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BUILDING STRUCTURE IN-SERVICE INSPECTIONS DATA MANAGEMENT AND PROCESSING

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ABSTRACT

The paper discusses problematic areas of ageing management implementation for building structures. The issue is illustrated on the basis of practice and experience with the implementation of ageing management of NPPs in Czech Republic. A key issue in the whole data processing management is the evaluation of a significant amount of data obtained by inspections so that the whole evaluation process is controllable and at the same time manageable with reasonable effort. A combination of structured data storage in a database together with data visualization in a 3D model is proving to be a possible way.

INTRODUCTION

Extending of the service lifetime of existing NPPs beyond their design lifetime, together with the conversion of information into digital form, raises the need for a not changing and structured form of data collection and storage followed by automated or semi-automated data evaluation. The extending of service lifetime also expects a good understanding of the key degradation processes of structures or equipment. In case of building structures, most of the primary knowledge of structure state comes from visual inspections and their better understanding requires an increase of the extend and frequency of in-service inspections, both generating more data for storage and evaluation. Since almost every building is a prototype, the evaluation of these data is not straightforward and requires an experienced evaluator. The weight of the individual results depends on the location in the structure and the requirements for this part of the structure, local degradation factors and the mutual position with other damages. The key point of the evaluation of the overall structure is therefore the ability to display all the necessary information about the structure and all the results of the inspections in the common form, still easily readable for the evaluator.

ZERO POINT OF EXISTING NPPS

Original design required and specified in-service inspections (ISI) of building structures just for selected, safety important structures. Typical examples are containment or liner in some rooms, where collecting of leakage from equipment is required. For these structures, the method and criteria of inspections were determined in individual programs of quality assurance. The programs cover entire lifetime of safety important structures or equipment, starting with manufacturing and ending with decommissioning. During the operation period, the execution of periodical inspections is monitored by ISI program under supervision of the regulator. Each inspection is documented in the form of an inspection protocol, containing the type and location of the inspection, results of the inspection and their evaluation according to the criteria. In the case of building structures, the location of inspection is mainly represented by means of control points corresponding to the most representative parts of the structure. If there is a part of the structure requiring more interest or causing failures, the regulator usually requires to include the structure into ISI program even though there is no requirement for the inspection in the design.

Independently on the ISI program of safety important structures, standard periodical checks of buildings are taken. These mainly visual inspections are focused on the overall condition of the building and are the basis for a maintenance schedule or a more detail inspection. The results of these inspections are projected into the maintenance schedule and the corresponding financial plan. There is no detail technical documentation of inspections allowing future systematic processing of the inspection results.

Along with the application of ageing management, the unification of inspection programs is initialized. The methodology of inspections under the ageing management program is able to replace regular global checks of building and offers a uniform and more sophisticated form of documentation of inspections results. The inspections carried out within the ISI program are usually performed and evaluated separately in a manner approved by the regulator. However, the results of these inspections are transferred to the ageing management program either at the same level of detail or generalised to a larger view.

DATA MAGEMENT UNDER THE AGEING MANAGEMENT PROGRAM

At the beginning of implementation of the ageing management program on building structures, each building is divided into components according the typical material, the function of the structure and its exposure to the surrounding environment. A typical example of components in the case of regular reinforced concrete building is as follows:

- foundations
- underground structures
- concrete structures in outdoor conditions
- concrete structures in indoor conditions
- paint
- anchor plates in concrete structures
- machinery foundations
- fire stop fillings
- siding
- roof deck

A similar division is used for steel or masonry buildings. In addition, components with a specific function are defined, such as steel liners or air locks. For each component, degradation mechanisms are specified along with the corresponding type of inspection. During the inspection all deviations from the usual state are documented as a finding. If the criteria are exceeded, the status of the finding is changed to a fault and a repair is scheduled with the priority according the importance of the fault. All findings are reported in forms and transferred to a common database covering all NPP structures and equipment.

