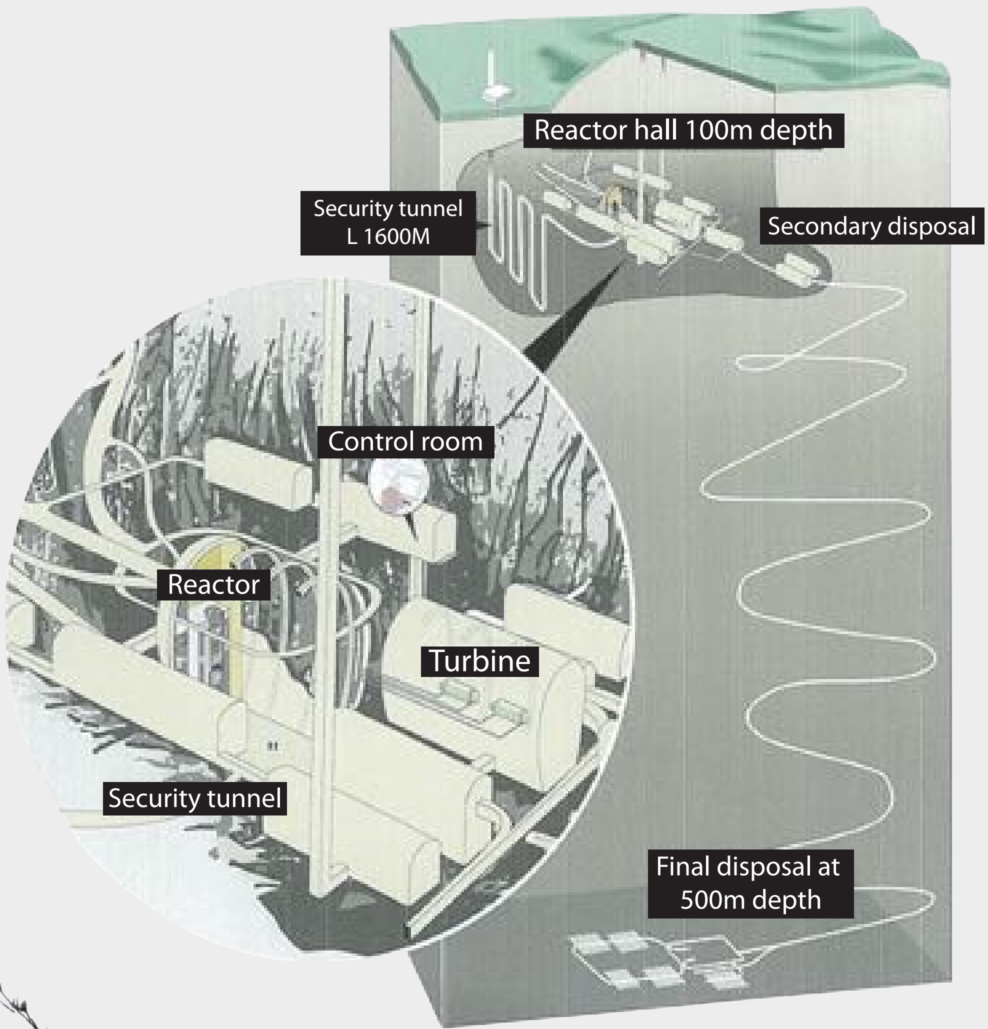
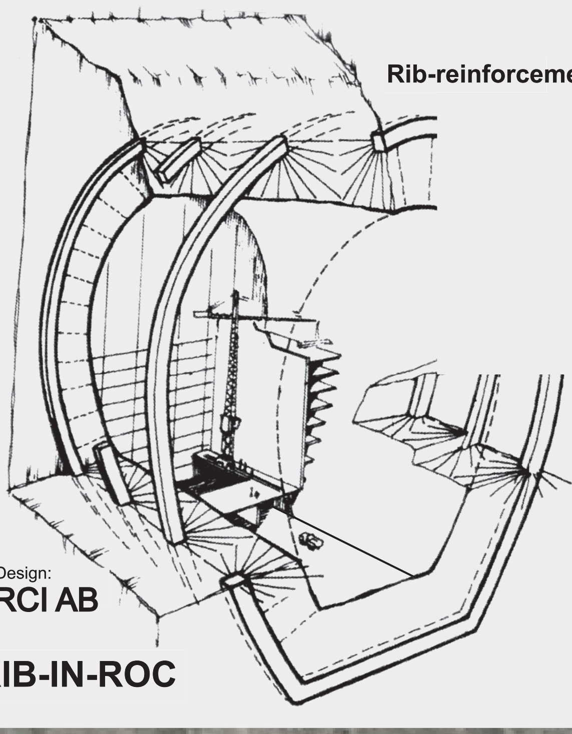
RCI AB
SWEDEN

