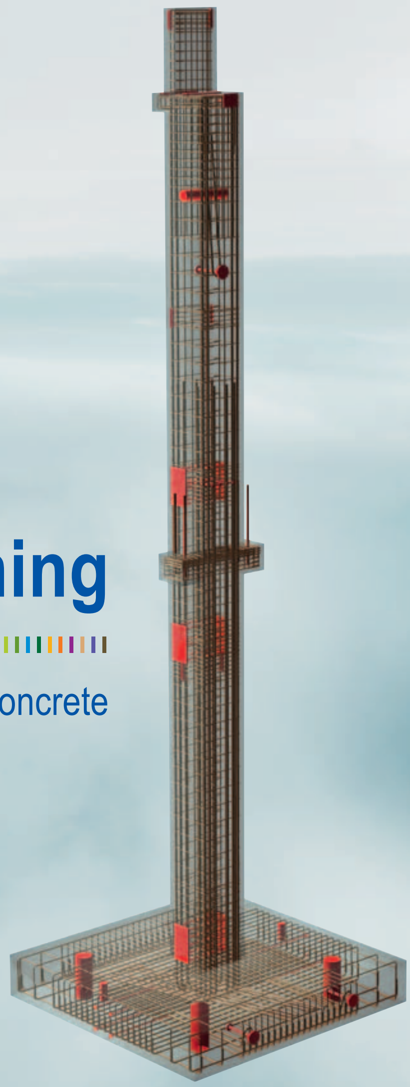
Industrialised Planning

in Reinforced Concrete and Prestressed Concrete Precast Parts Construction



This is a report from Dipl.Ing. Markus Molz and Günter Werle.
They tell us something about the first steps with Allplan Precast and planning with 3D, their experiences and perspectives.

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Industrialised Planning in Reinforced Concrete and Prestressed Concrete Precast Parts Construction

In this report, the introduction of 3D planning is explained, together with the creation of complex shop drawings, named "element plans", for reinforced concrete and prestressed concrete precast parts construction. The method used is based on the creation of a basic 3D volume model, which becomes a 3D model made of intelligent "elements" by adding attributes. After this, on the basis of the "element plan technology", these "iParts" become "verifiable" element plans with reduced planning time and high planning quality.
The side effects, such as 3D PDF for communication with the clients and other specialist planners, as well as the creation of machine data, like meshwelding maschines, is made possible from this and lead to higher acceptance by the project participants. The provision of 3D planning data via the Internet to the client is still unusual, but will presumably establish itself in the future.

1 Introduction

The tension triangle of time, quality and costs constantly faces the engineering offices with new challenges in the project; a reason to rethink and rearrange CAD planning. Putting it plainly, daring to take the step from 2D to 3D.

The claim: planning in 3D completely, right up to the execution planning. The goal: Generating added value from the 3D model and making it economically usable for the client, as well as for the engineering offices, as contractors.

Such a changeover requires the willingness to accept changes and make investments. Today, the authors can already forecast from the initial realised products that the path chosen was the right one and they see that this paradigm shift opens up opportunities.

2 Expectations of 3D planning

As an engineering office for the construction industry, the authors mainly work in industrial construction and have specialised in the creation of concepts, static calculations and overview/workshop drawings for reinforced concrete and reinforced concrete precast parts construction.

With the consideration regarding planning in 3D, they let themselves by guided by the desire for the component plans to essentially be generated automatically (element plans) after creating the building model.

Other aspects, such the being able to evaluate the building model according to all facets, providing it to planning partners and communicating better, were points from which they hope for direct and indirect advantages. Very pragmatic things, such as "verifiable" element parts with reduced planning time and at least the same planning quality, were their requirements.

3 Implementation and process for the new 3D planning

3.1 Initial experiences

The initial project experiences were of an organisational nature, as more information is required during the starting phase of a project for 3D planning than one usually receives. Therefore, the 3D model contains all specifications, such as recesses, fixtures for component connections, fixtures for technical systems in the building, execution details and the relevant installation aids, such as transport anchors, mounting pipes and cast pipes, etc. (Figure 1).

These days, this information is consistently requested by clients and the relevant specialist planners. For the information and details that are not clarified by the client's specifications, constructive solutions are proposed, which are generally accepted by the participants. Through this, the "support structure planners" can live up

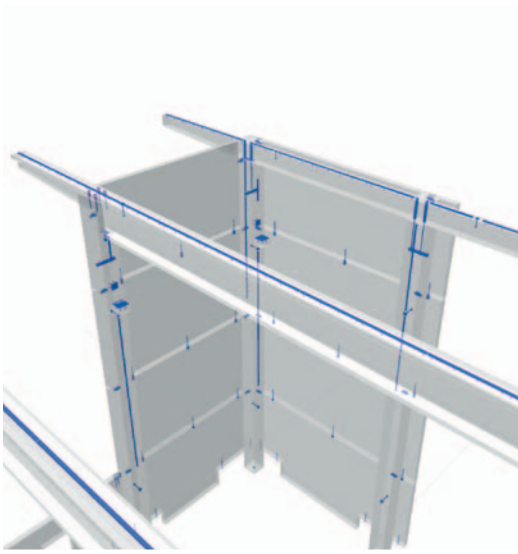


Figure 1. Extract from the model with all fixtures.

to their name and the task and deliver a building model early with constructive proposals, which leads to a positive response from the planners and clients. After all, the authors are willing to accept somewhat more effort at the start of the project, as they no know retrospectively that this time is made up for again with the preparation of the element plans. This is because the frequently difficult and hidden points emerge earlier on the basis of the 3D model and then can be solve significantly faster, better and more efficiently using the vivid display possibilities.

In the building meetings, a PC projector is used and the planning is discussed by presenting the virtual structure and providing the model to the participants as a 3D PDF. This 3D PDF is quasi a by-product. For the planning specialists, as well as for people without “plan reading qualifications”, this is an optimum means of communication. Anyone can use it, understand details immediately and directly embed comments or print out any 3D perspective and cross-section and supplementing it by hand or with the appropriate software (Figure 2“).

