EARTHQUAKE REPORT

TO

COMMITTEE 9
SEISMIC DESIGN FOR RAILWAY STRUCTURES

AMERICAN RAILWAY ENGINEERING
AND
MAINTENANCE-OF-WAY ASSOCIATION

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FEBRUARY 28, 2001 NISQUALLY, WA EARTHQUAKE

Earthquake

At 10.54 AM PST, a Magnitude 6.8 earthquake occurred northeast of Olympia, Washington, near Nisqually. The hypocenter depth was approximately 50 km. The mechanism was rupture of a normal fault, in the subducting slab. Aftershocks with magnitudes of 3.4 and 2.7 occurred within the following 24 hours. No other aftershocks of significant magnitude occurred. The earthquake caused damage and injuries but no fatalities.

Recovery

Post-earthquake inspections were essentially complete by 5:00 PM on the Burlington Northern and Santa Fe and about one hour earlier on the Union Pacific. Union Pacific had no significant damage. BNSF lines north of Seattle were returned to service at 4:15 PM PST. Other main lines and branch lines used for commuter service were returned to service by 6:00 PM, except for a 7 mile segment near East Olympia. On this segment, Main Track No. 1 was returned to service with a 25 mph speed restriction at 7:30 PM PST and Main Track No. 2 was returned to service with a 25 mph speed restriction at 11:30 PM PST. Passenger trains were not operated on this segment on March 1. Speed restrictions were removed after enough traffic to consolidate disturbed ballast had run over the segments. A branch line in Olympia with both bridge and track damage was returned to service on March 6, completing the recovery.

Damage

Locations of damage to railroad facilities, other than buildings, are shown in Figure 1. Location of epicenter is indicated by a star.

Track Damage

At various locations between MP 30 and MP 37 on Seattle Subdivision, track settled at bridge ends, embankment settled and shifted and ballast was lost under ties. Typical damage in this area is shown in Figures 2 to 4. Track movements were, in general, less than 1 foot. Most damage was to Track 2. Embankment for Track 2 was constructed against embankment for Track 1 after Track 1 had been in service for a number of years. Tracks are at 13 ft. centers. Location is about 10 miles from epicenter.

There was considerable liquefaction affecting track with settlement and sand ejection, as shown in Figure 5, near Capitol Lake in Olympia. Maximum settlement was in an area where trestle approaches to a bridge had been filled. Track settled between 1 and 2 feet until it rested on caps of trestle which were left in place when stringers were removed. Settlement at east end of bridge is shown in Figure 6. Lateral spreading was observed in the area. Location is about 10 miles from epicenter.

Track was out of line near Ravensdale, about 35 miles from the epicenter.

Bridge Damage

A bascule bridge in Seattle, about 30 miles from the epicenter, was open at the time of the earthquake. Following the earthquake, it was impossible to close the bridge as the pivot pier and rest pier had moved together about 0.5 ft. Two spans in the east approach moved together about 0.3 ft. Additional movement amounting to several inches occurred during the following week. The bridge, in the open position, and cracks from lateral spreading due to liquefaction are shown in Figure 7.

One framed end bent of a trestle across Capitol Lake in Olympia, about 10 miles from the epicenter, was rotated toward the channel about the end of the deck. There was considerable liquefaction and lateral spreading in the area.

Signal Damage

The mounting mast for one signal on a cantilever signal installation in Seattle was broken. The location is between 30 and 40 miles from the epicenter.

Two batteries were tipped over at Centralia, about 30 miles from the epicenter and two were cracked at Kelso, about 70 miles from the epicenter.

Other Damage

Landslides about 15 miles from the epicenter blocked the track ditch at locations over a distance of about one mile but did not affect the tracks.

Railroad buildings in Seattle and their contents suffered varying degrees of damage.

Recommendations

Certain lessons learned from this earthquake are applicable to all railroads in seismically active areas.

Moveable bridges should either have provisions to allow closing after movement of supporting piers or be normally kept in the closed position.

Restoration of track to normal standards following an earthquake may require sizeable quantities of ballast.

