POLICIES & STRATEGIES FOR SAFE BUILDING/HOUSING CONSTRUCTION IN INDIA

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CHALLENGE OF EARTHQUAKE DISASTERS

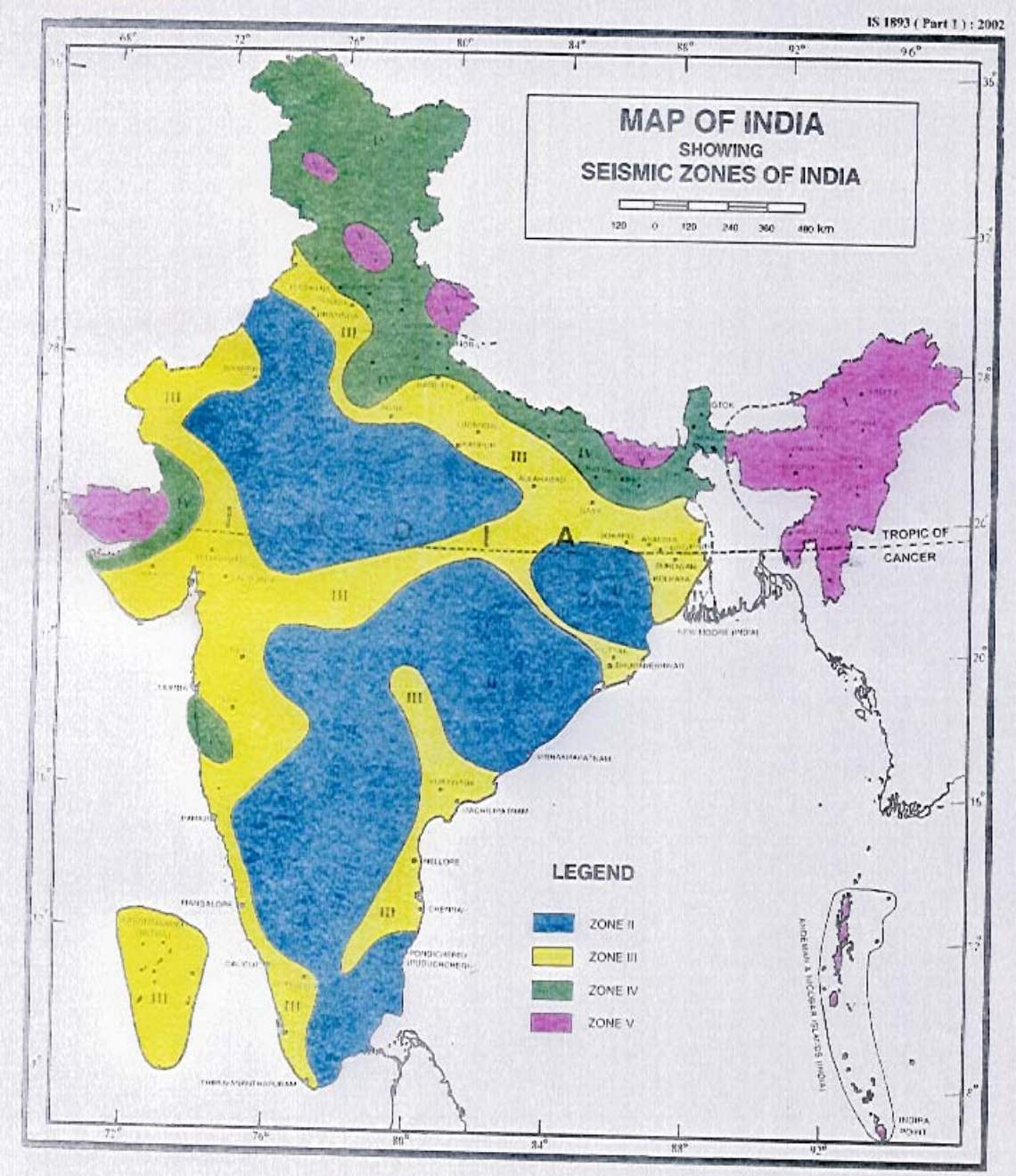
- Loss of 100,000 lives due to earthquakes in 100 years.
- Loss of 20,000 lives in Kangra earthquake of 1905
- 13,000 were killed in 1934 in Bihar- Nepal in M 8.4 earthquake, again 900 killed in Aug. 1988 in M 6.6 Quake (M6.6 is 1/500 of 1934 Quake of M8.4)
- Anjar in Kachchh was destroyed in 1956 and again now in January 2001.

