DAMAGES OF OIL STORAGE TANKS FOR OFF MIYAGI PREFECTURE EARTHQUAKE OF JUNE 12, 1978

by K. Kawano[I], T. Oda[II], K. Yoshida[III], S. Yamamoto[IV], T. Shibuya[V], S. Yamada[V]

SUMMARY

This report presents the investigation of the damages caused to the oil storage tanks by the Off Miyagi Prefecture Earthquake of June 12, 1978. As a result of the investigation, the damages of the oil storage tanks were classified into the following five basic categories:

1) Failure of annular bottom plate at bottom corner joint with oil spills
2) Settlement along perimeter of tank
3) Buckling of rolling ladder connected to floating roof
4) Pullout of anchor bolts
5) Slight buckling of upper shell courses

1. INTRODUCTION

The Off Miyagi Prefecture Earthquake that occurred on June 12, 1978 damaged many buildings, structures and roads in Sendai city which is located about 100 km from the epicenter. At the Tohoku Oil Sendai Refinery in the suburbs of Sendai city, three oil storage tanks were damaged severely, resulting in flow-out of the contents. This paper presents the findings of the investigation made to assess the extent of damage on the eighty or so tanks in the refinery.

2. SUMMARY OF OFF MIYAGI PREFECTURE EARTHQUAKE OF JUNE 12, 1978

The parameters of the earthquake are as follows:

Date and Time	:	17:14 (JST), June 12, 1978
Epicentral region	:	Off Miyagi Prefecture
Hypocenter	:	38° 09'N, 142° 13'E, Depth 30 km
Magnitude	:	7.4

Fig. 1 shows a map of the seismic intensities. The Tohoku Oil Sendai Refinery is located near Shiogama city adjacent to Sendai city. At the

I. Dr. Eng., Engineering Consultant (Stress Analysis) of Advisors & Engineering Consultants Office of Chiyoda Chemical Engineering & Construction Co., Ltd. P.O.Box 10 Tsurumi, Yokohama, Japan.

II. Deputy General Manager of Engineering Department of Tohoku Oil Co.

III. Director, General Manager of Corporate Development Division of Chiyoda Chemical Engineering & Construction Co., Ltd.

IV. Dr. Eng., Manager of Civil & Applied Mechanics Research Department of Chiyoda Chemical Engineering & Construction Co., Ltd.

V. Research Engineer of Civil & Applied Mechanics Research Department of Chiyoda Chemical Engineering & Construction Co., Ltd.

Shiogama Port and Harbor Construction Work Office, the strong motion seismogram showed maximum acceleration on the ground surface to be 266 gals in the NS direction, 288 gals in the EW direction, and 166 gals in the vertical direction.

3. DAMAGES OF CYLINDRICAL STEEL TANKS

The layout of the cylindrical steel tanks in the Tohoku Oil Sendai Refinery and the damages are as shown in Fig. 2. Typical features of the damage are as follows:

3.1 Tanks T-217 and T-218 (31,500 Kl) and Tank T-224 (23,700 Kl)

These tanks failed at the annular bottom plate along the inside fillet weld toe at the corner joint with the shell plate as shown in Photo. 2 and Fig.3, and the contents flowed out and covered the refinery area as shown in Photo. 1. Measurements made of the annular bottom plate thickness after the earthquake revealed that the thickness of the annular bottom plates in these tanks decreased by corrosion.

3.2 Tanks T-130 and T-131 (31,500 Kl)

These tanks settled an average of about from 100 mm to 140 mm along the perimeter similar to the settlement shown in Photo. 3. Also, because of the settlement, the annular bottom plate deformed so much that an acute angle was formed with the shell plate as shown in Fig. 4. In addition to these tanks, T-118 and T-203 (11,300 Kl) settled an average of more than 100 mm along the perimeter as shown in Fig. 2.

3.3 Tank T-355 (2,000 Kl)

The anchor bolts of water tank T-355 were uniformly pulled out about 15 cm as shown in Photo. 4. Also the anchor bolts of water tanks T-301 and T-302 (2,000 Kl) were pulled out.

3.4 Tanks T-1, T-2, T-3, T-6, T-7, T-8 (102,000 Kl), T-5 (74,000 Kl) and T-9 (55,000 Kl)

The rolling ladder on the floating roof of these tanks was buckled or deformed and oil flushed out on the floating roof as shown in Photo. 5.

REFERENCES

1) S. Yamamoto ; Structural Analysis and Seismic Design of Oil Storage Tanks 3rd National Congress on Pressure Vessel and Piping Technology, June 25-29, 1979.

2) Technical Standard Committee for Dangerous Substances in Fire Defense Agency ; Report on Investigation of Cause of Tank Rupture in Tohoku Oil Sendai Refinery owing to Off Miyagi Prefecture Earthquake of 1978 (Japanese).

