

Reconstruction and Recovery Experience After Kachchh Earthquake in India (Build Back Better)

Dr. Anand S. Arya, FNA, FNAE
Padamshree awarded by President of India
Professor Emeritus
Indian Institute of Technology, Roorkee
Former National Seismic Advisor (EVR)
GOI-UNDP-DRM Program

22.03.2010 at USA

KACHCHH EARTHQUAKE IN GUJARAT

Date of Occurrence : 26th January 2001

Time : 8.46 a.m.

Epicenter : 23.6^o North Latitude and
69.8^o 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

TOTAL DESTRUCTION OF MASONRY BUILDINGS



કચ્છ જિલ્લામાં ધરાશાયી
થયેલાં મકાનો.
કચ્છ જિલ્લે મેં ધરાશાયી હુણ
મકાન ।
Houses collapsed in
Kachchh district.

BAD PERFORMANCE OF MASONRY BUILDINGS

- Old decaying buildings predating modern construction practices
- New buildings not built to Indian earthquake Codes
- Lack of knowledge understanding or training in the use of these Codes by local builders
- Buildings erected without the owners seeking proper engineering advice
- Improper detailing of masonry building
- Poor materials, construction and workmanship used
- Absence of 'header' or 'through' stones and long corner stones in random rubble (RR) masonry
- Buildings having poor quality foundations or foundations built on poor soils
- Alterations and extensions being carried out without proper regard for effects on structure during an earthquake

