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A Study on Earthquake Resistant Construction Techniques

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Abstract: Apart from the modern techniques which are well documented in the codes of practice, there are some other old traditional earthquake resistant techniques which have proved to be effective for resisting earthquake loading and are also cost effective with easy constructability.
Keywords:catastrophic damage, non-engineered buildings, traditional architecture, lack of proper seismic knowledge, details of seismic resistant construction.

INTRODUCTION

Disasters are unexpected events which have adversely affected humans since the dawn of our existence. In response to such events, there have been attempts to mitigate devastating effects of these disasters. Results of such attempts are very encouraging in developed countries but unfortunately and miserably poor in developing countries including ours. Earthquakes are one of the nature's greatest hazards on our planet which have taken heavy toll on human life and property since ancient times . The sudden and unexpected nature of the earthquake event makes it even worse on psychological level and shakes the moral of the people. Man looks upon the mother earth for safety and stability under his feet and when it itself trembles, the shock he receives is indeed unnerving. Mitigation of the devastating damage caused by earthquakes is of prime requirements in many parts of the world. Since earthquakes are so far unpreventable and unpredictable, the only option with us is to design and build the structures which are earthquake resistant. Accordingly attempts have been made in this direction all over the world. Results of such attempts are very encouraging in developed countries but miserably poor in developing countries including our country India. This is proved by minimal damage generally without any loss of life when moderate to severe earthquake strikes developed countries, where as even a moderate earthquake cause's wide spread devastation in developing countries as has been observed in recent earthquakes. It is not the earthquake which kills the people but it is the unsafe buildings which is responsible for the wide spread devastation. Keeping in view the huge loss of life and property in recent earthquakes, it has become a hot topic worldwide and lot of research is

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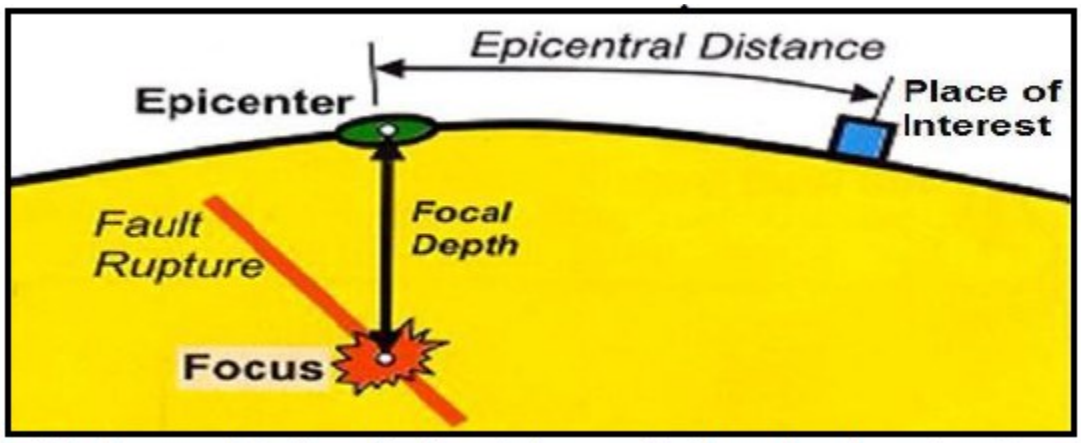
going on to understand the reasons of such failures and learning useful lessons to mitigate the repetition of such devastation. If buildings are built earthquake resistant at its first place (as is being done in developed countries like USA, Japan etc) the devastation caused by earthquakes will be mitigated most effectively. The professionals involved in the design/construction of such structures are structural/civil engineers, who are responsible for building earthquake resistant structures and keep the society at large in a safe environment.

Understanding of earthquake and Basic Terminology

Earthquake is defined as a sudden ground shaking caused by the release of huge stored strain energy at the interface of the tectonic plates