NUCLEAR POWER PLANT PRODUCTION IN A CLOSED CIRCUIT UNDERGROUND

THE FUTURE

ENERGY PRODUCTION IN A CLOSED CIRCUIT UNDERGROUND





Advantages of constructing the underground Nuclear Power Plant:

- In case of eventual breakdowns, underground nuclear power plant can totally reduce the nuclear overhang into the atmosphere, because the greater part of the activeness is being held inside the mountains
- Provide safer security control against sabotage and terrorism
- Underground nuclear power plant is effective protection against war
- Under the ground it gives a great freedom for closure and the possibility of a large storage facility locations
- Underground power plant provide tremendous protection of the human security environment
- Underground power plant provide much better security during the earthquake, because disturbances in 50 to 100 m of depth do not normally happen
- Underground nuclear power plant enables the eventual dismantling of the plant closing much more and many components can be left through the pumping of clay in these areas
- Underground nuclear power plant can be performed as a closed system, where nuclear power plant is temporary stock and permanent storage capacity of waste is planned in a closed system, where nuclear waste is never taken out to the surface
- Underground nuclear power plant has a great psychological importance for public acceptance, because it gives the feeling that all security aspects are applied to the maximum, until an alternative is found to a new source of energy that can replace nuclear power in the future
- Underground nuclear power plants give very low possibility for liability risk
- Underground nuclear power plant provides safety for a stabile production

Fig I provides a view of the Rib-in-Roc method of pre-reinforcement. Before any full-scale excavation takes place, an entry is made in the host rock and rib raises are driven around the proposed opening. These raises are spaced at intervals dependent upon rock quality; an opening in poor rock needs more ribs per length of opening. As the ribs are driven they are used as a site from which competent rock bolting can be carried out. As a rib is excavated, it is filled with reinforced concrete. Finally, after the proposed opening has been reinforced, the displacements are automatically controlled as the opening is being excavated. Using this method, openings with a span of 60-80m (200-260ft) and a height of 80-100m (260-300ft) can be achieved. At present, the largest man-made openings in rock, for permanent installations, have span of 35m (115ft); for example the turbine hall of Waldeck I in West Germany is 33.5m (110ft) (Abraham et al).

Mining technique for high-level nuclear waste repository

The nuclear industry is deeply concerned with the problem of disposing of the waste from both civil power plants and military plants. One problem that it faces is the length of time for which the waste must be isolated. Because the intention in Sweden is to dispose of the spent fuel without reprocessing, that period extends to several thousand years – a time frame much longer than any for which human society has experience of planning. Rock suggests itself as an outstanding host environment for such waste as long as no tectonic movements can be expected that would affect the selected area. In Sweden planning has to take account of an expected glaciation within a time-frame of about 10 000 years. In consideration of the weight of the ice and the effects of erosion a safe repository will need to be placed at least 200 m below the present surface. The reason for placing the repository even lower is that in Sweden the rate of water flow and hydraulic conductivity of the rock generally decrease with increasing depth. Several locations with good, homogeneous bedrock have been identified, and an extensive drilling programme has indicated the promising sites. It is difficult, however, to obtain information from drilling and surface measurements alone, so it is important to have a design of sufficient flexibility to allow for surprises at the stage of underground investigations that might otherwise affect long-term safety. One of the alternatives that is being considered is the WP-cave method, which has a special layout that is easily adaptable to different rock qualities.

