Basic Construction Materials
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Module No # 08
Lecture No # 39
Metals 4 – Part 2 (Structural Steel)

Welcome friends. I am Arul Jayachandran, faculty at the Department of Civil engineering IIT Madras. I will be talking about how the steel construction is going to talk our skylines possibly in the next decade.

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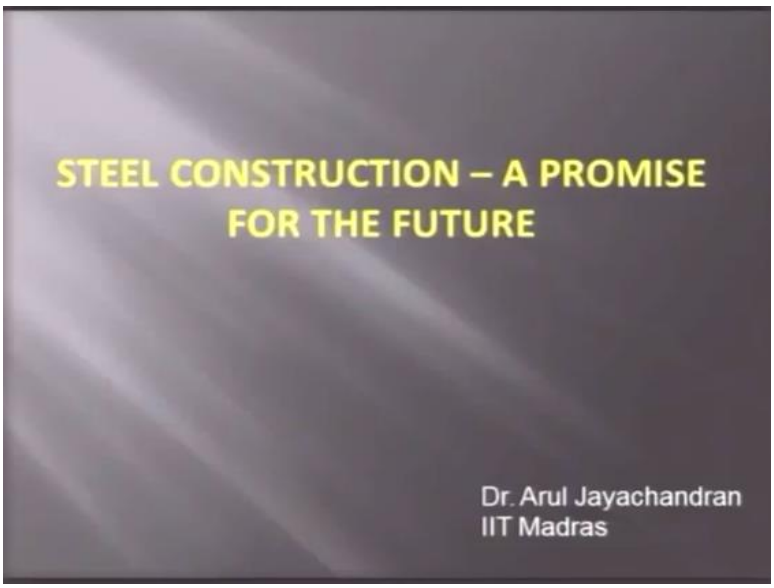

And the lecture will be titled as steel construction a promise for the future.

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In fact, if you see the growth of steel consumption in India, you cannot say it is an amazing journey. But we all started the effort in 1999, and a decade later, the usages of steel were has doubled. The reason is there is a metric in the economy which say is the growth of a country is directly related to the consumption of steel. This means the infrastructure is growing, the housing infrastructure is growing, so possibly more steel is being consumed.

So the government of India wants another about 20 million tons of steel to be used in another few years. So this is that the usage of steel in construction, not on the traditional avenues, has definitely had a barrier on the Indian economy.

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Now, these are the areas of the potential large growth of steel construction in India particularly. I am not talking about the traditional avenues like industrial structures; you have trusses very small amount of steel construction. But it is an amazing new type of structure; the one is the housing, the second is the medium to large span. Because the requirement of these bridges is not by the strength or the load, it will be entirely a community dictated design parameters.

I will tell you what are they as the lecture goes on? Secondly, we talk about you know all these FDI foreign direct investments in India. Which; is going to create quite a number of market places which are for a short duration. So possibly steel is a very good option, and the number will increase are quite amazing. And the last point is that today, we are talking about sustainability, and every citizen is very sensitized about environmental awareness. So steel is suitable for an environmentally sensitized society.

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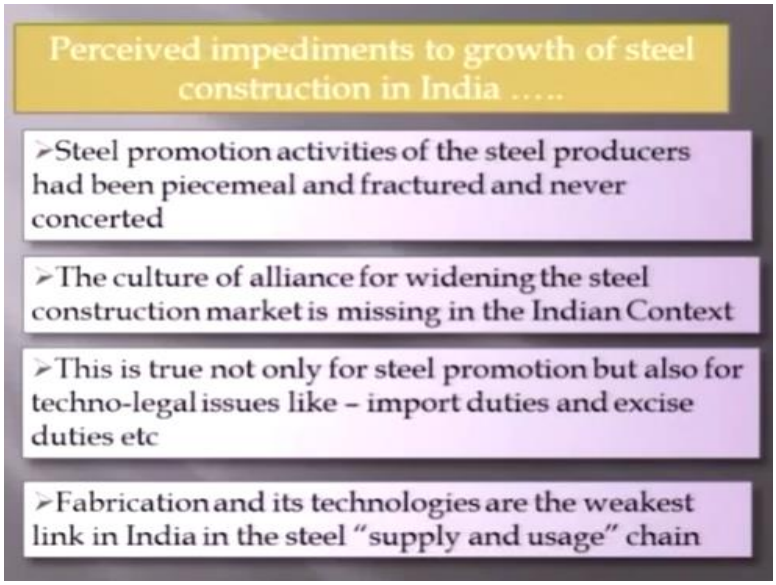

Now I did not say that impediment, but I say I perceived pediments to the growth of steel construction in India. Possibly we can overcome them very easily; the first one is steel construction involved very players we say the steel chain we have producer we have a fabricator we have a contractor we have a designer. The chain is very long, and there has to be some institution; which plays which unites all these are stack holders in this business.

Unfortunately, we do have an organization of a big amount of India it is doing its best, but all the private place should come together to make it more meaningful today it is piece and fracture.

Now the culture of lines like every company wants to you know to make their product. But one of them comes together like they make iron so that the steel can complement construction areas that are unfortunately missing in the Indian context.

So this is not only for steel construction but also for technical issues; if the stack holders or the place come together, all these issues, which are the steel construction is facing, can be dealt with in a much better way. And finally, we have to admit that the weakest link for steel construction in India is in fabrication. Because we do not have a medium-grade fabricator, we have top-notch fabricators or roadside fabricators. Possibly this is one of the points I mean the avenues that India has to grow right.

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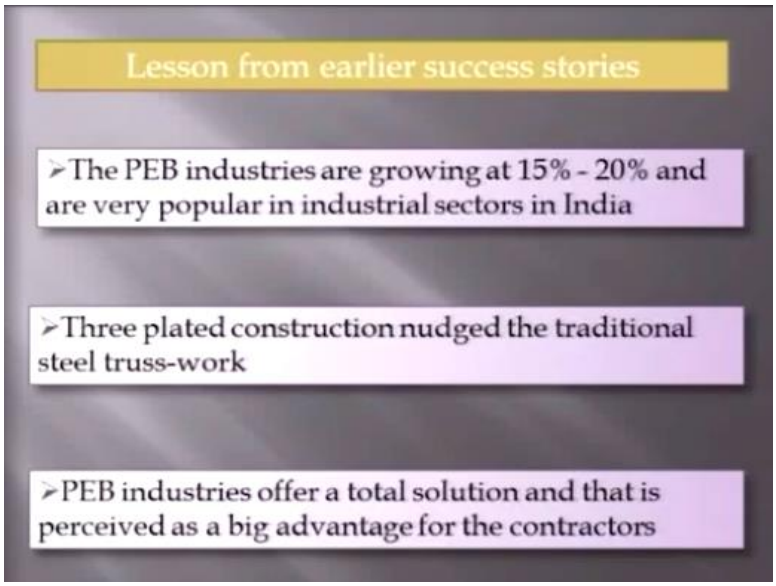

If the impediments are not a problem for us because we have success stories, we have started constructing the pre-engineered buildings called the PEB's in 1999, and today it grows around 20 to 25%. And it is almost nudged out the traditional structural steelwork you find every industrial structure will be pre-engineered building. But when; the PEB's introduced the market or the contractors were not very receptive.

