Sustainable Architecture
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Lecture - 33
Materials and Resources-III

Good morning. Welcome back to the 3rd lecture of this week where we are discussing about Materials and Resources as part of the online ongoing course on Sustainable Architecture. So, in the previous two lectures, we have discussed about the criteria, which is related to reduction of waste during construction and also post occupancy. So, how the design of the building has to be made in order to provide space for collection of the waste, sorting it, sending it for recycling so, segregation, recycling; so, all of that has to be included right in the pre construction phases of design.

And during construction how the wastage of material can be reduced and then how the materials can be diverted from being sent to the landfills and then when we were talking about post occupancy in these sustainable buildings, how segregation of waste should happen, how the collection should happen and how it should eventually go to proper recycling is what we have seen.

In today's lecture, we will be seeing about the different properties associated with the materials, construction materials which we need to know about and how selection of materials should be made based upon these properties.

Now, the discussion around these properties and also the compliance criteria varies from different rating systems to different rating systems; however, the intent remains the same. So, one of the most important properties of materials construction materials is embodied energy.

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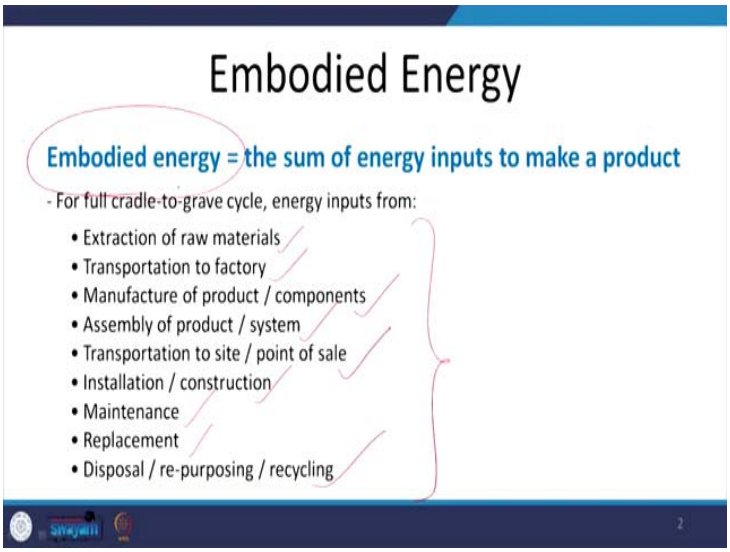

Now, what is embodied energy? Embodied energy is the amount of energy inputs which are required to make a product. Now the concept of embodied energy and what all energies are taken into account while calculating the embodied energy of a material, they depend they vary from definition to definition from scope to scope.

So, usually the embodied energy is calculated for a full cradle to grave cycle. Now cradle to grave implies that from raw material extraction which is going to be used for manufacturing the product, transportation of the raw material to the manufacturing site, the processing, manufacturing and then transporting the finished product to the client to the consumer. Installation of that product and the disposal at the end of the life which is the grave of the product the material, energy consumed at all these stages of a materials life is what will be counted towards the embodied energy of a material.

So, if we are looking at embodied energy, we are talking about extraction of raw materials, transportation to the factory, manufacturing of the product, assembly, transportation to the point of sale, installation, maintenance, replacement and disposal. All these together and the energy consumption at each of these stages is what will be called as embodied energy.

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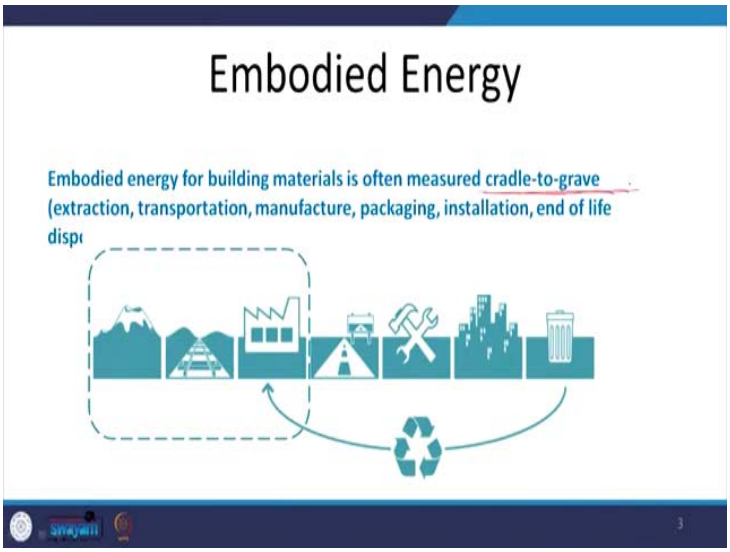

Now, if the scope is limited for example, there are different scopes. So, instead of cradle to grave, we also have cradle to cradle which is further increasing. So, not just disposing the material, but taking it back into the manufacturing system where it goes back into the manufacturing for some other purpose for some other process that makes it cradle to cradle. There is also cradle to gate. So, from raw material extraction till the delivery at the consumer's site, that is cradle to gate.

