

# Design Criteria for reconstruction of Houses in Tsunami affected areas in India

A Report

2005  
National Institute of Disaster Management  
Ministry of Home Affairs  
Government of India

# Contents

<b>1. TRANSITION SHELTERS</b>	<b>2</b>
<b>2. RECONSTRUCTION OF BUILDINGS IN ALL COASTAL AREAS</b>	<b>2</b>
<b>2.1. BASIS OF DESIGN CRITERIA</b>	<b>2</b>
<b>2.2. USE IMPORTANCE OF THE BUILDINGS</b>	<b>3</b>
<b>2.3. PERFORMANCE LEVEL DESIRED</b>	<b>3</b>
<b>2.4. GENERAL DESIGN VALUES/FACTORS FOR COASTAL STATES &amp; UTS</b>	<b>3</b>
<b>2.5. RCC DESIGN CRITERIA FOR ALL COASTAL AREAS</b>	<b>3</b>
<b>3. SPECIFIC RECOMMENDATIONS FOR ANDAMAN &amp; NICOBAR ISLANDS</b>	<b>4</b>
<b>3.1. IMMEDIATE NON-STRUCTURAL MEASURES</b>	<b>4</b>
<b>3.2. STRUCTURAL MEASURES</b>	<b>4</b>
3.2.1. ANDAMAN DISTRICT	4
3.2.2. NICOBAR DISTRICT	4

## Tables

Table 1. General design values/factors for coastal states/UT's.....	3
Table 2. Specific design values/factors for Andaman & Nicobar Islands.....	5

### **ANNEXURE 1:- LIST OF PARTICIPANTS**

### **ANNEXURE 2:- MINUTES OF THE MEETING ON “DESIGN CRITERIA FOR RECONSTRUCTION OF HOUSES IN TSUNAMI AFFECTED AREAS IN INDIA” HELD ON SUNDAY 09<sup>TH</sup> JANUARY 2005 AT NIDM.**

### **ANNEXURE 3:- INFORMATION ON COASTAL REGULATION ZONE**

# **Design Guidelines for Buildings in Tsunami Affected Areas of States and Union Territories**

The group's deliberations generally covered three main aspects as listed below:

1. Transition shelters
2. Reconstruction of completely damaged buildings in Andaman & Nicobar Islands
3. Damage assessment of partially damaged buildings in Andaman & Nicobar Islands and the mainland

## **1. Transition shelters**

- No consensus was reached on whether to have transition shelters or not as the group felt that it is out of the group's purview.
- However there was a strong feeling in the group to have proper transition shelters as the reconstruction process may exceed more than 6 months and the existing make-shift arrangements (tents etc) are harsh for living for longer time such as 6 months.

## **2. Reconstruction of Buildings in All Coastal Areas**

### *2.1. Basis of Design Criteria*

Considering the multi-hazard proneness of the coastal districts, the design criteria will have to cover the following aspects:

1. Design wind velocity under cyclone condition.
2. Effective wind pressure near sea coast.
3. Height of storm surge with concurrent tide level (50 % of the highest astronomical tide above MSL may be taken as concurrent)
4. Tsunami affects:
  - Height & velocity of tsunami wave
  - Designing for dynamic pressure of the wave
5. Earthquake effects
  - Design seismic co-efficient
  - Soil investigation for checking liquefaction potential
  - Providing appropriate foundation
6. Fire safety
7. Flood inundation & flood flow (velocity of flow)
8. Building aspects
  - Shape, size & height of building
  - Use importance of the building
  - On stilts or without stilts
  - The roof to act as shelter or not,
  - Choice of building material and construction technology
  - Durability of the building (design life), corrosion resistance
  - Thermal comfort

## 2.2. Use importance of the buildings

Classify the buildings as follows:

1. Ordinary (housing, storage)
2. Important (hospital, school, fire station, power house, substation, telephone exchange, VIP residence etc.)
3. Very important installations, cyclone/tsunami shelters

## 2.3. Performance level desired

Decide about the desired performance level.

