OAK RIDGE National Laboratory | SECOND TARGET STATION

CV & TSS PDR Neutronics Contributions: Monolith Heating

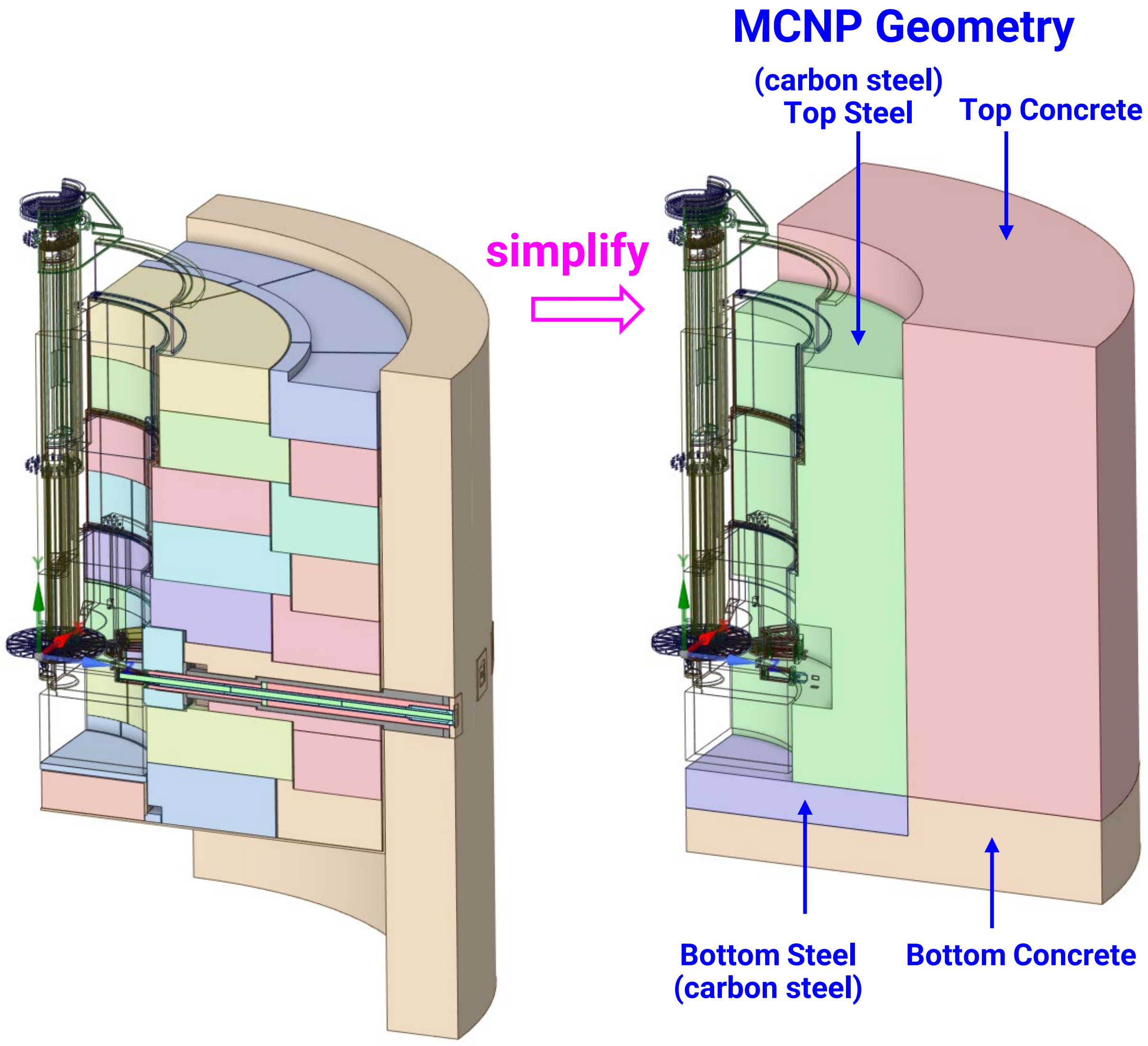
Thomas M Miller, Min-Tsung Kao, Kumar Mohindroo

