Earthquake Resistant Architecture

Lecture 8

Hand Moulded Layered Construction

In the previous lectures I spoke about there are multiple types of earthen construction that happen in across the world so multiple of this construction usually happens in areas it is very prone to earthquake that is even though the technological advancement had come in and various types of new technologies that kind of made the disadvantages of more towards advantages sites of the earthquake resistant construction when it comes to mud earthen building still there is like a lot of weight what a long way to go in order to become a completely earthquake resistant construction, so are the first and foremost the thing that you understood in the previous lectures is that lecture about the earth and construction is that there are multiple types of earthen construction and each construction and different parameters that to be considered while creating a quick earthquake resistant structures, so in this particular lecture we're starting with hand moulded layered construction that's one style of the earthen construction and these are the most primitive and weakest type of construction because of the low percentage of moisture employed to make the hand moulding and poor level of compaction attained.

It's basically in this particular construction what happens we have a lot of mechanical compactors come in right now but then this particular thing we use complete to compacting with the hand as of the amount of compaction the level of compaction week anything because of this is very limited so that it makes it very weak and the construction type very weak, so all the clay is not activated either by moisture or by compaction,

Even though a small amount of moisture is used depending on the soil some orders some horizontal and also vertical fissures normally appear, So basically you can't avoid fissures in this kind of construction. This should be controlled by adding straw as much as possible to attend a reasonable workability of the mixture. Straws kind of you may use as a component that kind of Arts them and strength of the clay whenever we take it to construction so as much as possible has to be added to it in order to make it more strong and with the level of compassion there is anticipated can be tailed. this is not possible course sand could be used as an additive instead of this things straw to do in the smallest experimental proportion for an excess of course sand will inevitably reduce the Wall strength so basically when you have course sand is very important to understand the unit that the very small proportion exceeding which the strength of the wall will naturally come down so basically what we use it is an additive to increase the strength of the mould will actually become the reason to reduce the strength of the mud.

Generally it is to be necessary to moisten the area of the lower layer which will be contacted with the mud in order to avoid sudden drying of the contacts on which produces the fissures.

Next is the Adobe or block construction that will be seen in the case of cut as well as moulded Brock the strongest unit correspond to plastic or clay soil, however the blocks strength places secondary role in the masonry strength is the joints between block becomes critical.

Blocks used should be well dried in order to avoid future distractions blocks are made in different sizes in various countries it may be stated that the dimensions of the block not the way this place has serious effect on the strength.

Traditional practice obtain an adequate block without important fissures either by mixing Sandy or clay soil while looking after the block so dries without restrictions that's a eliminating the fissures.

The usual good principles of bonds in a masonry should be adopted for construction of Adobe walls that is all courses should be lead level the vertical joints should be broken between two consecutive causes by overlap of Adobe and must be carefully filled with motor the right angle joins between the walls should be made such a manner that the walls are properly join together and through vertical joints is avoided.

The next for construction type that we would be seen as Tapial or pise construction, Tapial or pise construction are rammed earth Constructions in which moist soil is poured in wooden forms of the wall and competitive achieve the design density, so you have wooden form in either side of the wall and in between that moist soil is poured in and then you a compact it to achieve the density that we wanted to achieve, while Adobe constructions acquire the strike by activation of the clay throw moisture contain of the soil, Tapial construction to the compaction using small percentage of moisture in the soil so basically in Adobe construction we have use more moisture in the soil and tapial construction we do compaction and used rest moisture in the soil so the highest strength is obtained by humidity and compaction when the clay is present we use of low moisture content and the control of the amount of clay by adding the coarse sand to the soil required are required to control the shrinkage fissures of drying.

So if the amount of course sand excessive the strength dimishes dangerously it is recommended to make the wall test with increasing percentage of sand under fissuring is reasonably under control the best way to ensure Monolithic structure of the taple wall is sufficient quantity of water at subsequent joints the sub join that every 10 centimeter.

The use of excessive amount of straw in the mud mixture more than 1:1/ 4 the volume is self defeating because it causes a strength reduction so the amount of straw in the mixture has to

be reduced 2.25 to 1 in order to help make it more strong ones excise that the strength will consider be reduced which becomes in which in turn becomes a negative to the construction.

Moving on to the last and the final of construction technique that we discuss we're discussing in this lecture that is the earthen construction with wood or cane structure so it causes of vertical force and horizontal blocking members of wood, cane or bamboo the panels being filled with cane and bamboo or some kind of read mating plasting of both sides with mud so basically you have horizontal vertical blocking members of wood or cane bamboo and that is the basic structural member of this particular construction type the construction could be done in the rudimentary way building element by element over using prefabricated panel, so basically previously would be used to do tie one by one and start doing it but now we as a technology in advance we do prefabricated as impanels then bring it to the sight and then construct with it is the behavior of this type of construction could be very good as long as the following fundamental rules.

