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

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Former National Seismic Advisor (EVR)
GOI-UNDP-DRM Program

22.03.2010 at USA
KACHCHH EARTHQUAKE IN GUJARAT

Date of Occurrence : 26\textsuperscript{th} January 2001

Time : 8.46 a.m.

Epicenter : 23.6\textdegree North Latitude and 69.8\textdegree 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
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
POWER PLANT SWITCH YARD
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

Over 50,000 School rooms damaged / destroyed

Bhuj General Hospital

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

Indirect losses

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

Tertiary losses

- Long-term development
- Overall investment climate
- Funds reallocation
- Community migration/relocation

Gujarat earthquake

- Estimate: Rs 15308 Crores
- Estimate: $3364 Mn

- Estimate: Rs 3047 Crores
- Estimate: $670 Mn

- Estimate: Rs 10067 Crores
- Estimate: $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

Mitigation
Planning, Monitoring, Implementing

Reconstruction
Planning and Program Management

Emergency Response

Guidance & Monitoring
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

• International rescue teams arrived: Netherland, France, Japan, Ukrain, 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, Ukrain, 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, household 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 families
HOLISTIC APPROACH

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

- Physical Infrastructure
- Housing
- Social & Economic Rehabilitation
- Livelihood Rehabilitation
- Urban Reconstruction
- Education
- Health
- Capacity Building

Holistic Reconstruction & Rehabilitation
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 erose 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Rs. in Crores</th>
<th>$ million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>2692</td>
<td>592</td>
</tr>
<tr>
<td>Health</td>
<td>376</td>
<td>83</td>
</tr>
<tr>
<td>Education</td>
<td>758</td>
<td>167</td>
</tr>
<tr>
<td>Public Infrastructure</td>
<td>2594</td>
<td>570</td>
</tr>
<tr>
<td>Industry</td>
<td>1112</td>
<td>244</td>
</tr>
<tr>
<td>Livelihood</td>
<td>48</td>
<td>11</td>
</tr>
<tr>
<td>Community Participation</td>
<td>60</td>
<td>13</td>
</tr>
<tr>
<td>Disaster Management Capacity Building</td>
<td>315</td>
<td>70</td>
</tr>
<tr>
<td>Others</td>
<td>249</td>
<td>55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8204</strong></td>
<td><strong>1805</strong></td>
</tr>
</tbody>
</table>
## MAJOR SOURCES OF FUNDS

<table>
<thead>
<tr>
<th>Financial Resource</th>
<th>(Rs. crores)</th>
<th>$ Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Bank</td>
<td>3341</td>
<td>734</td>
</tr>
<tr>
<td>ADB</td>
<td>1656</td>
<td>364</td>
</tr>
<tr>
<td>European Commission</td>
<td>172</td>
<td>38</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>170</td>
<td>37</td>
</tr>
<tr>
<td>Government of Gujarat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&amp; others Governments in India</td>
<td>2417</td>
<td>531</td>
</tr>
<tr>
<td>(State and Central)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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)

B. International Monographs

   (translated into Spanish for use in various Spanish countries).

   (translated into Persian for use in Iran).
C. Guidelines Published by Gujarat State Disaster Management Authority, By A.S.Arya


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
Examples

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lintel band</td>
</tr>
<tr>
<td>2</td>
<td>Roof/lood band</td>
</tr>
<tr>
<td>3</td>
<td>Vertical bar at corner</td>
</tr>
<tr>
<td>4</td>
<td>Door</td>
</tr>
<tr>
<td>5</td>
<td>Window</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lintel band</td>
</tr>
<tr>
<td>2</td>
<td>Eave level (Roof) band</td>
</tr>
<tr>
<td>3</td>
<td>Gable band</td>
</tr>
<tr>
<td>4</td>
<td>Floor band</td>
</tr>
<tr>
<td>5</td>
<td>Plinth band</td>
</tr>
<tr>
<td>6</td>
<td>Vertical bar</td>
</tr>
<tr>
<td>7</td>
<td>Rafter</td>
</tr>
<tr>
<td>8</td>
<td>Holding down bolt/Vertical bar</td>
</tr>
<tr>
<td>9</td>
<td>Door</td>
</tr>
<tr>
<td>10</td>
<td>Window</td>
</tr>
</tbody>
</table>
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
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*

<table>
<thead>
<tr>
<th>Seismic Zone</th>
<th>Cost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>2-3%</td>
</tr>
<tr>
<td>IV</td>
<td>3-4%</td>
</tr>
<tr>
<td>Most severe seismic</td>
<td>4-6%</td>
</tr>
</tbody>
</table>

*Reinforced concrete buildings of 4 – 8 storeys*

<table>
<thead>
<tr>
<th>Seismic Zone</th>
<th>Cost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>2.6-3.2%</td>
</tr>
<tr>
<td>IV</td>
<td>3.2-4%</td>
</tr>
<tr>
<td>V</td>
<td>5-6%</td>
</tr>
</tbody>
</table>

( 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

- **Task 1**: Relocation and Rehabilitation
- **Task 2**: Development Plans
- **Task 3**: Town Planning Schemes
- **Task 4**: Infrastructure Development

- 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 different 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 REHABILITAION

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

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 stakeholders).

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