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HOW TO MINIMIZE THE EFFORT OF STRUCTURAL ENGINEERING AT DECONTAMINATION TASKS

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ABSTRACT

After the shutdown of a nuclear power plants (NPP) the decommissioning and the decontamination of the components and buildings is crucial for the dismantling of the plant. The structural engineering of decontamination tasks on buildings can be time consuming. By using the time between the shutdown and the beginning of the decontamination tasks the effort can be minimized.

Therefore, the available documentation (construction and reinforcement drawings, structural analyses, etc.) is compiled, reviewed and sorted according to buildings. This documentation is referred to as structure file. It can be documented in some simple kind of folder structure (digital or analogue), but also using a 3D building model.

However, the structure file is more than documentation. Using the time between the shutdown and the beginning of the decontamination tasks the structural engineer analyses the buildings with respect to the structural relevance of its members. These analyses are used to classify the decontamination task in three cases. Case 1 includes all decontamination tasks on non-structural members. Case 2 summarizes the task where contamination is only locally or near the surface on structural members. The remaining tasks are assigned to case 3. The effort for the structural engineering is reduced for case 1 and case 2. By analysing the members a-priori the non-structural members are already known. For case 2, the structural analysis is reduced to an analogy or plausibility proof.

As decontamination tasks of case 2 and 3 are also documented within the structure file, the structure file documents the actual building state after the decontamination tasks and can used for the demolition of the buildings.

INTRODUCTION

By end of this year all of Germany´s nuclear power plants (NPP) will be in decommissioning (KernD (2020)). One of the last steps before the NPP is released from regulatory control of the Atomic Energy Act is the decontamination of the buildings containing a hot zone. Depending on the operational use and the age of the building the contaminated material infiltrated more or less in the members of the building. Therefore, it is often necessary to evaluate the decontamination task from a structural point of view.

For the mandatory approval process of changes on buildings, the responsible authority assigns a proof engineer independently reviewing the corresponding structural analysis. Performing a detailed structural analysis of all necessary decontamination tasks just in time of the decontamination process is very inefficient. Considering the timeline, preliminary work concerning the structural analysis can be done in advance. This saves time during the decontamination tasks and the buildings can be released from regulatory control earlier.

STRUCTURE FILE

As a basis for communication and coordination with the authorities or the proof engineer, the documentation of the actual state of the buildings before, during and after the decontamination is important. Therefore, the structural engineer compiles, reviews and sorts the available documentation (construction and reinforcement drawings, structural analyses of the construction time and of changes during operation time, etc.). For the individual buildings containing a hot zone, the relevant structural aspects of the existing structure are summarized. With this documentation, the structural engineer is able to provide quick assessments of the structural relevance of planned decontamination measures. Furthermore, the structural framework of this building is described based on these documents. Thereby, the structural engineers pay special attention to components decisive for the stability of the building or parts of it. The results can be documented using some simple kind of folder structure (digital or analogue) but also using a 3D building model. This documentation is the basis of the so-called structure file. An exemplary set up for a structure file is shown in Figure 1.