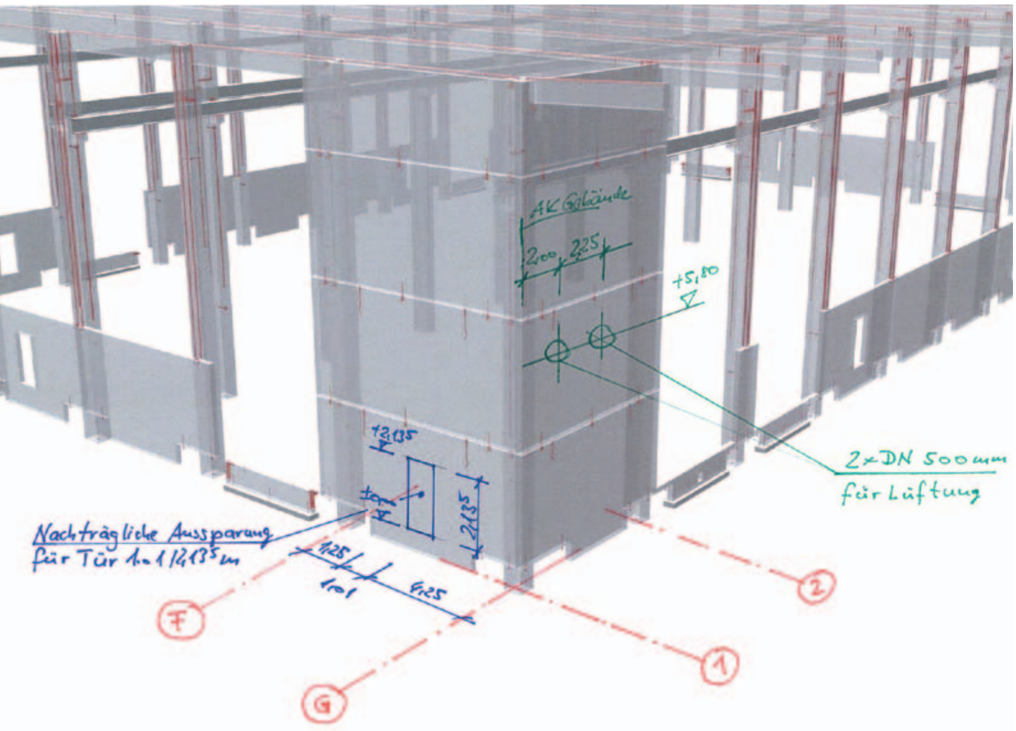


Figure 2. Extract from a 3D PDF with comments, made during a meeting with other specialists.

3.2 Automatic plans from complex components

From precast parts such as hollowcore, ceilings, double walls, it is known that the formwork and reinforcement drawings can be automatically created from an overview plan. So, why not model an entire building, completely or partially designed with precast parts, in order to then automatically have the element plans generated for the structural precast parts, such as supports, wall panels, prestressed concrete girders, support beams or prestressed concrete TT plates? Is automation able to generate readable and inspectable plans together with possibly required machine data for controlling laser projection systems, bending machines, mesh welding systems or shuttering robots? And how flexibly can changes be reacted to?

The requirements for this are not limited to basic parametrised components, as they occur in steel construction, for example. In fact, they are based on the complex components of reinforced concrete and prestressed concrete precast part construction, which are comprised of a conglomeration of reinforced concrete, steel bar, mat or prestressed steel reinforcement and fixtures. As the structures are becoming more and more complex in terms of design and the situation of building onto existing structure/ into existing voids tends to be the standard today, the key requirement for the software is the greatest possible flexibility and efficiency. The answer to these questions are 3D elements, which can be converted into so-called iParts after modelling from any volume models or predefined, parametrised components, such as supports, wall panels or prestressed concrete girders. In the further planning process and the creation of a model, the creator adds fixtures and other characteristics to these iParts, thereby allowing them to become intelligent components. Regardless of what a component looks like – iParts then automatically creates plans. When the building is completely available with its elements in 3D, one obtains an element plan, with all of the necessary information for a ready-to-build plan, at the push of a button. The automation initially supplies this “readable” plan (Figure 3).

One also has the possibility of dealing with the biggest problem in the planning process for support structure designer, the frequent changes by the specialist planners involved, as well as the client, in a much more relaxed way.

The reason for this is that with the element plan technology explained above, it is possible to carry out the changes either on the finished 3D model, with automatic transfer to the element plans, or on the finished element plans with automatic transfer to the 3D model. The result is identical, however, the effort is partially significantly less. Therefore, a real advantage is created, compared to working in 2D.

However, the more complex the parts become, the more this plan will need to be supplemented and revised. In addition to the model, another “2D plan” is now available on the screen. The major advantage is that this can be processed using CAD, as usual. Now, the question naturally arises of what happens to these changes or additions, which are carried out in the “2D plan”. So far, one knows that after exiting from 3D from the plan, no possibility exists to return to the model.

This is one of the reasons why 3D has not established itself so far in execution planning. This problem is solved with the element plan technology. Regardless of where one is working, in the model or in the element plan – the information is simultaneously carried along in each display. It is therefore not a one-way street, but rather, one can work in both directions. For example, the authors designed their reinforcement plans this way (Figure 4).

