Structure and Architecture
Lecture 4

Modular Construction

By definition, modular buildings are sectional fabricated buildings that consist of multiple sections called modules. This might be a little vague to understand but if you look at the definition mentioned, you'd notice that modular construction is a term used to describe factory produced pre-engineered building units that are delivered to site and are assembled as large volumetric components and are substantial elements of a building. Every single word in this definition is so important and this definition has been scripted so beautifully such that, even if you miss a couple of words from this definition, you would not be able to perceive its true meaning in its total complexity. Let's break this definition down, into smaller parts to understand what exactly is modular construction all about. It's a term used to describe factory produced units. By factory produced, what they mean is, we don't produce units on the site, where the building is being constructed. These units are produced in an off-site facility, not on the site, in a factory. Moving on, 'factory produced pre-engineered buildings', what is pre-engineered? When working on a particular thing during construction, its called engineering which is being done on-site. Pre-engineered means anything where the conceptualization phase has been done before execution. That is what is meant by 'pre-engineered buildings'. Here, the units are pre-engineered in a factory set-up and are produced in an off-site facility called 'the factory'.

Describe the factory use of 'pre-engineered' buildings that are delivered to site. If you see these words, 'that are delivered to site'. Again, these are not manufactured on site like I mentioned earlier, these are delivered to the site from the factory we talked about earlier. By means of cargo, trucks, by means of other transportation means, they are delivered to the site and are assembled, not constructed there, because they are already factory produced. They are assembled as large volumetric components. We don't assemble small micro components because, if we start assembling microcomponents, the time taken in assembling small components is extremely high. If you start assembling by making large pieces and then begin building your units, it takes much lesser time to complete the entire building. They assembled it as large volumetric units or as substantial elements of a building. What is substantial here? In a regular construction, a brick is a substantial unit because you don't have to make every inch of the wall, you only have to do 23 cm at a time. That was a substantial measure of construction but that type of construction took a large amount of time, it was and is an intensive process. In order to speed up the process of traditional construction, we have modular construction technology which will help us in taking lesser time in constructing a structure of very similar quality. If you see what exactly these substantial elements are, this could be an entire wall in its

entirety with its doors, windows, all the openings together as one single component, they will be lifted from where they were kept and assembled into the building with the help of cranes, with the help of other lifting tools. The substantial elements can range from a simple wall to an entire room, a six sided room itself can be assembled using modular construction, that is the speciality of it.

If you look at Modular construction, this is not modern technology at all. This might come as a surprise to you but the moment when man started to collect materials of similar sizes and started building, that is when modular construction began. When you meticulously begin collecting things, leaves or branches and begin assembling them, you have started modular construction there. When you start chopping down wood of similar size and then connecting them together, to form a wall, then you have started modular construction. Modular construction are made up of modules. Modules are nothing but simple sections which can be repeated multiple number of times and used in such a way that the overall construction becomes faster and easier but modernization of this modular construction came up much later in history. These modules can range from simple walls to rooms or sometimes more complex structures like lifts, staircases and even toilet modules. There are two types of module construction, one is; the self supporting type and the other one is the one with the structural network. The self-supporting network, is just like using simple structural blocks like how kids play. You stack one block on top of the other block, by the virtue of the one block itself, the whole structure is stable, just like what they have done in this assembly. They have constructed one panel, another panel and then further levels are stacked right on top of this without any frame or any other framework to support it. Whereas, in the other types where there is a structural framework or a network, there is something like this. This is a structure which we saw in the previous episode. This is a tented structure where we use four pillars at four corner tied up with ropes and these pillars support the fabric or the material that encloses it, thereby becoming a structure itself. If you look at the picture below, the framework has been raised in the building. The infills, the openings between the framework, the infills will be filled with lightweight materials like bricks, blocks or any other kind of material. Thereby allowing you to construct faster and giving you the flexibility to have different windows and doors.

