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CONSIDERATION OF THE PEAK HORIZONTALVELOCITY

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SUMMARY

Examining the relation between peak horizontal ground acceleration and peak horizontal ground velocity of past earthquakes, the ratio of velocity increase to acceleration increase is small for larger motions. The reason is guessed that if the earth stiffness enters the plastic zone or the earth is destroyed at high level motion, the resistance to velocity increases.

Therefore, when seismic design is formulated by considering the plastic zone of materials at high-level motion, the motion energy method using velocity is more suitable than the force method using responded acceleration.

INTRODUCTION

The seismic force method using responded acceleration is used traditionally for seismic design of plants. The plant destruction or damage by an earthquake is caused by the motion energy rather than by the seismic force. Recently, on the seismic design for high-level motion, the motion energy method using velocity is more used than the force method using responded acceleration.

Using the motion energy method, the problem in designing is how to determine the peak horizontal velocity.

Our examination of the relation between the peak horizontal ground acceleration
and the peak horizontal ground velocity for past earthquakes revealed that they have a uniform relation at large earthquakes.

THE RELATION BETWEEN PEAK HORIZONTAL GROUND ACCELERATION AND PEAK HORIZONTAL GROUND VELOCITY

Fig. 1 shows the relation between the peak horizontal ground acceleration and the peak horizontal ground velocity for past earthquakes.

At the earthquakes of Niigata(1964.6.16),San-Felnando(1971.2.9), Mexico(1985.9.19),Loma-Prieta(1989.10.17),Kobe(1995.1.17), large horizontal ground velocities were observed in comparison with horizontal ground accelerations. And these earthquakes recorded the max horizontal ground velocity to the each horizontal ground acceleration.

The ratio of velocity increase to acceleration increase is small for larger motions. For example, acceleration increases from 400 gal to 1200 gal (3 times), while velocity increases from 89 kine to 128kine (only 1.44 times). Consequently, the seismic force increases 3 times, but the motion energy increases only 2.07 times (equal to square 1.44).

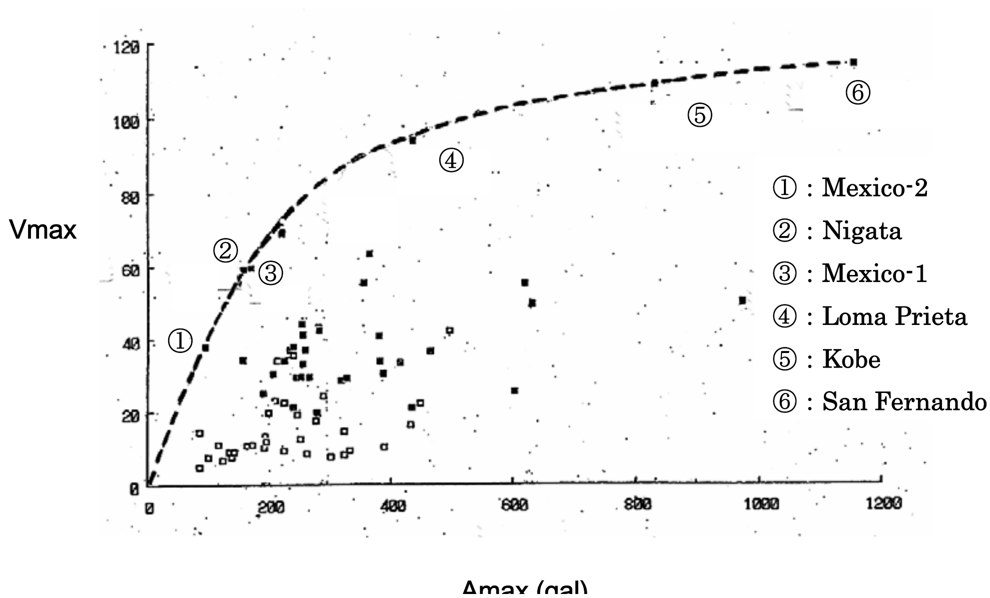

Fig. 1 the relation between the peak horizontal ground acceleration and the peak horizontal ground velocity

Fig. 2 shows the relation between peak horizontal ground velocity and peak horizontal ground acceleration for the large earthquakes. The relation between peak horizontal ground acceleration (A) and peak horizontal velocity (V) is shown in the following expression.

$$A=31.6 \cdot 10^{v/80} \quad \cdot\cdot\cdot\cdot \quad (1)$$

Therefore , when we conduct seismic design considering the plastic zone of the material at high level motion, we can do design better by using the motion energy method based on the peak horizontal ground velocity than the force method based on the peak horizontal ground acceleration.