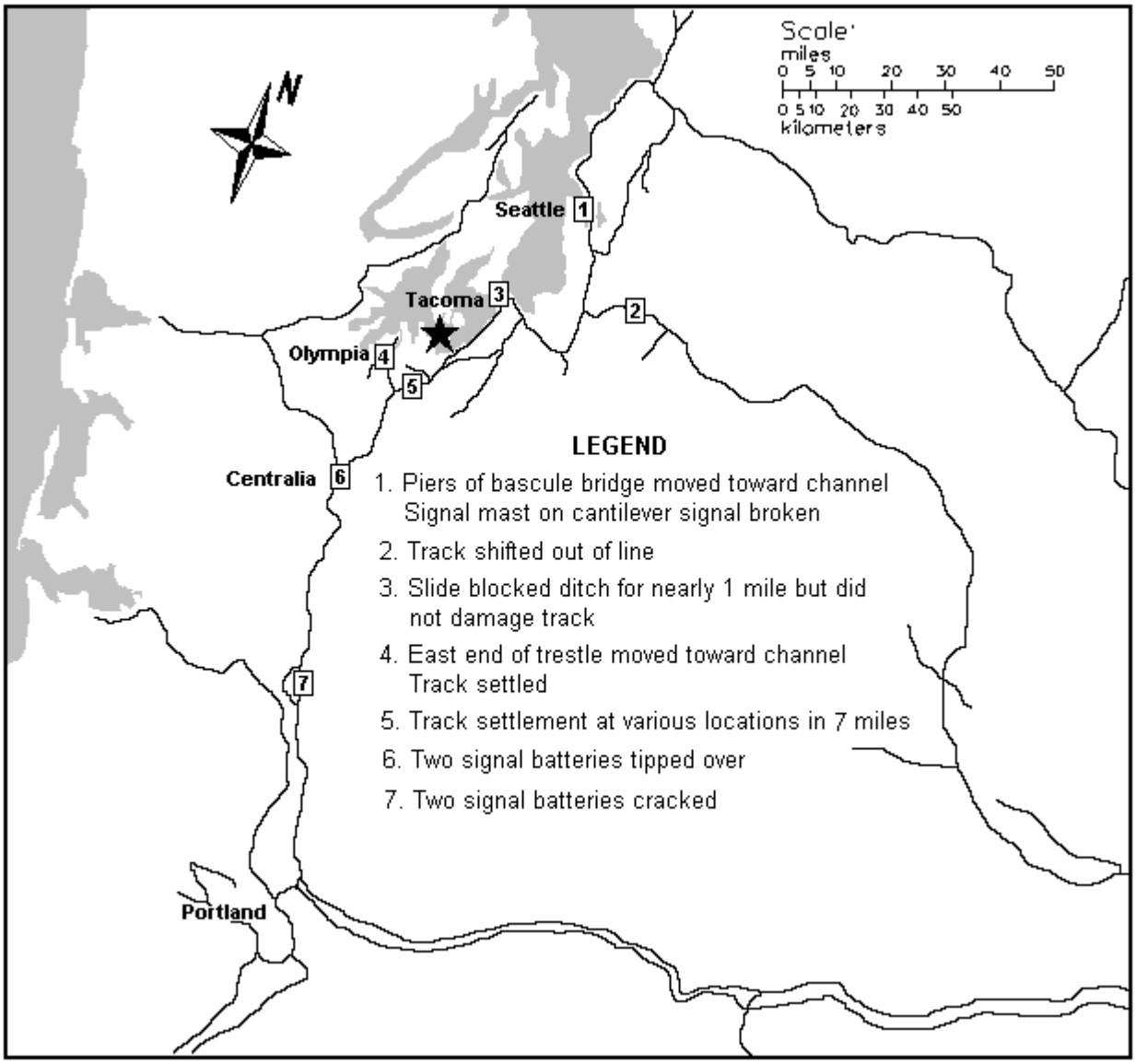

Figure 1. Damage to railroad facilities other than buildings.

Figure 2. Settlement under track at MP 30.9.