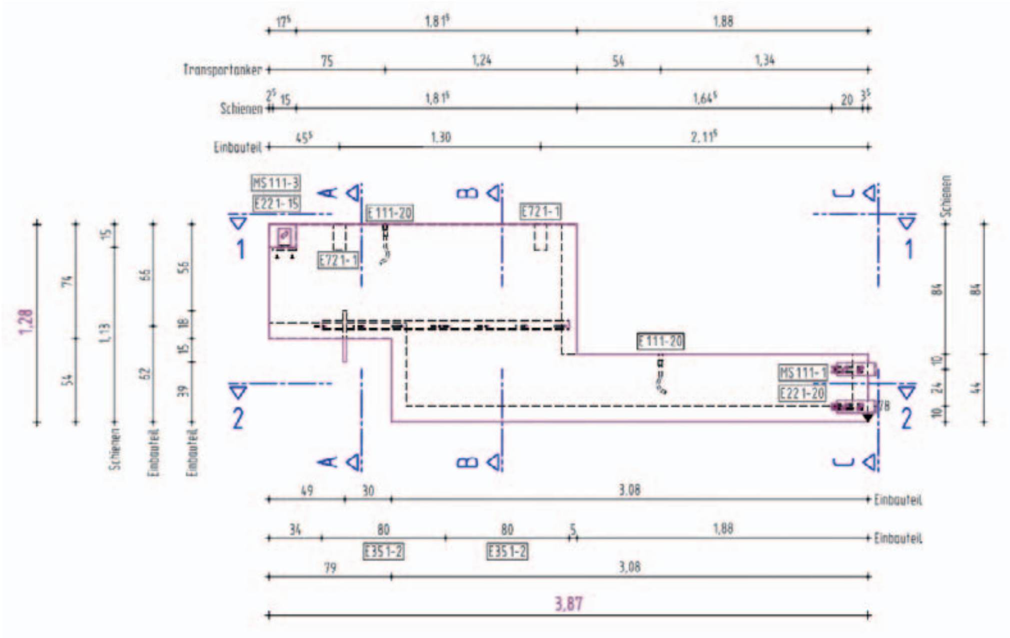


Figure 3. Abstract from an automatic element plan. Formwork drawing of a sandwich element.

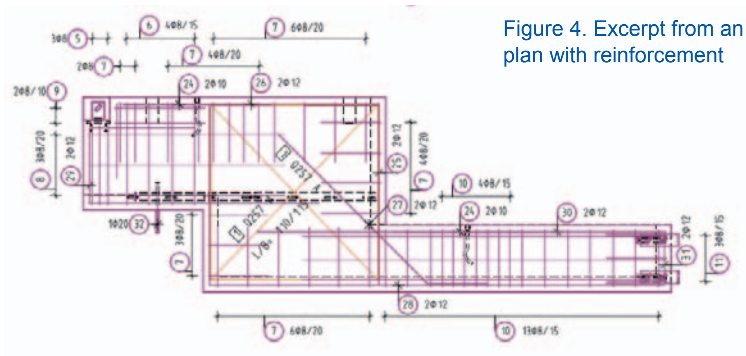


Figure 4. Excerpt from an automatic element plan with reinforcement

3.3 Hybrid method, e.g. for designing the reinforcement

The designers have always wanted a bending form to the designed or laid where it is best, in terms of the geometry. For example, a stirrup in the section and the laying in the view. In doing so, it can be determined how the stirrup basket should be displayed in the plan. Previously, the designers were economical with views and section, because it was laborious to always show the plan logically with all of the sections and views, and even more complex to consistently follow the changes. Now, any number of sections can be generated easily in order to be able to design optimally. The reinforcement basket is now practically created in the model. The program checks for reinforcement clashes and it can be easily identified whether the design can also be product, under consideration of the fixtures, etc. (Figure 5). At the same time, one has the perfect, familiar illustration in the plan, as usual.

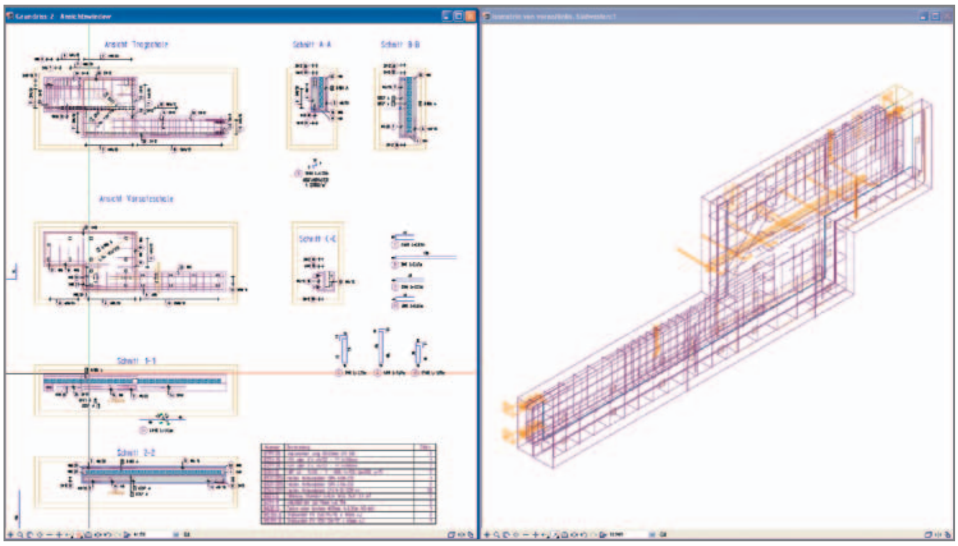


Figure 5. Screenshot with the processing and visual check of the fixtures with the formwork and reinforcement. On the left, display in the usual 2D method, on the right, in the “3D model”

3.4 Achieving plan layouts that function as business cards for the office

In order to obtain optimum plan layouts for all types of components, the prototypes/templates can be created using a graphic Layout Editor. For example, the authors define a plan layout with sections, views, dimensional chains, lettering, legends and a stamp field for a specific type of support.

With this one-time preparation, one has the guarantee of obtaining the same type of readable and structure-specific plans. The illustration of geometry, reinforcement, fixtures, etc. can also be switched separately for a better overview. The experience from the initial projects shows that the automatic plan barely needs to be reworked for more basic components. More complex components are developed further, with an eye for detail. Therefore, the graphic layouter is a tool for ensuring a uniform quality standard.

With the creation of an element plan, an automatic steel list is expected for each steel variety and steel type used, as well as an automatically generated list of fixtures and installation parts (Figure 6). However, even more can be controlled. For example, a plan header can be automatically created with the important values for a precast part, such as the component and plan description, volume, weight, number of units, concrete quality, exposure classes and fire protection requirements, etc. (Figure 7).

How does the planner ensure that the concrete quality from the plan header and the appropriate hatching or filling in the sections correspond? By checking it and – if changes occur – hoping that nothing is overlooked. In the element planning, this is regulated automatically. If a support receives a different concrete quality, regardless of whether it is in the large overview model or in the plan, i.e. a single attribute, everything is consistently changed. The new quality appears in the plan header and all sections have the appropriate filling.