They have quite many questions and today PEB's unstoppable so possibly because it offers a total solution and these have been considered a big advantage by the contractors. So I am sure in future the steel construction is going to grow in a big way in a country like India.

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I will now give the avenues of large uses of steel construction, precisely what I said earlier. This is not about the steel, which is going to go into traditional avenues, which I have already been used as already new avenues. The first one is a take about residential construction; at the end of the lecture, I will show a live example of residential construction that is currently happening in Chhattisgarh.

And this one was fortunate to go and document a residential flat about 180 flats why all these quick time constructions or rapid construction came up. Because in India, we have started feeling that time is money, we all know that the western world runs on the principle time and money are the same.

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I want to give an example; this is a 180 flat multistory building that has come up in the tenth street of Atlanta, very near to Georgia, and the specification for the construction is not the strength; it is not the material but the time. They said that the entire construction is to be completed within nine months and has to be house around 180 students. So the time was the primary parameter for this.

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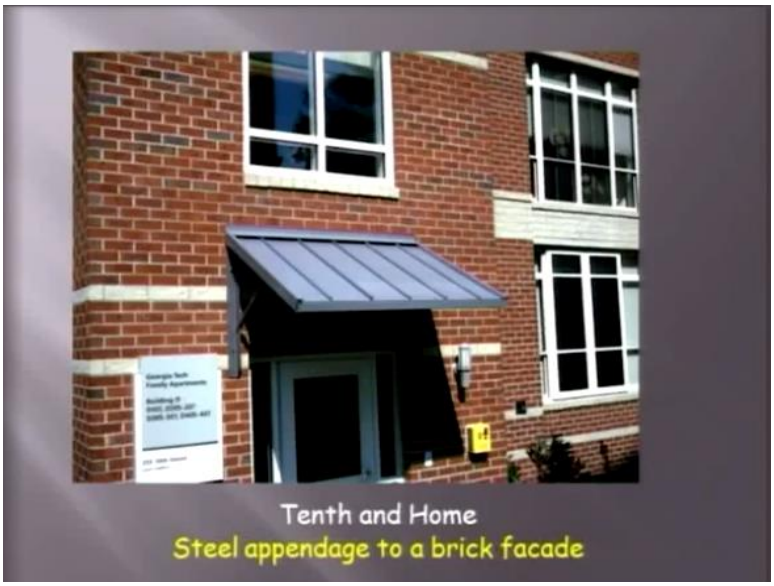

Now all these flats are steel-concrete composites; you can see this much of the steel is appended to the existing factor you can see here. We have sunshade, which is happening to the brick façade. You can see that all these sun shades or any other appendages that can be fabricated outside can be quickly fixed on to that. So you can see this is not a brick façade but just a CP

board, and externally we have pasted small bricks giving us a beautiful view of a traditional brick building.

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I said again that a steel staircase is used; you can see a layer called a resilient layer so that the noise of the steel stack does not come into account. But many of these structures can be fabricated, and they can be shifted to the site, and the construction made can be made very quickly or right.

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So this the external view of the tenth and home as I told you that about 180 flats are there but do not look like you know steel-concrete composite building or even cold form steel building. It

presents a beautiful view which merges with the existing other structures; it is not like transplanting something else, but you can see this. So the residential construction steel we use this growth will be much higher in India in the future.

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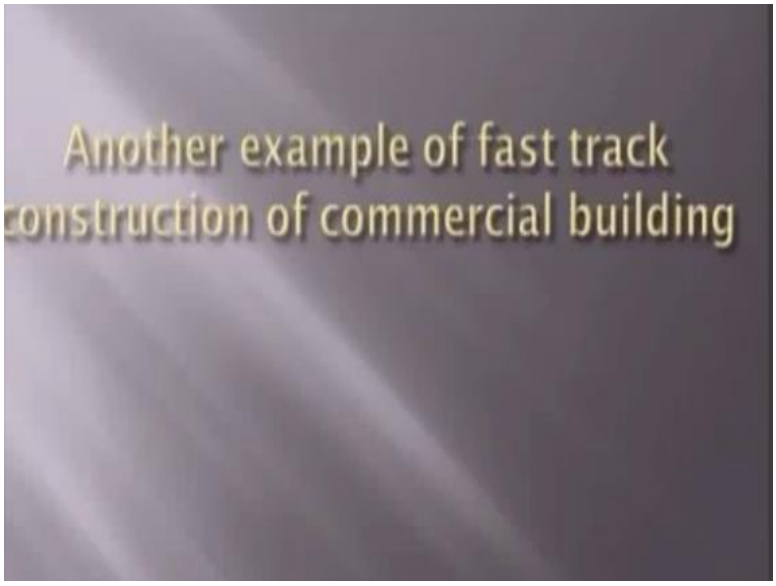

Now, this is not the residential sector (()) (08:25); the commercial buildings, as we all know like this time, are the significant criteria for the commercial buildings.

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So I was fortunate to document one of the commercial buildings called the Turner broadcasting in Atlanta. Again the specification for this is six months because this is purely a competition

between 2 different places and then say a particular company comes and tell the contractor but this time I want my structure to be ready and the operation also so that I gain into the market.

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So this was a very good case for me present you can see here this I have just taken a photograph on the third floor that means the next day was the concreting. So you can see in the third floor you can see the main steel beams you get. The secondary is on which we are putting a steel deck sheet which has got corrugations to give us the moment of inertia. So we will have to put a small amount of reinforcement and then concrete on top.

Now that gives you an advantage that you can see here the second floor is ready for work in fact when I was there the in the second floor was occupied by the service crew. They start putting the pipes they start putting the vents. As I will show in the next slide, the services are nearly completed on the first floor. So what we can see is that the construction sequence not necessarily; wait for entire frames to be ready all the walls to be ready.

In fact, by floor and flor, when the last floor is finished, I think the ground floor can be made ready for occupancy.

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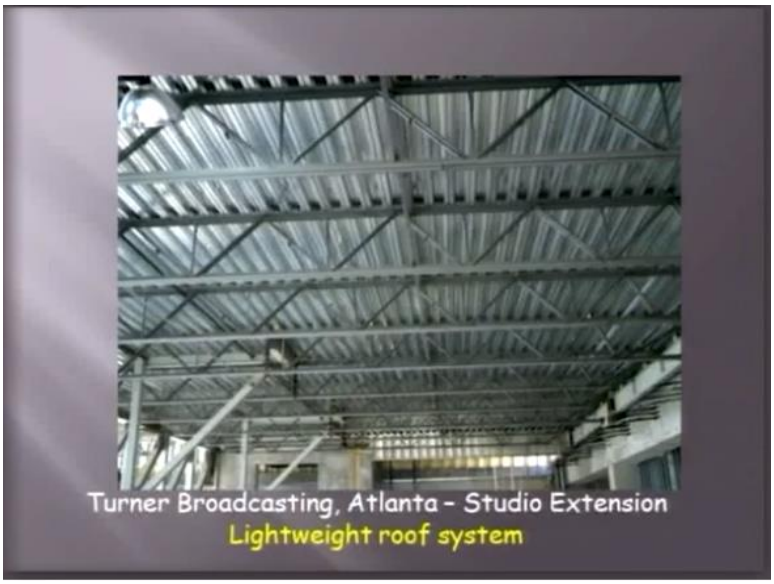

One of the disadvantages I said the fabrication the great advantage of the steel construction is much of this material I mean the components are fabricated elsewhere. So it does not block the site it is brought to, and then they are bolted outside very quickly by using pneumatic tools. But probably India has to grow in this particular area. You can see here the man is working; he is a service crew member.