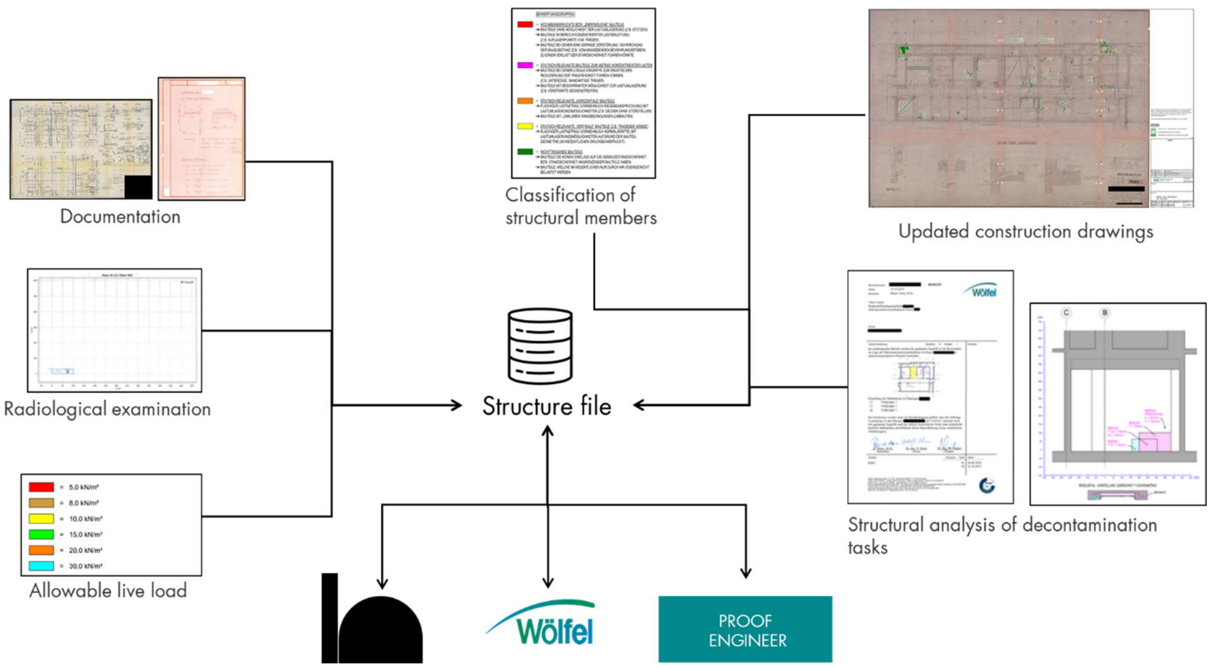

Figure 1. The structure file

However, most of the buildings were constructed using a nowadays-outdated building specification (e.g. DIN 1045:1972-01). During the decontamination procedure the load bearing behavior of the building might change. Acc. to Musterbauordnung (2002) buildings in Germany must satisfy the effective building specifications such as the DIN EN 1992-1-1:2011-01 for concrete structures. Knowing the differences of the building specifications (e.g. concrete covering, shear design, structural fire design, material nomination) before the decontamination procedure can save time, too. Because this is also an important topic for conventional buildings, there is already literature and specifications for the design of existing structures in Germany available (Schnell, J. et al. (2012), BMVI (2011)).

The buildings were designed for an operational state of the NPP. In decommissioning, the heavy components are demolished before the decontamination of the buildings starts. These leads to increased load capacities. During the decontamination the buildings are weakened and the structural engineer can use these increased load capacities to avoid detailed structural analyses or auxiliary measures.

EVALUATING STRUCTURAL IMPORTANCE OF BUILDING MEMBERS

After documenting the actual state of the building, it is evaluated using the structural analyses from the construction or the operation time is evaluated. The structural engineer assesses and classifies the construction members according to their structural relevance and their sensitivity to decontamination measures. Therefore, a colour code is used as depicted in Figure 2.

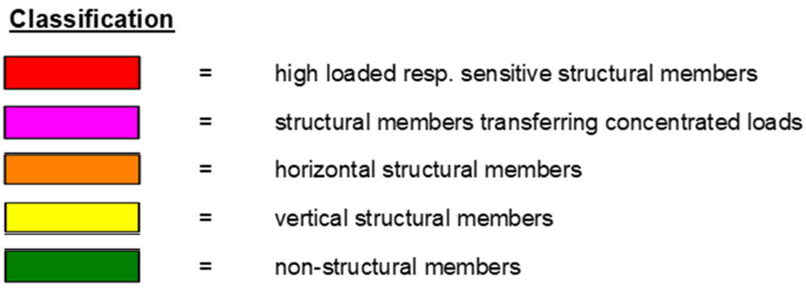

Figure 2. Colour code for member classification

Red colouring identifies high loaded resp. high sensitive building members. These are members without any possibility of load distribution (e.g. columns), member parts with concentrated load application such as the supports of beams and members where minor weakening or destruction (e.g. of decisive reinforcement) leads to a loss in stability.

Purple colouring indicates structural members transferring concentrated loads, such as beams. At these building members local interference leads to a major reduction of the structural stability. In addition, purple colouring shows members with a limited possibility of load distribution, e.g. strengthened parts in slabs.