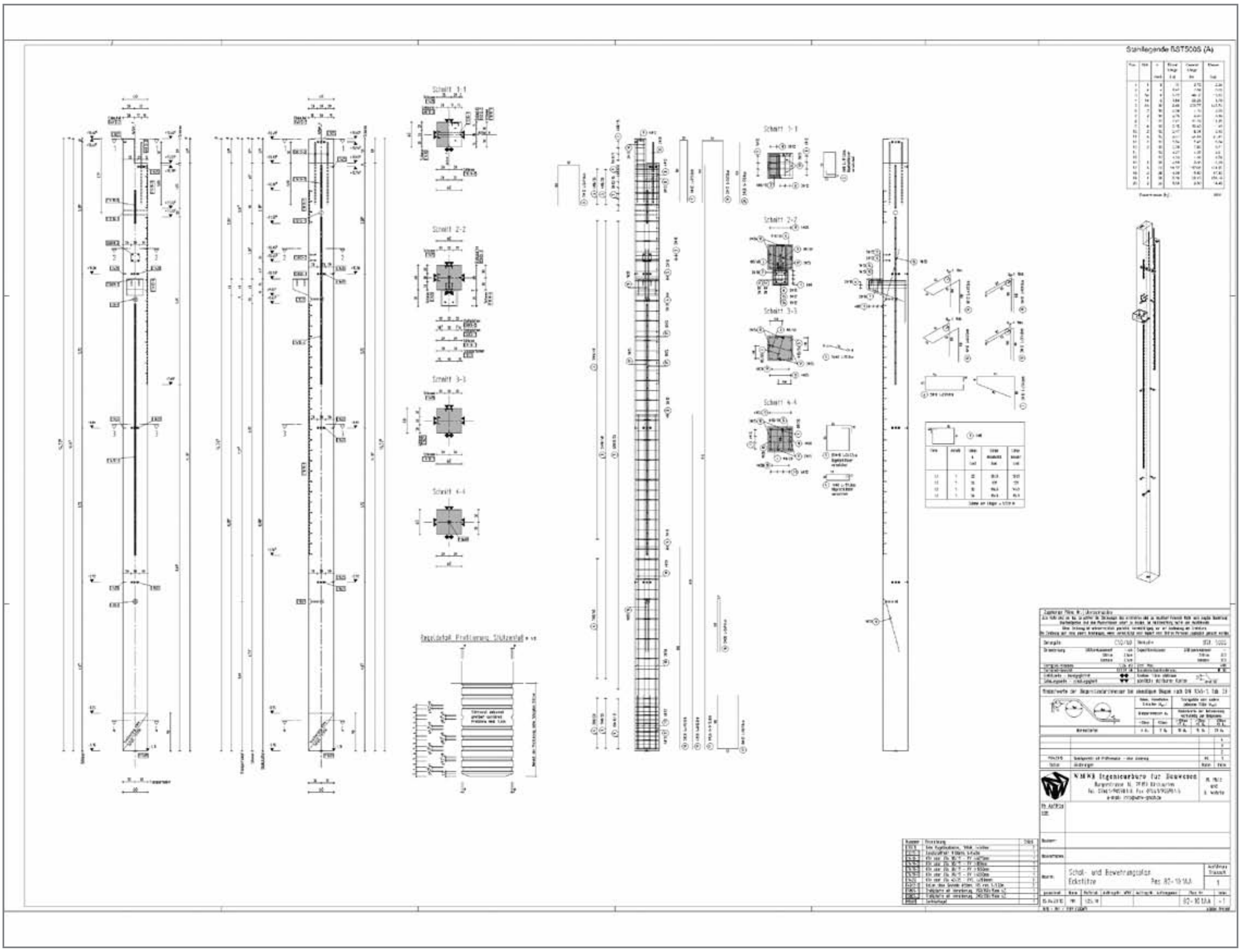


Figure 6. Extract of an automatic element plan with partial manual modification

4 Investments in changes

Of course, it must first be learned how to use a 3D program and experiences need to be gathered. Just as we previously needed to think about layer concepts, symbols, etc., we need to formulate this “newly” for 3D. This can be nicely described using a fixture as an example.

In the computer animation, the part should be displayed as realistically as possible, while on the plan, in a reduced display on the basis of the dimension. And because the results are expected at the “push of a button”, this also occurs for the significant projections. The result is then also impressive. Figure 9 shows the computer animation of an assembly with a steel plate and welded-on bars. With this, one then receives a view and section with dimensional chains and texts at the push of a button in the element plan. A section from the fixtures plan – fully automatic – shows (Figure 10).

Another important point was the conception of the layouts for the element plans already described above. In order to ensure that all employees comply with the defined standard and therefore planning quality can be guaranteed, technically and in terms of content, the authors invested a great deal of time. The employees apply these as a matter of course and no longer need to deal with many technical and content matters. The creation of an individual template now also takes barely any time, which, however, is returned multiple times with the creation of each plan.

Overall, the authors can look back and conclude that for the training period, regardless of the employee structure and the level of education in the field of CAD, as well as the relevant hardware requirements, approx. three to six months need to be calculated. In the authors’ engineering office, the first project was already tackled after approx. six weeks of training and was successfully completed after another six weeks. However, it is worth mentioning that they had previously already completed the step from 2D to 3D. The employees are enthusiastic about the innovations and the forward-looking method and are collaborating enthusiastically with a great deal of commitment.

Figure 7. Plan header filled automatically with all important attributes from the concrete part

5 Shifting of tasks

An experience that we had initially regarded as disadvantageous, we now think is extremely positive. The pyramid shown (Figure 11) illustrates the two fields of activity in the current planning cycle: At the top, the model is created, while at the base, the element plans are processed. At the start of a project, somewhat more effort is needed for the 3D model, because more information is required for the model creator at an early stage.

The creator of the model has the complete responsibility for the project and the overview across all planning documents. This means that the horizontal line in Figure 11, the interface between “project management” – engineer/technician and element plan creator – draftsmen has moved downwards in the initial processing of the model / the element plans, compared to the previous method.