That means well, the concrete will be the civil crew there on the third floor, and the second floor is occupied by this the service crew. This is the photo of the first floor. You can see where these are called wall studs. These wall studs are going to receive your cement particle boards or gypsum boards. So they almost already you can see here the inside of all, the wall studs are ready, and the occupancy and all the services can be started.

This is also a lightweight roof that is each of the same building built in about two and half months.

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But so, I would like to go another avenue for steel is called the public structures; many of us think that the public structures are being not used, but they are being abused. So steel is not a preferred material for public structures quiet. I found many public structures in the western world or even some parts of Delhi amazingly performing.

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So I will just give you a few examples of how steel has been used in public structures. This is the Hartsfield Airport; you can see here all these RC beams, and on the top of the RC beam, they have synthesized a steel space roof.

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This is the steel space frame or a space roof that is architecturally synthesized; you can see on top of it steel sheeting. Amazingly, it has been integrated or synthesized with the existing concrete structure. So we can see steel, can you know to be a complementary material in very many situations, especially for beauty for aesthetics and construction time. So these space structures, which I will cover a little later.

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And you can see here we talk about sustainability; this was an underground station in Mid Town Atlanta. So there are simple trust structures have been put with you know the light natural light is to come in almost entire day time you do not need any light you can see here the lights have been switched off. And you are getting quite an ample amount of light inside the station. So what I am

saying this steel can merge with see material like glass or any other material, which will give you a service advantage also.

So this is one of the public structures in which glass and orthogonal truss systems are used in public places.

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This is beauty, you can see here all the columns used here or steel concrete infield columns; you can see here that the service the some of the water drains we call the drain into the pipe has been taken in. This is the public structure and very nicely integrated with the lighting. You can see the buses. And you can see this is another view of the public station.

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And you can see a lot of floor space is available for them because the inter-column space is quite large and the size of the column since we are putting a steel outer shell. And we are in filling with you know high set concrete the column can be relatively slender and then we for the same area we get more usable floor area. So there are the circular columns not only for visual appeal but also for giving us a good sense of beauty. So it is not a genuine concern that steel cannot be used in public structures.

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Now the next is for architectural splendor.

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This is the Walmart Lithonia you can see here there a large column free space.

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In fact, you see the next slide. You see, almost it is like unsupported free space columns a very splendor. They do not even come into your line at all, so you can see here the marketplace is going to include that is the point I was making. Today India is moving towards emerging, and globalization is taking place in a big way quite many market places, not only for the consumer's goods. But even for you know storage of production materials all right so that steel can give you a very good advantage. So this is also a beautiful architecture you can see is light and tresses have been merged. It gives a fantastic view you got a very large space in which you never knew

like such a structure. I mean, steel structure has been put in so it merges you can see the sheeting or the top steel and all these are simple trusses you can see the fly braces.

I mean small elements are put together into a quite rigid system which offers as a very good advantage for steel for architectural beauty. So this is a Walmart Lithonia store.

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Also, in the case of the fern bandwidth, we will have the sum of very monumental structures in the feature now we see monuments are being built for, I mean very popular political leaders or for remembering a particular event. So in all of them, steel provides a very good this is the atrium of the fern bank museum of the natural history again in Georgia. So you can see here sthat the glass and the traditional steel truss work have been combined to give a beautiful view.

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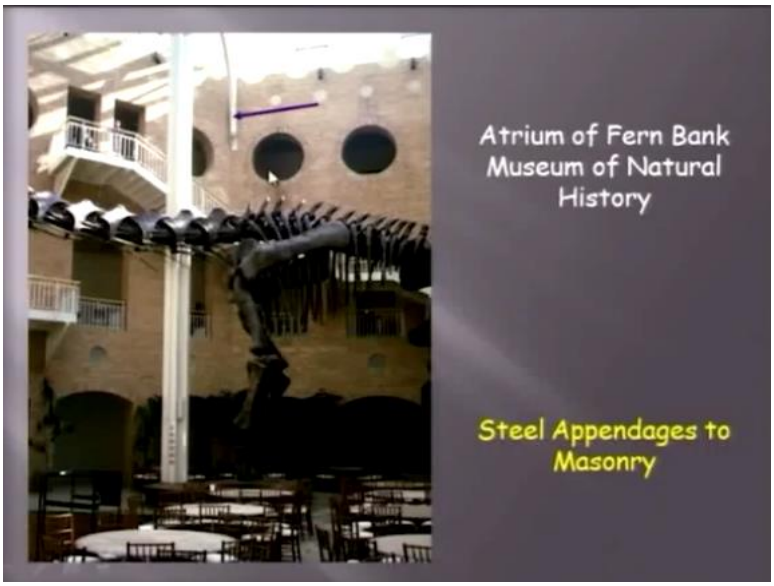

Not only that, you can see here that steel has been appended to their existing masonry as well. So this particular material is not standalone for use, but it will merge with masonry and quite nicely with concrete. And the usage, the steel say for example there is a large party hall, so you have a column-free space taken only by one particular central octagonal column. So this column supports a big truss work and truss work on top of it we put glass.

So even in the evening, sometimes they got moonlight dinner here with no lighting at all; it is just purely by the moonlight thing I mean the dinner is being conducted. So the point I am making is that steel can be appended or complement any architectural space. So you can merge with the masonry, you can merge with concrete at the same time; this can also be used to take care of the load.

You can see here that the truss reaction is transferred to the masonry wall by an appendage. So this kind of integration provides steel very good for an architectural purpose like.

