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IKEA pattern and revolution of the construction industry

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Abstract: The construction industry has had a low level of efficiency for many years. In an attempt to change this, the IKEA approach to management is used as a basis for improvement, with two key factors being identified that are particularly relevant to construction projects - design without errors and appropriate sequencing of production processes. The use of Virtual Prototyping (VP) technology is proposed to take these factors into account. This involves the use of two VP software products, Catia and Delmia, together with adoption of the IKEA style production management. A case study is described to demonstrate the application of the approach to construction projects.

Keywords: Construction industry, IKEA approach, 3D instruction, Virtual Prototyping, simulation.

1 Introduction

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Construction management and technology are two key factors influencing the development of the construction industry. In the past 40 years, although some new and advanced technologies have been applied to construction projects, the efficiency of the industry is still in decline. The main reason for this is that the new technologies do not effectively reduce the cost of design and construction, especially for Design/Build (D/B) projects, or improve the management of construction. For example, although Computer Aided Design (CAD) technology has improved the efficiency of drawing, the number of design errors, and therefore the amount of rework, remains unchanged. CAD also offers little prospect of reducing costs through the optimisation of construction processes or enhancement of management decision making. What is needed, therefore, is both (1) appropriate new technology and (2) a change in current management concepts to improve the efficiency of the construction industry.

The IKEA organisation is well known for its efficient management and manufacturing approach for home furnishings. With suitable technological adaptation, the approach offers a new way for the management and construction of construction projects. In the following sections, the IKEA approach is briefly introduced and the adaptations necessary for use on construction projects are described. Finally, a case study is described to illustrate its use in practice.

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2 The IKEA approach and construction projects

IKEA is a famous brand of home furnishings, and its vision is that “IKEA offers a wide range of well-designed, functional home furnishing products at prices so low that as many people as possible will be able to afford them” (IKEA website). The purpose of the IKEA approach is to fulfil this vision. This involves designers working with manufacturers to find smart ways to make furniture while still using existing production processes. Consumers choose the furniture themselves, pick up at the self-serve warehouse, and then assemble them easily using the 3D instructions provided (an example shown in Figure 1 and Figure 2, IKEA website) without any professional help. This means that IKEA incur no assembly costs and are therefore able to reduce the sale price accordingly. Note that the appropriate manufacturing sequence is the basis of the 3D instructions.

Figure 1: An IKEA dining table

In theory at least, the IKEA approach is also suitable for construction projects, especially design and build/construct projects. If a construction project can be

simplified sufficiently, just like a table, it may also be easily constructed based on 3D instructions.

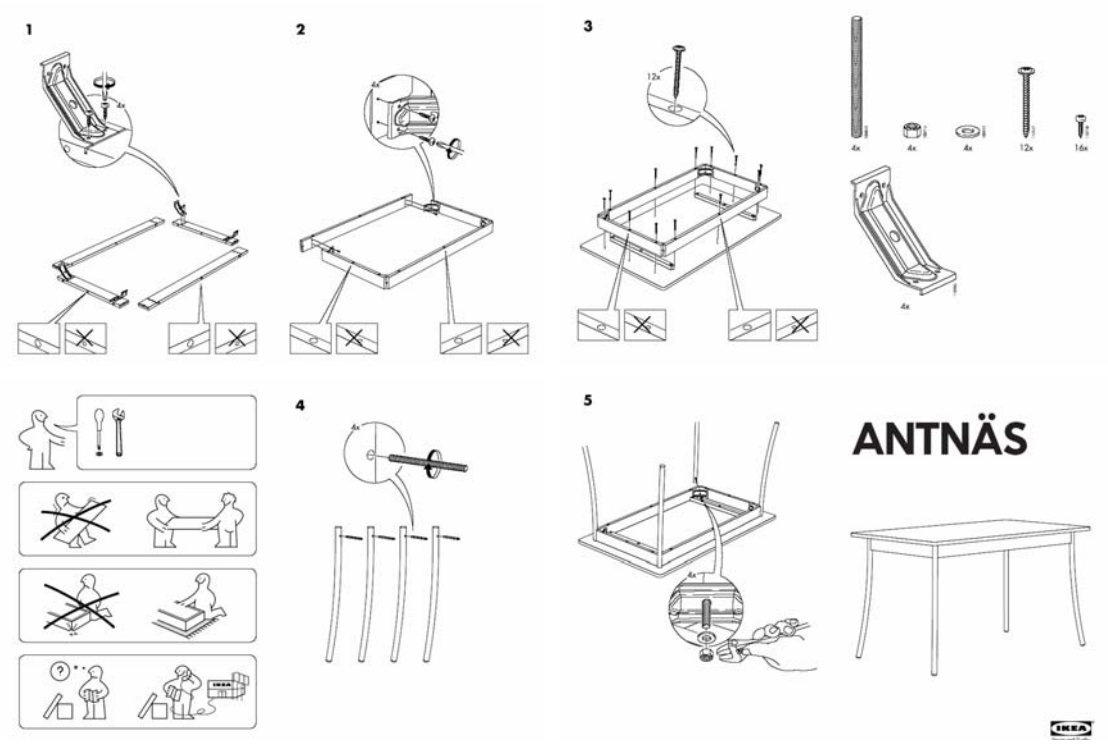


Figure 2: 3D assembly instructions for IKEA dining table

In order to make appropriate 3D instructions for a construction project, two key issues need to be addressed: (1) the design has to be error free, and (2) an appropriate construction sequence has to be devised. However, the designs and construction sequences of construction projects are quite different from home furnishings. Construction projects have no fixed design plans and construction sequences. With current technology, it is far too costly to check the design or manufacturing sequence of a project in the same way as home furniture. Instead, what is needed is a virtual environment, in which design plans and construction sequences can be tried again and again to develop a design and appropriate construction sequence. In addition, the design of a construction project involves many specialist activities, for example

