

Review and preview of artificial seismic sources of ACROSS

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Since ACROSS (Accurately-Controlled Routine-Operated Signal System) was proposed, many type of seismic vibrator based on the concept of ACROSS. The following vibrators are representative ones actually used for the research for monitoring the temporal change in the subsurface structure, in which fundamental concept on technical aspect is data stacking with the ability of accurate synchronization between source and receivers.

- 1) Proto-type ACROSS was created as a rotary source of a laboratory scale in 1994 and was deployed in the campus of Nagoya University. The data stacking is established with synchronization by radio and/or line telemetry.
- 2) Type-1996 vibrator was created as a first model for practical use, which were deployed in two test site in Awaji island and Toki, Gifu prefecture. It produces 20 tons of sinusoidal force with 25, 35 and 50Hz. As the force is proportional to the square of rotation velocity vibrators of different eccentric moment were made to cover wide frequency range. This type has already removed from the site and stored in Takayama observatory for future usage. (Ikuta et al. 2002, GRL)
- 3) Type-1999 vibrator was created with similar concept of Type-1996 but without water-cooling circuit, which are deployed in Sakurajima volcano and Toyohashi, Aichi. It can produce 10tons at 20Hz for one unit and is designed to be operated with several units. It was being operated in Toyohashi in more than 10 years. (Yamaoka et al. 2014, EPS)
- 4) Type-2004 vibrator was created for producing large force in lower frequency range than before. It can produce 20tons at 7.5Hz. It is deployed in Morimachi, Shizuoka and are used to monitor secular change in seismic velocity in this area (Tsuji et al. 2018, EPS).
- 5) Type-2011 vibrator to produce 40 tons at 50Hz was designed and produced. One is now deployed by JOGMEC in Aquistore project in Canada. Horizontal deployment is regarded as essential in this vibrator to produce P wave efficiently. It is designed, in contrast to the
- 6) Type 1996, to produce wide frequency range upto 50 Hz with one unit. (See Kasahara and Hasada (2016) published from Gulf Professional Publishing) Type-2014 vibrator was designed to reduce the production and deployment cost of previous ACROSS vibrators, which is a main obstacle to be used. This type is deployed in Toyohashi, Aichi. Small bearing, horizontal emplacement, simple basement and standard unit configuration reduced the initial introduction cost. This new type ACROSS vibrator has been operated without trouble for more than two years now. The same type vibrator is deployed in Kuju, Oita by Kyushu University.

Operation methodologies of ACROSS vibrator were developed in early years of ACROSS development (Kumazawa et al. 2007, JAEA-Research). FM operation and switching operation system were developed and used as a fundamental operation system. The design of the system is based on the technology in 20 years ago, therefore, up-to-date technology is now being employed to reduce the complexity and resultant cost of the system, which will be used in size independent source system or multiple-source operation.

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