



Research Paper

Emergency Operations Plan: Tsunami Annexe

A Guidance for Coastal Industrial Complexes

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Abstract

Tsunamis represent one of the most devastating natural disasters. The vicinity of subduction zones, exposes long stretches of coastal regions around the world, to this hazard. Due to industrialization, more personnel are operating near and along the shoreline. Also, resident communities may be in the inundation zones. An emergency response plan, along with preparedness and effective alert systems, remain the cornerstone towards the objective of reducing loss of life and destruction of property. In Section A, the author of this paper discusses the aspects of this phenomenon, from the disaster management perspective. In Section B and C, an emergency evacuation plan and emergency response plan has been proposed, after extensive review of scientific and technical articles. The recommendations of local and international expert committees have been given due consideration. The plans as such applies to the Petroleum Complex Project but may be modified as per local needs of other similar projects and areas.

Section A: Tsunami, a Disaster Management Perspective.

In recent times, tsunamis have wreaked havoc on the coastal regions, in several parts of the world. In the Arabian Peninsula (AP), both local population and expatriate workforce reside and operate in the coastal regions. Rapid industrialization has also resulted in infrastructure encroaching the coastal space. This paper reviews the current body of knowledge regarding the phenomenon, and its impact, and formulates emergency management plans both for the general workforce and visitors, and for the personnel responsible for carrying out the field response.

Background

The phenomenon¹⁻³

Tsunamis are caused by sudden vertical movement of a large mass of water in the ocean. The most common causes being earthquakes, volcanoes, and landslides, occurring in the ocean bed, and can also occur in seas and lakes. These events generate a single or series of waves that have a long wavelength(breadth), but are initially, small in height. The waves, then propagate towards land, at about 600-800 km/hr, increasing in size and height, and makes landfall as giant ocean waves.

Impact^{4,5}

The gigantic waves carry along with them massive force of impact, and the ability to drown anything and everything, and then sweep out any movable objects, with the receding waves. The boxing day tsunami of 2004 caused huge casualties and damage to infrastructure. The 2011 Japan earthquake and tsunami also caused critical infrastructure damage to a nuclear power plant.

The problem^{6,7}

Due to the submarine nature of the events, initial low height waves, and the actual propagation starting thousands of kilometres from the coast, the early detection poses several challenges.

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Tsunamis are rare events, the resident community and emergency response planners, may have low-risk perception, and may not, be effectively implementing risk mitigation and preparedness options.

Objective

This author plans to conduct review of existing scientific literature and formulate an emergency evacuation plan applicable to the Petroleum Complex Project (PCP) and addressed to general workers and visitors. A second extended plan contains procedures of implementation for the field responders.

Research and Methods

A review of topics addressing the entire disaster management cycle as pertinent to the problem of tsunamis were accessed. Popular scientific databases were used to gather information on hazard assessment, risk, and vulnerability studies, and to delineate current recommendations in mitigation and preparedness.

Results

Hazard assessment(HA)⁸: Tsunamis, pose problems to coastal areas of the entire world, which are near to any subduction zone. They are characterised by short, intensive, and highly destructive events, and long return periods (hundreds to thousands of years). Most coastal regions do not have accurate historical records. Recent history suggests that this low frequency/high consequence phenomenon induces considerable uncertainty, and their probable impact is often underestimated.

Risk and Vulnerability (RV): Large part of the population, reside in the coastal regions. Also, rapid industrialization has led to infrastructure encroaching the coastal regions, and complex built environments. Project personnel has seen steady operational presence in the coastal areas.

Technical committees, have formulated and designed maps, that delineate specific dimensions of

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the disaster management cycle including hazard (probability and geographical extent of impact), exposure (populations, infrastructure), evacuation (time, feasibility), and aggregated risk and vulnerability. These maps can point to the possibility of significant damage to life and property if a tsunami is to happen.

Mitigation and Preparedness(MP)^{9,10}: Experts have recommended the integration of early warning systems, risk communication, and effective formulation and implementation of evacuation and response plans as the cornerstone for reducing the impact of these hydrologic events.

