UNIT 1 EARTHQUAKE

Structure

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1.0 OBJECTIVES

After studying this Unit, you should be able to:

• discuss some of the damaging earthquakes that have occurred in recent years in India;
• describe the important aspects of rescue and relief in the areas affected by earthquake;
• highlight the lessons learnt from these earthquakes and identify the seismic zones in the country; and
• understand the government action pertaining to relief and rehabilitation.

1.1 INTRODUCTION

Earthquakes are one of the most dangerous and instantaneously destructive natural hazards. The impact of the earthquake phenomenon is sudden with hardly any warning. It is not possible to forecast earthquakes in terms of exact time of occurrence, place of occurrence and magnitude of the event. Thus, such a situation gives no time for making preparations at that stage to reduce the loss of lives and property. The major damage in case of earthquake takes place in terms of collapse of buildings and damage to infrastructural facilities, disrupting the normal life. Electric short circuits and gas leaks can create big fires and broken water mains and damaged water tanks can lead to severe flooding compounding the misery of the affected community. A large portion of our country is vulnerable to earthquake activity of varying magnitudes. Most of the highly vulnerable areas are in the Himalayan and sub-Himalayan regions, Andaman and Nicobar Islands and Kutch area of Gujarat. These areas have faced at least six earthquakes of magnitude 8+ on the Richter scale in the period of recorded history of earthquakes in the country.

The nature and impact of earthquake disaster is dependent upon a number of factors including its magnitude, geological and soil conditions, location of fault, construction of major structures and prevailing construction practices in the particular areas. The occurrence of earthquakes of significance is increasingly felt even in regions that were earlier considered less vulnerable to earthquakes. For example, the Latur earthquake of September 30, 1993, occurred in seismic zone one. As per the seismic zone map of the country, this area was considered to be less active seismically. On the other hand, the devastating earthquake at Bhuj (Gujarat) on January 26, 2001 occurred in a highly prone area. Thus, no place seems to be free from the fear of earthquakes, big or small. Hence it is essential to have a good understanding of this phenomenon in the Indian context.
Earthquakes are categorized according to their magnitude in five categories as follows:

- Less than 3 in magnitude: Mild, micro or tremor;
- 3 to 4.9: slight;
- 5 to 6.9: moderate;
- 7 to 7.9: great; and
- 8 or more: very great

India has a very long history of earthquakes. The occurrence of earthquake is not a new phenomenon for most of the northern parts of our country. In the past we have already faced some major earthquakes like Rann of Kutch (1819) magnitude 8.0, Assam (1897) magnitude 8.7, Kangra (H.P.) (1905) magnitude 8.0, Bihar-Nepal border (1934) magnitude 8.4, Andaman Islands (1941) magnitude 8.0 and Assam (1950) magnitude 8.6. Besides these major earthquakes, a large number of other moderate and minor earthquakes have been experienced in different parts of the country. In the recent past, India experienced major earthquakes at Uttarkashi (1991), Latur (1993) and Jabalpur (1997), Chamoli (1999) and Bhuj (2001). In this section we will discuss in detail a few of these recent earthquakes.

### 1.2.1 Uttarkashi Earthquake

<table>
<thead>
<tr>
<th>Magnitude of the Earthquake</th>
<th>6.6 on Richter Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of occurrence</td>
<td>20 October, 1991</td>
</tr>
<tr>
<td>Focal depth</td>
<td>12 km</td>
</tr>
<tr>
<td>Epicenter</td>
<td>Village Agora (30.7° N, 78.68° E)</td>
</tr>
<tr>
<td>Time of occurrence</td>
<td>02h 53m 16s</td>
</tr>
<tr>
<td>People killed</td>
<td>770</td>
</tr>
<tr>
<td>People injured</td>
<td>5000</td>
</tr>
<tr>
<td>Cattle head lost</td>
<td>3100</td>
</tr>
<tr>
<td>Houses fully destroyed</td>
<td>20184</td>
</tr>
<tr>
<td>Houses partially damaged</td>
<td>74714</td>
</tr>
<tr>
<td>Villages affected</td>
<td>2093</td>
</tr>
<tr>
<td>Affected property</td>
<td>425000</td>
</tr>
</tbody>
</table>

#### a) Seismic History of the Region

The earthquake affected area has a known history of earthquake occurrence. In the last 100 years, this region had experienced about eleven earthquakes of magnitude ranging 6.0 and 6.6 on Richter scale. The return period for the earthquake of similar magnitude is about 8-9 years. The entire area is under seismic zones IV and V with a higher vulnerability for seismic losses.