The majority of the time in the top half of the pyramid – engineer and technician hours – is gained back again through the reduction of plan checking. The engineer/technician working has have more responsibility than previously. Heclarifies all of the interfaces, which entails direct, tangible advantages for processing the element plans.

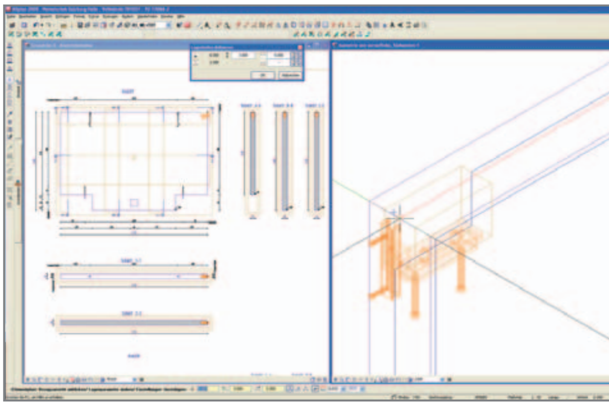


Figure 8. How to work in views and in the model. Both ways are possible

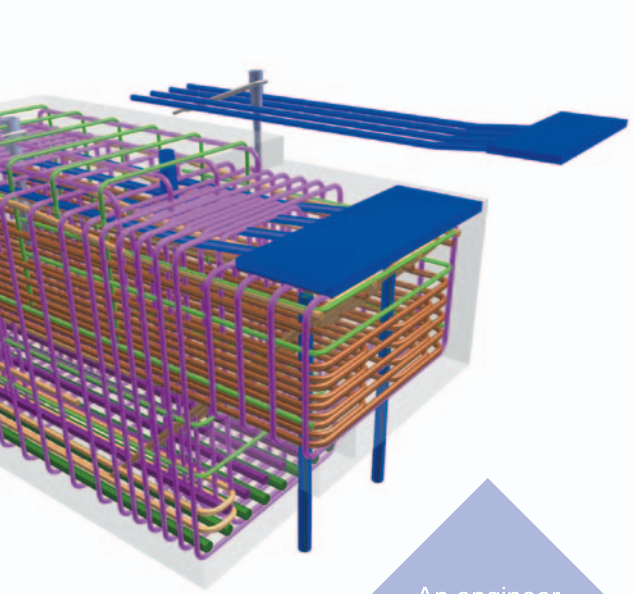


Figure 9. Screenshot from a complex insert

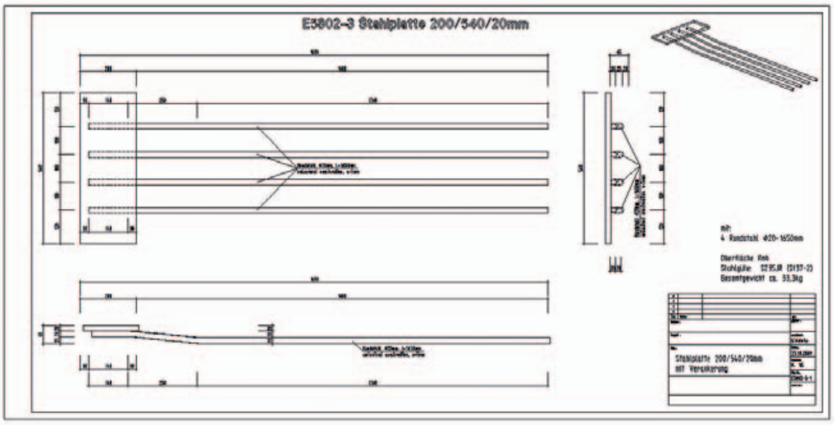
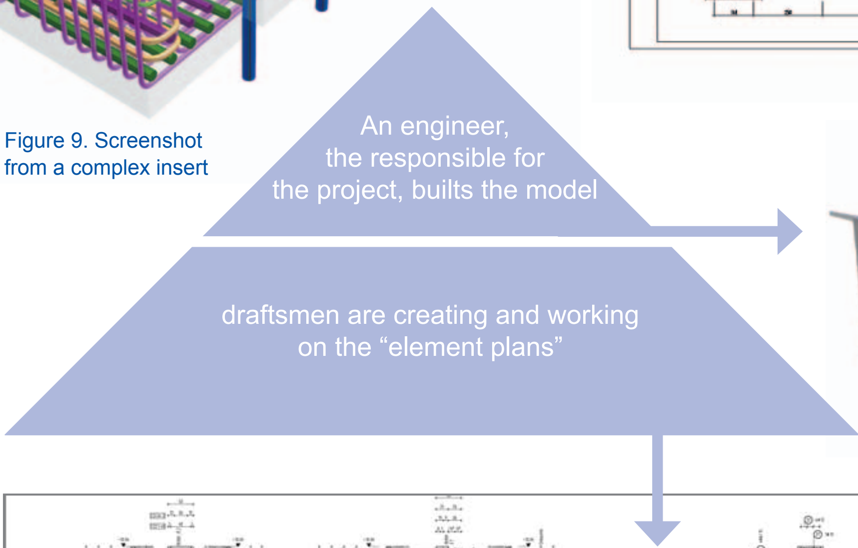
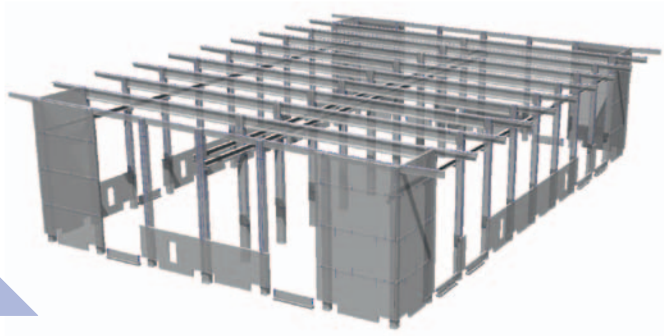


