

occur in areas of concentrated population, or under conditions of severe, repeated shocks to structures.

2. The current funding for earthquake engineering research is not only far smaller than the losses sustained by transportation modes in recent earthquakes, but is apparently much less than potentially preventable losses.

3. Existing building, highway bridge, railroad bridge, and pipeline design codes in use in the United States have been shown to be inadequate against earthquake forces. Consideration of lateral forces is minimal and little notice has been taken of vertical accelerations.

4. Existing transportation structures in high-risk earthquake areas are susceptible to great damage because of inadequate design provisions against earthquake shocks. Cost/benefit analyses should be made to permit selection of structures to be retrofitted to insure high probability of usable escape and emergency routes in high risk areas.

A program for placement of strong-motion instruments in transportation structures is needed to obtain basic data on the parameters of earthquake effects to these structures. Such data are mostly not available due to lack of instrumentation of transportation structures. With sufficient data, it should be possible to make appropriate revisions to design details for new construction as well as existing structures.

6. There is a pressing need to obtain basic earthquake hazard information for all high risk areas in the United States. Such information can be gathered only through greatly expanded geodetic, geological, and seismicity mapping. The information is needed for decisions as to placement of structures, design of structures, and assessment of risk.

7. The existing fragmented Federal and state programs for earthquake research require formal coordination by a single Federal agency to insure the most efficient use of available funds.

8. Rapid reconnaissance of earthquake-hit areas throughout the world would furnish invaluable information. Emergency inspection are needed in standby status, ready to

proceed upon notice, in order to be able to obtain data firsthand to increase available knowledge of the results of earthquakes.

9. Exchange of earthquake information of all types on an international basis should be increased to permit all nations with earthquake problems to benefit from the experiences of other nations.

10. It is apparent from the San Fernando, California, earthquake damage that relatively minor, inexpensive modifications to highway bridges will provide much greater protection against the collapse of bridge structures. The provision of wider seats with retention devices should act to prevent bridge sections from slipping from their supporting structures. Single column designs should be reevaluated as to adequacy against earthquake shocks.

XIV. RECOMMENDATIONS

The Safety Board recommends that:

1. Consideration be given by the President's Office of Science and Technology to the need for coordination of all Federal agencies now involved in earthquake-related activities to increase the availability of knowledge, to make the most efficient use of available funds, and to present a coordinated request to the Congress for a greatly expanded program to increase protection against earthquakes.

2. The Secretary of Transportation consider undertaking the following programs to increase the resistance of transportation structures to earthquakes in risk areas:

- a. Revision of highway bridge design standards.
- b. Revision of railroad bridge design standards.
- c. Revision of pipeline design standards.
- d. Improved design criteria for airport control towers and other vital structures.
- e. Conduct of cost/benefit analyses in high-risk areas, in coordination with the States involved, to arrive at decisions for retrofit programs for existing structures on the interstate highway system to reduce

potential loss of life and provide emergency routes.

- f. Increased funding for research into earthquake-resistant design of highway structures.
- g. Examination of structures in the Saint Lawrence Seaway to ascertain resistance to earthquakes in that high-risk area.
- h. Analysis of methods by which the Federal Government can assist the states and railroads in retrofitting selected transportation structures.
- i. Installation of strong-motion seismic equipment on bridges and other transportation structures, in coordination with the National Oceanic and Atmospheric Administration of the Department of Commerce.
- j. Examination of contingency emergency relief transportation planning, looking toward improvements for earthquake risk areas.

3. The National Oceanic and Atmospheric Administration of the Department of Commerce and the Geological Survey of the Department of the Interior undertake a coordinated program of expanded and improved geodetic mapping, geological mapping, and seismographic networks, with special emphasis on high-risk zones, in order to permit better planning for the installation and improvement of transportation systems.

4. The Office of Science and Technology establish coordinated 5- and 10-year plans for all Federal agencies involved in the earthquake problem, including a sound cooperative program to be established with other nations having problems with damage from earthquakes. In this connection, emergency funds and trained professional personnel should be available for the inspection and analysis of earthquake damage throughout the world.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/JOHN H. REED

Chairman

/s/LOUIS M. THAYER

Member

/s/ISABEL A. BURGESS

Member

Oscar M. Laurel and Francis H. McAdams, members, filed the attached dissent.

February 8, 1972