WP-cave method

The structures are of the order of 250 m high and 100 m wide. The storage space for the spent fuel is excavated in the centre, a buffer zone of rock being left outside to hinder the dispersal of dissolved radio nuclides. This rock mass is totally surrounded by a shield of low-permeability bentonite clay and sand, about 3-5 m thick. The clay barrier is intended to be constructed by a method similar to cut and fill mining with sand fill. The clay-sand mixture can be well compacted to produce a shell of very low hydraulic conductivity, so that the inner rock mass will be completely isolated from the outher.

The outer barrier, the hydraulic cage, consists of horizontal annular tunnels interconnected by drill-holes in a pattern such that all water-carrying joints are short-circuited. This means that in the future, when the water-table has returned to the normal level above the repository, the cage will act as a communicating vessel. Groundwater will flow into the cage more easily than it will flow in the rock mass since the pressure at the base of the cage will be lower than in the rock mass. The water will then flow in the cage past the centre of the repository, penetrating the bedrock on the downstream side. The function of the hydraulic cage is similar to that of a Faraday cage in electro-technology.

Key advantages

One main advantage of the structure is that the properties of the rock mass can be investigated step by step, first from the surface, then form the underground tunnels and, finally, from the drifts and drill-holes of the hydraulic cage.

The method of excavating the barrier produces successive exposure of the rock walls for mapping and control of fissures and joints. By the time the barrier is complete every square metre of the walls will have been checked. It is possible to register joints that might be part of water-carrying joint systems passing through the hydraulic cage. The information obtained should be used for blocking those water paths. The result of the step by step investigation of the rock mass is a considerable knowledge of the places where the nuclear waste is to be stored.

Another main advantage of the structure is that the separation of the inner rock mass from the surrounding rock can be achieved with the required degree of isolation in many different types of rocks, as long as the structural strength of the rock allows for the excavation. This feature of WP-cave, being less dependent on rock quality, gives greater choice in the location of the repository.

Theoretical analyses make it possible to minimize several of the risks of failure, and a further step to technical feasibility analysis can be taken by constructing a demonstration WP-cave. When such a structure has been built and tested over a few years without fuel more accurate data will be available as a basis for the decision on the building of a full-scale repository. Finally, it is worth mentioning that the close similarity between the WP-cave excavation technique and cut and fill mining is no coincidence. Swedish mining engineers have made a vital contribution to the development of the concept and the excavation methods employed are more familiar to the miner than to the construction engineer: WP-cave thus provides a bridge between the two branches of rock engineering.