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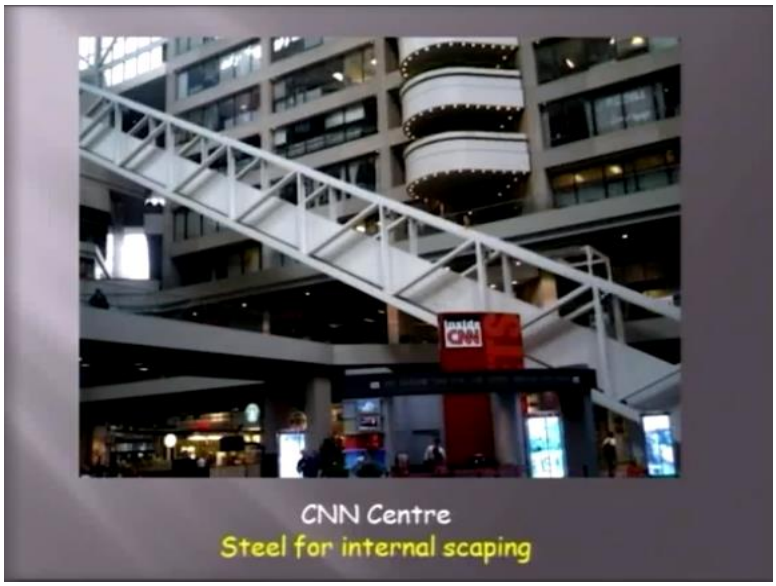

When I went and saw the CNN center, I thought it was a staircase, or it is just for landscaping. They have been introduced to a large space. The architects introduced this just to break the monotony to give a feeling of that. This is just actually an entity that is only provided for internal scrapping. So it was another innovative use of steel that I have seen even architects use the, I mean the fair use of steel in this in the construction both for architectural splendor.

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Now I move on to some of the real-world space structures because, as I told you, the marketplaces will come up in a big way.

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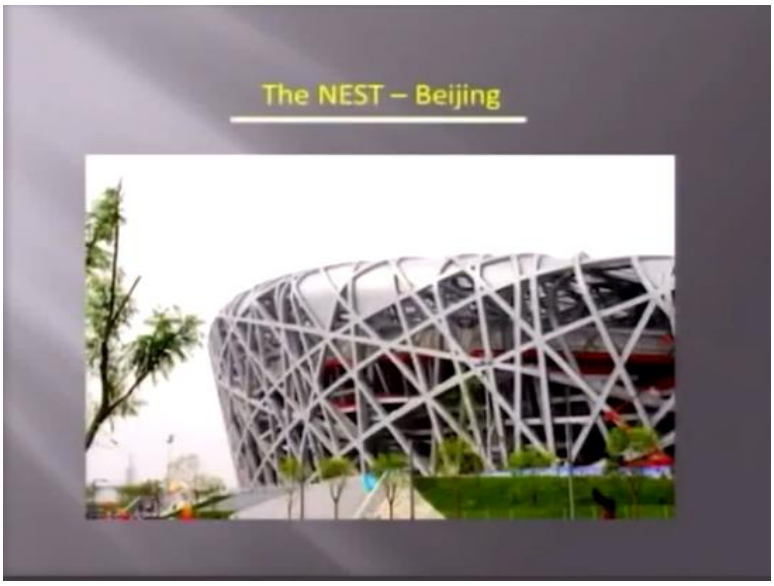

So we will have quite a lot of space structures, and of course, everybody knows the most popular nest and the Beijing molecules, which created what many things can be done with steel. Not necessarily in a prismatic and nice way but in for we can do shapes that can represent nature like the nest.

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The next one is this double-layered space construction is quite popular; you might have seen this as many petroleum outlets. But in near this Cyberabad or the Hyderabad area you can see the large amount of these space structures what the advantage is? All these components are very slender, and you can cover a large unsupported space. Here, the column is a very slender column with a tripod over which you have an arch the two layer trusses there.

So these can be dismantled, and you can use them elsewhere, so one of the significant advantages of this is the future. There will be lots of marketing space steel can be an ideal material for quick erection, and say it has to be shifted somewhere it can be very easily shifted. So the double-layered grid it is a perfect system to span temporary but, of course, large spaces.

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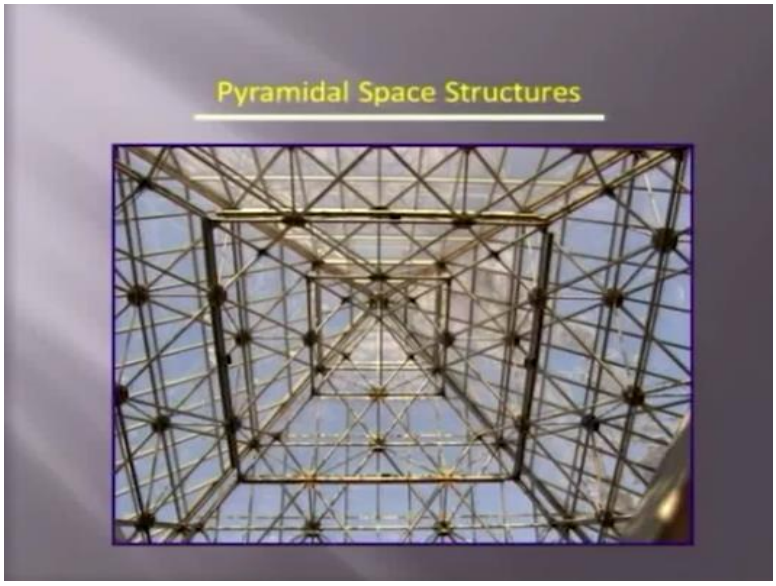

This is one of the pyramid structures you can see here; the space structures have been used for architectural beauty. One particular reason for all this space structure is that you do not need a big skill to construct it. Once you have got all the Mach number of all these space structures, that will tell you like the member will be north or the south or the east, and then every member is numbered.

Every node will be numbered, so the connection between the numbers is just by simple people. So we can get untrained labor also to construct all these space frame structures.

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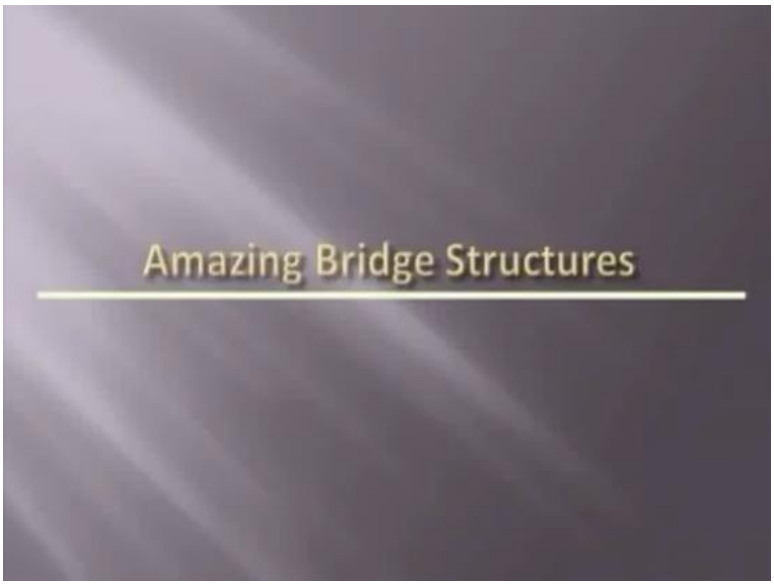

So the next part is bridging quiet. Unfortunately, the bridge was the primary construction material for the bridge structures for the British times and even during our independent periods. But unfortunately, the high deep sections were not available, and the fabrication did not support the steel bridges' growth. So possibly, there was a drift between the steel to prestress concrete and other structures.

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This is what the point which I made now the bridge structures like let us say in urban-like in metropolitan cities or tier 2 cities. It will come not by the strength and the traffic but by the constraints space will offer. So this is one of the curved box bridges; imagine in Chennai or in Mumbai we will have a bridge you cannot locate the bridge peers as freely as we think.