- Minimum – Non-collapse though structurally damaged
- Safe – Damaged but without significant structural damage
- Operational – Capable of avoiding/resisting all expected hazards & forces

## 2.4. General design values/factors for coastal states & UTs

**Table 1. General design values/factors for coastal states/UT's.**

		Housing	Important Buildings	Cyclone shelter/ very imp. Installation
<b>Wind speed</b>		IS: 875(3)	1.15 x IS: 875(3)	1.3 x IS 875 (3)
<b>Factor for pressure</b>	<b>k1</b>	1.0	1.08	1.08
	<b>k2</b>	1.05	1.05	1.05
	<b>k3</b>	1.00	1.00	1.00
<b>Seismic IS:1893 (1)</b>	<b>coeff.</b>	I=1.0, R as per code	I=1.5, R as per code	I=1.8, R as per code
<b>Storm Surge</b>		As per Vulnerability Atlas of India, 1997 riding over maximum astronomical tide level		
<b>Fire safety</b>		1.5 hr rating	2 hr rating	≥ 2 hr rating
<b>Flood safety</b>		Plinth height at recorded high flood level or corresponding to		
		10 yr flood	50 yr flood	100 yr flood
		<b>Otherwise:</b> Use plinth height of 60 cm above ground level & needed stilts		

Note: The roof may be made hipped shape or flat with slanting on all sides and rainwater harvesting should be made standard part of the roofing.

## 2.5. RCC design criteria for all coastal areas

Concrete (Exposed to coastal Environments)

- (i) Plain: Min M20, Cement: min 250 kg/m<sup>3</sup>
- (ii) RCC: Min M30, Cement: min 320 kg/m<sup>3</sup>

Max aggregate: 20 mm

Min cover for slabs: 20 mm

Min cover for beam: 30 mm

Min cover for column<sup>1</sup>: 40 mm  
Reinforcement: TMT – HCR Fe 415 for up to 2 stories. Use Fe 500 for frames in taller buildings

(iii) HCB: To be casted using M 20 concrete with fly ash. Reinforcement TMT – HCR Fe 415 bars, concrete filling M 20 grade.

### **3. Specific Recommendations for Andaman & Nicobar Islands**

#### *3.1. Immediate Non-structural measures*

- Capacity building of the local engineers and masons to be taken up to facilitate faster reconstruction. This means that these engineers and masons will have to be trained well ahead of reconstruction process is initiated such that
  - No delay in reconstruction process due to dearth of trained manpower
  - The maintenance of new constructions is not hampered due to lack of trained manpower.
- Coastal zone regulations have to be implemented (An extract of CRZ is attached as Annexure III). It was observed that no dwellings should be allowed in the specified exclusion zone (refer CRZ III) and to encourage the dwellings deep in the main land as far as possible.
- Lifting the ban imposed on the forest cut for facilitating the reconstruction purposes. Detailed guidelines have to be drawn in consultation with the Forest Department.
- All timber, bamboo, cane etc chosen for reconstruction purposes must be chemically treated to prevent white ant damage and ensure durability in the buildings.

#### *3.2. Structural measures*

##### **3.2.1. Andaman District**

Normal housing with emphasis on the earthquake resistance features was considered as appropriate for taking seismic zone V code provisions into account.

- Minimum damage due to earthquake and tsunami.
- The community is well versed with the contemporary constructions.

These buildings have to comply with the existing modified building codes.

##### **3.2.2. Nicobar District**

The group observed that the Nicobar District was maximum affected due to the earthquake and tsunami. The presentations have clearly brought out the impacts of both the phenomenon. In addition, this district is least developed and being inhabited by tribal who prefer to live in their traditional dwellings, as a difference from the preferences of Andaman Islanders. Hence, it was decided to provide a basket of housing options to these islanders to choose from. The recommendations of the group are given below:

- Houses have to be erected on the stilts made of RCC/steel columns with a proper earthquake resistance features such as proper anchoring with the main structure etc

---

<sup>1</sup> For columns with 200 mm side and 12 mm dia reinforcement bars, the cover could be kept 30 mm