So, varying depending upon this varying scope the embodied energy of a material would vary. But usually most commonly we are looking at the cradle to grave scope of the life cycle for any material and the embodied energy associated with it.

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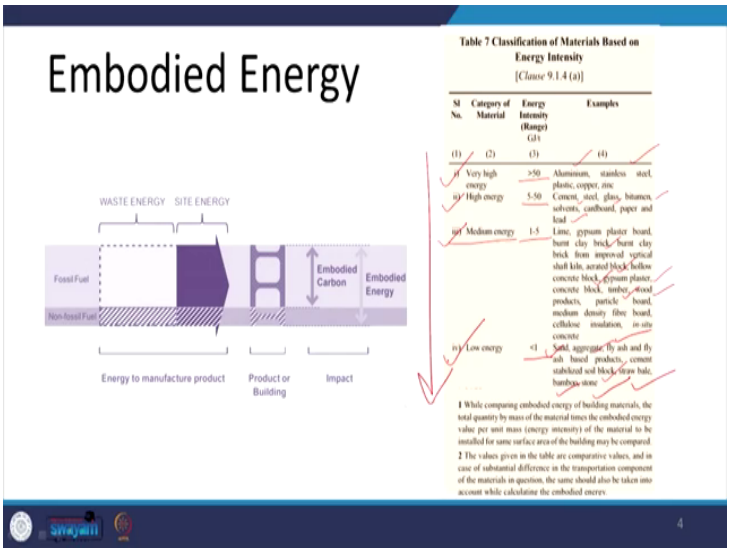

If you look at the national building code of India in its latest 2017 revised version, we can see that a discussion has been incorporated which talks about the embodied energy of different materials and how should we select these materials.

So, unfortunately in India the database related to embodied energy is still not commonly available and there are several materials for which we do not really have the embodied energy values. However, the developed countries especially Europe they have huge databases available for embodied energy. So, some of these databases have been and the values have been taken from the western databases. However, the number is more or less remain the same across the world because the technology of manufacturing also remains the same.

So, whether an aluminum ~~is~~ extraction plant is set up in India or it is set up in Europe, there will be very little difference between the energy that goes into manufacturing that. Yes, the energy which is going into the transportation of raw material depending upon from where the raw material is being brought in that would vary and that would affect the overall embodied energy as well, but largely the industrial processes they remain the same.

So, what NBC has done is, NBC has categorized all the materials into four categories the first one is a very high energy intensive category of materials which have the embodied energy or the energy intensity greater than 50 Giga joules per ton of the manufactured

material. Some of the materials which fall into this category are aluminum, stainless steel, plastic, copper, zinc; so, most of the metals they come into this category.

Then the second category is that of high energy materials which have their energy intensity range from 5 to 50 giga joules per ton where we are talking about materials like cement, steel, glass, bitumen, solvents cardboard even paper which appears to be a very fragile material and lead. Then we have a category called medium energy intensity category which has the energy intensity range from 1 to 5 Gigajoules per ton.

Here we are talking about materials such as lime, gypsum plasterboard, burnt clay brick, aerated blocks, hollow concrete blocks, gypsum plasters and so on. Even the timber and wood products come into this category and when we are talking about the low energy materials; we are talking about materials which have their energy intensity less than 1 Giga joules per ton. So, some of the materials which we see here are fly ash based products, Cement Stabilized Soil Blocks CSSBs, straw, bale, bamboos, stone, sand aggregates which are naturally occurring materials which require no processing.

So, anything that requires processing implies it will consume energy through its processes. So, when we are looking at materials based upon their embodied energy, it is always preferred to use materials with low embodied energy low energy intensity. However, embodied energy is not the only property which needs to be considered while selecting a material as we will see subsequently.

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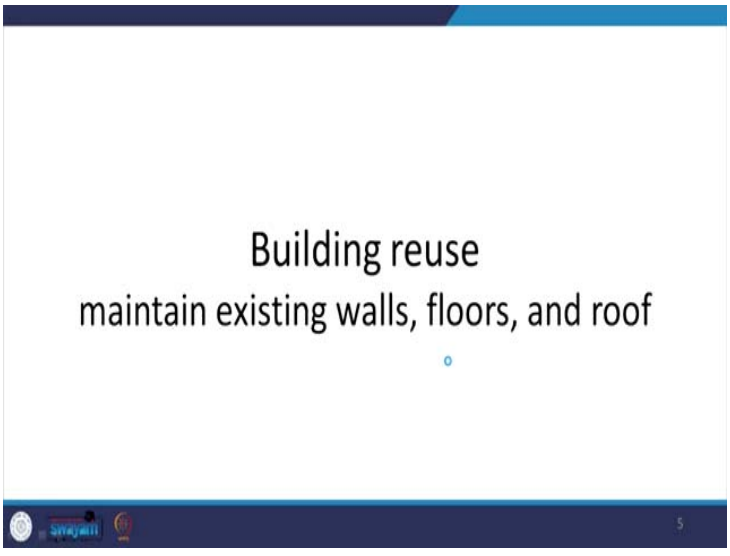

Another very important criteria when we are talking about material conservation and efficient use of materials in buildings. So, one of the very important strategies here is building reuse. Now here as first compliance criteria we are talking about these structural elements.