Horizontal structural members with load distribution over a wide area (mainly bending forces), but with enough possibilities of load distribution are highlighted in orange. Such members are mainly slabs without major interferences.

In yellow, the vertical structural members such as walls are shown. They are characterized by distributing loads over a wide area (mainly normal forces) and by showing enough possibilities of load distribution due to their geometry.

The last group are the non-structural members, coloured in green. They do not influence the stability of the building or adjoining members and are mainly loaded by their own death weight.

The results of this classification is stored in the structure file, e.g. in plans (see Figure 3) or in a 3D building model-

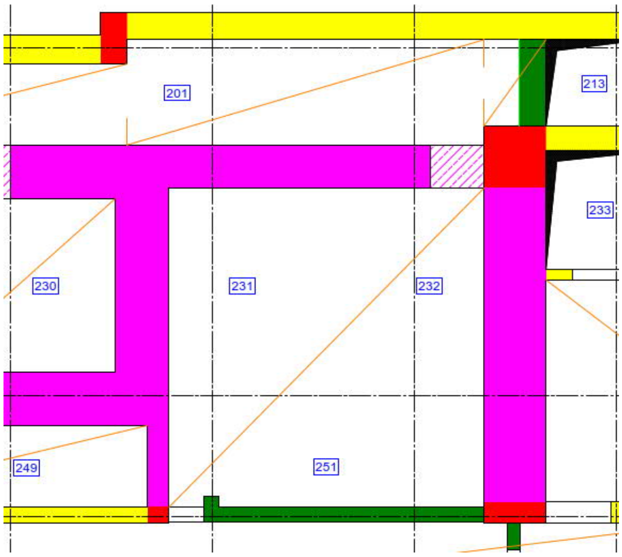

Figure 3. Documentation of member classification

SIMPLIFYING THE APPROVAL PROCESS

The introduced classification is also used for the communication with the authorities and the proof engineer. During the permission process for the structural decontamination measures three cases of measures can be laid down in the permission for the structural decontamination, see Figure 4. By specifying these cases the structural engineering is simplified and therefore, accelerated. If the case groups are laid down in the dismantling permission, the following procedure depending on the case group is possible.

At the beginning of a decontamination task, the operator defines the necessary measures to ensure the decontamination of the structural member. Using the structure file, the operator assigns the measure to the case groups.

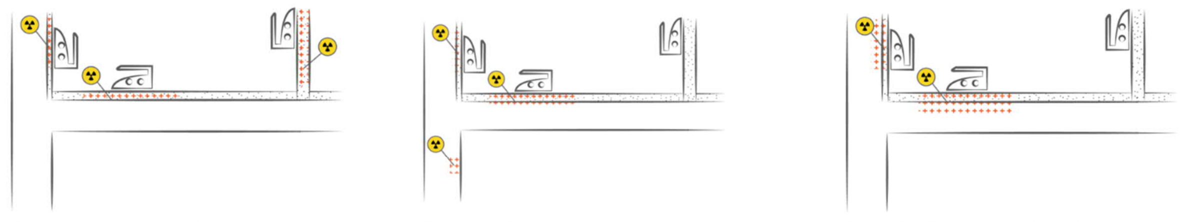

Figure 4. Case groups for decontamination measures

Case 1: Contamination in/on non-structural members

As non-structural members do not have resp. only have a negligible influence on the structural stability, decontamination measures on this members do not really affect the structure of the building and it members. Therefore, there is no need for a structural analysis.

Nevertheless, the operator informs the proof engineer about planned decontamination measures sorted to case 1 and the starting time of the execution. The structural engineer verifies the assignment to case 1. After the execution of the decontamination measures, the radiation protection checks if the decontamination was successful. If not, the operator plans a new measure and assigns it to the case groups. After the successful decontamination, the structural engineer checks whether the executed measures have any influence on the building and if necessary, documents them in the structure file. One example for such a decontamination measure is the deconstruction of a non-structural masonry wall. The wall itself is not important for the stability of the building, but the structural engineer can use reduced death weight due to the missing wall to avoid auxiliary measures for other decontamination measures.