WHY?

EARTHQUAKE HAZARD ZONES 2002

Zone V MM IX or more
" IV MM VIII
" III MM VII

Zone II MM VI
" I MM V or less
together now make
Zone II MM VI or less
Area under the zones
V 12%
IV 18%
III ~27%
Total damageable
~ 57%



SEISMIC RISK TO BUILDINGS

TABLE 3 -VARIOUS BUILDING TYPES BY WALL MATERIALS IN INDIA*

Wall Type		Number of Housing Units		Damage Vulnerability in MSK Intensity		
		Million	% of Total	VII	VIII	IX
Earthen Walls (mud, unburnt brick/blocks)	R	67.2	34.46	M	H	VH
	U	7.5	3.83			
Stone walls	R	17.3	8.87	M	H	VH
	U	4.4	2.23			
Burned Brick Walls	R	36.35	18.64	L	M	H
	U	32.25	16.54			
Concrete Walls	R	1.16	0.59	VL	L	M
	U	2.80	1.44			
Wood & Ekra Walls	R	2.00	1.02	VL	L	L
	U	1.12	0.58			
GI and other metal sheets	R	0.25	0.13	VL	VL	L
	U	0.76	0.39			
Bamboo thatch, leaves, etc	R	18.43	9.45	VL	VL	L
	U	3.20	1.64			

**Census of Housing 1991, total housing units = 195 million. R = Rural, U = Urban, VH = Very High, H = High, M = Moderate, L = Low, VL = Very Low*

Relationship of Seismic Intensity, Building Type & Damage Grades

Few : Less than(15±5)%; *Many*: Between(15±5) to(55±5)%;

Most: Between (55±5) to100%

	Type of Building	Zone II MSK VI or less	Zone III MSK VII	Zone IV MSK VIII	Zone V MSK IX or More
MASONRY BUILDING	Mud and Stone	*Many* of grade 1*Few* of grade 2(rest no damage)	*Most* of grade 3*Few* of grade 4(rest of grade2or1)	*Most* of grade 4 *Few* of grade 5 (rest of grade 3,2)	*Many* of grade 5 (rest of grade 4&3)
	Brick	*Many* of grade 1*Few* of grade 2(rest no damage)	*Many* of grade 2*Few* of grade 3(rest of grade 1)	*Most* of grade 3 *Few* of grade 4 (rest of grade 2)	*Many* of grade 4 *Few* of grade 5 (rest of grade 3)
	Concrete & wood frame	*Few* of grade 1(rest no damage)	*Many* of grade 1 *Few* of grade 2 (rest of grade 1,0)	*Most* of grade 2 *Few* of grade 3 (rest of grade 1)	*Many* of grade 3 *Few* of grade 4 (rest of grade 2)

KACHCHH EARTHQUAKE IN GUJARAT

Date of Occurrence	:	26th January 2001
Time	:	8.46 a.m.
Epicenter	:	23.6 ^{0} North Latitude and 69.8^{0} East Longitude, 20km North East of Bhuj
Magnitude	:	6.9 Richter Scale 7.7 Moment magnitude 7..9 Surface Wave magnitude
Intensity, maximum	:	IX-X MSK Scale

Affected Areas

21 Districts affected out of 25 Districts.

7633 out of 18,356 villages of the State affected.

Total Population affected : 16.04 million.

DAMAGE TO HOUSES:

Houses totally collapsed or destroyed: 2,33,660

Houses partially damaged : 9,71,538

Total Houses Damaged : 1. 2 million

High-rise buildings collapsed in Ahmedabad: (700 killed)

Four Towns in Kuchchh lie in ruins, 450 villages flattened,

Casualties

Human lives lost	13,811
Total Injured	1,66,836
Seriously Injured	20,717
Operation Performed	17,000

Community Buildings to be Repaired/Reconstructed:

Anganwadis	:	3186
Women hostels/creches	:	85
General hospitals	:	3
Other health buildings	:	1930
Schools rooms	:	20,000