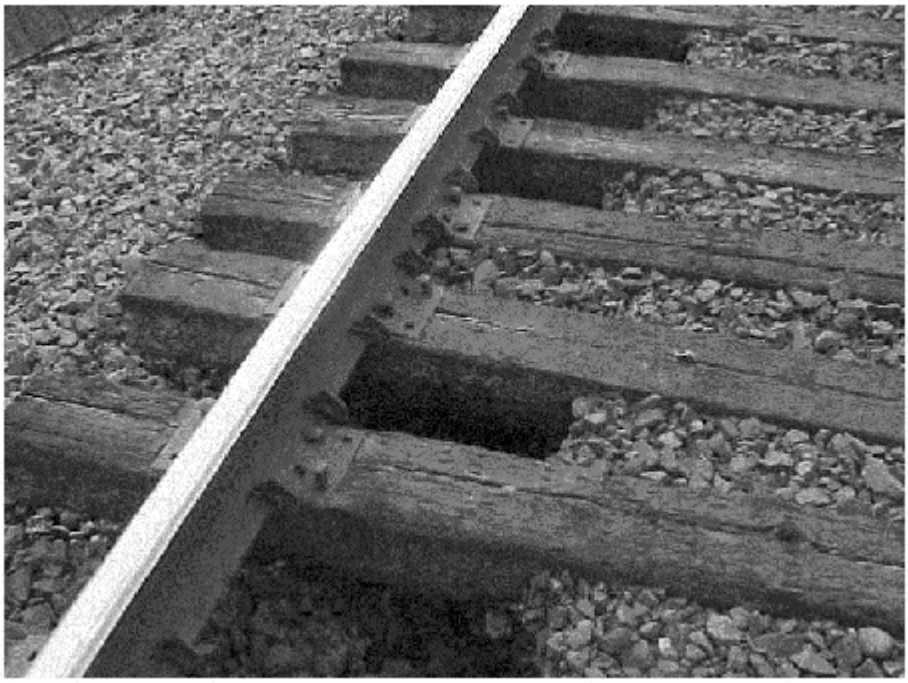

Figure 3. Ballast loss over pipe culvert at MP 30.92.

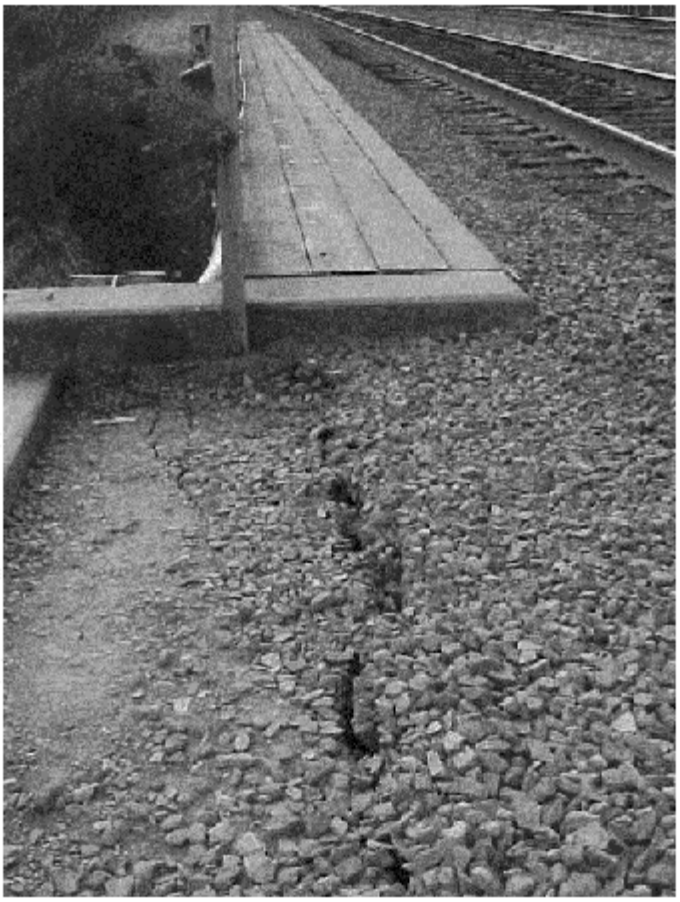

Figure 4. Settlement at bridge end at MP 31.6.

