**Earthquake Resistant Architecture**

**Lecture 6**

**Buildings in Fired Brick and other Masonry Buildings**

Here you can see a picture of an earthquake that sometime back and you can see Auto destruction that has happened so there are certain building the distance driving because there is many buildings which completely give up so in order to be this and not be this is why we are understanding the particular unit so buildings in fire bricks solid concrete block and hollow concrete blocks motor blocks are dealt with in this chapter.

The general principles and most details of earthquake resistant design and construction of brick buildings are applicable to those using other rectangular masonry units that is solid bricks of mortar concrete stabilizer hollow blocks of motor blocks having of conference having adequate compressive strength so some construction details only differ for hollow block.

The creation of tensile and shearing stress in walls of mason building is a primary cause of different types of damage suffered by such buildings usually. So talk about a masonry unit in the previous lecture its self I had explain how tension and shearing are the major issue that happen in a building the other the major Enemies in a building when earthquake effect so we kind of went through the day in detail about understanding what is the tensile stress and what is the shearing stress, so that would be the base for you understand this part of the particular unit.

The Non and structural damages that happens is that due to which the strength and stability of the building is not affected such damage occurs very frequently even under models in intensities of cities of earthquake. so basically what happens once an earthquake I attract as I spoke about before in my previous lecture there too many types of damages that occurs in a building. That is structural damage and non structural damage.

Non structural basically nothing that can happen to it can happen to it because there are some cracks and some small failures will happen in the buildings but still the building will with stand that because will apply an opposite kind of force that will actually help with stable and not fall and become debris. But then in structural damage is what actually fix a building and completely ruined the building any actually slowly and steadily each one part of the building will collapse in all together on itself and it becomes a kind of debris under which people property and if and every position of person can have can go, to crack meaning of masonry parapet, roof chimney, large cantilever cornices and balconies is one thing that can happen because of this non structural feeling.

Falling of plaster from walls and ceiling particularly when it was loose creaking of partition walls and cladding wall from inside frame, cracking and failing of ceiling cracking of Glass panes falling of loosely place objects overturning of carbon extra so basically what you're saying is that maybe because of this plaster can happen if you have a totally cantilever roof for a cantilever in your building as such it might break and it might follow or may be if there is a water tanker loosely phase anything there is on top of that my collapse if there is any continuous which is not I will call this is that is which part of a building is not rectangular or proper shape there is something that is projecting outfit that might fall off like a corner structures so those kind of things can happen when an earthquake strikes in nonstructural damages see if you can see in this picture as explain in the previous lecture again the same similar picture and explain how you can say 1 shows the earthquake motion that's happening in the building and basically 2 is the horizontal cracks happens in cables in a building .

Then 3 is a diagonal crack class that happen due to share this is actually usually happens between two or three opening the place together in one row up or down there will be a small crack the happens diagonal in between that and that is called those are this cracks. And then four a cracks due to bending of the walls or when a force is completely applied on a particular wall and whichever wall tension so the roof gets in a distributed between four walls.

Adhesion between the roof and the walls are good as I told the previous lecture they were there then they will distribute the tension in such a way that wall can take maximum tension. So if u can see when a small bending will occurs because where does bending cracks you can see in vertical cracks and they happen.

**Damage and Failure of Bearing Walls**

Failure due to racking shear is characterized by diagonal cracks which could be diagonal compression or diagonal tension such failure maybe either through the pattern of join or diagonally throw masonry unit. These cracks usually initiate at the corner of the openings and sometimes it centre of the wall segment and this kind of failure can cause partial or complete collapse of the structure.

A wall can fail as a bending member loaded by seismic inertia forces on the mass of the wall itself in a direction. Transfer to the plane of the wall tension cracks occur vertically at the centre ends and corners of the wall so what happen when the two wall kind of come together there will be kind of usually happen when if there is a construction failure anything like that there is a small problem in that adhesion the amount of motor between the joins of the two walls, so when that happens at that particular point I'll be tension crack that can be gives rise to complete structural failure of the building and longer the wall and longer the openings more prominent is the damage.

Since earthquake effects occur both axis of the building simultaneously the bending and sharing effect occur cause often together and the two modes of failure then open combined failure in the fires occur due to the combine action of the flexor and shear. so what happened as we discussed for a building basically supposed to have a particular in the earthquake prone area basically we should follow up building that is proposed within size is a building is very linear or there are much number of openings on the floor on the far side of the building there is self may give rise to a lot of failures which can be fast in the process of a structural failure in a building.

