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RELATION BETWEEN GROUND STRAIN AND GROUND ACCELERATION, VELOCITY AND DISPLACEMENT

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INTRODUCTION: Seismic ground motion data obtained by a very densely located seismometer array network, installed in Chiba Experiment Station of the Institute of Industrial Science, the University of Tokyo, was widely used to study the engineering properties of the earthquake motions (Ref. 1). In the present paper the characteristics of pipe strain are compared with those of ground acceleration, velocity and displacement.

It is usually thought that the ground strains contain only long period components and their time histories have strong resemblance to those of the ground particle velocities. In this paper it is shown that these assumptions may not always be true, and depending on the characteristics of individual earthquakes, the pipe strains may show very different behaviour.

EARTHQUAKES USED FOR THE ANALYSIS: Seven of the best records already obtained by the observation system were analyzed. The selected events shows different behaviour with their magnitudes being between 4.9 and 7.9 (on Richter scale) and the focal depths from 2 km to 452 km and epicentral distances from 5 km to 705 km. The detailed characteristics of the seven earthquakes are given in Ref. 1.

RESULTS: First the pipe strain and the ground acceleration, velocity and displacement are compared in terms of their peak values (Figure 1). Apparently, the pipe strain is more strongly correlated with the ground particle velocity than with acceleration or displacement.

A better understanding of the behaviour of the ground strain is achieved when its time history and frequency content are compared with those of acceleration, velocity and displacement. Three different cases are distinguished. In the first case, there is a rapid decrease in amplitudes of acceleration, velocity, and displacement, as well as strain, as the time passes. The overall similarity between time histories of strain and those of acceleration, velocity or displacement is not notable (Figure 2a). For the second case, with the lapse of time, the reduction of accelaration amplitude is remarkable while there is not any significant reduction in the amplitudes of velocity and displacement. The amplitude of pipe strain remains at almost the same level, but the short period components in the initial parts are replaced by longer period components in the latter parts. In this case also it is difficult to find any similarity among the waveforms of strain and those of acceleration, velocity or dispalcement (Figure 2b).

In the last case, although the acceleration has almost the same amplitude throughout the event (with the maximum of only 5 gals), the strain amplitude is very small in the initial part with significant increase in the latter part of the event. Unlike the previous cases, very good agreement between the waveforms of the pipe strain and ground particle velocity exists (Figure 2c).

In terms of the frequency content of these quantities, a better similarity between dominant frequency contents of the pipe strain and ground particle velocity is observed.

CONCLUSIONS: Although the number of available data is yet insufficient to arrive at any conclusive result, the important findings obtained during this study are as follows. Pipe strains do not contain only long period components, they may have short period components as well. In term of peak values, strains were found to be more strongly correlated with the ground velocity than with acceleration or displacement. The frequency contents of the strain also show similarity to thoes of ground velocity. However, it is difficult to find any agreement among the waveform of strain and those of acceleration, velocity or displacement. Only for earthquakes with very long period components, there is good agreement between the waveforms of strain and ground particle velocity.

REFERENCE

1. Farjoodi, J.,"Evaluation of Engineering Properties of Earthquake Motion From Dense Seismograph Array Data", Doctor of Eng. Thesis, Department of Civil Engineering, University of Tokyo, Dec. 1986, Tokyo, Japan.

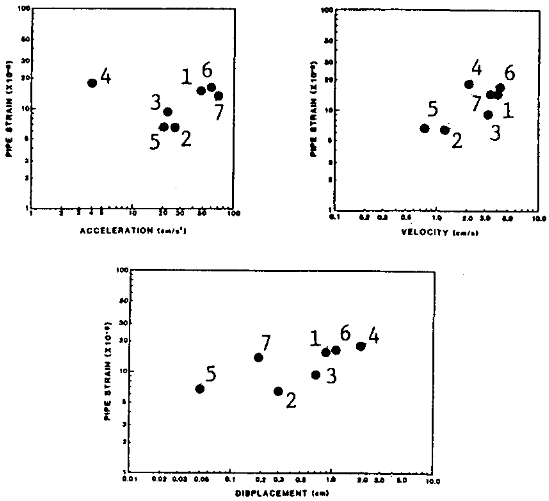

Fig. 1 Relation Between Peak Pipe Strain and Ground Acc., Vel. and Dis.

