

Activities of Research Initiative for Natural Disaster Prevention of Oil and Gas Spill in Industrial Parks



Naomi Kato
Osaka University

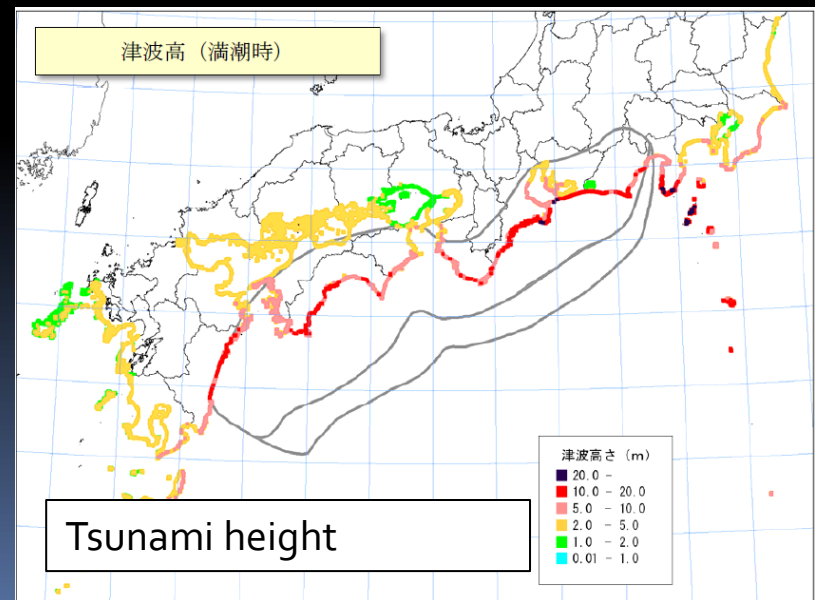
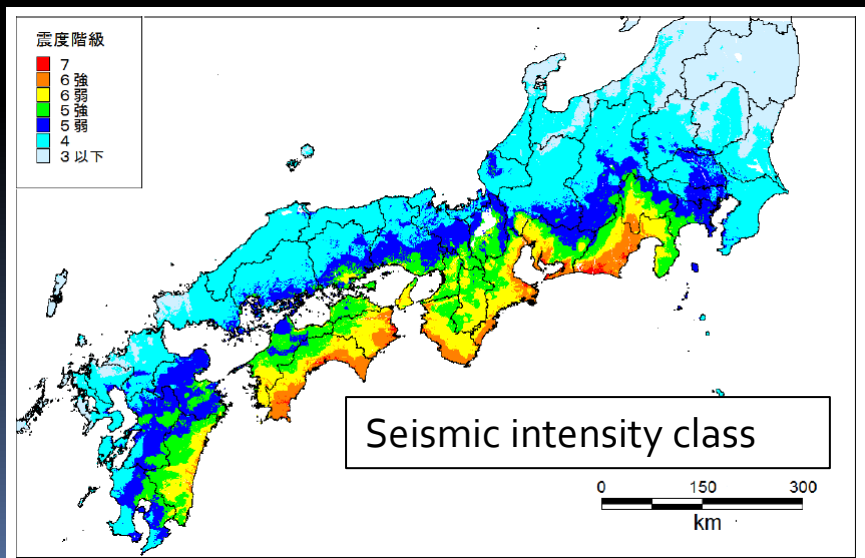
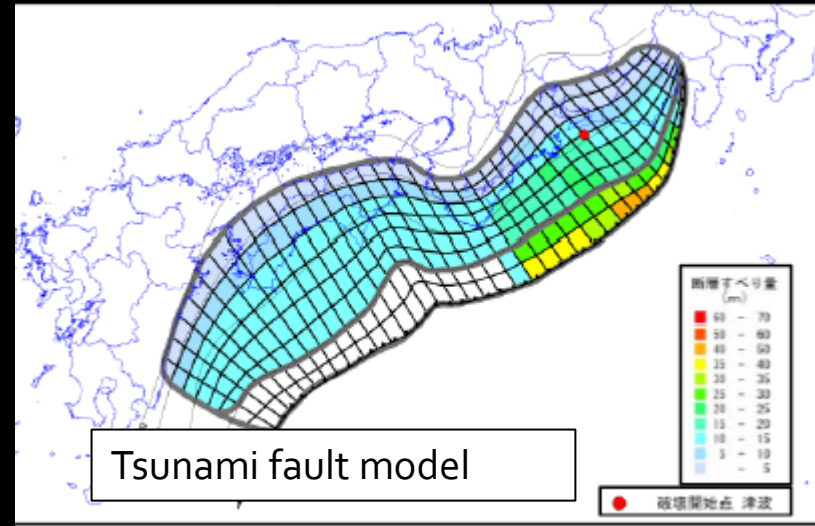
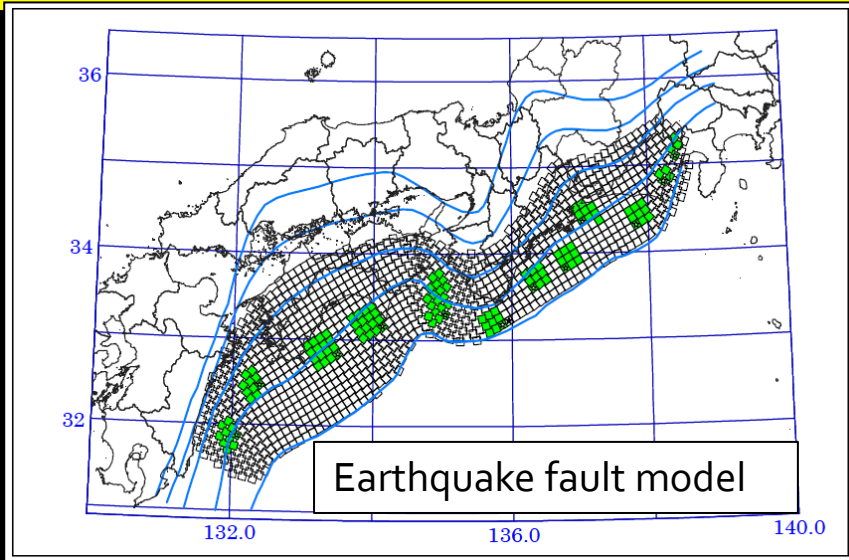
Background

