Fukushima Frozen Ground Monitoring

Fukushima, Japan

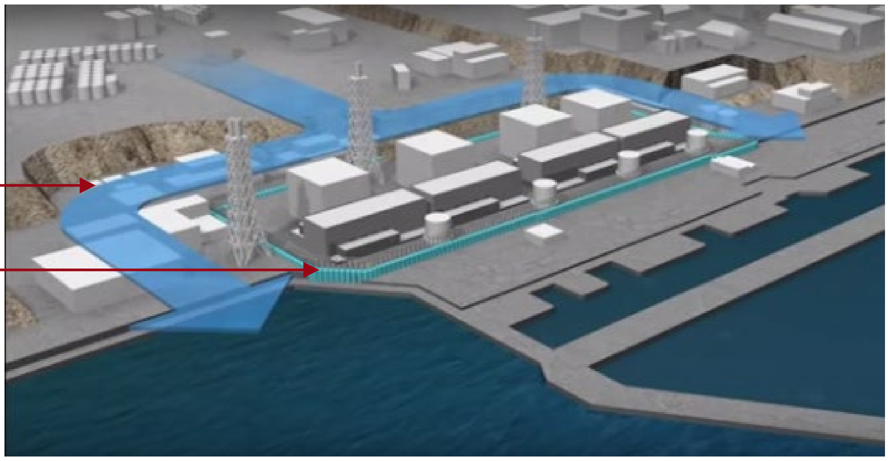
In March 2011, a major earthquake just off the coast of eastern Japan resulted in 13-meter-high tsunami waves that caused equipment failures at the Fukushima nuclear power plant. Flooding at the plant disabled the generators that provided coolant water to keep the fuel rods from overheating. The overheating in turn led to hydrogen-air explosions, severely damaging the four plants, and water began to drain out of the spent fuel pools. Later it was discovered that radioactive water was leaking into the sea.

In order to contain the water inside the plant, and to prevent groundwater from the countryside from seeping in, it was decided to construct an underground barrier of frozen earth (an “ice wall”). To do this, 1590 coolant pipes with a length of 30 meter each were installed around the perimeter of the plant, spaced one meter apart.

In order to monitor the temperature conditions of the coolant pipes, AP Sensing was selected to provide a fiber optic-based Distributed Temperature Sensing (DTS) solution to monitor the frozen earth and ensure complete impermeability.

Groundwater runoff routes

Frozen wall perimeter



Frozen wall location and water runoff routes in Fukushima

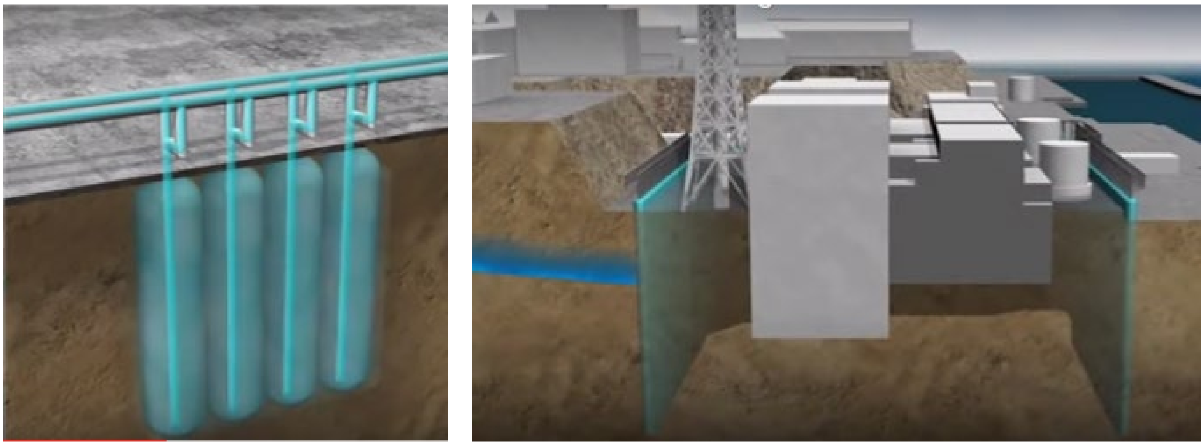
The frozen earth solution

In order to construct the wall of frozen earth, a technique was used that is similar to the one used to create skating rinks. Coolant is circulated through the pipes, which eventually freezes the soil, forming a solid barrier down to the bedrock.

The volume of contaminated water was a major challenge. Before constructing the wall, 400 tons of water a day was used to cool the reactors, and another 400 tons a day of groundwater was seeping into the structure. 800 tons of contaminated water a day needed to be diverted to storage tanks and treated before it could be safely released.

The frozen barrier keeps contaminated water inside and redirects groundwater around the plant to prevent it from entering the reactor buildings. The “frozen earth” approach provides a reliable seal without disrupting any other underground pipes or obstacles. The huge reduction in the volume of water that needs to be stored and treated has made it possible to concentrate on other cleanup activities.

AP Sensing’s regional partner NK Systems planned and coordinated the project, which is designed to protect the plant and keep the environment safe, as work continues to dismantle the plant.



Left: Underground pipes with coolant to freeze the surrounding earth;
Right: The frozen wall prevents groundwater from entering the plant

The AP Sensing solution

AP Sensing was selected to provide the fiber optic-based DTS system to monitor around 300 of the drill holes. It is vital to monitor every meter of the frozen wall to ensure there are no unfrozen areas where seepage could occur. If an area of seepage is detected, the coolant temperature can be adjusted – similarly, energy can be saved if sections are over-cooled. The entire earth wall needs to remain completely frozen and impermeable. These special requirements were thoroughly considered in the concept and design phase for the setup of the monitoring solution.

System Configuration

Six AP Sensing DTS devices were installed, each with 12 channels and a 4 km measurement range. Together the devices measure 36 fiber loops that monitor the drill holes. A dual-ended configuration was applied to better address changes in the fiber attenuation that are expected in a radioactive environment, and the automatic calibration function of AP Sensing's dual-end mode reduced the time required for field commissioning.

Radiation-resistant multimode sensor fibers were used. In order to keep the installation time to a minimum, the fibers were pre-constructed with plugs.

Thanks to AP Sensing's Distributed Fiber Optic Sensing solution and expert design, integration and commissioning of this complex project, the environment is much more protected, which allows for further work on the damaged plant to continue.