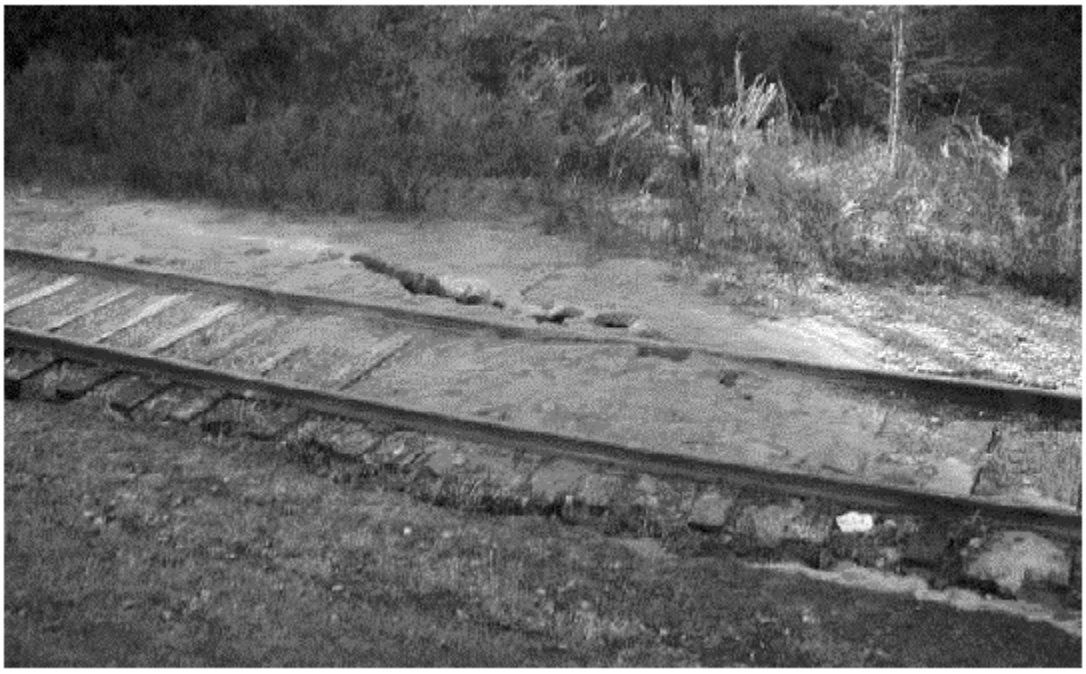

Figure 5. Liquefaction near Capitol Lake in Olympia.

Figure 6. Settlement at bridge end at Capitol Lake.

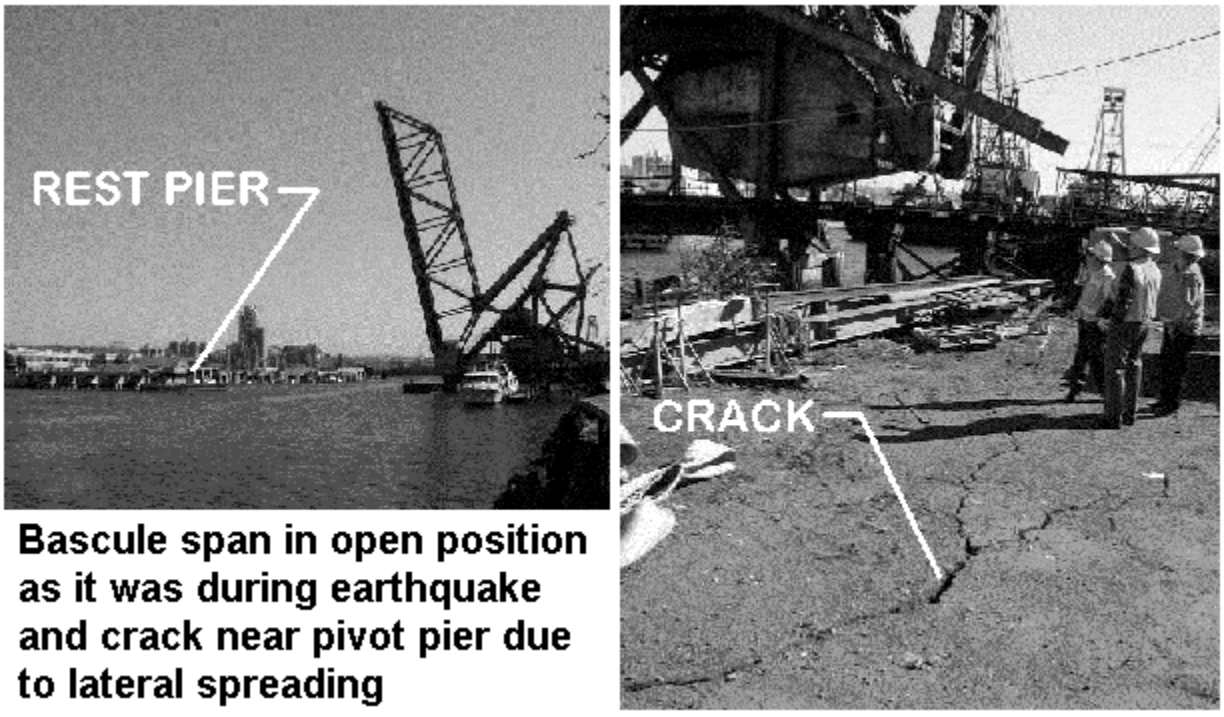

Figure 7. Bascule span in open position and cracks in ground behind pivot pier.