Tsunami Risk Mitigation Strategy for Thailand

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The project was undertaken by NGI in cooperation with:
NORSAR, UiB, UiO, NIBR, B.Heyerdahl, NTNU, Sintef
The 26 December 2006 disaster

- Caused by M 9.3 earthquake
- 220,000 fatalities
  - 180,000 in Indonesia
  - 30,000 in Sri Lanka and India
  - 8,000 in Thailand
Elements of the project

- Determine causes and consequences of Dec. 2004 event
- Establish future earthquake and tsunami-generating scenarios and their return periods (hazard)
- Model future tsunamis and their inundation levels
- Assess future risk to human life and acceptance criteria
- Recommend risk mitigation measures
- Ensure local involvement and dissemination of results
Regional seismicity and plate movements

From Lay et al. (2005)
Plate movements in subduction zone

- Tsunami
- Indian plate
- Sunda plate
- Rate of movement: 15-65 mm/yr
Summary of consequences of 26 December 2004 tsunami

- Zone 1: 4-7 m
- Zone 2: 6-8 m
- Zone 3: 7-12 m
Observed inundation - Bang Niang
Case Patong City

- Major tourist city
- 15 - 30,000 inhabitants
- 10,000 tourists
- Ground at +3.5
- Inundation +5-6
- 160 died
Case Bang Niang resort areas

- 12 km long beach with about 100 tourist resorts
- About 3000 of 15000 people killed
- Ground level +4 -+5
- Inundation level +10 -+12
Case Nam Khem fishing village

- 3000 out of 4800 inhabitants killed
- Ground level +3-5
- Inundation level +7-8
The earthquake of 26 Dec 2004 was the second largest since 1900

1. 1960 May 22, Southern Chile, M=9.5

2. 2004 Dec 26, Off west coast of N-Sumatra, M=9.3


4. 1957 March 9, Andreanoff Islands Alaska, M=9.1

5. 1952 Nov 4, Kamchatka M=9.0

Source: USGS
Future earthquake scenarios

• The energy released in the 2004 event means it will take several hundred years before a similar event can happen in the future

• It takes earthquake larger than M 8.0 to create tsunami of any significance, but not all will do so

• Largest credible earthquake in the next 100-200 years is M 8.5
Extent of Dec. 2004 seabed movements
Considered future scenarios

Water depth

M9.3

M8.5 S

M8.5 N

M7.5 S

M7.5 M

M7.5 N

M7.0
Estimated future tsunami risk to human life in Thailand

- Conservative risk estimate
- Average risk estimate
- Low risk estimate

Risk to Human Life

Acceptable
Tolerable
Unacceptable

Years after 26 December 2004

Risk to Human Life

1E-006
1E-005
0.0001
0.001
0.01
1
10
100
1000
10000
100000
1000000

1 2 5 10 20 50 100 200 500
Conclusions from risk assessment

• Within next 50-100 years maximum credible earthquake affecting Thailand is M 8.5 giving inundation level +2.5 to +3.0 at high tide.

  Such tsunamis will give small consequences in Thailand

  No immediate mitigation measures strictly necessary, but increased public awareness is desirable
Conclusions from risk evaluation

• In the Long term (100 – 400 years) the probability of occurrence of a major tsunami will increase gradually with time.

• If no risk mitigation measures are taken, the societal risk due to a major tsunami will be unacceptably high after about 50 – 100 years, approaching catastrophic levels in 200 – 400 years.

Mitigation measures are needed to reduce long term risks
Tsunami Risk Mitigation Measures

Main question:

Should it be the responsibility of present societies to reduce inevitable and unacceptable risks some hundred years ahead?
Types of mitigation measures

- Awareness building (and warning systems)
- Land Use and Master Plans
- Building Codes
- Site and Project Planning
- Functional network of escape routes to safe places
- Establishment of safe places (elevated land, buildings or other structures)
- Physical protection barriers
How to ensure lasting awareness is a key issue
Building measures

- Upper floor safe from tsunami surge
- Easily accessible escape to safe floor
- Bedrooms at safe level ($H_{\text{max}}$)
- Main structure shall not collapse
- Front and back walls at ground levels may be designed to collapse
Elevated areas for housing or escape pods

- Required height in relation to tsunami inundation level
- Fill from dredging or land pits
- Can also function as escape pods
Protection barriers

- Practical upper limit of height?
- Core and protection material
- Outlets through dike
- Limited overtopping may be acceptable
Specific recommendations for Thailand

- Within next few years implement measures to ensure lasting long term awareness
- Within next 5-10 years implement at least some physical measures to reduce consequences of future tsunamis.
Case Nam Khem fishing village

Harbour
Commercial area
Public park
Escape routes
Community service
Escape hill
Dikes
Tourist resorts area
Beach

Ban Nam Khem masterplan proposal
Thank you for your attention!

Special thanks to:

DMR

CCOP

NORWEGIAN MINISTRY OF FOREIGN AFFAIRS

The project team!
Case - Bang Niang Resort-
example of proposed site plan
Case Patong City - masterplan

Patong city
Masterplan proposal

Dike

Open green area
Escape routes
Commercial areas
Beach
Escape hills, public parks
Dike
Causes and consequences
Calculated tsunami Dec. 2004

![Graph showing surface elevation over time for Bang, Niang, and Patong locations.](image-url)
Return periods for the scenario earthquakes

<table>
<thead>
<tr>
<th>From seismicity data:</th>
<th>From subduction rates:</th>
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<tbody>
<tr>
<td>M 8.5: ~1100 years for Andaman-Nicobar</td>
<td>M 8.5: ~200 years for Nicobar-Andaman South</td>
</tr>
<tr>
<td>M 8.5: ~200 years for Sumatra and Java trenches</td>
<td>M 8.5: ~400 years for Nicobar-Andaman North</td>
</tr>
<tr>
<td>M 9.3: ~1100 years for Sumatra North</td>
<td>M 9.3: ~300 years for Sumatra North</td>
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</tbody>
</table>
Design criteria for Thailand

- Magnitude 8.5 is largest credible tsunamigenic earthquake to be prepared for within next 50-100 years
  
  Inundation 1.5 – 2 m above mean sea level, + 1 m for tide and storm surges