- Follow engineering solutions with least emphasis on the cost
- More emphasis on pre-fabricated, pre-engineered and modular composite structures
- As an alternative, the government is to provide all the support in erecting the framework of the house while the people may put up the in-fill walls, flooring and roofing etc based on their local preferences, for which necessary guidelines to be prepared.
- As transport is costly and number of houses to be built is large, more emphasis needs to be given on materials such as steel, hollow concrete blocks etc
- The hollow concrete blocks need to be made on the main land in view of lack of normal water for curing purposes and preferably fly ash be mixed for improving impermeability and corrosion resistance
- Sloping roofs may be used with asbestos or Corrugated Galvanized Iron (CGI) sheeting
- Water harvesting have to be made part of the roof design as per the ‘demand’ criteria rather than the ‘supply’ criteria. For small houses, cost of the rainwater harvesting should not exceed Rs 2000 and for larger structures Rs 5000
- The height of the base of the houses may preferably be kept 3 m above the ground based on the contours available or buildings be constructed on stilts
- Corrosion resistance measures has to be given priority in all RCC and steel constructions

**Table 2. Specific design values/factors for Andaman & Nicobar Islands.**

	<b>Parameter</b>	<b>Housing</b>	<b>Imp. Building</b>	<b>Very Imp. Installation</b>
<b>Wind</b>	Wind speed factor for cyclonic winds	44 m/s	51m/s	57 m/s
	k1	1.0	1.08	1.08
	k2	1.05	1.05	1.05
	k3	1.00	1.00	1.00
<b>Earthquake Coefficient</b>	Ductile RC Frame[IS:1893(1)]	0.09, R=5.0	0.135, R=5.0	0.162, R=5.0
	Load bearing wall Bldg. (IS:4326)	Cat.D	Cat.E	Cat.E+ (to be elaborated)
<b>Fire safety</b>	Fire rating	1.5 hr	2 hr	≥2.0 hr
<b>Storm surge with max. astronomical tide<sup>1</sup></b>	Andaman District	1.0 m	1.0 m	1.0 m
	Nicobar District	1.0 m	1.0 m	1.0 m
<b>Tsunami Nicobar<sup>1</sup></b>	Height, minimum	3 m	4-5 m	5-6 m
<b>Tsunami Andaman<sup>1</sup></b>	Height, minimum	2 m	3 m	4 m

<sup>1</sup> Storm surge and tsunami values are tentatively estimated.

