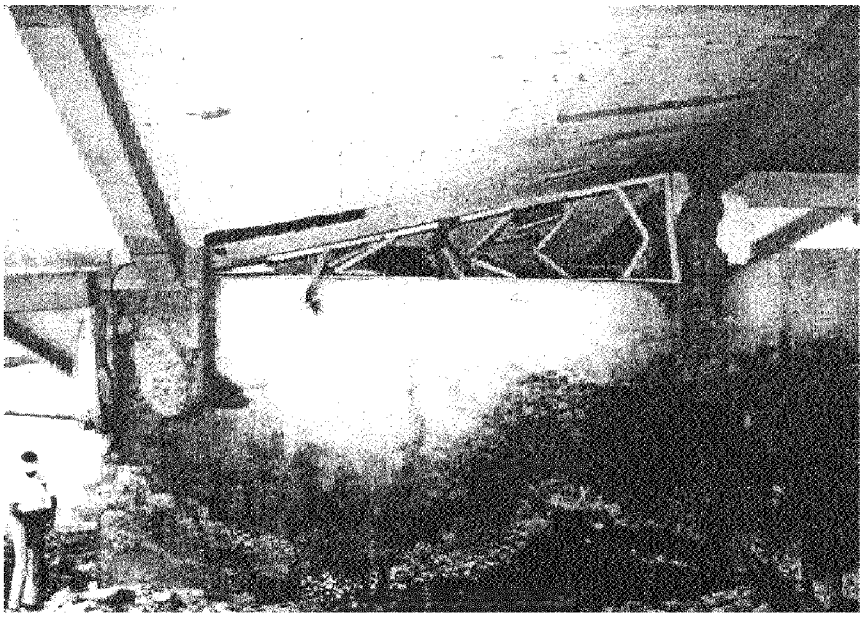
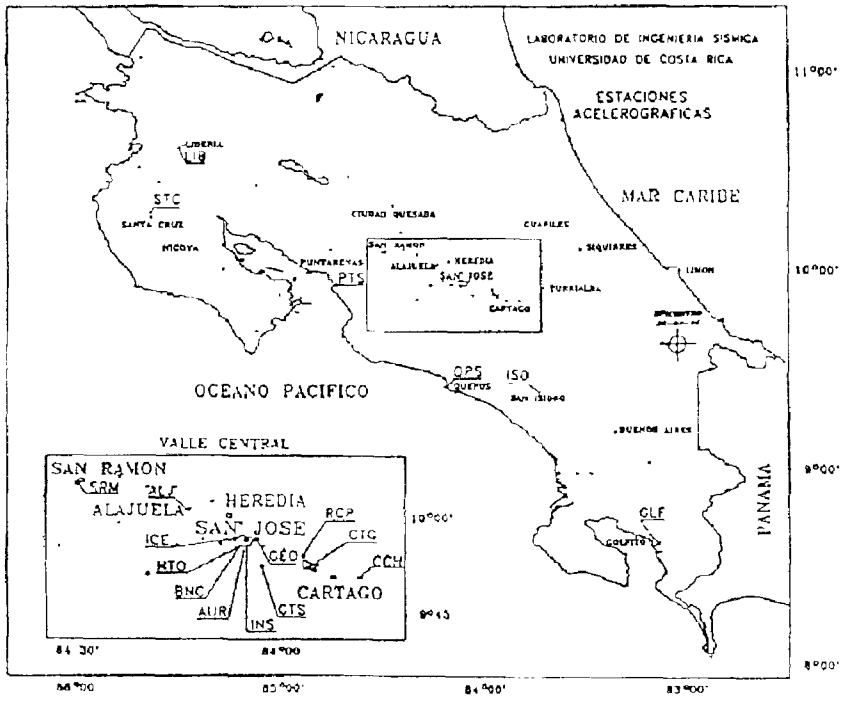
Costa Rica **Earthquake of April 22, 1991**



Hotel Los Olas near Limon. Short column on left failed while one on right did not.



Accelerograph station locations.

INTRODUCTION

A magnitude 7.6 earthquake occurred in Costa Rica, Central America, on April 22, 1991 at 2157 GMT. The event killed at least 52 people, injured 600

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Reconnaissance Team

EERI in conjunction with the National Academy of Sciences, dispatched a team of scientists and engineers to investigate the effects of the Costa Rica earthquake of April 22, 1991. With support from NSF, NCEER, FEMA, and ASCE, team members will study the results of the earthquake in Costa Rica in an effort to identify lessons that can be learned.

