R & P REACTOR BUILDING IN-SITU DECOMMISSIONING VISUALIZATION
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The R & P Nuclear Reactor facilities at the Savannah River Site (SRS) have become obsolete and are no longer needed for their designed missions. As part of the Department of Energy's footprint reduction activities at SRS, both reactor buildings have been identified for decommissioning. As part of the decommissioning process, all below grade portions of the buildings will be filled with grout to immobilize residual contamination. The Savannah River National Laboratory (SRNL) has assisted with building visualization through the development of 3D CAD models and scale physical models developed in the SRNL Rapid Additive Manufacturing (RAM) Laboratory.

I. INTRODUCTION

During the early 1950s, five production reactor facilities were built at the Savannah River Site. These facilities were built to produce materials to support the building of the nation's nuclear weapons stockpile in response to the Cold War. R-Reactor and P-Reactor were the first two facilities completed in 1953 and 1954.

R-Reactor was removed from service in 1964 due to a combination of increased efficiency of reactor operations and a slowdown of the arms race. P-Reactor was taken off-line in 1988 to update the facility. Work to modernize the facility stopped in 1990 with the end of the Cold War. Both reactors have sat in a cold and dark state since that time, and have been identified as the first two reactors at SRS for final closure.

Final closure for the reactor buildings involves a technique called In-Situ Decommissioning (ISD). This involves filling all below grade levels of the buildings with grout. This will immobilize any residual contamination contained within the building and structurally stabilize the buildings. The reactor vessel itself will be filled with grout to the maximum practical extent and capped with a reinforced concrete cap. In addition, certain above grade sections of the buildings will be demolished and capped.

SRNL assisted in the ISD process by creating a virtual 3D model of the reactor buildings in CAD using original construction drawings. Physical models have also been produced at 1/96 scale. Both the virtual and physical models have been used to develop the grouting strategy, determine grout quantities, direct work planning, and facilitate pre-job briefings.

II. REACTOR BUILDING VIRTUAL MODELING

R- and P- Reactors are heavy water production reactors. In a heavy water reactor, the heavy water is used both for moderating and cooling the nuclear reaction. Production reactor buildings differ considerably from commercial power reactor buildings. Production reactors were designed to safely place target material into the reactor, irradiate the material, remove it and then perform preliminary processing before transferring the material to other facilities. Preliminary processing requires large basins to allow the target material to cool before pre-processing can begin. This requires considerably more equipment and space than commercial reactors. An aerial view of R-Reactor is shown in Figure 1.

Figure 1 - Aerial View of R Reactor

To construct these buildings required hundreds of drawings, all drawn on drafting boards in the early 1950s. Changes to the design during construction plus updates

through the years of operation have cluttered the drawings with revisions. This combined with the drawings being almost 60 years old have made them very difficult to read and few people who were involved with the construction are still available to assist. Site Decommissioning and Decontamination Engineering (SDD Engineering) was tasked with developing the closure plans for the facilities. They tasked SRNL with interpreting the drawings and turn them into a more readily understood and useful format.

SRNL chose PTC's Pro/Engineer (Pro/E) 3D CAD software for the virtual modeling. Pro/E was chosen due to the power of the 3D modeling tools as well as SRNL's familiarity with the software.

Modeling started with the anticipated starting point for grouting on R-Reactor, the Deposit and Exit (D&E) Canal. The modeling proved its worth almost immediately when an unknown void space was discovered, Figure 2. This void space was not easily identified by reviewing the drawings. It was only by trying to recreate the drawings in CAD that the void became apparent. Subsequent structural calculations showed that had grouting started as anticipated, there was a strong possibility of a structural failure of the canal floor over the void.