The one I should be good connections between the wood or cane elements as to ensure and integrate behavior of the structure to you have to the preservation of wood or cane elements while charging the surface of pointing by coal tar. Especially in the path embedded in the foundation we should preferably of concrete stone of bricks laid with cement lime or gypsum mortar.

Additional is recommended the panel filling material should consist of wood or cane mesh over which a layer of mud and straw 1:1 in volume is placed on each face of the to form a plaster so very often the meshes are knit in themselves around the structure so basically what do you have is a horizontal and vertical frame like this of a wood or a bamboo a place and then either side you'll have 1:1 proportion of mud and straw that plays like blasters and that's out the construction actually happens in houses builders continuous systems as in those made with prefabricated panel and upper ring been should be placed the purpose of it being two fouled, One the integrity at all walls and two distribute evenly the roofing load only after fixing the upper ring beam after completing the nailing the mud filling was be placed so this will avoid fissuring caused by the strokes of the nailing operations basically fissuring is a biggest enemy when it comes to Earthen construction site.

If can see in this picture this is a rudimentary or continuous way that we discussed before basically what we do is we usually tied horizontal and vertical members that can be either in the bamboo or wood cane whatever and you have a blaster made of mud or straw that is enough kept on either side so you also can have rudimentary used to have cane knitting above the wood or bamboo Rapping that we have you so basically around that we used to have a clean knitting that kind of made it stiff and it uses test and then you would mud plaster and now present the wood be used in prefabricated panel what we have it look like this so once you

bring in there then we just like a mesh or a matter and then on top of that will have a mud and straw mixture plastering on this is kind of more strong and the more modern technique than this so if you see in the picture you can see the adequate configuration recommended.

Basically you can see that adequate configuration is one flow construction and with roughly square room so you need to have a symmetric distribution of walls small openings and the user blasters.

Seismic Design of RC Buildings

Moving on to the next major part that is one of the most major consideration the present day scenario that is a seismic design of RC buildings so basically most of the building then construct in the presentation building and very important to understand the basic consideration for the construction of such buildings when it comes to earthquake efficiency, So this is a typical RC building can see you have beams columns floors walls this are the major components of a ceiling of an RC building and basically the construction while constructing it shall we can follow certain rules and regulations at my actually help us make building more efficient.

In recent times reinforced concrete building that become common in India particularly in towns and cities reinforced concrete simply RC consists of two primary materials that is namely concrete with reinforcing steel bars concrete can be molded into desired shape and steel bars can be bent into the desired shape hence structures of complex forms a form with this particular type of construction that itself makes it difficult for it to be a earthquake efficient in order to that we need to understand what are the various consideration the meaning to understand not to create an earthquake resistance building and get to have different forms and different look that we want to have you can see this is a very different types of building types of RC building which shows multiple number of openings in the corners how to make it look as in different and yet to have earthquake efficiencies what we want to see in this particular unit .

Earthquake forces are random in nature and unpredictable the static and dynamic analysis of the structures of become the primary concern of Civil Engineers or Architects. The main parameters of the seismic analysis of structures are load carrying capacity ductility stiffness damping and mass

openings in the corners how to make it look as in different and get to have an earthquake efficiency is what we want to see in this particular unit so basically is 1893-2002 carry on the seismic analysis of multi storey building, So I talk about this week analysis of structures analysis type that should be used to analyse a structure depends upon. One the external action two the behavior of structural or structural material and the three type of structural model selected.

Concrete is made of sand stone, curst stone aggregate and cement all mix with pre determining amount of water concrete can be molded into any desired shape and steel bars can be bent into any shapes, so The structures of complex shapes as I said a possible in RC. A typical RC building is made from horizontal members that is beans and slabs and vertical members as columns and walls and bases by foundations rest on the ground.

The system comprising of RC columns and connecting beams is called RC frame and the Rc frame participates the resisting the earthquake forces the earthquakes shaking generate inertia forces in the building which are proportional to the building mass.

Since most of the building mass is the present that's low levels earthquake induce inertia forces primarily developed at the floor level. These forces travel down words with the slab and beam to column and walls and then to the foundation from where that are dispersed to the ground.

So basically what happens the forces are created at the floor level was the created at the floor level and then what happens this Travels through the force lab and then to the beans and then to the columns and then to the walls and then it slowly moves to the foundation and then it gets disposed in the ground. so as inertia forces accumulate down words from the top of the building the columns and the walls at lower storey is experience higher earthquake induced forces and therefore design to be stronger than those in the storey's above so if you can see in the picture I can see the total horizontal earthquake Force in the building increases down words towards its height. Most of the building the geometric distortion of the slab is negligible in the horizontal plane this behavior is known as the rigid diaphragm action so in this figure you can see the floor bands without with the Beam but that moves all the columns at that level together so basically beam moves with it and the column kind of dislocate.

