Computational Modeling of Deep Borehole for DSRS Disposal

Ícaro Vaz Freire, Roberto Vicente
Nuclear & Energy Research Institute - **University of São Paulo**

INTRODUCTION

- **Computational modeling** is a powerful tool to predict the behavior of complex-coupled physical systems.
- It can be used to assess the **feasibility** and **safety** of various disposal methods for radioactive waste.

BACKGROUND

Figure 1. Radioactive materials confined by metal shells.

SEALED RADIOACTIVE SOURCES

- SRSs are radioactive materials encapsulated into metal containers to **isolate** their radioactivity.
- **Harmful** for the environment & human health.
- Appropriate disposal required upon the end of their working life (**Disused SRSs**).
- Growing population of DSRSs demands a long-term safe solution for disposal.

THE DEEP BOREHOLE CONCEPT

- Narrow well drilled into a **selected geological setting** encased by a steel tube & settled by cement mortar.
- Supports long-term storage of DSRSs isolating radiotoxic material from the **biosphere**.
- Optimal candidate for disposal of DSRSs due to its safety and cost-effectiveness.

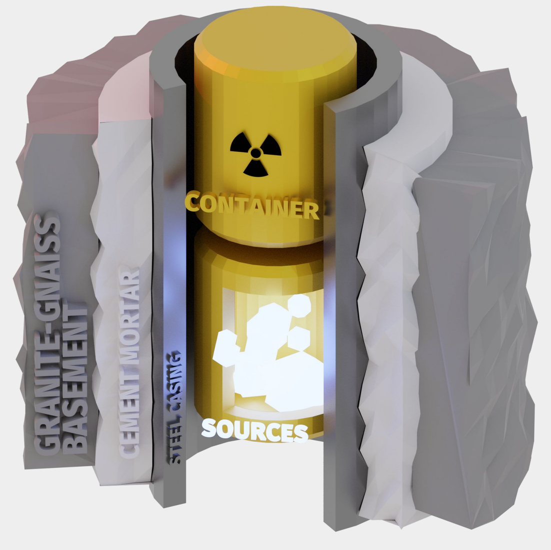

Figure 2. Deep borehole concept structural diagram.

THE GEOLOGICAL SETTING

- Granite-Gnaiss rock **~ 3×10^2 m** deep acts as natural barrier for DSRSs.
- Local geological profile highly impact quality of deep borehole repositories.
- Humidity, groundwater & rock fractures speed up borehole deterioration.

OBJECTIVES

- Develop an **interactive** tool for simulation & visualization of deep borehole **features**, **events** and **processes** (**FEPs**), which can be used as a tool in facility licensing procedure.
- Assess repository long term **performance** & **safety**, given waste characteristics, natural & engineered barriers and other parameters.

3D **game engines** make for **interactive tools** in radioactive waste management industry.

MORE ON **GitHub**

METHODOLOGY

- Creating **3D resources** for visualization of borehole structure & underground geological profile.
- Numerically solving **physical models**, including fluid flow, geomechanics, thermal dissipation & **finite element analysis**.
- Models are differential equations solved numerically applying **Euler's method** given the system's initial & boundary conditions.
- Evaluating well's behavior under **stress**, **extreme scenarios** & likely **events** such as seismic activity, flooding, rusting, human intrusion, etc.

TOOLS

- **Blender:** 3D modeling software used to create visual resources.
- **Godot:** game engine in which physical models & logic were implemented using GDScript & C# programming languages.

RESULTS

- The application features: 3D visualization of the borehole system & underground substrate layers.

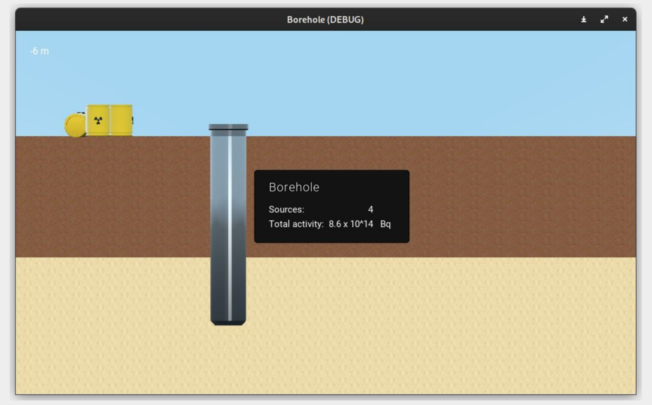

Figure 3. Snapshot: dummy borehole (side view).

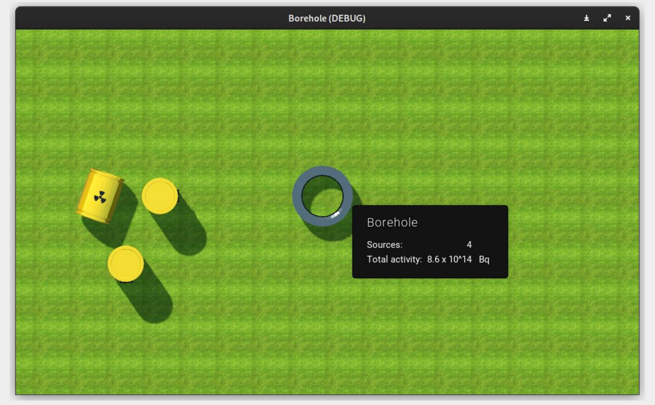

Figure 4. Snapshot: dummy borehole (aerial view).

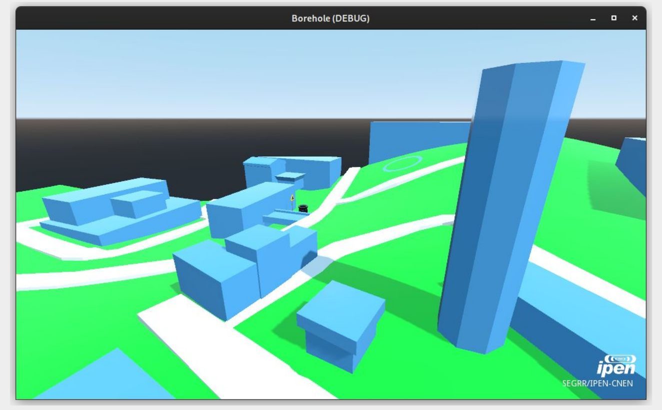

Figure 5. Snapshot: conceptual model from IPEN site.

CONCLUSIONS

- Modern softwares used for **game development** can be used in radioactive waste industry to build powerful & useful interactive applications.
- Interactive computational models can significantly hasten the **licensing process** for **borehole repositories construction** due to facilitated access to relevant information.

CNEN Comissão Nacional de Energia Nuclear
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