LESSONS LEARNED

Reconstruction and New Construction Of Buildings and Infrastructure Elements

(i) Familiarity with the seismicity of the Area

(ii) Learning the Earthquake Resistant Codes & Guidelines

(iii) Adoption of safe Building Practices in Seismic Zones

(iv) Provision of Disaster Resistance Requirements in Building Bylaws

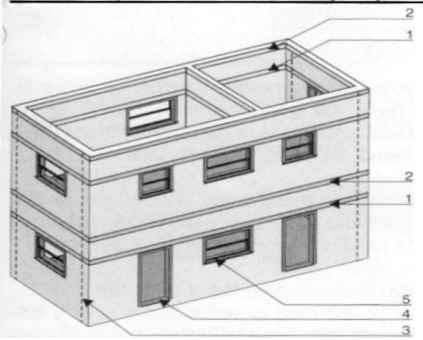
(v) Provision of safe Planning Requirements in Local Area Development Regulations

(vi) Effective Enforcement of Bylaws and Regulations

C. Guidelines Published by Gujarat State Disaster Management Authority (GSDMA) authored by Dr. A.S. Arya

1. *Reconstruction and New Construction of Houses in Kachchh Earthquake Affected Areas of Gujarat,* first printing June 2001 and 2nd printing in January 2002.
2. *Control on Quality of Construction in Earthquake Affected Areas of Gujarat,* printed in June 2001.
3. *Guidelines for Construction of Compressed Stabilised Earthen Wall Buildings,* printed in December 2001.
4. *Guidelines for Cyclone Resistant Construction of Buildings in Gujarat,* printed in December 2002.
5. *Restoration and Retrofitting of Masonry Buildings in Kachchh Earthquake Affected Areas of Gujarat,* printed in March 2002.

* यहां (टौर) सरिये का व्यास दिया गया है।
* Diameter specified here for H.S.D. (TOR) bars.

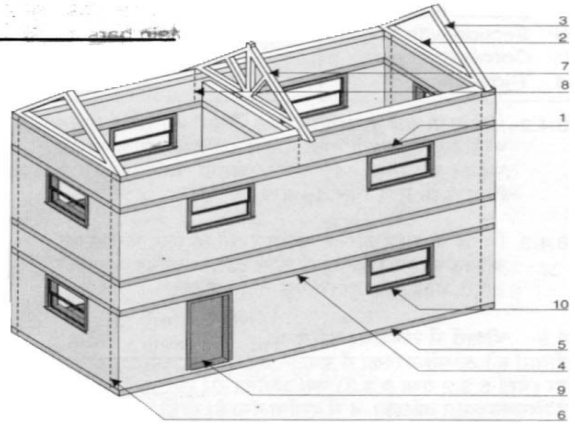


चित्र १३: दो मंजिले चिनाई वाले भवन में प्रबलन की पूरी व्यवस्था

Fig. 13: Overall arrangement of reinforcing in masonry double storey buildings

१. सरदल पट्टिका
२. फर्शी पट्टिका
३. कोने में उर्ध्व सरिया
४. दरवाजा
५. खिड़की

1 Lintel band
2 Roof/floord band
3 Vertical bar at corner
4 Door
5 WindoW



चित्र १४: ढलान छत वाले दो मंजिला भवन में प्रबलन की व्यवस्था

Fig. 14: Overall arrangement of reinforcing in masonry double storey building having pitched roof

१. सरदल पट्टिका	1. Lintel band
२. वलीक पट्टिका	2. Eave level (Roof) band
३. त्रिअंकी पट्टिका	3. Gable band
४. फर्शी पट्टिका	4. Floor band
५. कुर्सी पट्टिका	5. Plinth band
६. खड़ा स्तर	6. Vertical bar
७. रैफ्टर	7. Rafter
८. स्थापक काबला	8. Holding down bolt/Vertical bar
९. द्वार	9 Door
१०. खिड़की	10 Window

Preventive Strategy for Damage Reduction

NEW CONSTRUCTIONS

- Government Sector Buildings & Infrastructure:
  - Follow the E.Q. Resistance Codes Strictly.

- Public Sector and Private Undertakings
  - Mandatory use of Building Codes.

- Private Buildings in Local Body Areas
  - Improve Building Bye Laws with Earthquake Resistance Provisions and Ensure Effective Implementation.

- Private Buildings in Rural Areas
  - Demonstrative Constructions,
  - Building Technology Centres,
  - Awareness and Training to Artisans.

STRATEGY FOR UPGRADING THE STRENGTH OF EXISTING CONSTRUCTIONS BY RETROFITTING

PRIORITIZATION OF BUILDINGS AND STRUCTURES

(a) Buildings:

The following and others to be identified:

(i) Instructional, laboratory and library buildings of educational institutions (schools, colleges, institutes and Universities).

