B. ARCHITECTURE

CONSTRUCTION TECHNOLOGY (AR6013)

CONTRUCTION TECHNOLOGY FOR HIGH RISE BUILDING

Lecture – 6

Definition of High Rise Building:

High Rise Building are defined differently by different standards.

Emporis Standards:- The Emporis standards defines is a multi-story lecture which is between 35-100 meters tall, or a building of unknown height from 12-39 floors this is termed as high rise buildings

Building Code of Hyderabad, India

A high rise building is one with four floors or more or 15 meters or more in height

National Building Code (part 4) – Fire and Life safety defines as all buildings 15 meters above height shall be considered as high rise buildings

The International Conference on Fire Safety defines it is any structure where the height can have a serious impact on evacuation

The Massachusetts, United states General Laws defines a high rise is being is any building that is being higher than 70 feet that is (21m).

Tall Building Structural Systems:

So what are the different functions, what are the different parts, different components of high rise buildings. We will talk about the structural systems of tall building little bit. The structural system of tall buildings can be classified based on the structural materials which are used such as concrete or steel. The structural system of tall buildings can also be divided into two broad categories

1. Interior Structures
2. Exterior Structures

This classification is based on the distribution of the components of the primary lateral load resisting system over the building. A system is categorized as an interior structure when the major part of the lateral load resisting system is located within the interior of the building. Likewise, if the major part of the lateral load resisting system is located at the building perimeter, a system is categorized as an exterior structure. It should be noted, however that any interior structure is likely to have some minor components of the lateral load resisting system at the building perimeter and why exterior structure may have some minor components within the interior of the building also.

So what are the various components of the Interior structural system

1) Rigid Frame
    - A rigid frame in structural engineering is the load resisting skeleton constructed with straight or curved members interconnected by mostly rigid connections which resist movements induced at the joints of members. Its members can take bending moment, shear, and axial loads.
    - It also consist of columns and girders joined by moment resistant connections
    - It can build upto 20 to 25 floors

2) Sheer Wall Structure
    - These are concrete or masonry units that are classified as continuous vertical walls that may serve both architecturally partitions and that may serve as architectural partition and also structurally to carry gravity and lateral loading. Very high in plane stiffness and strength make them ideally suited for bracing tall building
    - It can be usually built as the core of the building.
    - It can be built upto 35 floors.

Tube System

The Tube System concept is based on the idea that a building can be designed to resist lateral loads by designing as a hollow cantilever

perpendicular to the ground. In the simplest in condition of the tube the perimeter of the exterior consists of the closely paced columns that are tied together with deep spindle beams through movement connections. This assembly of columns and beams forms a reject frames amounts to a dense strong structural wall along the exterior of the building. The different tubular systems are frame tube, brace tube, bundle tube and tube which is placed inside the another tube.

Diagrid Systems

- With their structural efficiency as a varied version of the tubular systems, diagrid structures have been emerging as a new aesthetic trend for tall buildings in this era of pluralistic styles
- Early designs of tall buildings recognized the effectiveness of diagonal bracing members in resisting lateral forces
- Most of the structural systems deployed for early tall buildings were steel frames with diagonal bracings of various configurations such as X, K and chevron. However while the structural importance of diagonals was well recognized, the aesthetic potential of them was not appreciated since they were considered obstructive for viewing the outdoors.
- Efficiency resists lateral sheer by axial forces in the diagonal members but have complicated joints

Space Truss

- Space truss structures are modified braced tubes with diagonals connecting the exterior to interior. In a typical braced tube structure, all the diagonals, which connect the chord members – vertical corner columns in general, are located on the plane parallel to the facades.
- However, in space trusses, some diagonals penetrate the interior of the building.

What are exist skeleton structures?

In exist skeleton structures lateral load resisting systems are placed outside the building lines away from the façades. Due to the systems compositional characters, it acts as a primary building identifier which place one of the major roles building facades in general cases. Fire proofing of the system is not a serious issue due to its location outside the building line.

Super Frame Structure

- Super frame structures can create ultra-high-rise buildings up to 160 floors
- Super frames or Mega frames assume the form of a portal which is provided on the exterior of a building
- The frames resist all wind forces as an exterior tubular structure. The portal frame of the super frame is composed of vertical legs in each corner of the building which are linked by horizontal elements at about every 12 to 14 floors
- Since the vertical elements are concentrated in the corner areas of the building, maximum efficiency is obtained for resisting wind forces.