Case 2: Contamination only on the surface resp. locally restricted contamination of structural members

To this case group all measures in or on structural members are assigned that have obviously no influence on the load capacity of the member. Therefore, a detailed structural analysis is not really justified and necessary. In most cases, an analogy or plausibility proof is sufficient. Measures assigned to case 2 are for example core drillings in walls and slabs where there is no interference, the ratio of drill diameter and wall/slab area is small, etc. Additionally, measures with locally restricted concrete removal or concrete removal only on the surface of the structural member are assigned to case 2.

After verifying the assignment of a measure to case 2, the structural engineer prepares a structural assessment of the planned measures in shape of an analogy or plausibility proof. As the structural engineer knows the load capacities and the load bearing behavior of the building already and the structure file contains the necessary documentation, the effort for the assessment of the decontamination measures is minimal. The planned measures are then documented in the structure file. After the approval of the proof engineer of the assignment to case 2, the measures can be executed. Afterwards the radiation protection checks if the decontamination was successful. If not, the operator plans new measures and assigns them to the case groups. To reduce the amount of analyses the structural engineer considers a-priori an execution buffer. For example, a bigger diameter for core drillings than the one required by the operator is considered. The structural engineer only takes into account the construction buffer if it does not affect the assignment to case 2 and it does not increase the effort for the structural analysis. After the successful decontamination, the changes on the structural members are inspected and documented in the structure file.

Case 3: Contamination on/in structural members

All measures not covered by case 1 or case 2 are assigned to case 3. These are measures whose influence on the structural members is not obviously negligible and for which a structural analysis is necessary. For some measures, auxiliary measures are necessary. Measures assigned to case 3 are e.g. measures in or on reinforced concrete columns, beams, at support points of beams, in high loaded slab or wall sections or the removal of concrete at a wide area.

After verifying the assignment to case 3, the structural engineer prepares a detailed structural analysis of the planned interferences on the structural members. If the measure concerns a structural member with enough possibility for load redistribution, a simplified analyses is often sufficient. In other cases, e.g. measures on foundation slabs, the structural engineer needs to prepare a detailed analysis, including for example a finite element model. If necessary, the structural engineer also defines (temporary) auxiliary measures necessary during or after the decontamination. This auxiliary measures are for example reducing the allowable live load on floors, the deconstruction of the non-structural building members or in worst case repairing the concrete covering after removal. The planned measures and if necessary the auxiliary measures are documented in the structure file. After the approval by the proof engineer, the measures are executed. Afterwards the radiation protection checks if the decontamination was successful.

If not, the operator plans new measures and assigns them to the case groups. After the successful decontamination, the changes on the members are inspected and documented in the structure file.

Similar to case 2, the structural engineer also considers a buffer for the measure. For example, the operator plans to remove 10 cm of concrete on a reinforced concrete wall at an area of 1x1 m. To reduce the possible amount of structural analysis if the decontamination task is not successful, the structural engineer takes into account a buffer of 20 cm circumferential around the removal area and 2 cm buffer concerning the depth of the concrete removal, see Figure 5. Of course, this buffer is reduced when it affects adjacent building members. To minimize the coordination between structural engineer and operator, the buffer is set a-priori and is considered by default in the structural analysis.

