DEVELOPMENT OF POST-EARTHQUAKE DAM INSPECTION PROCEDURES FOR NINE EARTHEN DAMS IN SANTA CLARA, COUNTY, CALIFORNIA

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SUMMARY

This Paper presents the criteria and procedures used to develop a rapid-response post-earthquake dam inspection program by the owner of nine earthen dams in Santa Clara County, California. The inspection program is described, and its performance through late 1983 is evaluated.

INTRODUCTION

The Santa Clara Valley Water District owns nine earthen dams in Santa Clara County, California. The District has countywide responsibilities for flood control and is also responsible for wholesale water supply and groundwater basin management for much of the County. The County Seat, San Jose, is about 50 miles south of San Francisco. The County has an area of 1,300 square miles and population (1983) estimated at 1.35 million people. The climate is mediterranean, with dry summers and with most of the rainfall occurring in the winter. Until the 1950's, the county was characterized by rural development and modest population growth. Rapid population growth and rapid industrialization and urbanization have occurred since the 1950's.

The dams range in height from 30 to 240 feet; reservoir capacities range from 46 to 91,280 acre-feet. Seismic stability analyses were completed in the late 1970's and early 1980's for the eight larger and older dams. Major modifications were found to be needed at one dam, and the others were found to be able to withstand the maximum

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credible earthquake without catastrophic failure. Nonetheless, it is vital to have rapid and competent reporting of the condition of each dam after any moderate or larger earthquake in order to issue correct information to the large downstream population centers and to disaster coordination teams.

POST-EARTHQUAKE INSPECTION PROGRAM

Even considering the reassuring results from the seismic stability analyses done by the District's consultants, the District staff realized that the present conditions call for an immediate inspection of its dams after any significant local or regional earthquake. The lessons of past earthquakes are that the consequences of dam failure are too great to ignore the residual unknowns inherent in a technical analysis of dam stability, and that prompt authoritative communication about the condition of a dam after an earthquake is necessary to reassure the public and to combat rumors.

When the dams were built in the 1930's, 1940's, and early 1950's, dam design and construction techniques and standards were assuredly less sophisticated than they are today. It is a tribute to the designers and constructors of these large dams that only one failed the standard earthquake analysis made available by today's technology. When the dams were built, the areas downstream were largely rural and lightly populated. Today, these downstream areas are either densely developed with homes, businesses, and industry, or are under pressure for such development. The consequences of a dam failure today are certainly many times greater than in the predevelopment years.

When the District's Emergency Operations Manual underwent a periodic review in 1982, the staff decided to expand and formalize the dam emergency chapter to be consistent with the present state of the art in earthquake preparedness and disaster response, and to be consistent with the District's growing ability to utilize the state of the art.

Program Development

The authors developed a post-earthquake dam inspection procedure which is based on three assumptions:

1. The time of occurrence of earthquakes is not restricted to normal working hours or occasions when all personnel are at their normal work stations.

2. It is better to overinspect than to underinspect, and

3. Inspections should be done "automatically", on the basis of preset criteria, rather than only on orders from headquarters.

The dam inspection program, as developed, relies on two levels of inspection, starting with an initial and immediate inspection by field operations personnel. By assigning responsibility for inspecting one or two dams near the employees' home, the likelihood of having someone available to inspect the dams after a non-working-hour earthquake is increased. The assigned dams are also within the employee's normal geographic area of job responsibilities, to increase the probability that the employee will be near his assigned dam(s) during normal working hours. All of the field operations technicians assigned to dam inspections are provided with a radio-equipped District pickup truck, which they use for commuting from home to work, and which is therefore available to them 24 hours a day. The trucks are furnished with the usual assortment of supplies and equipment needed in the normal work assignments which are also necessary for the dam inspections: flashlight, two-way radio, AM (commercial broadcast) radio, tools, notepads, local maps, and facilities reference and operating materials, and the post-earthquake inspection forms package. Each dam has a principal inspector and a backup inspector.

