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Virtual Prototyping (VP) In Construction

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ABSTRACT: VP means virtual prototyping is a computer aided design process. It is the latest and cost effective way to visualize real circumstances that enhance effective communication of design and ideas without manufacturing physical samples. Virtual prototyping involves the integration of different design softwares during each and every stages of a construction process, visualizing the construction site environment in different stages. This process enhance the capability of engineers to detect the problem areas. Now a days construction safety is a serious problem in construction industry worldwide, especially in the case of large scale construction projects. We can adopt the VP technology to improve the safety management performance through the identification of key factors that cause accident.. This report is an overview of virtual prototyping technique, its application for simulating construction process for the easy and effective execution, life cycle management of a construction process and to improve the safety management in construction projects.

KEYWORDS: Virtual prototyping, Simulation, Safety management.

I. INTRODUCTION

II.

Construction project planning has been considered as a critical process in the early project phases that determines the successful implementation and delivery of projects. During this stage, the project planner needs to develop main construction strategies, to establish construction path and assembly sequences, and to arrange construction methods and resources, required for the execution of work packages.

Now a days the traditional 2D drawings was not sufficient to communicate building design and construction operations. Construction planners realize that they have to rethink the construction project and to introduce best practices and carry them over from one project to another. Thus there is need to present building components in 3D and to present construction operation in virtual environment so that the idea of planners can be captured, communicated and reused.

By implementing virtual prototyping for construction operation evaluation, constructability data can be evaluated and captured. The construction manager can use this data to check design feasibility and to provide feedback to the design team. It allows to detect the problems earlier and to minimize cost of change.

In the past days, construction documentation has been normally prepared in standard two dimensional (2D) drawings and paper based delivery process, thus limited the capability of visualizing and understanding the subsequent construction work involved. This traditional approach impose a heavy burden on project teams and their performance should be limited.

The development of 3D computer aided design systems have reduce the burden on verbal and written communication. A number of softwares are introduced for the design process (ie.Archi CAD, 3DS MAX, REVIT etc). The latest research development relates to the development of graphical presentation of construction plan via the four-dimensional (4D) geometrical model. The 4D visualization technique provides an effective means of communicating

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temporal and spatial informations to project participants. 3D graphics combines with time generates the 4D-CsAD model. Visualization of construction plans allows the project team to be more creative in providing and testing solutions by means of viewing the simulated time-lapse representation of corresponding construction sequences and prompting users to think about all missing details. This representation or simulation process using all these techniques comes under virtual prototyping and this helps in the life cycle and safety management of a construction project.

II VIRTUAL PROTOTYPING (VP)

Virtual prototyping (VP) is a computer aided design process concerned with the construction of digital product model (virtual prototypes) and realistic graphical simulations that addresses the broad issue of physical layout, operational concept, functional specifications and dynamic analysis under various operating environment. The VP technology has been extensively and successfully applied to the automobile and aerospace fields. An automobile can be fabricated virtually using the VP technology and allows various team members to view the 3D image of finished products, evaluate the design, and identify the production problems prior the actual start of mass production.

Through various research efforts, the VP concept is formed as an effective dynamic construction project planning and scheduling tools. Researchers at the university of Teesside (UK) developed the VIRCON (virtual construction) as a prototype application for evaluation, visualization and optimization of construction schedules with in a virtual reality interface. The Virtual Design and Construction Method (VDC), Virtual Facility Prototyping (VFP), Immersive Virtual Environment (IVE) etc all are designed to improve the project planning process by generating and reviewing construction plans in a virtual environment. Waly and Thabet developed an integrated virtual planning tool called the Virtual Construction Environment (VCE) which allows the project team to undertake inexperience rehearsals of major construction processes and examine various execution strategies in a near reality sense before the real construction work.

The 4D CAD is now become an effective tool which plays an important role in virtual prototyping. 4D Models link components in 3D CAD models with activities from the design, procurement, and construction schedules. The resulting 4D production model of a project allows project stakeholders to view the planned construction of a facility over time on the screen and to review a 3D CAD model for any day, week, or month of the project.

4D models enable a diverse team of project participants to understand and comment on the project scope in a proactive and timely manner. They enable the exploration and improvement of the project executing strategy, improvements in constructability with corresponding gains in on-site productivity, and the rapid identification and resolution of time-space conflicts. 4D CAD models have proven particularly helpful in projects that involve many stakeholders, in projects undergoing renovation during operation, and in projects with tight, urban site conditions.

III. IMPLEMENTATION OF VIRTUAL PROTOTYPING

There are three main phases in implementing virtual prototyping. They are project requirement collection phase, 3D models building phase and process simulation phase.

A. . Project information collection phase

In this phase the major project challenges are identified and these becomes the basis for defining the scope of works. The challenges can be divided into design related and construction related. Design related challenges come from co-ordination of building components and temporary work facilities design details to ensure a harmonized building design and construction operations. The major design challenges are joint designs, reinforcement layout uncertainities, co-ordination of working platform design etc. The major construction challenges are overloading of tower cranes, the sequence of

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installation of precast components, rebar fixing, formwork fixing etc. The people involved in this phase constitute the architect, engineer, project manager of main contractor and representative from major sub contractor.

