Supplementary material

Supplementary material 1: Reactor pool cavity dimensions and cost model

Optimization of natural circulation district heating reactor primary heat exchangers

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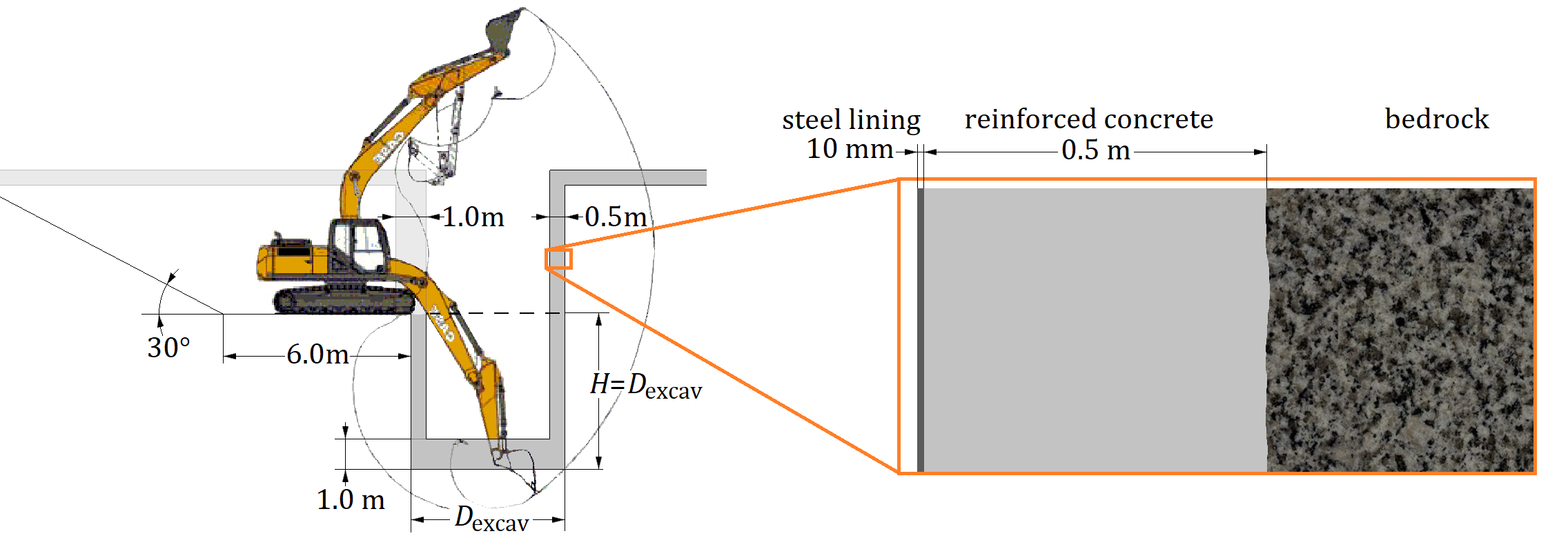
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The 7-meter deep main pool is unaffected by the heat exchanger design and considered part of the fixed cost *C*SMR. Only the cost of the cylindrical cavity extending below the the main pool varies as a function of the heat exchanger dimensions and the height D*H* to the RPV bottom. The cavity cost *C*cav, is thus evaluated in the cost model. This consists of two components: excavation *C*excav, and wall construction *C*cav,w.

The cavity has a 500 mm thick steel reinforced concrete wall with 10 mm steel lining. The concrete cost is the sum of material and labor costs per cubic meter. The material cost of the steel reinforced concrete *C*mat,src is obtained from the rebar-to-concrete mass ratio *r*, 0.11 for reactor buildings in Gen IV nuclear systems [36], using index-corrected [37] specific costs in [36]. Since the pool cavity walls are likely more complex to construct than typical substructures, the installation labor demand is estimated at an average of substructure and superstructure labor [36]. The cost estimates are summarized in Table S1.

Excavation costs depend much on soil and the methods used. In dry, soft soil as little as 30 €/m3 [34] has been estimated; bedrock excavation is typically 4-6 times more expensive, the high end corresponding to non-blasting methods. Here 175 €/m3 has been considered. The minimum excavation volume corresponds to a cylinder with a depth and diameter exceeding those of the cavity depth by 1 m. To clear the cavity of rubble, excavator must reach the bottom, limiting reach to approximately the diameter of the cavity (Fig. S1). For a cavity deeper than its diameter, a 6.0×6.0-meter working plateau must be cleared, with a ramp no steeper than 30°. The working space and ramp are re-filled during the wall construction. The wall thickness against re-filled soil is doubled to 1.0 m, and labor demand estimated according to nuclear-site superstructure [36].



**Figure S1.** Pool cavity structure and excavation dimensions.

**Table S1.** Reactor pool cavity cost components.

|  |  |  |  |
| --- | --- | --- | --- |
| **Commodity** | **Property** | **Unit** | **Value** |
| Concrete | density | kg/m3 | 4000 [36] |
| cost | €/m3 | 289 [36] 1 |
| cost | €/kg | 0.072 2 |
| Rebar | density | kg/m3 | 7850 |
| cost | €/t | 1772 [36]1 |
| cost | €/kg | 1.77 2 |
| Reinforced concrete | density | kg/m3 | 4385 2 |
| rebar/concrete | kg/kg | 0.11 [36] |
| cost | €/m3 | 1012 2 |
| Installation labor, reinforced concrete | installation time, superstructure | h/m3 | 5.2 [36] |
| installation time, substructure | h/m3 | 2.6 [36] |
| installation time, cavity wall | h/m3 | 3.9 2 |
| labor cost, total | €/h | 50 |
| cost multiplier for engineering,  supervision, inspection | - | 1.5 |
| Steel lining | density | kg/m3 | 7850 3 |
| cost | €/kg | 4.4 3 |
| cost multiplier for installation,  engineering, supervision, inspection | - | 3.0 |
| Excavation, bedrock | cost | €/m3 | 175 |
| Re-filling excavated rock | cost | €/m3 | 30 |

1 Index correction according to [37]

2 Calculated from other values

3 ASTM 304 stainless steel assumed