# FOREWORD

Numerous seismologists and earthquake engineers have devoted great efforts to mitigate the hazards of earthquakes during the past half-century. As a consequence, the primary nature of the response vibration of structures during earthquakes has been explained to a considerable extent. Various matters learned about earthquake responses of structures have been incorporated in codes for earthquake-resistant design of structures to result in decreases in earthquake hazards. However, much about the minute aspects of responses of structures to earthquakes still remains unsolved. Therefore, the present codes contain conservatively stated provisions taking these circmumstances into account. Structures which have been carefully designed under a sufficient understanding of the philosophies of the codes and built observing individual provisions of the codes are able to resist strong earthquakes, and the hazards which affect people's lives have been greatly reduced. Most of the structures suffering damage in recent earthquakes were those built before the present codes were written. It is desirable for these old structures to be strengthened so as to satisfy new requirements, but it is not an easy task to carry out reinforcing work because of economic constraints.

As a result of the increase in our knowledge about the primary nature of earthquake responses of structures, the damage to structures has been reduced to a considerable extent, but it is not possible to prevent earthquake damage completely. This is because there are causes of earthquake damage to structures other than the response vibrations of the structures. One of these other causes is the existence of defects in structures and subgrades. Defects of structures include imperfect welding, minute scratching, corrosion, deterioration and fatigue of materials, while defects of subgrades include faults, seams, openings, and layers of sand containing large quantities of water.

Defects of structures can be eliminated to some extent by careful work execution and good maintenance, but it is rarely the case that there is no defect in the subgrade. The weak points mentioned above do not appear as distinct defects at ordinary times. However, when strong impulsive or repeated forces are applied to structures and subgrades during earthquakes, failures will occur at these weak points, and local failures will grow into complete collapsing of structures. Therefore, it is considered necessary to clearly identify behaviors of defective points during earthquakes. However, studies of this matter are rarely made compared with those of response vibration of structures, and many problems have remained unstudied.

An example of research related to this matter will be given. Earthquake observation was carried out inside hard rock in the northern part of the Kanto Region. The rock had seams in it and a number of seismometers were installed sandwiching the seams. Several earthquake records were obtained. For example, the accelerations at a certain time in rock above and below a seam 30 cm in thickness 16 m underground in the earthquake of 4 August 1974 were 16 and 15 gal, respectively, while in the earthquake of 20 March 1978 they were 62 and 51 gal. This suggests that when earthquake intensity is high the motions on the two sides of a seam can be discontinuous.

Another example is the case of observations at a dam site of the behaviors during earthuqake of seams that had been treated. The dam was an arch type 155 m in height which was completed in 1969. The foundation rock is hard granite and there were several vertical seams at the rock comprising an abutment of the dam. The seams and the sheared zones in their vicinities were removed by water jets and the gaps that resulted were filled with concrete. Several accelerographs were installed sandwiching the filled concrete to measure the behavior during earthquake of this portion. On 14 September 1984 there was an earthquake of magnitude 6.8 at a point approximately 30 km southwest of the dam site and accelerations of about 30 gal were recorded. In this case, discontinuous motions were not seen at the two sides of the seams. The thickness of the concrete filled was 1.7 m, the widths were 20 to 30 m, and lengths 12 to 96 m, and it was shown that this treatment had been appropriate for maintaining safety of the dam.

The problem of defects is something that cannot be avoided when many years have elapsed since a structure was built. Many structures now existing have already experienced long periods of time since construction. Therefore, they should be inspected, and appropriate measures taken if necessary.

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