March 27, 2025

Monolith Heating

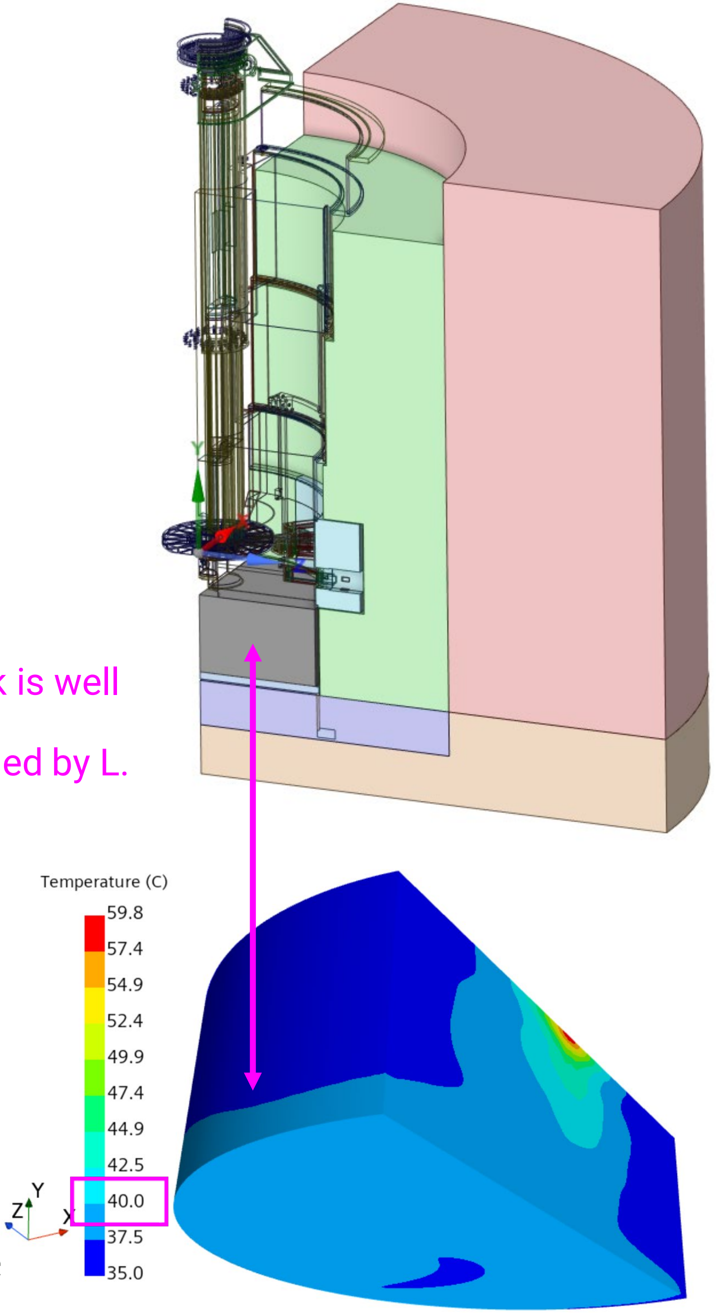
Monolith Shielding Heating and Thermal Analysis

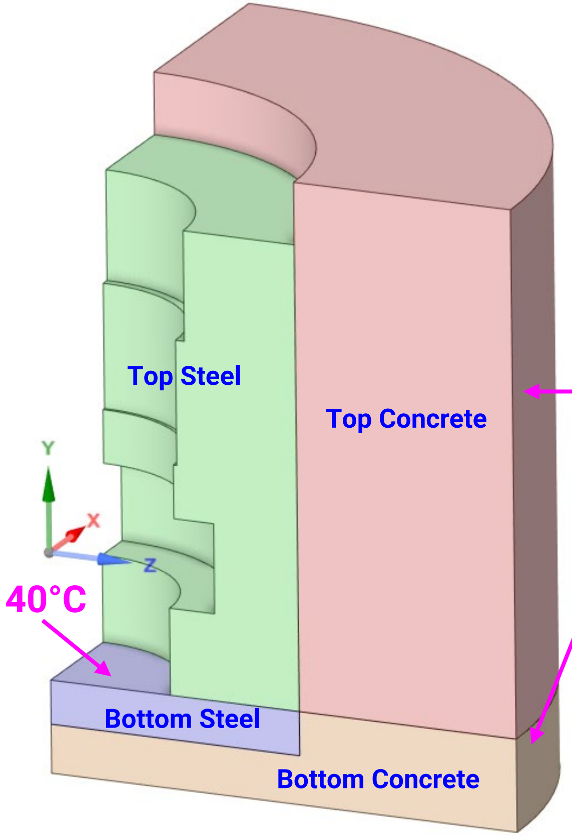
- Objective is to ensure the concrete temperature is below 65°C
- A greatly simplified geometry was analyzed for preliminary design



Monolith Shielding Heating and Thermal Analysis

Bottom shield block is well cooled.
Heating data provided by L. Zavorka





Concrete outer surface temperature will change the heat transfer coefficient, h. Therefore, the value of h for each case in this presentation is slightly different.