## List of Participants

Sr. No.	Name& Designation	Organization Phone no. & Email address
1.	Shri Rajeev Sood Sr. Appraisal officer (Arch)	HUDCO, 24648425 <a href="mailto:raj@hudco.org">raj@hudco.org</a>
2.	Shri Deepak Bansal Appraisal Officer (Eng.)	HUDCO, 24649610 <a href="mailto:deepak@hudco.org">deepak@hudco.org</a>
3.	Mrs. Manju Safaya Dty. Chief (Arch)	HUDCO, 24648425 <a href="mailto:manjusafaya@hudco.org">manjusafaya@hudco.org</a>
4.	Dr. D. K. Paul Professor & Head	<a href="mailto:dpaulfeq@iitr.ernet.in">dpaulfeq@iitr.ernet.in</a> 01332- 285522 Fax - 276899
5.	Dr. A. Meher Prasad Professor	Dept. of Civil Engg. IIT Madras 044-22578307 <a href="mailto:prasadam@iitm.ac.in">prasadam@iitm.ac.in</a>
6.	Dr. N. Lakshmanan	Director, Structural Engg. Research Center, Chennai, India
7.	Dr. Prem Krishna	Civil Engg. Deptt., IIT Roorkee
8.	Shri Rajarshi Bhattacharya	OSD & ex Officio JS/MHA
9.	Shri S P Gaur ED,	National Institute of Disaster Management 23702445 / <a href="mailto:spgaur@nidm.net">spgaur@nidm.net</a>
10.	Prof. Anand S. Arya	National Seismic Advisor, MHA-UNDP 9818997029 / <a href="mailto:anand.s.arya@undp.org">anand.s.arya@undp.org</a>
11.	Dr. Amar Singh JS (RD) (RH)	Ministry of Rural Development 23382313 <a href="mailto:dramar@nic.in">dramar@nic.in</a>
12.	Prof. Santosh Kumar Prof. Policy& Planning	NIDM , MHA, 23702433 / <a href="mailto:Santosh@nidm.net">Santosh@nidm.net</a>
13.	Shri Hazari Lal Director (H) M/oUEPA & CMD-HPC	M/o Urban Employment/ PA 23014206, 26340915
14.	Shri Yogaraja Executive Director	Bamboo Development Agency, Director of Industries Govt. Mizoram & Bamboo Dev. Agency, Mizoram
15.	Shri V. Lal Rem Thangd Dy. Resident Commissioner	Govt. of Mizoram, New Delhi
16.	Mr. Avtar Singh Saihta Dir @ M/o RD	M/o Rural Development Krishi Bhawan, New Delhi Tel 23384980 , 2338404
17.	Shri H. S. Dogra	New Delhi 23742532
18.	Shri C. Gosakan Dy. Secy.	Ministry of Tribal Affairs, Shastri Bhavan, N. Delhi -01 Ph. 2338 9881 <a href="mailto:cgosakan@hub.nic.in">cgosakan@hub.nic.in</a>
19.	Shri M. N. Mathur Executive Director	BMTPC, core 5 A, India Habitat Centre, Lodhi Road, New Delhi 24638096, 24636759 <a href="mailto:bmtpc@del2.vsnl.net.in">bmtpc@del2.vsnl.net.in</a>
20.	Shri J. K. Prasad Chief (Building Material)	BMTPC, Core 5 A, India Habitat Centre Lodhi Road, New Delhi – 03 Ph 24638095, 24636759 <a href="mailto:bmtpc@del2.vsnl.net.in">bmtpc@del2.vsnl.net.in</a>
21.	Dr. G. S. Mandal Retd. Addl. DG	Indian Meteorological Department 26481281 / <a href="mailto:gsmandal2002@yahoo.com">gsmandal2002@yahoo.com</a>
22.	Shri Ankush Agarwal Technical Officer	UNDP Ph 9312433169 Email: <a href="mailto:ankush.agarwal@undp.org">ankush.agarwal@undp.org</a>
23.	Shri SVRK Prabhakar	UNDP 9811299711
24.	Shri H. S. Dogra Engineer-in-Chief	New Delhi Municipal Council 3 <sup>rd</sup> Floor, Palika Kendra, Sansad Marg, New Delhi – 110 001 E-mail : <a href="mailto:hsdogra@ndmc.gov.in">hsdogra@ndmc.gov.in</a> Ph 011-23742532, 51500289
25.	Ms. Kiran Dhingra	Joint Secretary, Ministry of Textiles, New Delhi

**Minutes of the meeting on “Design Criteria for Reconstruction of Houses in Tsunami affected areas in India” held on Sunday 09<sup>th</sup> January 2005 at NIDM.**

**Introduction:**

A meeting was called at short notice by Prof. A. S. Arya, National Seismic Advisor, GOI-MHA and Shri Rajarshi Bhattacharya, OSD & Ex officio JS, GOI-MHA. The meeting was chaired by Shri S. P. Gaur, ED, NIDM. The persons who attended the meeting are listed in *Annexure - I* to the minutes.

**2 Highlights of the Discussion:**

Presentations were made during the meeting as follows:

1. Shri Rajarshi posed the problem of reconstruction of houses in Andaman & Nicobar mentioning three parameters
  - a. The monsoon in Andaman & Nicobar start from 15 May and last for seven months. Hence, the construction needs to be completed before the onset of monsoon.
  - b. The reconstruction should ensure acceptability by the people so that people feel ownership of reconstruction of programme.
  - c. There are serious constrains on the availability of the construction material in the A & N. This should be taken care of in recommending the housing reconstruction technology
2. Shri H.S.Dogra who had worked as Chief Engineer in Andaman & Nicobar Island for three years presently working as Chief Engineer, NDMC, made the following points.
  - a. The climate in A & N is hot and humid and the timber is eaten by white ants.
  - b. The availability of sand and aggregate is extremely limited, that too in Andamans. Availability in Nicobar is negligible.
  - c. Andaman group of islands is well connected but the Nicobar group of Islands not so well connected.
  - d. After the Earthquake the water level in most of the wells has gone up, in some it has become salty.



