



APPLYING MULTI-USER TECHNOLOGY FOR MODELING COMPLEX CAD OBJECTS

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Abstract. Complex CAD modelling occurring in engineering design and construction processes relies upon the effective management of teamwork where a variety of specialists work together on the development of one compound object that leads to the following issues which have to be dealt with in order to make this process time- and cost-effective: i) difficulties in exchanging technical information (including drawings) due to modifications in the CAD model; ii) difficulties in tracking modifications performed by other project participants; iii) difficulties in working with elements connected to another element already used by other participants; iv) assessment of various object versions. To facilitate these processes and manage the flow of technical information between project partners, multi-user technology is considered. It operates with a complex CAD object in the same way as an electronic archive system in engineering document management systems and offers a level of control over the information flow within the construction process.

Keywords: computer aided design, engineering document management, multi-user technology.

1. Introduction

The complexity of engineering CAD design and modeling requires the effective management of teamwork and internal collaboration across technical departments. The designed objects usually have a large and complex structure where various specialists have to simultaneously work on different elements of the CAD model. The elements in the CAD model are usually continuously modified at both early and later development stages leading to the consequent modification of properties and technical data (Apanavičienė, Juodis 2003).

Such development resulted in constant information exchange between project participants and with the assessment of different model versions can make the collaborative process between project partners rather difficult and introduce many mistakes. It is especially relevant when working on a complex construction solution for compound and multi-structured objects. Furthermore, failure to effectively locate and manage technical

information during a project may result in delays and incorrect decisions. To control over the information flow within the project team, multi-user technology is developed (Gabrielaitis, Baušys 2005).

Multi-user technology is developed to operate with complex CAD objects in the same way as an electronic archive system implemented in engineering document management systems (EDM). It offers the structure of the hierarchical linking of technical data and documents. EDM also offers standards for quality management and quality assurance along with technical information customizing and tracking. The features of quality system documentation are adopted by a multi-user technology, including information and data control requirements (Aspin *et al.* 2001).

2. Engineering Product Design Processes and Existing Technologies

The complexity of engineering design operations and internal collaboration required across engineering de-

partments are dependent on efficient CAD modelling processes and on the management of technical documents. The documents (including drawings) are costly to produce and hard to track since they are typically only of value as a part of a large complex set of documents. The consequences of using the wrong version of a document can be very serious.

In the CAD modelling process, the model and drawing are typically saved in one file that becomes huge in size for a larger project. As a result, the speed of design process is decreasing and team work on the same project becomes complicated and time consuming. File exchange of model elements is inefficient and might be difficult to apply due to many versions and modifications.

The existing technology that facilitates the design of a complex model is based on an external file reference (X-ref). The basic idea behind the technology is that before designing the complex model, a strategy should be developed to split up the model between project partners. The split part is placed in the external file X-reference which becomes a work place for the project participants. However, X-ref inserted into the model can only be reviewed (when X-ref file is open). The link between the source file and inserted X-ref is preserved and any modification made in the source file is uploaded into the model. This technology reduces the size of the model because only the 'image' of the object from X-ref file is used in the model. The typical X-ref hierarchy is presented in Fig. 1 where links between the model and X-ref files are depicted.

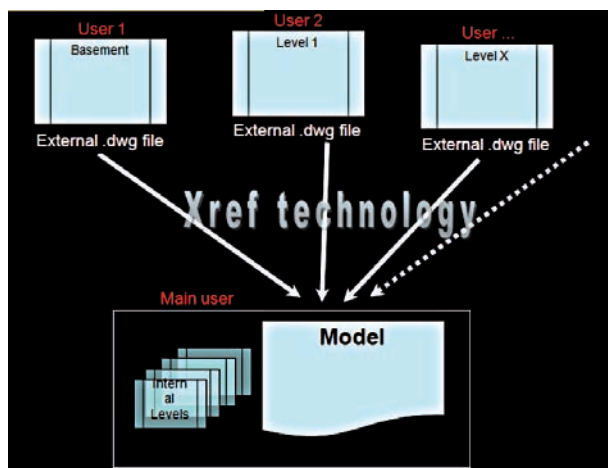


Fig. 1. Technology based on external file reference (X-ref)

This technology has been implemented to facilitate the design of multi-levelled buildings or constructions where the model is divided up level by level. This

technology permits to work separately on different levels and modify objects at the current level. However, objects, in our cases construction elements such as truss, steel frame, stairs or joints located at one level cannot be split up further. This technology is used in Architectural Desktop and AutoCAD Architecture with Project Navigator.