SALT FACTORY AT CHIRAI



POWER PLANT SWITCH YARD



ANJAR SUBSTATION



WATER TREATMENT PLANT – WALLS BROKEN OFF



A Terrible Human Tragedy

**Over 1.1 million homes affected;
4 Kutch towns in ruins**



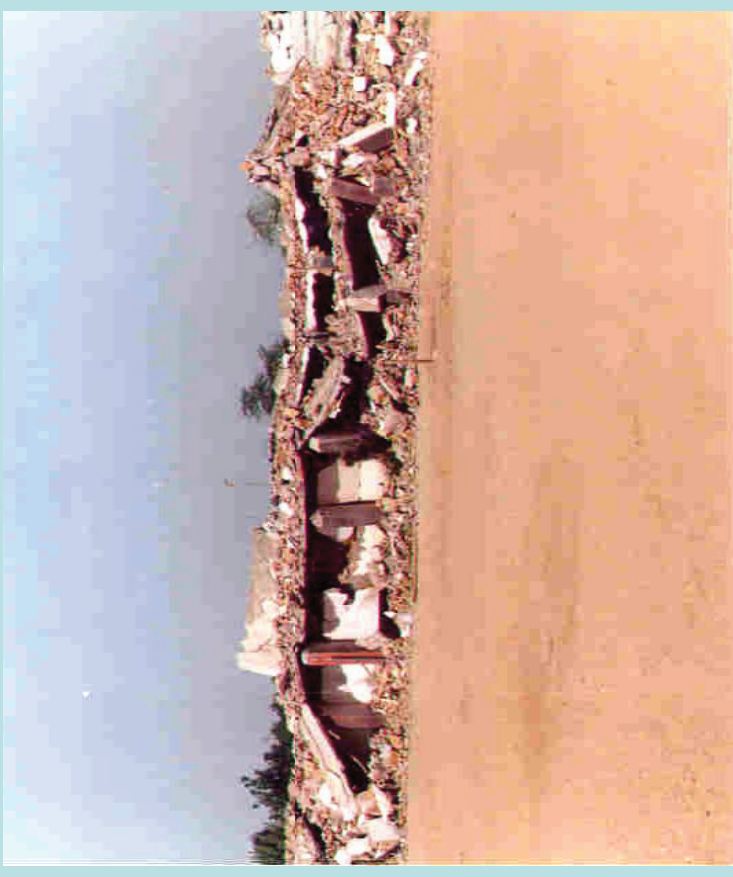
A Terrible Human Tragedy

**Over 5,000 Health units
damaged / destroyed**



Bhuj General Hospital

**Over 50,000 School rooms
damaged / destroyed**



High School of Dudhai Village

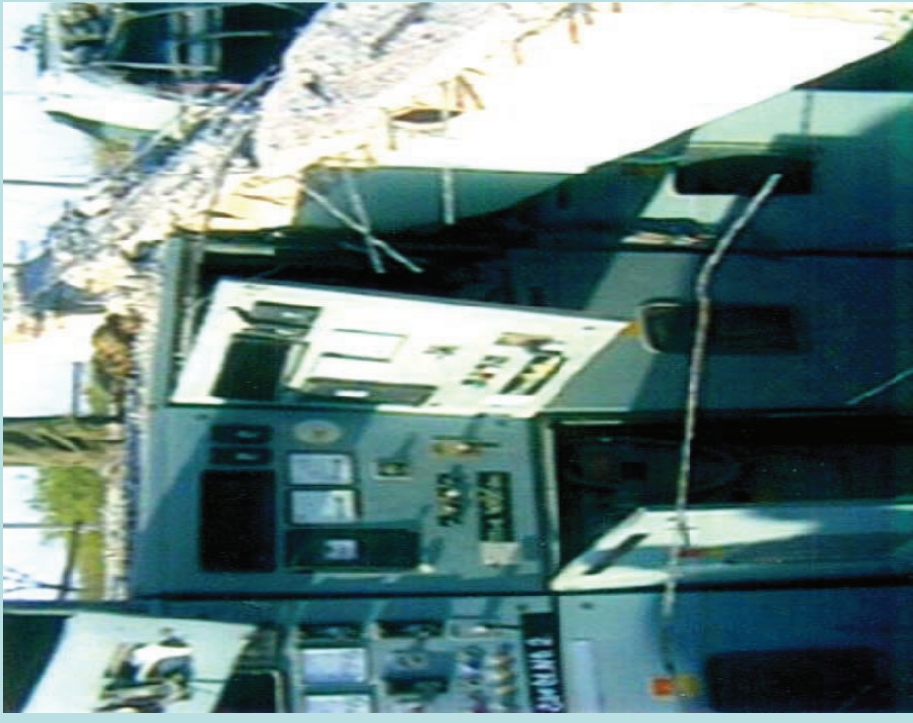
A Terrible Human Tragedy



- Over 50,000 artisans lost their livelihood.
- Over 10,000 small and medium industrial units went out of production.

A Terrible Human Tragedy

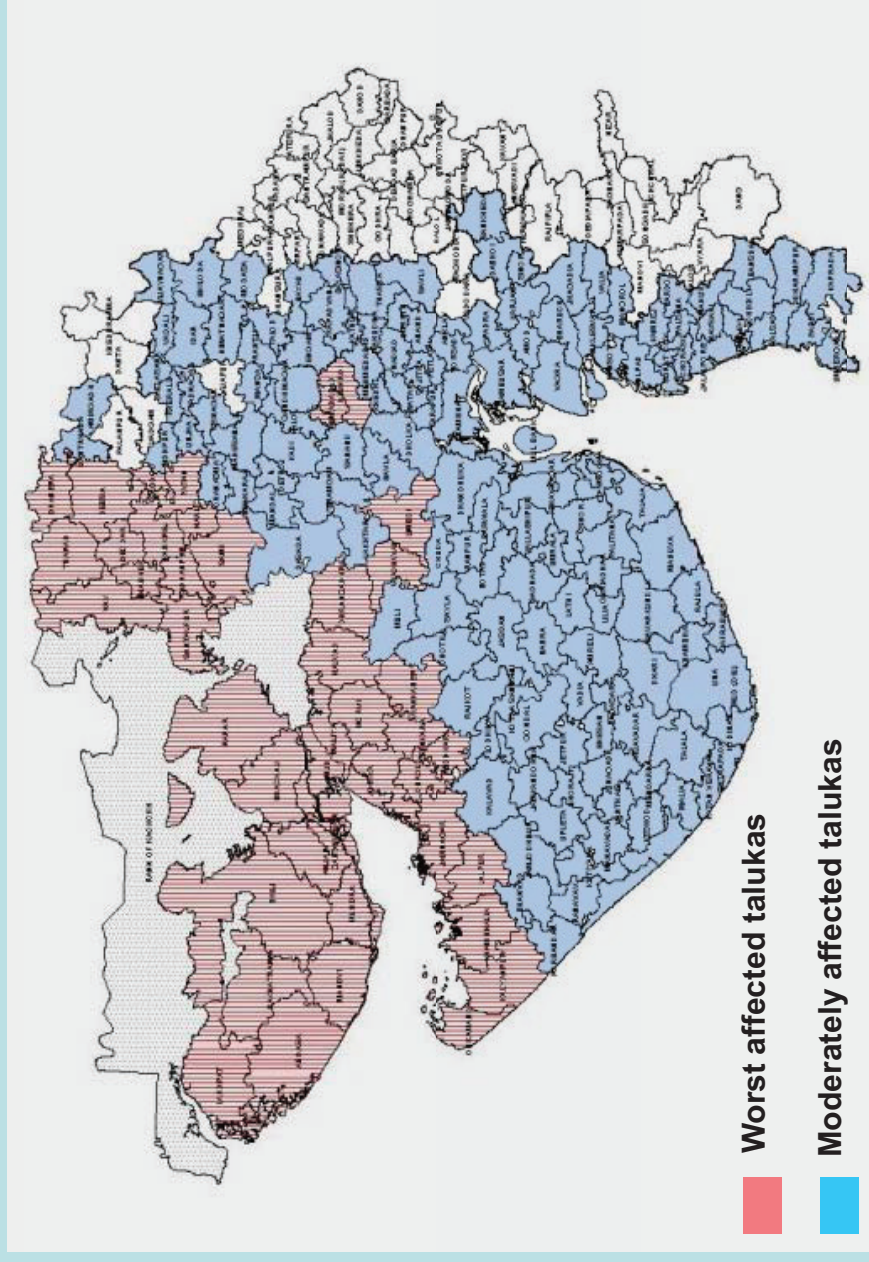
- **Massive damage to telecom, power, water supply and transport infrastructure.**



