WIND DAMAGE INFORMATION RELATED TO INDIA

INTRODUCTION

- Cyclones cause considerable havoc in different parts of the world resulting in loss of life and property, and considerable damage to residential houses, industrial buildings, power transmission and communication towers/masts, and other structures. Every year a large number of residential and industrial buildings are razed to ground by cyclones associated with extreme wind speeds, particularly in the coastal regions of India.

  Annually on an average five to six cyclones form in the seas and one or two of them cross the Indian coast.

  Structural Engineering Research Center (SERC) Madras has obtained all the cyclone tracks available in graphical form for the period of 1891 to date from Indian Meterorological Department (IMD), Pune. All the tracks of cyclones have been digitized in the form of longitudes and latitudes and a database has been prepared.

- There are seven tropical cyclone basins (Oceans) where cyclonic storms occur on a regular basis. India is affected by cyclonic storms in three tropical cyclonic basins viz. the North Indian basin (affecting both east coast and west coast), the Southwest Indian basin (affecting the west coast), the South India/Australian basin (affecting the East coast of India and the West coast of Australia).

- In addition India and its neighbors are threatened by the possibility of storm surges, whenever a tropical cyclone approaches.

- World wide attention has been focused on the need for better disaster mitigation programs for all natural hazards. Although it is not possible to completely avoid natural disasters, their effects can be minimized by creating proper awareness of their likelihood and their impact by developing a suitable warning system, disaster preparedness and management of disasters through application of GIS and remote sensing.

- Orissa is one of the cyclone prone state of the Indian sub-continent. Mainly the coastal districts of Orissa are victims to the cyclonic hazards from time to time causing considerable loss to lives and properties. Besides the coastal districts, the adjoining districts are also ravaged and shattered by the cyclone.

  The analysis of the cyclone disturbances in the Bay of Bengal region during the period (1891-1990) reveals that in the past 100 years, 1138 disturbances occurred. Orissa has highest number of depressions (273) which is 38.78% of the total number of depressions.

- **THE YOKOHAMA MESSAGE**

  (May 1994, International Decade for Natural Disaster Reduction 1990 – 2000)

  (i) Those affected most are the poor and the socially disadvantaged in developing countries as they are least equipped to cope with the situation.
  (ii) Disaster prevention, mitigation and preparedness are better than disaster response.
  (iii) Disaster response alone yields temporary relief at a very high cost.
  (iv) Prevention contributes to lasting improvement in safety.

- **Apropos the Yokohama Strategy for Safer World in 1994, stated above, the Ministry of Urban Development and Poverty Alleviation, Government of India (1994) had constituted an Expert Group to study the following issues related to impact of natural hazards particularly with respect to housing and infrastructure.**

  (i) Need to identify vulnerable areas with reference to natural hazards such as earthquakes, cyclones, floods, etc., having a potential of damaging housing stock and related infrastructure.
  (ii) Preparation of a vulnerability atlas showing areas vulnerable to natural disasters and determination of risk levels of houses.
  (iii) Formulation of a strategy for setting up Techno-legal regimes for enforcing disaster resistant construction and planning practices in natural hazard prone human settlements.

