be accumulated in the BIM information system so that during the maintenance stage as well, 3D structure analysis and BIM information can be compatible. For example, if the structure analysis process is added to the maintenance stage, enabling the information accumulated in the process and construction execution to be utilized, then high-level evaluation and reinforcement design can be achieved. Such workflow changes are crucial for the identification of the structural behaviors in the process of continuous maintenance.



(a) Analysis modeling for damage

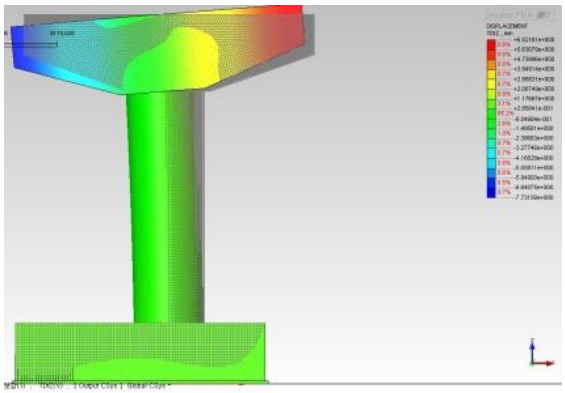


(b) Analysis model after reinforcement

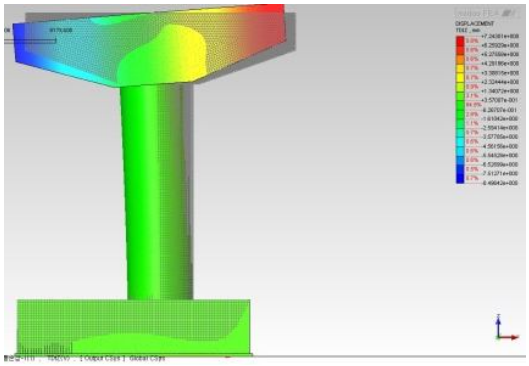


(c) Revision of BIM modeling

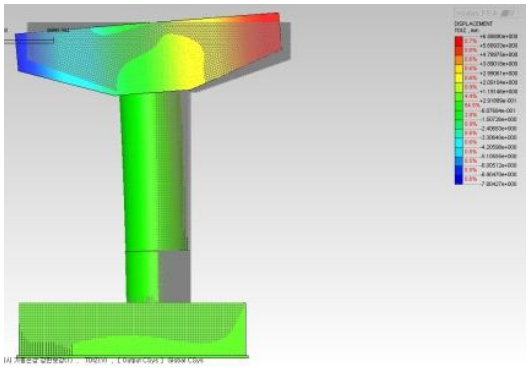
Figure 3. 3D structure analysis modeling before and after steel sheet reinforcement (maintenance stage)



(a) Before damage



(b) After damage



(c) After reinforcement

Figure 4. 3D structure analysis results before and after the column damage and after reinforcement (maintenance stage)

CONCLUSION

In the construction field, if the existing workflow is a discontinuity of information, then the workflow under the CIM system will be a continuity of information utilization. If the information on all the structures during the entire life cycle is based on the BIM information system, and unified informatization is implemented, the CIM system can be constructed. The workflow changes based on such a system can only be imaged for now, but continuous R&D will realize such workflow changes in the not-so-distant future.

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