- Large oil spill from oil tanks and fire of entire city of Kesen-numa at Great East Japan Earthquake
 - 22 oil tanks (each volume: 40~3,000kL) of 23 oil tanks were drifted. Volume of spilled oil reached **11,523 kL** at Kesen-numa City.
- Huge disaster at large-scale industrial parks in Tokyo Bay, Ise Bay and Osaka Bay after possible Nankai Trough Great Earthquake

Research Initiative for Natural Disaster Prevention of Oil and Gas Spill in Industrial Parks

- Initiated since 2015 as a cooperative institution of national project SIP (Strategic Innovation Promotion Program) (Resilient Disaster Prevention)
- perform risk assessment of damages and hazardous materials releases caused by large scale earthquake and tsunami, propose countermeasures to decrease such disasters, and present guidelines for them.

Estimated Earthquake and Tsunami by Nankai Trough Great Earthquake by Cabinet Office

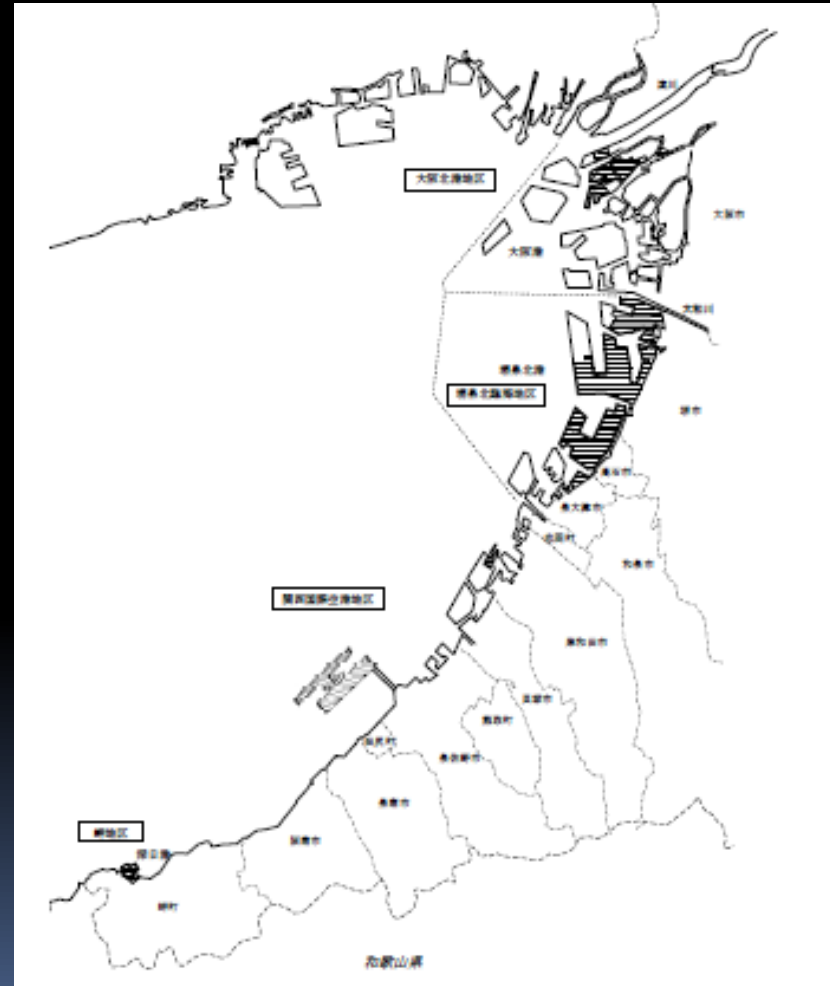


Characteristics of Kansai Area in terms of natural disaster

- Intensive distribution of energy related infrastructure along coastal line of Osaka Bay

12 special disaster prevention areas from Wakayama Pref. to Hyogo Pref. based on “Act on the Prevention of Disaster in Petroleum Industrial Complexes and Other Petroleum Facilities”

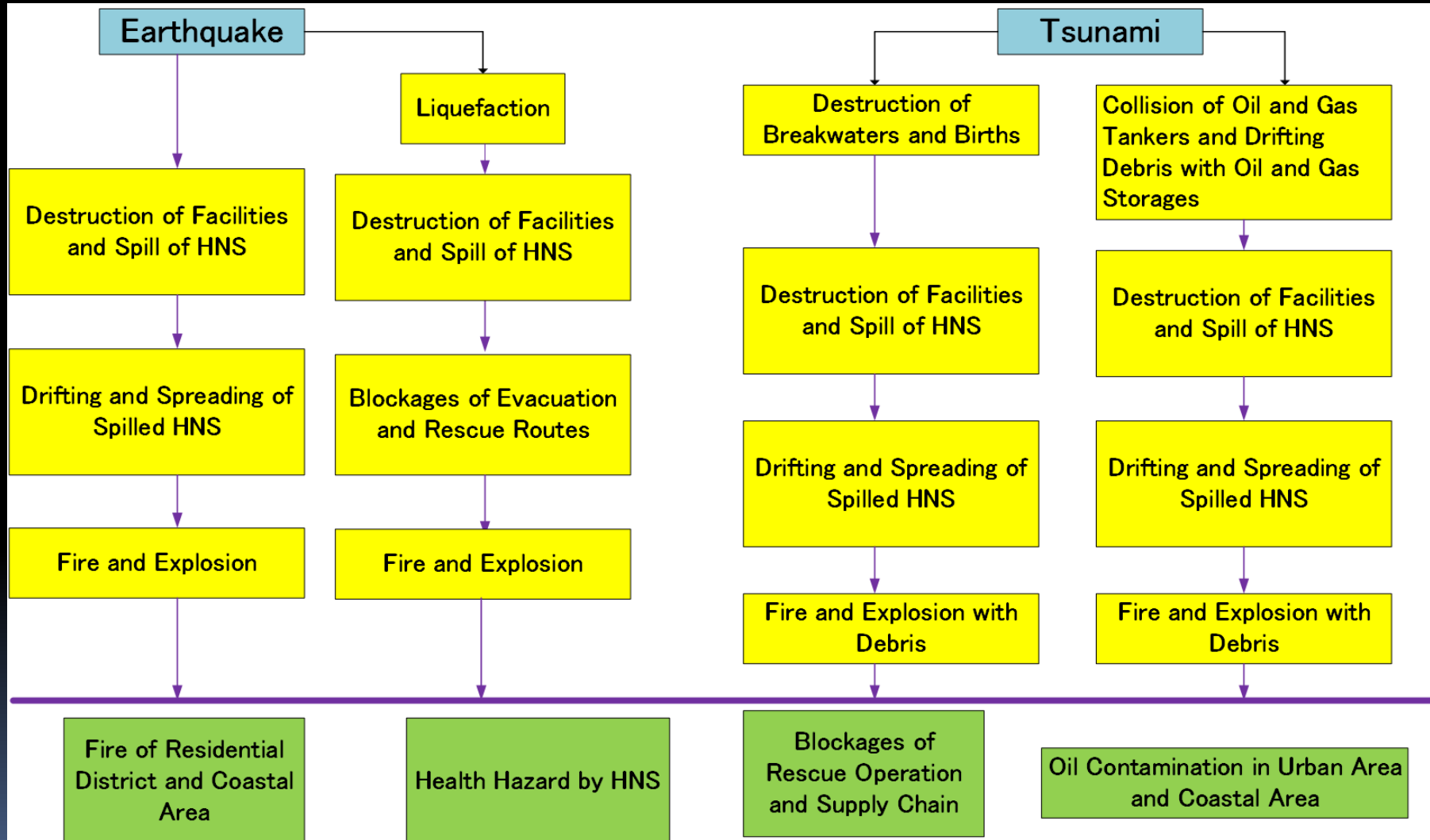
Possible Nankai Trough earthquake will cause earthquake with a seismic intensity of 6 or smaller at Osaka Pref. and tsunami with wave height of 6 m at maximum along coastal line of Osaka Bay