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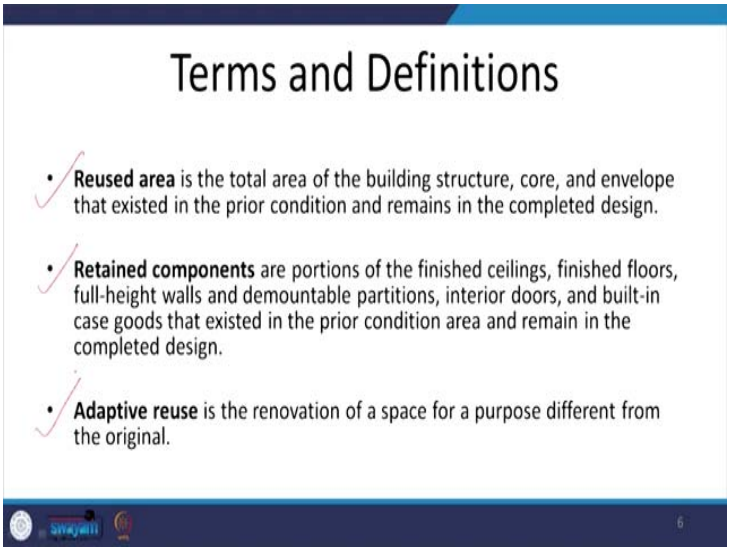

Whenever we are talking about the building reuse, often this criteria is not applicable for buildings which are new construction absolutely new construction. However, for all other buildings where part of the building has already been constructed there is a major renovation or there is an existing building where large a major addition or innovation is happening will often go for this compliance criteria. So, do not get confused that this criteria is not available when we are going ahead for new buildings new constructions.

So, when we are going for building reuse which is a very strong strategy for conserving materials, we are talking about reused area. Now this is the total area of the building structure which can be reused in the new design as well. Then we are talking about the retained components, here we are only talking about these structural components. So, the finished ceilings, finished floors, full height walls and demountable partitions all of that that can be retained in the existing structure.

We also talk about adaptive reuse or adaptive reuse of is a very robust strategy when we talk about the historic cities, the historic settlements so, that the old buildings which are well intact, they can be used for some other purpose. For example, a residential Haveli

could be converted into a restaurant or a hotel a boutique hotel or something like that or a museum. So, that is adaptive reuse.

Now, when we are talking about this building reuse for its structural components, the intent is to use the existing structural elements without a change, but it does not imply that we do not strengthen ~~the~~ them. Over the years of the building being in use some elements structural elements might need strengthening. If they need strengthening that will be added, but all these structural elements or whatever portion of the structural element can be retained will be considered towards the compliance.

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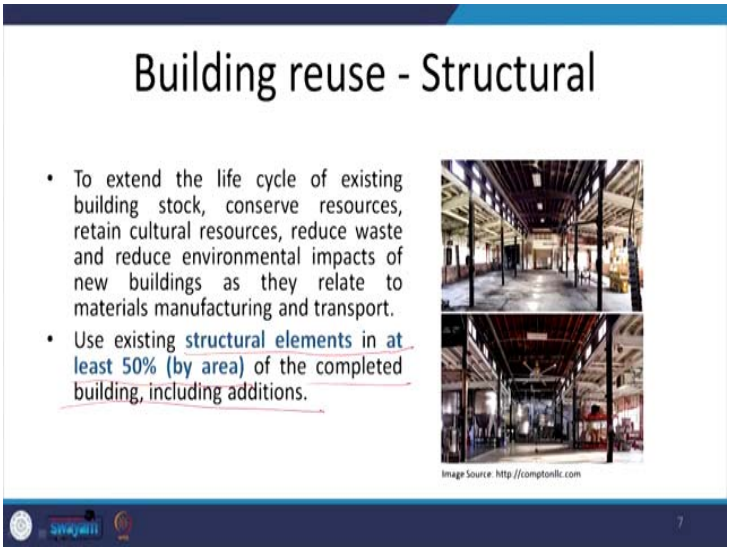

And the compliance criteria is to use the existing structural elements in at least 50 percent that is by area of the completed building including additions.