Widespread damage took place due to this earthquake. The detailed break-up of the damage under various categories grouped by Districts is given in Table 2.
Table 2: Damage Due to Uttarkashi Earthquake 1991

<table>
<thead>
<tr>
<th>District</th>
<th>Affected Villages (No.)</th>
<th>Affected Population (in lakh)</th>
<th>Damaged Houses Fully</th>
<th>Damaged Houses Partly</th>
<th>Human Lives lost</th>
<th>Injured Persons</th>
<th>Cattle loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uttarkashi</td>
<td>601</td>
<td>2.50</td>
<td>14857</td>
<td>19811</td>
<td>653</td>
<td>4710</td>
<td>562</td>
</tr>
<tr>
<td>Tehri Garhwal</td>
<td>605</td>
<td>1.00</td>
<td>4730</td>
<td>21954</td>
<td>63</td>
<td>43</td>
<td>71</td>
</tr>
<tr>
<td>Chamoli</td>
<td>699</td>
<td>0.72</td>
<td>573</td>
<td>1973</td>
<td>2</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Dehradun</td>
<td>116</td>
<td>0.02</td>
<td>26</td>
<td>452</td>
<td>-</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>Pauri Garhwal</td>
<td>72</td>
<td>0.01</td>
<td>34</td>
<td>449</td>
<td>-</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Nainital</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>2093</td>
<td>4.25</td>
<td>20222</td>
<td>44643</td>
<td>718</td>
<td>4774</td>
<td>657</td>
</tr>
</tbody>
</table>


i) Damage to Buildings/Houses:

The buildings/houses in the earthquake affected area can be classified into (a) engineered and (b) non-engineered structures. It has been observed that the performance of these two types of buildings during the earthquake was different. The non-engineered buildings found throughout the rural areas and the old stone buildings in the towns suffered severe damage. The engineered buildings were also there in the earthquake affected area such as the buildings in the irrigation project colony at Maneri and Indo-Tibetan Border Police Colony at Mahitanda. Buildings in both these colonies faced the earthquake in a very safe manner and suffered no damage, except for minor cracks in the buildings that were observed.

ii) Damage to Infrastructural Facilities

Large scale damage to infrastructural facilities took place in the earthquake affected area. The damage to roads was due to rockfall, landslides and rock-slides along the road side slopes causing heavy damage to road network in the earthquake affected areas. The other services like communication network and power supply system were affected very badly due to the severe damage to telephone and electric poles. In case of social infrastructure, the buildings that house health and education facilities had suffered damage. The surface water tanks at Uttarkashi and Maneri did not suffer any damage, however, the joints in the piped supply lines failed due to ground shaking, resulting in disruption of the water supply in certain areas for quite some time.

iii) Damage to Bridges:

Due to difficult terrain a large number of bridges were located to cross the rivers and deep river valleys throughout the hilly area. The performance of steel bridges was found satisfactory except the Gawana bridge on the road to Gangotri about six km from Uttarkashi. The stone
b) Rescue and Relief