Characteristics of disaster in industrial parks by large scale earthquake and tsunami

- High impact, but low probability
- Concurrence of compound events
- Strong interference between events
- Hazardous influence on
 - citizens' lives and property,
 - land and maritime logistics,
 - environmental contamination
- Large obstacles to rescue operation and restoration
- Collaboration among central ministries and local ministries
- Regulatory barrier between ministries

Concurrence of Compound Events



Natural-Hazard Triggered Technological Accidents (Natech)

- Working Group of Chemical accidents of OECD organized a workshop on Natech in 2002.
- European Commission Joint Research Centre organized workshops on Natech in 2003 and 2007.
- Research Initiative for Natural Disaster Prevention of Oil and Gas Spill in Industrial Parks of Osaka University organized International Symposium on Natural Disaster Impacts to Large Industrial Parks on March 11-12, 2015
- The reduction of risk from technological and environmental hazards is specifically included in the Sendai Framework on March 14-18, for Disaster Risk Reduction 2015-2030 adopted by the General Assembly of the United Nations.
- OECD Natech II Project in cooperation the UN Joint Environmental unit has been organized for 2017-2020. It will hold a workshop in 2018.

Construction of Comprehensive Risk assessment

- **Safety for Instruments, workers, residents, marine logistics, disaster recovery responses**

Viewpoints

- Protection of Supply Chain
- Sharing of Information
- Arrangement of tools for disaster recovery responses
- Various mitigation tools
- Scheme of operational command
both on land and at sea

- **Risk Analyses of Oil Spill, Fire and Gas Explosion both on Land and at Sea**

Domestic Policies on Safety of Industrial Parks

From the viewpoint of petroleum industrial complexes

- ◆ Act on the Prevention of Disaster in Petroleum Industrial Complexes and Other Petroleum Facilities
 - Special disaster prevention areas in local areas
 - Disaster management plan of local government
- ◆ Fire Service Act
 - Guideline for disaster prevention in petroleum industrial complexes
- ◆ High Pressure Gas Safety Act
- ◆ Basic Act on Disaster Control Measures
- ◆ Liaison conference between Fire and Disaster Management Agency, Ministry of Health, Labor and Welfare, and Ministry of Economy, Trade and Industry for disaster prevention in petroleum industrial complexes since 2014

Domestic Policies on Safety of Industrial Parks

From the viewpoint of maritime affairs

- Act on Prevention of Marine Pollution and Maritime Disaster
- Marine Disaster Prevention Center
 - (1) Preparedness, response and co-ordination to pollution incidents from Hazardous and Noxious Substances(HNS) are carried out upon the request from the contractors such as ship owners and petrochemical companies, and Director General of Maritime Safety Agency.
 - (2) Maritime disaster safety service for petrochemical companies under normal condition and in emergency

Domestic Policies on Safety of Industrial Parks

From the viewpoint of safety of lives and Properties of residents near industrial parks

◆ Dependence on disaster management plan of local government

- /Evacuation Guide and training
- /Protection of Supply Chain
- /Sharing of Information
- /Emergency rescue tools such as shelter
- /City planning

Sources of oil and gas spills in industrial parks by large scale earthquake and tsunami

Earthquake-oriented sources are

- (1) **Sloshing** of oil and gas in their storages caused by long period oscillation of ground,
- (2) **Liquefaction** of ground under oil and gas storages,
- (3) **Structural damages** of oil and gas storages,
- (4) **Non-structural damages** of peripheral systems of oil and gas storages like power supplies.