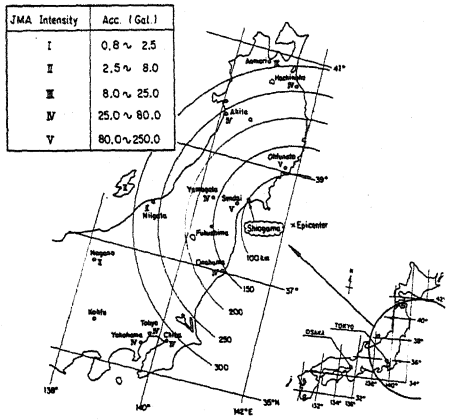

Fig. 1 Epicenter and Seismic Intensities

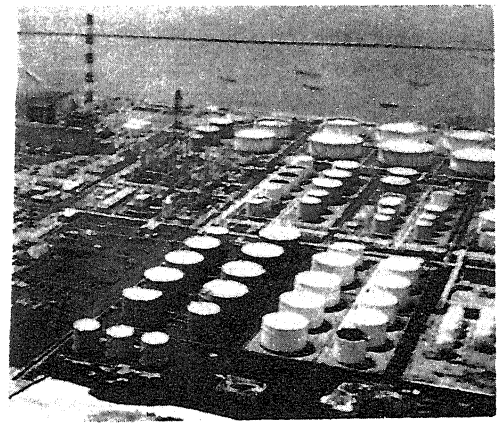

Photo.1 Oil Spill from Three Damaged Tanks Covering Site of Tohoku Oil Sendai Refinery

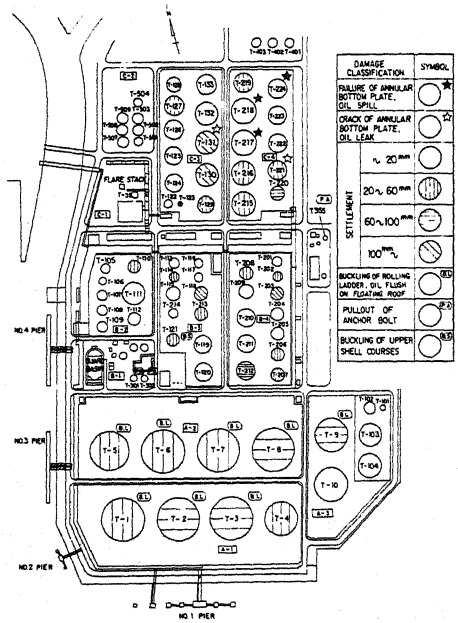

Fig. 2 Plot Plan of Oil Storage Tanks in Tohoku Oil Sendai Refinery

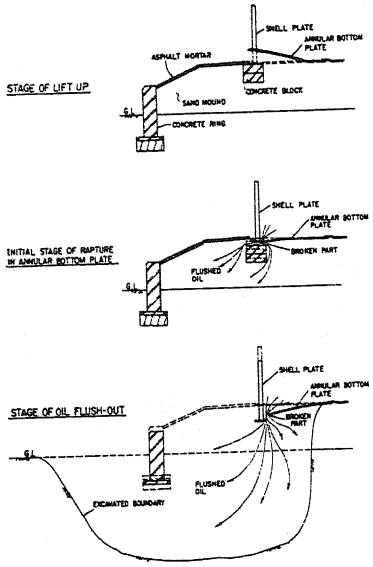

Fig. 3 Damage of Annular Bottom Plate (Tanks T-217, T-218 and T-224)

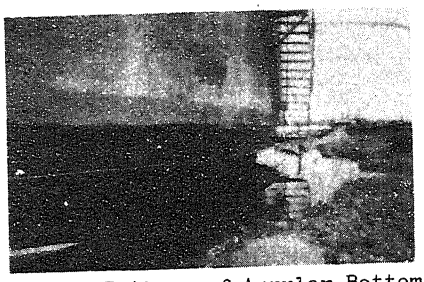

Photo.2 Failure of Annular Bottom Plate (Tank T-217)

Photo.3 Settlement along Perimeter (Tank T-118)

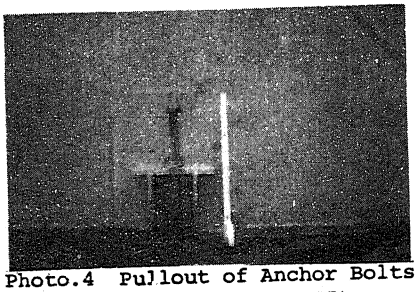

Photo.4 Pullout of Anchor Bolts (Water Tank T-355)

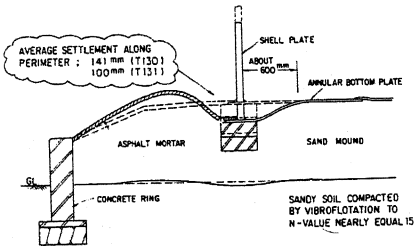

Fig. 4 Feature of Setttlement (Tanks T-130 and T-131)

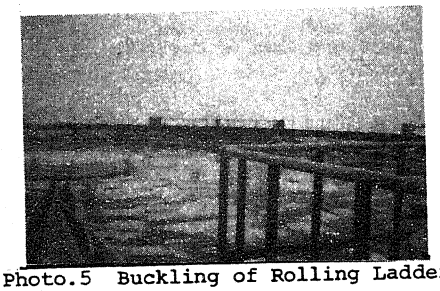

Photo.5 Buckling of Rolling Ladder and Oil Flush-out (T-2 Tank)