And it is going to be determined on the space available or the kind of structures available so very many constraints as a going to come. So if you want to build a bridge quickly, a curved bridge or box curved bridge and steel are wonderful options.

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I can show you these are the composite decks you might have seen this today; the NHAI proposes many of these steel concrete composite bridges to span over the railway bridges; what is the reason? Because I can quickly launch, there is no blockage of traffic either train or road. So the columns are erected over the columns; we go and insert our beams, and you can see here these beams will have what is called shear connectors, and these are all braces.

Like every; traffic goes, a lateral movement has also come we would like to introduce these braces for the best performance of this bridges. So this is quite popular now in India; most of the bridges between roads or the rails, I mean railway tracks or coming by this composite technology. So that is a significant advantage for us because we can just put it on that concrete deck very easily. The concrete is very good; we put reinforcement.

And it can be cast without blocking anything at the bottom. So these kinds of space constraints bridges are becoming quite popular in India as well.

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Of course, the suspension bridge with the cables we can see here you have the cable you have the suspenders and deck this is a classic example. We have a couple of examples of bridges in Goa, which are cable suspended bridges. However, the only thing as the technology and the car's competence, the engineers or contractors, start increasing by doing a couple of bridges. I think more bridges will be there.

This is mainly for crossing the waterways; we have the problem; you know space is being covered, we have the navigation space so all these can be covered. So this is a good example of where steel can be used.

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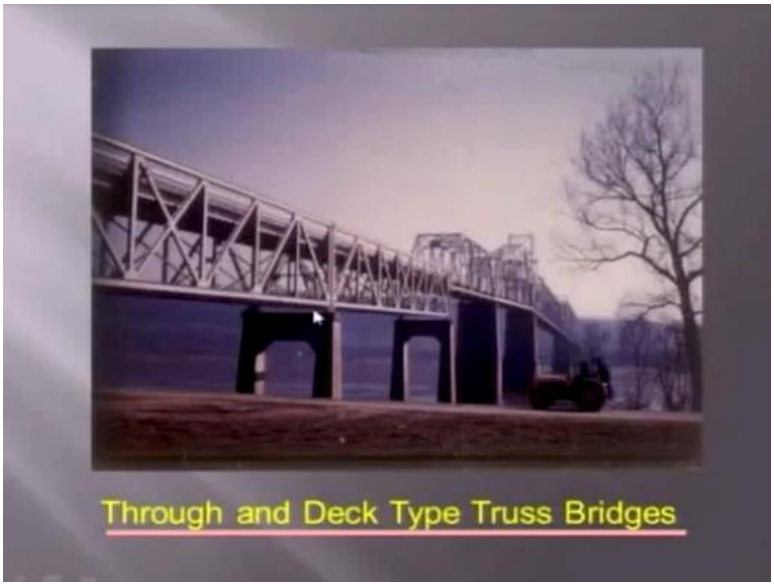

And again, this is an example you can see we have a deck bridge, which I mean immediately converted you are through a bridge. This is because of the navigational depth which is required. So many times, the structures are built not for the strength or the amount of load that comes; it is not about you know how many broad gauge trains are going to come. But it is navigational because we will you know abstract the navigational way possibly the fisherman or the fish species to migrate.

So all the structures are going to, you know, translocate into a very serene environment, so most of the time, the structural systems are determined mainly by the environmental conditions. You can see here the clear example of a large I mean, navigational way height is required. So a bridge from a deck has been converted into a through a bridge. So such kind of special usage can be there.

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And this is called a transportable bailey bridge right many times the army used it in their operations this kind of bailey bridges are quite popularly used in the northeast of our country where deep ravines. And you know, small spaces to be crossed, you can use these bridges. These bridges are transported inside, and the deck is paved, and you can cross with that.

Some of you may remember that when the arch bridge in the Jawaharlal Nehru stadium before the commonwealth case failed within about a week, the army people came and put the bailey bridge for the pedestrian to go.

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Another one is the point which I say this is a really fantastic bridge that I have read about. In 2012 this bridge was built in Japan,s and the reason is a beauty you can see here: you know a backwater,s and you can see an estuary over here. This is the land for lots of birds and fish species also, and the egret is one of them. It is like a crane now the construction constraint came because the vertical pylons obstructed the navigational way of these birds, the Egret birds.

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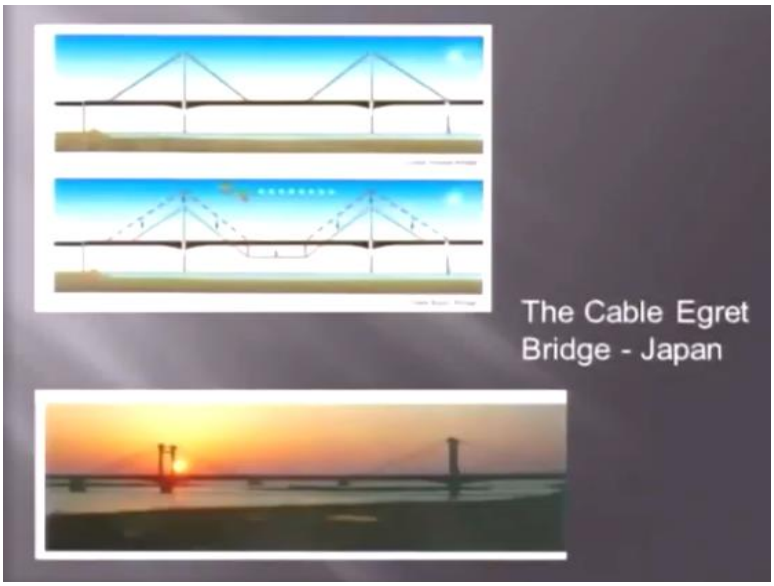

So what happened what they did was that from the traditional bridge, they have just lowered the support; you can see here this was the regular cable state bridge that we use it. So this support this pan alone was taken down; you can see here this is the space in which the Egrets fly. So in

this area, the system was lowered so that the pylons do not abrupt the space of the Egrets. And this is the actual bridge; you can see the support at the bottom, and it is not for the entire stretch.

But not only in the stretch for the estuary, so when these kinds of environmental constraints are going to come naturally in India, it is also going to come. I think steel is a fantastic material where you can customize the use; this was a bridge. You can read about it in the Japanese institute of steel construction. It is a fabulous structure how the entire mechanic team, the environment is all of them sat together to provide an unobstructed space in the estuary.

So this is what they call the cable egret bridge in Japan, so my point is that the requirements of that I means the structures are not necessarily going to be with respect to the structural parameters but sometimes mainly the social parameters the environmental parameters in which steel can play a significant role.

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The next part that I want to say is the steel-concrete composite structures in which we are getting the best of steel and concrete. I was amazed when I was moving in towards the East Coast Road.