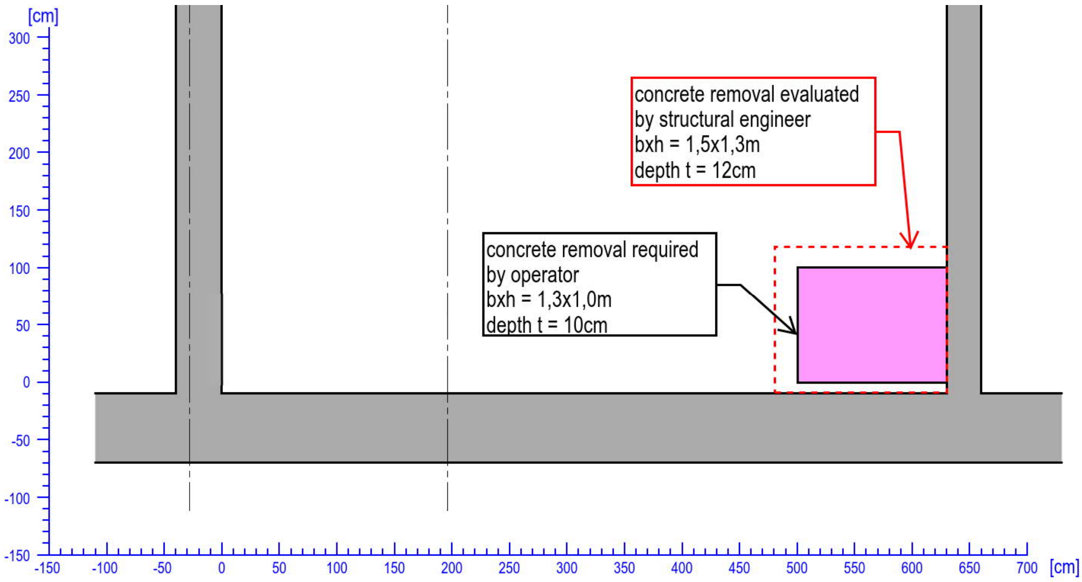

Figure 5. Required vs. evaluated area of concrete removal

ORGANIZING THE PLANNED DECONTAMINATION MEASURES

Structural engineers and the radiation protection define a building differently. For the radiation protection, a building is a collection of surfaces, for structural engineers the building consists of members. During decontamination measures it is decisive that both parts are on the same page

Therefore, the notation of the surfaces used by the radiation protection are included in the structure file. This means that every building member has two surface numbers, see Figure 6. This documentation is important if the planned measures are summarized for each room and only one structural analysis is done for each room.