Architecture, Structure, Building Service (BS), temporary support, etc. Thus collaborative design among different parties is also needed. To do this on a virtual platform involves the use of Virtual Prototyping (VP) as the key technology.

3 Collaborative design

3.1 Virtual Prototyping

Virtual Prototyping (VP) is a computer-aided design process concerned with the construction of digital product models (virtual prototypes) and realistic graphical simulations that address the broad issues of physical layout, operational concept, functional specifications, and dynamics analysis under various operating environments (Shen *et al* 2005; Xiang *et al* 2004; Pratt 1995). Dedicated VP technology has been extensively and successfully applied to the automobile and aerospace fields (Choi and Chan 2004). For instance, an automobile can be fabricated virtually via the VP technology and allows various team members to view the 3D image of the finished products, evaluate the design, and identify production problems prior to the actual start of mass production.

VP technology has also been applied to some extent in the construction industry in the form of construction process simulation, with the Construction Virtual Prototyping

Laboratory (CVPL) of Hong Kong Polytechnic University being a prominent leader in the field (Huang *et al* 2006). It is believed that VP can be used to check the design efficiently, enable rapid modifications, and then simulate the construction process in a virtual environment so as to present a clear and easily-operated 3D construction instruction. For construction projects, this involves the use of two software products, Catia V5 and Delmia V5, both belonging to Dassault Systemes.

3.2 Design error checking

The design of construction projects is much more complicated than that of home furnishings because of many participants involved and the great deal of information required. As a result, design errors often occur during the process of design or the period of construction. In order to successfully and conveniently construct a building using IKEA-like 3D instructions, these errors must be eliminated before the project is begun. Through the 3D main model of the project, design errors can be found easily. The procedure of checking design errors is presented as follows:

(1) Construct a 3D main model using Catia V5, including architecture, structure and BS, for example the 3D model of a spectator stand (see Figure 3); and (2) automatically detect clashes between all components in the model (see Figure 4), for instance clashes found in the model of the spectator stand (see Figure 5).