Unreinforced gable and masonry walls a very unstable and the startling action of purlins imposes additional force to cost a failure horizontal banding tension cracks a cost in the gable that we discussed before to the deep beam between the two openings one about the other is a very weak point on the wall and the lateral in plane force cracking in these zone occurs before the diagonal of the pair in order to prevent it and enable the full description of shear among all pears either of rigid slab or RC band must exist between them.

If you can see a when there are like two opening End of this opening there will be a small crack there will be forming me so when there are so many openings in the front side of the building the exit of the building can see will be like a lot of a such cracks and slowly they a becoming diagonals crack kind of Merge formed and in front of the building. In order to prevent it so need to create a full distribution of shears amongst all pears so they need to actually need actually place a rigid slab on RC band that is reason of that is how we can prevent this from happening, so walls can be damage also due to seismic force of the roof which can cause the formation of tension cracked separation of supporting walls this mode of Failure is the characteristics of massive flat roof supported by the joints.

Which in turn are supported by bearing walls but without proper connection with them also the connection with the foundation is not adequate the wall cracks there and slide and this may cause failure of the plumbing pipes too, so what happened if the connection between the roof and the wall as I said is not proper when the roof transfer the tension of the roof to the part which that holding that what happens that kind of doesn't equally distribute the load based on the capacity of each walls in that kind of create may help in a make the wall slowly Bend and fall even if the stable and the connection is proper if the foundation and the wall is not proper bound same force can force the wall to overturn which actually create a complete structural failure.

Failure due to damage in unsymmetrical building occurs due to torsion and warping in an the earthquake this mode of failure causes excessive cracking due to shear in all walls. Larger damage occurs near the corner of the building Arches across openings in Walla are often badly creaked since the arches tends to lose their end thrust under the in plane shaking of the wall.

Under savior prolonged intense ground motion the following major problems happen in a building. The crack become wider and the masonry units become very loose the partial collapse and gabs in walls occur due to falling of falling of loose masonry units.

Falling of spandrel masonry due to collapse of piers.

Falling of gable masonry due to out of plane cantilever action. Walls get separate at corners and intermediate T-junctions and fall outwards.

Roof collapse either partially or fully certain types of room smells like the top wall and roof beams fall down and masonry arches across the wall opens as well as those used in roof collapse completely. Now we talking about failures of the ground so there are various failures that happen in the ground so first and foremost thing will be discussing is inadequate Dept of the foundation.

Shallow foundations deteriorate as the result weathering and consequently become weak for earthquake resistant.

I said before other there are main major things it can happen around the foundation, the foundation does not deep enough to make things can happen one is weathering because of weathering what happened because very Shallow and we shall over at the end of that. And that may cause the wall to completely overturn and another thing is happen is soil liquored fraction on the solid soil around the foundation about the found in can actually come close to water and then it can mix and become a semi liquid state and that can actually make the foundation very easy and the world will turn over the fall down.

Differential settlement of foundation is another thing during civiler round shaking liquefaction of loose water saturation sand and differential compaction of loose soil occur which leads to extensive tracking and tilting of building which may even collapse completely.

Sliding of slopes: Earthquake cause sliding failures in manmade as well as nature hill slopes and any building resting on such a slope have a danger of complete disastrous disintegration.

In the areas of hill in case of areas of a completely earthquake prone area what we do is we should choose site in a very clever way in such a way that you know there is no Hill around it obviously not on a naturally for artificially created hill what happens in such cases when the earthquake happens a very much also the chances of a Foundation giving a hole building overturning and become a debris on the floor on the road or ground becomes more you know why because of the slope of the area the next is a failure of a sudden dislodging of roofing material happens and that is when the failure of roof and floor so now we discuss the failure of the building and Non structural failures of the building basics structural failures of the building

and then we discuss the failures of the ground and now and we talking about the failure of the roof and the floor, so that dislodging roofing material is one major thing that happens when an earthquake strikes.

