Schils HPP, a Pilot Project: Coordinated in BIM and executed without drawings

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Executive Summary

The «Energiewende[1]» in Switzerland is leading to the necessity for numerous adaptations and expansions of existing hydroelectric power plants. The aim is not only to increase the energy production from renewable energy, but also to introduce new digitalization approaches in the design and implementation phase.

The renewal of the 100 year old Schils Powerplant in Switzerland is a pilot project for the application of Building Information Modelling (BIM) in hydropower. For a hydroelectric power project, this is the first time that the entire coordination and BIM2Field are consistently implemented in BIM.

For coordination, the BIM method offers a new form of cooperation for all parties involved (client, designers, equipment suppliers and civil contractors). This means they can jointly develop and coordinate the digital models of the power plant before construction begins.

By using the BIM method, problems are detected early on. This increases reliability in design, and reduces problems detected on site and changes during execution, which results in less change orders and greater reliability in scheduling and cost.

KW Schils is one of the first construction sites in Switzerland where model-based construction is used and no paper drawings are needed or produced. The models for excavation, retaining wall, formwork and reinforcement are uploaded into the cloud and used directly by the contractor to construct the power plant.

This article explains the experiences gained by using this approach and the methods tested in practice for the design and construction coordination using the BIM method and for BIM2Field on the basis of the pilot project KW Schils.

1. Renewal of the Schils Powerplant

The SAK (St. Gallisch-Appenzellische Kraftwerke AG) Schils Powerplant will be the third-largest hydroelectric power plant, after renovation is complete, in the canton of St. Gallen, Switzerland. The structural modifications will increase annual production by around 20% to 48 GWh. One of the intakes, the high-pressure penstocks with 500 m head and the powerhouse in Flums with two Pelton units with an installed capacity of 14 MW are being completely rebuilt.

The upgrade of the 100-year-old Schils Powerplant is a pilot project for the application of Building Information Modeling (BIM). For the first time for a hydropower project, the entire coordination between all parties involved and BIM2Field are consistently implemented in BIM. While this applies to all new-built structures, this article focuses on the powerhouse.

[1] The Swiss Energiewende essentially comprises of 3 fundamentals (1) exiting from nuclear power production, (2) increased reliance on renewable energy, and (3) improved efficiency of existing power generation sources and consumption

2. Coordination with the BIM Method

Design and coordination using the collaborative BIM method was carried out for the powerhouse in the summer of 2019. The complete powerhouse was developed together with the client, designers, equipment suppliers and the civil contractor.

In the first part of the coordination phase, the focus was on the joint development of the powerhouse. The arrangement and design of the equipment, the static requirements of the civil structure, the requests of the client and the requirements for the execution were all coordinated together. In the second part of the coordination phase, the focus was on resolving collisions. In a first step this was done visually, in a second step it was done in an automated way. The attributes stored in the models, such as the name of the equipment, material of pipes, purpose of embedded parts or type of concrete, supported the coordination.

The following was key to successful coordination:

- Working with sub-models
- Model updates on a weekly basis
- Use of a software that manages so-called "issues"
- Collaboration workshops (so-called ICE sessions)

Over 60 digital sub-models are used in the powerhouse. Each party is responsible for the sub-models representing their scope. There is basically no overall model that covers the entire powerhouse. Rather, the various sub-models, which are all georeferenced and stored in the cloud, are displayed together in a viewer.

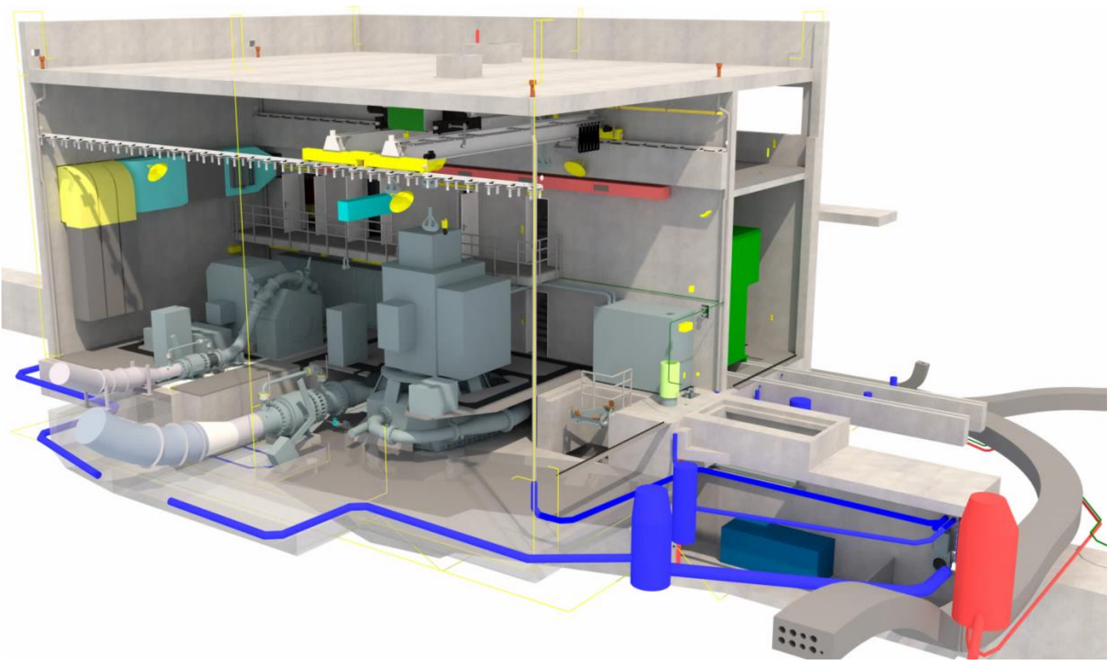

Fig. 1. The combined sub-models of the Powerhouse of KW Schils

The model updates are done on a weekly basis throughout the design phase. On a specific day of the week, all parties involved have to store their current design status in the cloud. From the following day on, the updated sub-models are available to all other participants. The outdated models are stored in the archive, which ensures the traceability of changes.