(ii) Hospitals including wards, dispensaries, clinics, etc.

(iii) Congregation halls, temples, churches, cinemas, theatres etc.

(iv) Residences of VIP's and top administrative officers in the districts (Collector, SP, CMO and the like needed for immediate Response.

(Continued)

(b) Service Structures & Infrastructure:

The following among others:

(i) Water tanks and towers

(ii) Telephone exchanges, fire stations, water supply pump houses

(iii) Bridges and culverts

(iv) Electric power houses and substations

(v) Monuments, Heritage Buildings, Museums

(vi) Critical and Hazardous industries

(vii) Railway stations, Airport buildings and towers

Priority may be given in order of Zones V, IV & III.

LOSSES IN A HYPOTHETICAL EARTHQUAKE, IF OCCURRED M=8.0 AT KANGRA, HIMACHAL PRADESH IN 1991

TABLE 5 – DISTRIBUTION OF HOUSES BY PREDOMINANT MATERIALS OF ROOF AND WALL* AND LEVEL OF EARTHQUAKE DAMAGE RISK

KANGRA DISTRICT **HIMACHAL PRADESH**

Wall and Roof Combination		Census Houses		Level of Risk under Eq Intensity MSK				Notes
		No. of Houses	%	≥IX	VIII	VII	≤VI	
				Area in %				
				98.6	1.4	0.0	0.0	
CATEGORY – A	Urban	738	0.19					Building Categories
A1. Mud Wall	Rural	23,239	5.84					*Category – A*
All roofs sloping	*Total*	*23,977*	*6.03*	*VH*	*H*			Buildings in field-stone, rural structures, unburnt brick houses, clay houses
A2 Unburned Brick Wall	Urban	4.596	1.16					
	Rural	271,017	68.24					*Category-B*
a) Sloping roof	*Total*	*276,017*	*69,40*	*VH*	*H*			Ordinary brick buildings; buildings of the large block and prefabricated type, half-timbered structures, building in natural hewn stone
	Urban	83	0.02					
b) Flat roof	Rural	574	0.14					
	Total	*657*	*0.17*	*VH*	*H*			
A3. Stone Wall								
a) Sloping roof	Urban	2,676	0.67					
	Rural	16,530	4.16					
	Total	*19,208*	*4.83*	*VH*	*H*			
b) Flat roof	Urban	1,114	0.28					
	Rural	2,641	0.66					
	Total	*3,755*	*0.94*	*VH*	*H*			
Total – Category – A		**323,614**	**81.37**	**VH**	**H**			*Category – C* Reinforced building, well burnt wooden structures
CATEGORY – B								
B. Burned Brick Wall	Urban	3,028	0.76					
a) Sloping roof	Rural	20,077	5,05					
	Total	*23,105*	*5.81*	*H*	*M*			
b) Flat roof	Urban	7,199	1.81					*Category – X* Other types not covered in A,B,C These are generally light.
	Rural	34,083	8.57					
	Total	*41,282*	*10.38*	*H*	*M*			
Total-Category – B		**64,387**	**16.19**	**H**	**M**			
CATEGORY – C								
C1. Concrete Wall	Urban	76	0.02					
a) Sloping roof	Rural	228	0.06					
	Total	*304*	*0.08*	*M*	*L*			
b) Flat roof	Urban	153	0.04					*Source*: Census of Housing, GOI, 1991
	Rural	456	0.11					
	Total	*609*	*0.15*	*M*	*L*			
C2. Wood Wall	Urban	653	0.16					
(all roofs)	Rural	1,287	0.32					
	Total	*1,940*	*0.49*	*M*	*L*			
C3 Ekra Wall	Urban	1	0.00					
(all roofs)	Rural	19	0.00					
	Total	*20*	*0.01*					
Total Category – C		**2,873**	**0.72**	**M**	**L**			*Ref*: Vulnerability Atlas of India 1997, prepared by Expert Group, MOUA&E, GOI, and pub. by Building Materials & Technology Promotion Council (BMTPC)
CATEGORY – X	Urban	111	0.03					
X1-GI and other Metal Sheets (all roofs)	Rural	385	0.10					
	Total	*496*	*0.12*	*M*	*VL*			
X2 Bamboo, Thatch Grass, Leaves etc. (all roofs)	Urban	238	0.06					
	Rural	6,120	1.54					
	Total	*6,358*	*1.60*	*M*	*VL*			
Total – Category – X		**6,854**	**1.72**	**M**	**VL**			
GRAND TOTAL		**397,728**	**100**					