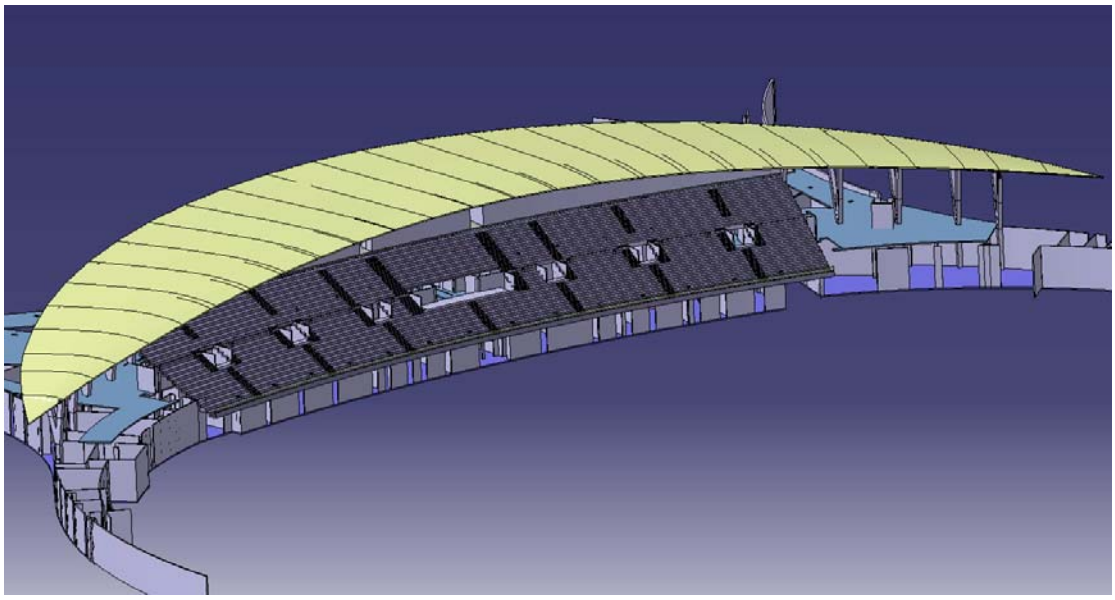


Figure 3: The 3D model of a spectator stand

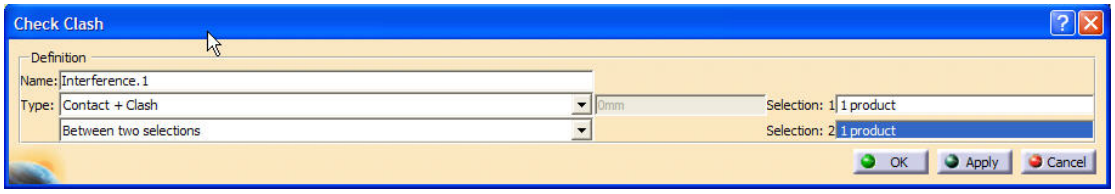


Figure 4: Checking design errors automatically

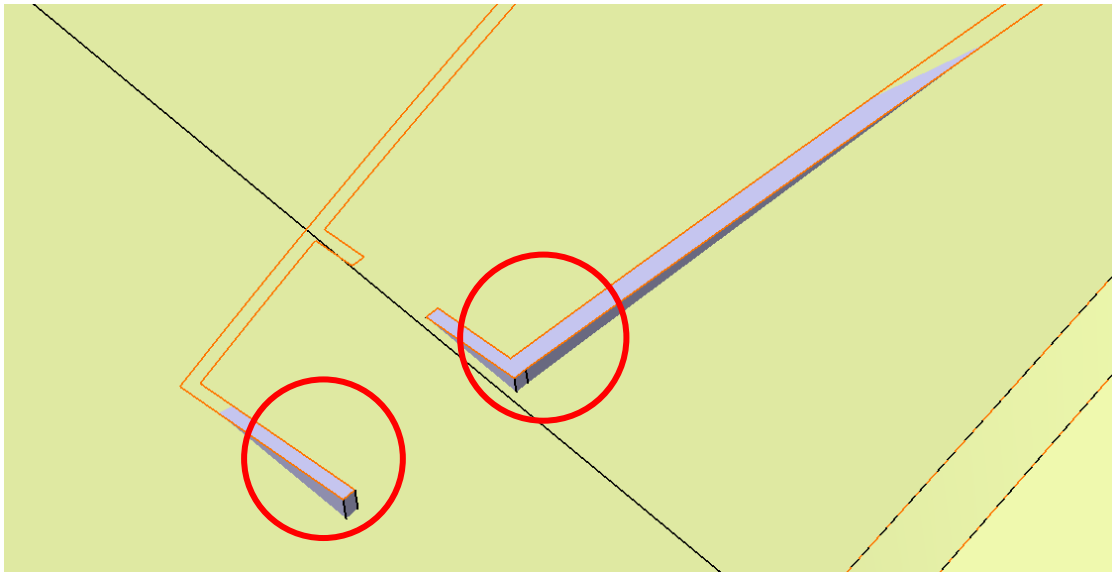


Figure 5: Clashes between roof and partitions

After finding the design errors, all participants can discuss and modify them in the 3D main model.

3.3 Modification of design

The process of design can be illustrated in Figure 6. In order to improve the efficiency of design, all the design errors detected must be modified rapidly. In the virtual environment, it is easy to modify these errors using Catia V5. When any element is modified, the 3D main model can be updated automatically. Figure 7 shows an example for modifying a column. To modify the length of this column type all that is needed is to edit the property “length” of the column. All instances of this column type are then modified automatically in the 3D main model.

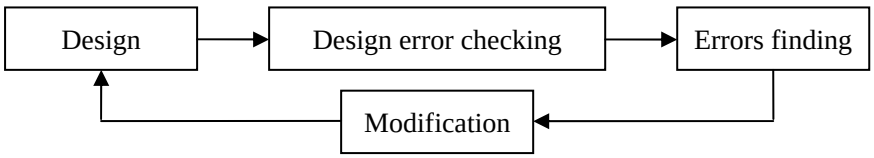
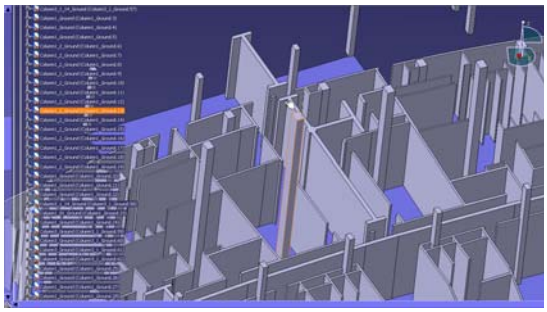
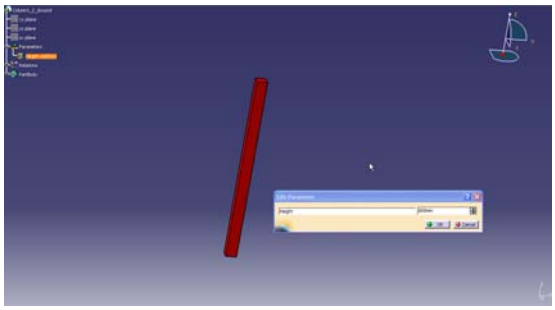


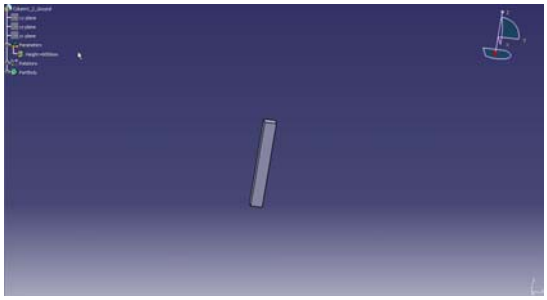
Figure 6: The process of design-modification