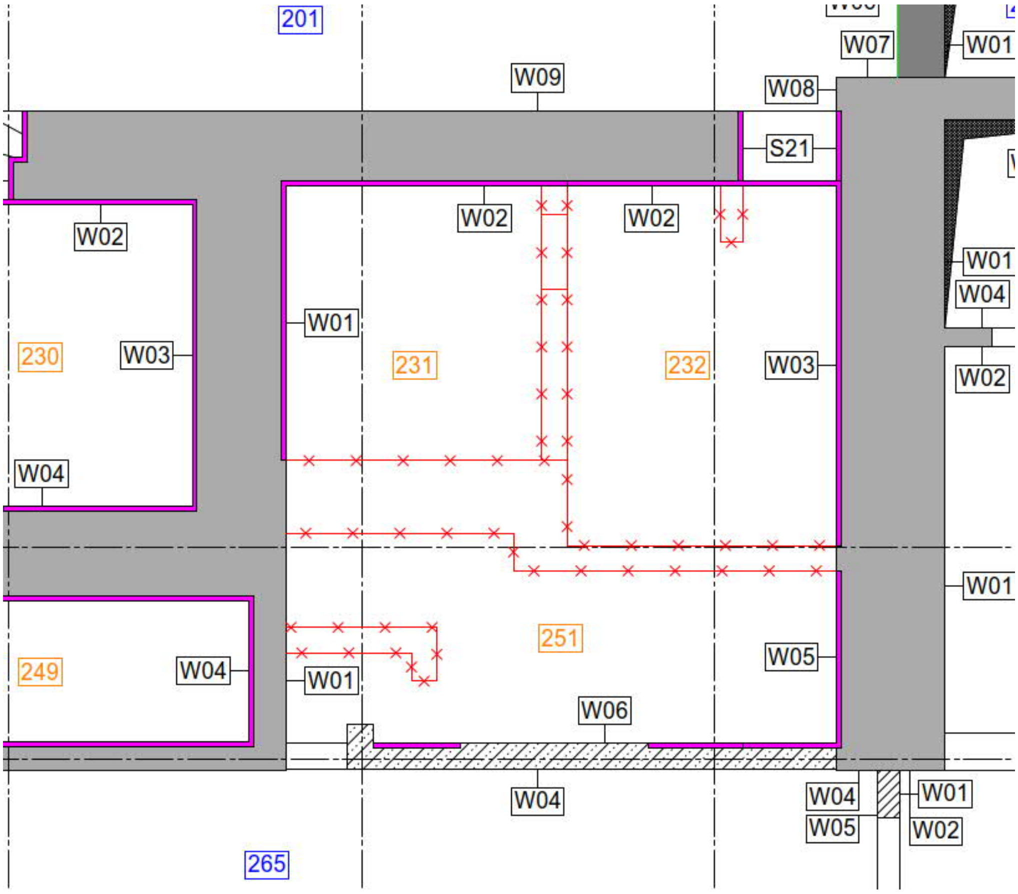

Figure 6. Notation of the wall surfaces

For case 2 and case 3, it is mandatory to document the planned measures. Therefore, drawings of the member surfaces are created. To address the planned measures, a notation is introduced including the name of the affected surface and a consecutive number. Figure 7 shows such a drawing. Measures where only T is given, indicate an area with concrete removal to a depth T. Except measure W02-04 all measures are categorized in case 3. Measure W02-04 is assigned to case 2. If multiple measures are analysed together, the worst case governs the procedure.

After the successful decontamination, the structural engineer documents the executed measures in the structure file, see Figure 8. Now, the structural engineer can take into account the reduced amount of the decontamination measures to avoid time-consuming auxiliary measures. Comparing Figure 7 and Figure 8, one can see that only a small part of the decontamination measures was executed. This is accounted to the knowledge gained before the decontamination task, as the structural engineer was able to analyse a greater extent at measures than eventually needed. This saves time during the decontamination task.

