

Seismic Design of Reinforced Concrete Buildings

(09-10 January 2004)

REPORT



Under GoI-UNDP Disaster Risk Management Programme

Organised by

Government of NCT of Delhi

Office of the Divisional Commissioner

At

Auditorium, PHD Chamber of Commerce and Industry

August Kranti Marg, New Delhi

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A REPORT

Background

Delhi, the national capital is extremely vulnerable to earthquakes. The densely populated areas with large amounts of unsafe building stock, non-engineered structures, sizeable number of unauthorised colonies and urban slums compound vulnerabilities. The syllabi of engineering institutions so far did not have earthquake engineering and hence the practicing engineers, need to be trained in seismic design methods. This workshop was aimed at training the practicing engineers from government and private institutions in designing of earthquake resistant Reinforced concrete buildings.

Key Resource Persons

Prof. Sudhir K Jain, IIT Kanpur
rof. C.V.R Murty, IIT Kanpur

Participants

Around 200 engineers from both central and state government organizations as well as private practicing had participated in the programme, which includes Engineers from DDA, MCD, PWD, NDMC, MES, BSF, CIDC, Indian building Congress, BSNL, NBCC, NTPC, Ircon International Ltd, Punj Lloyd, Indian National Group of International Association of Bridge and Structural Engineers, BIS, DGHS, HUDCO, CWE, DUAC, among others.



Faculty and students from IIT Delhi, Jamia Millia Islamia, Netaji Subhash Institute of technology and Delhi college of Engineering were also invited to give them an exposure to the topic

Venue

The workshop was organised in the Auditorium of PHD Chamber of Commerce and Industry, located in South Delhi at Khelgaon Marg.

Proceedings of the Workshop

DAY 1

09 January 2004 (Friday)

0930-1030 hours: Registration

Registration of participants started at 9.00 AM. Engineers from different departments started pouring in and the process continued till after the inaugural session.

1030 – 1100 hours

Inaugural Session

Welcome address was given by Shri Sanjay K Jha, State Project officer, GoI-UNDP Disaster Risk Management Programme. The guests were welcomed with flowers.

The workshop was inaugurated by lighting of traditional lamp by the Divisional Commissioner, Government of NCT of Delhi, Smt. Sindhushree Khullar.



In her Inaugural address **the Divisional Commissioner said that** “Delhi is in Seismic Zone IV: at high risk to earthquakes. Its densely populated areas with many that have unsafe building stock with non-engineered structures compound our vulnerabilities. An earthquake of moderate to high magnitude can cause unprecedented and colossal damage to Delhi”. She mentioned that “The GoI-UNDP Disaster Risk Management Programme in Delhi is a national initiative to reduce vulnerabilities of communities in most hazard prone districts of India. She said that the government of Delhi is determined to transform Delhi into a world-class global city. She said that the focus of engineers involved in construction and design should be to create new structures with utmost care to face the disasters will seek to build community capacities in preparing for, mitigating and preventing disasters. In the context of Disaster Risk Management, she has announced the notification of the Delhi Disaster Management Authority, under the leadership of the LG of Delhi, with the CM and all ministers as members. This is a very important milestone for the Government, against the backdrop of the extreme vulnerability of Delhi to various manmade and natural disasters.”

Shri Saroj Kumar Jha, Assistant Resident Representative, UNDP addressed the gathering and talked about the government initiatives in the Disaster Risk Management Programme.

This is the first training in the series and many more such training programmes are being planned. He talked about the Bhuj earthquake when the response time of relief and rescue teams was too high. The government realised the need of improving the response mechanism and hence started training of BSF and other battalions in all kinds of disaster response.



He said that we now have specialised trained teams who can reach any place within two hours. They have been trained in the latest technology. India with its diverse geo-climatic conditions is extremely vulnerable to natural disasters and the risks are evident in the physical and socio-economic vulnerability profile of the country. Around 60% of land in India is at high risk to earthquakes. Shri Jha expressed his concern that there are very few experts in the field of earthquake engineering. He emphasised on the need of having more such specialised personnel. He requested all the participants to take more interest in the subject and at least sensitise the engineers they come across, if not train them.