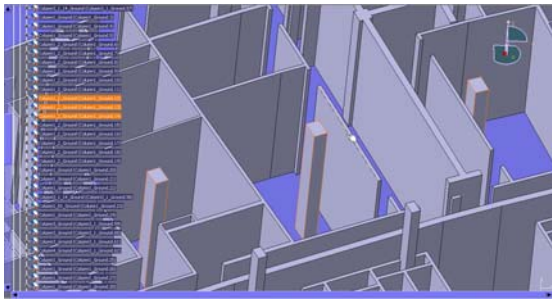
(1) A type of column to be modified



(2) Modify the property of the column



(3) The column modified



(4) The 3D main model updated

Figure 7: The rapid modification of design errors

An appropriate and detailed design plan is then developed through several cycles of design-modification.

4 Construction process simulation

The core idea of IKEA approach is to provide 3D instructions for the site workmen. The 3D instructions must comprise a detailed and appropriate construction sequence. As mentioned earlier, the construction sequence of a construction project cannot be repeated in a real environment and must therefore be tested in a virtual environment. This is the aim of construction process simulation and its procedure is shown in Figure 8. Based on the above-presented design, the simulation of construction process is conducted in a virtual environment using the Delmia V5 software product.

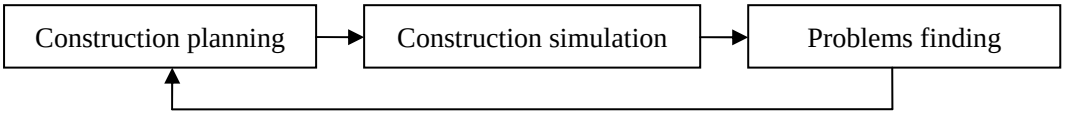


Figure 8: The process of construction planning-simulation

4.1 Test of construction sequence

Through simulating different construction sequences using Delmia, their feasibility can be analysed, including collisions, conflicts, safety, etc. As an example, Figure 9 shows the simulation of construction sequence of a V-column installation. Here, it is obvious that the temporary support is outside of the first-floor slab and therefore the

construction sequence is not feasible. Similar instances can also be identified and the construction sequences modified until all of these problems are solved.

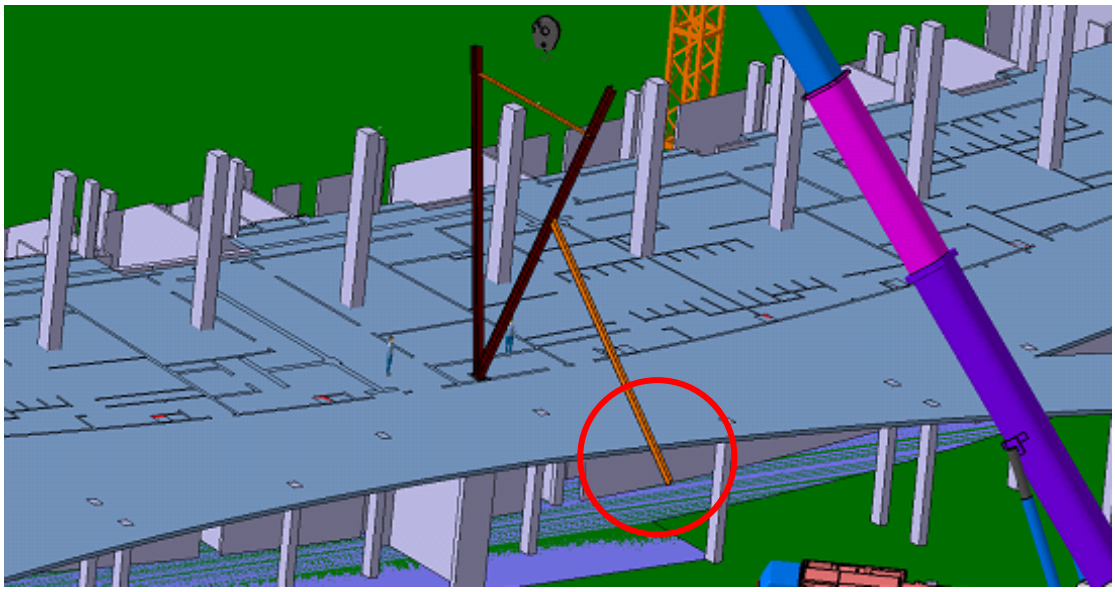


Figure 9: The simulation of V-column installation

4.2 Optimization of construction sequence

Feasible construction sequences, including resources levelling, sequence reordering, etc., may be optimised further. By adjusting sequencing, construction time may be reduced and, via resources levelling, construction cost saved. Figure 10 shows the schedule for installing a V-column.

By testing and optimising the construction process, an appropriate construction plan is eventually developed. This provides the guideline for compiling the IKEA-like 3D construction instructions.