RCI AB Ivar Sagefors, Sweden

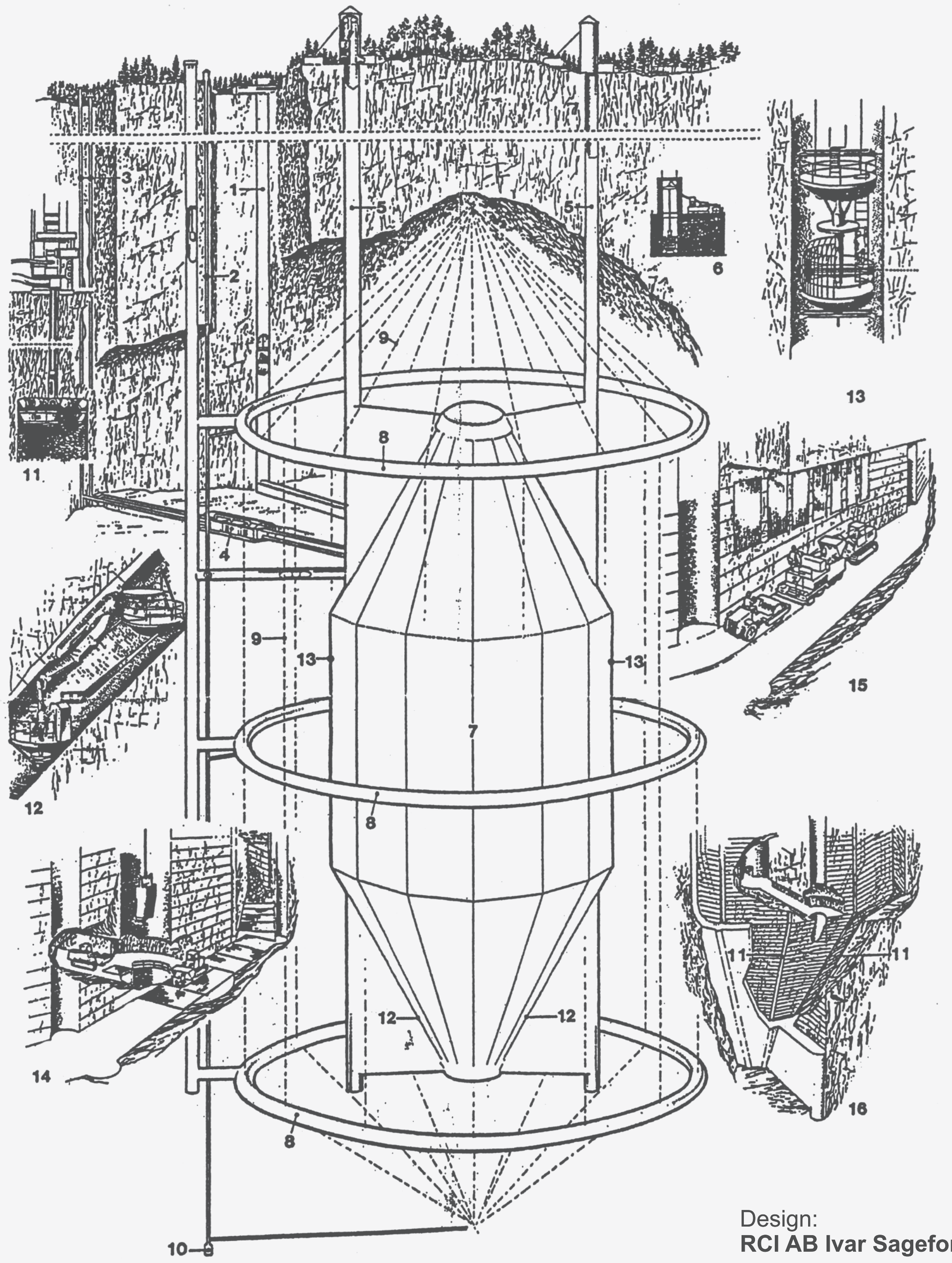
NUCLEAR POWER PLANT PRODUCTION IN A CLOSED CIRCUIT UNDERGROUND

The Solution for your CHILDRENS` FUTURE

WP-CAVE

SUPPLEMENTED WITH HYDRAULIC CAGE

EXCAVATION AND REFILLING OF SLOT



Design:
RCI AB Ivar Sagefors

1. TRANSPORTATION OF CANISTERS
2. MANWAY PASSAGE
3. VENTILATION SHAFT
4. HEAT EXCHANGE STATION
5. MAIN SHAFT FOR EXCAVATION AND REFILING OF SLOT
6. FULL-FACE DRILLING OF SHAFTS
7. BENTONITE-QUARTZ BARRIER WITH A THICKNESS OF 5M.
8. DRIFT FOR HYDRAULIC CAGE
9. DRILLHOLE FOR HYDRAULIC CAGE
10. PUMP STATION
11. RAISE BORING OF SHAFTS
12. SLOT EXCAVATION-DRILLING IN INCLINED SHAFTS
13. SLOT EXCAVATION-DRILLING IN VERTICAL SHAFTS
14. MUCKING AND HOISTING OF ROCK. THE REFILLED BENTONITE-QUARZ IS COVERED WITH STEEL PLATES
15. REFILLING OF THE SLOT. THE STEEL PLATES HANG ON THE ROCK WALL
16. GEOMETRY OF THE EXCAVATED SLOT

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