The dam inspection forms were developed in draft form based on the District's own files of As-Built drawings, current topographic maps, and current aerial photographs. Vital input was obtained from operating personnel who were most familiar with the idiosyncrasies of each dam - for example, water lines under other ownership passing near, over, or across three dams. The draft inspection forms were revised by "dry run" field inspections performed by two of the authors (R.E.T. and L.D.W.). These inspections were invaluable in making the inspection forms useable by the people assigned to use them. Final revisions to the forms were made after they were used in a "dry run" by the field personnel. It should also be noted that the "dry runs" revealed certain improvements that could be made to the telemetry systems used to report water levels: several items of equipment were found to need better anchorage to prevent damage to them during a major earthquake.

The question of when a dam should have a post-earthquake inspection is settled by a simple standing order: when in doubt, inspect. Upon becoming aware of an earthquake which is felt in the District, the field personnel undertake simple steps to determine its nature. During normal working hours, if not first contacted by headquarters, they will query headquarters by two-way radio, and monitor the available two-way radio frequencies as well as commercial AM broadcast radio for news of the earthquake. As a practical matter, past experience suggests that careful monitoring and evaluation of the news broadcast by commercial stations can provide some of the quickest access to information about an earthquake's magnitude and epicenter location. The primary sources of information broadcast by the commercial stations are the various seismographic stations and the State of California Emergency Services Office. Following a major earthquake, commercial radio might be the only source of information to field personnel in a remote area if the

County and District two-way radio systems are disabled or operating under reduced power.

The guidelines developed for field personnel to initiate a post-earthquake dam inspection are given in Table I.

TABLE I

GUIDELINES FOR AUTOMATIC INITIATION OF POST-EARTHQUAKE DAM INSPECTIONS

1. On direction from headquarters.

2. After any earthquake felt by the technician or coworkers strongly enough to realize that it lasted about 10 seconds or more.

3. After any earthquake reported as Magnitude 5 or greater and located in the County or within 20 miles of a District dam.

4. After any earthquake strong enough to be rated at Modified Mercali Intensity V or greater at the field person's location or within 20 miles of a District dam.

The field personnel will report their findings as soon as possible by the quickest available means.

During normal working hours, the District's Emergency Operations Center would be activated following a significant local earthquake. The District geologists would report to the Center to assist the engineer in charge in evaluating reports about the earthquake, and thus assigning priorities for dam inspections if advisable. Outside of normal working hours the responsible personnel would report to the Emergency Operations Center on the criteria given in Table I. Senior inspection teams would be developed from the available professional personnel and assigned to followup inspections based on the technicians' reports.

A helicopter from a commercial helicopter service, equipped for night operations, will be available under a previously negotiated agreement for aerial inspections of the dams. The suitability of landing sites at each dam has been determined by actual test. Landing sites near the homes of several potential senior inspection team members have also been identified and marked on maps furnished to the helicopter service. In the event of communications breakdown following an earthquake, the helicopter service will automatically dispatch a helicopter to the District headquarters. The criteria used by the service for automatic dispatch are the same as given in Table I. A portable two-way radio operating on District frequencies is kept at the helicopter base and will be put in the helicopter used for District work.

Finally, the entire program is reviewed annually with the field technicians assigned to perform initial inspections of the dams. This program provides both formal training for new personnel and review for experienced personnel. Experiences from inspecting the dams in the previous year are reviewed and used to improve the program. During the course of the year, the technicians also do an inspection of their assigned dams each six months if no earthquake-initiated inspections have been done in that time period.

Experience to date has led to an automatic inspection on one occasion: the Coalinga earthquake in May, 1983. Review of the work accomplished indicated that the program functioned well. A followup inspection was done on one dam where the first inspector noticed a damp spot which he correctly interpreted as due to local runoff from an earlier rainstorm; but he reported it as a matter of course.