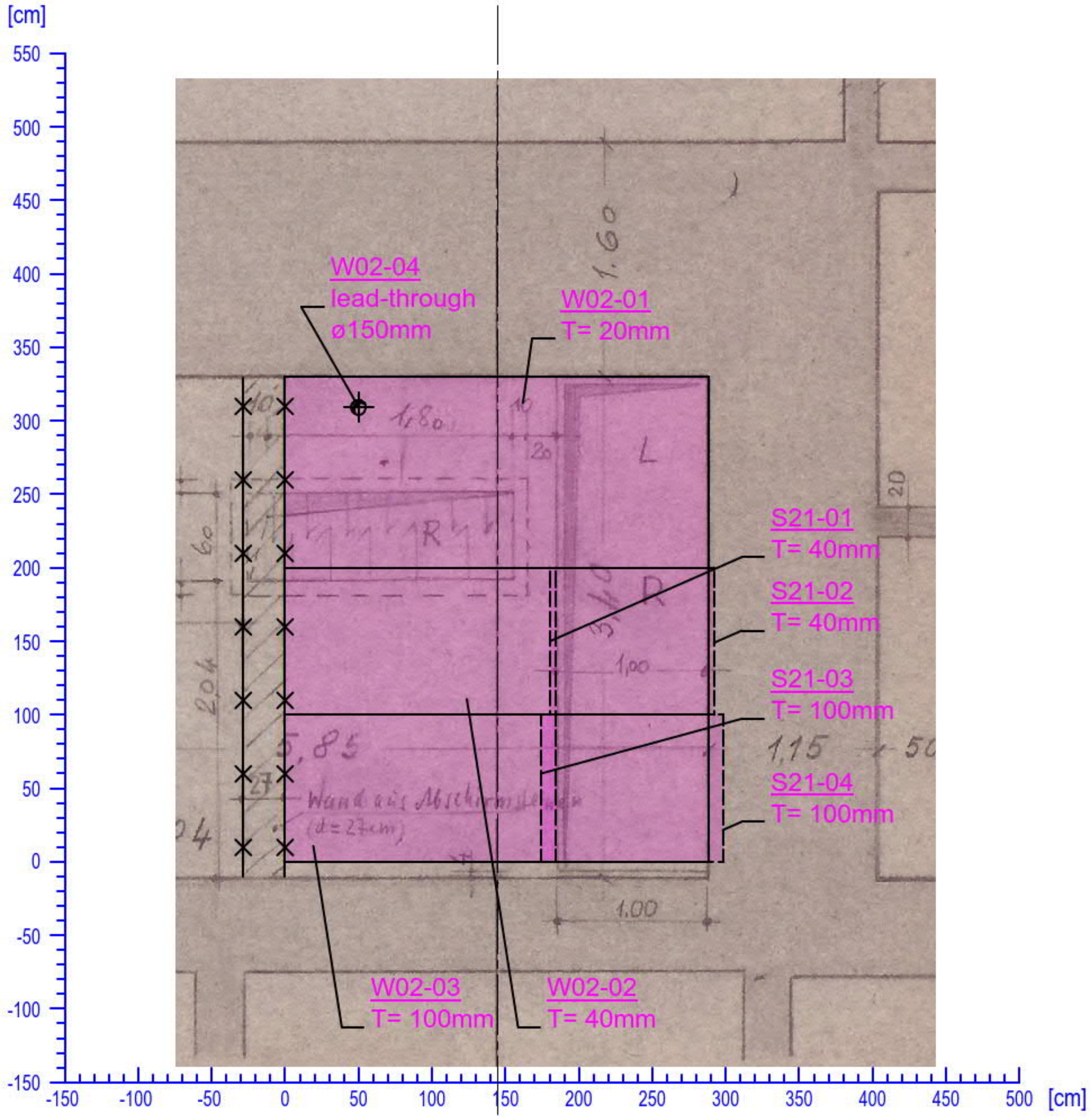

Figure 7. Drawing of the wall surface W02 including planned decontamination measures

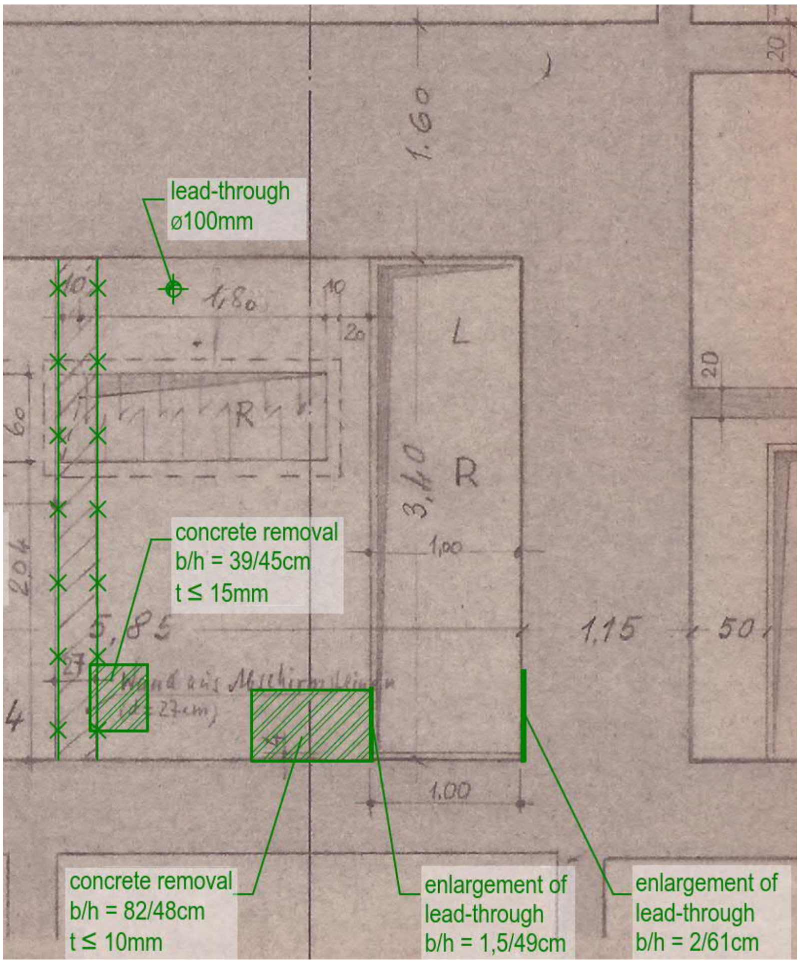

Figure 8. Extraction of an updated construction drawing including the actual executed measures

CONCLUSION

This paper presents an approach to reduce the effort of structural engineering during the decontamination of the buildings. The time between the shutdown and the beginning of the decontamination in the buildings is used to prepare a structure file. The evaluated as-built state and the continuous documentation of executed decontamination measures helps to speed-up the assessment of future measures. The introduced case groups lead to faster decontamination procedures as the structural analysis for case 1 and case 2 are minimized. Therefore, the buildings can be released from regulatory control earlier. As an additional benefit, the structure file can be used for the demolition of the buildings after the release.

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