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BRIEF NOTE

ON SOME RESULTS OF OBSERVATION OF TORSIONAL GROUND MOTIONS AND THEIR RESPONSE ANALYSIS

By

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1. Introduction

This short report is a summary of the results of the observation of torsional ground motions using a newly developed moving-coil-type torsional motion pick-up.

Recently we are discussing on the possibility of failures by torsional response of structures caused by their non-symmetrical configuration. However, if the ground motion contains such torsional component, there may be very much difference in the result of response analysis. The authors have been trying to clear out this problem since 1972. By the end of 1976, the authors obtained about ninety records. During these periods, three pick-ups were used, and recently it was found that the cross-talk term of one of them was significantly bad, however, the results described in this report has not been compensated.

2. Pick-ups

This moving-coil-type pick-up was developed by Professor Furukawa, Chuo University to measure torsional vibration of machine tools like vertical axis turning lathe. Its schematic cross-section is shown in Fig. 1. The pendulum, which consists of coils and supporters, is suspended by very thin and short wires. Magnetic path is approximately D-shape. Its size is 65 mm in diameter and 100 mm in height. Its natural frequency is 1.0 Hz and the critical damping ratio is 0.7. The electro-motive-force from the pick-up is proportional to torsional velocity in the range from 1 Hz to 30 Hz according to the authors' test. The cross-talk term between torsional motion and horizontal acceleration is less than 10 %* in general, however, one of them is extremely bad.

Mean sensitivity of six pick-ups, which the authors have, 5×10^{-1} mV/m rad/sec. Here 1 m rad/sec = 1×10^{-3} rad/sec.

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* ratios of observed value of torsional ground motion to cross-talk term induced by the corresponding observed horizontal vibration.

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3. Site and Foundation

This pick-up is set on a concrete foundation 1 m x 1 m x 1 m, which is buried on the free-surface ground, approximately five meter thickness Kawanto Roam layer, with other three components of acceleration pick-ups. This foundation is 2,490 mm from the wall of a two story reinforced concrete building for instruments and recorders. This site is located at the point 1 km far from cliff line along the former sea-shore line (Chiba Field Station, Inst. of Ind. Sci., Univ. of Tokyo)(1).

4. Results

The authors obtained about ninety records the period from Feb. 1972 to July 1976. Out of these data, nineteen date, of which the maximum torsional velocities exceed 0.04 m rad/sec, are plotted as shown in Fig. 2. The gradient of the average line in a logarithmic chart is almost 1/2. Therefore, the relation of the maximum horizontal acceleration (NS component) to the maximum torsional velocity is expressed by following equation:

$$\dot{\Omega}_{max}(\mathrm{mrad/sec}) = 1.893 \times 10^{-3} \alpha_{max}^{1.988}(\mathrm{gal})$$

5. Their Response Characteristics

The authors made response analyses of some of them. Fig. 3 and 4 are shown the comparison of those to the torsional ground motion and the horizontal ground acceleration of a near-field earthquake. At peaks in the lower frequency range around 5 Hz, both curves are similar to each others, however, in the higher frequency range, the torsional ground motion is more dominant than the horizontal ground acceleration. This is also observed in the result of Fourier analysis as shown Fig. 5.

In some cases of other near-field earthquakes originated from another nest of sources, the higher frequency component is less than the peakes of the coupled modes around the frequency 5 Hz, however, the case shown-above, the higher frequency components more than 10 Hz are the most dominant. The peak shape of Fourier analysis of the torsional ground motion in the range of 5 ∿ 6 Hz is only similar to that of NS component of the horizontal ground acceleration. The building is located in the south side of the instrument's foundation.

6. Remarks

There are still many uncertain factors which should be cleared out to discuss on the torsional ground motion. The instrumentation system has a room to be improved. The effect of the adjacent building should be evaluated. The authors is continueing the observation on other instrumentation foundations far from the building and also on a axi-symmetrical model. To reach to some conclusions for the design, we need to continue observation study few more years.

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7. Reference

(1) SHIBATA, Heki and others:
On Fluctuation of Responses of a Structure, Proc. of 5 WCEE(Rome), #367, (June 1973) p.2891.