Thus, it can be difficult to work on a large and complex model located on the one level because it is not possible to divide it up into smaller or common construction elements.

The disadvantages of X-ref technology are as follows:

1. Splitting strategy of the model should be developed beforehand, which requires some experience.
2. Splitting the model is manually performed.
3. Experience and special measures are required when inserting X-ref into the model (it can only be done by a participant of the design process).
4. Rigid modification management process: the model cannot be modified any time. To change the model, a source X-ref file has to be modified first.
5. No control process over the current status of the working process and no version control functions.

To overcome difficulties in X-ref technology, multi-use technology was developed to offer control over the flow of technical information.

3. Engineering Document Management Systems (EDM)

This section describes the multi-user technology that has adopted the feature of an electronic archive system implemented in engineering document management systems (EDM) (Björk 2002). EDM has the following features:

1. multi-level hierarchical structure where documents are cascaded from higher to lower levels. When a version or contents of a document change at the parent level, it will affect changes in children levels. Hence, document control should provide change traceability from one level to another;
2. horizontal process and document linkages – internal collaboration across engineering departments. The flow of documents through the entire design processes is cross-referenced and linked to validate the quality of the process;
3. linkage between documents and product data – the documents act both as input to the processes

of product development (most product designs are driven by some kind of specification) and as output;

4. documents have various statuses and versions. When a document is developed, it passes through different product life-cycle stages with a specific status, e.g., reviewed, approved, distributed or obsolete.

According to the above-mentioned classification, document management tools have functions that enable (Rezgui, Debras 1996):

- Relationship Functions (Parent/Child relationship for assemblies and parts),
- Version Control Functions (Check In/Check Out), authentication Functions,
- Property Management (Linking properties, updating properties),
- Workspace Management (managing a local copy of CAD files and critical events); external document relationships, Excel spreadsheets, Word docs, PDFs, bitmaps); version Control Functions (Lock, Release).

The above-described approach is applied to control technical information when modelling a complex CAD object with a group of multiple users.

4. Multi-User Technology

The main difference between engineering document management systems (EDM) and multi-user technology is that EDM operates with a document and its properties while multi-user technology operates with the construction element in the CAD model (Kubicki *et al.* 2006). The properties and technical data in this case are attributed to a construction element or a group of construction elements. Multi-user technology adopted the above-described functions of document management and transferred them to a construction element.

This technology permits multiple users to navigate and interact in a shared virtual environment that facilitates the modelling process, especially when working on complex construction solution for compound and multi-structured models, such as presented in Fig. 2.

The basic features of the introduced technology are described below. First, the element can be ‘separated’ from the model (Figs. 3a and 3b) at any time without destroying the actual model and preserving its representative characteristics. Then, it can be modified and ‘returned back’ to the model. Referring to the characteristics of EDM described in the previous section, this feature is implemented through Relationship Functions (Parent/

Child relationship for assemblies and parts) and Version Control Functions (check In/Check Out) (Kubicki *et al.* 2006; Rezgui, Debras 1996). The attribution of properties to the construction element and the assessment of properties are implemented through Property Management (Linking properties, updating properties).

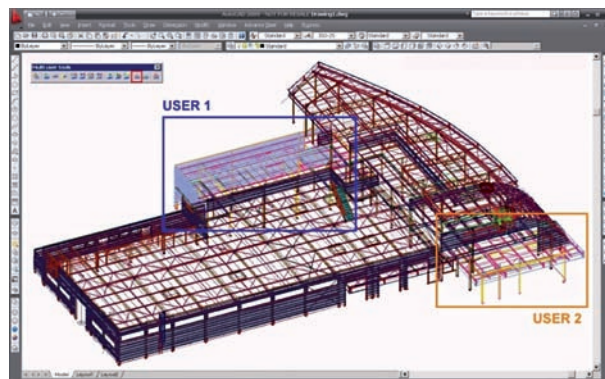


Fig. 2. Compound and multi-structured model adopted to use multi-user technology

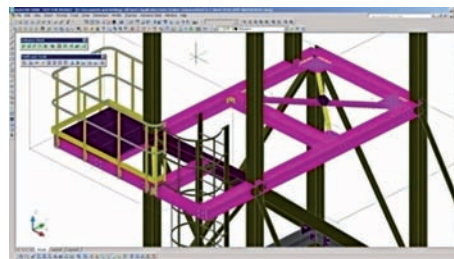


Fig. 3a. Project participant borrows an element from the model

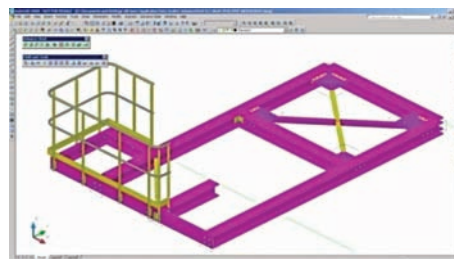


Fig. 3b. Project participant displays an element in his working environment

Moreover, multiple users can work on the same element. For example, several project partners can partially borrow (check out) the same beam in order to connect other beams to the common one (see Figs. 4a and 4b). This is managed through the Version Control

Functions (Lock, Release) and workspace Management functions.