Widespread Impact

- 21 out of 25 Districts.
- 181 out of 225 Talukas
- 7633 Villages
- Area affected - 182,639 sq.km. (Larger than Haryana & Kerala put together)
- Population affected over 30% of 50 million

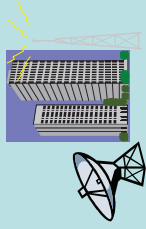
Affected Areas



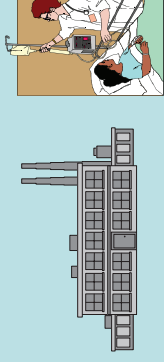
IMPACT: A LARGER PICTURE

➤ Direct losses

- Human lives
- Livestock, other animals
- Private property
- Municipal infrastructure
- Power/ telecommunications infrastructure
- Health/ education assets



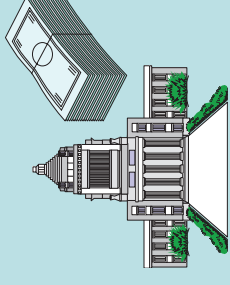
- Gujarat earthquake estimate: Rs 15308 Crores
- \$ 3364 Mn



➤ Indirect losses

- Export/ import
- Agricultural output
- Industry/ services output
- Remittance income
- Fall in earning potential (due to disability, trauma etc.)
- Unemployment
- Health hazards

- Gujarat earthquake estimate: Rs 3047 Crores
- \$670 Mn



➤ Tertiary losses

- Long-term development
- Overall investment climate
- Funds reallocation
- Community migration/ relocation
- Gujarat earthquake estimate: Rs 10067 Crores
- \$2213 Mn

The need of the hour...

An agency to carry out...

- **Implementation of massive Relief, Rehabilitation and Reconstruction work**
- **Co-ordination between GoG and several donors, funding agencies like WB, ADB**
- **Quick Policy Making**
- **Effective Financial Management**
- **Monitoring and Quality Inspection**
- **Planning for long-term Disaster Management**
- **Disaster Mitigation**

The Answer – GSDMA

Gujarat State Disaster Management Authority

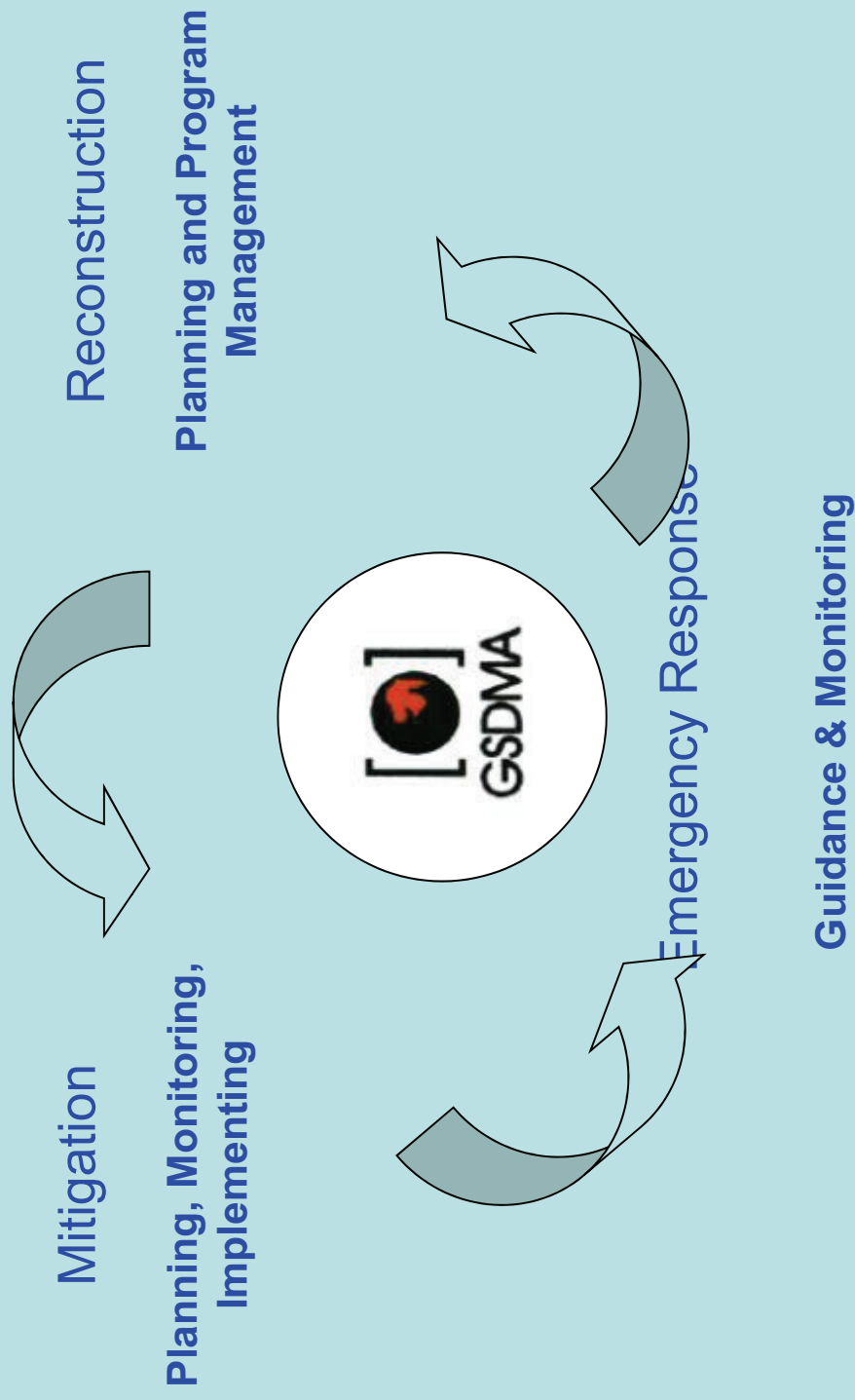
(Preside by Chief Minister of the State)