It was quite a difficult task for the administration to organise relief work just after the earthquake due to heavy damage to roads, communication network and bridges, etc. The prime issue involved in the first stage of rescue and relief was to reach the affected village with necessary relief materials like food, warm clothes, medicines, etc. For this purpose, the army and other para military forces like Border Security Force (BSF), Indo Tibetan Border Police (ITBP) along with the services of Directorate General for Border Roads (DGBR) were pressed into service. A large number of other social groups like NCC cadets, NSS volunteers, Task Force of Uttarkashi administration and several NGOs also came forward to help the local administration in the rescue and relief operations. To reach the inaccessible villages, the services of five heavy and seven light army helicopters were utilised immediately after the earthquake. The DGBR took up the challenge of repairing the damaged roads on a war footing. The government provided food items like flour, pulses, rice, oil, sugar, milk, sliced bread, etc. As the winter season was approaching fast, it was not possible to reconstruct all damaged houses; hence community centres were immediately constructed to provide shelter to the affected community. Besides the community centres, tin sheets, tarpoline and tents along with blankets were distributed free of cost to protect people from the cold. The district wise distribution of these items is given in the Table 3.

Table 3: Distribution of Relief Materials

<table>
<thead>
<tr>
<th>Districts</th>
<th>Tin Sheets</th>
<th>Tarpoline/Tents</th>
<th>Blankets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uttarkashi</td>
<td>338241</td>
<td>33123</td>
<td>102277</td>
</tr>
<tr>
<td>Tehri Garhwal</td>
<td>170280</td>
<td>8792</td>
<td>25093</td>
</tr>
<tr>
<td>Chamoli</td>
<td>11576</td>
<td>620</td>
<td>3654</td>
</tr>
<tr>
<td>Dehradun</td>
<td>776</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>520873</td>
<td>42535</td>
<td>131024</td>
</tr>
</tbody>
</table>

Source: Department of Revenue and Relief, Govt. of U.P. Lucknow

To provide relief to the people, who had lost everything as a result of this earthquake, the government had issued orders to pay each family Rs. 750/- per month from November, 1991 to January, 1992. Later on, this amount was raised to Rs. 1000/- per family. This amount included the cost of 20 kg of food items, one blanket per person up to a maximum of 5 blankets per family and a cash subsidy of Rs. 200/- per unit per family.

a) Reconstruction of Earthquake Affected Area

In order to reconstruct the houses which had been damaged completely by the earthquake, a detailed district wise scheme was drawn up. The finances for this scheme were procured from HUDCO and under Indira Awas Yojna. The details of the reconstruction and the progress reported up to April 1994 is given in Table 4.
Table 4: Uttarkashi Reconstruction under HUDCO Loan and Indira Awas Yojna (upto April, 94)

<table>
<thead>
<tr>
<th>District</th>
<th>HUDCO</th>
<th>Indira Awas Yojna</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Houses Under Construction</td>
<td>Houses Under Construction</td>
</tr>
<tr>
<td>Uttarkashi</td>
<td>11798</td>
<td>2816</td>
</tr>
<tr>
<td>Tehri Garhwal</td>
<td>3479</td>
<td>954</td>
</tr>
<tr>
<td>Chamoli</td>
<td>243</td>
<td>93</td>
</tr>
<tr>
<td>Total</td>
<td>15520</td>
<td>3863</td>
</tr>
</tbody>
</table>

Source: Department of Revenue and Relief, Govt. of U.P. Lucknow

1.2.2 Latur Earthquake

An earthquake of moderate magnitude of 6.4 (on Richter scale) struck the Marathwada region of Maharashtra state on 30th September 1993. The impact of this earthquake was felt in the adjoining states of Andhra Pradesh and Karnataka also. In all, eight districts in Maharashtra and three districts in Karnataka have been affected. However, the severely affected areas were mainly the Latur and Osmanabad districts of Maharashtra. The total area affected due to this earthquake was about 52,000 sq. km. The fact sheet of the earthquake is given in Table 5.

a) Seismic History of the Region

The major portion of the earthquake affected area lies in zone one of the seismic zone map of India. Accordingly, prior to this earthquake this area was considered relatively safe from the earthquake point of view because geologically speaking, it was located in a stable continental region (SCR). The village Killari, where the impact of the earthquake was most severe, had earlier also, prior to this earthquake experienced small tremors in 1962, 1967, 1983 and 1992. In 1992, about 125 tremors were felt between August and October 18-19,1992.