The processing of the in-service inspections results (reported findings and faults) is in the first step focused on the individual evaluation of each component. This part is usually based on general knowledge of material degradation and the criteria are well-defined. The next step is an evaluation of the individual parameters over time if the results of inspection is possible to represent in a comparable form. The last step is a transfer of results for each individual component into a global view of the building condition. In this step, it is necessary to put together the individual results and place them in space and time. This step is very challenging for the evaluator, especially due to the low level of support of current tools for data management. Storing data in forms and database entries comes from the ageing management of equipment where the equipment level is the final level and the evaluation is focused on the reliability of individual types of equipment. In the case of a building, the reliability of the building depends on the interaction of the various components and due to the non-exchangeability of the building, the economics of timely repairs is also an important part of assessing the condition of the building.

POSSIBLE MODIFICATION OF THE DATA MAGEMENT PROCESSES

The collection of individual information and its transfer into one global view of the building condition was identified as a weak point of the actual data management process. One possible solution is to store the results of inspections primary in a 3D geometric model of the building. Because the registration of results does not require detailed and accurate 3D models of building, it is possible to either use an existing model, if any (e.g. a BIM model) or create a new one from schematic drawings of the building. An example of such a simplified model of machine building is shown in Figure 1.

During the inspection or immediately after it, all findings are drawn into the 3D model at their real location and in their real shape and the corresponding data of the findings are filled in – see Figure 2. Connection of visual representation with database representation in one application significantly simplifies the evaluation process at the whole building level. Structured data enables through filtering to regulate the scope of visualised data and the visualisation of all findings in some part of the building independently on the type of building component enables to identify a common cause of faults. Changes in time can be visualized using animations or different colors. The exact location of the findings in the model also helps with repeated inspections – it is easy to locate the findings and evaluate if there are any changes since the last inspection.

The range of data stored in the 3D model fully covers the actual list of parameters stored in the database for ageing management of all components and equipment of NPP, so it is compatible with already established processes. The exchange of data between the 3D model and the database is possible to link seamlessly in both directions without the need to add any extra activity.

CONCLUSION

Actual experience with the processing of the building structure in-service inspection results shows, that the application of the same approach as for of equipment, based on the evaluation of individual parameters, is not sufficient. Building structures are composed of heterogenous substructures and materials and their contribution to the global structure is not just an envelope or a sum of individual parameters. A possible solution for the conversion from an individual to a global view is a 3D model of the building structure, including both structural information and inspection results and enabling the filtering of these parameters and supporting the visualization of changes over time. This model is possible to link bidirectionally with databases collecting inspection data and the evaluation of the structure condition is possible to perform easily, by visualization the results on the building structure geometry.

