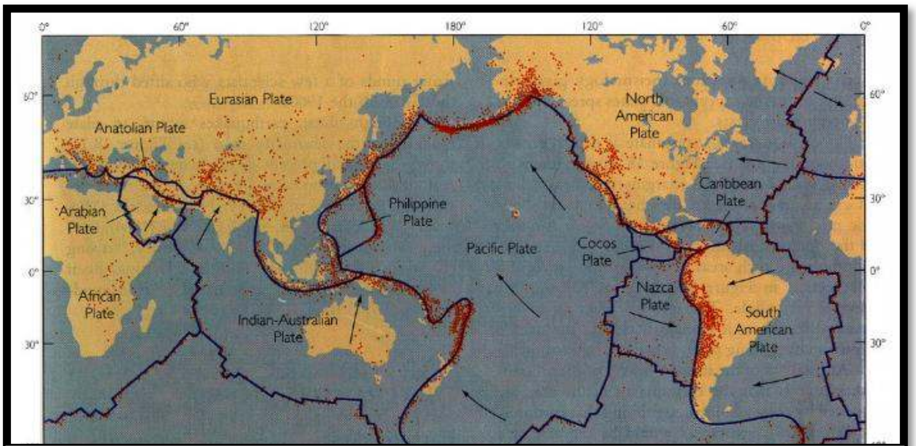
KOEBERG'S MULTI-LAYERED PROTECTION AGAINST EARTHQUAKES AND TSUNAMIS

Introduction

Nuclear facilities are designed so that earthquakes, tsunamis, and other external events will not jeopardise the safety of the plant. In France for instance, nuclear plants are designed to withstand an earthquake twice as strong as the 1000-year event calculated for each site. It is estimated that, worldwide, 20% of nuclear reactors are operating in areas of significant seismic activity. The International Atomic Energy Agency (IAEA) has a Safety Guide on Seismic Risks for Nuclear Power Plants. Various systems are used in planning, including Probabilistic Seismic Hazard Assessment (PSHA), which is recommended by the IAEA and widely accepted.

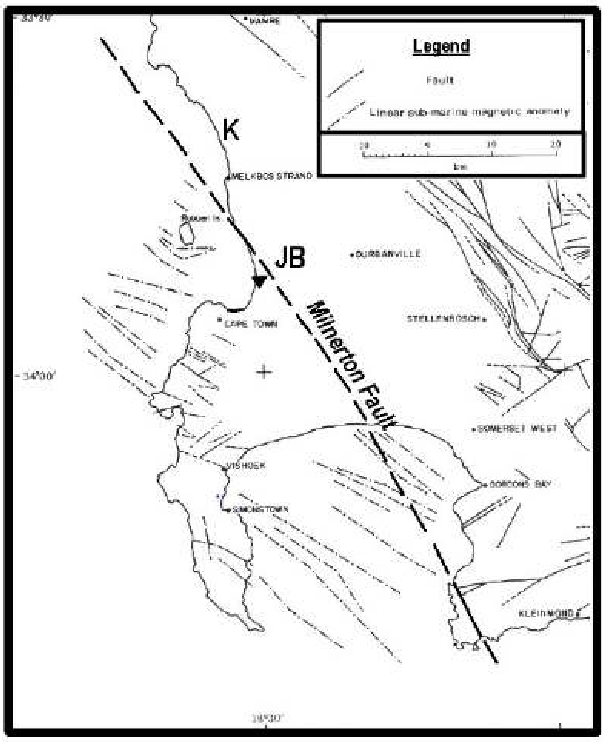
Background

Earthquakes are vibrations caused by rocks breaking and shifting under stress. The effects produced by earthquakes includes ground-shaking, landslides and rock-falls which can cause damage to property and loss of life.



A large proportion of global seismic activity takes place near the boundaries between tectonic plates, but significant earthquakes can, and do, occur far from tectonic plate boundaries

On a global scale, South Africa is considered a relatively stable region, because it is located away from boundaries between tectonic plates. Therefore, its activity rate is lower than in seismically active regions like California or Japan. Even though earthquakes are comparatively rare, they can occur from time to time, and sometimes this manifests itself as earthquake swarms that can last for several years.



