Earthquake Resistant Architecture

Lecture 3

Behaviour of Various Types of Buildings

So behaviour of various types of building structures Equipments, lifeline collapse patterns all are consider while designing a seismic resistant building. if you can see in the picture of building actually gave up and it fell on another building that's what usually happens like starting happens when building give up give the pitfalls on something else in that give up in that wasn't something else and I was on top of each other and kind of a debris is created that usually happens during the earthquake.

If you can see in this picture the one you can see in doted lines how the building used to be before the earthquake struck and I as you see when we all can the Waves travel this is how the earthquake the building reacted to the earthquake and its shade with it.

If you can see there in a building which is six stories high and there is a building that is 20 stories so what happens when a building is taller kind of tend to be more prone to the earthquake and why is that so this particular figure shows the vulnerable group that is in Mexico City 1985 earthquake.

What was notice that periods of in the 6 to 20 story range resonated with the frequency content of the earthquake.

Why it that happen so if you can see the building display gets displaced during an earthquake and how an earthquake force happens on in the building and what happen so what is an earthquake design with design a resistant design philosophy for building. When minor shacking happens you can see the hardly any damage in the particular building if there is a moderate shacking there is minor damage on the structure of the building and when the Savoir shaking her you can actually have civil structural damage but we can actually prevent collapse based on earthquake resistant design philosophy of the building.

Typical Damage and Failure of masonry building.

The creation of tensile and shearing Stresses in walls of masonry building.

The non structural damage is the damage the due to with strength and stability of the building is not affected to such damage occurs very frequently even under macerate intensifiers of earthquake. so what happens in non structural damage what happens building what happens in non structural damage what happen the building is in that nothing happen to the building but what happens minus structural damage that happen you know that happen maybe crack on a wall or certain things fall off but the major stability and strength of structure is maintain intact so that is what is a non structural damage during the earthquake.

Cracking and overturning of partition walls from inside of frames as I said maybe roof chimneys large cantilevered cornices in balcony draw the blasters follow following of plasters on the wall happen ceiling and it particularly loose when there is the loose ceiling plaster ceiling they fall off

cracking and overturning of partition was filler walls and cladding wall from inside of the frames happen do not usually active account for calculations this type of damage reduces the lateral strength of the building then what happened there is cracking and falling of ceilings when the ceiling light

of others ceiling than that cracked servers down there if there are glass painting hey to crack and a fall down that happens , when the loosely place objects on the particular building like maybe water tank they follow that can happen and then they can be overturning of cupboards that can happen so and so those kind of things happen in a non structural damage in the earthquake going on who is this building a when the earthquake strikes you can see there are like the structure is intact you can so sudden this kind of things happen in the building like when this is a earthquake motion that happens you can see the horizontal cracks in the building then the red

Diagonal cross did you see here and there are cracks due to the bending of the wall and when the world kind of bends with the earthquake will be a small crack induced. Non structural damage to the building but nothing in it won't given fall over when we added to the laws of the earthquake resistant architecture so failure due to Racking is characterized ,diagonal cracks which could be due to diagonal compression or diagonal tension.

Such failure maybe either through the pattern of joint or diagonally through masonry units.

So this joint describes usually initiate at the corner of the openings in sometimes at the centre of the wall segment in you can see abs failures due to the shear you can see the like this happens at the corner of the opening and there something happen in the middle of the opening send this kind diagonal tension .

These cracks usually initiate at the corner of openings and sometimes at centre of wall segment. If the foundation is Shallow so they did you rate as a result of the weathering or constant weak and we can get there is earthquake resistant when the foundational shallow so we have to make sure that on in the earthquake resistant areas of earthquake prone areas particularly the foundation has to be kept deep and the area around the foundation has to be made sure rigid.

Another thing that can happen is the differential settlement of foundation during civil ground shaking what happens liquefaction or loose water saturated sands about the foundation kind of give a mixes with the water and it forms from solid to the liquid as we discussed in the previous lecture that is what is the process of liquefaction that occurs, And that creates a kind of a

differential compaction of weak and soil, and that kind of create excessive cracking in the foundation and which in turn give rise to the a falling of the building.

another thing that happen is a sliding of slopes or earthquake cause, so sliding failures in manmade as well as Natural hill slopes and any building receiving on such slow forward danger of complete disasters disintegration of the building so as we discuss in the previous lecture landslides occur mainly because of the earthquake and this is again an example of the sliding of slopes.