- e. The population in the islands is composed of people settled from almost all states in India.
3. A photographic presentation made by Prof. Santosh Kumar, NIDM, highlighted the damage caused by Tsunami waves in Tamil Nadu. It also shows the damage done to number of houses by the debris consisting of boats of various sizes which were transported by Tsunami and hit the buildings. The loss of life in a two storied building occurred to even people living in the upper floor. This clearly brought out that the height of Tsunami at that point was more than six meters.
4. A very comprehensive photographic presentation of the damage caused by the EQ as well as by Tsunami in the Andaman and Car Nicobar Islands was presented by Dr. D. K. Paul, who had visited the harbor facilities in particular on the invitation of the Administration from the December 28, 2004 to January 03, 2005. The following are the highlights
  - a. The earthquake intensity in the Island was about VI on MSK intensity scale and VII on the coasts.
  - b. The marine soil is loose, and showed liquefaction at many places in the coastal areas. The structures founded on open foundations sank and tilted but those resting on deep foundations consisting of piles did not suffer damage due to liquefaction.
  - c. In most reinforced concrete buildings on the sea shore, corrosion of reinforcement was clearly visible.
  - d. The provision of break waters in front of jetties and wharf's saved those structures from the onslaught of the Tsunami waves.
  - e. It was also pointed out during discussion that the Car Nicobar Island is almost flat; the inner land may not be more than 3 metres higher than the coastal land.
5. Ms. Kiran Dhingra, mentioned that the Andaman and Nicobar Islands have recent geological structures. She made the following points :
  - a. The population can be divided into the tribals and migrants from the main land.
  - b. The Car Nicobar Island is mostly populated by the tribals and the Govt. employees in various departments.

- c. Whereas the most population in the Andamans lives in usual construction built on ground, the Nicobari tribal population prefers to live on stilt houses consisting of coconut stump columns, sleeping and cooking in the hut above ground and carry on other activities on ground. She also pleaded the use of local materials even the coconut stump technology in the reconstruction planning.
  - d. During discussion it was brought out that there are some saw mills as well as chemical treatment plants in the islands which are, however, mostly non functional.
6. Dr. Arya made a detailed power point presentation covering the subject of
- (i) situation of losses and damage in the various affected States and UTs,
  - (ii) the multi hazard situation in the areas, consisting of EQ, Cyclone, Flood, Storm surge and Tsunami, which requires a holistic approach in developing the design criteria for reconstruction of houses, buildings and infrastructures in the Tsunami affected areas in the country. A copy of the presentation including the data and proposed criteria is attached herewith as ***Annexure – 2***.

### **3. Discussions**

In summary, it was agreed that the house designs should cater for the following important points:

- i) Socio economic and cultural needs of the population.
- ii) Selection of construction materials from the view point of local availability as well as transport facility from the main land.
- iii) Appropriate designed wind velocity.
- iv) Effective wind pressure near the sea coast.
- v) Height of Storm Surge above the concurrent tide level.
- vi) Cater for the Tsunami affect in the designs.
- vii) EQ design considerations including liquefaction effects.
- viii) Inundation by floods and dynamic effect of flood flow.

It was agreed that whereas the present context is *reconstruction of housing*, the design criteria should be so defined that other buildings which may be of important or exceptionally critical nature and heritage buildings may also be covered. Also building aspects affecting their

behavior under the hazards such as: shape, size and heights, use of stilts, use of deep foundations and corrosion resistant aspects should also be taken into account. In addition to the above the fire safety and thermal comfort may also be taken care of in the design of the buildings.

#### **4. Further Action**

After these discussions, the participants were divided into two groups to review and discuss the Design Criteria as proposed by Prof. Arya, and also make specific recommendations suited to Andaman & Nicobar. In the re-convened total group meeting, the design criteria along with the recommendations were finalized as enclosed.