Damage due to Latur Earthquake

Widespread damage took place due to this earthquake. About 25 villages around the epicenter of the earthquake were damaged very severely while another 58 villages suffered severe damages. The entire region had a traditional system of dwelling unit construction which involved heavy stone walls, and a massive roof over the wooden timber sub-structure. The wall has been constructed in such a manner that it could not resist the impact of any earthquake. During the earthquake most of the houses were destroyed causing death of people in large numbers as also a wide spread damage to installations and properties in the affected areas as indicated in Table 5.

Table 5: Fact Sheet of Latur Earthquake

| Magnitude of the earthquake | 6.4 on Richter Scale |
| Date of occurrence          | Sep. 30,1993         |
| Focal depth                 | 15Km.                |
| Epicenter                   | Village Killari (76.34°E, 18.03°N) |
| Time of occurrence          | 3h, 55m, 47.5 S      |
| People killed               | 11484                |
| Cattle head lost            | 14845                |
| Houses fully damaged        | 34313                |
| Houses partially damaged    | 16.5 lakh            |
| Villages affected           | 95.8                 |
| Affected property           | 30000                |
Besides the housing, other infrastructural facilities also received severe damages. The infrastructural losses incurred in the two worst affected districts of Latur and Osmanabad are shown in Table 6.

### Table 6: Infrastructural losses due to Latur Earthquake

<table>
<thead>
<tr>
<th>Types of Infrastructure</th>
<th>Amount Lost (Rs. in Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Latur</td>
</tr>
<tr>
<td>Electric Installation</td>
<td>3.90</td>
</tr>
<tr>
<td>Water Supply System</td>
<td>7.20</td>
</tr>
<tr>
<td>School buildings</td>
<td>35.50</td>
</tr>
<tr>
<td>Samaj Mandirs</td>
<td>3.70</td>
</tr>
<tr>
<td>Health Department Buildings</td>
<td>14.44</td>
</tr>
<tr>
<td>PWD Buildings</td>
<td>12.80</td>
</tr>
<tr>
<td>Gram Panchayat Buildings</td>
<td>4.00</td>
</tr>
<tr>
<td>Total</td>
<td>81.54</td>
</tr>
</tbody>
</table>

Source: Government of Maharashtra Rehabilitation Proposals

**b) Rescue and Relief:**

In the aftermath of the earthquake an overwhelming response by administration, voluntary organisations and local community was noticed. Army services were pressed into action for the rescue operation. This involved clearance of rubble, rescuing the injured, removal and cremation of dead bodies. The army personnel had succeeded in rescuing about 9000 people. Along with the treatment of injured, medical teams were deputed to take up the preventive measures against the spread of any epidemic. Provisions were made for temporary relief shelters to the survivors of the earthquake. These shelters were made up of G.I. (galvanized iron) sheeted roofs over the bamboo or wooden frames. About 30,000 families were provided the temporary shelters in the two worst affected districts of Latur and Osmanabad.

**c) Rehabilitation of Earthquake Affected Area:**

The Government of Maharashtra had started a very ambitious programme for the rehabilitation of the earthquake affected area. The Maharashtra Earthquake Reconstruction Project (1993) was one of the most comprehensive reconstruction and mitigation projects ever taken up in India. It encompassed all aspects of complete rehabilitation. This programme had the following components.

**i) Housing Construction and Repair**

Under the rehabilitation programme, about 49 villages were rehabilitated on new sites with 23000 houses and all necessary infrastructure and amenities. About 29,600 houses were reconstructed while 1,80,000 houses were retrofitted, for better earthquake resistance.

**ii) Infrastructure**

This comprised repair, reconstruction and strengthening of public buildings and other infrastructure including schools, health centres, social service facilities, roads, bridges, etc.
iii) Economic Rehabilitation

This included the replacement and reconstruction on a grant basis, of business losses/agricultural losses like minor equipment, bullocks, milch cattle, sheep, goats and repair and reconstruction of dry wells.

iv) Social Rehabilitation

Under this head provision was made for special facilities and activities to address the needs of women and children affected by the earthquake along with the improvement of various facilities in all the affected districts. The restoration of various social facilities have been taken up like old age homes, balika sadans, homes for handicapped, community centres for women etc.

v) Community Rehabilitation

Under this, provisions were made for the cost of works and materials to re-establish essential services within the affected community.

vi) Technical Assistance, Training and Equipment

Under this the provisions were for design, supervision and monitoring of project components. The component also included the development of a disaster management programme for the state of Maharashtra and a seismic monitoring and research programme for the Government of India.