Section B: Tsunami Annex; Emergency Evacuation Plan(TA_EEP)¹¹.

According to experts, hired by the National Government (NG), the PCP worksite, which operates in the coastal regions of the AP, faces the possibility of being inundated by tsunami waves. The threat to life and property, complicated by few and confusing warning signs, and narrow window of evacuation opportunity, has led to the generation of this EEP, as per the mandate of the NG. The objective of the EEP is to save as many lives as possible, by guiding earliest evacuation to designated areas.

Literature review

Current guidelines recommend the integration of an early warning system, with risk communication and an emergency evacuation and response plan, to reduce the loss of life^{12,13}.

Results

HA^{14,15}: The Makran Subduction Zone(MSZ), lies in vicinity of northern and eastern coastline of the AP. The western part of the MSZ has shown low seismicity, but deterministic and probabilistic assessment predict credible threat to the entire coastline. The Persian Gulf (PG) remains relatively safe due to low maximum depths of 60 meters, and the protective function of the Musandam

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Peninsula. Inundation maps, generated by technical committees have predicted major impact in the project operating areas.

RV: The worksite personnel, and visitors will be directly impacted. The chances of drowning, being hit by debris, getting trapped under collapsed structure, and being swept out to the ocean remains a possibility.

MP: All visitors and personnel should adhere to the standard operating procedures and should keep up to date with documents disseminated electronically from the site emergency operations centre (SEOC).

Tsunami Alert System(TAS)¹⁶

The SEOC is in grid X34 and is considered safe from being directly impacted by natural disasters, if they are to happen. The Regional Tsunami Watch Providers (RTWP), gathers information from seismic and sea level sensors and other electronic modalities, and processes the information. It then forwards the processed data to the National Tsunami Warning Centre (NTWC). It also provides modelling and forecasting reports to the NTWC. Depending upon the data received, the NTWC issues alerts, varying in criticality from event notification(watch) to emergency evacuation advice(warning). The NTWC maintains several communication modes for disseminating messages and alerts to recipient emergency management agencies (EMAs) and Emergency Operation Centres (EOCs). The main components are teletype, satellite, and automated notification system. The SEOC maintains direct teletype and satellite link with the NTWC. Additional modes of communication include data, telephone, and radio systems.

In the event of receiving a tsunami warning message, the SEOC will activate omnidirectional sirens placed at strategic locations in the project area. Announcements over the public address system (PAS), will also be made. A wireless emergency alert (WEA) system, consisting of nodes situated in the EZ, will also be used to transmit warning messages. Worksite personnel and visitors are also

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advised to remain alert to unusual natural events, viz, earthquake tremors and sudden recession of the ocean from the shore, which may indicate an impending tsunami. The SEOC maintains several coastal observation points (COPs), to monitor the same.

Tsunami Inundation Map (vide document NG_DMA_tim2022)

Areas expected to be flooded by tsunamis, has been identified by technical committees set up by the NG. The map has been refined using software modelling. Sophisticated bathymetric, seismic, and topographical data collected electronically has been used. The SEOC have used signages to identify the possible inundation areas.

Tsunami Evacuation Map (vide document PCP_SEOC_tem2022)

The above map identifies the following.

- a. The evacuation zone (EZ): areas expected to be inundated.
- b. Evacuation site (ES) and assembly areas (AA): where personnel should go when the TAS has been activated.
- c. Recommended evacuation routes (RER): The routes identified by signages, to be used in case of evacuation.

Evacuation Standard Operating Procedures

1. Once personnel begin to hear the siren, they should immediately evacuate their respective work areas, if it falls under the EZ, and proceed to the nearest ES or AA by foot.
2. It is recommended to move at least 2 miles inland if the EA or AA remains inaccessible or routes are congested. High ground of at least 100 feet is another option.
3. The SEOC has installed signages to designate RERs, ES and AAs. First Responders will guide and assist evacuation, but following the signages will save valuable time.
4. Evacuees can also use personal vehicles.