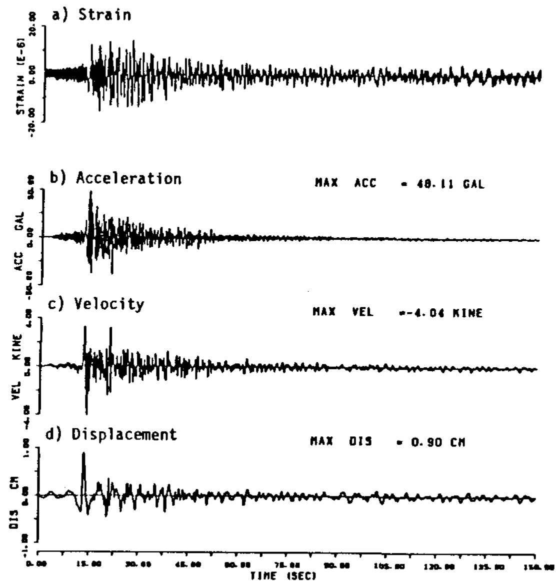

Fig. 2a Pipe Strain, Ground Acc., Vel. and Dis. Event No. 1 (1983.2.27)

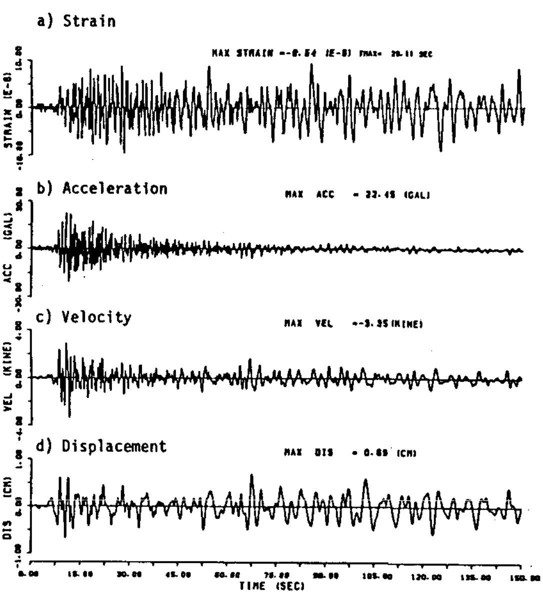

Fig. 2b Pipe Strain, Ground Acc., Vel. and Dis. Event No. 3 (1984.3.6)

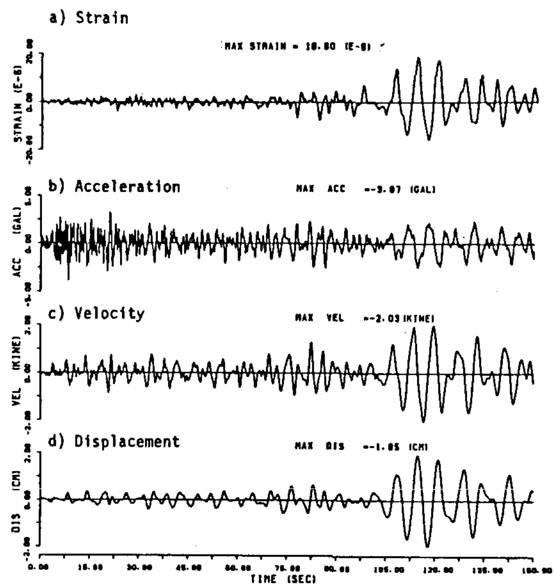

Fig. 2c Pipe Strain, Ground Acc., Vel. and Dis. Event No. 4 (1984.9.14)