Figure 10. different views from the insert





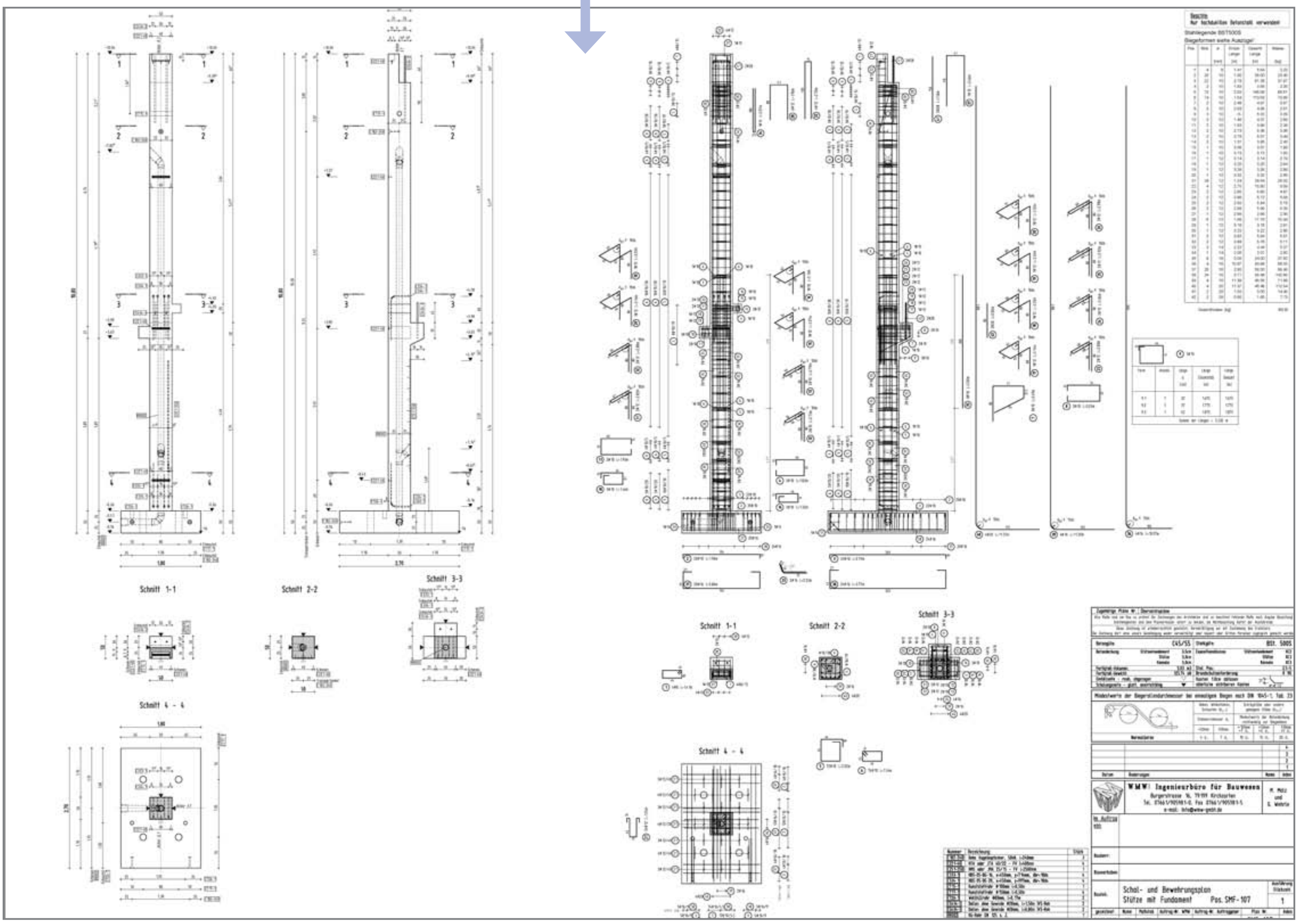


Figure 11. The responsible project manager, engineer and technician process the model, the designers receive the automatic element plans at the push of a button and develop them further.

6 Reduction of planning time

When the model is complete (Figure 12), the automatic component plans are immediately available. Fixtures and installation parts, which are generally also recorded already, are in the item list, as well as additional pre-defined information, such as weight, concrete quality, etc. (Figure 7). A “clash control” of the components, as well as the visual checking possibility of the 3D components in the model sustainably relieves the technician from having to look through the “other” planning documents, such as architectural plans. (Figure 13). The geometric plan checking can be reduced as the elements underlying the model are identical with the element plan.

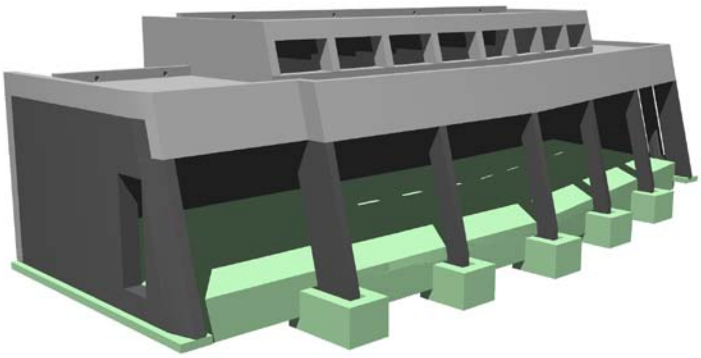


Figure 12. Model of a geometrically complex garage with precast walls and precast support (shown in dark grey) as well as ceilings, etc. in in-situ concrete

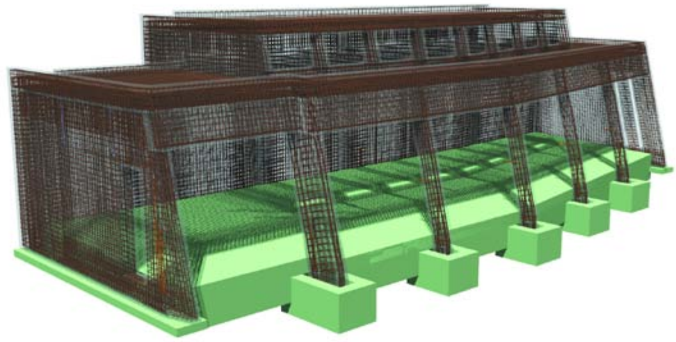


Figure 13. Clash control of the reinforcement from the various precast elements with the reinforcement of the in-situ concrete components in the 3D model

The draftsmen now create the reinforcement plans and with this, the optimisation of the formwork and reinforcement also begins. Already during modelling, the system has recognised which components are identical and has provided these accordingly with a position number. For example, for five identical components, an element plan is received with five as the number of units. The component is reinforced (Figure 14), the element plan is completed.