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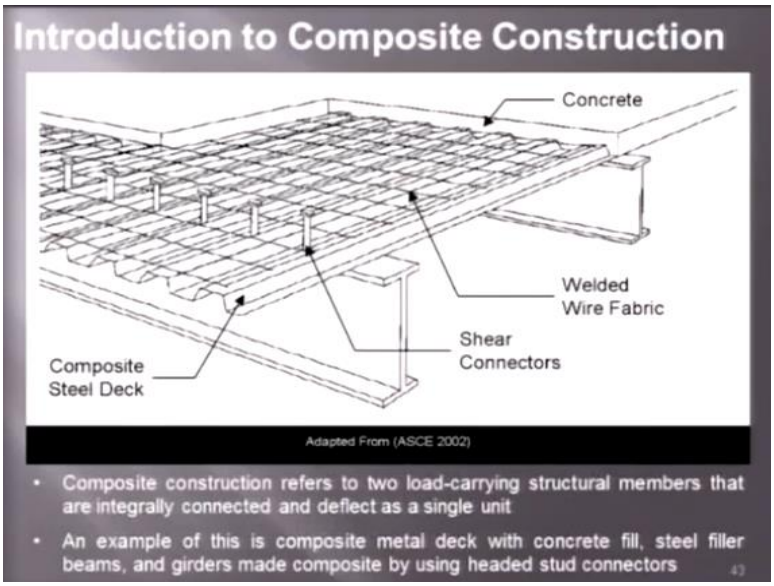

I found a couple of steel-concrete composite buildings have been completed not by engineers but by non-engineer. But it was a non-engineered construction; when I approached, it was done by a contractor who has just gone abroad and saw a building and comes back. So he said this option is going to work, so this is a steel-concrete composite system. You can see here that this is the steel beam over which we put the deck sheets; this is also a steel sheet, say possibly of 1 mm thickness 0.8 or 1.6 depending upon the span I want to cover.

Then over the top of it, I put nominal reinforcement just for you know, shrinkage and temperature, and we put shear studs. These shear studs are the elements that are going to integrate the concrete deck and the steel part. The advantages are if once I have the steel beams ready, I can just put the sheets on top of it, we can drive the shear connectors, and we can concrete it. No support, no propping is needed, and no formwork is needed. So this was the one I was talking about that happen in the Georgia tech commercial building.

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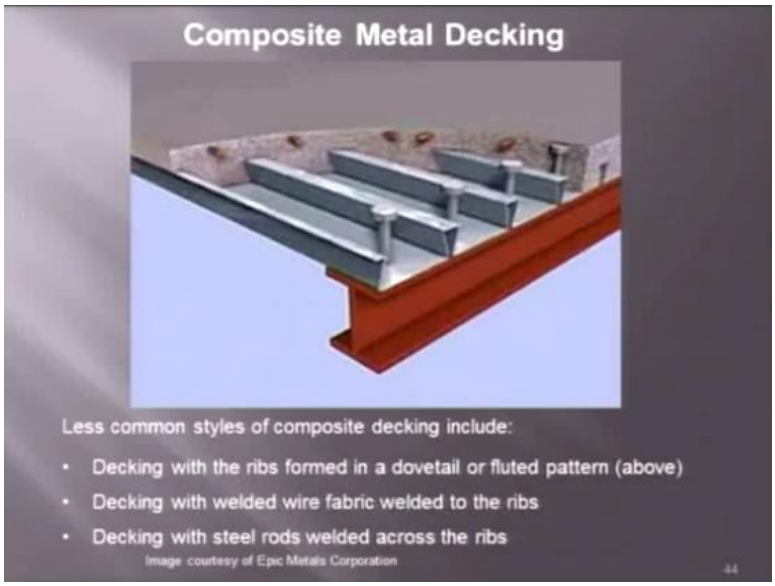

Now, this is an actual composite of how it looks like; we can see here the x model I mean, the modulus of the steel and concrete have different. So at the interface, they will try to slide across as they would like to come out so we have to provide the deck, so the uplift or the separation between the steel and the concrete is done. So this is exactly how the system would look like.

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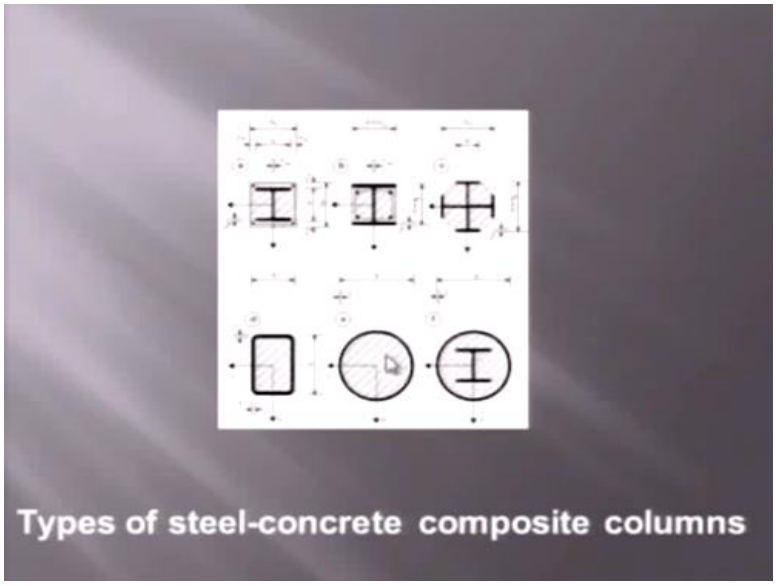

We also have concrete columns in which we can have a steel column, and we have put concrete around for, say, fire protection, or we can have a steel shell or tubular section. An RHS, SHS, and then we can infill concrete into it or both; this is the best system in which we have said that if you can use either of these two, we get quite a good advantage in terms of strength.

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Now, this is the actual system; let us look; you can see here these are columns these are the primary beams. These are the secondary beam directions; we have just put the sheeting, and then we have put the stud you can see here.

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This is nominal reinforcement that we are going sto use it.

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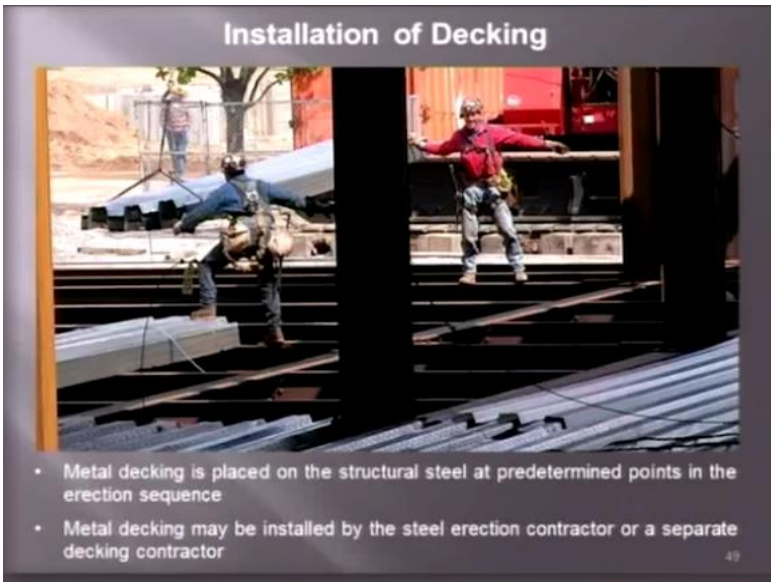

We can come and see here how the decks are placed. See, this is the primary beam between the column, so we have the secondary's just over the secondary beams we can put the sheeting. This sheeting can be made to any length because the rolling is done on the site we got a large coil. So we can load it quite nicely on the secondary beams, and after this, the studs are driven. And the studs, or you can see here the studs are driven on the secondary beam; after that, it is ready for concreting.