This mode of failure is typical on sloping roof particularly when slaves, clay, tile etc. Are used as a roofing material so what happens when earthquake strikes the roof if the roof is not attached to the connected to the wall properly and the Adhesion between the wall and roof is not properly the roof on be able to transfer the amount of load properly into this transport to the walls which is holding a bearing it .So when that happens roof kind of gives up and either is a slide the throw disintegrate this is usually happens when the roof not strong enough and be used materials like slaves, clay, tile etc. bridle materials asbestos cement may be broken if the process and treating people is not properly brace together week roof grow support connection is the cause of separation of roof Truss from Support.

so all the complete mostly roof collapse mostly occurs due to the collapse supporting structure the rupture of the bottom code of roof Truss may cause collage the trust as well as that of the walls so heavy roof are used in rural areas with large thickness of earth over around Timbers that causes large inertia forces on the top walls and that may lead to complete collapse in savior earthquake. As i said that before whenever an earthquake strikes every part of a building every small part of the building will have what happens forces acting on it.

If the roof and everything that is connecting to each other trying kind of a unit tries transferring it those forces into each other so what happened when it is the roof material is very heavy what happened amount of that is created in will be more and then there is transferred to the wall the walls want a kind of bend and overturn that happens in many causes.

This is lean to roof easily causes instability in the lower supporting walls on fires and collapse easy due to lack of ties , if you can see in this picture one is the earthquake motion and two is the wall of the column and three is rupture of the try and after what happens this is how to other at like two columns of walls on which the roof was sitting and the earthquake the number one force acts the Wall of the column kind of gifts up and a kind of overturn because of the amount of inertia force is being transferred from the roof and so that actually intern causes the tie after the after like this and then you can see this kind of gifts away the wall and makes it overturn rupture of bending or crack in the column and as such everyone collapse all together because of this happening.

The next thing that we discussing will be discussing in this lectures are the causes of damage in masonry building, so the main weaknesses in the masonry building and unreinforced masonry construction are heavy weight very stiff buildings and their tracks last week inertia forces as I said once the weight and stiff building increases or any word the building. when the

earthquake strikes amount of inertia forces that kind of increases which is directly proportion to the weight of the heaviness is of the stiffness of the building so that can cause damage in masonry building very low tensile strength particularly with poor Motors.

Low shear strength particularly with poor mortars so what happens if the motor is not strong enough and well made usually with tensile stair strength.

Brittle behavior in tension as well as compression we connection between wall to wall as I said that particular area where is wall and wall is connected motor is not strong enough then that might give rise to a crack in that area and that having over in a lead to the overturning and then stress concentration of corners of Windows and doors overall asymmetry in plan and elevation of building.

Defect in construction as use of substandard materials, unfiled joints between bricks, not–plumb walls, improper bounding between walls at right angles etc.

**Typical Strength of Masonry**

So basically asymmetry is a very major cause as I said in to lectures back we discussed what are the various planning criteria that we should consider while constructing an earthquake resistant building.

The major think we discussed was the plan had to be proportional and a simple plan is always best for earthquake resistant construction so when this happens if there is a asymmetry in the plan of the plan to Linear than the kind of create imbalance in the whole structure and then the internal creates damage in the masonry building now talk about the typical strings of masonry. so masonry walls have its own natural inbuilt strength which actually helps it with stand earthquake by itself even though it is not enough for you considering it as an earthquake resistant building.

There are some in innate forces with inside that they actually for the benefits of that particular building. The crushing strength of masonry used in the position of walls depends on many factors such as the first major thing is the crushing strength of the masonry unit .

The second is a mix of motor used and it was the motor used for different wall construction varies in quantity as well as strength. It is generally described on the basis of the main binding material such as cement or lime motor. Cement Lime composite motor, hydraulic lime mortar clay models also use many countries particularly in rural areas so next is the slenderness ratio of the wall that  is smaller of the ratio of the effective height and effectiveness length of the wall to its thickness.

Larger is the standard is ratio smaller the strength so that's why for an earthquake resistant building is always advisable to make more of a rectangular order proportional building with a considerable amount of portion between order to also manage its slenderness ratio of the wall

Eccentricity of the vertical loads on the wall largest eccentricity smaller the strength.

Percentage of openings in the Wall of the opening smaller the strength to the Tensile and shearing strength of masonry mainly depend upon the bond or adhesion of the contact surface between the masonry so what happens when there is like a long wall and there are so many small openings on them there will be kind of the amount of masonry on that particular wall is reduced because of their mode of openings on it's the amount of crushing strength of adhesion have with its reduced because of which it might Fail.