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5. Always keep an emergency kit in stock, to be carried along to the EA.
6. Avoid venturing into other areas of the EZ.
7. Enough time may not be available for proper evacuation procedure, in case of local tsunamis, and personnel are requested to maintain a state of vigil.

Cancellation, Re-entry, Return to Normal.

SEOC will receive message of cancellation or downgrading of warning from the NTWC.

Additionally, at least 2 hours must have passed from the time of the last observed wave in the inundation zone, or the expected time of arrival (ETA), of the last tsunami wave, as predicted by the NTWC/RTWP. Once these criteria are met, SEOC will issue Restricted Access phase 1 and phase 2 (RAp1 and RAp2) orders. During RAp1 and RAp2, only first responders and then other field responding agencies will be allowed entry to the EZ, respectively. Once all agencies, has completed initial response operations, the SEOC will issue an “All Clear” message for general personnel as per feedback received. Timeline will vary depending upon the extent of damage, and scale of relief, response, and recovery operations.

Maritime areas and beaches will remain closed for 12 hours.

Section C: Tsunami Annexe; Emergency Response Plan(TA_ERP).^{17–20}

The coastal location of the PCP, has resulted in scrutiny of the hazards and risks faced by the project. Given the massive destructive force, tsunamis can inflict to the operating areas, and rapidity of the probable onset of events, the NG has mandated, that project authorities maintain and exercise an emergency response plan, outlines the SOPs, and roles and responsibilities of the responding personnel. This last section focusses on the same.

Background

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Rapid industrialization, has led to increase in human activity in the coastal areas of the AP.

Complex built environments has also increased, in these areas. Due to the vicinity of the MSZ, experts are of the opinion, that the region faces credible threats, from near field, regional and local tsunamis. Tsunamis has caused massive destruction of property and huge loss of life, incomparable to any modern disaster in recent times.

Research and Methods

A careful review of best practices, as advocated by technical committees has been used to formulate the emergency response plan. Existing format and content from industry leading organizations have been used to guide the formulation of strategic, tactical, and operational procedures.

The Problem

The coordination of various responding personnel, remains a vital component, during the response phase of the disaster. Confusion, regarding roles and responsibilities, operational scenario, etc can lead to a less than proficient disaster response. The rapidity with which a tsunami can strike, and the successive waves of impact, adds to the complexity of the situation.

Literature Review

Recommendations of various expert committees set up by governments, and or international organizations, has been accessed. The complete disaster management cycle of tsunami has been taken into consideration. Reports on hazard assessment and risk and vulnerability studies, have been used to recommend further steps^{19,21}.

Context

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The PCP operates in the coastal region of the AP. Its main work is the refining and processing of offshore petroleum products. The demographic profile of the workforce are mainly expatriate workers, from various countries.

The Hazard

The extensive shoreline of the project exposes the workforce and infrastructure to local, regional and near field tsunamis, due to the vicinity of the MSZ. An impact would lead to inundation of the operating area, and massive fatalities. The chances of being drowned, swept out to sea, being hit by debris and other objects, and being trapped under collapsed structures, are the risks in case of such an event.

Tsunami Alert System (TAS)

The SEOC will activate the sitewide sirens, in case of a warning received from the NTWC or the COPs. It will simultaneously communicate the warning message using the PAS.

ERP activation

The sounding of sirens, announcement over the PAS, and or warning message received, over radio transceivers, will lead to the automatic activation of the ERP. All departments/sections listed in the tsunami incident section of the Site Emergency Support Function Annex (vide document PCP_ESF_2022), should proceed to their respective muster points.

Immediate actions (Incident+12 hours)

First responders, to assist personnel and visitors towards ES and RER. Plant and field supervisors to initiate lockdown procedures. Responding sections will assist in guiding evacuation activity until 30 minutes prior to the estimated arrival time (ETA), of the first tsunami wave. After that, all responding personnel to remain outside the EZ, until a RAp1 order is received.

