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Planning Instrumentation Monitoring in Dams

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SYNOPSIS : This paper outlines the seismic instrumentation being adopted for river valley projects in India. More than 60% of Indian sub-continent lies in an active seismic belt. Of this the middle and lower Himalayas constitute a major area wherein lies a huge untapped hydro-power potential. Being primarily constituted of younger rock formations, frequented by faults, thursts and shear zones and lying in a high seismic risk zone, observations through instruments play a significant role in perspective planning of projects in this area. Setting up of seismological observatories in advance of construction of dam projects, forms a part of investigative planning to assess the seismic status of the area. The observations are continued after construction to monitor any changes in seismicity due to reservoir impounding. Present approach is to also provide instrumentation and continued observation to a possible prediction of earthquake. A typical case of instrumentation for a dam on active fault is also cited.

INTRODUCTION

Earthquakes as natural phenomenon are characterised amongst themselves by their frequency and amplitude content depending upon the geotectonic setting of the region of earthquake occurrence, its magnitude and other related parameters. A strong motion earthquake and its effects on any structure involves many variables, solutions to which are complex and are based on a number of simplifying assumptions. Observational approach therefore not only provides an important tool in assessment of structural behaviour but also the effect of foundation-structure interaction. In case of storage dams of reservoir-foundation-structure interaction. In recent times, a number of high dams in India have been adequately instrumented.

NETWORK PLANNING

India has been among the leading nations of the world so far as seismic monitoring of dams is concerned. A number of dams spread all over India, such as Beas, Bhakra, Ramganga, Yamuna, Ukai, Kadana, Koyna, and Iddiki etc. have a network of seismic observatories as also strong motion recorders in the body of the dam. However, in most of these cases the network became operational during the final stages of construction or only after construction. To arrive at a design accelerogram at a particular site, the network planning now aims at installation of observatories during investigation stage itself. At present about 30 accelerographs and a number of high sensitive seismographs are in operation at various observatories in various river valley projects in India. During the ensuing decade, seismic monitoring stations are likely to be further strengthened. Structural response recorders, tiltgraphs etc. are also in operation in selected areas. High dams are extensively instrumented with accelerographs to record both ground accelerations and responses during strong earthquakes. Figure-1 shows a typical network planning in operation to monitor seismic events for some of the projects located in the area.

RESERVOIR INDUCED SEISMICITY : CASE HISTORIES

Koyna Dam, in Maharashtra State on its first filling of reservoir, in 1962, indicated a