This element plan can now be transferred completely, or in selected parts, to similar components, thereby saving the design work. As is conventional with 2D, things are copies, only now in 3D and with automatic embedding in the model. The real structure that is executed then corresponds to the model (Figure 15). The methodology offers important advantages. The planning work and number of plans is minimised. At the same time, the opportunity exists of optimising lot sizes, as the system automatically recognises identical parts. One receives assured numbers of units across the entire model and all plans. Furthermore, everything is checked by the software. Identical geometry, reinforcement, fixtures and, of course, the attributes, such as concrete quality, etc.

The authors are convinced that a great deal more benefit can be achieved in the precast factor using this methodology, as the expensive formwork construction can also be optimised.

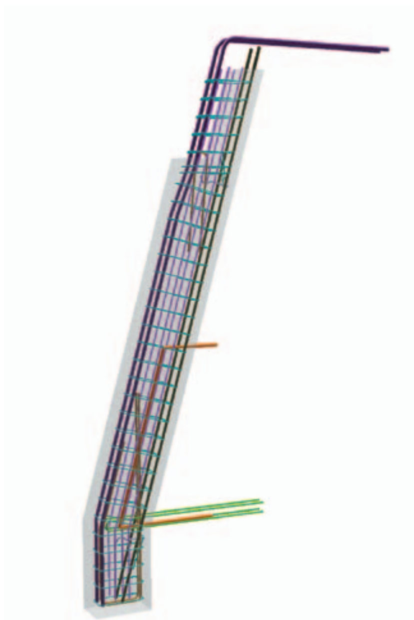


Figure 14. Precast support with reinforcement and fixtures as a 3D model

7 Utilising rationalisation potential

With the processing of the components, engineering offices are repeatedly faced with the questions of how to handle fixtures that come from manufacturers such as Halfen, Schöck, etc. As already described above, the related, current data are required in an appropriately prepared way, in 3D and 2D, each in different forms. As an engineering office, the authors do not regard themselves as sales agents of these manufacturers, however, it is de facto the case. Therefore, they expect all the more that the manufacturers will supply significantly improved data material in the future. This holds major rationalisation potential, which should be utilised.

Figure 15. Result of the planning prior to shuttering the ceilings and support beams.

8 Working in 3D with the virtual structure via the Internet

For 3D CAD work, trained engineers, technicians and designers are required. Once the model is completed, it could also be used by “CAD laypersons”. The authors make their virtual structures available to the clients and other persons involved in planning via the Internet (Figure 16).

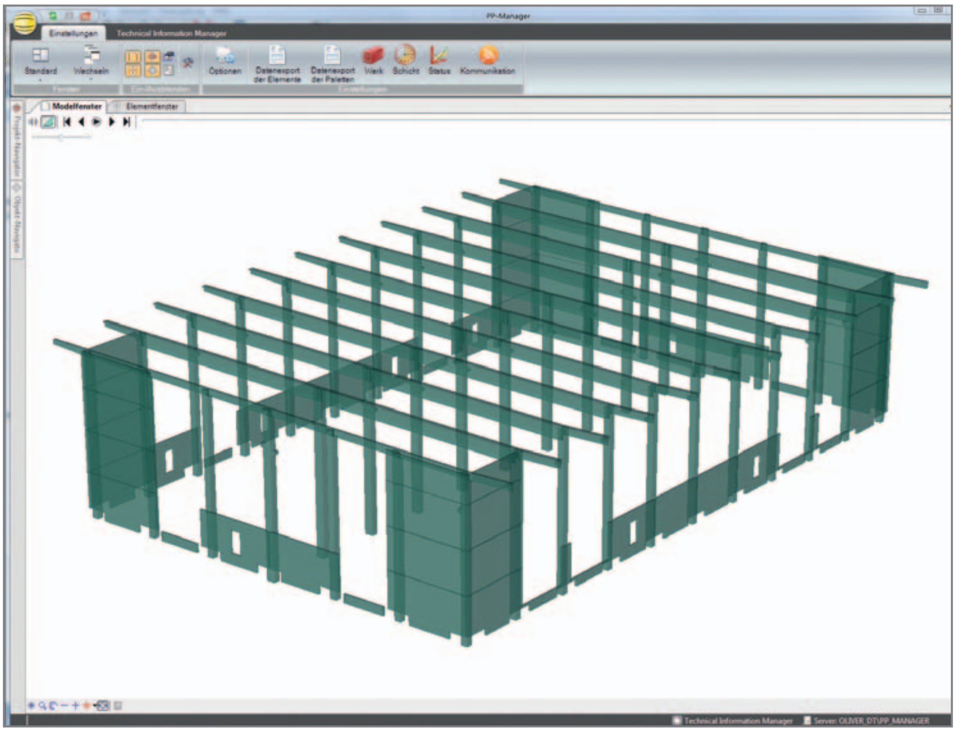
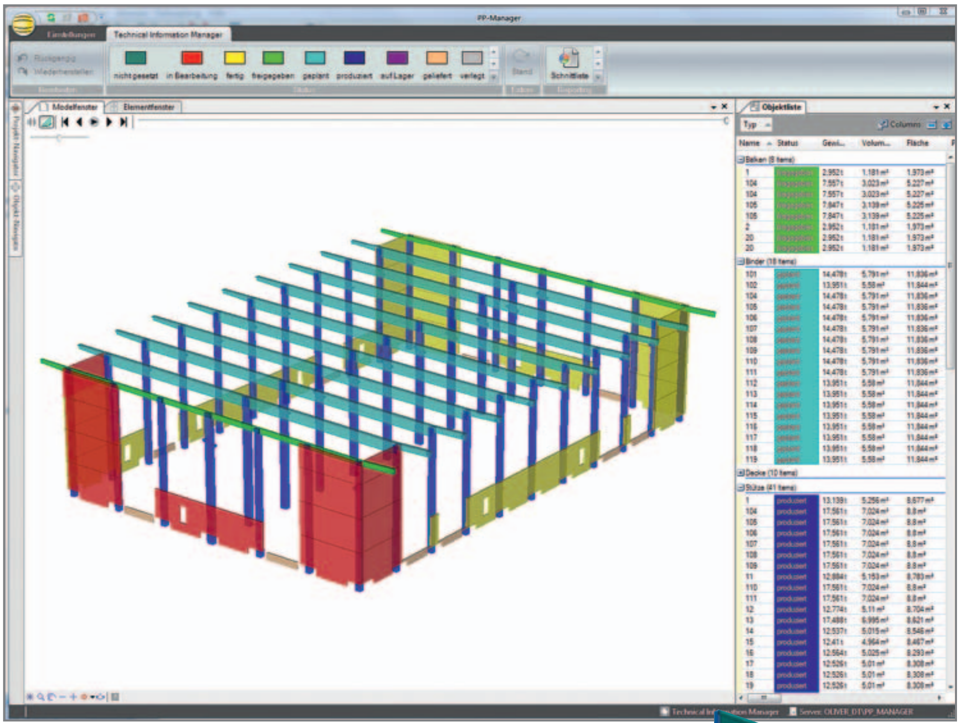