- **The Gujarat State Disaster Management Authority** was constituted by the Government of Gujarat vide its GR dtd.08/02/2001
- An effective response to the enormous challenges posed by natural calamities.

Objectives of GSDMA

- To undertake relief, rehabilitation and reconstruction of social and economic activities to restore normalcy.
- To minimize the impact of natural calamities through mitigation programmes.
- To study and conduct Risk and Vulnerability Analysis of Gujarat.
- To suggest remedies to prevent or minimize the effects of natural calamities.
- To optimize the use of funds, grants, donations, assistance received from GOI, donors and other funding agencies

Gujarat State Disaster Management Authority



EMERGENCY RESPONSE

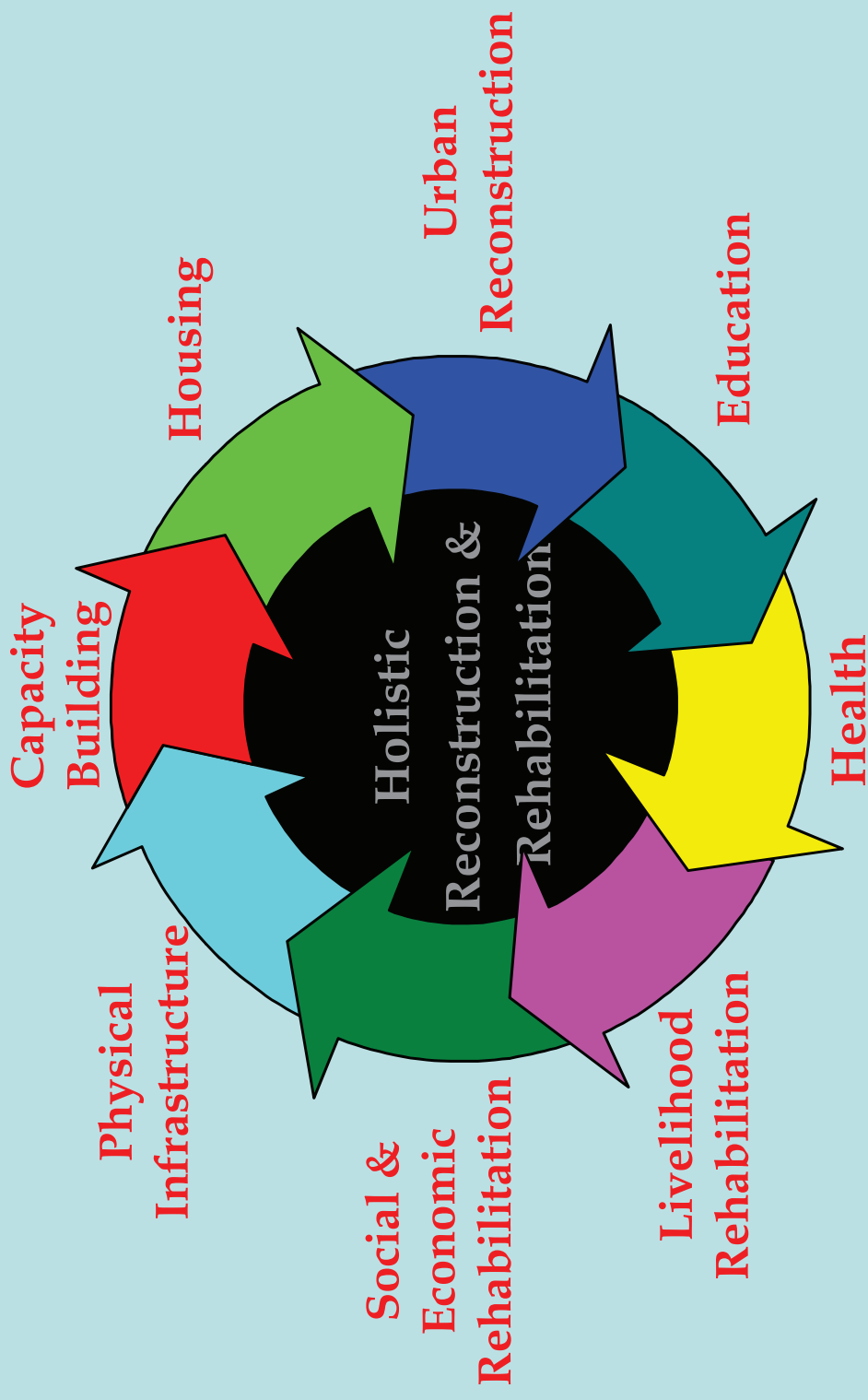
- Rescue Equipment (5449): JCBs, Cranes, Bull Dozers, Excavators, Dumpers, Trucks, Gas Cutters
- Vehicles (5022): Jeeps, Ambulances, ST buses
- Personnel (29140): Technical, Non-Technical, Labourers, Medical Terms
- International rescue teams arrived: Netherland, France, Japan, Ukain, Switzerland, UK, Russia, Germany, Bulgaria and Israel
- Injured: 167,000 cases treated (19,000 serious nature)
- Army Hospital at Bhuj opened its door to civilians
- Hospitals set up by State Government & IMA, Israel, France, Ukain, Denmark, Red Cross Societies of Norway, Finland & Germany