After columns and floors in the same building are cast and the concrete hardens vertical spaces between the columns and the floors are usually filled in with masonry walls demonstrate floor area into functional spaces rooms.

Normally this masonry walls also called infill walls are not connected to surrounding RC columns and beams when columns receivers on resources at flow levels we try to move in the horizontal direction but masonry walls tend to resist this moment. Due to the heavy weight and thickness these walls attract last week and see in the figure thickness these was attract large was on the forces say we can see in the figure think and see the infill walls move together with the columns under the earthquake shaking you can see that it moves together along with the column how since the masonry is a brittle material these was developed cracks once their ability to carry horizontal load is exceeded.

Thus infill walls act like sacrificial fuses in building they develop under severe ground shaking but help share the load of the beams and columns until cracking basically we introduce

particular element in order to actually help the building when the earthquake effects, so the earthquake performance of infill walls is enhanced by Motors a good strength making proper masonry courses and proper packing of gaps between RC frame and masonry infill walls so talking about the horizontal effects.

Horizontal effects of earthquake effects are different gravity loading due to self weight and contains on building causes RC frames to bend resulting in stretching and shortening at various location.

Tension is generated of surface that stretch and compression of those are shortening if we can see in this particular figure. The figure shows earthquake shaking the reverse tension and compression members So you can see that once particular gravity loaded building an earthquake load happens what happened the member kind of stretches and location certain location the tension the created because of the tension on either side on both directions it kind of gives up and is kind of tense to fall.

Under gravity Road stands in the beams is at the bottom surface of the beam in the central location and is at the top surface of the end on the other hand earthquake loading causes tension and beam and column faces locations different from those under gravity load. Relative levels of the tension in technical terms that is bending moment generated in members are shown in the figure that we just spoke about. So the level of bending moment due to earthquake loading about the level of bending moment due to earthquake loading depends on severity of shaking and can be exceed that due to gravity belonging. Thus under strong earthquake shaking the Bend and The Beams can develop tension or either to the top and bottom faces since concrete cannot carry this tension steel bare required on both faces of beam to resist reversals of bending moment similarly Steel bars required on all faces of a columns too.

Strength Hierarchy

Strength hierarchy for a building to remain safe during earthquake shaking columns which receives forces from the Bean should be stronger than that of the beams and foundation is receive forces from columns should be stronger then Columns .

Further Connections between beams & columns and columns & foundation should not fail so that beams can safely transfer forces to columns and columns to the foundation. so when the story is adopted in design damages likely to occur first in beams if you can see in figure 5a strong columns and week beams damage happen then always week columns and strong beams damage you can see that all damage is done only in a single stories and not in a multiple stories.

When beams are detailed properly to have large ductility the building as a whole can deform in the building as a whole can be formed a large amount of despite progressive damage caused to consequent meaning of being in contrast of columns are made because they suffers severe local damage at the top and bottom of a particular storey this localized damage can lead to collapse of building, Although columns at storey's about remain almost undamaged.

Talking about strength hierarchy for a building to remain safe during earthquake is very important to understand why and when the strength of a particular building and why certain parts of the building should be more stronger Each Other when you come to strength hierarchy so basically as in the beginning of this particular subject in the lecture 1 I spoke about how the load is being transferred from the roof of the building to the foundation of building and when be tension forces are created because of an earthquake how the load transfers from the top most part of the building and goes the bottom most of part of the building the same way once each part of the building that connects to the other part of the building and from where the load gets transferred from to wear gets transfer to you should see that where ever it gets transferred to be stronger than from where it comes from so basically when you see the roof of the building and wall of the building are connected roof is where the slab is where the first and is created and then gets transferred to the Beams so Beam should be stronger than the slabs and from the slab it gets transferred to the walls of the columns, that should be stronger than be a beam and then from there goes to the Foundation the foundation should be stronger than the walls and then get separated so further that the connection between the beans and the columns in the columns of foundation should not fail so basically if the foundations the connection between each structure is particular part of the building is not strong this Transformer may not happen even though one particular member is stronger than the other one and the hierarchy of the string is maintained even though the hierarchy is maintained and the bonding is not proper then there is no use of it because then the correct transfer of load doesn't happen.

So also if you can save you understand this if you can save you understand this there should be a particular strategy that we should adopt in creating a beam and column structure in RC structure and we should you always understand that we should have stronger columns and weaker beans than a week of beans and strong columns as I mention so whenever the columns are stronger than the beans the loads damage is distributed to all the storey's is equal but where is Beans are stronger than the column there be only damage in one story and that kind of gives rise to the whole structure feeling and everything falling down causing the more damage.