alone that have been estimated to exceed $8 billion. Although the number of people killed was surprisingly low, the greatest loss of life took place nearly 100 km from the epicenter in the collapse of nearly 1.5 km of the upper deck of the Cypress Viaduct in Oakland (Fig. 33).

The EQGMs generated by this EQ were recorded by strong-motion instruments in more than 130 stations. The instrument closest to the epicenter was at the Corralitos Station, 7 km from the epicenter (Fig. 1) and perhaps just 1 km from the fault. At this station, the recorded PGA was 0.64g, and the vertical PGA was 0.47g. The most distant strong-motion station to record EQGMs originated by this EQ was the Bodega Head Doran Beach Station, 175 km from the epicenter. The horizontal PGA at this station was 0.04g and the vertical PGA was 0.02g.

Lessons Learned From the Loma Prieta Earthquake of October 17, 1989. In judging the lessons taught by this EQ, it should be kept in mind that it was a M_S=7.1 EQ whose epicenter was nearly 100 km from San Francisco and Oakland. The EQGMs that have been recorded can be considered a moderate diagnostic test for structures located in these cities: bigger and more devastating EQs are certain to come to the Bay Area.

The most important features (characteristics or signatures) of the effects of this EQ can be summarized as follows.

1. It generated a wealth of strong motion records, the largest body of well-instrumented data recorded for an EQ of $M_S \geq 7.0$. Records of the responses of more than 57 structures (53 buildings, 2 bridges and 2 dams) were obtained.
2. The duration of the EQGMs was short (<12 sec) for an EQ of M_S=7.1.
3. The significant variations in the dynamic characteristics of the ground motions in the Bay Area, even at recording stations located the same distance from the epicenter, reveal the significant effects of soil conditions (soil profile and topography).
4. There was widespread liquefaction-induced damage on bayshore fills in both San Francisco and the Oakland/Alameda areas.
5. There were a large number of landslides and rockfalls.
6. There was a large amount of damage to the transportation system, which resulted in the closure of several main highways and roads. This damage included the dramatic collapse of the Interstate 880 Cypress Street double-deck viaduct and of a section of the Bay Bridge and the serious damage to other overpasses and bridges.
7. The buildings in San Francisco's Marina District collapsed as a consequence of strong shaking, liquefaction of the soil and inadequate foundation-superstructure systems.
8. A large number of houses were damaged.
9. Large numbers of people have been displaced from their homes.
10. There were large economic losses stemming from the loss of function (continuous operation) of facilities owing to damage of their structures, in the case of lifelines, and in particular to damage of nonstructural components and contents in the case of industrial facilities and buildings.

Although none of the above features can be considered unexpected, they do emphasize the importance of certain lessons that have been learned in previous EQs. The Loma Prieta EQ might be called "the transportation and geotechnical engineers' EQ" because of the large number of highways, roads and bridges that were damaged [and the spectacular failures of some of these bridges (Fig. 34) and double-deck viaducts (Fig. 33)], the economic impact of these failures, the many failures related to geotechnical effects, and the wealth of strong motion records which will permit study of these effects. However, the above features also emphasize that the greatest current threat to life and safety in urban areas, assuming moderate ground motion, is posed by existing hazardous facilities, including not only buildings but also other facilities such as viaducts and bridges. Furthermore, they emphasize the need for us to consider the functional aspects of our facilities during and immediately after the EQ. A brief discussion of each of the above main aspects follows.

The records from 131 stations [38 operated by the U.S. Geological Survey and 93 operated by the California Strong Motion Instrumentation Program (CSMIP)] are already available. It is hoped that other records obtained from stations operated by private groups, most of them records from instrumented private facilities, will become available. There is no doubt that analysis of this wealth of strong-motion records will be of tremendous value in advancing our knowledge of the characteristics of EQGMs generated by EQs, the reliability of present suggested attenuation laws, and the importance of local site conditions (soil profile and topography) on the dynamic characteristics of the resulting EQGMs. It is unfortunate, in the interest of advancing our knowledge of the effect of local soil conditions, that there are practically no records from down-hole instruments: as this information is of great engineering interest, the planning and installation of down-hole instruments needs improvement Study of the records obtained from the

Fig. 33 (a) The part that survived the EQ

Fig 33 (b) The part that collapsed

Fig. 33 CYPRESS STREET DOUBLE-DECK VIADUCT: (a) THE PART THAT SURVIVED THE LOMA PRIETA EQ; (b) THE PART THAT COLLAPSED