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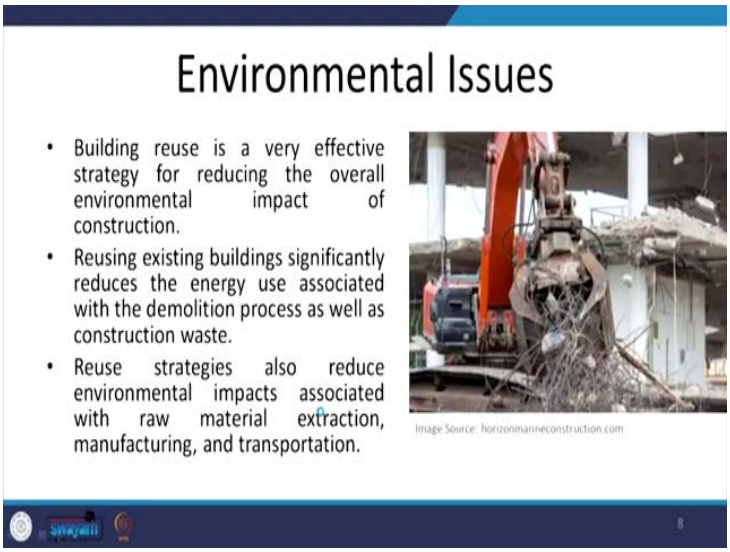

So, when we are talking about building reuse, it ~~is it~~ has a several environmental benefits. Simply because we are reducing the amount of material which would otherwise be required to construct this portion of the building, which is now being available, made available as a reuse portion. So, this is offsetting a huge energy demand, transportation demand, water demand, a lot of pollution totally away by just reusing the structural components.

Now, besides the environmental impacts and the environmental benefits, there are a lot of economic benefits of course, they are quite obvious. If we do not do not have to create or construct a structure all over again, we are saving enormously on our economic cost. Now when we are going to adopt or we decide that there will be a case for building reuse, it is often not a very simple exercise.

So, the project actually has to start with documenting and preparing an inventory of what is existing. So, minute details and inventory development for the existing building will have to be done. Measure drawing for the existing building of each and every space each and every element including the structural walls the non structural walls the ceilings, the floorings, the doors, windows, foundation footing pavement around the building everything will be done and then inventory will be made.

Once that has been done, then the architectural designing would take place in order to retain as much of structural component as possible while at the same time not

compromising with the function of the new building whatever is intended to be there placed there. Once we have done that when a new design has been created and inventory management would be done where we would I identify that which of these structural systems will be retained and which ones would be taken off, and how can those structural elements which are taken down they can be reused back.

So, it is a detailed exercise, it needs to be planned well in order to reuse the maximum portion of the building.

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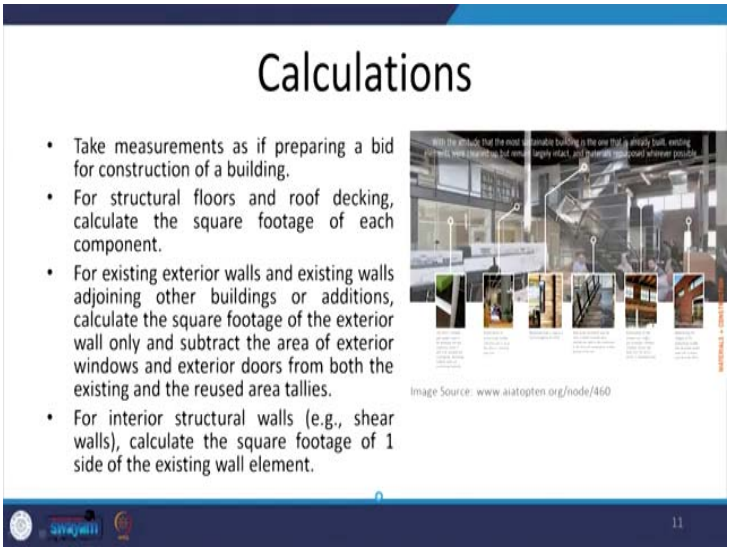

Now, if you are going for this particular criteria, proper calculations have to be done and they have to be shown in order to achieve credits. The first is as ~~i~~I have already discussed preparation of detailed drawings and inventories and then the bidding has to be the bid, the tended~~r~~ document has to be prepared, the proper quantities of the materials to be consumed will have to be calculated. And then we also calculate the amount of material requirement which has been offset because of reuse of existing building or the structural component or non structural component.