On the one hand, the coordination was carried out by collaboration workshops, so-called ICE sessions (Integrated Concurrent Engineering), and on the other hand by software. The latter allows the recording and management of so-called "issues", which include collisions, change requests or possible problems. Parallel to the scheduled model updates, these issues are processed and updated by communicating adjustments to the models or suggesting alternative solutions. All parties involved in the issue must then check the solution in the models and approve the solution found before the issue is closed.

The simpler issues are dealt with by software only, the more complex issues are dealt with by ICE sessions. All parties involved are present at the ICE sessions, and advantages and disadvantages of proposed solutions can be directly and efficiently discussed. Quite often new ideas emerge which lead to improved solutions.

Fig. 2. An ICE session in the BIM-Lab at AFRY in Zurich

In this way, civil structures and equipment are gradually refined and coordinated. The aim of the coordination phase is to ensure that all interfaces between structures and equipment are coordinated. At the end of the coordination phase, the concrete outlines of the civil structures, including all block-outs and embedded parts, are finalised.

From this point on, the detailed design is carried out by equipment suppliers and designers. For example, detailed structural calculations are executed and reinforcement models are created. At the interfaces, changes are only permitted in "emergencies".

Some of the demonstrable advantages are that the BIM method simplifies the coordination of interfaces between the various parties involved in the project.

In addition, many issues can already be identified and solved with the help of the model during the design phase, as coordination is carried out earlier and in more detail. This increases reliability in design, and reduces problems detected on site and changes during execution, which results in less change orders and greater reliability in scheduling and cost.

Without BIM, such issues would most likely arise later on at the construction site and would have to be dealt with using the limited remaining options that would then still be available. This would most likely lead to delays and cost overruns.

3. BIM2Field – the Model Based Construction Site

After the design stage, the construction activities at KW Schils were also completely digital. Once coordination was complete, the detailed models for excavation, retaining wall, concrete outlines and reinforcement were prepared for the construction site from the AFRY office in Zurich .

Via cloud, these models were synchronised directly to the construction site in Flums, and from there to the equipment of the civil contractor, STRABAG.

The work preparation takes place in the main office of the contractor and in the site offices of the foremen. The various models can be analysed in detail on the computer. Rather than walk around site with rolls of drawings the site foremen can simply use their site computers or a tablet, onto which all the models and information needed is uploaded.

The model for the first stage concrete was further used by the civil contractor, for example to design the model-based formwork. Formwork elements including supports can thus be optimally assembled and delivered to the construction site with no changes and at the right time.

The models for the excavation are loaded directly onto the computer in the operators cabin on the excavator. Thus, the excavator bucket can be precisely navigated by the machine operator using the model as a basis.

Fig. 3. Total station and tablet in use for staking out the retaining wall

Stake-out points are still required for placing the formwork, for positioning embedded parts in the concrete, or for placing the anchors of the retaining wall. Rather than measure such points by measuring tape, these points are prepared directly from the model and synchronized with the total station. If a point is selected on the total station, its laser pointer indicates precisely where it is located.

Fig. 4. Placing the reinforcement – in the foreground of the picture: a tablet with the reinforcement model

The reinforcement models are loaded directly onto the foremen's tablets. The reinforcement bars can be displayed layer by layer and the necessary information can be displayed for each stage of the work.

To date, not a single drawing has been published for this construction site. One of the advantages is that as no execution drawings are produced, there is no loss of information between the design office and the construction site. All required information is transmitted digitally throughout and is immediately available to all parties everywhere. With the permanent use of digital models, all information is always up to date, there are no inconsistent drawings and misinterpretations of drawings are avoided.

4. Summary

The pioneering example of Schils Powerplant demonstrates that BIM can be applied in hydropower engineering and that the consistent implementation of BIM results in significant advantages, both for coordination and for execution through BIM2Field.

Especially in powerhouses of hydropower projects, where typically a lot of equipment has to be coordinated and to be placed and integrated in a limited space, the BIM method provides significant added value for the client.

By applying the BIM method, issues can be detected early on, conflicts can be resolved before they come to site, changes during execution are significantly reduced, which results in greater reliability in scheduling and cost.

New and innovative approaches were taken at the Schils Powerplant - but the potential of BIM was far from being exhausted. It will be interesting to see how BIM will change the design, execution and operation of hydroelectric power plants.

5. Film "From Collaborative Planning to the Model-Based Construction Site"

A film was produced covering the topics of this article. The film gives a very close and illustrative insight into the topics BIM method and BIM2field. The link to the film is: https://youtu.be/VazMPkP8CoE

Fig. 5. QR-code to watch the film with any mobile device

6. Acknowledgement

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The Author

Gregor Heyer graduated as M.Sc. in Civil Engineering from the Swiss Federal Institute of Technology, Zürich and has nearly 20 years of experience in the structural & hydraulic designs of hydropower schemes and structures; in the preparation of feasibility studies, basic designs, detailed designs including tender documents, and construction designs of hydropower schemes; and in project management, project coordination and site supervision. Mr. Heyer has been responsible for assignments for hydropower projects, mainly in Switzerland, the Middle East, the Indian Subcontinent and South America. Recently, he has built up AFRY Switzerland's BIM competence in hydropower and has led the BIM project Schils as project manager and BIM manager.