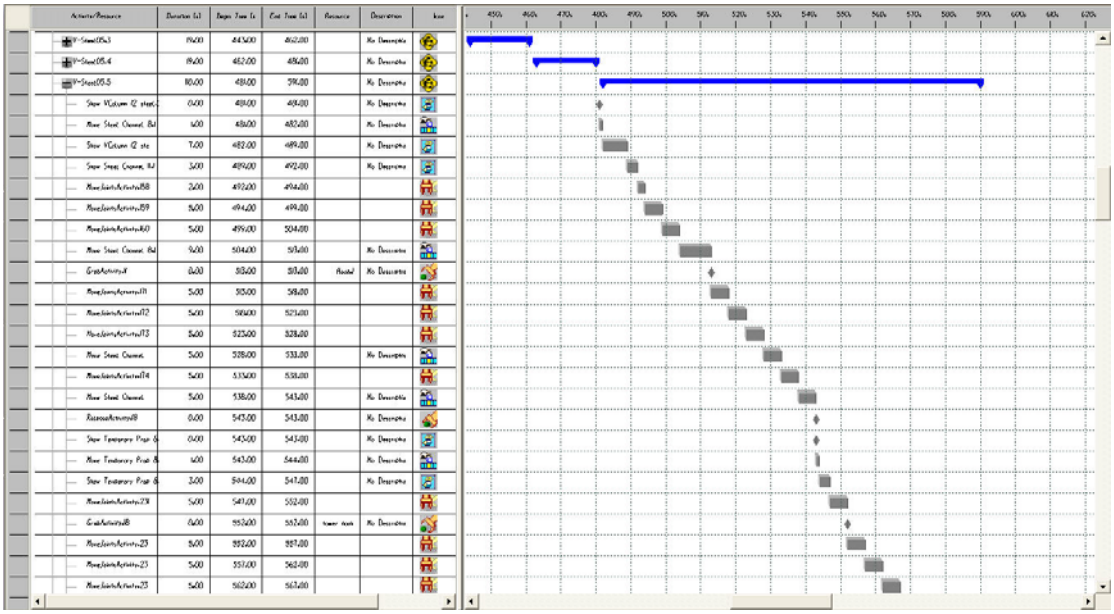


Figure 10: Schedule of a V-column installation

5 The IKEA approach to construction project management

Based on above-mentioned design errors checking and construction process simulation, an appropriate design and construction plan is identified. Following this, the IKEA approach to construction project management becomes possible, namely 3D construction instructions are developed. The process is illustrated in Figure 11.

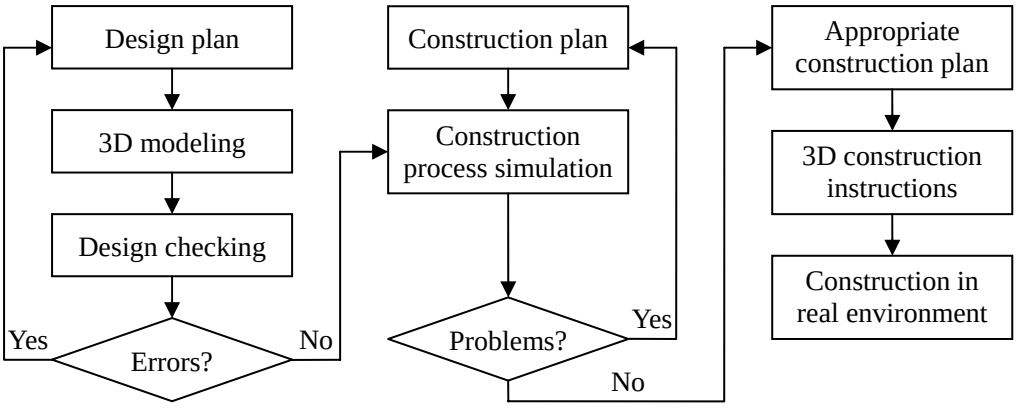


Figure 11: The flow of applying "IKEA" pattern into construction projects

The 3D construction instructions are step by step and very clear. Therefore, by referring to the 3D instructions, workers are able to work smoothly without the need for any other technical help.

6 Case study

The “V-column installation” of a construction project is taken as an example to illustrate the application of IKEA approach to construction project management. Firstly, related 3D models should be established, including V-columns, columns, slab, partition, etc (see Figure 12) using Catia. Secondly design errors are checked, for example the clash shown in Figure 13.

