**Earthquake Resistant Architecture**

**Lecture 7**

**Wooden Structures**

Moving on to the first and foremost part of the seismic design and detailing of wooden structure. So basically you why are you learning about the wooden structures what is the basic importance of understanding about the construction details of wooden structure, when you go to any part of the world there are many earthquake prone areas where in wood is definitely used as the major material of construction there in that is the most naturally available material that that is a construction technique there are many places were wood is used in major form of construction for which is very important for us to understand how to tackle wood and how to go about constructing would instructors and get make it earthquake resistant.

Wood has highest strength per Unit Weight and is therefore very suitable for Earthquake resistance construction so but heavy cladding walls could impose hire lateral load on the frame. Although seismically suitable use of timber is declining in building construction even where it used to be the prevalent material on account of vanishing forests due to population pressure.

Basically even though wood is considered to be a very strong material nobody knows the basic value of wood against earthquake resistance construction so wood definitely is a very suitable material for the earthquake resistant construction and there are many things many things that we have to follow in order to keep wood acting positively towards earthquake and still resisting the earthquake load. Timber will be used in those areas and countries will be available close areas and countries where it is still abundantly available or in unavoidable situations only. Some construction details only differ for hollow blocks, which are also indicated as necessary. So that typical features of earthquake damage to wooden buildings are as follows.

The Roof tiles easily slide down during earthquake, if they not properly fastened to the roof, tiles might actually fall off during earthquake and that can be one of the major reason Basically the previous lectures that I told you the major thing affect human life in an earthquake is falling of structural or dismantle of structure on them. so one major think might hurt them in the wooden structure is The Falling off of roof tiles so the failure of joints connecting the columns and girders frequently occurs in a wooden structured accompany the following of finishes one by one so as a in clash of building increases is restoring force against distortion decreases due to the structural deterioration roof and finally that become negative which resulted complete collapse of the building.

Then the particular standing buildings when building incline of destruction that kind of gives rise to the structural failure the strength of the building or the roof kind dimension as it goes

slanting that way one by one, one thing collapse everything will collapse one by one. So as you can see in the picture they might be a rupture of columns that connects brace at the this will fall all three of them will Fall one by one and rupture fall people and that might causes distraction again here you can see the rapture of columns the connection the landing of this particular this thing more. That kind of creature rupture at the corner which connects all part of the building that kind of breaks the hole building.

In the case of two storey building the first story usually suffers several damage than the second storey it is often seen that the first storey falls down second storey is undamaged. So if you can see in this picture you can understand that the second storey is undamaged and first story kind of gives up in the joints and kind of rupture, so damages is considerably influenced by the ground condition on which the building. The damage due to differential settlements of foundations is also observed for building on soft ground. side of the building has a hold is sometimes seen when there are no anchor balls connecting the stile to the foundation basically I found the connection between the sill and found in is the basic thing that may keeps the building standings, when an earthquake touches the building if you can see anchor balls between foundation and sill is not perfect then the whole building may slide. so this can see the picture it shows the sliding is insufficient connectivity between sill and footing this is what happened so other types of damage in wooden building are failure of wooden gable frames and failure due to rupture of bottom chards of roof truss.

The Most Crucial destruction of wooden building has been due to fire resulting from electrical short circuit or kitchen fires during the earthquake shaking and spreading into configuration thereafter precautions against fire are more important is a wooden building. So you can see the wood is very prone to fire so once the fire happens in a wooden building is almost impossible to contain it because it's spread really fast. So usually as I Said in the previous lectures in there are so many aftermath's of the earthquake that can happen and one of the major aftermath is the fire. Once the fire happens if the building wood it is really very difficult to contains that is the major problem in a wooden building when comes to earthquake.

The Coming lecture you will see how it over how and when the fire happens and how to contain it so if you can see in particular picture it shows the failure modes of the gable flame so you can see that the earthquake force that is one that happens to the particular frame and you can see the joint here fail as a result of which the particular hole roof frame collapses so once the earthquake touches here this particular kind of Moves away and slips based on which the roof that is sitting on top of which kind of tills and the whole thing falls down again below we can see when the earthquake force act the whole thing completely falls down is one go to one side. This is the two different types of failure of a gable frame when earthquake strikes a wooden building.

Typical Characteristics of wood

It is non-homogeneous and anisotropic material showing different characteristics not only in different directions but also in tension and compression.

Shrinkage of wood on dying is relative Large, particularly the joint slack easily by contraction in the direction perpendicular to the fibers. Therefore dry wood shall be used and moisture content should be less than 20%.