- Heat transfer coefficient, h = 1.38 W/m^2-K
- Environment temperature, $T_\infty = 35°C$

- Adiabatic boundary condition for the rest surfaces (top, bottom, and inner surfaces).

- **Perfect contact** for **radial interface** between **steel** and **concrete** (to maximize heat transfer to concrete)
- **Thermal contact resistance** for the **horizonal** interfaces

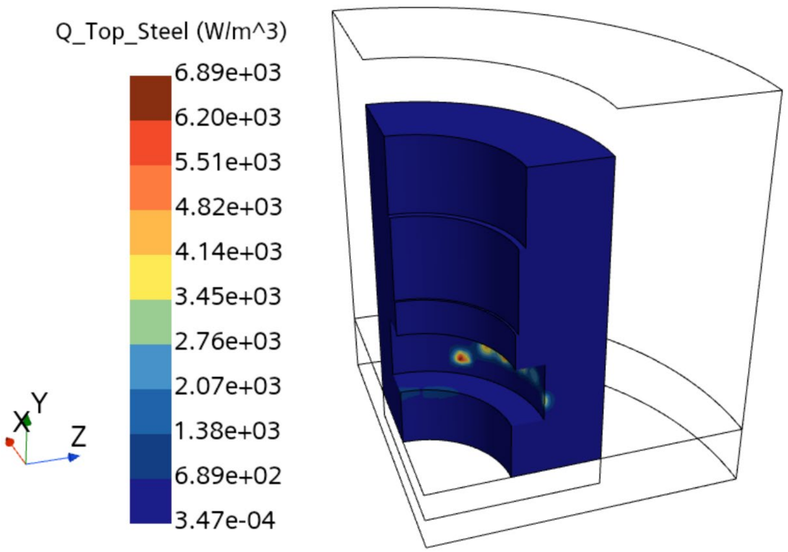
Monolith Shielding Heating and Thermal Analysis

Volumetric Heat Sources from Thomas Miller

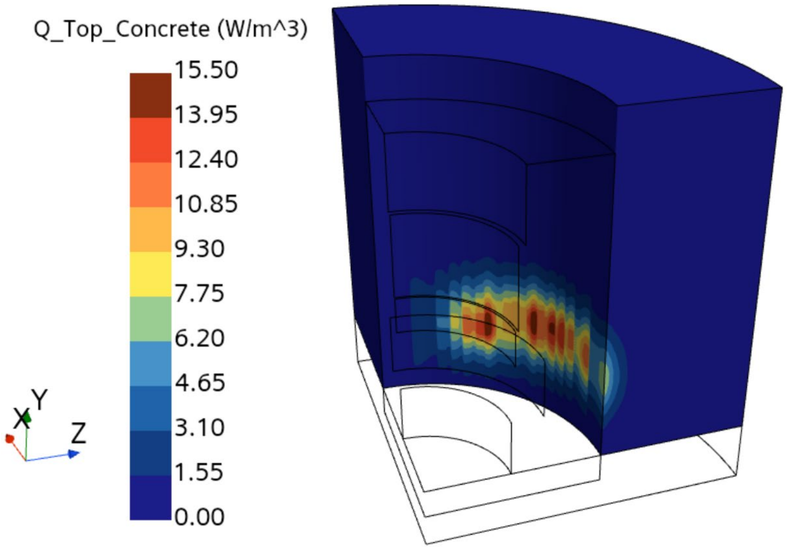
- The volumetric heat sources were calculated from MCNP with **rectangular** meshes, which did not exactly capture the geometry boundaries.
- The volumetric heat source of the top steel in this thermal analysis was multiplied by a factor of 1.232 to match to total heat from MCNP calculation.