LOSSES IN HYPOTHETICAL EARTHQUAKE

TABLE 6 - LOSSES IN MAGNITUDE 8.0 HYPOTHETICAL EARTHQUAKE IF OCCURRED AGAIN IN KANGRA, HIMACHAL PRADESH IN 1991
(Total housing units in the affected area = 1815,858)

S.No.	Item	Scenario if all buildings are *without* earthquake resistance		Scenario if all buildings are *with* earthquake resistance	
		Physical Damage	Loss in Rs* (million)	Physical Damage	Loss in Rs. (million)
1.	Loss of Lives	65000	6500	12000	1200
2.	Total collapse of buildings G5	136339	9540	8298	580
3.	Destroyed buildings, G4	263356	18430	94997	6650
2+3	**Buildings to rebuild.**	**399695**	**27970**	**103295**	**7230**
4.	Heavily damaged buildings, G3 (to repair & retrofit)	915602	12820	312382	4370
5.	Moderately damaged building. G2 (to repair & retrofit)	357510	3750	648040	6800
6.	**Total losses**		**51040**		**19600**

*Losses estimated in 1997 at 1997 costs

(Source: A.S. Arya, 12WCEE, Paper No. 2824, 2000 (Ref. A7)

BENEFIT/COST OF SEISMIC RESISTANCE

(Hypothetical Repeat EQ of 1905 in H.P.)

	Case (a)	*Case (b)*	*Case (c)*
Seism. Resist. Cost	Nil	635 crores	1525 crores
Life Loss	65000	12000	12000
Physical Losses	5104 crore	1960 crore	1960 crores
Net saving as Compared to (a)	-	2509 ``	1619 ``
Indirect Losses & Trauma	A	20 – 25% of A	20 – 25% of A

Case (a) – Existing situation of buildings.

Case (b) – If all buildings were earthquake resistant initially.

Case (c) – If all buildings are retrofitted now.

EXTRA COST IN PROVIDING SEISMIC RESISTANCE

Building in	*Masonry in Cement Mortar*	*RCC framed Buildings 4-8 storeyed*
Zone III	1.5 – 2 %	2.6 – 3.2 %
Zone IV	3 – 4 %	3.2 – 4.0 %
Zone V	5 – 6 %	5.0 – 6.0 %

GOVERNMENT OF INDIA INITIATIVES

EARTHQUAKE RISK MITIGATION PROJECT

- To cover **229** districts in **21** States in seismic zones IV and V
  - Putting techno-legal regime in place.
  - Capacity building/training of engineers/masons etc.
  - Awareness through technology demonstration.
  - Retrofitting of life line buildings and public utilities.
  - Formulation of preparedness and response plans.

TECHNO-LEGAL REGIME AND CAPACITY BUILDING FOR ITS COMPLIANCE

Working with States in seismic zones III, IV and V

- Model Building Bye-laws and Development Control Regulations
- Awareness generation meetings/ workshops /visits to educational institutions
- Assistance to States for training of engineers / architects / masons

TECHNO-LEGAL REGIME AND CAPACITY BUILDING FOR COMPLIANCE [CONTD.]

- National Programme for Capacity Building of Architects in earthquake risk management- assistance to States to train **10,000** architects.
- National Programme for Capacity Building of Masons in Earthquake Risk Mitigation—assistance to States to train **30,000** masons.

EARTHQUAKE SAFETY OF LIFELINE BUILDINGS AND CRITICAL INFRASTRUCTURE

- Steps initiated for examination of the **structural safety of life-line buildings** from the seismic point of view. (airports and control towers, hospitals in seismic zones, railway stations/bridges in seismic zones), Power for safety of power generation and transmission systems; Telecommunication for safety of telephone exchanges and lines

CONCLUSION

- Carry out the engineering, architecture and planning measures
  - Land use zoning.
  - Planning of habitat,
  - Implementation of building codes in all new constructions, and
  - seismic retrofitting of existing buildings and infrastructure.

- Create the supportive structure of
  - public awareness,
  - education and training
  - research and development about the safety from earthquake hazard.

- Appropriate policy, financial and institutional support at national and state levels are being provided for putting this strategy into a workable action plan.

Thank you for your attention.