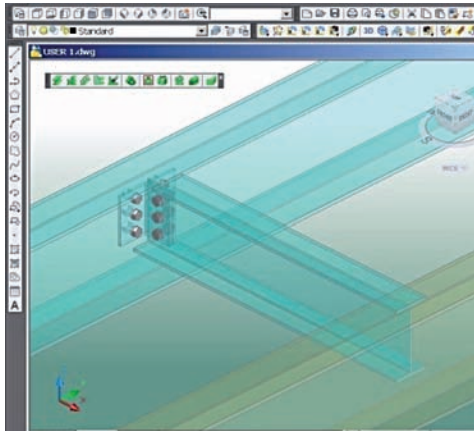


Fig. 4a. User 1 creating the Joint between the common checked out beam and left beam

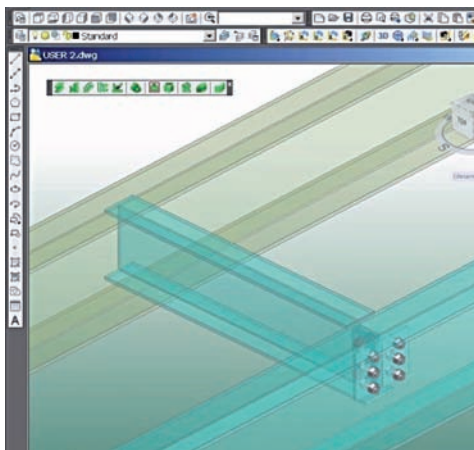


Fig. 4b. User 2 creating the Joint between the common checked out beam and right beam

The shared virtual environment in multi-user technology has the following features:

1. Control over the work process where project partners are informed on the real time of modifications made by another partner working on the same model; project partners can borrow (check out) a part of the model (i.e., element) and display only that particular element.
2. Several methods to check out elements. Project partners select the element graphically or use the search tool to find an element according to different criteria.
3. Partial check out of an element when the element properties can be viewed and accessed but

cannot be modified. Several project partners can partially check out the same element in order to connect other elements to the common one (see Figs. 2a and 2b above).

4. Security. Warning is presented if the selected element has already been borrowed by another participant. Warning is also issued if a model is being modified while some elements are still checked out.
5. Graphical information control. The graphical information is presented on who is working on which element. The elements checked out by a specific participant can be displayed along with the elements checked out by all participants.

This technology does not demand much additional preparation work or knowledge from a participant of the design process. A basic knowledge of engineering document management (EDM) systems is desired from a project leader. To start a multi-user session, the project leader initiates a new project of defining the project number. Besides this operation, in the vault of technical documentation, a new tree representing the structure of project documentation appears and the new project is initialized. Next, a designer creates settings common to all participants of the project embracing project settings, CAD properties and templates. This includes defining dimensions, layer style, text style and a selection of CAD standards. Consequently, project participants can start their work following their usual routine.

5. Implementing Multi-User Technology

The multi-user technology was tested during the implementation of team-based design for the complex oval shape of steel structure (Fig. 6b). It was constructed for a conference hall in Vilnius, Lithuania. The advantage of this technology was using the functionality of 'partial element check out' which permits to view and access the properties of a common element but prohibit any modifications. Two project partners including one working on the upper part of the oval steel structure (Fig. 5a) and the other - on the lower part of the oval steel structure (Fig. 5b) partially use the same element which is four legged steel construction.

The relationships between common and individual elements offer the possibility of working on individual elements connected to common elements and using their properties. Four legged construction was commonly used by both project participants connec-

ting the lower and upper elements of the oval structure. After the steel structure of the lower and upper parts were combined (Fig. 6a), the joining bars between both parts were designed (Fig. 6b). The design of the conference hall containing 8 tonnes of steel structure was performed by UAB *Butina* and work on implementing this object started in 2008.