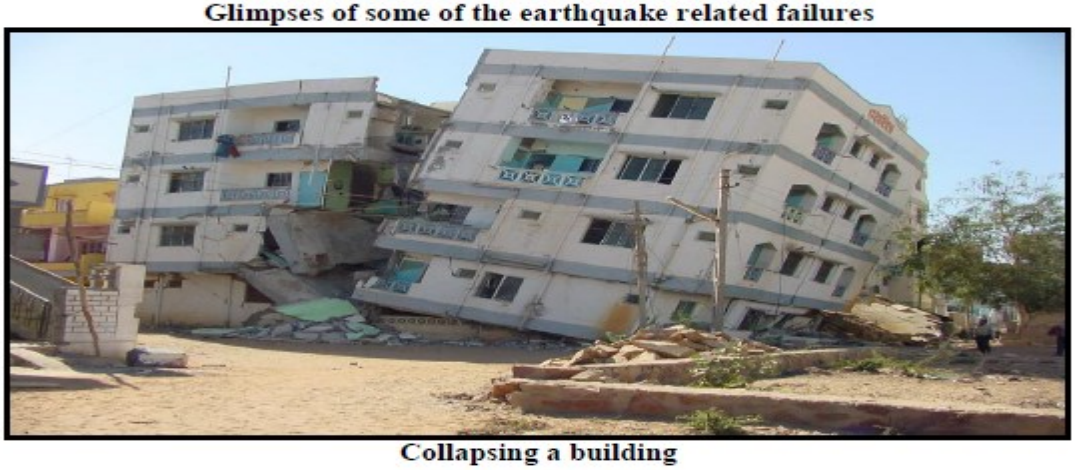
Epicenter:-It is the point on the free surface of the earth vertically above the place of origin of an earthquake. Focus:-It is the point within the earth from where the seismic waves originate.

Focal Depth:-It is the vertical distance between the Focus and the epicenter.



The figure explains the related terminology used in the earthquake engineering

Glimpses of some of the earthquake related failures



Collapsing a building

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A total collapse of a building

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Sway mechanisms are often inevitable with soft storey ground floors (Izmit, Turkey 1999)

Soft Storey Failure

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Table 1. District wise Deaths, Houses damaged partially as well as fully in Kashmir Valley

S.No.	DISTRICT	No of deaths	No of injured persons	No of fully damaged houses	No of partially damaged houses	No of temporary shelter units constructed
1	Anantnag	Nil	Nil	10	112	11527
2	Baramulla	674	399	14710	91334	-----
3	Budgam	01	08	44	10560	7995
4	Kupwara	276	94	8994	66887	-----
5	Pulwama	Nil	Nil	13	120	-----
6	Srinagar	02	316	11	5857	19522
	Grand total	953	817	23782	174870	

BEHAVIOUR OF MASONRY BUILDINGS TO GROUND MOTION

Ground vibrations during earthquakes cause inertia forces at locations of mass in the building. These forces travel through the roof and walls to the foundation. The main emphasis is on ensuring that these forces reach the ground without causing major damage or collapse. Of the three components of a masonry building (roof, wall and foundation) (Figure (a), the walls are most vulnerable to damage caused by horizontal forces due to earthquake. A wall topples down easily if pushed horizontally at the top in a direction perpendicular to its plane (termed weak direction), but offers much greater resistance if pushed along its length (termed strong direction) [Figure (b)].

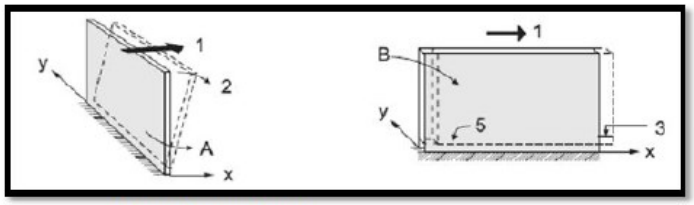
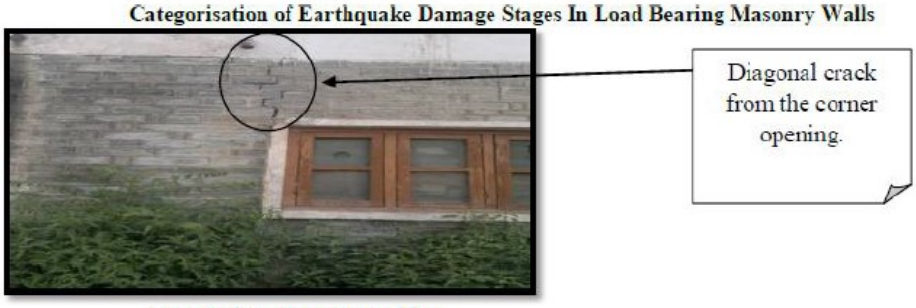