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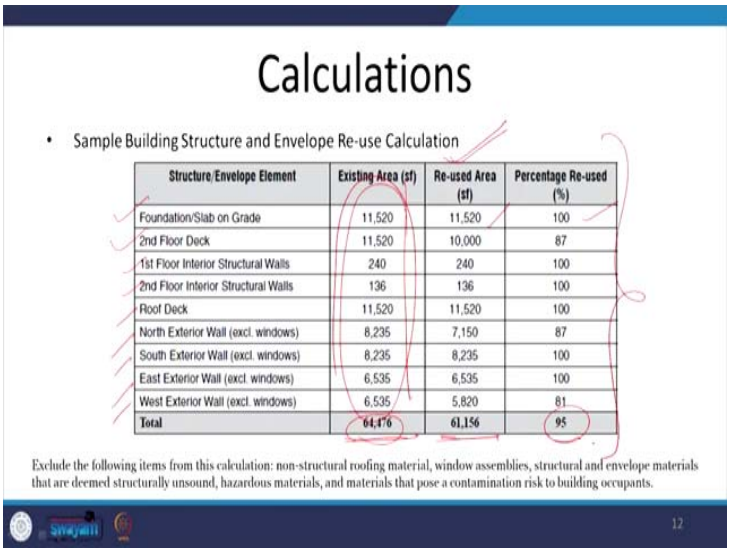

So, when we are talking about calculations, we will be preparing it in a tabular format like this. So, what we would do? We would identify the different types of structural elements which are present in the existing building. We would then calculate their existing areas that how much of the area of each component is there in the existing building. We then calculate how much of this will be reused out of the existing ones and we calculate the percentage.

So, then if you see of the overall total existing structural components, how much of the area has been reused and we calculate the percentage of it. So, for compliance 50 percent of the structural elements, they have to be reused and this kind of a calculation would ensure would show the compliance criteria being met.

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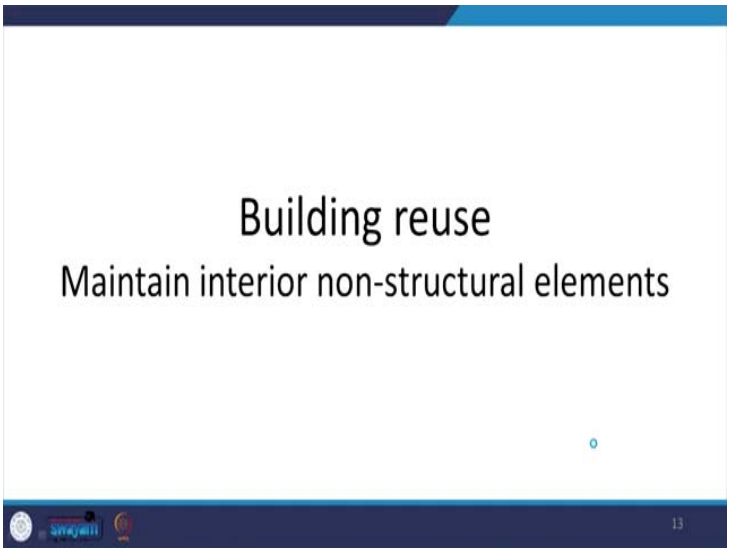

The same thing is there for the non structural elements. Here we were talking about columns, beams,; the structural walls the load bearing walls and the building envelope.

When we are talking about the non structural elements, we are talking about reusing the non structural elements such as the ceilings or the partition walls, the false ceilings, the doors. So, these kinds of non structural elements also have to be reused and they can be reused.

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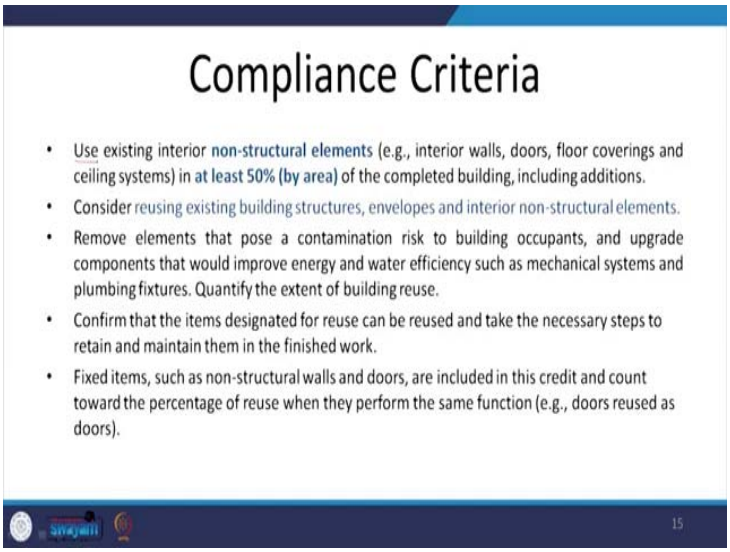

So, the compliance criteria says that use existing interior non structural elements which includes interior walls, doors, floor coverings and ceiling systems in at least 50 percent by area of the completed building which includes additions.