The team is led by Eugene Cole, structural engineer with Cole, Yee, Schubert & Associates in Sacramento, California. The local coordinator in Costa Rica is Guillermo Santana, of the Civil Engineering Department at University of Costa Rica. Team members also include Jogeshwar Singh, of Geospectra; Donald Ballantyne, of Kennedy/Jenks/Chilton; Nigel Priestley, Department of Structural Engineering, University of California/San Diego; Klaus Jacob, Lamont-Doherty Geological Observatory, Columbia University; Allan Lavell, Central American Research Program, University of Costa Rica; and Benigno Aguirre, Department of Sociology, Texas A & M University.

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Photos by Gene Cole

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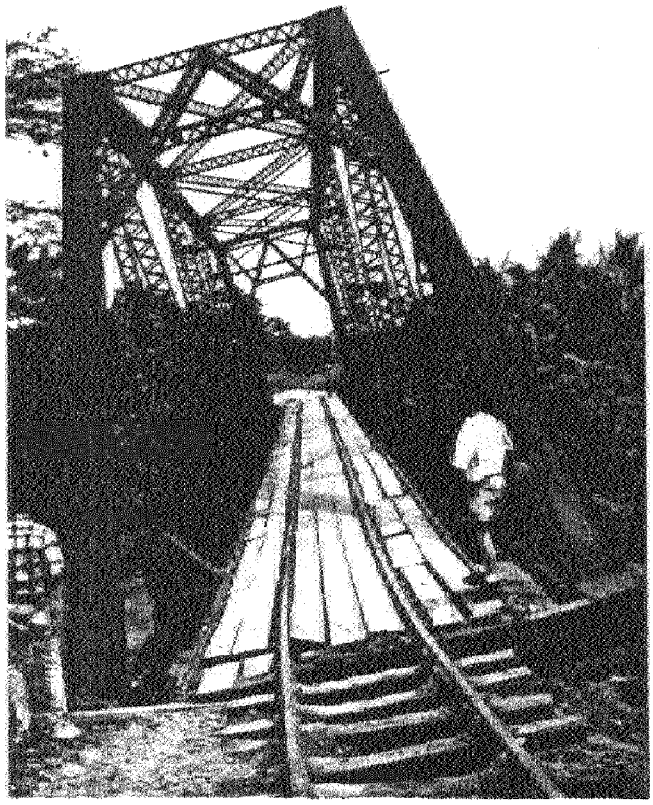
people and left 500 homeless. Severe damage occurred in the Limon-Batan area.

The following brief notes were faxed to the EERI office on Tuesday 4/30/91. They were preceded by earlier versions, even briefer. We must admit, however, that communications are not as good as this might indicate - we have been unable to identify the source! We would be happy to acknowledge this generous contribution, if only we knew who were responsible.

REPORT RECEIVED APRIL 30.

Bridges and Roads:

The major part of Limon and the whole southeast coast were cut off from the San Jose central valley by the collapse of a ~20 meter section of the concrete bridge over the Rio Chirripo del Atlantico. This was repaired Saturday (4/27/91) by pushing gravel/soil fill between the previous abutment and the sheared end of the bridge. Extensive liquefaction, spreading, and settlement of the roadbed caused severe fractures and dips in the pavement from Batán to Limon. Fissures were more or less continuous over ~40 km of road. As of Monday (4/29/91) heavy equipment has graded the debris into a passable road of intermittent pavement and gravel. East-west commerce from Limon to San Jose is approaching normal. South of Limon, along the coast highway, extensive liquefaction duplicated the Batán-Limon road damage, but more severely. In soft soil areas and bridge abutments, fissures as wide as 1 meter were common with settlement of 1-2 meters at some locations. As an estimate, ~50% of the paved highway was severely fractured from Limon south along the coast to Cahuita. It was very difficult to pass even by jeep. Grading the fractured highway has just started, in order to create a passable gravel/soil road surface.



Rail bridge over Rio Bananito Sur showing partial collapse as a result of failure of caissons and support blocks.

