

PROJECT BRIEF

# Kawaski Refinery Seismic Retrofit

## PROJECT PROFILE

CLIENT:  
TONEN Corporation

LOCATION:  
Kawaski City, Japan

### VALUE:

- Extensive risk assessment to quantify the sources and magnitudes of risk from earthquake related causes and to determine the most cost effective means of reducing risk
- Methodology was successfully applied to three sites saving the clients millions

### SERVICES PROVIDED:

- Developed a risk based methodology to assess the risk created by earthquake shaking
- Probabilistic analyses conducted to determine overall risk for the site
- Evaluated various potential means of reducing risk

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## SEISMIC ANALYSIS AND RISK ASSESSMENT

TONEN contacted Professor T. William Lambe who had consulted on the original development of the site. Working as Technical Manager for T. William Lambe Associates, Dr. Allen Marr was assigned Project Manager for this work. After an initial assessment of the site conditions, the Lambe team determined that conventional approaches to foundation design would be very costly and might not result in a corresponding improvement in safety. Dr. Marr assembled a team of experts to develop a risk-based methodology to assess the risk created by earthquake shaking. That methodology included an evaluation of historical regional seismicity, development of a site-specific seismic intensity curve, and development of event and fault trees to determine which seismic related events and which failure modes contributed to overall risk. Probabilistic analyses were conducted to determine overall risk for the site, where risk was measured as both a probability of failure and a cost of the consequences. The main cause of risk was identified to be failure of multiple tanks due to deformation of their foundations from earthquake shaking. The most cost effective means of risk reduction proved to be lowering the ground water level within the hydraulic fill. The methodology was successfully applied to three sites at a cost savings of \$60,000,000 compared to more conventional methods.



## BACKGROUND

In the early 1970's, TONEN Corporation became concerned with the seismic stability of three large oil storage tank farms at their Kawasaki Refinery. The refinery is located in a high seismically active region. The entire facility was constructed over reclaimed land made by sedimenting sand and silt dredged from Tokyo Bay. The original foundation design did not consider earthquake loads.