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Preparatory examination into feasibility of an existing artificial elastic wave source used as a controlled signal system

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Regarding the pending Tokai-big-earthquake, new observation systems or new tools are being developed in order to detect slow-slip events as a forerunner of the earthquake; there is the development of an accurately controlled routinely operated signal system among them. Its results show that transfer functions of subsurface including plate boundaries have been extracted and that signals produced by the system were observed at locations with 100km epicenter distance (Yoshida et al, 2007); in addition, they show that long-term stability of the system has been achieved and that we are having hints of detection of state changes in subsurface.

On the other hand, we have several microseisms whose production process has been estimated. Among them, there is a microseism that moving heavy bodies (railroad trains) produce with piers (Mori et al, 1991); we can expect that we may use the source of the microseism as an artificial seismic source with stability. From this point of view, based on the research results mentioned above, I have preliminarily examined the artificial seismic source with stability. I will report the results here.

The elastic waves produced by transmitters should have following features: 1) sufficient power; 2) coverage of the frequency band that can be observed by existing seismic observation networks; 3) stability of the power and the frequency. In addition, 4) it is demanded to synchronize transmission and reception in order to make deconvolution of source-functions properly. The stability and the synchronization are directly related to the usability of the transmitters; the power and the frequency are closely related to necessary stacking days.

An outline of the artificial seismic source with stability is as follows. 1) Power: its maximum force is 1.4x10∗∗6N, which should be loaded on the subsurface, under the conditions that weight of one car is 6.0x10∗∗4kg, total bridge length related to the pier is 120m and the length of one car is 25m. In addition, its impulse is 5.0 x10∗∗6Ns under the conditions that total length of train is 292.5m, train speed is 58m/s, they make a signal with 7.1s length and produced source function has triangle shape. The impulse will be loaded on the basement with area of 1.5x10∗∗2m∗∗2. 2) Frequency: the source function has peaks around 2Hz and 6Hz. 3) Stability: it depends on train speed and train weight. One person weight, 60kg, could be only 0.1% of one car weight; the change of train speed from 58m/s to 57m/s could be 2% effect. We can find trains with 58m/s around 60 times per day recently. On the other hand, the parameters of the transmitter installed at Mori-machi are as follows. It transmits sine wave with frequency range from 3.5Hz to 7.5Hz; its force is 1.8x10∗∗5N or 4.0x10∗∗4N; data length is 200s; stacking can be made 36 per day; I estimate its impulse could be 3.6x10∗∗3Ns.

These considerations reveal that the artificial seismic source with stability has possibility of using as one of accurately controlled transmitters. Nonetheless, I have recognized that we need to get source feature data at the location of the source in order to evaluate the followings: 1) effect of pier-base area (not point) to power, 2) how to manage non-sinusoidal signal for stacking, 3) stability of train-speed, 4) how to synchronize transmitter and receiver with non-sinusoidal signal and 5) short data length, namely 7 seconds.

References:

Yoshida et al (2007): Active monitoring in Tokai region using seismic ACROSS transmitter installed at Mori-machi, Chikyu Monthly, 29, No.8, 498-505

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