Potential for real-time Tsunami Monitoring using DAS Technology

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DAS (Distributed Acoustic Sensing) technology was introduced in 2011 for the demands of pipeline monitoring and intrusion detection in Oil & Gas business. The latest optical fiber sensing technology using ‘differential phase’ data now allows DAS to record seismic signal including VSP (Vertical Seismic Profiling). In addition, it has been experimenting to monitor the well production status qualitatively using flow measurements by detecting vibration noise induced by the flow. The system is called ‘hDVS’ (heterodyne Distributed Vibration Sensing).

Unlike conventional monitoring system, which usually use electro-magnetic sensor such as geophone, hydrophone and pressure gauge, hDVS uses optical fiber as vibration sensor. It measures dynamic strain of the optical fiber, either SMF (Single-Mode Fiber) or MMF (Multi-Mode Fiber) for entire length or a section defined by the user.

Conventional electro-magnetic tsunami sensors have been installed in the Pacific Ocean off the coast of Tohoku region and all over the coastline of Japan after the Tohoku earthquake and tsunami in 2011, together with seismometers. However, the measurement of the conventional sensors are point basis, while installation cost and environmental ratings of the conventional sensors limits the number and location of the sensor installations. Hence, the distance between the sensors is quite large in reality, so that the tsunami passing through between the sensors cannot be monitored.

When the Tohoku earthquake and tsunami in 2011 occurred, the expecting height of the tsunami wave when it reached the coast and the time of arrival were calculated based on the available data from limited number of tsunami sensors and the data from seismometers. There was an opinion [NHK documentary et al.] that uncertainty of such information might lead delay or misplace of the evacuation for the affected people. It is impossible to monitor and predict the behavior of a big tsunami that is beyond expectations using the data from very limited number of sensors.

In case of hDVS system, any existing ocean bottom optical fiber installations, which have been used for data transmission purpose mainly, would become line shaped flow sensor. This fact allows installation cost and time minimized. Especially, the international ocean bottom optical fiber cables were installed over the seismogenic areas where the boundaries of the plates existing, toward the seacoast of Japan straightaway. Hence, it would be possible to monitor the water flow from the seismogenic areas to the seacoast successively. Such flow data would be potential to be a certain data representing behavior of tsunami when hit. The intensity of the vibration to be increased when height of tsunami increases, therefore, the estimated height of tsunami would be able to be calculated based on the hDVS data. It was reported that several ocean bottom fiber cables were damaged by tsunamis in 2011 Tohoku earthquake, which resulted loss of optical communication, however, hDVS seismic monitoring can still be continued from the interrogator up to the damaged point.

Using hDVS technology by monitoring the development of tsunami continuously from several tens of kilometers off the coast would trigger certain tsunami warning on time, it is believed that loss of human life would be minimized from upcoming big tsunami events.

Keywords: DAS, hDVS, optical fiber, tsunami, real-time monitoring, flow