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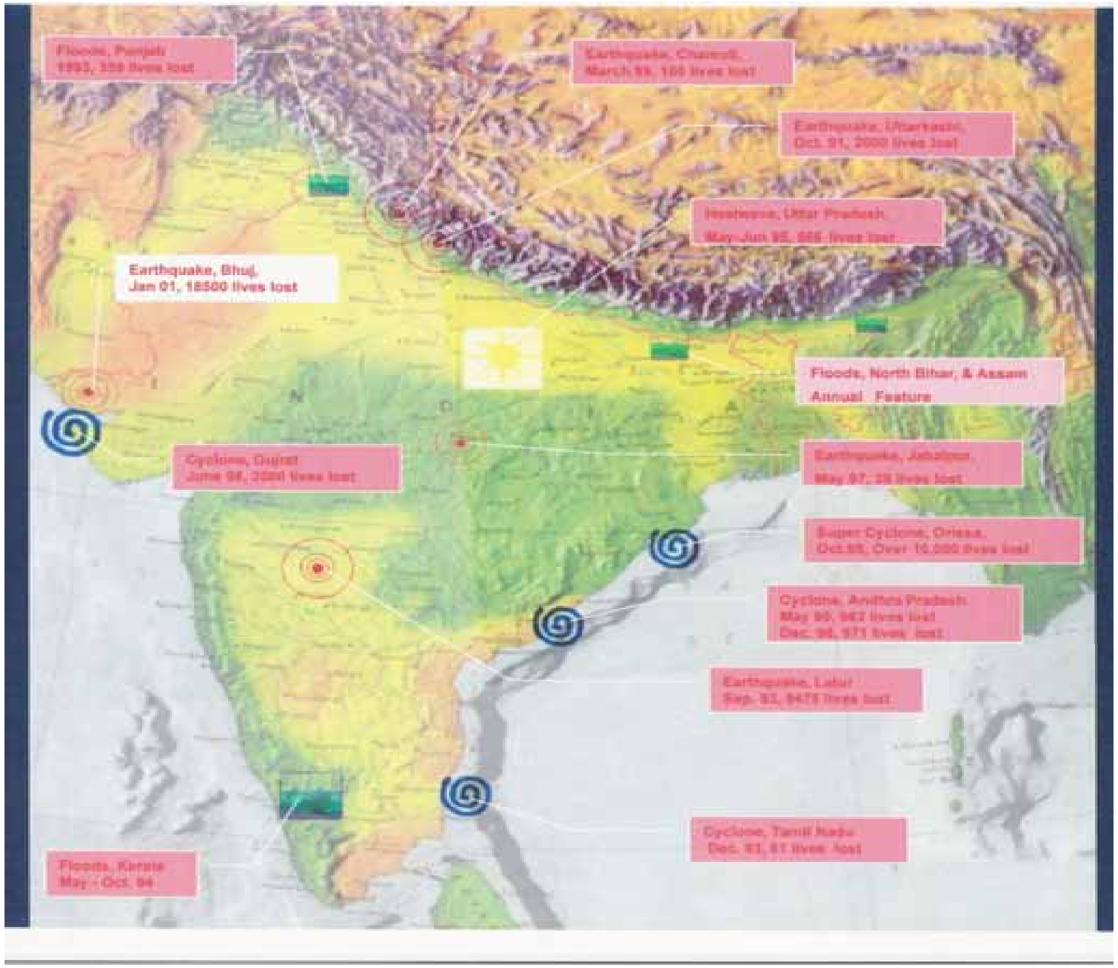
PICTORIAL REPRESENTATION OF MAJOR DISASTERS IN INDIA



[Source: SEEDS, Manu Gupta]

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Table 1: Data for all catastrophes Vs wind for Asia-Pacific region [1985-2000]

Sl. No.	Item	All catastrophes	Wind	%
1	Loss events, Nos.	3,220	1,020	31.7
2	Economic Losses US $million	4,26,270	62,120	14.6
3	Insured Losses US$million	21,970	12,470	56.8
4	Loss of life, nos.	4,33,480	60,250	13.9

[Source: "Topics – Annual Review: Natural Catastrophies – 2000", A Report by – Munich Reinsurance Co., Germany]

Table 2: Comparison of Great natural Disasters decade – wise

Decade	I 960s	I 970s	1980s	1990s
Numbers	27	47	63	84
Economic losses (US $ billion)	73.1	131.5	204.2	591

[Source: Prem Krishna, Indian efforts towards wind resistant housing, J. of Wind Engineering, No. 89 October 2001, APCWE V, Kyoto, 2001]

Table 3: Disaster Losses 1985 – 2000

	Worldwide	Asia-Pacific	Percentage
Lives Lost	536,250	443,480	82.7
Economic Losses (US $ million)	895,800	426,270	47.5

[Source: Prem Krishna, Indian efforts towards wind resistant housing, J. of Wind Engineering, No. 89 October 2001, APCWE V, Kyoto, 2001]

Table 4: Losses in the Asia-Pacific due to Wind Storms Vs Total, 1985-2000

	Total (for all natural disasters)	Due to Wind	Percentage
Lives Lost	443,480	60,250	14.0 *
Economic Losses (US $ million)	426,270	62,120	14.6 *

***** *This percentage is very much higher for North America*

[Source: Prem Krishna, Indian efforts towards wind resistant housing, J. of Wind Engineering, No. 89 October 2001, APCWE V, Kyoto, 2001]

Table 5: Deaths associated with noteworthy tropical cyclones

India		Bangladesh		Other countries		
Year	Deaths	Year	Deaths	Year	Country	Deaths
1737	300,000	1822	40,000	1780	Antilles	22,000
1833	50,000	1876	2,50,000	1881	China	3,00,000
1864	*1,75,000	1897	1,75,000	1990	Texas	6,000
1942	75,000	1960	5,149	1923	Japan	2,500
1971	10,000	1961	11,468	1960	Japan	5,000
1973	5,000	1963	11,520	1963	Cuba Haiti	7,196
1977	10,000	1965	19,279			
1999	10,000	1970	3,00,000			
* 3 Events		1988	5,708			
		1991	1,32,000			

[Source: G. S. Mandal "Tropical cyclones and their damage potential", Status of Wind Engineering in India Volume, Department of Civil Engineering, Indian Institute of Technology Roorkee, India, 1995.]