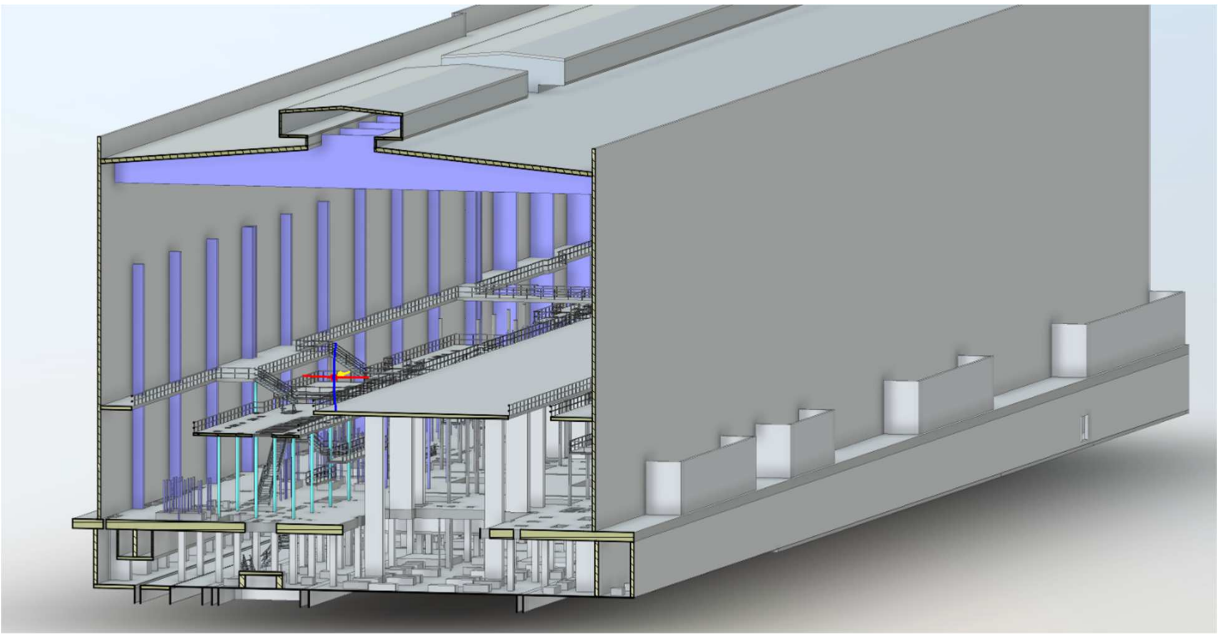

Figure 1. An example of simplified model of machinery building

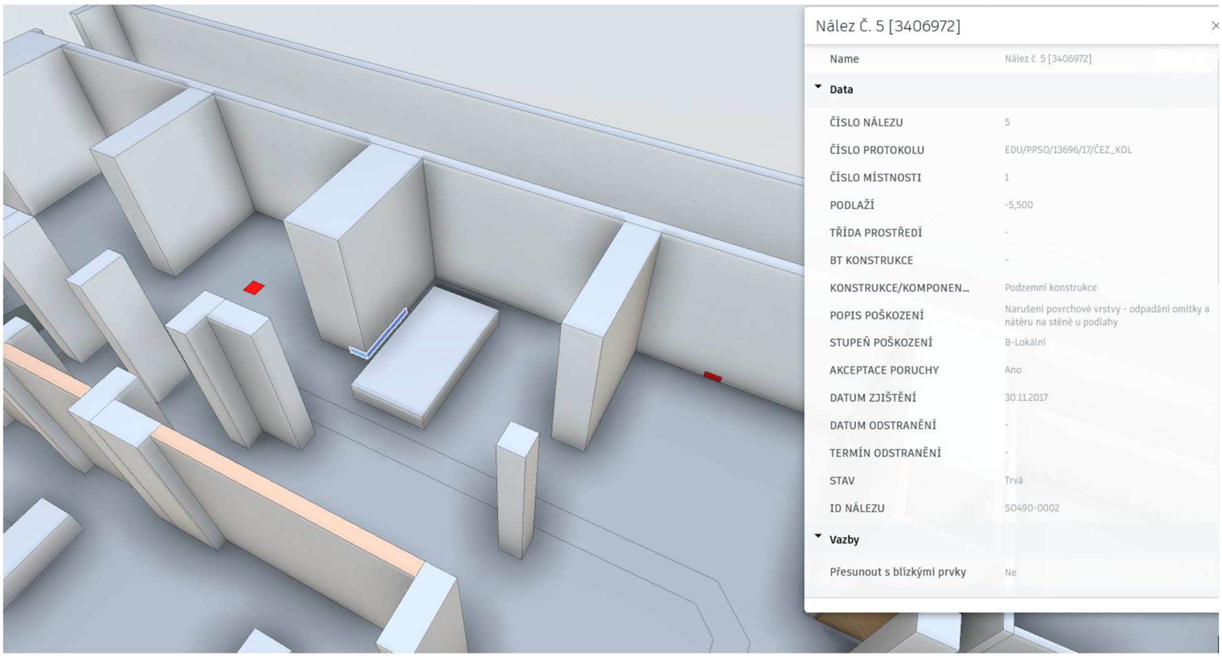

Figure 2. Graphic representation of findings (in red) and list of data for one selected finding (blue one)