Fig. 3.174. Kashiwazaki Port—eastern berth. Evidence of minor settlement adjacent to a pile-supported (?) bollard anchorage located along the northern face of the terminal (N37.36680° E138.53825°).

Fig. 3.175. Kashiwazaki Port—eastern berth. Evidence of very minor lateral movement of quay walls and minor settlement located along the northern face of the terminal (approximately N37.36680° E138.53825°).

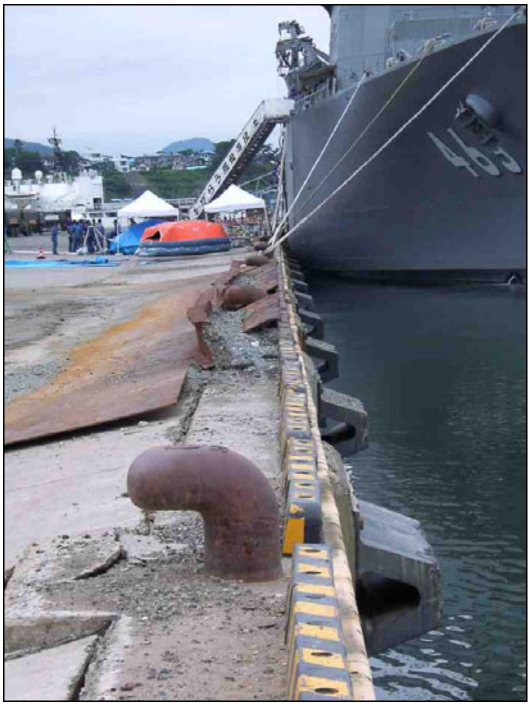

Fig. 3.176. Kashiwazaki Port—eastern berth. Evidence of more extensive lateral quay wall displacement and ground settlement located along the eastern end of the terminal (approximately N37.36680° E138.53825°).

Fig. 3.177. Kashiwazaki Port—eastern berth. Significant liquefaction-related damage to the quay walls located at the eastern edge of the terminal adjacent to the mouth of the U River (approximately N37.36680° E138.53825°).

Fig. 3.178. Kashiwazaki Port—eastern berth. Significant liquefaction-related damage to the quay walls located adjacent to the U River (approximately N37.36680° E138.53825°).

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Taiheiyo Cement Tanks. This facility is located in the backland portion of the eastern berth terminal. The issue of business interruption at the port was considered by the reconnaissance team. Because of the regional need for concrete in restoration efforts following the earthquake, the operation of this facility is important. Inspection of the tank foundations revealed minor ground settlement of 5 cm to 12 cm adjacent to the tank foundations (Figures 3.179 and 3.180). Liquefaction effects were negligible in this area. The tanks and appurtenant piping appeared to be in good shape with negligible damage; however, the facility was not in operation at the time of the investigation.

Fig. 3.179. Kashiwazaki Port (Taiheiyo Cement Facility)—Evidence of minor settlement of sandy fill adjacent to one of the large diameter tanks (approximately N37.36665° E138.53983°).

Fig. 3.180. Kashiwazaki Port (Taiheiyo Cement Facility)—Evidence of minor settlement of sandy fill adjacent to one of the large diameter tanks (approximately N37.36665° E138.53983°).

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The eastern boundary of the Port of Kashiwazaki is located along the mouth of the U River. None of the breakwater structures located offshore of the port complex (west bank) or the levee and breakwater structures along the east bank near the river mouth were investigated during this reconnaissance. The Minatomachi Seaside Park, bounded to the west by the U River, was entirely occupied by Self Defense Forces and was being used for temporary housing and staging areas for relief efforts. The area is generally open parkland and a very cursory walk-through inspection was made. Evidence of liquefaction was prevalent throughout the park. Ground cracks, sand boils, and damage to paved surfaces were widespread. Numerous sand boils and extensive ground cracks associated with lateral spreading were observed on the beach. No structural inspections were performed to assess the performance of building foundations in this area.

The oceanfront from the Minatomachi Park to the mouth of the Sabaishi River, located roughly 2.5 km to the northeast, consists of two public beaches followed by a long reach of wave armor units backed by concrete seawalls. A long portion of the seawall extending southwest from the Sabaishi River was inspected by the reconnaissance team.

The mouth of the Sabaishi River is protected along its southwest bank by a wall constructed of sheetpiles with concrete filling (Fig. 3.181). Negligible lateral movement of the riverfront wall was noted and roughly 5 cm to 7 cm of settlement was noted adjacent to the sheetpile wall. Evidence of approximately 30 cm of lateral spreading in the sand deposits behind the sheetpile shore protection was also observed. In addition, minor lateral deformation and damage to the concrete slope armor panels was observed across the river from this site. The extent of lateral spreading at this location was considerably less than what would be anticipated for a waterfront site where shaking in the underlying firm soils was likely in excess of 0.30g, indicating that the sheetpile and concrete wall restrained the adjacent soil mass from moving.