In order to expedite some Type Designs of appropriate houses for reconstruction in A & N Islands, the following organizations/institutions agreed to complete this task upto 13<sup>th</sup> January 2005

1. HUDCO (Design & Development Division)
2. BMTPC (Design Office)
3. IIT – Roorkee, Department of Architecture.

These designs will be reviewed at NIDM on 13<sup>th</sup> January 2005 in a short meeting. The organizations were also requested to prepare cost estimates based on plinth area rates as per Delhi scheduled of rates.

The group felt strongly that a team of experts may visit Andaman & Nicobar islands for consultation with the local administration & opinion makers in the islands to discuss the appropriateness of the type design &/or to develop alternative designs so as to finalize the same at the earliest possible. The team may also discuss the needs for assessment of damaged buildings from the point of view of rehabilitation & retrofitting.

The meeting ended with the vote of thanks with chair.

**(Prof. Anand S. Arya)**  
National Seismic Advisor  
GOI-MHA

**(Shri Rajarshi Bhattacharya)**  
OSD & Ex-Officio, JS  
GOI-MHA

**(Prof. Santosh Kumar)**  
Professor Policy Planning &  
Community Issues, NIDM,  
GOI- MHA

# INFORMATION ON COASTAL REGULATION ZONE

(Meeting to discuss the issues related to Coastal regulation zones  
Convened by Planning Commission 3<sup>rd</sup> May, 2004)

## COASTAL AREA CLASSIFICATION AND DEVELOPMENT REGULATIONS

Classification of Coastal Regulation Zone:

6(1) For regulating development activities, the coastal stretches within 500 metres of High Tide Line on the landward side are classified into four categories, namely:

Category I (CRZ-I):

(i) Areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals/coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty/historically/heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared by the Central Government or the concerned authorities at the State/Union Territory level from time to time.

(ii) Area between Low Tide Line and the high Tide Line.

Category-II (CRZ-II):

The areas that have already been developed upto or close to the shoreline. For this purpose, "developed area" is referred to as that area within the municipal limits or in other legally designated urban areas which is already substantially built up and which has been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains.

Category-III (CRZ-III):

Areas that are relatively undisturbed and those which do not belong to either Category-I or II. These will include coastal zone in the rural areas (developed and undeveloped) and also areas within Municipal limits or in other legally designated urban areas which are not substantially built up.

Category-IV (CRZ-IV):

Coastal stretches in the Andaman & Nicobar, Lakshadweep and small islands, except those designated as CRZ-I, CRZ-II or CRZ-III.

## NORMS FOR REGULATION OF ACTIVITIES.

### CRZ-III

**(i) The area upto 200 metres from the High Tide Line is to be earmarked as 'No Development Zone\*.**

[Provided that such area does not fall within any notified port limits or any notified Special Economic Zone.]

[ No construction shall be permitted within this zone except for repairs of existing authorised structures not exceeding existing FSI, existing plinth area and existing density, and for permissible activities under the notification including facilities essential for such activities.] However, the following uses/activities may be permissible in this zone - agriculture, horticulture, gardens, pastures, parks, play fields, forestry, ^[mining of rare minerals] and salt manufacture from sea water.

(ii) Development of vacant plots between 200 and 500 metres of High Tide Line in designated areas of CRZ-III with prior approval of Ministry of Environment and Forests (MEF) permitted for construction of hotels each resorts for temporary occupation of tourists/visitors subject to the conditions as stipulated in the guidelines at Annexure-II.

(iii) [Construction/reconstruction of dwelling units between 200 and 500 metres of the High Tide Line permitted so long it is within the ambit of traditional rights and customary uses such as existing fishing villages and gaothans. **Building permission for such construction/reconstruction will be subject to the conditions that the total number of dwelling units shall not be more than twice the number of existing units; total covered area on all floors shall not exceed 33 percent of the plot size; the overall height of construction shall not exceed 9 metres and construction shall not be more than 2 floors ground floor plus one floor.** Construction is allowed for permissible activities under the notification including facilities essential for such activities. An authority designated by State Government/Union Territory Administration may permit construction of public rain shelters, community toilets, water supply, drainage, sewerage, roads and bridges. The said authority may also permit construction of schools and dispensaries, for local inhabitants of the area, for those panchayats the major part of which falls within CRZ if no other area is available for construction of such facilities].