The compliance procedure remains exactly the same and the path that we follow the process that we follow also remains the same. So, first of all we prepare an inventory of the existing systems, we in detail we prepare the drawings and we calculate how much of what element is available in terms of area and once we have done that, we calculate on the basis of the proposed design, how much of the existing inventory can be reused and we calculate the percentage of this reused component and calculate the overall percentage.

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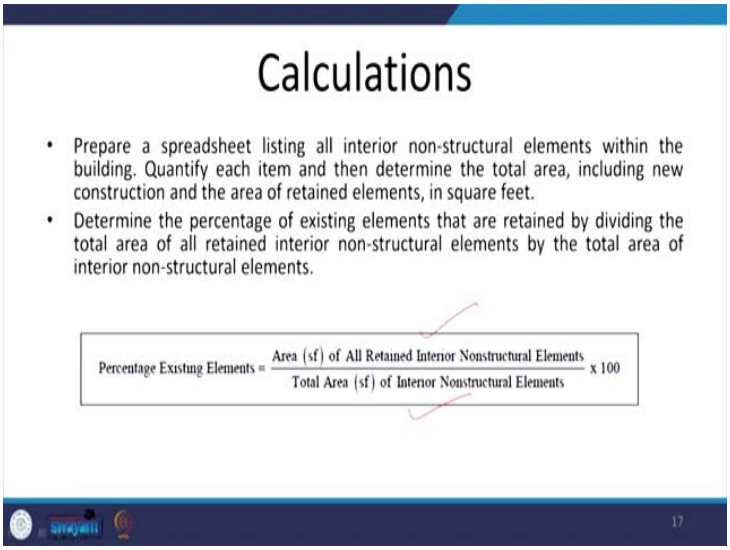

So, here again we are talking about the area of all the retained interior non structural elements divided by the total area of the interior non structural elements and calculate the percentage of it.

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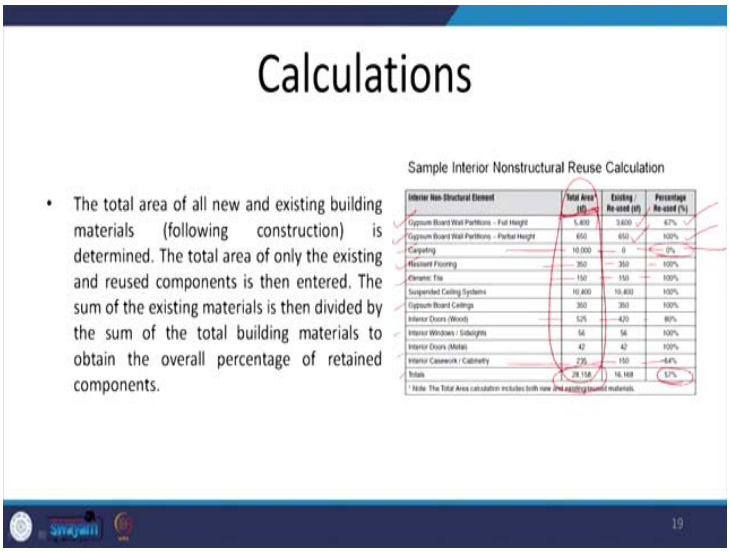

So, the process has remained the same and the calculations also remain the same. So, we identify all the non structural elements. For example, the gypsum board wall partitions which are full height, partial height, carpeting, resilient flooring, ceramic tile and so, on.

We calculate the existing area of each of these components and this is the total area of these different components identified. We calculate how much of it can be reused. So, if we see here the part of the gypsum board wall partitions they have been reused which is like 67 percent. 100 percent of the partial heighted gypsum board wall partitions have been retain 100 percent, but none of the carpeting has been reused here. So, this goes to be 0 directly.

Now, irrespective of what the cost of each of these components is, it is only based upon the total area and not upon the value the cost of each of these components. So, we see that some of the elements could be retained 100 percent, while some of the elements could not be retained at all could not be reused at all. Part of them have been retained used partly and overall when we calculate it is 57 percent of the non structural interior non structural reuse so, which clearly proves that, it is complying with the criteria.

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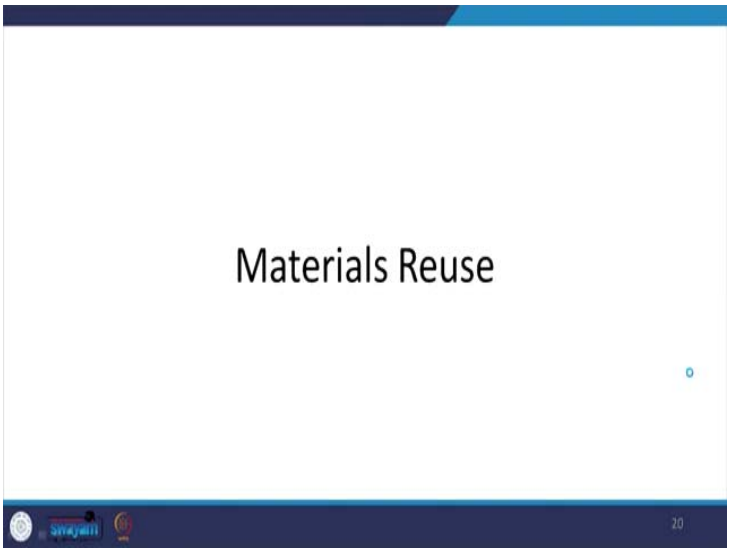