EMERGENCY RESPONSE

- All emergency telecommunication services restored within 24 hours
- Essential services like water,power, railway traffic, road ways restored in 36 hours in Bhuj and within 48 hours in entire Kutch
- Essential supplies of wheat, groundnut oil & sugar rushed to Kutch district for free distribution
- Free community kitchen services provided
- Cashdoles given to 9,11,096 Families, house hold kits to 3,72,027 Families
- Death Compensation paid to 13,378 Cases, Injury Assistance given to 19,648 Cases
- Emergency Shelter to 2,48,947 famili

HOLISTIC APPROACH

The reconstruction program has been designed to address the needs of beneficiaries comprehensively...



ASSESSMENT OF DAMAGE

- A very ticklish and difficult task
- Preparation of proformas for non-engineered buildings
- Preparation of proformas for reinforced concrete buildings
- Organization of teams for carrying out assessment of damage house by house (the teams consisted of an engineer, a revenue staff and a village head man.
- Establishment of grievance redressal mechanism
- Many issues and problems arose necessitating repeat damage surveys in some areas

A rational and reliable system of damage assessment needs to be developed

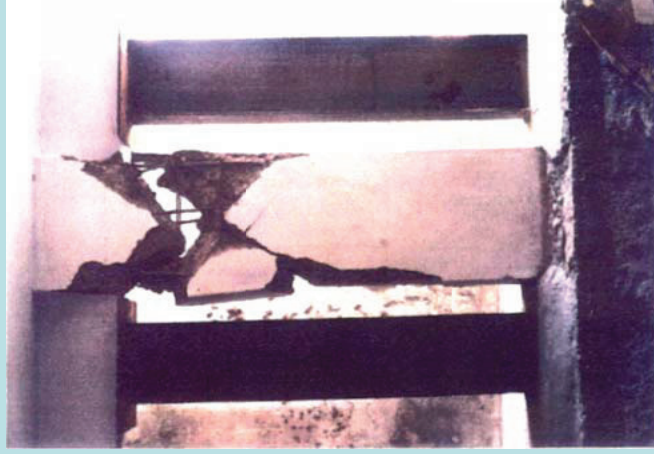
TYPES OF CONSTRUCTION

Non-engineered buildings are those which are spontaneously and informally constructed in the traditional manner without any or little intervention by qualified architects and engineers in their design.

Engineered constructions include reinforced concrete buildings and structures used for various purposes normally designed by Architects and Engineers working in various Govt. departments or consulting organization.