If you see how this modular construction was started, the modularization of modular construction started with the advent of industrial revolution. The industrial revolution started in England, the Great Britain then. When the industrial revolution started, there was a lot of processes previously that were done by manual labour which got converted to machinaries. The textile industry saw a very great boon and application of technology. Similarly, transportation industry and every other industry thereby benefitted from the advancement of industrial revolution but advancement always comes with a price. There was a huge population

increase, rather known as a population explosion in Great Britain in the 1800s. If you look at the facts, the population in Britain increased from 10 million to 40 million in the 1800. Manchester city, the city of fabrics, the textile hub of the world, Manchester city experienced a six time population increase between 1771 and 1831. In 60 years, a 6 time population increase. The city of Bradford experienced a population increase of 50% every ten years, starting from 1811 to 1851. By the end of 1851, what happened in Bradford was, only 50% of the population of Bradford were actually born in Bradford, everyone else had come from nearby. The population of the cities increased, thereby requiring a greater amount of accommodation facilities, greater number of facilities for all these people to use. Large number of modular construction owed to industrial revolution. After the industrial revolution, we had a period of wars, we had a series of greater wars like World war I and world war II. After the World War II there was a massive devastation in the entire world. Britain lost more than one fourth of its total economy. They lost a predominant number of people not due to war but because of starvation. Poland's state was pathetic since 80 to 90% of Poland was completely destroyed. But after World war II, there needed to be a fast, tremendous increase in the kind of facilities that were being built for the people. Technology that needs to be invented, needs to use lesser number of people, needs to be fast, low-cost, be very durable, in that period. That is when modular architecture, prefabricated architecture came of use.

Let us quickly get into the applications where modular construction can be used. It can be used in a variety of applications, starting from private houses, social housing, Apartments and mixed use buildings. It can be used in the educational sector in the student residences, Key worker sector and sheltered housing, Public sector buildings such as prisons and Ministry of Defence buildings, Health Sector buildings, hotels, fabrication is practically endless.

If you look into the advantages; it uses less labour, less money is quicker to construct. These were the main advantages but apart from that, what are the other advantages that you can get out of this modular construction. Economy of scale through repetitive manufacturing because we repeat the number of times we use the same thing. Economy becomes less because we are doing it in mass. To understand this, it is very simple. If you are buying a single product, it will cost you more but if you are buying ten thousand units of the same product from a bulk seller or a warehouse, this will cost you even lesser when you purchase from the retail store. The same concept, the same theory can be applied to the economy of scale too. Another thing big advantage is, the rapid installation of site and it can be installed at 6 to 8 residential units per day. That is the speed of construction and it usually has a high level of quality control because it is produced in a factory set up. Concept construction is where people do it on site, whereas in modular construction, they are manufactured best in off site facility called 'factories' and these components are produced in factory settings which means that each and every single

component that is manufactured undergoes a set of rules and precautionary methods, so that the moment they come out as products, they come out as certified products. They cannot go wrong massively in quantity, that is the advantage of factory produced products. It has a low self weight, which leads to foundation savings, that are suitable for projects with site constraints where methods of working require more off-site manufacture. In case of smaller sites where on-site construction is very difficult, the components can be manufactured offsite and can be easily transported to the on-site facility and it can be constructed. Limited disruption in the vicinity. Useful in building renovation project. Excellent acoustic insulation due to double layer construction, adaptable for future insulation. Robustness can be achieved by two corners. Stability of tall buildings can be provided by a braced steel core. There are a lot of good aspects to modular construction. You just look at other general considerations that needs to be done. Before that, we will take a sneak peak at different modules that are available.

Types of Modules

The types of modules can range from a simple component to a three dimensional subsided overall room module. One such module is called a 'four sided module' where it has, all the four sides of this. You can see it in this picture. Another type of module is a partially opened module where if your building plan works this way, you can put modules in such a way that it can be partially open on one side and that side you would use it as a balcony or as an opening or as any component for the building. There is another type of module called 'open sided module' or the 'corner-supported module'. The corner-supported module only supports all the four corners you see in the picture. All the other things can be customized any way you want. Take a look at the picture on the right, that is made out of modular construction and it looks so beautiful.