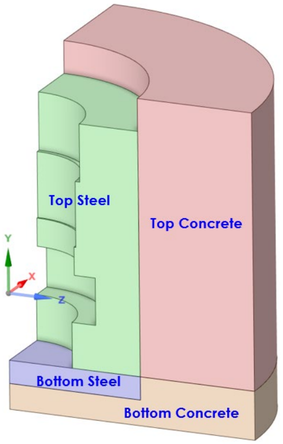
Q_Total = 546 W

$Q\_Top\_Steel = 519W$

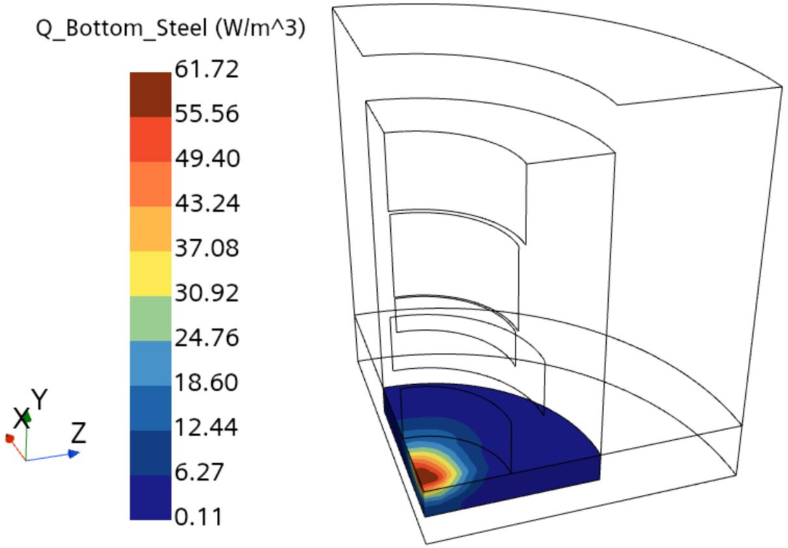


$Q\_Top\_Concrete = 12.7W$

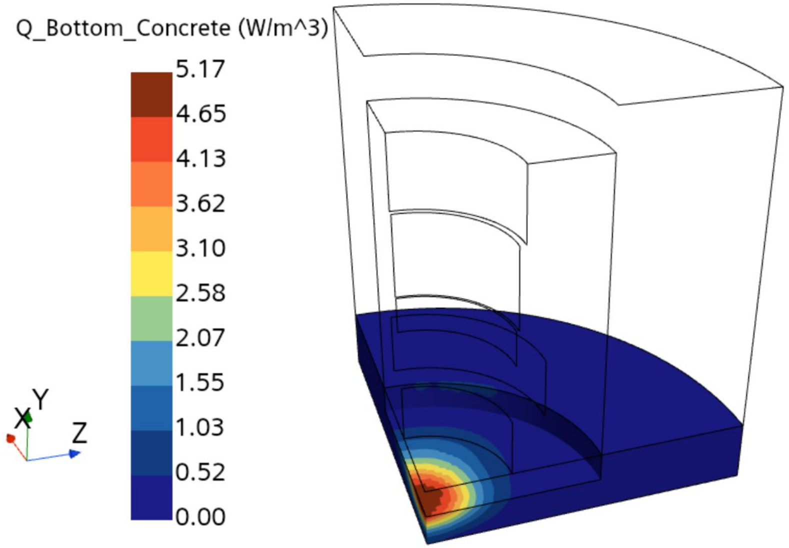




$Q\_Bottom\_Steel = 12.3W$



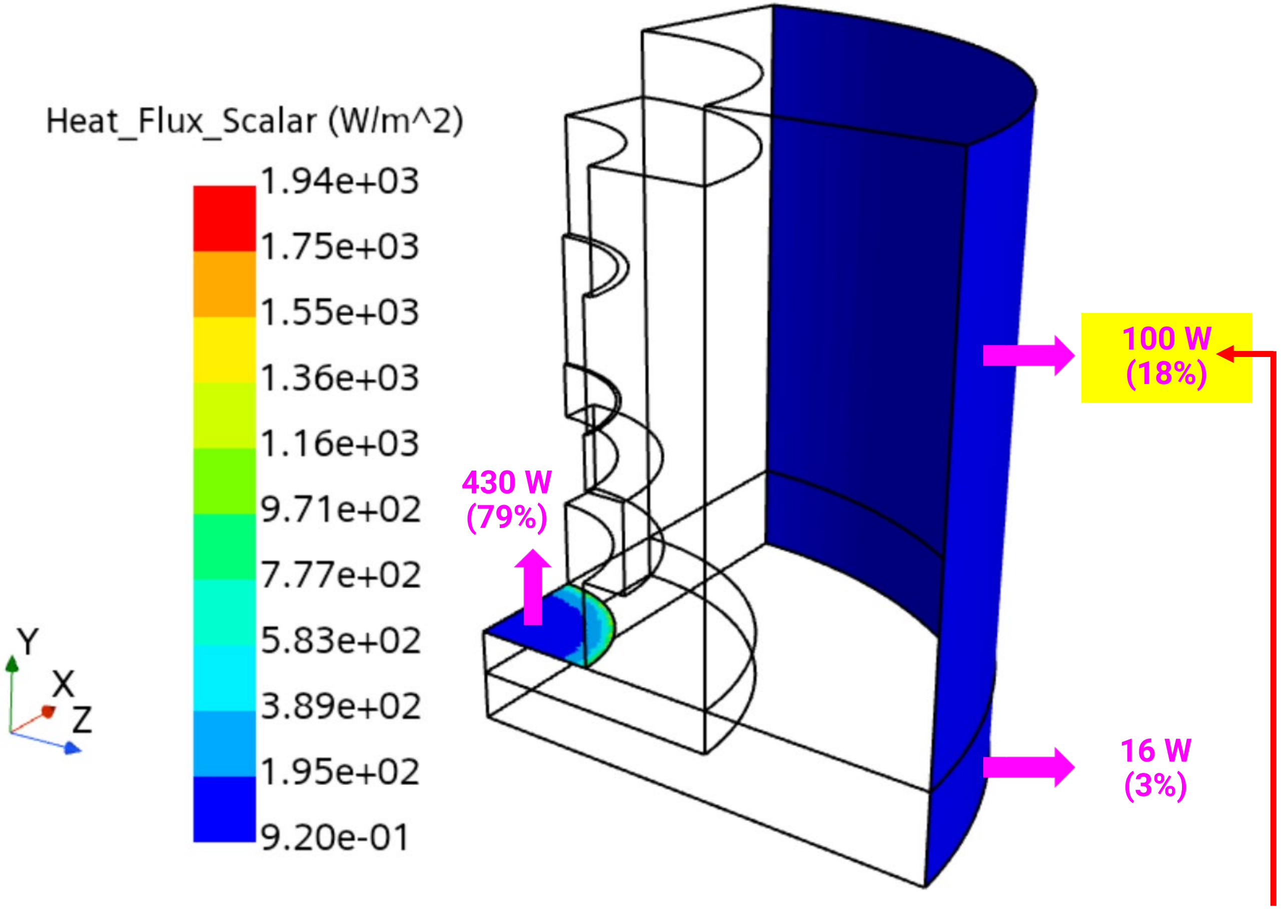
$Q\_Bottom\_Concrete = 2W$



Monolith Shielding Heating and Thermal Analysis

Heat Removal on Boundaries