POOR PERFORMANCE OF R.C. BUILDINGS

- (i) *Soft First Storey used without necessary design*
- (ii) *Inadequate Design for Earthquake forces*
- (iii) *Long Period Effect*
- (iv) *Local Soil Condition. Foundation tie beams not used.*
- (v) *Substandard Quality of Materials and Construction*



GOVERNMENT ASSISTANCE PACKAGES

- For reconstruction of non-engineered houses in damage categories G4 and G5 based on areas of the affected houses
- For repair and restoration of damaged houses under categories G1 to G3
- For reconstruction of residences of reinforced concrete buildings
- For repair of residences in reinforced concrete buildings
- For livelihood restoration
- For rehabilitation of industrial undertakings

Estimated Reconstruction Costs

	<i>Rs. in Crores</i>	<i>\$ million</i>
Housing	2692	592
Health	376	83
Education	758	167
Public Infrastructure	2594	570
Industry	1112	244
Livelihood	48	11
Community Participation	60	13
Disaster Management Capacity Building	315	70
Others	249	55
Total	8204	1805

MAJOR SOURCES OF FUNDS

Financial Resource	(Rs. crores)	\$ Million
– World Bank	3341	734
– ADB	1656	364
– European Commission	172	38
– The Netherlands	170	37
– Government of Gujarat & others Governments in India (State and Central)	2417	531

Approach adopted by Gujarat Government

- Total 213685 houses to be reconstructed in 290 villages and four worst EQ affected towns
- Two broad approaches adopted for reconstruction of houses damaged/destroyed by the EQ
 1. Owner Driven Reconstruction (176012 houses 82%)
 2. Public Private Partnership Program (PPPP) (37673 houses 18%)

ISSUES IN RECONSTRUCTION, RESTORATION AND RETROFITTING OF BUILDINGS

- Ensuring Earthquake Resistance
- Available Technical know how
- Development of Appropriate guidelines
- Appropriate Awareness Creation
- Capacity building for carrying out the works
- Control and assurance of required quality of construction
- Facilitation of the constructions through materials banks

Available Technical Know how

A. Indian Standards (Codes/Guidelines)

1. IS: 1893-2002 “Criteria for Earthquake Resistant Design of Structures, Part 1 (Fifth Revision)” July 2002.
2. IS: 13920-1993 “Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces- Code of Practice” November 1993.
3. IS: 1326-1993 “Earthquake Resistant Design and Construction of Buildings- Code of Practice (Second Revision)” October 1993.
4. IS: 13828-1993 “Improving Earthquake Resistance of Low Strength Masonry Buildings-Guidelines” August 1993.
5. IS: 13827-1993 “Improving Earthquake Resistance of Earthen Buildings-Guidelines” October 1993.
6. IS: 13935-1993 “Repair and Seismic Strengthening of Buildings-Guidelines” November 1993.

B. International Monographs

1. Arya A.S. et al, *Earthquake Resistant Non-Engineered Construction*, Monograph pub. by International Association for Earthquake Engineering, 1980, Revised 1986.
(translated into Spanish for use in various Spanish countries).
2. Arya A.S. *Construction of Educational Buildings in Seismic Areas*, Digest No. 13, pub. by UNCSCO, Bangkok, 1987
(translated into Persian for use in Iran).

C. Guidelines Published by Gujarat State Disaster Management Authority, By 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.

Reconstruction through NGOs

- The decision on the relocation/in-situ reconstruction of the village is passed through Gramsabha (all voting adults of the village)
- The relocation of village is done only when the majority of the community agrees on it.
- Only 5225 houses (2.5% of the total) are fully relocated
- 10299 houses (5% of the total) are partially relocated
- For rest of the houses, reconstruction is done in-situ

Owner-driven Reconstruction

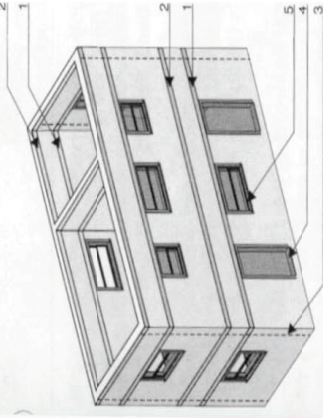
- Houses constructed by the owners themselves
 - It ensures that the design of the houses are determined by the owners themselves, as per their needs and preferences
 - Also ensures that instead of being uniform, the houses reconstructed are of different patterns as found in case of organic evolution of the common villages
- Approach ensures 'Technology Transfer' to the community and subsequently the sustainability of program.

Owner-Driven Reconstruction

- Financial, technical & material assistance provided by the government
- The designs for seismic reconstruction of houses provided by the government
- The material assistance provided through 1082 material banks (cement bags and other materials provided at subsidised rates)
- More than 180 public consultations held for town planning.
- Design of 20 model houses provided to the public to choose from with an option to have one's own design

* यहां (टीए) सरिये का व्यास दिया गया है।

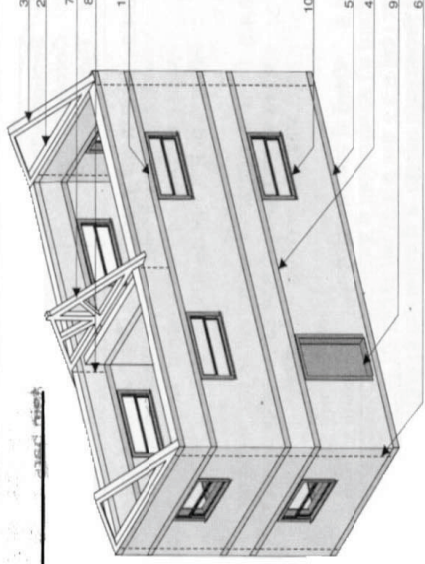
* Diameter specified here for H.S.D. (TOR) bars.