B. 3D models building phase

In 3D models building phase, 3D CAD models of building components, plants and temporary work facilities are built according to the need for identifying design, construction and safety challenges. The large works should be divided into small units that suits the simulation of construction operations. The level of details of the 3D models has to be discussed in this phase so that the models can reflect the situation that needs to be examined. The 3D models cannot built into every bolt and nut details. The models just need to be built to the details that reflects both dimensional and space conflicts, and sometimes for examining safety issues. The plants in virtual prototyping have physical properties like degree of freedom in movement, speed and acceleration of movement and association between different mechanical joints. After the creation of 3D models, digital mockup will be arranged for checking dimensional conflict between building components, between temporary work facilities. . The works in this phase are done after producing workshop drawings and before manufacturing of building components and temporary work facilities, so that dimensional conflicts can be rectified before manufacturing to reduce reworks in the actual construction. Information required in this phase include workshop drawings and layouts of building components, temporary work facilities and plants, and detailed program showing divided working bays. The people involved in this phase include project planning team of main contractor, suppliers of building components and temporary work facilities.

C. Process simulation phase

The simulation phase is to simulate planned construction process, validate construction sequence, find time space conflict, check and optimize resource utilization and try alternative construction plan. Construction process are simulated to identify construction challenges. The process detailed as every movement of a human or plants can be simulated in virtual prototyping environment. . Some times it is not necessary to simulate the behaviour of workers, or every detailed work process, but just to highlight building components that are under construction. . The level of details of simulation depends on the nature of the construction challenges we need to tackle. For tracking work space related problems, we probably need to simulate every step of a construction process and the measurement of both human and plan involved.

But for reviewing overall work sequence of resource utilization of a floor cycle, using colour highlight can be good enough to reflect the physical conditions of the construction site. When a higher level of details are available, should take more effort from the virtual prototyping team to make the simulation, and also from the contractors project team to provide more detailed productivity and planning informations. The information required in this phase include detailed process program, productivity rates of different activities, and safety plan. The people involved are the contractors project team and representatives of major sub-contractors.

The process simulation phase usually starts at the construction project planning stage and stops at the actual construction stage. Process simulation helps contractors to tackle construction challenges in the planning stage. The simulation can then be used as 3D work instructions for communication among the project team members and for giving guidelines to workers. During construction stage the actual productivity data are recorded and compared with that of the simulation. Adjustments to the simulation will be made if there is any discrepancy. The adjustment simulation will serve as knowledge base for reference by future projects.

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IV. APPLICATIONS

A. For simulating construction process

One of the main concerns of planners for the construction project planning is the issue of which construction approaches and methodologies to be adopted during the real construction execution. The construction virtual prototyping (CVP) system developed helps to provide a rapid prototyping of projects and present the feasibility of construction method statement. The proposed CVP model has chosen the „Product"; „Process" and „Resource" (PPF) models of Dassault systems for programme development. The first model is the „Product" represents the building which is intended to be constructed. The „Resource" is another model which relates to the construction equipement and temporary work to be used for moving or supporting building components. The „Process" model represents the procedure of how the how the product is built by using the resources. The CATIA V5 and DELMIA V5 are two core softwares in the PPR framework. The CATIA allows the users to create the 3D models of building, temporary works as well as construction equipements, while the DELMIA helps define and simulate construction process. The DELMIA shares the single, unified interface with CATIA.

The CVP application is commenced from the 3D CAD models which are provided by architects or planners. The resources plan (i.e., construction equipment and temporary work) however are usually not generated in the digital design. In the proposed CVP, the digital model of temporary work can be constructed as the components of building (i.e. columns, walls and slabs) from scratch in *CATIA V5* and linked to a digital design. To enable rapid prototyping, parametric models are developed to generate temporary works elements (i.e., wall form, slab form, beam form and working platform)

One important step of the development of the project-specific CVP relates to the definition of the construction equipment. The construction equipment in CVP is established by using the *Device Building* workbench. The 3D CAD models of equipment parts are first generated through the *CATIA V5*. To accomplish the equipment motion, every movable part has to be distinct. If the construction equipment required *n* degree of freedom, the distinct parts of *n+1* are needed for the *n* movable part with one fixed base. Using the tower crane as an example, the tower crane has three degrees of freedom. The jib circumvolves with the base and the roller moves along with the jib. The hook is put down and raised by the roller. Finally, the 3D model of tower crane consists of four parts including base, jib, roller and hook.

B. Life cycle management of construction projects

Based on LCM model of a construction project and its information flows, the theoretical model of a VP-based LCM communication and collaboration platform is developed . The information platform provides a virtual environment that includes two main modules, i.e. a „main model module" and" process simulation module". The „main model module" is used to build the digital mock-up of the project, the so-called main model, which consists of static information from the life cycle phases of the project, e.g. planning, design; and the „process simulation module" focuses on the dynamic information of projects, e.g. the construction process and methods, and space analysis. In this way, all the information concerning the life cycle phases is integrated into the platform.