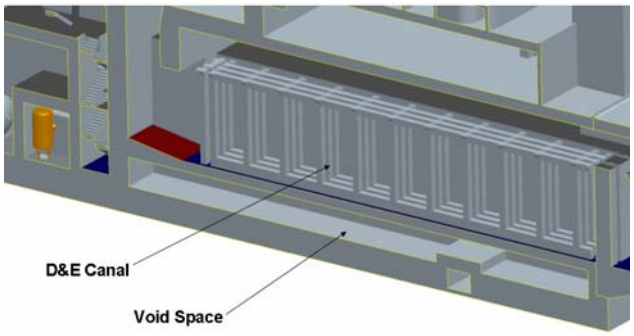

Figure 2 – D&E Canal and Void Space

Virtual models were subsequently created for the rest of R- and P-Reactor. This included the Assembly, Purification, Process, Engine Houses, and the Stack areas of the buildings, Figure 3.

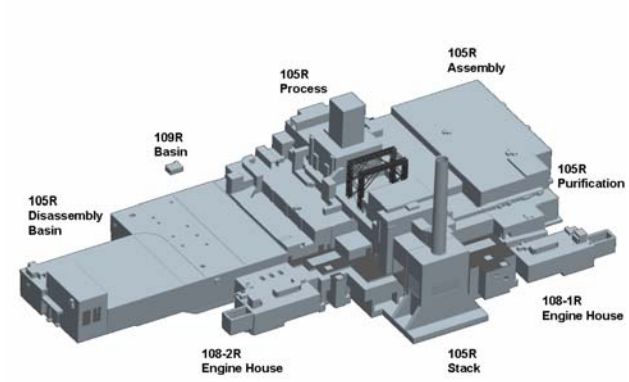

Figure 3 – 105R Virtual Model

The level of detail included in the virtual model was dictated by the end use. The models are being used for visualization of the environment, room volumes for grout calculations, grout flow paths, work plan development, and operator training. As such, the detail includes all concrete structures, floor grates, pipe holes through walls where grout might leak, and major equipment. Details such as electrical conduit, small diameter piping, and minor equipment were not included, but could be added at a later date should the need arise. The Process area has this level of detail for all below grade sections and the ground floor, but only floors and exterior walls are included for all upper levels. Due to the scope of the ISD, the Disassembly Basin, Stack, Purification, and Assembly areas required the models to be complete to the roof. Figure 4 shows the level of detail in the various sections.

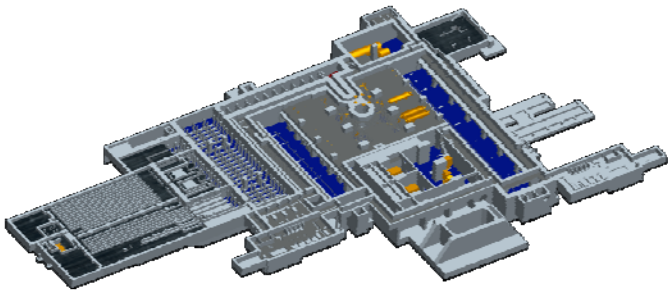

Figure 4 – 105-R Building Cross Section

These models have been used to gain a better understanding of the building construction. They have also been used to help determine the grouting strategy, i.e., the location and order of grout placement. Figure 5 shows a proposal for slick line placement for grout delivery.

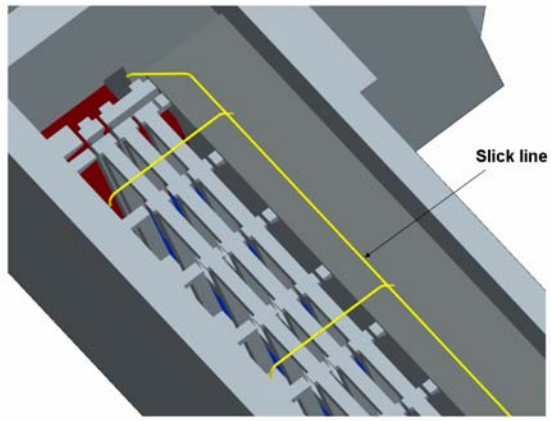

Figure 5 – Slick Line Routing for Grout Placement

III. REACTOR BUILDING PHYSICAL MODELING

Once the virtual models were complete, it was desired to have physical models. The virtual models greatly improved the visualization of these large buildings over using original blue prints. However, even though the virtual models are constructed in 3D, they are still presented on a 2D monitor or paper. This still requires a level of interpretation by the user. The creation of the 3D physical models provides another improvement in visualization by presenting the information in true 3D.