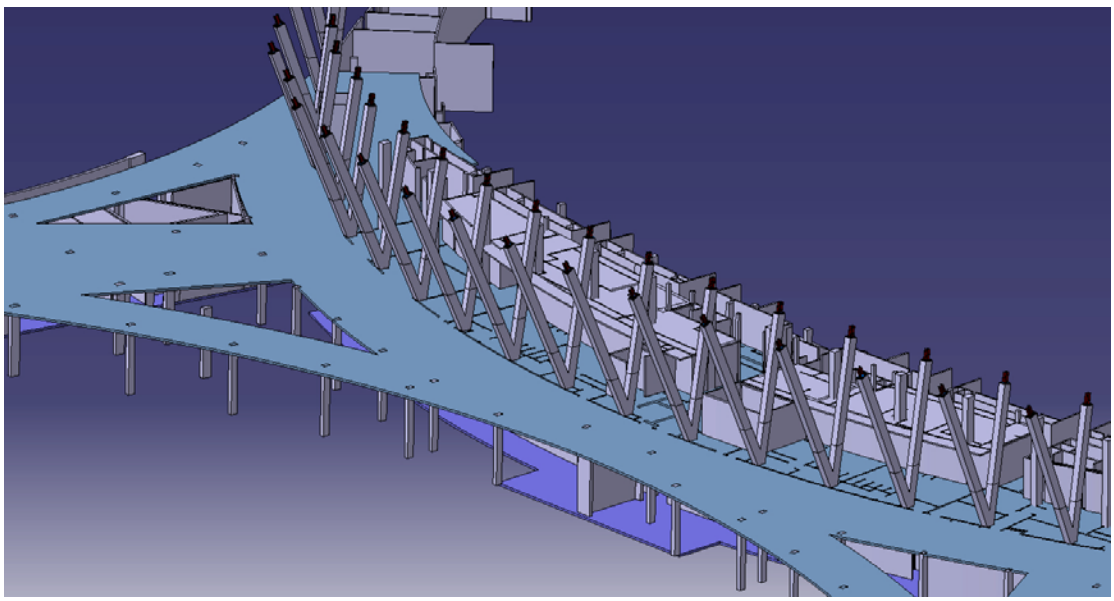


Figure 12: 3D models of components related to the V-column

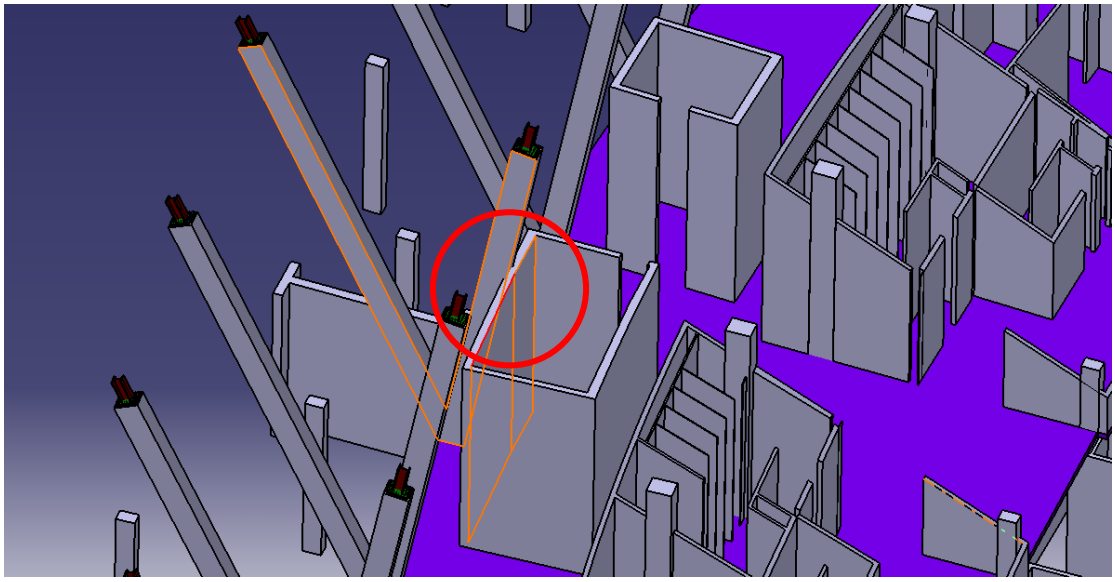
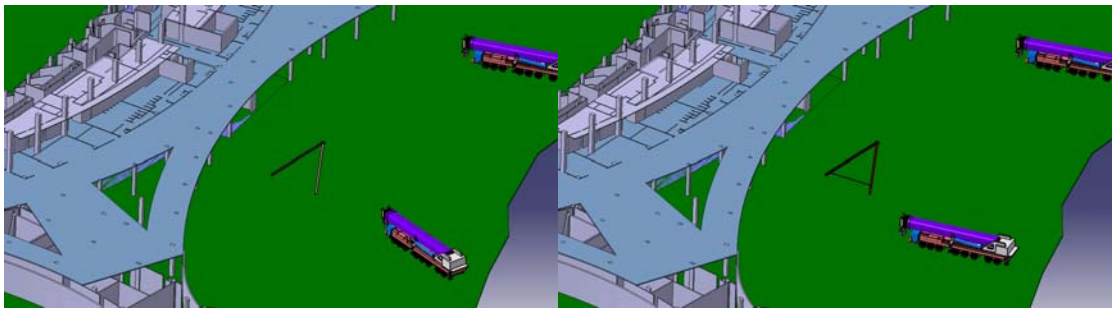
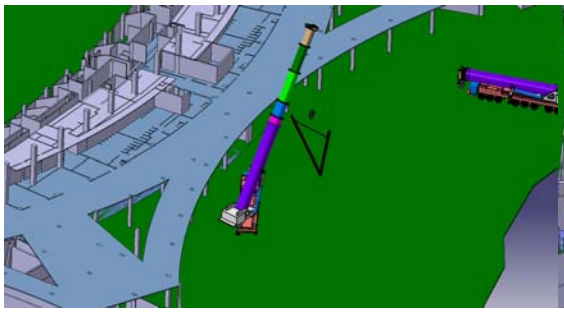