Tsunami-oriented sources are

- (1) **Drifting and tumble** of oil and gas storages,
- (2) **Scission of pipes of oil and gas tankers** under loading caused by those drifting,
- (3) **Collision of oil and gas tankers** and drifting debris with oil and gas storages,
- (4) **Spreading of spilled oil and gas** in land and on sea surface, and
- (5) **Non-structural damages of peripheral systems** of oil and gas storages like power supplies.

Concept of Formal Safety Assessment of International Maritime Organization

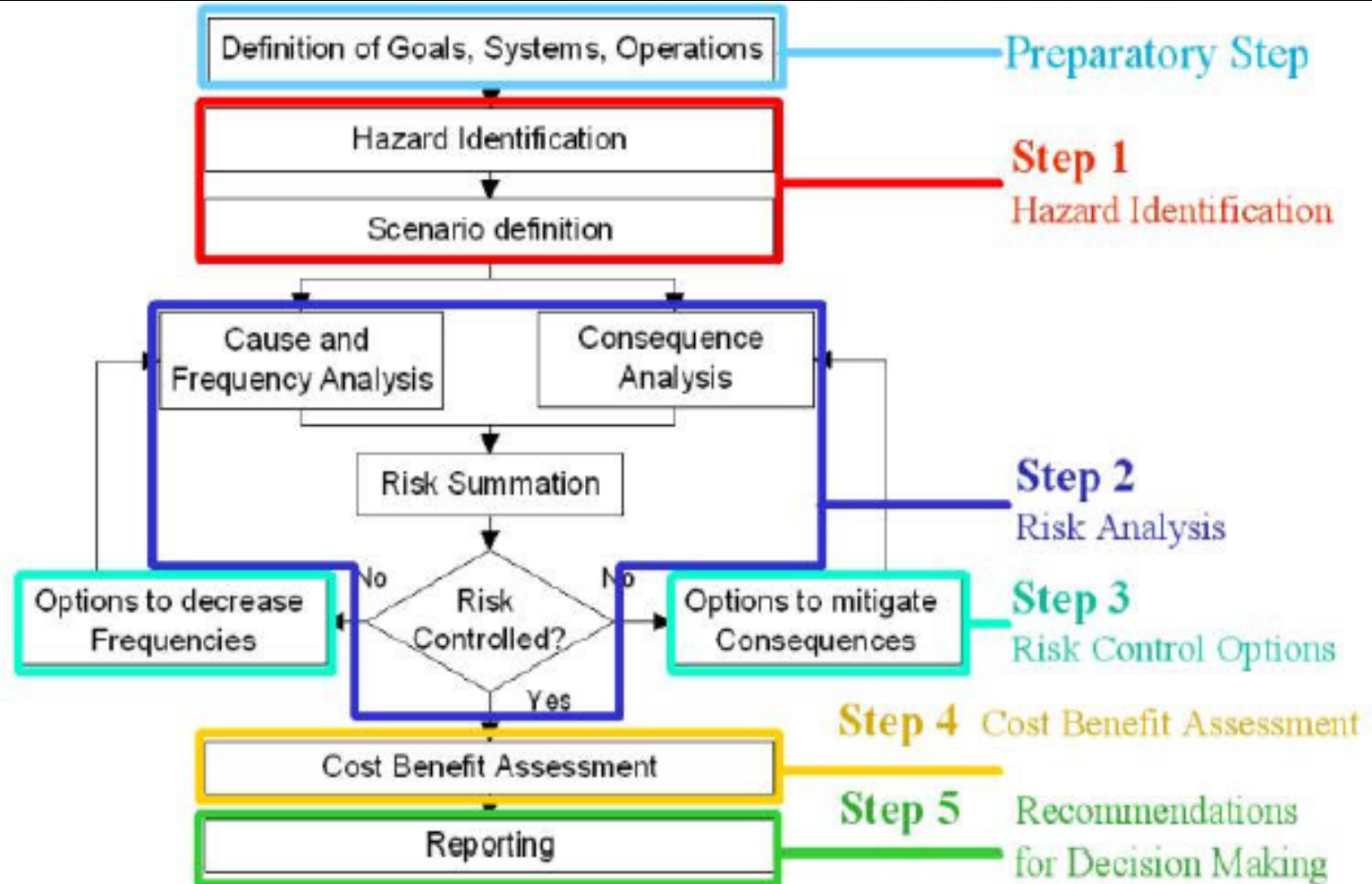


Fig. 3-2

FSA Flowchart [IACS – MSC 75, 2002]