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One of the advantages of this is the nesting; all the deck sheeting material can be easily nested. So it causes it provides me leisure on computation I mean transportation cost and storing space is significantly less. So it is not only in the strength alone but all in the construction practices the

steel-concrete composite structures will give us a good advantage. This is already we have seen how the deck series are in place.

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You can see here a very long deck sheet as a single piece; right, you have the primaries between the columns you have the secondary's between 2 primary beams on which you are putting the deck sheeting. How are these long sheets transported? You do not need to transport; you can just go; you have a rolling mill of the side, and it will roll it. For any length you want, the advantage of these deck sheets is that there is no need for you to make the sheets have to be transported.

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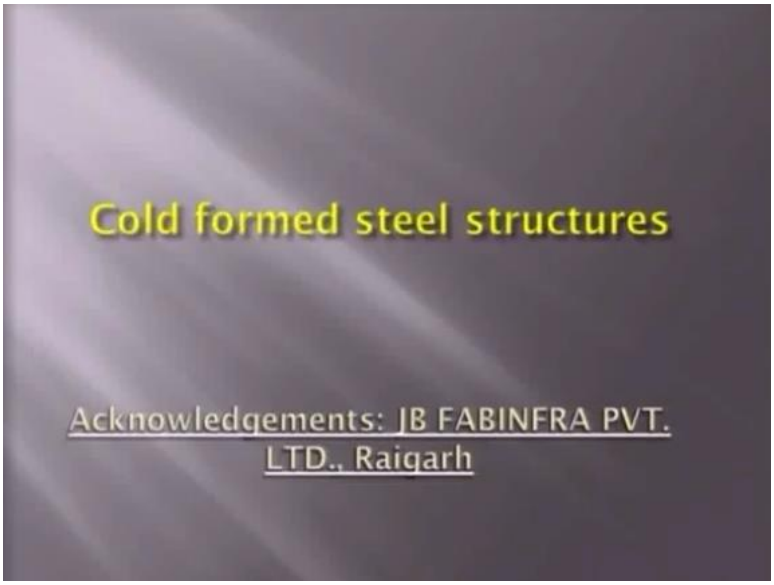

The cold form steel structure is one of the avenues in which IIT Madras also has a long tradition of research and design. So one of this project which I was personally involved like to explain.

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And what we see here is called a rolling machine; now, the rolling is the one which makes all these structural sections.

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You can see here the steel comes as just like you know paper rolls that we see in toilets these kinds all these steel rolls can be cut into the desired width for us to make the sections. So once they are cut, they are fed into the rolling machine like that, so structural sections have come out; you can see here nowhere at a section a channel is produced from this. The length of the sections

depends on the length of the coil or the roll. Now, this can be made into structural members and also structural framing.

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Now once they are made in the shop, they are transported like this. So from the factory to (33:17) we have; got 12-meter long trucks, and we can load all these materials onto the truck to the side.

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And there we have a very light foundation you can see here the foundation is just a simple spread is not very deep no piling. This foundation was for G+ 3.

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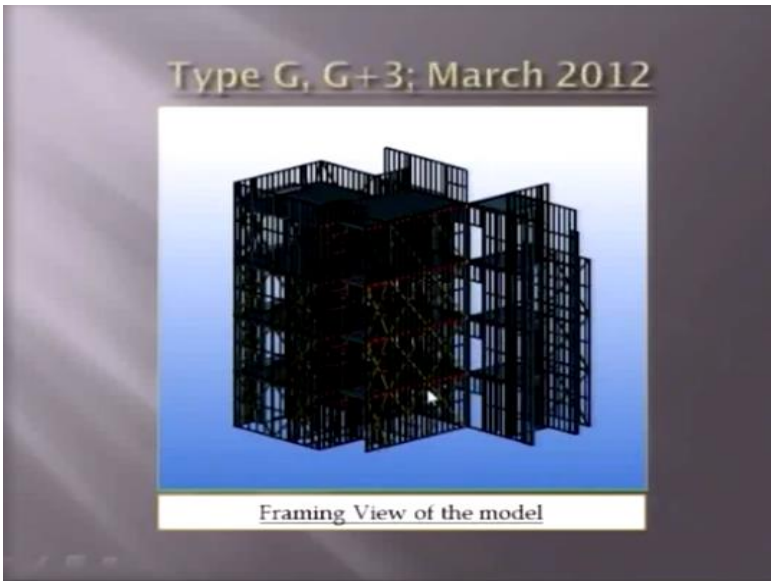

So it was a simple foundation on which we will erect; this is the computer design model, a vertex model of a G+ 3 system. Fully coal-formed, all these members are made out of the rolling bell of the channels.

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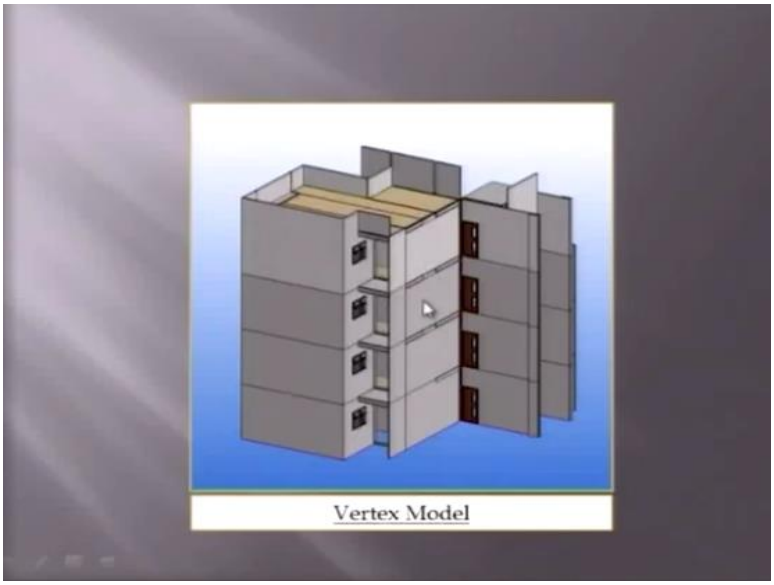

Now, this is the final the rendered model of the house; this is the house that we are going to build G+ 3 system.