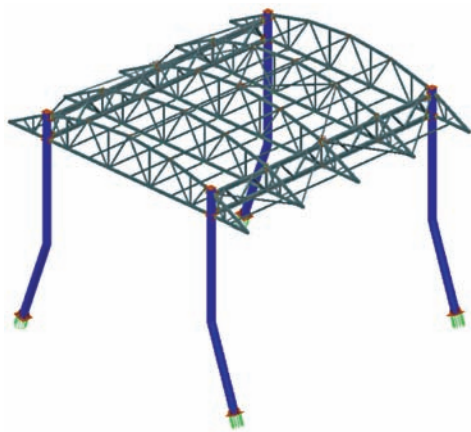


Fig. 5a. The first participant of the project has designed the four legged steel structure of the upper part of the oval

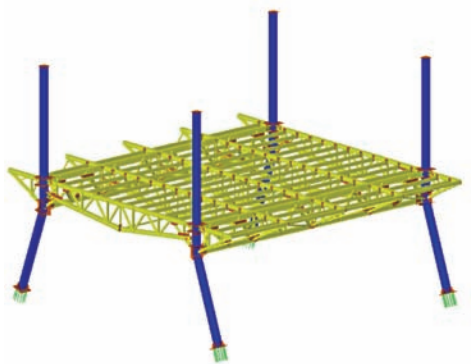


Fig. 5b. The second participant has designed the structure of the lower part of the oval

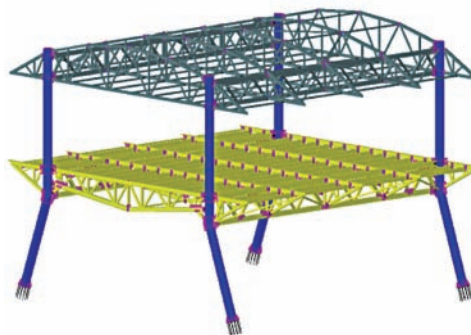


Fig. 6a. The steel structures of the lower and upper parts were combined

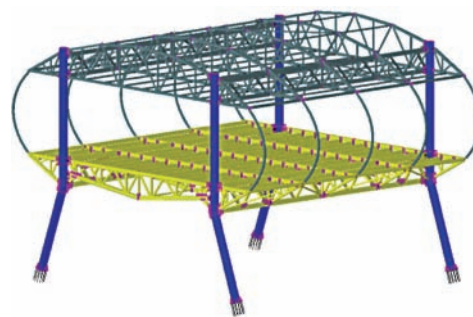


Fig. 6b. The final project

6. Conclusions

Multi-user technology permits multiple users to navigate and interact in a shared virtual environment where a construction element in the CAD model operates on self-determined bases. It can be ‘borrowed’ from the CAD model to work independently while preserving the representative characteristics of the actual model.

The complexity of engineering CAD design requires that relationships between construction elements and documents (properties and technical data) should be explicitly defined. These relationships create the possibility of integrating search to be performed along with version and property control functions.

The presented approach was followed during the implementation of team-based design for the complex oval shape of steel structure. It was constructed for a conference hall in Vilnius, Lithuania. The observed results indicated that obvious improvement was achieved not only because of transfer automation (CAD elements, technical information) between project partners but also due to the relationships between the construction elements and technical documents.

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„MULTI-USER“ TECHNOLOGIJOS TAIKYMAS KOMPLEKSINIAMS STATINIAMS PROJEKTUOTI

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Santrauka. Modeliuojant didelius kompleksinius statinius, efektyvus projektavimo procesas priklauso nuo komandinio darbo suderinamumo. Tiek vienos projektinės grupės projektuotojai, tiek atskirų projektinių dalių inžinieriai, dirbantys prie vieno didelio objekto, susiduria su tokiomis problemomis: 1) dėl CAD modelyje vysktančių pasikeitimų techninės dokumentacijos (brėžinių) apsikeitimo procesas tarp atskirų projektavimo grandžių yra sudėtingas; 2) projekto dalyvio įvesti taisymai laiku nerodo pasikeitimų; 3) sunku efektyviai projektuoti, jei vienas bendras konstrukcinis elementas arba objektas naudojamas atskirų projektuotojų; 4) versijų sekimas. Šio darbo tikslas – pateikti naujausią „multi-user“ technologiją, kuri leidžia valdyti projektavimo procesą tarp projekto dalyvių, vykdant kompleksinių statinių CAD modeliavimą.

Reikšminiai žodžiai: automatizuoto projektavimo sistemos, techninės dokumentacijos valdymas, „multi-user“ technologija.

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