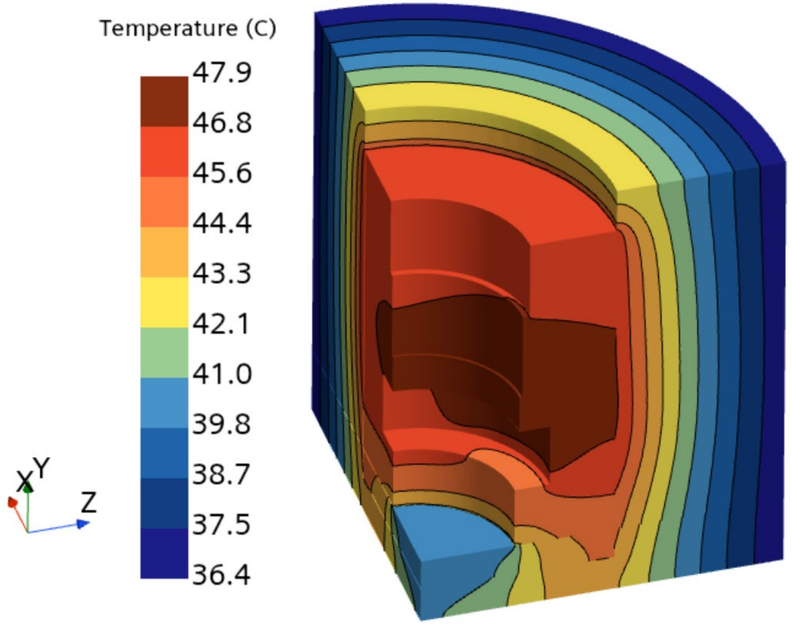
Portion of the 519 W in **top steel** and the heat in **top concrete** flow **outwards** to the **concrete outer surface**. Therefore, it is ok to assume perfect contact radially between concrete and steel because the top concrete is mainly cooled by the 35°C environment, not by the 40°C cooled surface.