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Once an RAp1 order is received, the first responders will initiate priority activities in the EZ, viz., search and rescue (SAR), acute medical care, patient evacuation, mass care activities, emergency public messaging, firefighting. Clearing of evacuation routes prioritized to facilitate casualty evacuation. An initial safety and damage assessment to be made.

Upon receiving feedback from first responder section leader, a RAp2 order will be released. All other sections/departments, included in the tsunami incident section of the Emergency Support Functions Annex, to enter the EZ (vide document PCP_ESF_2022), and initiate chartered responsibilities. Further, SEOC will call upon separate sections/departments as per situation, and feedback received. External Agencies will be called upon as per the Mutual Aid Annexe (PCP_MA) and as per National Disaster Management Agency (NDMA) regulations (vide resources on NDMA website).

Communication and Reports

The SEOC maintains several modes of communications to facilitate information sharing with all responding sections/departments. Radio transceivers and satellite phones are available to all section and departmental leaders. It also operates internet-based systems to manage emergency response, and to coordinate with external agencies. Mobile ad hoc networks, wireless mesh networks, and wireless sensor networks will be deployed to the operating area, to address the issues of redundancy and resilience. These will be supported by ICT terrestrial networks, outside the inundation area. All reports pertaining to alerts, situational awareness, and operational requirements are preformatted as per the National Emergency Management System (NIMS).

Activation and response protocols

Once the response plan is activated, all responding personnel to gather at their designated muster points and await further instructions, from the section/departmental leader. Following further instructions will be issued:

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1. Location of deployment.
2. Probable tasks
3. Assignment duration.
4. Mode of transport.
- 5.

Equipment requirements. 6. Documentation requirements. 7. Required periodic situational and damage assessment reports while in the field.

During evacuation phase, activity should last only up to 30 minutes before the ETA of the first tsunami wave. After that, all responding personnel, including first responders, to remain outside the EZ, until an RAp1 or RAp2 message is received.

Resource Planning and Scaling of Resources

Preparedness: All local resources to be identified and typed, according to capability. Responding personnel to undergo qualifying, certifying, and credentialing procedures. Resource planning as per requirement assessment. Acquiring, storing, and inventorying to be completed. Agreements with external entities to be in place for urgent resource mobilisation.

Response: The SEOC identifies, and orders resources as per situational assessment. Field personnel identify, validate, and refine requests, and forwards it to section chiefs. Individual response personnel are mobilised as per sectional discretion. Mobilised persons should be provided details as per operational requirements. All personnel to maintain recordkeeping at incident site. Other resources are mobilised using the section deployment plan.

Contingency and Backup Plan^{22,23}

The PCP contingency plan addresses the construct of four major components, viz., emergency response (ER), crisis management (CM), business recovery and business resumption (BRR).

ER:

1. SEOC to conduct periodic tabletop and sitewide exercises.
2. Section/departmental chiefs to conduct readiness exercise to test response protocols and resource resiliency.

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3. SEOC under the aegis of the National Disaster Management Agency (NDMA), to implement awareness and training programs.
4. SEOC to notify PCP central office, once a warning is received from NTWC, or COPS.

CM:

1. PCP central office to activate the crisis management team (CMT).
2. CMT to establish communication with SEOC, and ensure SEOC receives all assistance as to resource mobilisation; CMT to stage resources outside the EZ.
3. CMT to maintain communication with all personnel who have evacuated from site and arrange for further aid and assistance.
4. CMT to maintain media and government communications.

Additionally, the NDMA and mutual aid organisations may co-ordinate with relevant stakeholders during the ER and CM phase.

BRR:

1. The contingency management group (CMG), to identify all critical infrastructure and processes (CIP); CMG to conduct business risk and vulnerability analysis.
2. The CMG, to devise and implement strategies to enhance protection and security of CIP; CMG to formulate written BRR plan.
3. Post stabilization, SEOC to provide CMG with reports on damage assessment, CMG to complete impact analysis.
4. CMG to implement resumption and recovery plan, as per impact analysis and BRR plan.

