Paper No. 171, Bull. ISET, Vol. 13, No. 4 December 1976, pp. 100–103

MONITORING OF LOCAL SEISMIC ACTIVITY

P.N. AGARWAL*

INTRODUCTION

The short term monitoring of local seismic activity may often be required around locations of multipurpose river valley projects, nuclear power plants, industrial structures like refinery complexes and other major and important engineering projects. Ordinarily, this may be necessary at those places where, in the historical past, there have been a few moderate size earthquakes or just one big earthquake and also if only the geological and tectonic features are indicative of such seismic activity in the geological past. It is now a generally accepted practice in number of countries to record local seismic activity few years in advance of the design and construction of all the multipurpose river valley projects and continue those during project operation stage as well. This has further assured greater importance in view of those cases where reservoir impounding has been associated with triggering or causing the seismic activity.

In general, the objectives of seismic recording for such special applications are different from those of usual seismic recording by regional seismological stations. These objectives have been identified and briefly given here. Naturally these differences are also reflected in the specifications of the instruments, general plan and layout of these two types of seismic recording. Some of these differences have been briefly discussed with special reference to the requirements for monitoring local seismic activity.

OBJECTIVES OF LOCAL SEISMIC RECORDING

Generally speaking the objectives of setting up a local network of seismological observatories for special purposes as given earlier may be as follows:

1. Finding the locations for contemporary near earthquakes (say within about 100 km) with an accuracy of about—1 km. This involves the determination of origin time, epicentral distance, azimuth with respect to a reference point and focal depth. The smallest size earthquake to be detected may be related to the general level of seismic activity and the period available for study.

2. Determination of the magnitudes for near events.

3. Identifying the source or sources of seismic activity and if any of those are associated with the geological structural features mapped in the region.

4. Determining the statistical trends in the recurrence of events from a particular source or all the events in the region as a whole.

5. Identifying the location of earthquake source region which could be considered as the potential location for largest and most critical earthquake during the life of the project under reference. Estimating the magnitude and return period of such an event.

6. Determination of the predominent frequencies of earthquake waves and ground vibrations and their possible applications for extrapolating the frequencies associated with the ground motion during largest earthquake anticipated.

7. The estimate of location direction and extent of actual seismic slip during the largest earthquake i.e. its focal mechanism.

* Associate Professor, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee.

8. Detecting changes in the statistical trend of the recurrence of events during various stages of the project and also if there is any systematic pattern of migration of epicentres of earthquakes.

INSTRUMENTATION FOR LOCAL SEISMIC RECORDING

The seismic instrumentation in special purpose seismological observatories for the local network of an engineering project to meet out the objectives of the project has to be different from that in the conventional standard observatory for seismological purposes. Some of the more important considerations making these differences necessary and the requirements of a local network are discussed here:

(a) A regional net of seismological observatories for seismological purposes may not be required to detect seismic events below Magnitude 2 or 3, whereas in order to acquire more complete data for a study over a limited time, a special purpose observatory may in general be required to detect even events of Magnitude upto—2 or so. The choice of the lowèr limit of detectability may also be influenced by the general level of activity of the region under study. This consideration has two important implications: (i) the instrument magnification in the short period range has to be large and (ii) the inter-station distances have to be small.

(b) A conventional observatory could be sited at a remote location where the general noise level is low. The observatories for an engineering project have to be necesarily around places of construction activity. This imposes restrictions on the type of instruments to be used, namely.

use of bore hole seismometer instead of surface seismometer and initial broad band recording and play back using suitable filtering techniques.

(c) The interest of a project is in the study of records of local earthquakes which contain high frequencies (10 cps or more). Therefore the recording speed may have to be few times larger than for the conventional recording. This may need change of the method of recording itself.

(d) Some of the recording sites may have to be shifted in view of the potential earthquake sources not being found in their anticipated positions or even their migration during the period of study. Thus the instrumentation and arrangements at most of the observatories must be of portable nature.

(e) The sites of observatories may have to be distibuted uniformly as far as possible around the area of interest. Thus the shape and size of the project area and the terrain would influence the interstation spacing. The interstation distances may at the most be around 30 km and should not be less than 5 km if accurate locations of small events within 100 km or so distance is intended.

(f) The sites for the seismometer location will have to be chosen with due regard to the signal noise ratio in addition to the tectonics and rock conditions. This may be ordinarily done by employing short period high gain portable instruments. At times a small shift of the site may greatly improve the quality of recording. The seismometers may be placed in shallow pits or bore holes as may be necessary.

(g) A single observatory may be enough to show whether there is seismic activity or not. A minimum of three observatories could be employed to give approximate epicentre locations only. Some limited inferences on focal depth may be possible under

favourable conditions and would necessitate assumptions regarding velocity distribution and structure, which may often be difficult. A net of five stations would form the minimum requirement for permitting complete locations, of course without providing check on the reliability or results.

In addition to the locations, if the focal mechanism has also to be studied, a network of suitably distributed eight observatories may form the minimum requirement. An effective distribution of recording stations can be achieved more easily if most of them are mobile.

(h) The areas where epicentres are concentrated are not known in advance of the establishment of the observatories. Also during the period of study, the activity may migrate in unknown direction. In order to permit reliable determinations, the data from the few permanent observatories need to be supplemented from a mobile array of seismic stations. There can be no definite guide lines to decide the proportionate number of stations in a net of eight stations as suggested earlier which have to be permanent or mobile in nature. Three permanent and five mobile observatories may form a good combination.

(i) For the purpose of determination of reliable magnitudes of small size local events, if occurring in the region, a pair of E-W and N-S- standard Wood Anderson Seismographs at one or two observatories in the network depending upon the spread of the project may be necessary.

(j) All the seismometer locations in the network could have recording arrangements independent of each other at respective locations or at central location with common time base for atleast three to five stations may be necessary. The portable stations could be provided with central recording with common time base.

(k) If an area has shown low seismic activity over several years of recording and this fact is also supported by past history it may only be desirable to continue the three permanent observatories and the mobile units could be spared for use elsewhere during the operation stage of the project.

CONCLUSION

Those objectives of local seismic recording only which could be considered common to all types of engineering projects have been given in the paper. The additional specific requirements of an individual project have not been discussed. It is hoped that the given discussions on the suitability of instrumentation for local seismic recording would be found useful in planning for such instrumentation particularly by non-seismologists. Generally speaking a high gain, high frequency, broad band and high speed common time base recording system like a magnetic tape recording telemetered seismic array with desired number of recording elements is considered suitable for such applications.

REFERENCES

1. Adams R. D., Gough D. I. and Muirhead K. J., (1973), "Seismic Surveillance of artificial reservoirs", Report of Working group on seismic phenomena associated with large reservoirs, third meeting the Royal Society in London Annex. I.
2. Bolt, B. A. and Hudson, D. F., (1973), "Seismic Instrumention of Dams," Journal of Geotechnical Engineering Division, A.S.C.E., Vol. 101, No. GT 11. Nov. pp. 1095–1104.

3. Crampin, S., Jacob, A. W. B., Noilson, G. and Miller, A., (1970). "The LOWNET Radio link Seismometer network in Scotland". Geophysical Journal of Royal Astronomical Society, Vol. 21, pp. 207–216.
4. Ellis, R. M. and Russell, R. D., (1972). "Monitoring of seismic activity during loading of Mica Reservoir", Seimi-Annual Technical Report to U.S.G.S., Contract 14-08–0001–13067.

ACKNOWLEDGEMENTS

The paper is being published with the permission of Professor and Head, School of Research and Training in Earthquake Engineering, University of Roorkee, Roorkee.