Typical Floor Construction Cycle:

In the construction of a high rise building, one of the planning objectives is to ensure the early completion of the structural frames to generate floor areas for the execution of finishing works, building services installation and internal fitting out. So it is imperative that any high rise building has to be completed within very fixed timeline, time is money so if construction goes on for ages we lose money the builder, the land owner all the stake owner in the state of law, the contractors, sub-contractors everybody is in state of laws. So the completion of the any high rise building has to be done with proper sequencing of activity and also for that we have to learn that is what is construction cycle in typical floor. The completion of the structural frames is therefore critical in the overall programme. For a building of 42 storeys high it may consist of 40 typical floors resisting on two podium floors. It is not surprised to have construction programme aiming at a 2-day or 4-day cycle for the typical floors. IT would be a time cost trade off in determining the duration for a project in project wise considerations or in selecting construction methods for major construction activities. Its the role of the Planning engineers have to balance the resources inputs and the duration for activities in order to ensure a smooth flow of work and sequences in meeting the project duration and delivering the project in time as per quality standards

In minimizing the construction costs for constructing a reinforced concrete frame, the formwork cost is one of the key concerns. It is well recognized that framework is a temporary work for forming moulds for we t concrete. The cost of formwork is highly related to the number of re-use or re-cycling.

It is general assumption that a set of formwork can be re-used for at least six to eight times and 100 times for timber and steel form respectively. Steel formwork systems are prevailing in high rise building construction because of their durability, good concentrate finish and environmental sustainability. However they are expensive unless the formwork system is designed to yield a high number of reuse. Taking the above example, a set of formwork for 40 typical floors is still uneconomical. Consequently it has to subdivide the floor area into zones in order to generate a high number of reuse.

The subdivision of a floor into two or four zones will be feasible solution. It is obvious that dividing the floor into four zones would yield a high number of re-use that is 160 times. The following example shows the arrangements of a 6-day floor cycle for a typical residential building block. For example if you take the example of the construction of a 42 storey building, each floor is divided into 4 zones, so one set of a steel wall form covering the quantity of one zone and two sets slab timber form with each set covering with the whole area of one floor are used. In order to speed of the construction the precast facades and semi precast slabs are employed in the construction. The construction cycle aims at smooth at ensuring smooth and balance resource allocation between the trade workers, concrete works and the formwork installation. As a result the resources rotate horizontally between zone one to zone to at the same level and move upward to the upper floor in the next construction cycle. The schedule is prepared assuming that the activities are carried out at constant duration. However the duration of activities varies due to factors such as supply of materials, skill of workers, weather and efficiency of plant and equipment.

So what happens in a construction cycle, a construction cycle is affected by various factors like we discussed it is affected by availability of materials. So if the materials that we are using in the construction of not available locally it takes a lot of time, it takes a lot of energy, it takes a lot of man power to procure the materials and bring it to site from one place to another. For example if the construction is happen at Chennai and the material is available in Delhi it takes a lot of logistics and in terms of and also lot of money that also adds to building cost and in terms of time and it also adds up a lot of man power to transport the material from Delhi to Chennai. So it is always advised that for an smooth and optimized construction cycle we need to always use locally available material. The second is man power when the man power is not available locally or the man power is not

available near the site or is not available on the site or for that particular activity the time required to do a particular activity extends so it also impacts the construction cycle and extends it and thus it impacts the total time line of the construction cycle of the particular flow. Then the next parameter is weather, the weather also its own impact, for example the construction site workers cannot work in very hot sun in very high temperature in rain or snow.

So weather has the role to play because it is not humanly possible to work an adverse climatic conditions. The efficiency of plant and equipment, if we are manufacturing plants and the equipment's at site or at various or the factories which are producing precast concrete for example are not good or the efficiency is not good or the efficiency is not producing right quantity of material proper quality of materials so that also impacts the construction cycle of a particular floor. Not only that but if there is no plan do check act mechanism at the working level it also adds to a lot of rework of construction activities that also builds up a lot of time take in to perform and activity that in turn affects the entire construction cycle in totality for a particular floor and also in totality of the construction of the high rise building. Material hoisting also plays an important role in high rise building construction as the building grows vertically the transportation time increases and thus extends the duration for the crane-related activities also.