Table 6: Recent cyclones in the Indian region

Sl. No.	**Cyclone**	**Peak intensity (m/sec)**	**OCS (m/sec)**	**MSDW (m/sec)**	**Size [Diameter of area of 17 m/sec wind (km)]**	**Peak surge (m)**	**Loss of human lives**	**Loss of property (Million Indian Rupees)**
1	Chirala cyclone of November 1977	70	28.5	31.0	750	5.2	10000	3500
2	Machilipatnam cyclone of November 1979	58	22.2	20.0	600	3.5	700	1700
3	Sriharikota cyclone of November 1984	58	11.5	12.2	300	3.2	604	4000
4	Bangladesh cyclone of November 1985	58	28.4	28.0	800	4.5	2500	(India) 1377 (Bangladesh) 9400
5	Kavali cyclone of November 1989	65	10.3	13.2	250	3.5	51	140
6	Machilipatnam cyclone of May 1990	65	23.2	23.9	550	3.5	967	22480
7	Bangladesh cyclone of April 1991	65	23.0	24.2	500	6.0	132000	-
8	Orissa cyclone of October 1999	72		42.0	200	5.5	10000	-

[Source: G. S. Mandal "Tropical cyclones and their damage potential", Status of Wind Engineering in India Volume, IIT, Roorkee, 1995]

Table 7: List of storm surges for Orissa Coast

No.	Date	Location	Damage
1	27 May, 1823	Balsasore, Orissal, India	Inundation up to 10 km inland. Several ships and whole villages disappeared
2	31 October, 1831	Balsasore, Orissal, India	2 to 5m surges. Extensive inundation. 22,000 deaths. 50,000 cattle lost. This might have been the same storm that also generated a surge at Barisal, Bangladesh.
3	October, 1832	Balsasore, Orissal, India	More violent storm than in 1823 (No. 1) but the surge was less destructive.
4	22 September, 1885	Cuttack (False Point) Orissa, India	7m surge. 5,000 deaths by drowning. 300 deaths by falling trees. 50,000 houses destroyed, 10,000 cattle lost
5	26 May, 1887	False Point, Orissa, India	Major surges
6	18 June, 1890	North of Gopalpur and Cuttack, Orissa, India	Extensive damage by the surge
7	September, 1895	False Point, Orissa, India	Up to 7 m water levels (tide and surge) on the north Orissa coast. More than 5,000 deaths.
8	9-11 October, 1967	Puri, Orissa, India	Water levels up to 9 m.
9	30 October, 1971	Paradip, Orissa, India	Water levels up to 6 m. The surge penetrated 25 km inland. 10,000 deaths.
10	10 September 1972	Barua, Orissa, India	3.4 m surge. 0.8 m tide.
11	22 September, 1972	Gopalpur, Orissa, India	Inundation in Puri district
12	11 October, 1973	Chandbali, Orissa, India	Mild surge in river esturies caused saline water intrusion in the coastal areas of north Orissa and West Bengal
13	1-4 June, 1982	Between Paradip and Chandbali, Orissa, India	2 m surges along the Orissa and west Bengal coasts. Peak surge of 4.8 m 35 km north of Dhamra harbour. 245 deaths
14	20 September, 1985	Close to Puri, Orissa, India	2 m surges. Inundation lasted for three days. Substantial damage.
15	16 October, 1985	Near Balasore, Orissa, India	Up to 4 m surge. Damage due to saline water inundation.
16	7-10 November, 1995	Gopalpur, Orissa, India	1.5 m, 96 killed, 2,84,253 hectare crops damaged.
17	17-21 October, 1999	Gopalpur, Orissa, India	1.5 m, 6 deaths, extensive damage.
18	25-29 October, 1999	Paradip, Orissa, India	7.5 m surge, 11,000 deaths, extensive damage.

[Source: S. K. Dube et. al, Marine Geodesy, 23: 75-90, 2000]

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Table 8: Cyclone damage surveys conducted by Structural Engineering Research Center [SERC], Madras

Year of occurrence	Location of land fall	Damage observed
1977	Machilipatnam, A.P., India	Life lines. Residential buildings. Industrial structures etc.
1977	Nagapatnam, T. N., India	Life lines. Residential buildings. Industrial buildings etc.
1984	Sriharikota (SHAR). A. P., India	Roofing, Elevated water tanks, Communication towers, Industrial structures.
1989	Kavali, A.P., India	Microwave towers, Large industrial structures and dwellings.
1990	Guntur, A. P., India	Residential buildings, Life lines.
1992	Miami, U.S.A.	Residential buildings and communication lines.
1993	Near Karaikal, T. N., India	Industrial structures, residential buildings
1994	Madras, T. N., India	Lamp masts, Hoardings, dish antennas.
1996	Kakinada, A. P., India	Residential buildings, transmission and communication towers, lamp masts, Industrial structures, etc.
1998	Near Porbander, Gujarat, India	Residential buildings, Communication towers, Lamp masts, Industrial structures, Port and Marine structures
1999	Near Paradip, Orissa	Residential buildings, transmission and communication towers, Industrial structures, Port and Marine structures.