Site Incident Command System

Level	Entity/Office/Designation	Roles/Responsibilities
Strategic	Site Emergency Operations Centre (SEOC).	<ol style="list-style-type: none">1. Coordinates the response effort.2. Activates the Emergency Response Plan.3. Notifies external support agencies as

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		<p>per feedback received.</p> <p>4. Notifies tactical offices.</p>
Tactical	First Responder office (FRO)	<p>1. Directs early response during evacuation and RA phase1.</p> <p>2. Directs preliminary life safety and damage assessment, SAR.</p>
Tactical	HSE Office	<p>3. Confirms incident from SEOC.</p> <p>4. Directs field HSE officers to maintain safety parameters.</p> <p>5. Advice SEOC regarding nature of relief, need for evacuation, requirement of external agencies, resources.</p>
Tactical	Security Office	<p>1. Traffic control</p> <p>2. Perimeter security.</p> <p>3. Law and order.</p> <p>4. Advice SEOC.</p>
Tactical	Medical Clinic	<p>1. Directs field medical team to assist in relief.</p> <p>2. Advice SEOC regarding support from external agencies.</p>
Tactical	Public Works and Engineering	<p>1. Directs debris management, structural support.</p> <p>2. Emergency repair and restoration, engineering support, construction management.</p> <p>3. Contracting services for life saving and sustaining.</p>

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Operational	First Responder Teams	<ol style="list-style-type: none"> 1. Initiates SAR, evacuation, clear emergency egress, other evacuation routes. 2. Stabilizes ongoing hazardous conditions. 3. Advice FRO regarding resources and support requirement.
Operational	Field HSE Officers	<ol style="list-style-type: none"> 1. Assesses situation and notifies HSE office. 2. Advice HSE office regarding resources, support teams, external agencies. 3. Undertakes periodic hazard and safety assessment.
Operational	PWE Teams	<ol style="list-style-type: none"> 1. Provides emergency engineering services
Operational	Field Medical Response Teams	<ol style="list-style-type: none"> 1. Initiates medical relief and transportation in co-ordination with FRTs. 2. Advice Medical Clinic regarding support required. 3. Undertakes periodic health impact and hazard assessment.
Operational	Other Emergency Support Function Departments (firefighting/HAZMAT/Logistics/Heavy Equipment operators/Specialised SAR and Extrication).	<ol style="list-style-type: none"> 1. Initiates relief, assistance, and mitigation efforts, as per domain of expertise. 2. Advice section chief regarding assistance and resources required.
Operational	Field Security Officers	<ol style="list-style-type: none"> 1. Maintains law and order. 2. Secure outer perimeter of EZ and

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		prevent entry. Traffic control. 3. Advice Security Office.
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Re-entry and clean up.

SEOC in general will issue RAp1 order at least two hours after the estimated time of arrival (ETA) of first tsunami wave if no wave is detected. In case tsunami waves inundate the EZ, RAp1 order is issued at least two hours of the last tsunami wave, observed in the inundation zone. The first responders must provide feedback, that it is safe for other ESF agencies to enter the EZ. A RAp2 message, will then be released. Once the above message is received, the Public Works and Engineering department to initiate cleaning and disposal of debris. SEOC may mobilise ESFs including HAZMAT, Safety and Energy, as per feedback received. Additionally, EMS to initiate environmental health assessment and rectification procedures. Damage assessment to provide input for other sections.

Maritime areas to remain closed for 12 hours.

Deactivation

The SEOC receives input from the section chiefs regarding situational status and will announce phased deactivation of the ERP. Depending on reports received, each section will be deactivated as its roles are no more required on the field.

Debriefing, Audit and Reporting

Section chiefs will debrief demobilised personnel. All returning individuals must complete a task completion report form, detailing on scene activity completed during deployment.

A separate audit will be conducted by the SEOC, within one month of the incident, to analyse degree of operational parameter achievement.

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