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DIGITALIZATION AND USE OF BIM IN DAM PROJECTS

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ABSTRACT

Building information modeling (BIM) is now widely used in most of the larger construction projects in varying extent. Even though BIM is widely used, most of the BIM-projects still ends up with 2D drawings, based on a 3D model, as deliverables. Norconsult carried out their first fully integrated BIM-project, the Vamma 12 hydropower project (125MW), in 2015-2019. This project was constructed based on the BIM-model itself, without delivering of traditional 2D drawings. Vamma 12 led the way for several new larger hydropower project. All carried out based on the same workflow, improved in each project. Now we are moving on to smaller hydro power projects, dam projects and dam rehabilitation projects. Separate dam projects or dam rehabilitation projects may be less complex than larger hydropower project and may use smaller contractors, with less experience and less equipment for operating fully digital. Experience however shows that the most important factor has not been equipment or software, but rather the attitude and mindset of the parties, and the workflow and structure of the project. The role of BIM in projects are also changing. From being just a tool or technology, into being an integrated part of the whole project. BIM creates opportunities for everyone to participate and to get an overview of the project. From workers at site to dam owners and authorities.

1. INTRODUCTION

Traditionally, dam projects have been carried out using 2D drawings for construction and design. The development of 3D modelling software from the early 2000s led way for visualization, and later for fully 3D modelling with the intention of creating 2D drawings as deliverables. These “hybrid-projects” is still largely in use in the industry but has several drawbacks. One of them is the fact that you are creating an almost complete 3D model of your structure before you transfer the data into 2D drawings. The 2D drawings are then used to build the actual 3D structure at site. Transforming the structure from 3D to 2D and then back again to 3D increases the risk of losing information and the risk of faults. Revision handling of drawings is also time consuming and may increase the risk of faults as you must update both the 3D model and the 2D drawings for each revision. As a cause of this we thought why not use the actual 3D model for construction, skipping the use of 2D drawings.

Norconsult carried out their first fully integrated BIM project in the Vamma 12 hydropower project (125MW) in Norway from 2015. In the Vamma 12 project all construction and design where carried out using one common BIM-model for the project. No drawings for construction where created. This project led the way for several more fully integrated BIM hydropower projects using the same workflow, gradually improved in each project. By improving our workflow and with the increasing experience of our project teams, we could move on to carry out smaller hydropower projects, dam projects and dam rehabilitation projects. Our first fully integrated BIM-dam-projects were the Songa dam rehabilitation project for Statkraft, and the new Mjåvatn dam project for E-CO Energi, both projects in Norway. Following these projects, several new dam projects, and dam rehabilitation projects are stating up, based on the same workflow. An example of the BIM-model used in the construction phase of the new dam Mjåvatn is shown in the figure below.

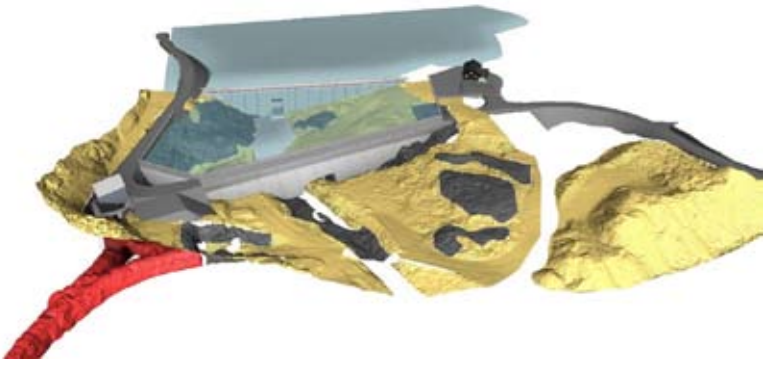

Figure 1 : Example of BIM-model from the new Mjåvatn dam and water tunnel, currently under construction for E-CO Energi in Norway. The existing dam, which is to be de-commissioned, is shown in the background

2. WHY BIM

2.1 The need for BIM in dam projects

The need for BIM on dam projects may be questioned by some, as one would think that a dam normally could be constructed based on only a few numbers of drawings. One might think that a dam normally follows a more or less straight center line, with the same or multiple cross sections which easily been shown on a few 2D drawings. This may be the case in some dam projects, but for most of our larger dam projects the situation tends to be more complex. In addition to more complex geometry, dams may contain gates, cable ducts, galleries, boreholes for grouting, monitoring facilities, control buildings, roads etc. The excavation of the dam foundation is usually also a significant part of the project that needs to be addressed. All this makes a dam project suitable for the use of BIM.

2.2 Control of cost and quantities

One of the most valuable assets of using BIM is the increased control of cost and quantities of the project. Most BIM-projects rely on continuously and accurate scanning of the project area as input into the BIM-model. With continuously scanning of the project area the elements of the BIM-model can be adjusted based on the scanned terrain during construction This has caused less uncertainties and discussions regarding quantities and cost. The scanned data is also valuable for continuously evaluation of the at-site conditions for the design team.

