

12 CONCLUSIONS

2004 Niigata-ken Chubu earthquake is an in-land earthquake and caused widespread damage particularly in the epicentral area, which extends from Nagaoka in north to Tokamachi in south and Teradomari in west Koide in East. The main characteristics of this earthquake can be summarized as follows:

- 1) The faulting was of blind-thrust type. However, no ground ruptures were observed on the ground surface associated with faulting. This may be due to soft 5km thick Neogenic folded sedimentary rocks overlain basement rocks.
- 2) Very large aftershocks have been observed and they are still continuing. It seems that the faulting plane propagating in NE direction as it terminated at a depth of 5km.
- 3) High ground accelerations with pronounced directivity effects did occur although the magnitude of earthquake is relatively small compared with, for example, 1995 Kobe earthquake. This feature of the in-land earthquakes is quite distinct with that of offshore earthquakes. Due to close proximity of the epicenter, the shaking effects become more pronounced. Furthermore, the U-shape of valley may further amplify and prolong the ground shaking as measured in Ojiya strong motion stations.
- 4) Permanent deformation of ground associated faulting did occur although no distinct ground ruptures observed. In addition to that of the faulting, the ground liquefaction resulted in widespread permanent ground deformations towards Shinano River and its streams.
- 5) Widespread ground liquefaction was observed throughout the epicentral region. The liquefaction caused lateral spreading and damage on various linear structures through relative movements, uplifting or settlement.
- 6) Many rock and soil slope failures took place, particularly in the mountainous area and along rivers. These slope failures destroyed roadways, expressways and railways. The large failure scale slope failures were directly associated with structural discontinuities in rock mass such as existing faults, bedding planes, folds. In some places, debris of slope failures resulted in natural dams.
- 7) The permanent ground deformations as well as ground shaking caused some structural damage to residential houses, buildings, bridges, roads, highways, railways, expressways, lifelines. Among them, the derailment of Shinkansen train is of great importance, which will definitely have a high impact on the rehabilitation and retrofitting of existing Shinkansen lines as well high-speed railway transport in other countries.

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This report has been written with a sole purpose of putting scientific and engineering information from different sources and author's his own observations and computations in a unified manner. The author is particularly great full to various institutes and people involved with various aspects of this earthquake and observations to make their information, data and computations accessible through INTERNET listed in References. If any material presented in this article goes un-referred, it is not done intentionally. This site investigation has been carried out with the collaboration of Prof. Dr. M. Hamada and his research staffs. The author also would like acknowledge the computation center of Marine Science and Technology School of Tokai University for their understanding and help putting this report on the INTERNET.