The concrete bridge over the Rio Limoncito (~50 meters length) was intact, but with abutment settlement over 1/2 meter, creating a severe step from the roadway up to the bridge deck. The concrete bridge over the Rio Banano (~100 m length) was intact, but with abutment slumps of about 1 meter. The concrete bridge over the Rio Vizcaya (~100 m length) collapsed. The concrete bridge (~50 m) over the Rio Bananito was intact. The steel truss bridge over the Rio Estrella (~150 m length) collapsed. The Estrella bridge is the ultimate barrier blocking even jeep access southward along the coast. The only alternate route serving the southeast coast is a narrow gravel road through the eastern side of the coastal mountains, by way of Limon through the villages of Santa Rosa, Beverly, Bananito Sur, to Pandora on the north side of the Rio Estrella. At the village of Pandora there is a one-lane, light-weight, steel suspension bridge. It will not support trucks, and looks strained even for jeeps. This is the "south-east passage." Extensive land-slides on the mountain road to Pandora were cleared, but when the heavy rains start in May, landslides are likely to close the road again. The coastal rail line is out due to bridge damage and settlement/buckling in the tracks. The only reliable access to the southeast coast is by helicopter. Currently the Sandanista Air Force seems to be providing most of the copter help.

The railroad line is a mess, due to settlement and liquefaction

beneath rails, and compression buckling.

Potable Water:

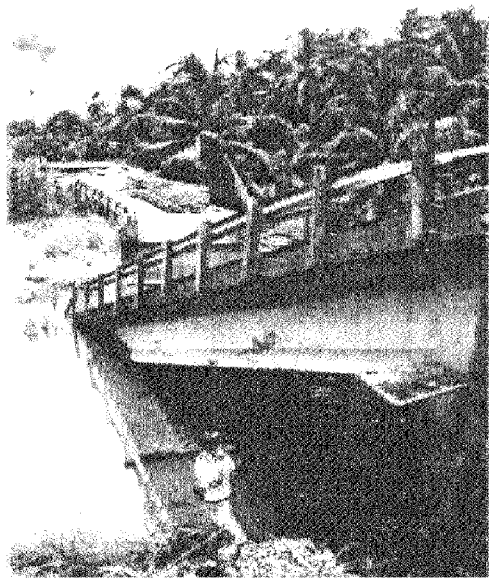
The Limon area is served by a water purification plant at the village of Bomba to the south. At the Bomba plant, wave damage destroyed the wooden baffle structures in the concrete sedimentation basins. The plant was otherwise OK and should be functional by now (4/30/91). Limon is served by two buried water mains, steel encased with a concrete lining, one routed through the mountains, the other line toward the coast and then north to Limon. The number of fractures on the water mains is unknown, perhaps dozens. When water will be restored to Limon is unknown, perhaps weeks. Currently, the lack of water service to this major population center is the major barrier to life returning to normal.

Structural Damage:

The only major building collapse in central Limon was the International Hotel, of four stories, the bottom one probably soft. Otherwise, perhaps 10% of the structures show obvious damage as viewed from the street, e.g., cracks, dislodged bricks. Most structures are 1-2 story. Limon is reported to be founded on an outcrop of rock. This may explain what appear to be MMI VII-VIII effects in Limon, vs. the MMI VIII-IX observed in the softer surrounding areas. In certain towns southward along the coast, and in the villages of Matina and Batán (perhaps aligned with the fault), collapse of 1-2 story wood frame structures approaches 50%. Several examples of collapsed water tanks (steel vessels atop braced frames) were also observed.

Industry

Liquefaction created settlement of ~1/2 meter in the Limon port facility (founded on fill). Damage was not otherwise serious and the port is back in operation. The port of Moine suffered minor damage and remains functional, off-loading oil tankers and pumping to the RECOPE refinery nearby. The RECOPE refinery continues to pump oil through the undamaged, ground-mounted pipeline that follows the highway toward San Jose. The RECOPE refinery (the only one that serves Costa Rica) suffered a fire that burned a small portion of the refinery installation as well as two tanks. The fire was extinguished with diesel-driven fire pumps. However, the smaller oil tank exploded, throwing the tank wall and roof ~30 meters. Out of ~20 oil storage tanks (various sizes), one failed, apparently at the welded wall/base seam. There are several tank farms near the port of Moine, some with excellent examples of elephant's foot buckling. The rule of ~10% tank failure seems to hold true here.



Automobile bridge over Rio Bananito showing two spans which have fallen from center abutment.

Electric Power

Bulk power flows from the central valley (San Jose) to the main substation at Limon over 138 kv lines. From there, power steps to 34.5 kv for distribution to Limon and along the coast southward to Panama. The substation had minimal damage. Bulk power (138 kv) was interrupted for about 1/2 hour due to relay actuation. Service was restored to Limon in ~25-36 hours (minor damage in distribution system). The 34.5 kv distribution lines southward along the coast highway suffered sporadic downed power poles and fallen pole-mounted transformers. The 34.5 kv system was restored southward at ~20 km/day. Lights came back on in Cahuita on Sunday (4/28/91) for example. The main substation at Limon also has 140 MW diesel engine and gas turbine power plant. The three new Hitachi gas turbines are OK. The four diesels had some settlement beneath foundations, and had not been tested as of our visit on 4/27/91.