We already looked into the advantages of modular construction. It is greener, smarter, the other advantages are; less material wastage, improved air quality, better flexibility in reuse, less material wastage, reduced construction schedule, elimination of weather delays because in constructing on site, the monsoon season might be fatal to speed of construction whereas here, the modules will be produced in the factory, which means, even if it is raining outside, the factory can still run. Its smarter because it is safer, better engineered, pre-engineered, produced in factory settings, it has all the good components of various smart buildings. How it reduces time is explained in this graph over here. The design engineering, the permits and approvals and times, the site and development foundation are all the same on both the kind of buildings; the Site built construction site, as well as the Modular construction site. Where we save time is actually in Site built construction, building construction itself is a big component, another big component is site restoration because here, the building construction need not be done on site, it can start parallelly in your factory and it can be completed by the time you complete your site development foundations, your building products are also complete. You

just have to install the site and then you just have to place it according to the plan you have already made, which takes much less time when compared to your regular building construction method. Look at the amount of time you have saved using modular construction.

General Design Considerations

There are a lot of considerations that you need to take care when you are doing a modular construction. Dimensional planning is one such thing, Stability and structural integrity of the component, surface interfaces, acoustic performance, fire safety; are all the things that need to be taken care of. By dimensional planning, what we mean is alignment and finishing requirements. For example; the building components need to be aligned in one particular axis. In modular construction you need to consider the entirety of the building during its conceptual stage itself because you need to take care of every single component and only then can modules be manufactured according to that. All the service modules, the fire safety measures, even your size of the fenestration windows, doors, openings, size of box cut outs, everything needs to be pre engineered and pre-determined. Only then will the construction go smoothly.

The grid planning - it needs to be designed for transportation. There is a very big disadvantage in this modular construction because during transportation, anything can go wrong. The modules that you are going to design, needs to be transferred from the factory to the site which means it needs to be transport friendly. The truck size, the maximum size of the truck determines the size of the whole thing inside. Each component cannot be bigger than the maximum allowable size that can be transported on a truck. This is a big limitation to the construction using the particular technology which needs to be thought about when conceptualizing itself.

Coming down to the disadvantages of this thing; volumetric - modular building sections take up a lot of space which means you need to definitely set up an off-site facility. That is the disadvantage. Flexibility is lost because module size can be limited. How is it limited? For instance; if you take a room, you can design the room for 3 meters by 4 meters in size. You can design the same room 4 meter by 5 meter size, you can make the room as big as possible but if you room is made up of 10m by 10m size, transporting an entire 10m by 10m thing will be very difficult because one thing is, you won't get a transport facility that big. Another thing is, even if you could transport it, lifting the whole thing up by means of cranes will be difficult and there is a greater chance of breakage and damage due to lifting transport. So, what we do is, if you to design a 10m by 10m room, split up the whole room into different sections, then we manufacture them separately, then you bring it.Sometimes if you design two rooms, one room is 3m and the other room is 3.3m. Sometimes you may have to sacrifice the room sizes to make sure you have one size and not two sizes. Sometimes, there is a limitation in the number of modules that you can build. For a certain site, there can only be a certain number of modules

which can be built. Producing an entirely new module, requires a mold which needs to be created and that requires a lot of money and a lot of effort. With the limited number of modules, you can design them properly, you can start constructing it, that is the best of doing a modular construction, which means the sizes of the modules are pretty much restricted. Increased amount of creativity is very difficult to achieve when it comes to modular construction. Coming down to another disadvantage, market acceptance is a great disadvantage here because anything that can be assembled, anything that can be put one by one, was always dismantlable too. The moment you say that it is dismantlable, people think that it is not a very sturdy type of construction, it can dismantle anytime, if that is the case, people get the stigma that it is not a very strong type of construction and people will start neglecting these type of buildings even though they are very good. Anything that is cheaper than a regular product, anything that takes lesser time to build than the regular type of construction is considered to be a compromise on quality, that is the general perception of the public, at least the laymen's view of looking at it. They believe that when the construction methods are good, the new methods where we are trying to reduce the time and increase the quality or increase the cost savings are all compromises on quality. We need to educate people on the importance of this kind of technology. Technology that can save a lot of money, a lot of resources, a lot of time, we need to educate the public such that they don't have such kind of inhibitions when going for a new type of technology.