Simulation Model for Typical Floor Cycle:

Simulation Model for Typical Floor Cycle as we discussed earlier that there are various activities that are included that are part that play a crucial role in a construction cycle of a typical floor. So it is very important to form a simulation model so that we can track the completion the start and completion of all the critical activities the provide as the satisfactory and result construction. So the stimulation techniques have been used to predict an activity duration and improve planning. However, the building up of simulation models requires planners to have a good knowledge of simulation. A network based simulation can be used in this study.

This simplifies the skill and knowledge required for modeling a simulation network as general simulation programme can be difficult for general users. What happens is if we have a complex simulation it will be difficult for any person, for example a contractor and architect, structural engineer, service engineer who is on the construction site a supervisor or general person to

understand if there is the complex simulation. So the objective of the simulation model should be to brake the activities and to displayed in a very simple manner so that anybody can understand that were the constructional activity is getting delayed where it is held up and what he should do to release the activity and close it on time.

Planners who have the knowledge in constructing critical path network and bar charts could be able to use the simulation model. The construction of simulation network for modeling is similar to the critical path network using the 'activity on node' format except that loops are allowed to show the re-cycling of resources. During the simulation process, the activities may either be inactive if the constraints are met or otherwise in an idle mode the constraint still exist.

So in the table you can see this table has activity on left hand side and the duration. The duration are divided into three parts one is mean duration, one is maximum and other is minimum duration. So for example in this activities as we go throw there are precast façade fixing, wall steel fixing, wall form fixing, wall concreting, stripping form, semi-precast slab fixing, slab form fixing, beam and slab steel fixing, electrical codulting etc., Beam and slab concreting so all this activities are important for a typical floor construction cycle. So now in this mean column we see in average time required to complete this activities.

Now in this maximum and minimum time it is provided so that we can compute the maximum time and judge the maximum time is required for with all constraints to complete this activity for example for the precast façade fixing activity if an average time required is one hour the maximum time with all constraints of man power weather etc may be computed to 1.25 hours and the minimum activity can also happen, there is the probability the activity happens well before time and it can take only 0.85 hours so all this such charts to be prepared in which all the activities has to be listed with proper duration which divided in to Mean, Maximum and Minimum time required so that we can compute we can plan and we can perform all the construction activities smoothly. The next table for you is Simulation result table, so in this result you see there is the breakage of working period and there are activity duration and there are cycles and then there are compared with 6-day cycle.

So for example an activity is happening from morning 8’0 clock to evening 6’0 clock and the activity duration is constant that means that it will take only this much of time for an activity to be completed no less and no more, so if we do this it will take 6.21 days to complete this activity, so if we compare it with the 6-day cycle it will take 3.5 days to complete this particular activities.

Similarly if the particular activity happens between the same time that is morning 8’o clock to morning 6’0 clock but its activity duration is variable based on man machinery and nature and its cycle days is 4.45 days it may exceed that it more time that is the time will come in negative it is 25.8 days probably so in a 6 day cycle we will fall back into loose of 25.8 days this kind of simulation table is required for optimizing the time required to carry out the construction activities for high rise buildings.

Since there were lot of complexities in construction if we do not do these activities we won’t nowhere the process is stock and what needs to be done to ensure a smooth movement of the process to execution.

Selection of Appropriate Schedule:

An appropriate schedule there will be a lot of schedules when we start a construction schedule, a construction process but a selection of an appropriate schedule is very important.

The simulations provide alternatives for planners to make decisions on initial scheduling and subsequent updating. The simulation results enable planners to locate the upper limit of the floor cycle. That is approaching to the crash time solution that is maximum time required to complete an activity. However, it is a general rule in planning stage unless the project duration would have already been overrun.

For example if the project is already in the closing stage we cannot use the general in normal time for the concluding in activity in that case we have to use the minimum possible time. When deciding the appropriate floor cycle duration, planners have to review the factors and the merits prior to determine the strategies as discussed earlier