Figure 16. Provision of a first, rough concept for our client after completion of the model.

For this, an initial, rough model is first provided, so that the client and his appointed specialist planner can use it to carry out their service specifications, work preparation and workflow or production planning.

The colours in Figure 17 signalise the status of an component (e.g. red – rough, blue – element plan drawn and sent to participants for review, green – ready for execution and approved, Figure 17).

As the planner provide a database for this, the client can also carry out any type of evaluation. The sorting and selection is extremely simple and the advantage exists that not only huge amounts of figures are processes, but the change is visible on the structure. Even a workflow simulation is conveniently feasible and it can be seen how the structure grows in a film.



With this service, the authors are breaking new ground, however, it is the consistent step for making the work of the engineering offices usable. The authors also see further potential in the future for acquisition, working with a 3D model during the offer phase is a minor revolution for the engineering offices, which the authors are now already partially making use of (Figure 18).

The supplemental display of the offer in a 3D drawing can be crucial with the awarding of services, in some cases. The authors are convinced that there will be more innovations in this regard.

Figure 17. Constant refinement of the model with information for a client, based on the project's degree of processing.

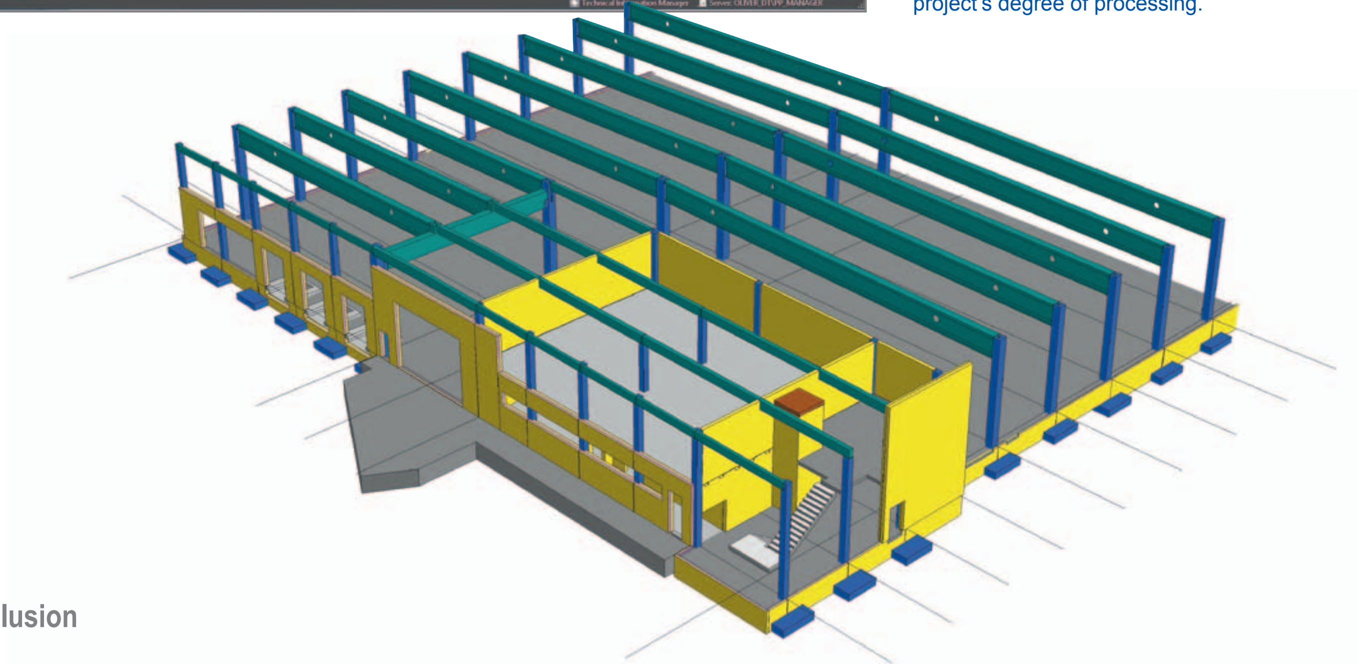


Figure 18. Screenshot of a model that was prepared as support for acquisition and the fee recommendation for support structure planning for a client.

9 Conclusion

Around 25 years ago, the engineering offices were confronted with CAD, which was a major advance. The pencil was replaced with software. Over the years, productivity and quality grew. 3D and its benefits has already been talked about for a long time, but it has only established itself in some areas of construction planning, particularly in the early design phase. We recognise that we can make the pure drawing work more profitable for the engineering offices and the executing companies and precast factors, if the utilise the opportunities arising from the 3D method.

The added value that can be created through the 3D method in the engineering offices can lead to crucial economic advantages for the engineering offices and precast factories, with consistent application and use of the data provided. The basis for this must be that in addition to "paper plans", data and information that mean real "added value" for the executing companies are rewarded.

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