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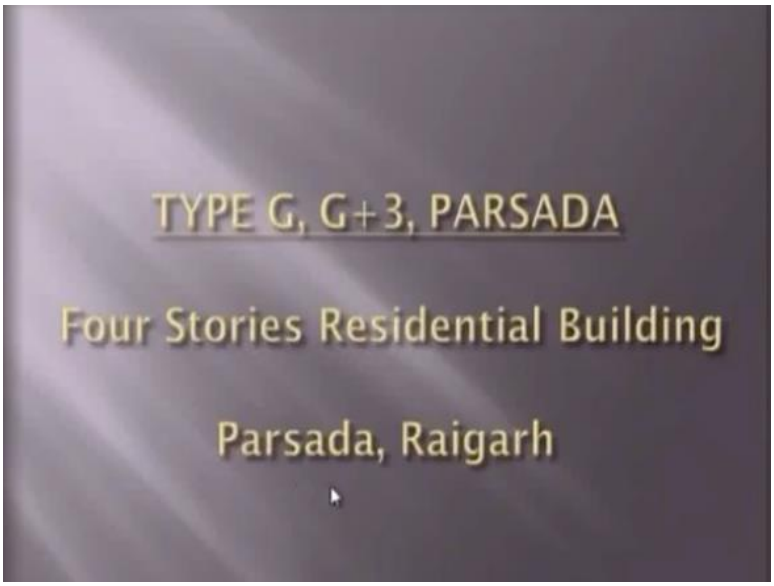

Now, this is how the residential G+ 3 was built in Prasada in Raigarh in Chhattisgarh.

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This stage is being considered; you can see here the stages of construction you have G1 to the third floor is being constructed. The total time taken for the G+ 3 was less than a month because all these skeletal members are manufactured; these are called cassettes. You can see the sidewall of the parallel units; these are called wall cassettes, and what is put on the top is called the roof cassettes. So the wall cassettes and the roof cassettes are transported, and you can see here the flooring is by CP boards.

In fact, in this project, we did 20 mm at the bottom and 18 mm at the top, and in between, we had a steel roof cassette and on top of it, we put normal ordinary tiles that we see in the buildings.

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Now, this is the finished work you can see here; this is the work that is completed, and this is just going to be complete. You can see here the vertical staircase is of, I mean hot rolled steel, so you can see the hybrid structure all these ones which are galvanized cold-formed steel G+ 3. And this is a hot roll steel staircase; now this is almost entirely over, you can see all the side walls or CP boards.

Like cement particle board, which have I mean painted to look like I mean the same color even the floor, it is not a concrete deck floor, as I explained earlier. The floor is 20 mm at the top and then 18mm at the tops, a sandwich with the roof cassettes. So we tested it and found it quite adequate to see here that another construction will start side by side.

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And this how the construction sequence was happening in this you can see here we are going to extend one floor what it is again on the circumferential wall this panel the wall cassette is fixed. And you can see this support are all temporary props till the top construction you can see here all the walls are ready in about a day or 2 then we put the roof cassettes and since the connections are very simple.

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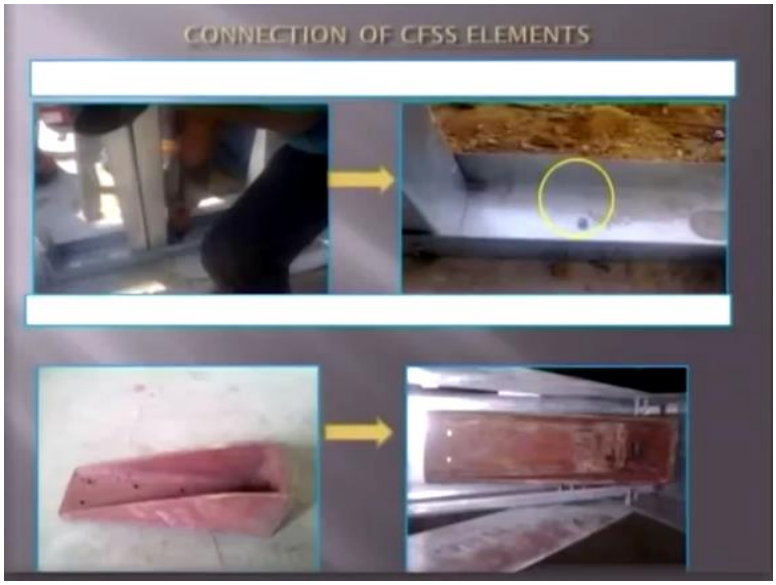

You can see here the connection between what we call the track with the bottom track to the vertical column we put a small shoe this is called the iron shoe. We can just pin this up into it, so this iron shoe will give you the moment rigidity at the joint. And how do you fix this track on to that straight away drive a pin on the say this is called I mean self-drilling self-tapping screws. So

what happens? They have a thread, and if you drive it from one side, there is no need for any not on the other side.

So the connections are quite faster, and that is how I said this is really when I experienced this a room wall was constructed nearly in about 10 minutes. So quickly, there is easy because the amount of dead the weight in this system will probably be very less probably in future lots of spaces can be acquired. Not necessarily we should have space any existing building if you can take a light load about say 2 kilo Pascal load can be there and easily this cold form steel systems can be appended this is the connection I said.

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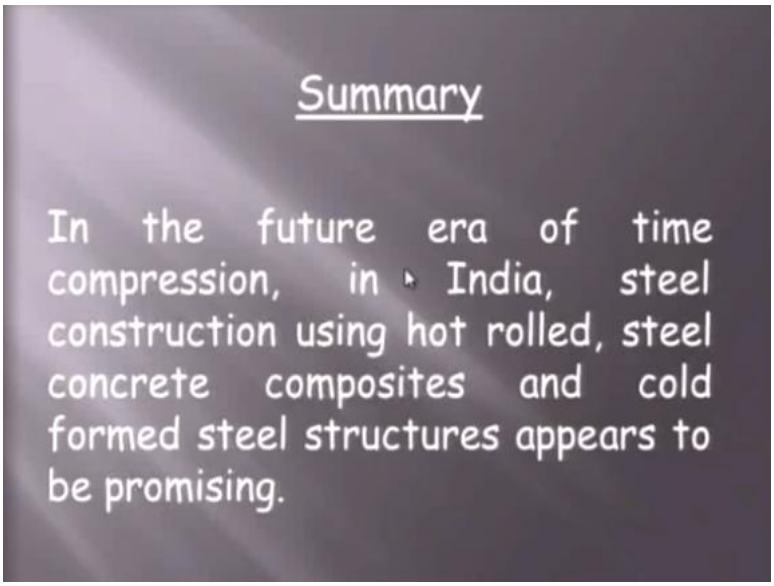

So finally, I would like to summarize my lecture; although this is a dream, what I tried to give an idea of was what is the future of the skyline going to be? In terms of steel construction now the future era, it will also be the era of time compression. Because every project is set against the particular time for which people have to complete and within the time the business grows. So in time compression, time is a significant investment will along with money.

So in such a scenario, I find the steel construction using hot-rolled, which I told earlier, and steel-concrete composites, which always get you the best of steel and concrete. And the cold form steel structures appear to be very promising of course, this is not my dream, but it is happening in India only thing we are in a starting phase when more students start learning this and more

institutions start doing research, and you will find the steel construction in India is to grow in a big way thank you.