Vote of Thanks by Shri Sanjay Jha, State Project Officer, GoI-UNDP Disaster Risk Management Programme

The Government of Delhi would like to thank the experts from IIT Kanpur who kindly consented to be the resource persons for the training programme and to give the participants a new insight and perspective on the subject.

TEA BREAK (1100- 1130 hours)

1130-1300 hours

Session I - Indian Earthquake Problem (Prof. S. K. Jain)

Prof. Jain started the session with brief introduction of the participants and requested them to tell their expectations from the training workshop.



The participants said that they expected the following knowledge from the workshop:

1. Cost implications of seismic design
2. Design Criteria to resist earthquake forces
3. Changes in the codes
4. How to make load bearing structures earthquake proof
5. Thumb rules of seismic designing for general public
6. Special considerations at the time of execution
7. Whether there is a need for filling up the expansion joints
8. Most economic method of retrofitting

9. Behaviour of buildings during earthquakes?
10. Detailing
11. What are earthquakes? How they happen? What are the effects?
12. What can engineers do for already existing buildings
13. General guidelines for all types of buildings
14. Assessment methods for seismic safety of buildings
15. How to repair cracks?
16. Can shock absorbers be put in buildings?
17. Dynamic analysis of irregular structures
18. Special precautions for ATC buildings and control towers
19. Guidelines for buildings of large span
20. Overboard ductility requirements
21. How to retrofit multiple storeyed buildings resting on half brick walls?
22. Basic philosophy behind earthquake resistant design
23. Prefabricated buildings
24. Earthquake resistant features for bridge design.

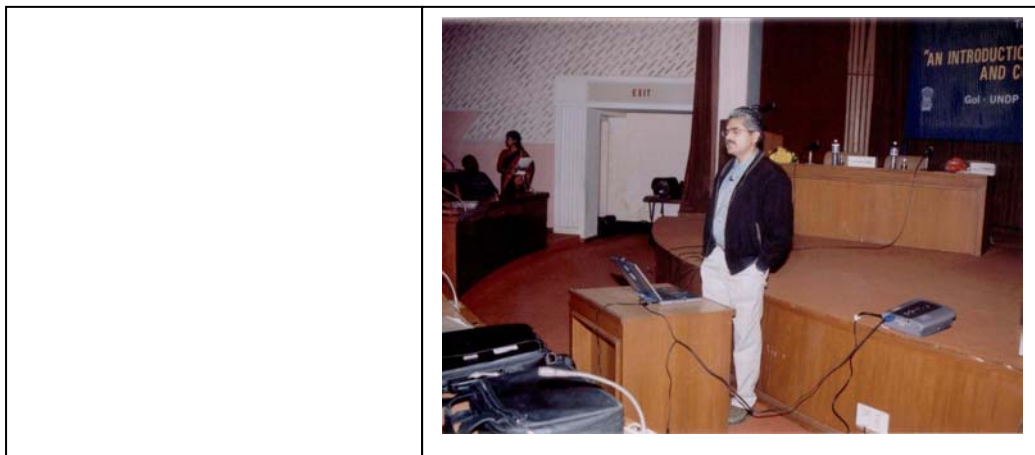
Prof. Jain said that most of the queries would be taken up during the various sessions except for bridge design, as bridge engineering in itself a very vast subject. Regarding multiple storey building resting on half brick walls, he said that we can just pray that it does not fall. For ATC buildings, he said that the organisation heads can issue orders specifying a safety factor they want to consider.

Prof. Jain talked about the great earthquakes occurred in the country in the recent past. He discussed the Koyna Dam which was an example of “reservoir induced seismicity”. Many of the buildings or large bungalows in which most of the government officials live, have jack arches. These are very bad for earthquakes. Jack arches work on principle of compression. Ties need to be provided which are not even costly. He talked about the Patparganj area of Delhi. He said that the ground consists of predominantly alluvial soil, which has a tendency of amplifying vibrations.

LUNCH BREAK (1300- 1400 hours)

1400- 1500 hours

Session II -Engineering Lessons From 2001 Bhuj Earthquake (Prof. C.V.R. Murty)



We need to remember that masonry infills behave as structural members when horizontal forces are applied. Regarding the Arch buildings he said that the T-shaped structures twist a lot. When it comes to earthquake safety the most important items are the vertical members.