Figure 13: A clash between a V-column and partition

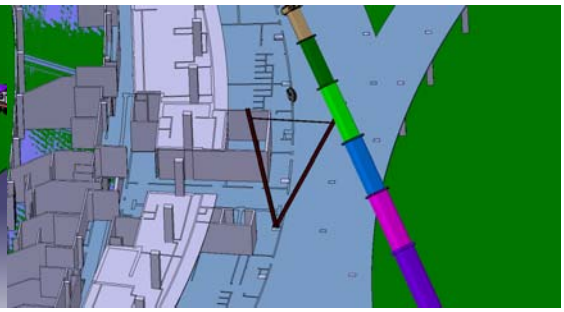
Thirdly these design errors are modified. The design errors are eventually eliminated after repeated design checking-modifications. Fourthly the process of installing the V-column is simulated with Delmia based upon the construction plan needed to make the process feasible. Some problems are found, for example the conflict shown in Figure 9. Fifthly the construction process is modified after discussions with sub-contractors. When all problems are solved, an appropriate process of installing the V-column emerges. Finally, the 3D instruction for the V-column installation is compiled as shown in Figure 14.



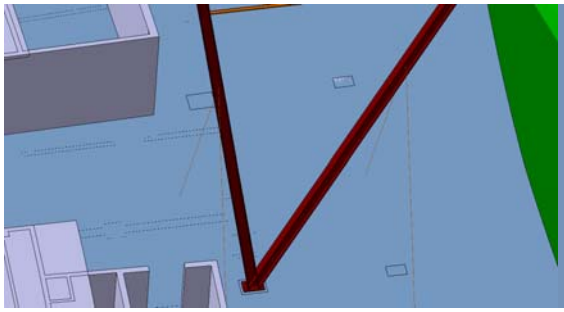
(1) Weld the UC columns of V-column (2) Install temporary steel channel