Elastic modulus is small consequently the members of apt to show large deformation notable phenomenon is seen due to the permanent vertical loads and this is important especially in snow areas.

Sharking occurs by compressive force in the direction perpendicular to fibers this is great influence to the amount of influence of horizontal member and chord members of built.

The defective and notches of wood influence greatly in the strength and stiffness. Consequently it's necessary select and to arrange structural members considering their structure properties.

Wood is easily decayed by repeated changes of moisture therefore seasoned wood should be used in construction.

Preservative treatment is necessary to avoid rotting and insect attack on timber so as to drive long life.

Wood is a combustible material as I said before Fire can easily affect wood it is really difficult to contain the fire, once in affect wood Precautions must be taken to minimize the danger of fire.

Long lens made in 3.5m and Large timbers are difficult to obtain hence call for splicing through connectors or gluing. So talking about the typical structure of wood there are large verity of timbers is used in various countries as I mention before it will never practicable to present the strength properties completely will be pertinent to mention that these depend on number of factors as follows.

Basically the Wood Specimen in matters.

The direction of loading Relative to grain of matter. So different types of wood will have different types of graining and that kind of depends on the availability of wooden area. Based on the wooden grain the direction of loading changes and that affects structure property of the wood.

Defects like knots, checks, cracks, splits, Shakes and wanes.

Sapwood, pith, wood from dead trees and dried wood conditions.

Location of use, viz inside protected, outside, alternate wetting and drying. These are the major properties affect the construction of the wooden structures.if you can see this is the failure due to rupture of bottom code of roof Truss, so I once a force acts in the centre if you can see basically the wall or columns. First of fall rupture you can see in this picture of this is from straight its kind of tills to one side and after that the ties is rupture and at the end of it the roof Truss completely falls down so the second figure shows a completely exactly what happens after the Rapture one by one once the columns fractures the truss and the tai automatically Falls down.

The building plan of the wooden structures the plan of the building should be surrounded and divided bearing wall lines.

The maximum spacing of the bearing wall lines is 8m not more than that.

The maximum width of opening in the bearing wall line is 4 meters and opening is at least 50 centimeter away from the corner.

Adjacent opening should be at least 50 centimeters apart.

All bearing wall lines of the lower story should be supported by continuous Foundation through sills or the columns should rest on the pedestals. so if you can see this picture, the picture shows the plant divided by wearing walls like I said before and also this picture shows the start wall construction off the wooden and buildings.

All Bearing wall lines of the upper storey should be supported by the bearing on lines of the lower storey and the height of the building shall be limited to stories of two stories plus attic. Nothing more than that so that we always when you seen in wooden building construction the height of the building are restricted to one particular level does not go beyond that.

**Earthen Structures**

Moving to the next part of the lecture that is seismic design & Detailing of non Engineering Construction that is Earthen Structures and other major construction technique that we follow while making building is the Earthen Structures there are many countries and still follow the same and there are multiple types of construction in Earthen structures basically in wood as you can see there is only one particular type of construction that we follow but the Earthen structure there are multiple different types Earthen Structures in the construction technique that we follows is very important for us to understand what are the basic implications of each type of Earthen construction styles and what are that various factors that has to be consider while creating a design Strategies for Earthen structures.

Earthen construction has been, is and will continue to be a reality as i said still happens.

Even this material has clear advantage of caustic aesthetics, acoustics and heat insulation and lower energy consumption, it also has some disadvantages such as being weak and earthquake forces and water action. So once earthquake strikes or water action happens or liquored fraction happens earthen building of the first one that usually give up during this. Even though the technology developed to date has allowed a reduction in its disadvantage stressing is most valuable and advantages. So basically what happened Technology advance are many construction technology had come and based on the what the disadvantages of the earthen construction has been reduced and many more advantages is been added, so earthen construction that are in general spontaneous and a great difficulty dissemination of knowledge about adequate use.

What are the typical damage and collapse of the earthen buildings?

Damage is always much more than severe in two storied building and one storey building so once the as tall the building is that much damage would increase in Earthen building, however single storey houses with flat roof constructed in good clay have to be found to be undamaged where is in the same location two storied houses were completely riot. So if you can see this picture the pictures shows the typical damage and collapse of a earthen building so basically if you can see the corner failure and out of plain collapse of walls that happens now and then other gables completely give up and we left with nothing but just for walls.