During pre-design investigations for the Koeberg Nuclear Power Station, the 'Milnerton Fault' was mapped in a northwesterly direction about 8 km offshore from the nuclear site, and it extends in a southeasterly direction beneath the Milnerton area. The Milnerton Fault may extend farther across the central Cape Flats and the northeastern part of False Bay to a large fault exposed on-land between Rooiels and Betty's Bay.

Major earthquakes in South Africa's recorded history

- 1809: magnitude 6.3 Cape Town
- 1912: magnitude 6.2 Koffiefontein
- 1933: magnitude 6.5 St Lucia
- 1969: magnitude 6.3 Ceres

Koeberg: prepared for the worst

Koeberg is South Africa's only nuclear power station. It has operated safely and efficiently since the start of operation in 1984. Finding the site on which to build Koeberg took almost seven years. Exhaustive investigations involved a massive task force of diverse persuasions. From doing geographic, seismological and environmental studies to considering the legal, moral and practical implications, experts of all disciplines joined forces. Koeberg's selection boils down to its position. It fitted national grid requirements, it was in a sparsely populated area, it is on the coast - so seawater can be used to cool the condensers; and the ground conditions were suitable for the construction of a nuclear station with its enormous loads.

Working groups were set up to investigate the site geology, hydrology, seismology and meteorology, ensuring that when work began on Koeberg, there would be no shortage of essential data. Between 1970 and 1974 very detailed seismological studies were done and Eskom took advice from three consultant organisations – the Bernard Price Institute of the University of the Witwatersrand, the Geological Survey Division of the Department of Mines, and the American soils engineering specialist organization Dames & Moore (they were responsible for selecting the "design basis earthquake" (DBE) for many nuclear stations in the United States).

The three organisations were requested to calculate the probability of the occurrence of an earthquake at Koeberg. The entire design and construction of Koeberg was based on a 'probabilistic approach' – in compliance with the safety standards demanded by the Licensing Branch of the Atomic Energy Authority before issuing a license.

Geological faults occur nearly everywhere. The geologists and seismologists investigating the possible sites for Koeberg needed to establish whether there had been *movement* in any faults. They used the presence of tiny shellfish called piddocks to determine the age of the rock formations. In the seabed rock samples they found the fossilised remains of piddocks and could establish how long ago they died – thus proving that the faults had not moved over a certain period.

The team used information like this, and many other parameters to come up with a design safety basis. It was postulated that a severe earthquake occurs on the offshore fault at its closest point to Koeberg and a Richter scale magnitude of seven was accepted (this is an earthquake which would generate about six times the energy as the one at Ceres in 1969, which registered 6,3 on the Richter scale).

Indentations left by tiny shellfish called piddocks

By this time, Eskom had decided that Koeberg would be built by the French and would be modelled on a similar nuclear power station at Cruas in France.

The nuclear island design-response during an earthquake

Eskom decided on the seismic raft design, referred to as Koeberg's nuclear island.

The nuclear island is 157m long and 89m wide and supported by a system of 1 829 aseismic bearings. It supports the reactor containment building, nuclear auxiliary building, electrical building and fuel building.

The seismic raft is 6m thick. The bearings consist of layers of rubber, steel and leaded bronze.

The bearings are designed to allow the pedestals (and the earth on which they rest) to move, while the nuclear station remains stable during an earthquake.