The elements of the BIM-model can be coupled with the corresponding items in the bill of quantity (BoQ). The elements can also contain measured quantities such as volumes, areas, numbers etc. This makes it easier to address the correct BoQ item for the different works, as well as making the whole payment and settlement process more effective.

As the project moves forward the BIM-model is usually updated with the latest changes, and when an element is finalized at site, the corresponding element is set to “as built” status. Progressive payment and settlement of “as built” elements during the projects can save a lot of time and discussions in the final settlement of the project.

2.3 Easier access for all parties

By using a BIM-model instead of multiple drawings one creates a lower threshold for new members to get an overview of the project. The threshold for using the software to navigate in the model may be big for some, but the assets when you are being able to navigate in the model can be big. Parties that are only briefly entering into the projects at different time intervals, such as authorities, company managers, external parties etc. does not necessarily have to use the model them self, but will get a much faster overview of the project when the model is used in communication and discussions.

2.4 Visualization

Landscaping around a dam site and the final visual look of the dam, including its surrounding, is an important factor of a dam project. The BIM-model itself gives a much better visual understanding of how the project will look when it is finished, than traditional 2D drawings would do. This “free” visualization model if a part of any BIM-project. The BIM-model can also be used in different landscaping and visual software tool to present a more realistic model with plants, grass, correct colors, sun etc. After our experience, visualizations play a more and more important role in the communication with external parts such as landowners, authorities and environmental NGOs.

3. PLANNING AND DESIGN

3.1 Structure the model and the project

After starting our first BIM-project we soon realized that the model structure (model tree) plays a very important part of navigating in the model and in the project. The same applies for the naming and identification of the different elements and structures. A good structure and naming from the beginning of the project is essential. We see that using the same structure in the BIM-model as in the whole project is very beneficial. Sufficient time should be set a side in the start of the project for planning the structure and naming of different components of the project.

3.2 Level of detailing

The correct level of detailing of the model is an important exercise. If you model all the details of the project you may end up with a very time consuming and costly design phase. This may not be in the interest of the dam owner and not necessary for the contractor to carry out their works. It is important to advice with the contractor on which level of detailing that is necessary for the different types of works. At the same time, one must also bear in mind that the level of detailing should be sufficient for use in the final documentation of the project. Supplementary documentation, detail sheets and direct communication at site may be more efficient for some works of the project. An example of the typical level of detailing for a dam section is shown in the figure below.

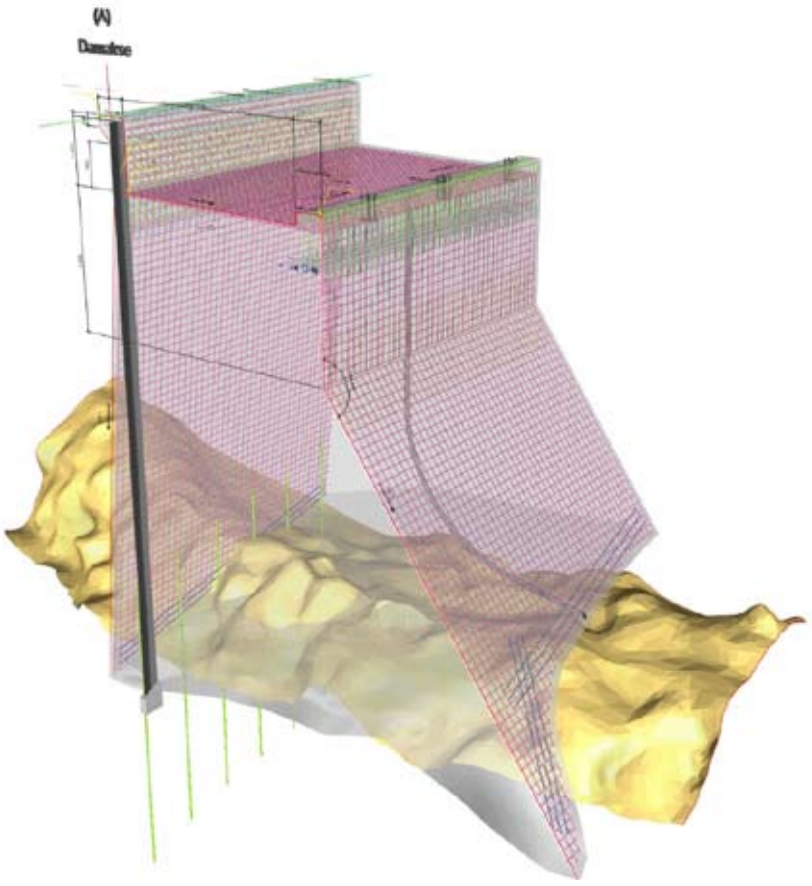

Figure 2 : Typical dam section of the new Mjåvatn dam in Norway with con-crete, reinforcement, grouted rock bolts and embedded parts.