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

Examples



Restoration and Seismic Retrofitting of Existing Buildings & Infrastructure Elements

(i) Identification of Critical Buildings

- Educational Buildings
- Health Buildings
- Other Community Buildings
- Buildings used for Gathering - Cinemas, Marriage Halls
- Religious Buildings – Temples, Mosques, Churches
- Disaster Management Staff Quarters & V.I.P Residences, etc

(ii) Infrastructure Elements

- Water Supply Structures
- Electric Sub-Stations
- Telephone Exchanges
- Railway Stations
- Fire Stations
- Airport Structures, etc.

(iii) Awareness, Incentives & Disincentives to the People

AWARENESS CREATION

- **Publications**
- **Public Displays**
- **Demonstrations**
- **Audio-Visual**
- **Trainings and Workshops**
- **Exhibitions**

AWARENESS CREATION

- **4 Shake Table Demonstrations** and video shows
- Displayed messages on hazard resistant construction on **600 state transport buses** in five worst affected districts.
- Seven types of **hoardings** at strategic locations in the state
- Disaster management taken as permanent agenda in **18000 Gram Sabhas** conducted during a period from 12th Jan'03 to 24th Jan'03 and in May '03
- A cell started in collaboration with BhADA and UNNATI to encourage people's active participation in the urban reconstruction & to link people with govt. set up thereby encouraging seismically safe reconstruction
- **Telemedicine software** to be installed at Ahmedabad Civil Hospital and one remote area



Shock No: I I ,T.M Collapse ,I.M End Wall Cracked



Improved Building Ready For Shock No: 14

AWARENESS CREATION

- Exhibitions conducted on safe construction; disaster reduction; disaster preparedness; progress of GEERP
- **Information dissemination** through
 - Pamphlets, Nirdeshika, posters, seismic construction guidelines by Dr. Arya, training literature, pocket booklets, booklets, handbills, press advertisements etc.
 - CDs on progress, video and audio cassettes on multi-hazard resistant construction using folk music, street plays, dance, jokes etc.
 - A **calendar** has been printed for awareness regarding “Do’s and Don’ts in wake of disasters”.
 - Publication of Plain Truth.

AWARENESS CREATION

EXTRA COST OF EARTHQUAKE SAFETY

Buildings constructed using the Indian Standard Codes and *Masonry*

Building

Seismic Zone III 2-3%

Seismic Zone IV 3-4%

Most severe seismic Zone V 4-6%

Reinforced concrete buildings of 4 – 8 storeys

Seismic Zone III 2.6-3.2%

Seismic Zone IV 3.2-4%

Seismic Zone V 5-6%

(in each case, including about 0.7% only for ductile detailing)

*Retrofitting of buildings, not initially designed for earthquake will cost:
2 to 3 times as much as the above mentioned costs.*

CAPACITY BUILDING

- In more than 50 training programmes, 6563 engineers and 29679 masons have been trained
- Workshops conducted for training engineers
- Q&A booklet based on various queries distributed.
- Five Booklets on Reconstruction and Retrofitting guidelines.
- Advertisements in local newspapers on earthquake resistant construction.
- Videocassettes on earthquake resistant designs and techniques shown on local cable television

Capacity Building Workshops and Training

- Training programs on multihazard resistant construction by IIT, Mumbai & Kanpur
- Training at Gandhinagar and Bhuj by International experts
- 3 days training program with NCCBM
- Capacity building hands-on training on reconstruction and retrofitting

RECONSTRUCTION HIGHLIGHTS

- Third party quality audit, NCCBM inspected 2,10,210 houses
- Payment of installments after engineers' certification
- Grievance redressal at village and district levels
- Insurance to 14 types of hazards
- Payment made directly in bank accounts
- Excise duty exemption for building materials procured in Kutch
- Minimal relocation and secondary displacement
- Choice of relocation decided by village community
- Multi-hazard resistant reconstruction
- 1082 material banks distributed over 18 Mn cement bags

