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## SB-1

# DIGITAL STRONG MOTION ACCELEROGRAPH ARRAY IN ASHIGARA VALLEY - SEISMOLOGICAL AND ENGINEERING PROSPECTS OF STRONG MOTION OBSERVATION -

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## SUMMARY

It is our object to report and discuss the strong motion observation system installed at Ashigara Valley, 70km south-west of Tokyo. Accelerographs with sufficient quality and telemetric data acquisition devices are deployed in order to cover seismological/engineering needs and to reduce inexpedient task for maintenance. The system is focused to compare the earthquake ground motion at sedimentary basin with the one at rock outcrops and to discriminate the response of seismic motion in the basin.

## INTRODUCTION

The progress of theoretical and experimental study on earthquake source dynamics have put forth the needs of near-source strong motion data. Earthquake engineering interests on the nature of strong motion have been extended to a broad frequency-band associated with the diverse natural-periods of man-made structures. The insight into propagation and site effects on seismic motion are also inevitable from the view points of seismology as well as hazard assessment. In order to include these requirements both from seismology and earthquake engineering fields, a renewal of traditional strong motion observation system is accordingly necessary.

The major problems to be solved in the framework of strong motion observation are those of appropriate site selections, layout of installation of seismograph, instrumentation and maintenance. The recordings of absolute or common time have become one of the most significant data in the strong motion observation. However, we have faced to difficulties in keeping the absolute timing with sufficient accuracy (Ref.1). This paper is an effort to overcome these problems.

## SITE CHARACTERISTICS

Seismicity The seismicity map of Ashigara Valley and its vicinity is shown in Fig.1, together with the locations of active faults. The epicentral locations of recent (1973-1988) events are marked by circles on the map using the data from Japan Meteorological Agency (JMA). Historical earthquakes (1600-1973) are plotted by diamonds on the map based on Ref.2. The seismic activity just beneath the site is not so high at present. In the surrounding area, however, swarms of earthquakes and events of small or moderate size are found. Therefore, we are able to measure the weak motion from remote events as well as moderate motion from small events at local distances. This might be convenient for investigating the site effects within a short time. It is also indicated by Shima and Asada (Ref.3) that the experienced frequency in Ashigara Valley of seismic intensity higher than 5 (JMA scale), roughly corresponding to the MM scale of 8, is highest inland Japan, since 1600. Table 1 shows the list of historical earthquakes brought the severe damage to houses or man-made structures in Ashigara Valley, since 1600. If we do not count the second event, recurrence time of damaging earthquake will be approximately 70 years. The energy release from each event, however, is not constant and the fault system of each event has not been clarified except for the 1923 event. Thus we cannot stress the future plausible earthquake in this area so conclusively as to the case of next Parkfield, California earthquake (Ref.4). Nevertheless, Ashigara Valley is absorbing from a view point of seismo tectonics, because the area is supposed to be a part of the boundary between the Philippine Sea and Eurasian plates.

Geology The Ashigara Valley is an alluvial basin extending of 12 km in length and 4 km in width. The basin is surrounded by low rise mountains: the Oiso hills at the east side, the Tanzawa mountains at the north side and the Hakone Volcanoes at the west side. Figure 2 shows the geological map of this area compiled by Yamazaki et al (Ref.5). The east-west geological cross sections are also reported by them, using bore hole data including those from 500 m deep well. They are shown in Figs. 3. As it can be seen from these figures, the geology in this area is very complex. Deposits found in the basin are mostly consisted of clay, sand and gravel which are accumulated by the Sakawa River and the other small rivers. Volcanic mud and pumice are partly included in the deposits. Rock outcrops are found in the hill or mountain side. Mudstones or sand stones of late Tertiary or early Quaternary are found at the east side of valley. Conglomerates of late Tertiary or early Quaternary and basaltic rock of early Tertiary are found at the north. Andesite rocks of Hakone Volcano of Quaternary form gentle slopes in the west of the valley.

The geological base rock of early Tertiary is assumed to be existed in the bottom of sediments, but it was not identified by the bore hole data of 500 m depth(Ref.5).

## LAYOUT OF ARRAY OBSERVATION NETWORK

At mountain side, accelerographs were installed on outcrops of sedimentary or volcanic rock. They are focused to observe less distorted incident waves to the valley. However, the rock outcrops are found only at the slopes, so that the strong motion data might not be kept out of, more or less, effects of surface topography. As we are not able to specify the location or fault of next plausible earthquake, a layout of array is not necessarily focused on the works of so-called source inversion. While those installed on the free ground surface in the Valley are directed to discriminate wave-types, propagation velocity and direction, amplification and attenuation factors of seismic waves in the soft sedimentary layers. According to a rough estimation of basin responses, the intervals of observation points in the valley were deployed so as to discuss the wave propagation centered at around 1 Hz. Observation points are shown on the map in Fig.4. At station S8, three tri-axial bore hole accelerometers are installed at depths of 10, 30 and 100 m. Geological/geotechnical data at the site are shown in Fig.5.