1.2.3 Bhuj Earthquake

On January 26, 2001, when the nation had just started the Republic Day celebrations, a devastating earthquake struck near Bhuj in the Kachchh region of Gujarat around 0845 hours in the morning. The magnitude of this earthquake was 6.9 on the Richter scale and it was the borderline earthquake between the “moderate” and “great” categories. Hitting a prosperous region of the country, its impacts were truly disastrous. The fact sheet is as in Table 7 below.

<table>
<thead>
<tr>
<th>Table 7: Fact Sheet of Bhuj Earthquake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnitude of the earthquake</td>
</tr>
<tr>
<td>Date of occurrence</td>
</tr>
<tr>
<td>Focal depth</td>
</tr>
<tr>
<td>Epicenter</td>
</tr>
<tr>
<td>Time of occurrence</td>
</tr>
<tr>
<td>People killed</td>
</tr>
<tr>
<td>Cattle head lost</td>
</tr>
<tr>
<td>Houses destroyed</td>
</tr>
<tr>
<td>Houses damaged</td>
</tr>
<tr>
<td>Villages affected</td>
</tr>
</tbody>
</table>

The destruction would have been much more but for the facts that Bhuj is a comparatively less populated area, the earthquake originated at a relatively deeper focus (25 km as compared to the focal depth of 12 km in Uttarkashi earthquake and 15 km in the Latur earthquake), and it occurred at a time when everybody was
awake and most were in the open. Nevertheless, this quake is the worst in the country in recent decades in terms of the persons killed and injured. Gujarat being the second most industrialized state in the country took a heavy beating in terms of adverse socio-economic impacts but it also had the resilience and the will to meet the emergency. The famous Gujarati philanthropy and an abundance of goodwill from across the country channelled relief supplies and services to augment the efforts of the central and state governments. The international aid from governmental and non-governmental sources also came in abundance.

The devastation was considerable in Ahmedabad the biggest city and the commercial and educational capital of the state although it was located km from the epicenter. It was apparent that many multi-storied buildings were constructed in defiance of the engineering norms and land-use regulations. The initial estimates put the total property loss in Gujarat due to this earthquake at around Rs. 15,000/- crore.

Check Your Progress 1

Note:  

i) Use the space given below for your answers

ii) Check your answers with those given at the end of the Unit.

1) Highlight the damage occurred due to the Uttarkashi Earthquake to buildings, infrastructural facilities and bridges.

2) How was the rescue and relief organised in the areas affected by the earthquake?

3) List the main components of the Maharashtra Earthquake Reconstruction Project launched in 1993.
1.3 LESSONS LEARNT FROM THE PAST EXPERIENCES

The most important lesson learnt by studying the past occurrences of earthquakes is that it has become possible to delineable seismic zones in the country as shown in Fig. 1.

It will be seen that the country is divided into five seismic zones with zone 5 being the most vulnerable.

The other important lesson from recent studies is that these appears to be an increase in the occurrence of earthquakes in recent years although there is no apparent scientific reason for this. If we take into account the earthquakes of magnitudes 6.0 and more i.e. those earthquakes that caused damage to life and property, India has experienced one such earthquake once in two years during the last 14 years. On the other hand during the 25 years (1950-75), there was one such earthquake in 6 years. In the period before that, such earthquakes occurred roughly once in 13 years during the 130 years period (1820-1950).