Also in manmade slops we can see if you create a natural natural slope in plain sight a and an earthquake happen things that is on top of the slope actually may give up and fall on the things on the bottom of the slop that kind of create a panic situation then and now I want to say is failure of roofs in the floor then what have the listing of roofing material that is improperly tile roofing material is disclosed the inertia forces acting on the roof and the this mode of failure typical of sloping roof what happen when the sloping roof is made you can see that actually elements has kept on the sloping roof was actually removable or they are not of structural materials that place so what happened when the earthquakes like this kind of materials kind of easily gives up and they fall down and create the damage for the people of the material surrounding and that can be a major cause of the damage during earthquake .Again What Happen roof to support the connection is a cause of separation of roof Truss from support. although the complete roof collapse mostly occurs due to the collapse of supporting structure this can also occur the give up if is not properly tied with the walls and everything happens heavy roofs as used in rural areas with large thickness of the earth over round Timber causes initial forces on top of the wall and that creates the rupture of the walls what happened in the villages what happened the rural area you can the timber and on top of that you have such a group captive just earth and walls

so when the roof give up that kind of give up initial around the top of the wall because the roof is kind of resting itself on the wall and a kind of trying to hold itself because of the because of resting on those walls this kind of creates rupture on the walls and finally eventually the walls given up ,so if you can see in this picture 1 is earthquake motion and a 2 is the wall of the column so you can see 3 what happen the ties of the rupture and they fall down and the four there is a crack on the column or wall based on the rupture of the column because of this and 5 the whole trust Internal so fast fall when the earthquake strikes what happens will be the column would give the wall and column would give up then there is rupture of ties and rupture then there is trust gives up and then eventually everything falls on top of each other and the whole structure of also that's how the roof gives up during earthquake itself .

what are the major causes of damage in masonry building during earthquake and heavy weight very stiff buildings attracting logic seismic forces that create that create rupture and when there is a very stiff Building and on top of that I heavyweight is place may be a heavy roof

and kind of inertia force on the wall because the roof is try to save itself I'm falling so they kind inertia falls on the wall ruptures and they fall down in turn and very low tensile strength and circularly for motor joints can cause earthquake .

Then there is low shear strength particularly with the because of the poor motors and that can happen brittle behavior in tension as well as compression when the building of the walls give up to the give up to the tension and compression and brittle know that kind of gift the bring down the hole building and eventually that creates damage.

Then there is weak connection because of one wall to wall. When there is a exclusion from one wall to another wall there is a weaker connection weaker point create a crack brings on both the wall there is connected to that

connection and then there is the stress concentration on the corner of the windows in the doors actually I as we saw in the previous like that there will small there on the wall at the corners of the opening elevation of a building see a foreign architecture building is very important to create symmetrical plan because when there is a symmetry in there is there is imbalance in the planning that I kind of gives makes the building give up very easily when there is a symbol position of openings in the wall that can also created create giving up of buildings during earthquake so what are the categories of building.

Categorizing the buildings with the purpose of achieving seismic resistance of economical cause 3 major parameters turns out to be significant the building.

(i) Seismic intensity zone where the building is located

(ii) how important the building is and

(iii) Tree House it is the foundation soil

A combination of the these parameters will determine the extent of appropriate seismic strengthening of the building.

Plan of Buildings

As I discussed before the plan of the building is very important and how the planning is done how what is the shape of the building how in symmetric the big builder how the regularity of the plants in creating an earthquake .First and for most of factor the we go in the plan of the building is symmetry of the plan of the building is a hold its various blocks because symmetrical especially in the earthquake prone areas about its both its axis.

An Asymmetry leads to torsion during the earthquake and that is dangerous so the kind of waves in a gives up to one heavy for the building giving up. What is the other major part is seeing is regularity of the plant simple rectangular shape how does not behave the bass better

in and out quick then the shape many projection so what happened torsion effects on the ground motion are pronounced in long narrow rectangular block. Therefore it is desirable to restrict the length of a block to three times its width. some another major factor that we see is the separation of the block so when there is a large buildings and rather than creating something like really linear it is better to split into different blocked with a symmetry and regularity of each block so really you no longer building doesn't perform much well when the earthquake strikes it is better the split into different compartments a different building.

The another major fracture that we seeing is simplicity so ornamentation involving large cornices is a vertical or horizontal cantilever so you projection faces stones and the search likely things are dangerous and undesirable from seismic point of view so what happens when there is ornamentation in the building and then there are large cornices in the building and such a heavy cornices is a given in one corner of the building even though the plan is simple when is a kind of iron cantilever is given in the building in that kind of a gives rise to the gives up during the earthquake and fall down so that has to avoided in creating a while creating an earthquake resistant building if you can see in the picture of given diagram given the one to one the earthquake force that happens on either side so two is the centre of stiffness of the assistant force and three is the centre of gravity.