## OBSERVATION SYSTEM

Accelerographs Specifications of strong motion seismograph for next generation have been proposed by several authors (e.g. Refs.6, 7). A newly installed strong motion accelerograph (SMAD-3) has similar specifications to those. A gain ranging amplifier of three steps (x1,x1/4,x1/16) attains a dynamic range of 108dB and a resolution of 78dB. That is, the full range of observable acceleration is ±2g and the least significant bit corresponds to ±15 micro-g. Therefore, we are able to analyze not only strong motion but also weak motion data with sufficient quality, as shown in Fig.6. The A/D conversion rate of 100 or 200 samples per second is selectable. The frequency response is flat between DC and the cutoff frequency for anti-aliasing( 30 or 60 Hz). New accelerographs were installed at the sites shown by solid circles in Fig.4, in 1987. Conventional digital accelerographs ( SMAD-1 or DSA-1) together with a self-adjusting time-code generator ( Ref. 8) have been installed at other 6 stations shown by solid squares in Fig.4, since 1983.

Telemetry A telemetric monitoring and data acquisition system was brought in and installed on April, 1988, for aiming at following items:
1) A low cost private or dedicated telephone line (50 bits/sec) is used for controlling the trigger on/off of the network, keeping the exact time at each station, detecting the error of instrument, controlling the order of data dispatch from a station to the central station and so on. These private lines at every stations marked by solid circles in Fig.4 are linked to the control station S8.
2) A public telephone line is used for communicating directly between local stations and the central station ( Office of Earthquake Research Institute). The data of triggered motion are available to get at the central station. The status of observation network, such as trigger mode and trigger level of each station, is varied by communicating with the control station S8. The transmitting speed using a public telephone lines is attained 4800 bits/sec at maximum.

A schematic representation of our telemetry system is shown in Fig.7. Triggered earthquake motion data are stored on the IC memory ( 2 Mbytes, maximum ) at the station. The data are transmitted to the central station according to the commands from the central station in case of manual mode, while they are automatically dispatched and stored at the central station when we use automatical mode.

The central station supported by a personal computer (NEC-9801) has following functions: 1) Vary the mode ( automatic<-> manual), 2) Obtain and display the header, such as trigger time and maximum acceleration, 3) Obtain the time history of earthquake motion recorded at each station, 4) Send the starting commands for recording test or examining the clock at the station, 5) Send the calibration commands to stations, 6) Alter the trigger mode or level, 7) Represent the state of each instrument, 8) Reset the system, 9) Initialize the system, 10) Self check, such as NCU loop back test, memory test, memory dump and so on.

## CONCLUDING REMARKS

We are planning to carry out geotechnical measurements in the valley and its surroundings, such as refraction/reflection surveys and shear wave velocity measurements using boreholes and so on. Several mobile stations will be installed in the near future, considering the complexity of surface geology in the valley. Because of a short time running of our telemetric data acquisition system, the practical efficiency of it is not clear, however, the followings are mentioned:
1) wave form data are obtained within approximately twice elapse time of real recording using a public telephone line, 2) we have never met to data loss during telecommunication.

## ACKNOWLEDGMENTS

The installation of the strong-motion array network at Ashigara Valley was carried out by the special subsidy from the Ministry of Education. Officials of Kanagawa Prefecture and local governments, Odawara, Minami-ashigara, Ooi and Yamakita were helpful during the installations of seismic station and geotechnical measurements. Professor Y. Osawa gave us continuous encouragements and invaluable advice. Discussions and suggestions from Profs. K. Mogi, T. Matsuda, M. Mizoue, M. Hakuno, T. Minami and H. Ishii were beneficial in the planning of the observation network. The database " SEIS" of Earthquake Prediction Data Center, Earthquake Research Institute was used for obtaining Fig.1. The instruments were manufactured by the technical staffs of Akashi Seisakusho Co., Ltd.. We are grateful to all of them.