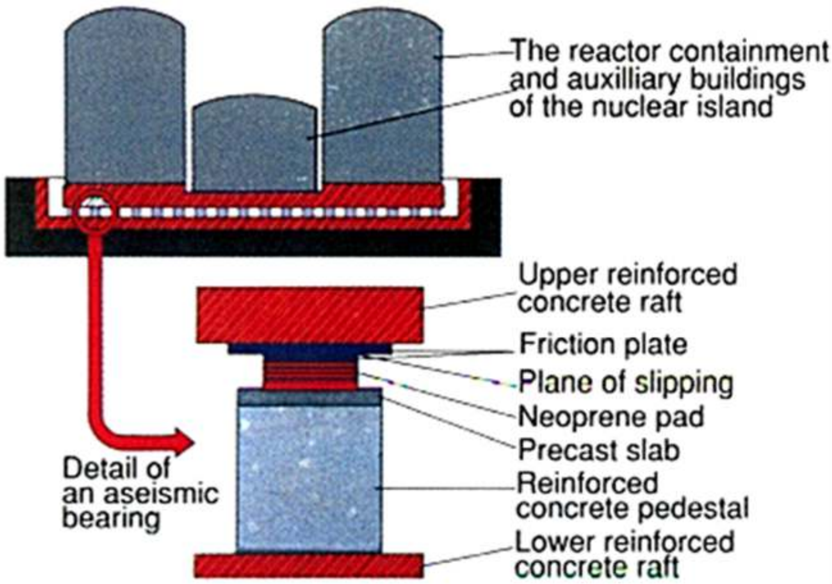
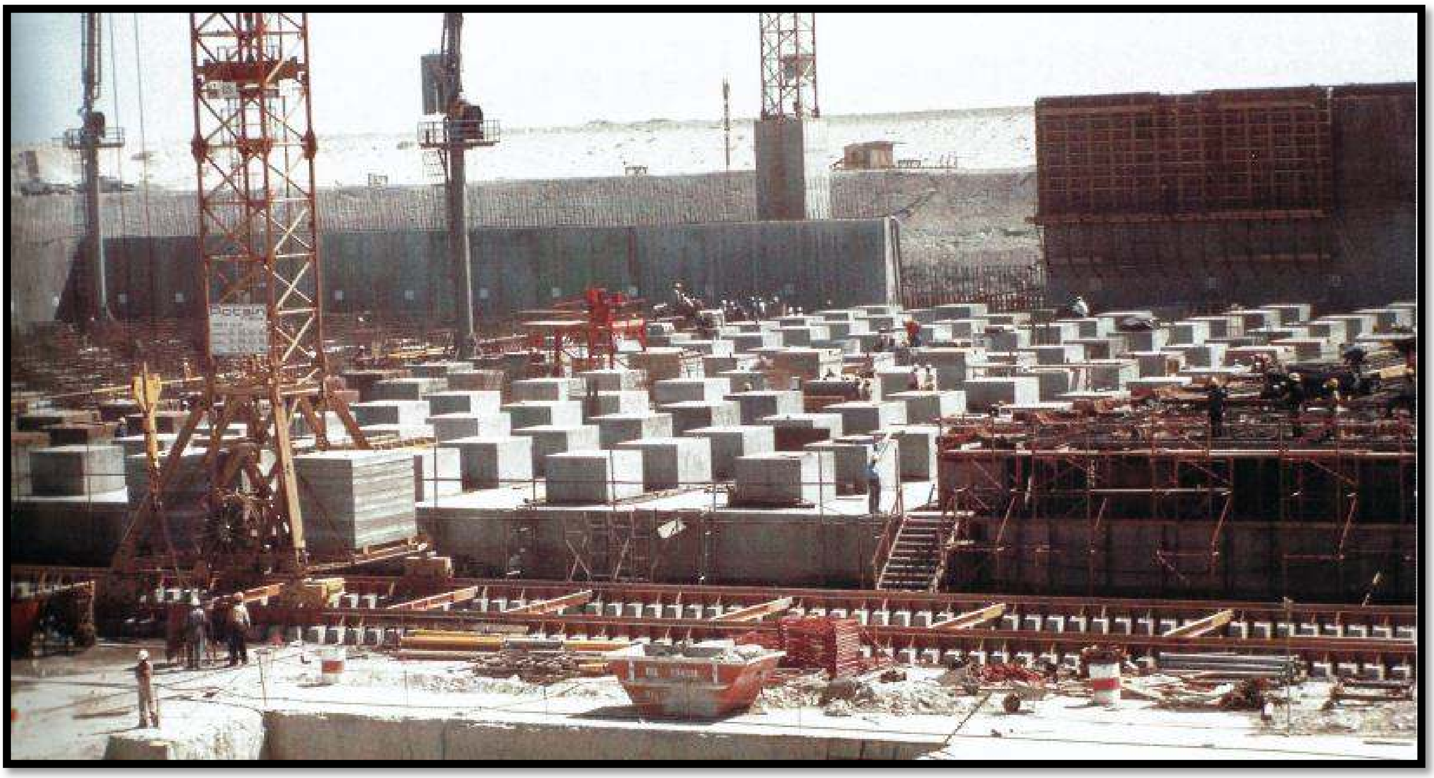
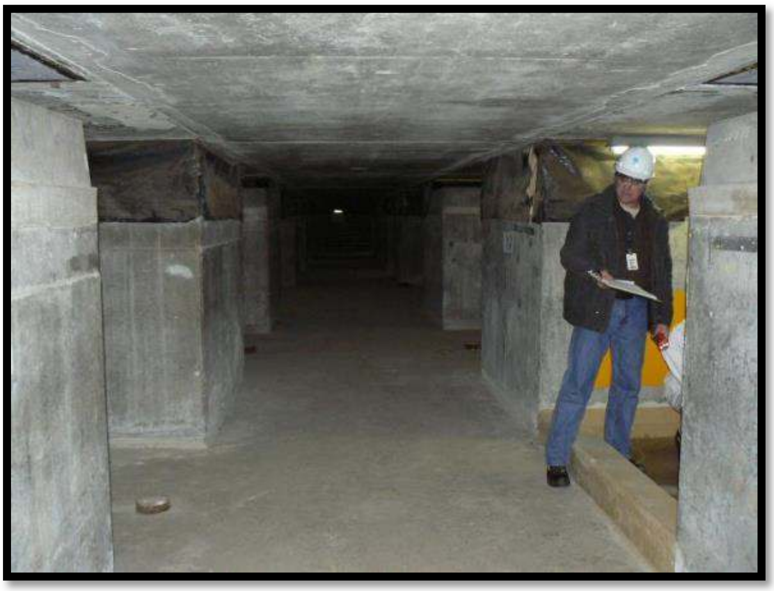