Monolith Shielding Heating and Thermal Analysis

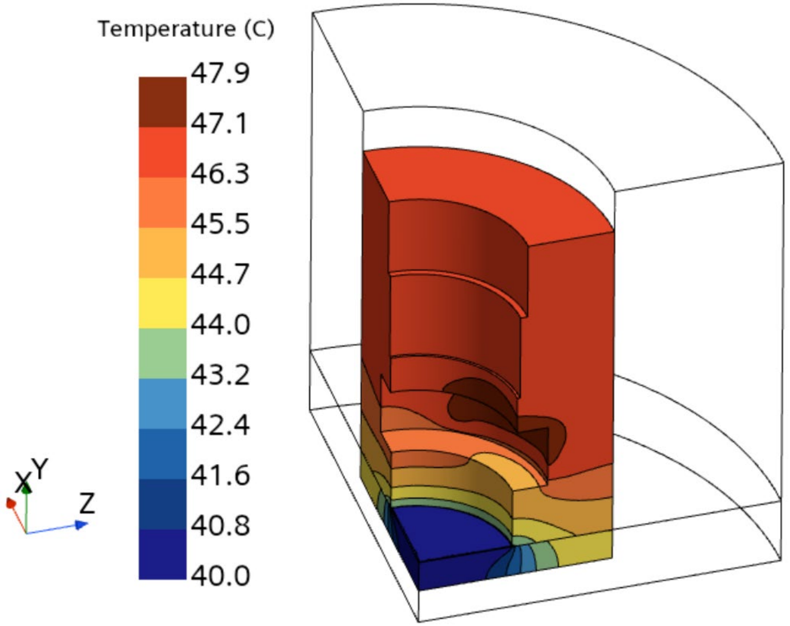
- **Heat transfer coefficient, h = 1.38 W/m^2-K**

Steel + Concrete Temperature



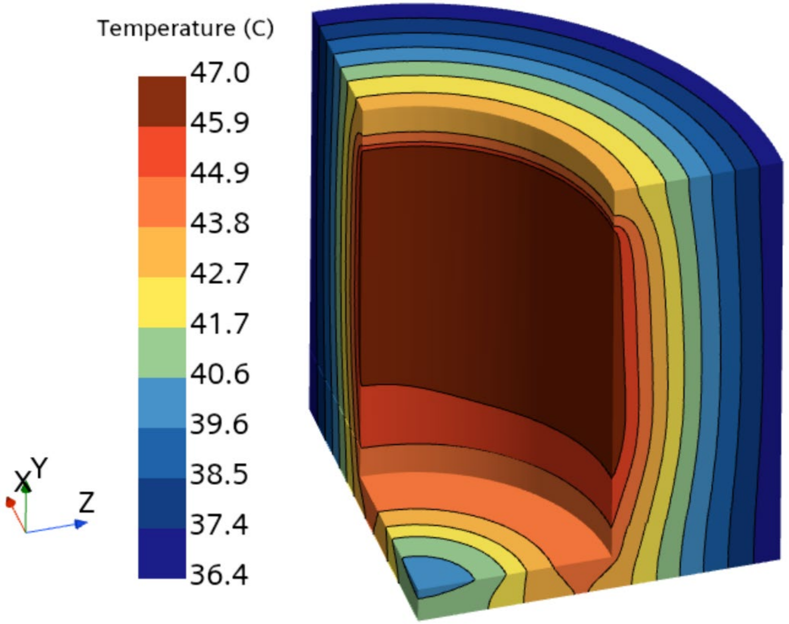
Steel Temperature

Peak: 47.9°C



Concrete Temperature

Peak: 47.0°C



Average outer surface temperature is 36.5°C.

⇩

This value was used to evaluate heat transfer coefficient.

Summary

- For the worst case analyzed in this presentation, the **peak concrete temperature is 47°C**, well below 65°C.
- Thermal contact resistance has no apparent impact for the temperature field because the average heat flux is very low.
- To evaluate the **peak concrete temperature**, **perfect contact** for the **radial** interface between steel and concrete is a more **conservative assumption** than using thermal contact resistance.