The intent for both of these is to reuse the material which is in good condition as much as possible both for structural as well as nonstructural uses. Now next we here, we are talking about the building reuse and the components of the building. Here through material reuse which is the next property and also one of the compliance approaches, we are talking about reusing the material back into the building or in some processed format.

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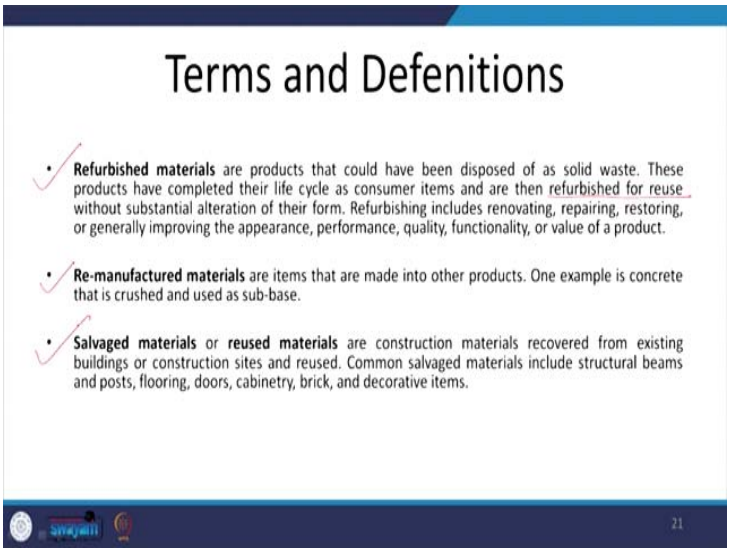

So, we are talking about three different types or three different types of material reuse, we are talking about refurbish materials which are the products, which could have been

disposed of as solid waste, but and they have already completed their lifecycle as that particular product, but then they have been refurbished for reuse without substantial alteration in their form. And this refurbishing has ensured that their appearance, their performance, quality and functioning and overall value has only enhanced this is what a refurbished material is.

The remanufactured material is where the material has been put back into the processing and has been transformed into some other product that is what a remanufactured material is. And salvaged or reused material is which are recovered from the existing buildings or construction sites and they are reused for example, brick. So, when a demolition when demolition of one building is happening from there the brick has been salvaged and reused in construction in some other site or many other materials are like that. So, there are three categories in which the material reuse can happen.

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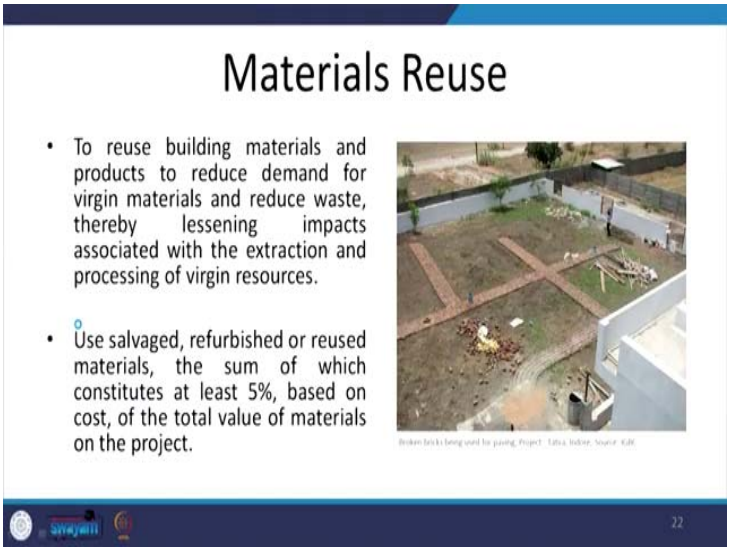

So, when we are talking about the material reuse the compliance criteria says that, ~~the~~ at least 55 percent not 50 percent 5 percent of the material should be reused material that is of the total cost of the material going to be used in the project. So, out of the total cost of material on the project, 5 percent of it shall be salvaged refurbished or reused material. Now again when we are talking about all these strategies in general, we are talking about the environmental impacts and benefits where the intent is to reduce the extraction of virgin material raw material from the nature.