T is the twisting of the building that happens when the earthquake strikes we can see when building is symmetrical or rectangular the amount of twisting that happens is very limited. Moving to another major part that is enclosed area. A Small building in closed properly into connected with earthquake transfers world increases as a length decreases if we can see in the picture maybe in this particular building respond better to the earthquake then this particular building. So as the purpose of the building is more rigid and small rectangle then it responds to earthquake be better than your building. Moving to the next important topic masonry wall.

So when there is only one masonry wall that is standing and then there is no enclose the roofs or a floor and an earthquake strike what happens after that so consider the free standing masonry wall as shown in the figure and the ground motion is acting transverse to a freestanding wall what happens next, The out of plain inertia Force acting on the mass of the wall tends to overturn it. you can see on the top F is the force what happens when there is an out of plain inertia force acting on the wall that kind of tensile as see in the picture like this and that kind of tense to overturn the vertical altogether it my policy the seismic resistance of the wall is by the weight and tensile strength of a motor very small and wall where will collapse by overturning under the ground motion another thing that will see your free standing over the distress on the ground as shown in the figure is subjected to ground motion and its plain so what have in this case the wall will offer much greater resistance because of it large depth in the director of the force and the plane of the bending .

Structure and fall down it will try to the earthquake I was turning standing itself to earthquake such a wall is termed as the shear wall that is the damage modes often unreinforced shear wall depends on the height and length ratio as they the aspect ratio of the wall another server the

large aspect ratio was generally developer horizontal crack of the bottom to the bending tension and then slide due to shearing if you can see in the picture with the larger aspect ratio its due to the sharing crack diagonally sharing has been shown in figure if you can see this is the wall with the moderate aspect ratio and that tends to creak in the middle.

So a wall with a small aspect ratio on the other hand made develop diagonal tension cracks on both side and horizontal creak in the middle so when I was small available with us crap so you can see where is network icon inside and then there's a horizontal crack in his intention so is in the centre of this happen because of the mind tension in particular.

Wall Enclosure Without Roof

Another major factor will be seeing the wall enclose without roof So happens when there is a enclosure of the wall but there is no roof on it so consider the combination of wall A and B as enclosure shown in the figure.

This is the wall A and wall B and this is the enclosure that we are discussing about, For the X direction of force as shown. Today share walls and besides taking the role inertia of a resistance greatest impact against the collapse of world as well if you can see this what happened a kind of actors and shear wall Taken all the land A kind as well as for them and I will create give support to it and try to making it stand stiff fall so what happen A now Act as the vertical slabs and they supposed to slabs the wall courses on their own so what happened there is a plain wall A now only will act as a vertical thing that is standing on plane so there will be a kind of an inertia force that is acting on A it's self so now B has a inertia force for that's kind of standing itself and also A but also has inside inertia forces acting with in itself.

Near the vertical edges the wall carry reversible bending moment the horizontal plane for which the masonry has little strength.

Consequently creaking and separation of the walls may accrue along these edges shown in the figure.

So you can see here because the tension in A by itself there will be a crack formed Here and that might occur because of this so what happens if the connection between walls A and wall B is not lost due to the bonding action of our bonding Action Replay the building will tends to act as a box and its resistance to horizontal loads will be much larger so what happened most reinforced masonry enclosures how ever have very weak vertical joints between walls meeting at right angle due to the construction procedure involving toothed joint that is generally not properly filled with motor,that consequently that particular corner fail and is a collapse so basically the tension in the particular walls A and B won’t act against that wont left the crack create rupture of the walls but what happened when there are two walls A and B being struck together

That particular joined is left out and because of the lesser application of the of the motor at the particular area. That a particular kind of rupture collapses and the best kind of gives or intern

leads to the collapsing of both the walls A and B so that will give up to give rise of where the whole thing would fall on it so basically in the summary

The basic understanding of the behavior of various building types when the earthquake happened so what we saw that when the earthquake happens how a particular building behaves how each part of the building Behaves and what are the non structural damage that happens when earthquake strikes in a building.

what is the difference between structural and nonstructural floor plan of a building is more relevant towards the sea Bass on the scenic point of view towards earthquake resistant architecture and how that particular planning help in improving the resistance of the building during earthquakes and the amount of resistance of building can have base on the plants shape and that is discussing understood so basically we understood that you know simpler and axle plant as a poster better during earthquake than having zigzag opposite plan in the earthquake prone zone is very good it's a rectangle square plants for building in such area.

Earthquake resistance and that is discussed we understood even though they have self energy and sell photos that is helping is saved by then if the motor at the joint properly then there are causes the crack and the old wall would come down.