Diagram showing the earthquake protection system installed at Koeberg Power Station



Above: 676 reinforced concrete pedestals for 1 829 seismic bearings under construction in 1978



The seismic raft

The 'ceiling' in this photograph is a 6m thick concrete raft carrying the two reactors in their containment buildings. The raft rests on 1 829 bearings consisting of layers of rubber, steel and leaded bronze, which rests on 676 concrete pedestals.

The bearings, hidden in the photograph by anti-corrosion plastic aprons, are designed to allow the pedestals and the earth on which they rest to move, while the nuclear station remains stable during an earthquake.

What about a tsunami?

Tsunamis are waves initiated by large and sudden forced displacements of the seawater, with characteristics intermediate between tides and swell waves. They are generated by various mechanisms, including submarine earthquakes and landslides, collapsing/exploding volcanoes, terrestrial rock-falls, asteroid impacts, meteoric conditions. Tsunamis generated by large earthquakes in subduction zones along the major plate boundaries contribute most significantly to the global tsunami hazard.

There is no evidence that the West Coast has been hit by a tsunami over the past hundreds of thousand years. During the site selection for Koeberg, tidal waves or tsunamis were considered and as a result, the terrace on which Koeberg is built is eight metres above sea level.

What about an earthquake at Vaalputs?

Vaalputs is South Africa's radioactive waste repository and is located about 600 km north of Cape Town. It covers an area of about 10 000 hectares, measuring 16.5 km from east to west and 6.5 km from north to south at its narrowest point. Approximately 100ha will be used for storage - including an interim spent fuel facility sometime in the future.

No known major seismic activity has occurred in the Vaalputs area in recent times - which is extremely important in terms of nuclear waste disposal. In fact, indications are that the area has not been seismically active for the last 35 million years.

Extensive geotechnical investigations were carried out at Vaalputs to establish the suitability of the site. These included ground and air geophysical surveys and an intensive drilling programme.

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