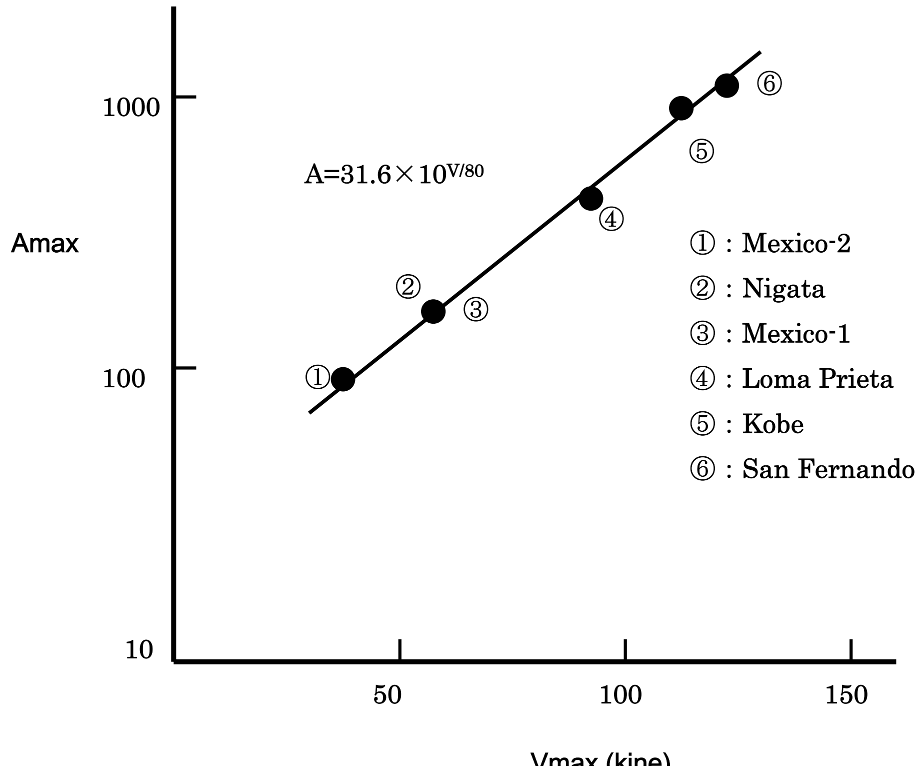

Fig. 2 the relation between peak horizontal ground velocity and peak horizontal ground acceleration for the large earthquakes

CONSIDERATION

The relation between velocity (V) and acceleration (A) of sine wave is showed as the following expression, here T is the characteristics period.

$$V = A \cdot T / 2\pi$$

As velocity is relative to acceleration and period, the period in soft earth is long and the velocity of soft earth becomes high. On the other hand, the period of hard earth is short and the velocity does not become high. The data of Niigata and Mexico were observed at soft earths and the data of San-Felnando, Loma-Prieta, Kobe were observed at hard earths. So the relation showed in Fig.1 can be understood qualitatively.

But the formula (1) shows that the relation of velocity and acceleration has no relation with period. If soft earth goes into plastic zone, the velocity resistance of earth will be increased.

On the condition that mass of earth is M, damping factor is C, stiffness is K, velocity is V, acceleration is A and displacement is X , the equation of earth motion is expressed as follows.

$$M \cdot A + C \cdot V + K \cdot X = 0$$

If the earth enters into plastic zone or is destroyed by high level motion, damping factor C becomes large. For this reason, damping term $C \cdot V$ becomes larger than anti-force of earth term $K \cdot X$. So, acceleration A has a great influence on velocity V and the ratio of velocity increase to acceleration increase becomes small for larger motions.

CONCLUSION

In this paper, we investigated the relation between peak horizontal ground acceleration and peak horizontal ground velocity for past earthquakes. The ratio of velocity increase to acceleration increase becomes small for larger motions.
The reason is guessed that if the earth enters the plastic zone or is destroyed at high-level motion, the resistance to velocity increases.

The peak horizontal ground acceleration has a ceiling at largest class of earthquakes, and this fact leads to a guess that the peak horizontal ground velocity will have a ceiling at high level motions.

Therefore, when seismic design is formulated by considering the plastic zone of materials at high-level motion, the motion energy method using velocity is more suitable than the force method using responded acceleration.

It is practically difficult to examine the relation between the velocity resistance and the stiffness of earth by a large scale experiment which earth enters into plastic zone or is destroyed as seen in many earthquakes.
Observation data at large earthquakes in the future will make good these relations.