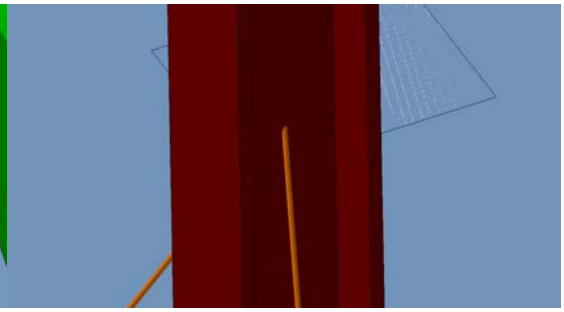


(3) Lift up V-column

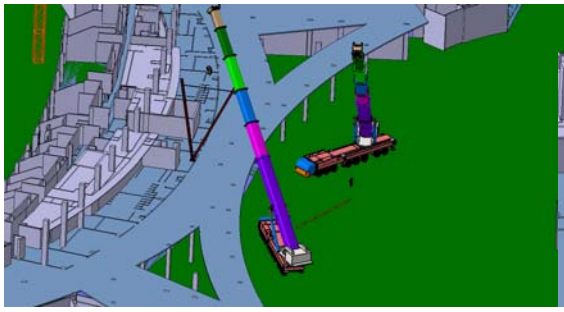


(4) Install V-column to the correct location

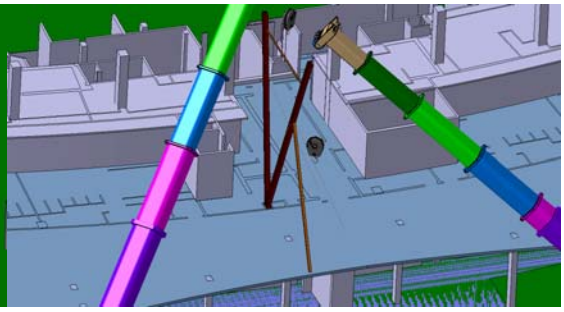




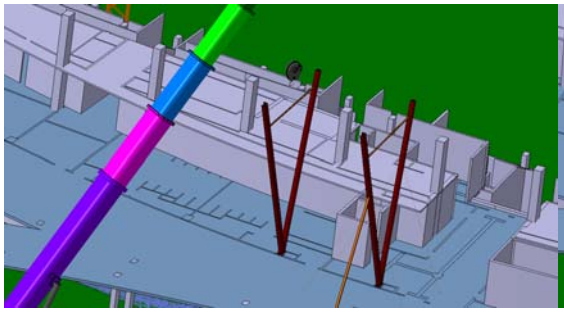
(5) Install temporary wire



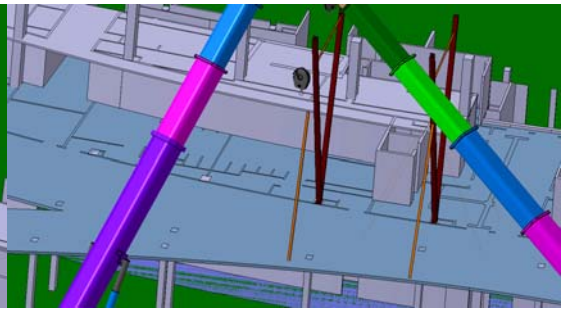
(6) Lift up temporary support



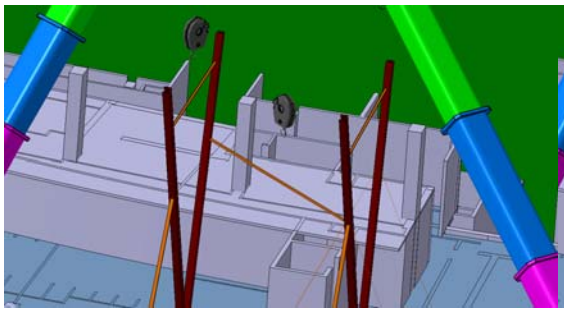
(7) Install temporary support

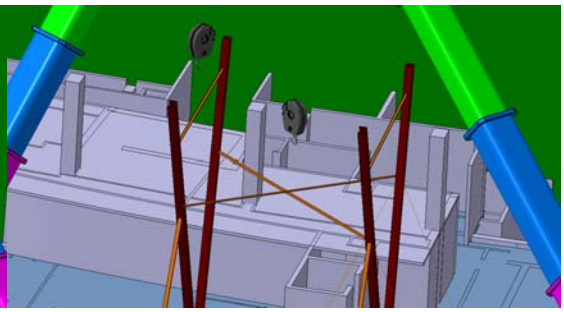


(8) Install another V-column

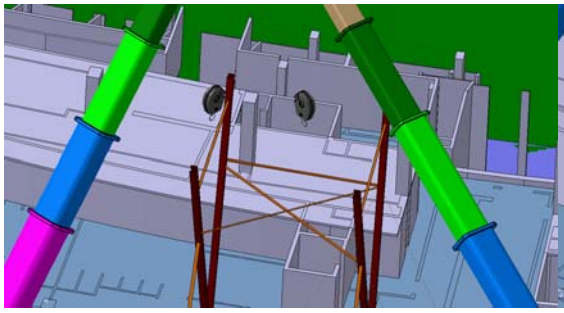


(9) Install temporary support

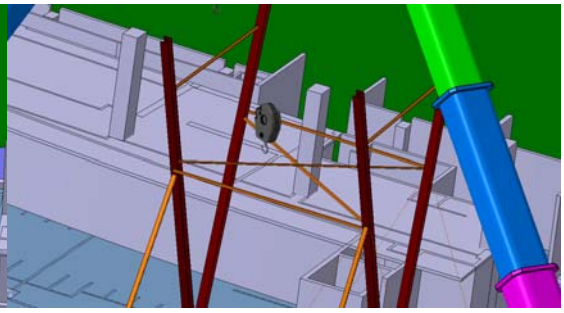




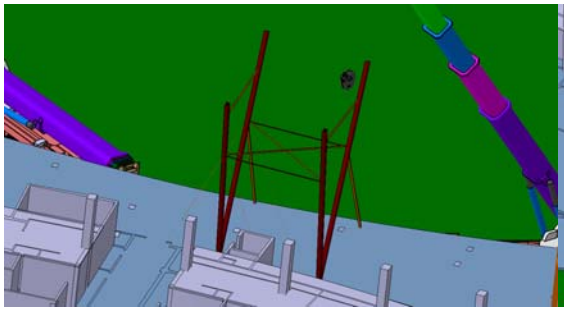
(10) Install temporary lateral bracing 1



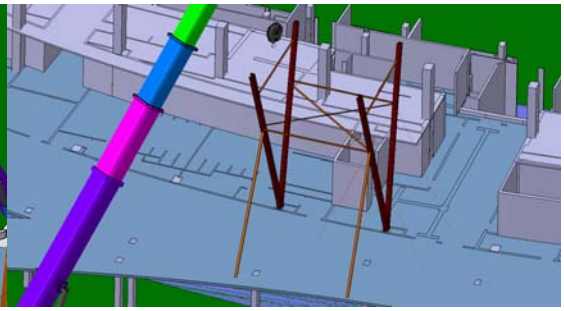
(11) Install temporary lateral bracing 2



(12) Install temporary lateral bracing 3



(13) Install temporary lateral bracing 4



(14) Two V-columns finished

Figure 14: 3D instruction of the V-column installation

As with the installation instructions for IKEA furniture, it is clear and easy for anyone to install the V-columns using the associated 3D instruction. This makes the installation process one of low cost and high safety. The development of the 3D instruction for the V-column installation indicates the IKEA approach with VP technology (Catia and Delmia) to be feasible for construction projects.

7 Conclusions

The new technology and management methods have led to gains in the efficiency of the manufacturing industry but have not been possible in construction due to the often

bespoke nature of construction projects. In order to enhance the efficiency of construction projects, the IKEA approach, as an efficient manufacturing and management means in the home furnishings field, may be introduced through adopting VP technology. Two key factors, design without errors and appropriate construction sequencing, were identified as being necessary for the implementation of the IKEA approach in construction project management using two VP software products, Catia and Delmia. The implications on the construction process were then summarised. From the case study it was shown that, when used in conjunction with VP, the IKEA approach may be suitable for use in construction projects to better instruct workers in their work.

It is believed that the application of IKEA approach in construction project management will improve the efficiency of construction projects and enhance the degree of safety of its workers. It is likely that design and build/construction projects, in particular, will be most amenable to the approach, which has the potential to revolutionise the way in which construction projects are undertaken.

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