Durability of Dukovany shallow land repository engineered barriers

A. Vokál, L. Nachmilner, R. Wasserbauer, J. Dohnálek
Nuclear Research Institute, Czech Republic

The main aim of this project was to explore the durability of engineering barriers used at Dukovany shallow land repository as a support of safety assessments.

This appendix summarises the principal results focused on durability of asphaltopropyleneconcrete (APC) hydroisolation and steel reinforced concrete construction.

Durability of asphaltopropyleneconcrete (APC) hydroisolation

One of the main disadvantages of hydroisolations based on asphalt is its organic components that are susceptible to microbial degradation. The study of durability of this barrier was therefore concentrated mainly upon this aspect of degradation.

Samples of microbial cultures of bacteria and fungi were repeatedly isolated from inside and the close surroundings of the Dukovany repository vaults (9.9.1992, 11.5.1993 and 5.12.1994) and both qualitative and quantitative determination of micro-organisms was carried out from water extracts of taken samples.

It was found that grampositive bacteria prevail in this region. On the surface of APC dominated the strain of Pseudomanas pseudoalcaligenes bacteria, various Micrococcus sp. strains and various Bacillus (G+).

The hydraulic conductivities of samples after radiation and microbial exposition were measured. A decrease of permeability after a longer term microbial activity was found. Isolated bacteria were incubated and inoculated to the cells with the microscopic glasses covered with thin layers of bitumen. After four months of cultivation it was possible even only by eye to observe the striking changes on bitumen samples.

The effect of temperature on the growth of some bacteria was studied at 5, 15, 30 and 40°C. It was detected that dominant biodeteriogen Pseudomonas Pseudoalcaligenes grows very well at 40°C , but can grow slowly even at temperatures about 5°C.

Metabolic activity of bacteria in the presence of bitumen and propylene oil, that forms the part of APC mainly from the reason of better workability of APC, was measured through determination of oxygen uptake by means of manometric method. The higher uptake of oxygen suggesting higher metabolic activity was achieved with bitumen samples.

On the surface of APC and concrete next to APC dominated the fungi of the family of Fusaria that were also present in the grass of the nearby slope. On the surface of concrete walls a higher extent of the fungi coming from soil or the surface of grass, namely Aspergillus sp., Alternaria or Clasterosporium was located.

The growth of isolated fungi on microscopic plates covered with bitumen was compared with the growth of the same strains of fungi on agar plates depending on relative humidity.

It was found that dominated Fusaria might grow at relative humidity of about 80%. (The relative humidity in some of concrete vaults may even exceed this value.)

The family of these fungi may also easily grow at temperatures about 5°C .

It is clear that neither temperature nor a lower humidity does not form a serious obstacle for growing of various kinds of fungi in concrete vaults.

A dramatic decrease of weight of bitumen samples grown in sterile soils inoculated by fungi and bacteria isolated at Dukovany Repository was observed. The change of weight was higher than the change of bitumen samples put in sterilized soil. This observation suggests the site specific and rather complex character of bitumen microbial degradation.

No definite conclusions from the results of the experiments, however, can be drawn for safety assessments. The problem is to quantify the microbial effects for real environment of Dukovany concrete vaults. The way forward is through long term field experiments and regular monitoring of possible microbial degradation throughout pre-closure period.

Durability of steel reinforced concrete construction

The durability of concrete vaults was estimated from the determination and comparison of concrete structure proportion in 1991 and 1995, i.e. 1 and 9 years after finishing of building.

The governing process that can lead to the failure of steel reinforced concrete walls is the corrosion of steel reinforcements mainly those that are in ceiling concrete panels.

The estimations made in this study were based on the assumption that the corrosion can only start after the thickness of the layer of the concrete above reinforcements amounts to the thickness of the carbonated layer, the possible effect of chloride ions has not been taken into account.

The layer above steel reinforcement was measured by means of electromagnetic indicator and the carbonated layer was estimated through measurements of change of pH by means of phenolphtalein indicator of drilled out samples.

From a comparison of results determined in 1991 and in this year it appears that carbonation process is slightly faster in walls than on the ceiling panels and is getting slower. For more realistic and more reliable results it will be necessary, however, to repeat measurements in longer intervals in future.

The rate of corrosion of steel reinforcement was estimated on the basis of empirical data collected for corrosion of uncovered concrete reinforcements in areas with various extent of pollution with sulfunc acid and air salinity.

On the basis of the results, obtained in the study, it was estimated that the total lifetime of the ceiling panels (including the carbonation interval and a decrease of steel reinforcements area to 50% at which the ceilings panels could with high probability sink down) is about 635 years.