Earlier the hooks in stirrups were applied at an angle of 90 degree. Now it is recommended to turn them at an angle of 135 degree so that they do not open up and resist the columns from buckling. With reference to design sequence Prof. Murty said that the international practice is to design Top down and construct bottom up, but in India we design and construct bottom up. The result is that we tend to have similar types of foundations irrespective of the height and other details of the super structure.

Lessons Learnt

1. Open ground storeys are bad
2. Violations of Bye laws is a problem
3. Slab reinforcement has to be anchored to the walls
4. Moment capacity of columns has to be more than that of beam..etc

1500- 1600 hours

Session III -Lateral Load Resisting Systems in Buildings (Prof. S. K. Jain)

Earthquake direction changes all the time and ground moves in all possible directions. When we design buildings, we must ensure that the buildings are able to take forces in two horizontal direction. Prof. Jain discussed the concepts of floor diaphragm, connections between slabs and vertical members. He explained the meaning of frames.

TEA BREAK (1600- 1630 hours)

1630- 1730 hours

Session IV- Earthquake Resistant Design of Masonry buildings (Prof. C.V.R. Murty)

The session focussed on masonry buildings. The three types of roof failures were discussed in detail. Bands in masonry walls were also explained. He explained how we could repair cracks. He said that when the cracks are vertical, the reinforcement has to be horizontal, while when the crack is horizontal, vertical reinforcement has to be provided.

1730- 1800 hours

Session V -Seismic Design Concept (Prof. S. K. Jain)

The session focussed on basic concepts of seismic design. Prof. Jain emphasises that strong mortar is not a good mortar. There is no single specification of mortar, which can suit all kinds of buildings. He discussed the various myths existing in traditional building practices.

After the session, Prof. Jain interacted with participants for their individual queries. He discussed the Mohr- Coulumb relationship. The various considerations while studying the site conditions for designing a building for earthquake safety should include soil property, stability of slopes and Site period.

DAY 2

10 January 2004

10:00 - 11:00 hours

Session VI-Indian Seismic Code IS:1893 (Prof. C.V.R. Murty)

The basic differences between the limit state design method, the working stress method and the plastic design method were explained in detail. Seismic coefficient method was also discussed. Prof. Murty said that while designing the buildings, the *importance factor* for all buildings is taken as 1 except for the buildings like life- line buildings where we can take it as 1.5.

He also shared the basics of Dynamic analysis. While talking about expansion joints, he discussed the joints between two adjacent buildings, those between two adjacent units of the same building and the amount of separation. He highlighted the fact that the soft storeys / open ground storeys behave as an inverted pendulum. There is a need to increase stiffness. In order to work on strength and stiffness of infill, dynamic/ static analysis needs to be carried.

TEA BREAK (1100- 1130 hours)

1130- 1230 hours

Session VII- Seismic Design of RC Frame Buildings (Prof. S. K. Jain)

He enlisted the basic rules of designing Reinforced concrete frames for seismic safety. He said that compression reinforcement should always be greater than or equal to tension reinforcement at every location in a beam.

The reinforcement bars should be continued at the joints. Lapse should not be provided at the joints since both the top and bottom bars are in tension. The specifications for spacing were also explained. We should not vary the reinforcement immediately above or below a beam. If we suspect more forces on any column, we must provide more stirrups. If any of the legs of stirrup is crossing 300 mm, a cross tie has to be provided in between.

LUNCH BREAK (1230- 1330 hours)

1330- 1430 hours

Session VIII- Seismic Design of RC Walls Buildings (Prof. S. K. Jain)

The specifications for bars, wires, bends, hooks etc were explained for reinforced concrete walls. Prof. Sudhir K Jain also explained the behaviour of reinforced concrete walls under the impact of earthquake forces.

1430- 1530 hours

Session IX- Seismic Structural Configurations (Prof. C.V.R. Murty)

The session revolved around the shapes and configurations of buildings. Symmetric and asymmetric frames, geometrical shapes and sizes, pre cast members, offset buildings, braced frames, indirect load path and earthquake

induced forces were discussed and the philosophy behind the calculations was explained. Prof. Murty emphasised that the buildings behave best if they are symmetrical. This symmetry should not only be kept in design but also loading.