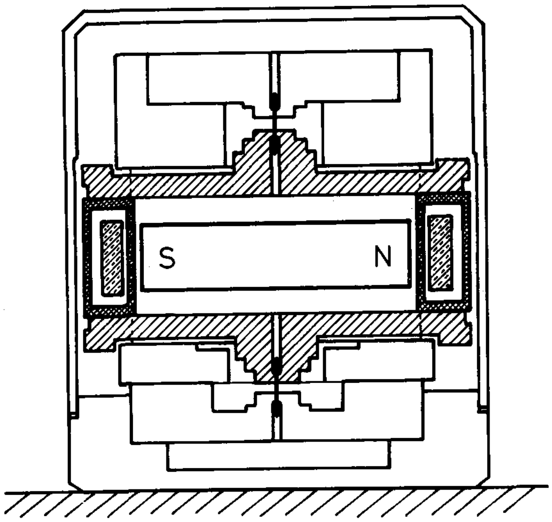

Fig. 1 Schematic Cross Section of Torsion Pick-up

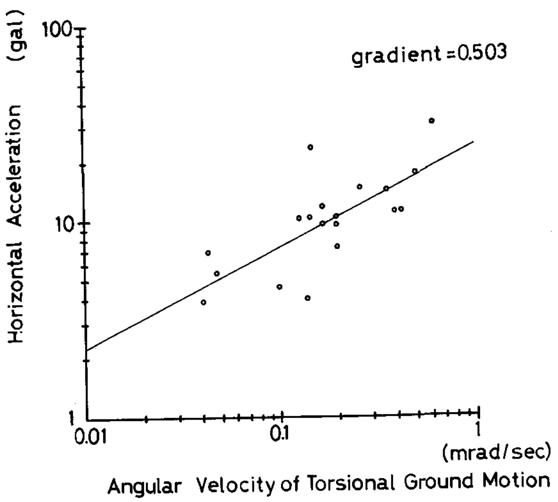

Fig. 2 Relation of the Maximum Horizontal Acceleration to the Maximum Torsional Ground Verocity

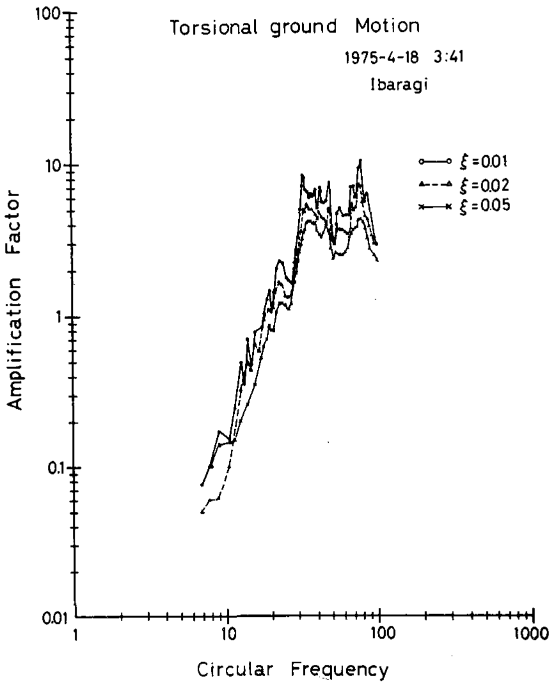

Fig. 3 Acceleration Response Spectrum of Torsional Ground Motion (1975/4/18 03:41)

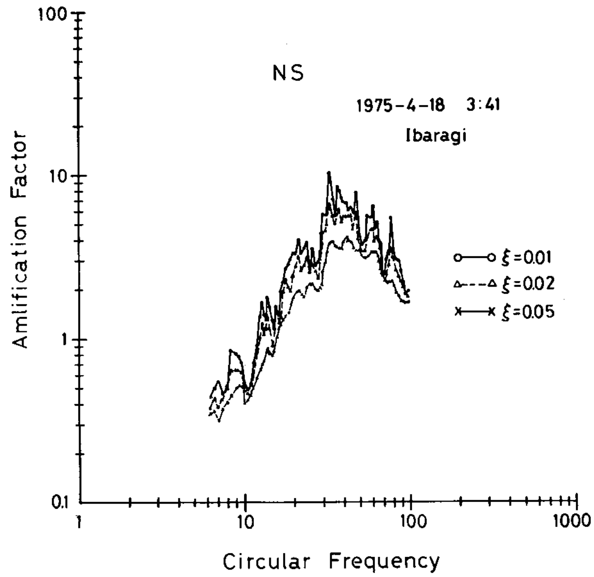

Fig. 4 Acceleration Spectrum of Horizontal Ground Motion (NS) (1975/4/18 03:41)

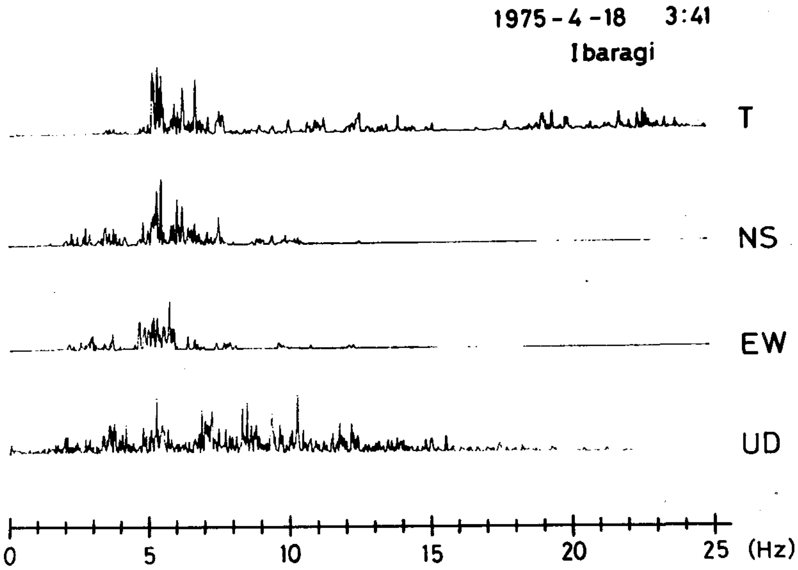

Fig. 5 Fourier Spectra of Torsional and Three Components of Ground Motion (1975/4/18 03:41)