Telecommunications

The phone system in Limon was undamaged except for the odd downed phone line. Both local and long distance service were retained, but of course immediately overloaded.

LABORATORIO DE INGENIERIA SISMICA
UNIVERIDAD DE COSTA RICA

ACELERACIONES MAXIMAS REGISTRADAS

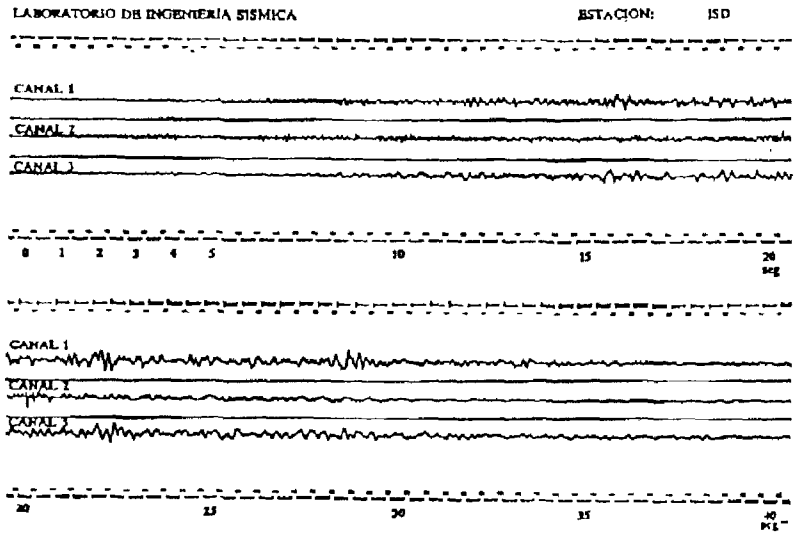
SISMO DE TALAMANCA, 22, DE ABRIL DE 1991

Nombre Estación	Código	Tipo Estr.	Distancia Epicentral	Aceleración Máxima	Orientación de ejes
San Isidro	ISD	B	73	0.20	0
				0.17	Arriba
				0.15	270
Cartago Cachí	CCH	R	80	0.15	0
				0.06	Arriba
				0.09	270
Cartago	CTG	C	94	0.27	0
				0.13	Arriba
				0.22	270
San José Guatuso	GTS	R	106	0.11	0
				0.04	Arriba
				0.06	270
S.José Biblioteca	CHA	A	109	0.16	270
				0.12	Arriba
				0.20	180
San José Hatillo	HTO	B	114	0.12	0
				0.06	Arriba
				0.09	270
S.José Edif.ICE	ICE	A	115	0.08	285
				0.06	Arriba
				0.09	195
Alajuela CIPET	ALJ	B	130	0.11	0
				0.05	Arriba
				0.09	270

NOTAS
Valores de aceleraciones máximas relativos a g
g=9.81 m/s², aceleración de la gravedad

Distancias en kilómetros

TIPO DE ESTRUCTURA
A: Edificio alto (3 o más pisos)
B: Edificio bajo (menos de 3 pisos)
C: Instalación en campo libre
R: Instalación en roca



Record from San Isidro, epicentral distance 73 km.

Miscellaneous

• In the high intensity areas there are numerous examples of overturned truck trailers and railroad box cars.

• The ability of local resources, with help from neighboring countries, to cope with the emergency, especially in airlifting supplies to the southeast coast, will make a very interesting study.

• With our jeep, the team was able to carry a load (unfortunately small) of emergency supplies to the village of Pandora for distribution at the local church (partially collapsed). Father Flavio Flores sends his thanks.

ACCELEROGRAM RECORDS

(Edited from a report by the Seismic Engineering Laboratory of the University of Costa Rica)

This preliminary report contains important records from stations in the Programa Nacional de Medición de Sismos Fuertes. The epicenter was 39.5 km to the SSW of the port of Limon on the Caribbean, at a depth of 21 km (Observatorio Vulcanologico y Sismologico de Costa Rica). The map shows the station locations; we include here the record from San Isidro, ISD, at an epicentral distance of 73 km. The table lists other records recovered so far, with maximum accelerations.

In the central valley, where the capitol city of San Jose lies, damage was not important compared with the province of Limon and the Panama province of Bocas del Toro. Intensities reached V or VI in places, less than in San Jose on 22 December, 1990, and similar to that of 25 March, 1990.