FIG. (a) Flexural wall

1 - Earthquake force
2 - Overturning
3 - Sliding

FIG. (b) Shear wall

Categorisation of Earthquake Damage Stages In Load Bearing Masonry Walls



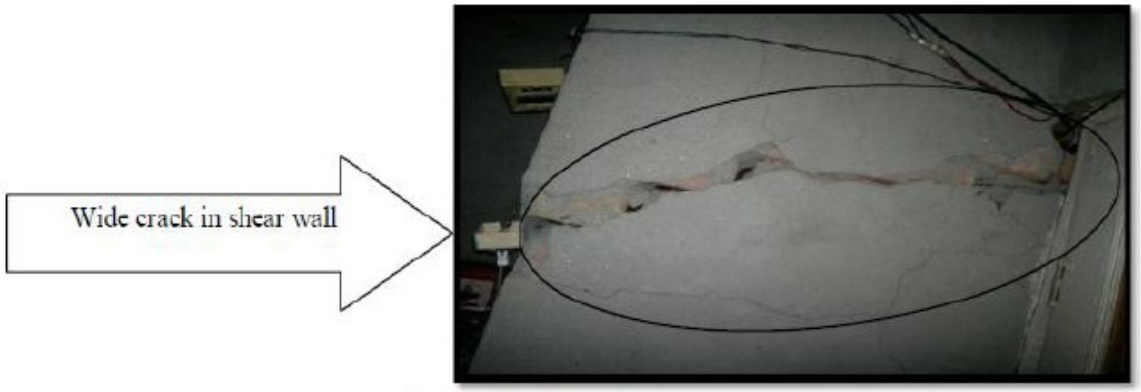
Stage I of Earthquake. damage

Stage I of Earthquake. Damage

Minor damage at the Roof base.

Crack more than 10mm

Stage II of Earthquake. Damage



Wide crack in shear wall

Stage II of Earthquake. Damage

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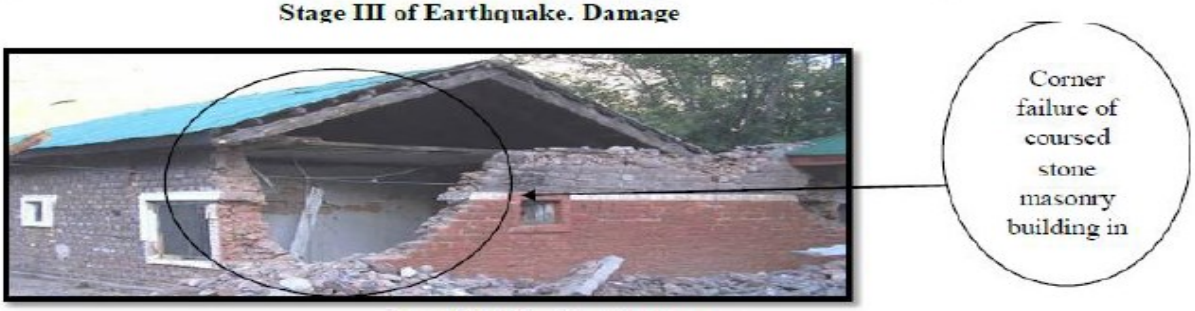
Stage III of Earthquake. Damage



Stage III of Earthquake. Damage

Stage IV of Earthquake. Damage

ROLE & RESPONSIBILITIES OF CIVIL ENGINEERS

It is not the earthquake which kills the people but it is the unsafe buildings which is responsible for the devastation. Keeping in view the huge loss of life and property in recent earthquakes, it has become a hot topic and worldwide lot of research is going on to understand the reasons of such failures and learning useful lessons to mitigate the repetition of such devastation. If buildings are built earthquake resistant at its first place (as is being done in developed countries like USA, Japan etc) we will be most effectively mitigating the earthquake disasters. The professionals involved in the design and construction of such structures are civil engineers. Who

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are responsible for building earthquake resistant structures and keep the society at large in a safe environment? It is we the civil engineers who shoulder this responsibility for noble and social cause.

GUIDELINES FOR EARTHQUAKE RESISTANT CONSTRUCTION

In addition to the main earthquake design code 1893 the BIS(Bureau of Indian Standards)has published other relevant earthquake design codes for earthquake resistant construction Masonry structures (IS-13828 1993)

1. Horizontal bands should be provided at plinth ,lintel and roof levels as per code
2. Providing vertical reinforcement at important locations such as corners, internal and external wall junctions as per code.
3. Grade of mortar should be as per codes specified for different earthquake zones.
4. Irregular shapes should be avoided both in plan and vertical configuration.
5. Quality assurance and proper workmanship must be ensured at all cost without any compromise.
6. In RCC framed structures (IS-13920)
7. In RCC framed structures the spacing of lateral ties should be kept closer as per the code
8. The hook in the ties should be at 135 degree instead of 90 degree for better anchoragement.
9. The arrangement of lateral ties in the columns should be as per code and must be continued through the joint as well.
10. Whenever laps are to be provided, the lateral ties (stirrups for beams) should be at closer spacing as per code.