- A tool for transparent decision making process among stakeholders
- Preventive tool for potential hazards before actual serious accidents
- Use of generic model, not viewed as an individual object in isolation, but rather as a collection of systems, including organizational, management, operational, human, electronic and hardware aspects which fulfill the defined functions.

Research Initiative for Natural Disaster Prevention of Oil and Gas Spill in Industrial Parks in School of Engineering, Osaka University

(1) Risk analyses of earthquake-oriented and tsunami-oriented damages of oil and gas storages in industrial parks (step 2 in FSA)

(2) Prevention and mitigation of such damages (step 3 in FSA)

Countermeasures corresponding to earthquake-oriented risk

Countermeasures corresponding to the tsunami-oriented risk

Risk analyses of earthquake-oriented and tsunami-oriented damages of oil and gas storages in industrial parks (step 2 in FSA)

1) Oil-Sloshing Impact due to Possible Nankai Trough Earthquake

- Developing a numerical simulation method for oil-sloshing using a mesh-free particle method
- Extensive sloshing simulations to estimate the amount of spilled oil from the tank
- Assessing the oil-sloshing impact due to Nankai Trough earthquake, and then providing a guideline to reduce the oil-sloshing disaster

2) Numerical and experimental studies on multiphase flow in tsunami with oil spill

- Development of numerical model for tsunami with oil spill including multiphase (liquid liquid gas), Convection on diffusion effect, and three dimensionality
- Numerical prediction of oil spill damage at Osaka Bay Area for Nankai Trough earthquake

3) Hydrodynamic forces on a storage tank and a pipeline by run-up tsunami and redesign of port configuration

- Experiments of tsunami forces on scaled storage tanks in tsunami basin
- Numerical simulation on redesign of port configuration

4) The study of disasters in petrochemical complexes caused by large earthquakes

- Seismic damage in chemical plant
- Analysis of the leaked gas diffusion
- Heat emission from pool fire of large scale tank

5) Analysis of ship evacuation during a tsunami

- Evacuation activities of the ships during Tsunamis
- disciplined ship evacuation method at the time of huge natural disaster

Prevention and mitigation of damages step 3 in FSA

1) Multiple Defense against Tsunami Flood with Use of Earth Banks

- Two types of tests on hardly-permeability of earth banks
 - i) Waterway overflow test on erosion and permeability and improvement of earth bank
 - ii) Model tests on permeability of soils under water pressure head

2) Study on lattice-pattern arranged vertical flexible pipes to decrease damage of oil and gas storage tanks caused by large-scale tsunami

- Combined countermeasures consisting of nature-inspired flexible pipes and earth bank
- Flexible pipes to decrease water current energy and wave energy
- Earth bank to reduce tsunami flood

Future works

- ❑ Connection of each research topics to make overall scenario of events
- ❑ Application of FSA concept from step 1 to step 3
- ❑ Cost benefit assessment in step 4 in FSA including organizational, management, operational and regulatory aspects
- ❑ Reporting in step 5 in FSA
- ❑ Real time monitoring on disaster of industrial parks
- ❑ Guidelines

- ❑ Building of International comprehensive safety regulation for industrial parks including certification system
- ❑ Collaboration with Asian countries for exchange of knowledge, experiences, and mitigations on natural disaster

Building of International comprehensive safety regulation for industrial parks including certification system

- **Safety Standard for machines ISO/IEC 51 Guide**
ISO 12100 : Basic concept of safety of machines
Standard for general concept of design
ISO14121 : Standard for risk assessment
ISO14***, 13***, IEC6**** : Group safety standard
Safety for life cycle, certification system by third party
- **Safety Standard for offshore structures after GOM spill in 2010**
Risk based regulation for design and operation in UK
and Norway
Command and Control in US
certification system by third party
- **International comprehensive safety regulation for industrial parks including certification system**

Thank you for your kind attention !