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Table 1. Historical disastrous earthquakes (Ref.1)

| Date Y | M | D | Location Lat.(N) | Long.(E) | Magnitude |
|---|---|---|---|---|---|
| 1633 | 3 | 1 | 35.2 | 139.2 | 7.0 |
| 1648 | 6 | 13 | 35.2 | 139.2 | 7.0 |
| 1703 | 12 | 31 | 34.7 | 139.8 | 8.2 |
| 1782 | 8 | 23 | 35.4 | 139.1 | 7.0 |
| 1853 | 3 | 11 | 35.3 | 139.2 | 6.7 |
| 1923 | 9 | 1 | 35.2 | 139.2 | 7.9 |

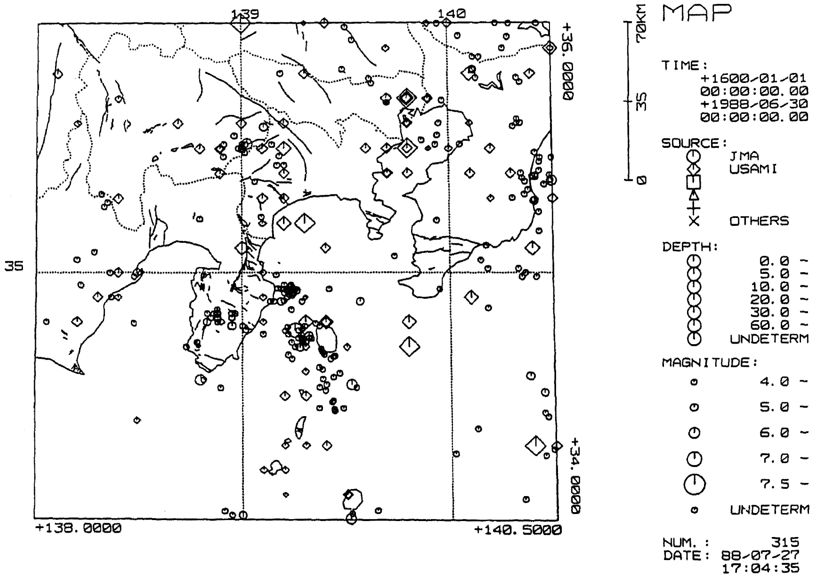

Fig.1 The location map of recent earthquakes ( after JMA, shown by circles) and historical large events (Ref.2).

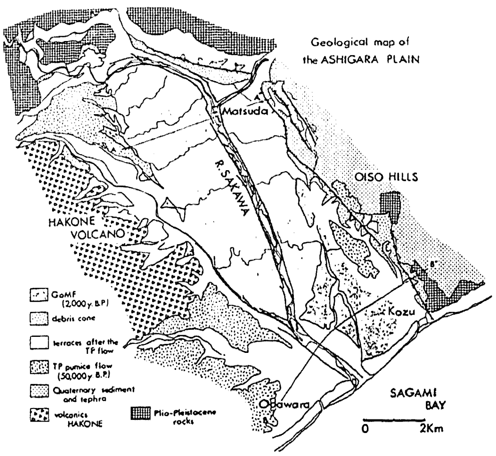

Fig.2 Geological map in and around the Ashigara Valley ( Ref.5).

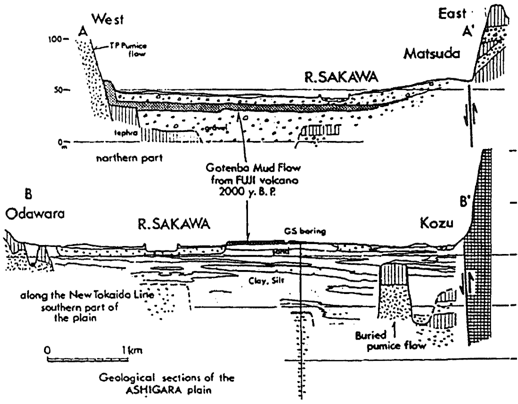

Fig.3 Geological cross sections along the lines shown in Fig.2 ( Ref.5).