So, reusing as much of the material which is existing and reducing the burden on the environment. And of course, it comes with a lot of economic benefits because simply a lot of cost for procuring new material has been offset by reusing the old material. So, it is not just environmentally beneficial, but it has it comes with huge economic benefits. However, at the same time the purpose for which these materials will be used, it has to be clearly identified and seen.

And besides that sometimes when we are talking about refurbishing the materials or salvaging them, sometimes the cost of salvaging them becomes greater than the actual cost of the material from an economic point of view for example, if we are salvaging the wood flooring. So, sometimes the pruning, trimming and polishing of these wooden floor planks may prove to be costly from labor cost point of view as compared to procuring and installing a new wooden flooring in some of the cases.

However, it would still come with a lot of environmental benefit because we have reduced the procurement of virgin material from the environment. So, a balance will have to be made at some point of time that where what kind of material would go handy.

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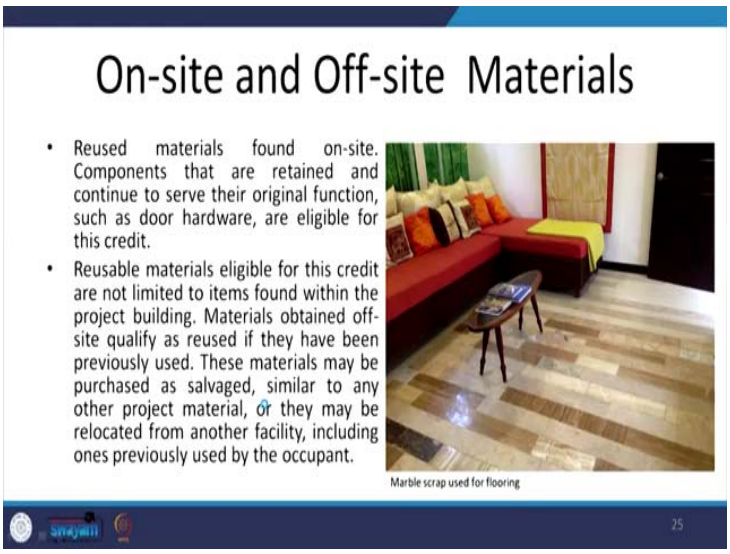

Now when we are talking about reused materials, some of these materials could be procured from the site itself. So, onsite reused materials or they could also be procured from some other site. So, this particular photograph if you see. So, the flooring is actually done using the marble scrap.

So, instead of procuring new marble pieces huge marble pieces, the scraps have been used though it would have required a lot of trimming and cutting and polishing of the edges before this entire floor has been cast. So, we have to weigh this, way out the benefits and also what is going in to using this material, reused material. So, here we are talking about the onsite and offsite materials. So, some of them may be available onsite for example, part of the building was demolished which was existing on the site.

And the material from that demolished building could be reused back for example, the brick or say the door frames or doors. Some of the material could be procured from offsite somewhere else and it could be a reused salvaged material.

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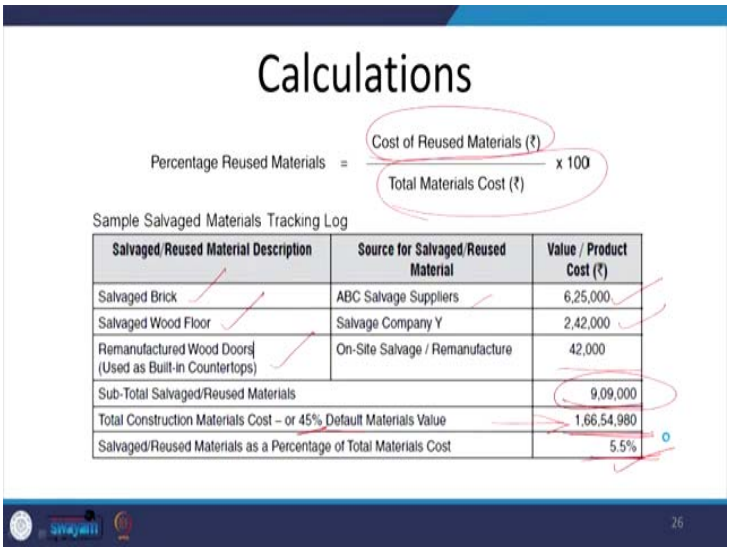

So, when we are showing the calculations, we are talking about the total cost of reused materials as a percentage of the total materials cost and this should be at least 5 percent. So, here salvaged brick which has been procured and the total cost of it.

Salvaged wood floor the total cost of it, remanufactured wood doors the total cost and the total cost of all the reused material here. And then for the basic total material cost either we have the total construction material cost or we take it as a default value which is 45 percent of the total cost of the project and we calculate the percentage here 5.5 implies that the product, this particular project complies with this criteria of material reuse.

Here, we would stop here and in the next lecture we would be talking about more properties of how to select materials for optimization of materials and resources in sustainable buildings.

Thank you for being with us. See you again in the next lecture.