Social Buildings through Community Participations

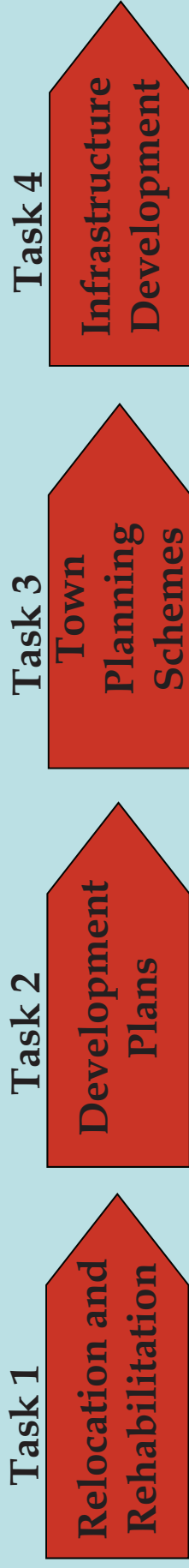
- Village Civil Works Committee constituted for repair of schools in rural areas
- over 42000 primary school rooms repaired so far through the committee
- Ward Civil Works Committee formed to repair schools in urban areas
- 1426 school rooms restored through the committee

PHYSICAL INFRASTRUCTURE

- **POWER**
 - Strengthening of transmission lines, equipment, distribution network
 - 252 staff quarters to be reconstructed
- **RURAL WATER SUPPLY**
 - 19 Rural and Bulk Water Supply Schemes
 - 794 villages and 22 towns will be covered
 - 1332 kms of pipeline laid, work of laying 536 Kms of pipe line
- **PUBLIC BUILDINGS**
 - 8,762 buildings restored, work of 2606 buildings is in progress
 - Out of 4,266 undamaged buildings to be retrofitted, 203 are completed
- **ROADS & BRIDGES**
 - 1470 km of roads strengthened, 144 bridges restored
- **DAMS & IRRIGATION**
 - Emergency repairs of 245 dams completed
 - Redesign of 222 dams completed

URBAN INFRASTRUCTURE

Tasks involved in urban reconstruction



- Development plans completed for 4 towns
- Town planning completed for 3 towns
- Modern Infrastructure facilities for 14 towns
- Outer ring road, middle ring road, radials, and grid roads are well planned on 'Equipment Based Technology'
- Wider roads to facilitate evacuation in case of emergency
- Water supply and sewerage system designed in view of population growth up to 2021

Community Participation Measures

- Formation of more than Self Help Groups (SHGs) to ensure knowledge percolation, coordination of activities and communication linkages between diff. Stakeholders.
- 106 Women's SHG formed for the restoration of livelihood
- Livelihood restoration programs do not aim only at women's financial independence but also empowering them by imparting proper training

LIVELIHOOD REHABILITATION

RURAL AND COTTAGE INDUSTRY

- Assistance given in the form of handlooms; subsidy to self employed persons; working capital; toolkits to artisans, masons, handicraft artisans
- 77,963 artisans have benefited, assistance is being provided to 5,997 artisans

INDUSTRY

- Assistance given in the form of subsidy assistance to small industries; cash assistance to small cabins and shops; subsidy and interest subsidy to service and trade units
- 18,125 units have benefited, assistance is being provided to 1,607 beneficiaries

LIVELIHOOD REHABILITATION

AGRICULTURE

- Assistance given in the form of input kits; irrigation assets; pucca structures on farms
- 1,83,036 units have benefited

WOMEN'S LIVELIHOOD

- Livelihood activities such as agriculture, tailoring, handcart, trading, animal husbandry, catering, flour mill; Trainings; Working Capital etc
- 9993 women have benefited, total 15,000 women to be covered

Towards Effective Disaster Reduction

Studies in progress:

- Review of Buildings Codes
- Damage & Loss Assessment
- Earlier Warning and Communication System
- Establishment of Emergency Response Centres
- Hazard Risk and Vulnerability Assessment
- Seismic Microzonation
- Information Technology for Disaster Management
- Setting up of Gujarat Institute of Disaster Management

A SUCCESS STORY

- A comprehensive reconstruction and rehabilitation program
- Progress during the first two years, no parallel elsewhere
- Involvement of expertise Awareness, capacity building and information dissemination
- and specialized knowledge of institutions and individuals
- Effective community participation
- Medium and long-term perspective

Awareness and Sensitization of Various Stakeholders

Practically all sectors such as

- houses,
- public buildings,
- other buildings (old type RC),
- roads,
- water supply,
- electricity,
- gas supply etc.

Which can be damaged/destroyed adversely affecting the functioning of the society needs to be sensitised.

Conclusion

Contd.

The main steps followed in the reconstruction programme of Gujarat Earthquake can be summarized as follows:

- i) Establishment of '*organizational structure*' in the first month of earthquake occurrence.
- ii) Detailed damage assessment in the affected area.
- iii) Estimate of required funds and preparation of assistance packages, and procurement of necessary funds.
- iv) Adopt holistic approach for disaster reduction covering: housing (Rural and Urban), education, health, physical infrastructure, livelihood and social rehabilitation.
- v) Decide reconstruction approaches:
 - a) owner driven b) public-private-partnership.
- vi) Capacity buildings (Engineers, Masons, NGOs. Other stake holders).
- vii) Creating awareness at all levels particularly beneficiaries.
- viii) Conference Buildings through shake table field test.
- ix) Social and livelihood building through community participation.

Thank You