On the disaster management side also, if we take care of the various lessons learnt from the past earthquakes, we can minimise considerably the damage resulting from future earthquakes. The following are a few points which emerged as a result of a study of past earthquakes.
Increased Understanding of Disasters

a) Disaster Management

i) After every earthquake, it becomes evident that the preparation to face the calamity is almost negligible. This fact has been faced again and again. In order to avoid such situations after the occurrence of earthquakes, we must start the requisite preparations for facing the event. We can achieve this through “action plans” prepared for different regions of the country. These plans must be tested for their effective functioning and must be evaluated and updated regularly according to the changing requirements.

ii) After every earthquake, a lot of relief material is sent by various voluntary groups, administration etc. Lack of coordination in the collection and proper distribution of such relief materials is very commonly felt after every earthquake. Mechanism has to be developed to ensure proper distribution of relief material.

iii) The narrow streets of the affected areas get blocked by the debris, preventing the escape routes for the affected community on one hand and on the other, hampering the rescue and relief operations during the emergency period. Similarly, the approach roads get blocked due to landslide and bridge failure in the aftermath of the earthquake in hilly regions. Alternative methods/techniques must be identified for providing the necessary relief materials like food, clothes, medicine, evacuation of injured, etc.

iv) People do not know adequately about the earthquake resistant features in house construction as well as the necessary precautions to be taken during the different stages of earthquake management. For achieving this, awareness campaigns have to be started on a very large scale.

v) Awareness and sensitization process should start from schools and through Panchayats and NGOs.

b) House Construction

i) Buildings with light weight building materials like timber, bamboo etc., performed better than the heavy material buildings like stone, brick etc. Hence, to improve the performance of buildings, light weight building materials should be adopted.

ii) The performance of buildings with irregular layouts is not satisfactory during the earthquakes, so buildings with simple, regular layouts must be constructed.

iii) The performance of non-engineered buildings was not found satisfactory during the earthquakes. So, the buildings should be designed by qualified engineers and the construction of these buildings should be done as per the provisions in the code. It has been estimated that constructing an earthquake resistant building adds only about 10% to the construction cost of a building.

iv) The collapse of heavy roofs is one of the major causes for heavy loss of lives during the earthquakes. So, the light material roofs with proper connections to the wall systems must be adopted. The performance of properly laid RCC slabbled roofs was found quite satisfactory. If possible, RCC slabs must be provided for roofs.

1.4 GOVERNMENT ACTION PERTAINING TO RELIEF AND REHABILITATION

Disaster management is the responsibility of the state governments in India. Every state has framed regulations to provide relief and rehabilitation to the affected community during and after the disaster situations.
The basic purpose of relief measures taken up by the state government is to provide immediate relief to the affected community not compensating fully for the losses incurred due to natural calamity. In case of earthquakes, the relief measures in terms of economic help can be taken up under the following heads:

i) damaged crops  
ii) cattle loss  
iii) clothes and utensils  
iv) ex-gratia payment to the next of kin of the deceased persons and also to the injured  
v) injured persons  
vi) provision for free food in the temporary relief camps  
vii) damaged agricultural implements  
viii) damaged houses

The amount of relief provided by various states during the time of calamity differs from state to state. For example in the case of the Jabalpur earthquake on May 22, 1997, the state government had taken up the following relief measures for the affected community.

i) It started 23 relief camps (12 in rural and 11 in urban areas) for 35256 affected people. Food was distributed free of cost in all these camps.

ii) The forest department of Madhya Pradesh provided bamboos and wooden logs free of cost to the victims of the earthquake, for temporary shelters in the affected villages.

iii) A sum of Rs.1,00,000/- was provided to relatives of the dead persons due to this earthquake.

iv) A sum of Rs.2,000/- to Rs.10,000/- was provided to the injured persons, depending upon the severity of injury.

v) A sum of Rs.3,000/- has been given to the house owners and tenants of the partially damaged houses.

vi) For the persons whose houses had been damaged fully, a grant of Rs.18,000/- and other necessary materials like bamboo and wooden logs etc. for reconstruction of houses were provided.

Check Your Progress 2

Note:  
i) Use the space given below for your answers.  
ii) Check your answers with those given at the end of the unit.

1) Discuss in brief, the measures that can be taken to minimise damage caused by earthquakes in future.
2) What necessary steps can be adopted towards construction of earthquake resistant houses?