Through the platform, all project participants share the relevant information and communicate with each other in real-time. The main model is a 3D digital model, which visually shows all the static information needed for a project. Each participant can understand it easily, and therefore the model allows all participants to conveniently communicate and collaborate with each other. On the other hand, the process module offers a virtual environment to all parties to "try before actually building". As we know, often the construction process is complex and irreversible and before actual construction is commenced, the construction schedule and methods must be checked and approved by owners or consultants in order to ensure a smooth construction process. Despite this, rework is inevitable as the traditional construction statement cannot be prepared in enough detail and many problems cannot be anticipated prior to actual construction. The process simulation module assists owners, consultants, even constructors to understand, discuss and modify the construction methods before actual construction so as to reduce rework or risks. It can also help with the maintenance and demolition of a building. From the point of view of LCM, the design of the building not only takes into consideration its construction, but also

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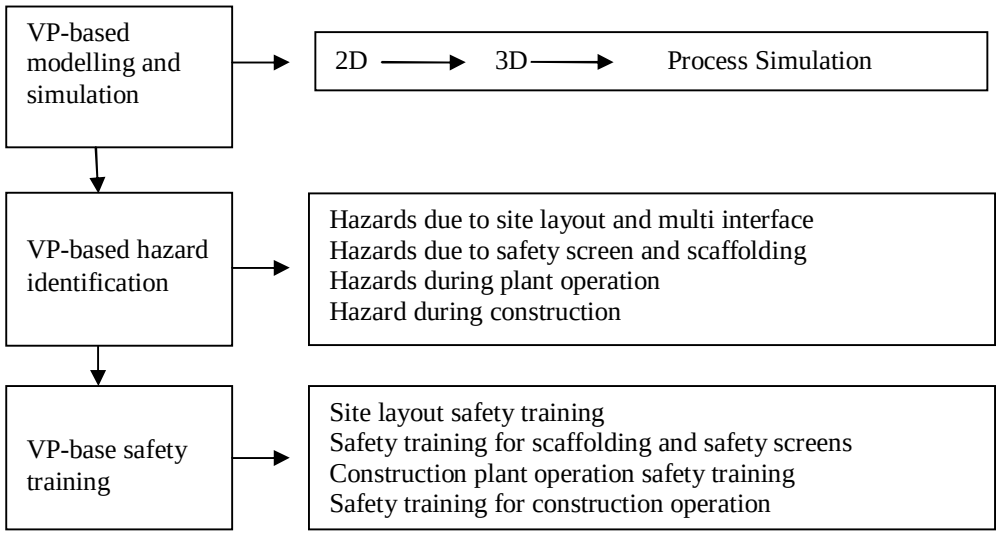
considers its maintenance and demolition in order to reduce the life-cycle cost and risks. That is the design should fit to maintenance and demolition as well as construction. The maintenance and demolition processes and methods of the building can be tried and tested by using the information platform to ensure that the design and maintenance and demolition methods are available for maintenance and demolition. This will also provide a 3D instruction for maintenance and demolition in the future.

C. Safety management

The conceptual framework of VP-SM platform is generally divided into three components: VP- based modelling and simulation, VP-based identification of unsafe factors, and VP-based safety training .Visual modelling and simulation are the prerequisites of the implementation of VP-based safety management. It provides visual models and construction processes in the virtual environment. It has been proved that VP technology can be used to build the 3D models of buildings and simulate the construction processes. Based on the 3Dmodels and process simulation, relevant potential unsafe factors are easily identified by the project manager. In the end, aiming at the unsafe factors, a series of safety trainings can be provided for site workers before construction commences so as to prevent accident from occurring.



VP –based safety management process

V. CONCLUSION

The purpose of using VP technology for construction simulation is to assist project planners to better understand the construction process and predict possible mistakes. This paper describes how a construction model and resource model can be prepared for VP in support of the construction planning process. Virtual prototyping increases the accuracy of project schedule and the ability to predict and plan construction tasks. The process has a leading hand in the tendering process and its ability to impress client is excellent. It is a tool which reduces rework and change orders, and improve co-ordination and communication effectiveness. As the workers are given 3D instructions, less onsite supervision and monitoring personal are needed. The CVP system also assists the project team to design a precise construction schedule so as to remove any potential unproductive activities. The rapid prototyping of the CVP system can be enhanced by improving the existing process and resource optimization, constructability and safety evaluation. Even though these advantages exists VP technology in construction industry is still in its infancy because of the lack of knowledge.

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REFERENCES

[1]. Jaafari A, K K Manivong and M Chaaya. (2001) "VIRCON: Interactive System for Teaching Construction Management" Journal of Construction Engineering and Management. 127, pp. 66-75
[2] Waly A F and Thabet, W Y (2002), "A Virtual Construction Environment for preconstruction planning, Automation in Construction", 12, pp.139-154
[3]. M Toole, "Construction site safety roles", *Journal of Construction Engineering and Management.* 128 (3) (2002) 203-210