OUTCOME IN RESPONSE TO YOKOHAMA CONFERENCE DECLARATIONS (RESOLUTIONS)

HAZARD VULNERABILITY IN INDIA

- 54% of land vulnerable to earthquakes
- 8% of land vulnerable to cyclones
- 5% of land vulnerable to floods

More than one million houses damaged annually+human, social, other losses

Due to wind and cyclones, In 21 cyclones in Bay of Bengal (India+Bangladesh) 1.25 million lives have been lost.

VULNERABILITY ATLAS OF INDIA

- State-wise hazard maps and district-wise risk tables have been made available. The wind storm and flood hazard maps are drawn for each state and union territory separately. Various district boundaries are clearly shown for easy identification of the hazard risk prone areas.

- The bureau of Indian Standards Committees on Wind Engineering have a velocity map including cyclonic winds for the country.

- Wind hazard related with wind speed are drawn on the maps to show various intensity zones. Along with design wind speed, the number of cyclones which have crossed each latitude of the sea coast in the past are also marked.

THE RISK TABLES

Number of housing units of various types classified by wall material and roof type, and number of building of each type are presented.

Table 9: Distribution of Houses by Predominant Materials of Wall and Roof and level of Damage v Risk - Extract from a typical table in the Vulnerability Atlas

Wall and Roof Combination		**Census Houses**		**Level of Risk under Wind Velocity (m/s)**			
		No. of Houses	**%**	**55 & *50***	**47**	**44&39**	**33**
				Area in %			
				5.0	***40.2***	***48.0***	**6.8**
CATEGORY - A							
A1 Mud Wall							
All Roofs sloping	Urban	5,422,316	2.78				
	Rural	57,104,950	29.28				
	Total	62.527.266	32.06	VH	H	M	L*
A2 Unburned Brick Wall							
(a) Sloping roof	Urban	1,937,714	0.99				
	Rural	9.951.794	5.10				
	Total	11 889 508	6.10	VH	H	M	L
(b) Flat roof	Urban	119,042	0.06				
	Rural	161,492	0.08				
	. Total	280,534	0.14	VH	H	M	L
A3 Stone Wall							
(a) Sloping roof	Urban	2,111,574	1.08				
	Rural	12.445.497	6.38				
	Total	14.557.071	7.46	VH	H	M	L
(b) Flat roof	Urban	2,308,017	1.18				
	Rural	4.838.903	2.48				
	Total	7.146.920	3.66	H	M	L	L
Total- Category -A		96.401,299	49.43				

**** Risk level: VH is very high, H is high, M is moderate and L is low.***

[Source: Prem Krishna, Indian efforts towards wind resistant housing, J. of Wind Engineering, No. 89 October 2001, APCWE V, Kyoto, 2001]

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VULNERABILITY AND RISK ASESSMENT

- A combination of local hazard intensity and vulnerability of existing house types has been used for carrying out risk analysis given in the district-wise tables. The Vulnerability Atlas, thus provides ready macro-level information for use by the authorities for natural disaster mitigation and preventive actions.
- The preliminary effort toward vulnerability assessment of buildings under cyclone intensities has been made by Structural Research Engineering Center, Chennai.
- Taking guidance from this work, the types of housing as existing in each district has been taken from the Census of India, 1991 and categorized from vulnerability consideration. The vulnerability of these types to various intensities of the hazards was estimated by the group, and the damage risk in each district has been presented in separate table. The area of the district prone to various hazard intensities has also been shown.

Table 10: Risk Coefficients for Assessing Housing Damage

Damage Vulnerability	VH	H	M	L	VL
Risk Coefficient, r	0.60	0.27	0.08	0.02	Zero

[Source: Prem Krishna, Indian efforts towards wind resistant housing, J. of Wind Engineering, No. 89 October 2001, APCWE V, Kyoto, 2001]

Table 11: Risk Coefficients for Assessing Human Casulties

Risk Level	VH+Surge	VH	H	M	L
Risk Coefficient, r	5 x 10E-2	5x10E-3	5x10E-5	5x10E-8	Zero

[Source: Prem Krishna, Indian efforts towards wind resistant housing, J. of Wind Engineering, No. 89 October 2001, APCWE V, Kyoto, 2001]

MAIN ITEMS THAT HAVE BEEN ADDRESSED

- Identification of various hazard prone areas.
- Vulnerability and risk assessment of buildings.
- Disaster damage scenarios
- Technical guidelines for hazard resistant construction of buildings
- Upgrading of hazard resistancs of existing housing stock by retrofitting and
- Techno-legal regime to be adopted.

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