3) What is the basic purpose of relief measures taken up by the state government in providing relief to people in case of earthquake? List the various heads of giving economic relief.

1.5 LET US SUM UP

India has a long history of major earthquakes particularly in the Himalayan Region. Earthquakes, as we have learnt in this Unit, cause extensive damage to buildings, infrastructural facilities, bridges etc. and result in loss of life and limb. Fire and flooding can follow an earthquake. In any such calamity, the prime issue is organising rescue and relief to the affected. The Maharashtra Earthquake Reconstruction Project embarked by the government in 1993, encompassing all aspects of rehabilitation was a significant measure in this direction. This unit has also highlighted the need to learn from past experiences to minimise the damage resulting from earthquakes whose frequency of occurrence appears to be on the increase.

1.6 KEY WORDS

**Ex-gratia**  :  As an act of grace or favour, without further responsibility or liability.

**Engineered Buildings**  :  These are those structures that have been designed taking into account the various effects that would be caused due to earthquake.

**Non-Engineered Buildings**  :  These are buildings that have been built without any guidance from a qualified professional and generally consist of one/two storey residential buildings.

**Code**  :  Rules, e.g. Building Code which means rules for construction of buildings.
1.7 REFERENCES AND FURTHER READINGS


Department of Earthquake Engineering, *Earthquake Problem, Do’s and Don’ts for Protection*, 1994, University of Roorkee, Roorkee.


1.8 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Your answer should include the following points:

- The non-engineered buildings suffered severe damage.
- Large scale damage to infrastructural facilities especially roads, communication network and power supply system.
- The steel bridges did not suffer much damage except the Gawana bridge on the road to Gangotri.
- The engineered buildings especially those in the irrigation project colony at Maneri and Mahitanda received only minor damage.

2) Your answer should include the following points:

- Necessary relief materials like food, warm clothes, medicines were provided to the affected villages with the help of army and other organizations like the Border Security Force, Indo-Tibetan Border Police and Border Roads Organization.
- The task involved the cooperation of many other social groups like the NCC Cadets, NSS volunteers, NGOs, the task force of Uttarkashi administration.
- Utilisation of five heavy and seven light army helicopters.
- Provision of food items like flour, pulses, rice, oil, sugar, milk, sliced bread etc. by the government.
- Repair of the damaged roads by the Border Roads Organization.
- Reconstruction of community centres to provide shelter to the affected community.

3) Your answer should include the following points:

- Housing construction and repair
- Strengthening of Infrastructure.
- Economic rehabilitation including replacement and reconstruction of dry wells, provision of bullocks, minor equipment etc.
Increased Understanding of Disasters - I

- Social rehabilitation in the form of special facilities for women, children, handicapped.
- Community rehabilitation.
- Provision for technical assistance, training and equipment.

**Check Your Progress 2**

1) Your answer should include the following points:

- Preparation of action plans for different regions of the country and their periodic evaluation and update.
- Development of proper mechanism to ensure proper distribution of relief material.
- Planning of alternate approach routes for the community to escape during emergency.
- Identification of alternative methods/techniques for providing necessary relief materials like flood, clothes, medicines etc.
- Proper campaigns to make people aware of various aspects of earthquake management.
- Making houses and buildings earthquake resistant either through proper engineered design at the construction stage or through retrofitting of the existing non-engineered houses.

2) Your answer should include the following points:

- Use of light weight building materials in the construction of houses.
- Construction of buildings with simple, regular layouts.
- Design of buildings by qualified engineers and their construction as per the provisions in the code.
- Provision for properly laid RCC slabbed roofs.

3) Your answer should include the following points:

- The basic purpose of relief measures taken up by the state government is to provide immediate relief to the community.

The various heads under which economic relief can be provided in case of earthquakes are:

- Ex-gratia payments to the injured and to the next of kin of the deceased
- Damaged crops – compensation for damaged houses
- Cattle loss
- Free medicines, clothes and utensils
- Free food in the temporary relief camps
- Grant to replace damaged agricultural implements.