TEA BREAK (1530- 1600 hours)

1600- 1700 hours

Valedictory Session

Welcome address by Ms. Aparna Kanda, Programme Associate, UNDP

Speech by Chief Guest Shri M.P.Sajnani

In recent years there has been a paradigm shift in perspective of the government in managing disasters. Earlier the thrust of Disaster management was relief. But now it has shifted to reducing risks associated with disasters. The government has taken many initiatives to shift the focus to preparedness and mitigation. Letters have been sent from the ministry of Home Affairs to the state government and all the ministries to take up assessment of buildings for seismic safety. The compulsory certification of engineers to allow them to practice is also in the pipeline. Shri Sajnani stressed on the role of engineers in disaster mitigation. He appealed to all the participants to play an active role in sensitising the engineering community about the disasters. He concluded by saying “Delhi is in your hands”.

Speech by Shri Sudhir K Jain, Professor, IIT Kanpur

It is a good sign that the government is taking an initiative. It is now for the professionals to take up the responsibility. The scenario of Delhi is of national concern. We need to have a road map for Delhi, where we can say that in a period of 3-4 years from now, we will have an X percent of new structures which would be earthquake safe. This training programme was like a tip of an ice berg. The knowledge is much more. It is available in books. We expect you to learn more on the subject and we are always there to solve any queries. I would like to thank the government of Delhi for organising this workshop and all the volunteers of UNDP for all the hard work they have done.

Award of Certificates to the participants by Shri M.P.Sajnani.

This was followed by a short film on Bhuj Earthquake against the back drop of the song “zinda rehti hain unki muhabbatein” by Prof. CVR Murty.

Vote of Thanks by Ms. Aparna Kanda, Programme Associate, UNDP

Annexure 1

Training Workshop on
Seismic Design of Reinforced Concrete Buildings
09-10 January 2004 at New Delhi

Programme

09 January 2004 (Friday)

09:30 - 10:30 Registration of Participants
10:30 - 10:35 Welcome Address by Shri. Sanjay K Jha
10:35 - 10:45 Inaugural Speech by Chief Guest, Ms. Sindhushree Khullar
10:45 - 10:55 Overview of National Initiatives in Disaster Management by MHA
10:55 - 11.00 Vote of Thanks

11:00 - 11:30 Tea

11:30 - 01:00 Indian Earthquake Problem (Prof. S. K. Jain)

01:00 - 02:00 Lunch

02:00- 03:00 Engineering Lessons From 2001 Bhuj Earthquake (Prof. C.V.R. Murty)

03:00 - 04:00 Lateral Load Resisting Systems in Buildings (Prof. S. K. Jain)

04:30 - 04:30 Tea

04:30 - 05:30 Earthquake Resistant Design of Masonry buildings (Prof. C.V.R. Murty)

05:30 - 06:00 Seismic Design Concept (Prof. S. K. Jain)

10 January 2004 (Saturday)

09:00 - 10:00 Indian Seismic Code IS:1893 (Prof. C.V.R. Murty) I

10:00 - 11:00 Indian Seismic Code IS:1893 (Prof. C.V.R. Murty) II

11:00 - 11:30 Tea

11:30 - 12:30 Seismic Design of RC Frame Buildings (Prof. S. K. Jain)

12:30 - 01:30 Lunch

01:30 - 02:30 Seismic Design of RC Walls Buildings (Prof. S. K. Jain)

02:30 - 03:30 Seismic Structural Configurations (Prof. C.V.R. Murty)

03:30 - 04:00 Tea

04:00 - 05:00 Valedictory Session

09-10 January 2004, New Delhi

Your Feedback

THE DESIGN OF THE COURSE

-
- ## THE CONDUCT OF THE COURSE

- | | |
|---------------------|--------------------|
| 90% - 100% () | 60% - 70% () |
| 80% - 90% () | 50% - 60% () |

70% - 80% ()

below 50% ()

Please indicate the overall strength of the course and its conduct.

Please indicate the overall weakness of the course and its conduct.

Which of the topics we went through too fast and which required more time to be spent?

Which of the topics we went through too slowly, and where we could have given more information during the lecture?

Please give suggestions for the improving the course.

Annexure 3