In the two storey house damages more can see the whole thing come kind of deplete and Falls over and also sometime when the split level roof is there almost half the roof is completely given again living walls. When you have the L shape building that's in type of building that we have in that usually what happens such buildings corners give up and when the earthquake strikes because it won't be really a tight and well tight so that with the whole building comes completely depletes, so in high walled houses again the height is really more has the height increases it becomes more and more to the prone earthquake again you can see the whole building depletes completely and in awnings stiff and the shortest path stance and the cantilever parts kind of give up and depletes, so talking about the graphic summary of the causes of failure you can say that this is a one hour more storey building the depicting here with roof tile basically there is a bond at the corners continuous vertical join and the vertical joints wont has motor and that again is a problem then there is poor Adobe quality without strong for mixed mud when we are not conducting which will be seeing next when in Adobe construction the quality is not proper and straw is not well with the mud then the construction failure happens.

Again lack of horizontal reinforcement which is not there in earthen buildings there is no horizontal reinforcement or the less horizontal reinforcement that kind of gives up to give the rise to the building falling due to earthquake. Then there is a lack of foundation and plan that might be another thing then the walls are way too high and too long as I said before as small the earthen buildings at the are that much stronger the buildings would be so when the opening that too close to the corners there are chances that in which kind of ruptures at the corners and when the opening the doors and windows the way to last there won't be any horizontal member which supports it so kind of that much that area there won't be any support round in that area is rupture.

The classification of earthen constructions

There are two major classification there is hand formed by the layers in Adobe or block in the hand formed by the layers where there is simple flaming Earth balls thrown and moulded as wall and then Adobe or blocks you have cut from hardened soil formed in mould modern compact. Then we have the Tapial or pise that is rammed earth construction that very common, Compacted by hand blows.

Mechanized or vibrating compaction that is basically a previously the construction was just compacted by hand blows later the technology advanced mechanical A vibrating comp actions are coming in that kind of that's another become another construction technique.

Wood or cane structure with wood or cane mesh enclosures plastered with mud. you have the continuous structure and prefabricated Panels wearing any you make the panel somewhere else and then you bring it then fix it on site and then put mad over that also happened, So talk about the suitability of soil.

The quality of materials particularly clay content of the soil may vary somewhat for the type of construction but in general the following qualitative tests are sufficient for determining the meaning the suitability of a soil for earthen construction. So the first test we conduct is the dry strength test what happens in this product test is 5 or 6 small balls of soil approximately 2 centimeter in diameter are made one is there dry after 48 hours each ball is crushed between the four finger and the thumb. If they strong enough none of them break the soil has enough day to used in Adobe construction and if sum of the ball breaks the soil is not considered to be earthquake because it does not have enough clay and should be discarded.basically in Adobe construction the major factors consider that is clay the quantity of the soil so if after 48 hours of the balls being made and the crushing between your 4 finger and Thumb when you press it if it doesn't break then that means that was the dry strength Test.

Fissuring control test, At least eight sandwich are manufacturer with Motors made with mixtures in different proposals of soil and coarse sand and so the sandwich having at least the

least count and of coarse stand when opened after 48 hours does not show visible fissures when indicate the adequate proportion of soil/ sand for adobe construction giving the highest string.

Next the strength of Adobe, the strength of Adobe can be qualitatively a certain that follow after 4 weeks of Sun drying the Adobe should be strong enough to support in bending the weight of a man if you break more clay and fibrous material should be added so find out so added construction as I mentioned before you used rayon fibers materials clear in order to the one that is made and block some made you dry that for four weeks in Sun and you bring that and when if it cannot handle the weight of one man then we need to add more materials to make it strong and then mould it again strong, so this picture shows the different field testing of strength of solid soil and adobe if you can see this is the drywall test I said you have you make the drywall of 2 centimeter diameter and then you compress it between your fingers and you can see if it doesn't break and still like this and that means it pass the test and hear that this is there testing of a adobe test if it break after 4 weeks of making and if it doesn't it is under a man's weight and then that means is good and it is go ahead and concert with it so this is a good features of earthquake resistant construction as you can see so basically you should have only one story and Arctic that is the best one see you need to seating as roof materials of cement tiles you need good Bond in the wall that it should be the bond the wall should be strong when you need to use a plain that is 30 centimeters minimum plain should be given you need to use column beam the roof trusses you need to use horizontal reinforcement which is very important because that kind of gives to the you need to have good bond between adobe alternate and vertical good join quality of adobe and rainy areas roof project minimum 50 centimeter and waterproof plaster should be there on the wall the opening should be minimum 1.2 meters away from the corners and the low walls maximum eight time thicker so I should be damp proofing and the plinth in order to avoid liquored fraction in case of earthquake and small door and window opening should be at the good location of the house.