Fig. 3.181. Mouth of the Sabaishi River showing the channelization and erosion control measures (approximately N37.38868° E138.56508°). The Ansei Bridge is visible in the background.

Along the waterfront to the southwest of the Sabaishi River and transverse to the riverfront sheetpile wall in Figure 3.182 is a seawall that extends southwest roughly 2.0 km toward the Minatomachi Seaside Park. This seawall was inspected for more than a 1-km length. Observations were made from the mouth of the Sabaishi River southwest to an armored rockfill breakwater located roughly 1.2 km to the southwest. The initial portion of the seawall is located along a narrow beach with wave armor units. This portion of the seawall exhibited lateral deformation, rotation, and structural damage along the counterfort ends of several of the individual wall sections (Fig. 3.183).

Fig. 3.182. Eastern end of the seawall located near the mouth of the Sabaishi River (approximately N37.38868° E138.56413°). Lateral spreading behind the wave armor units, as well as ground settlement and minor sea wall damage was widespread.

Fig. 3.183. Lateral displacement of the seawall located near the mouth of the Sabaishi River (approximately N37.38868° E138.56413°).

Approximately 120 m to the southwest, there is a seaward step in the seawall. This point was the location of a seawall failure that included a collapsed section of wall, significant settlement and cracking of the backfill, and settlement of the concrete panels located behind the seawall (Fig. 3.184). The backfill adjacent to the seawall is composed of clean, rounded cobbles (diameter > 15 cm) (Fig. 7.185). The lateral wall movement in this area was roughly 0.6 m.

The use of cobble backfill was observed over much of the 1 km length of the seawall that was inspected, and this fill was roughly 3 m to 4 m wide in most areas. The fill placed adjacent to the cobbles is predominantly sand with areas of sandy clay and clayey sand. For most of the reach between the Sabaishi River and Minatomachi Park a large embankment fill has been placed. The placement of the long embankment imposes static shear stresses in the foundation adjacent to the seawall. It is, therefore, likely that the additional seismic loading and associated seismic shear stresses were sufficient to induce widespread failures in the embankment and foundation, thereby, affecting the seawall (Fig. 3.186).

Fig. 3.184. Partial collapse of a portion of the seawall (approximately N37.38868° E138.56413°).

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Fig. 3.185. Close-up of the collapsed portion of the seawall showing the clean cobble backfill (N37.38868° E138.56413°).

Fig. 3.186. Extensive ground failures in proximity to the seawall located near the mouth of the Sabaishi River (approximately N37.38868° E138.56413°).

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As previously noted, the area located behind the seawall has been developed with a benched, earth embankment composed of sandy clay and clayey sand that extends almost the entire distance to the beaches near the Minatomachi Seaside Park. The seawall exhibited an increased seaward tilt as the investigation moved to the southwest (Fig. 3.187). The cumulative lateral deformation was crudely estimated to be approximately 1.5 m to 2.0 m. The actual lateral movement was very difficult to estimate in the field due to the cumulative impacts of lateral spreading, levee slumping, and foundation failure. The embankment exhibited pervasive longitudinal cracks along the crest and side slopes, and a less well-developed set of transverse cracks. The longitudinal cracks were noted on both sides of the embankment; however, the deformations in the seaward direction were much more pronounced (Fig. 3.188). The embankment is discontinuous and is bisected by several unpaved access roads. At these intersections it is clear that the embankment experienced significant differential settlement, transverse cracking, and longitudinal cracking extending through the entire earth structure (Fig. 3.189). The radial pattern of longitudinal cracks observed at the base of one of the embankment sections clearly demonstrated the extent of foundation failure and differential settlement of the embankment. No liquefaction features (for example, sand boils, vented sand) were observed in the embankment fill or in tension cracks. Several large voids (> 1 m^3) were exposed near the toes of failed portions of the embankment.

Fig. 3.187. Evidence of seawall rotation, ground settlement, and lateral spreading at the toe of the benched embankment.

Fig. 3.188. Representative ground cracking and lateral displacement of the clayey earth embankment adjacent to the seawall.

Fig. 3.189. Extensive ground deformations adjacent to the embankment and seawall.

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The lateral ground deformation associated with these embankment and foundation failures impacted the seawall and contributed to the development of larger displacements (Fig. 3.190). At one location near the southwestern end of this area, ground settlement and lateral movement of the seawall was accompanied by the failure of the top of the wall (Fig. 3.191). The inspection of the seawall was terminated at an armored groin structure (possibly an outfall structure). At that time a track-hoe was being used to move rockfill between the seawall and the concrete armor blocks that overlie the rockfill offshore (Fig. 3.192).

Fig. 3.190. Ground deformations adjacent to the embankment and seawall.