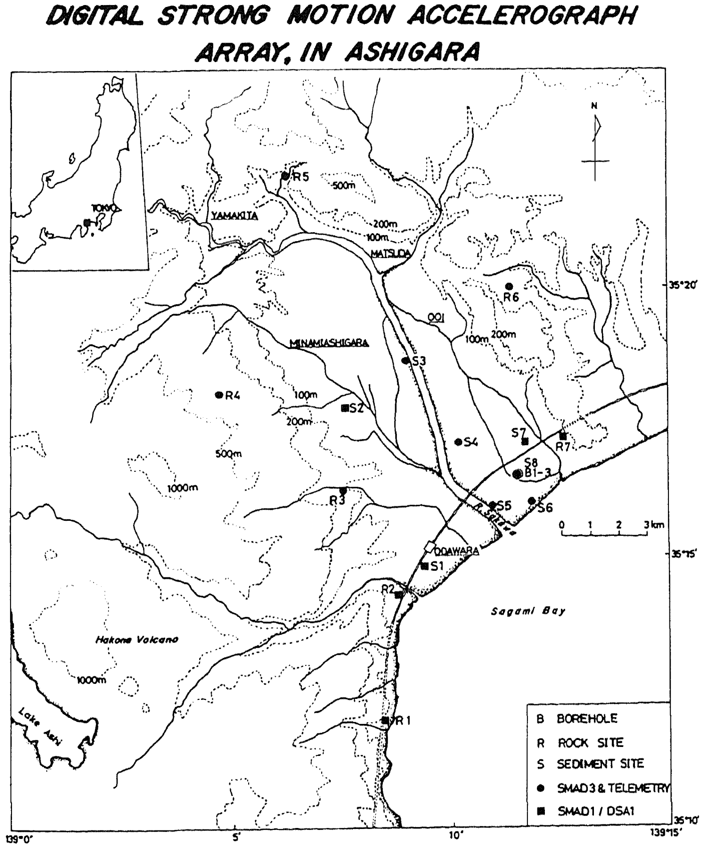

Fig.4 The location map of digital strong motion accelerographs in Ashigara Valley.

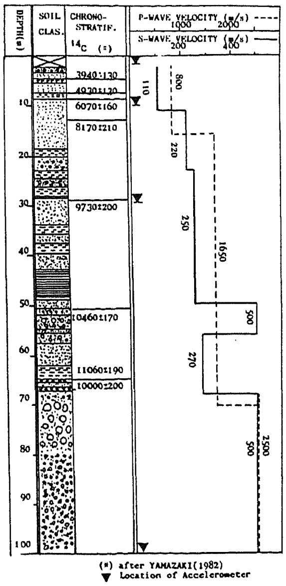

Fig.5 Geological/ geotechnical data and locations of borehole accelerometers at S8.

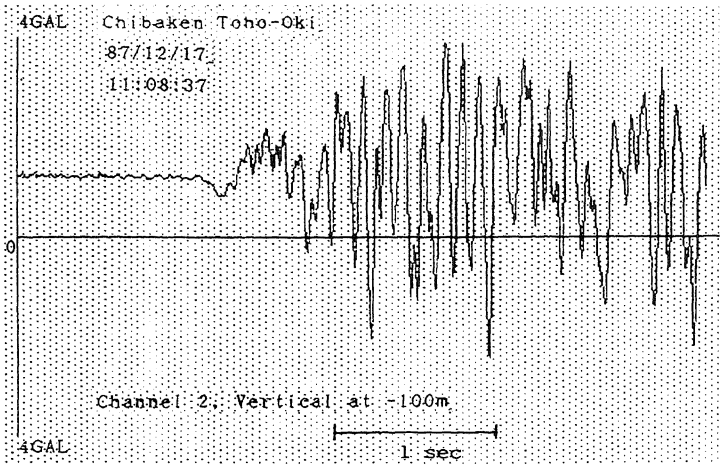

Fig.6 An example of accelerogram recorded at depth of 100 m (station S8).

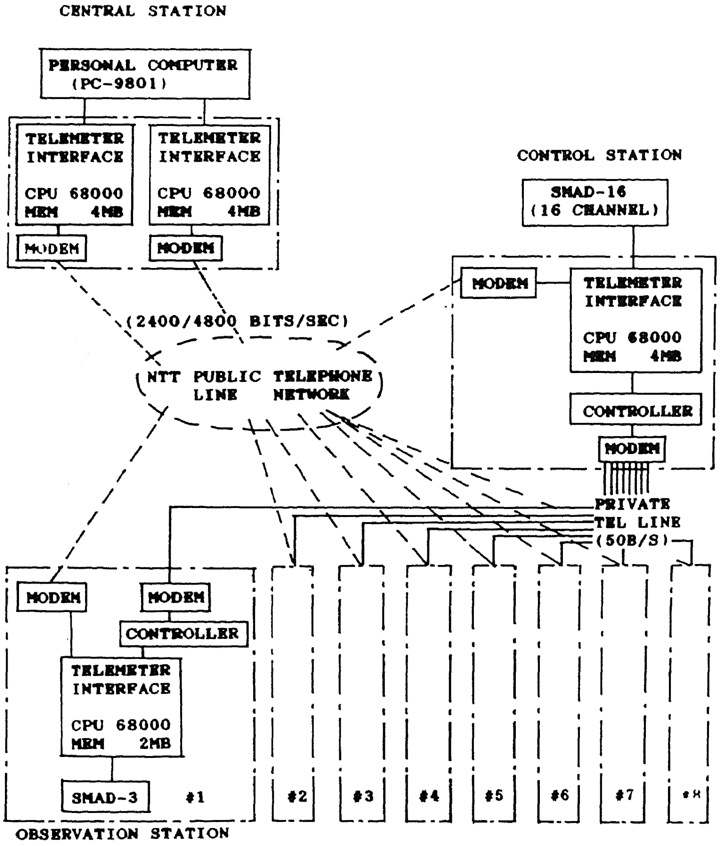

Fig.7 Schematic representation of a telemetric monitoring and data acquisition system used in the Ashigara Valley Strong Motion Accelerograph Array.