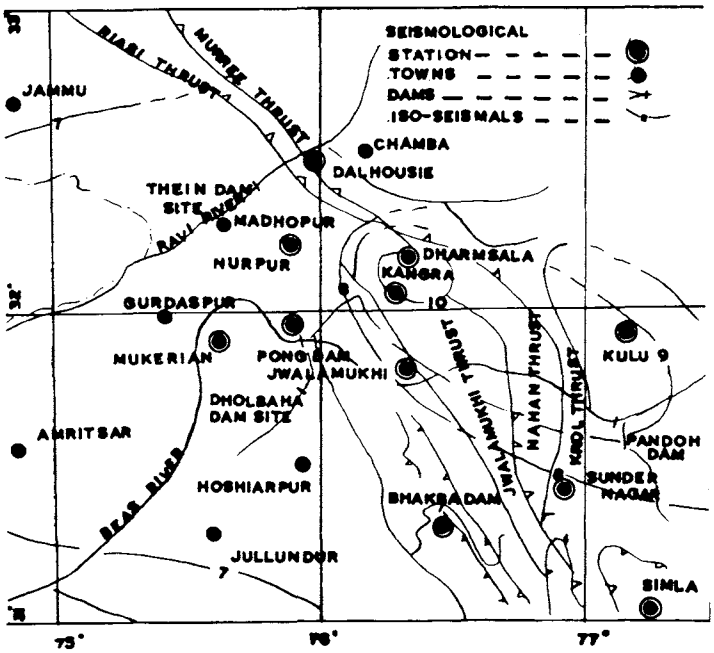

Fig.1 Seismotectonic Map Showing Network Planning

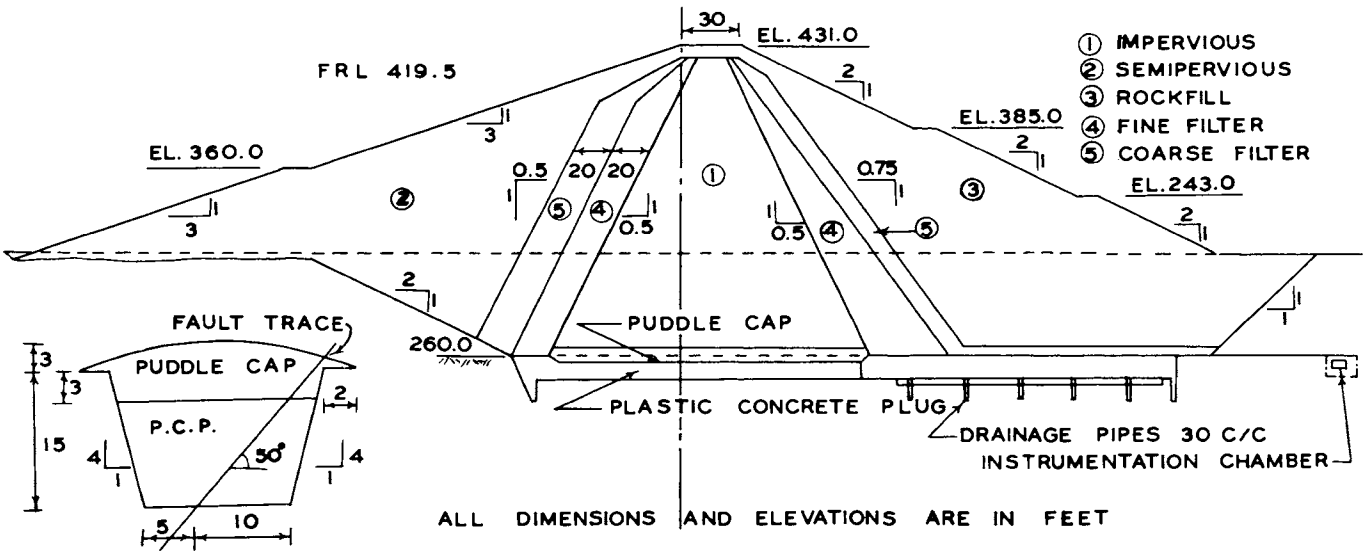

Fig. 2 Section of the Dam. The Instrumentation Chamber is in the downstream.

number of seismic events (Magnitude = 2 to 3), in the area which was hitherto considered seismically stable. As a consequence, first seismograph was installed in the body of dam in 1963 and a network of 4 seismic stations was established which was further strengthened by addition of 5 more stations. Since 1963 about 30,000 distinct events with magnitude, 1.0 to 7.0 have been recorded. An earthquake of magnitude 7.0 occurred on Dec. 11, 1967 when an acceleration of 0.6 'g' was recorded in the body of the dam. It was preceeded and succeeded by a number of earthquakes. It has been opined by many that the Koyna Earthquake has revealed significant characteristic features of reservoir induced seismicity and seismogenic features.

At Beas dam, located in the food hills of Himalayas in an active seismic zone, a series of observatories were established before taking up the construction of the project. The dam was completed in 1974-75 and the reservoir filled up. From the observed data so far it is seen that seismic activity in the vicinity has not increased due to reservoir impounding.

DAMS ON ACTIVE FAULTS

At a number of dam sites under construction, at present, the geotectonic setting of the area involves dealing with faults, thursts and shear zones. The activity of some of the faults during earthquakes cannot be rulled out.

Sedawgyi dam project (Burma), being designed by Central Water Commission (India) is located across a main regional boundary fault running parallel to the river course (River Chaungmagyi). The dam base is traversed by a series of sympathetic parallel and oblique faults. The dam site lies in a high seismic risk zone with earthquakes of intensities MM VIII to IX frequenting the dam site in the past. Fault activity during a strong earthquake, is, therefore, considered a distinct possibility. While a number of defensive design measures have been incorporated, it is proposed to be adequately instrumented. Besides other instruments, it is also attempted to instrume nt the dam in a manner so as to help in a possible forecast of the strong earthquakes as also evaluation of fault slippages. Figure-2 shows the section of the dam at the fault location. The instrumentation chamber located at the downstream houses one seismic observatory, as also :

i. Linear variable differential transformer
ii. Chain deflectometer
iii. Clinometer/Extensometer
iv. A network of observation wells downstream of the dam to s tudy ground water fluctuations vis-a-vis occurrence of earthquakes.

The linear variable differential transformer has been used successfully to record slippages across Hayward fault (U.S.A.) over a period of time. The dilatancy-water diffusion model and consequent changes in Vp/Vs ratio (Velocity of P and S waves) associated with such a model has been successfully used in Japan and USSR etc. to predict earthquakes. At Sedawgyi dam a series of observation wells have been proposed, to monitor the variations in water levels and to possibly forecast an earthquake and to initiate appropriate measures.

CONCLUSIONS

Seismic instrumentation forms an integral aspect of investigation, planning, design and operation of river valley projects in India. Collection of data and monitoring in advance of design-stage and also during the operation of reservoir is desirable feature in all major river valley projects.