To create the models, SRNL's Rapid Additive Manufacturing (RAM) Lab was utilized. Specifically, Stratasys Fused Deposition Modeling (FDM) machines were used to create the parts in ABS plastic. These machines produced parts that were a good compromise between level of detail, durability, and speed of manufacture.

Based on the size of the actual buildings and the level of detail desired in the physical models, a scale of 1/96 was chosen. This reduced 2 foot columns to 1/4 inch, which are easy to see and durable enough for the intended use. Even at 1/96 scale, the final model was still 8 feet long. Figure 6 shows the completed model.

The Stratasys FDM machines can produce a part with a maximum size of 16" x 14" x 16", so the virtual model needed to be cut into sections that would fit the machine. Parts were cut into logical sections, quite often at less than the maximum machine size. Figure 7 shows a typical section, with over 140 total pieces required to complete the model. To aid in visualization, various sections of the model can be removed to show lower floors. Figures 8 – 10 show views of the physical model.

Figure 6 – Complete 105-R Model

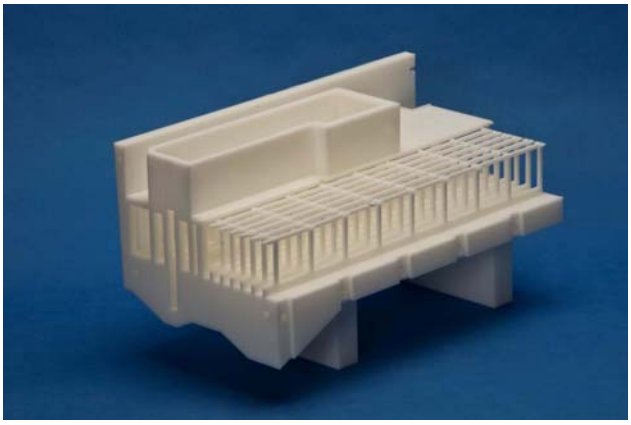

Figure 7 – Typical Model Section

Figure 8 – D&E Canal and Void Space

Figure 9 – Purification Building

Figure 10 – Purification Building with Roof Removed

IV. CONCLUSIONS

Having both the virtual and physical models has been a significant benefit to the project. A time savings was realized during the initial planning stages by not having to have the entire team familiarize themselves with the original prints. Planning meetings were held around the physical model, helping to insure all team members understood what was being discussed. As the grouting strategy was being developed, team members would sit in front of the CAD model and layout different options, looking at grout lift heights and volumes and slick line placement. This allowed rapid evaluation of multiple options, and then provided accurate grout and equipment quantities for procurement.

By actually using the prints to create the models, a much improved understanding of the construction of the building was achieved. This helped highlight areas of structural concern to the grouting operation.

In addition to the originally anticipated benefits, others were realized as well. Some of the uses include:

Virtual Model

- Atmospheric simulations were conducted that needed detailed building information. Considerable time would have been required to gather the exterior dimensions from the hundreds of detail drawings which were easily determined from the CAD models.
- Pictures taken from the CAD model were incorporated into work packages. This provided perspectives that would not have been easily provided through original prints or photography.

Physical Model

- Pre-job briefings discussing safety and upcoming work evolutions can be conduct in front of the model in a clean area instead of a contaminated work environment. This reduces the potential for worker exposure.
- There are many stakeholders requiring updates in a project of this size. The model is used to help discuss scope and status, reducing the need for tours of the buildings, again reducing potential exposure.
- Various phases of the ISD project have been subcontracted. The physical models have been used to help convey the scope of the project at pre-bid meetings.

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PHOTO CREDITS

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