3.3 Early stage design

An early stage BIM-model can be established in the planning phase of the project for evaluation of different alternatives, and for preliminary design. This can be very beneficial for the project as all parties gets better opportunities for evaluation the different alternatives and preliminary design.

3.4 Design team

Important factors of a BIM project are not limited to the software, workflow and structure of the project. The skills and encouragement of the project team members are just as important. Correct use of resources for the right tasks are important. Senior engineers may have greater experience in design and construction, while the younger generation tend to learn new software faster. It is important to utilize the best of all generations, and to give appropriate training for each team member. We experience that BIM is being a more and more integrated part of the design. Frequently collaboration between the modeler and the other team members is important as the design is being made in the BIM-modeling process. Making the BIM-model available for everyone is also important and creates ownership to the project. This also demands more skills and experience from the modeler.

3.5 Optimization

Better optimization of the different elements in the projects is usually achieved through a BIM-model because all major elements of the project are modeled in 3D and merged into one common BIM-model. Volumes and quantities can be optimized to the scanned terrain, and faults and collisions can be discovered in an early stage of the design to avoid disruption of the contractor's progress at site. After our experience less faults and collisions appear in projects based on a fully integrated BIM-workflow than in projects based on traditional 2D drawings. For dam projects collision control between hydromechanical contracts and civil contracts is one of the most important.

4. CONSTRUCTION

4.1 Contractors workflow

Contractors have different approaches to BIM-projects, depending on their skills and experience, as well as the size and location of the project. In general, the surveyor plays a more central role than before. Both in setting out from the model and gathering correct and frequently updated data from field. A dedicated and competent BIM-coordinator is essential to harvest data from the model, and to coordinate incoming and outgoing data to and from the site.

The enthusiasm for new digital tools among the contractor's staff varies a lot, as for the other parties of the project. While some may be reluctant to change, other may be enthusiastic. Forcing all workers and foremen to learn a new software and to be able to harvest data from the model may cause irritation, confusion and disappointment for some, while others tend to be very enthusiastic.

To achieve success for the contractor it is important to have managers which believe in the new workflow, and that are encouraging their work force in using the model. Let the enthusiastic players play the other players good, rather than forcing everyone to learn a new skill.

4.2 Tools and equipment

In our first projects, contractors startet to use tablets in field, such as iPads, RoughPads etc. The investment in tablets for the contractor can be significant, and their lifetime can also be limited in rough weather conditions, which is usual for dam projects in Norway. The contractors in the latest projects have tended to use one or several BIM-containers at the site, containing a computer with the software and model, set up in a dry and convenient environment. For smaller projects, a go through of today's work packages with the model in a morning meeting at the barracks may be sufficient. This is typical for many of our dam projects which can be limited in size and located in varying climate and weather.

For ground works such as excavation, drilling and blasting, backfilling etc., the data from the 3D models is usually transferred to the machines (excavators, bore rigs etc.), either directly, or by converting the data into the appropriate formats. Experience shows that the data, when used correctly, gives a very accurate execution of the works. There have been little discussions regarding the use of digital data and 3D models for ground works in general, and it has been in use for many years already and is known in the industry.

5. FINAL AND AS BUILT DOCUMENTATION

5.1 Final documentation of the project

When the project is finished the last revision of the BIM-model is regarded as the "as built"-model. The model can be saved in an archive in correct format for use in later works on the dam, or when necessary, for dam reviews or inspection. Some client may also want some drawings with overview of the dam. This could typical 2-3 numbers of drawing containing plan and typical sections. These drawings may be needed also in an emergence situation and may also be demanded by authorities to have in house. The few numbers of overview drawings can be created directly from the model with few additional adjustments.

5.2 Coupling with O&M software.

Possibilities for coupling the BIM-model with operation and maintenance planning software (O&M software) and are under development. This could be very beneficial for dams belonging to hydropower plants, drinking water treatment plants, factories or other process industry. Sensors, instrumentation and gates could be coupled with O&M software for monitoring and operation. Planning of inspections and maintenance, as well as storage of documentation and drawings may be combined in an O&M software.

Figure 3 : Borehole contours based on the BIM-model shown on a display in a tunnel rig. Example from the new Mjåvatn dam and water tunnel in Norway.

6. CONCLUSION

After our experience BIM-model workflow is very suitable for medium to large dam projects. For smaller dam projects, a fully integrated BIM-model may not be suitable until the workflow is further optimized. The attitude and mindset of the parties in the project, together with the workflow and structure, are important factors for success. The role of BIM is also changing from being just a tool and technology, into being a more integrated part of the whole project.

BIM creates opportunities for everyone to participate, and to get an overview of the project. It can be challenging to get all parties of the project to learn a new software and start using the model themselves. This is not necessary, as one can participate in meetings and collaborate with other team members which are handling the model. This can create a stronger ownership to the project for all generations and disciplines.