

Interior Design
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Lecture - 17
Interior Design: Materials - Stone

Namaste. Hello everyone. Welcome to my NPTEL course on interior design. We are discussing materials, and today we are going to talk about stone, which is a very important material for the building construction industry. So, we will see the story of stone and how it is inherently a part of civilization.

We will see some case studies, and I have also put down some references. So, when we talk about the story of stone, we say that the story of stone is the story of civilization. It is like a timeless material, and this is a very interesting image. You know how we try to understand stone as a necessity, how it became a tool, and later, of course, a part of our shelter and the building construction industry. So, this is like a gradual evolution in a journey.

The Stone Age is a broad prehistoric period lasting about 2.5 million years. And stone is a very timeless material. It has witnessed all the eras, and it narrates a timeline. It is available in abundance. It has always been available in abundance.

And you know there are varied products of daily use and varied applications in art and craft in architecture that we see stone being used in. And stone is very long lasting and it has stood the test of times. Earlier stone craft and architecture they were considered the two sides of the coin. But with the passage of time the relationship has changed. So, you know, earlier we saw the use of stone extensively in village constructions, in dwellings, palaces, temples.

But I see this focus is now shifting, you know, towards only sculptures or folk products or masonry for some urban areas. So, it's not an absolute way of defining a shift. There are few architects and designers and interior designers who still use stone very sensibly. But yeah, largely speaking, we see this shift happening. So if we look at different aspects of human civilization and we try to understand where the use of stone could be traced, we'll see references to artworks, rock paintings, of course, architecture, some utilitarian objects.

We see very aesthetic use of stone, then how it is used structurally and then also in applications such as installations. Now, if you have to understand stone types then you know there is one classification which is based on origin and within that order we can see igneous rocks, sedimentary rocks and metamorphic rocks. So, igneous rocks is when the molten rock cools and hardens and sedimentary rocks technically speaking these are formed from deposits that have undergone consolidation and crystallization. And when we talk about the third type, which is the metamorphic rocks, they are formed when other kinds of rocks are changed by great heat and pressure inside the earth. Now, this is just again listing of these three different kinds of, you know, the rocks that we just talked about.

So, this one is the igneous, and within the igneous family, we see basalt, granite, diorite, and cyanite. Then, the important one is sedimentary over here. Within this, we see sandstone, limestone, shale, and like there are some of the images—of course, there is a huge variety. Stone is a natural material, and it has a very, very wide variety. So, some images I have put over here.

Then, of course, the metamorphic one, where we see marble, quartzite, slate, and gneiss. Marble is used very extensively in the interior architecture industry. So, these are again some of the plates from a publication, and this was done by researcher Purna for DICRC at CEPT University. I was also working in that center at that time. Now, I am not going to focus on everything that is written over here.

Maybe, you know, you can refer to the lectures which are being put up on different platforms. But just to Give an overview, when we talk about sedimentary stone, we see examples like limestone, sandstone, soapstone, and fossil stone. And then there are also metamorphic stones, where we see, of course, marble that I just talked about. Then, when we talk about marble, again, there are like three interesting categories within marble.

There is dolomite, there is magnesium, and there is also calcite. Then there is slate, which is used quite extensively. There is also serpentine. And, of course, there are igneous stones. We use granite very extensively, especially in kitchens.

So that's again one example within the igneous stones. There are varieties of sandstones, and if we specifically talk about India, we will see them in different colors, different

pigments, different grain structures, etc. So, there is chocolate, which is deep brown, chocolate-colored sandstone. There is Kandala grey. There is copper, Marsan copper.

There is Rajpura green. There is Lalitpur yellow. There is Dholpur beige. There is a pink-colored sandstone. We also see this greenish-white, you know, which is Gwalior greenish-white.

There is Agra red. There is Khatu teak. And there is Khatu rainbow. So, these are some of the popular varieties that you will come across when you go for your market survey or when you use them for your professional projects. And because of this variety, sandstone is also used to achieve these kinds of diversity in color, and they are used in different places within interior architecture project lines.

Again, if we talk about sandstone, we see lots of examples. So, when we talk about the stone, there is a profound role to be understood in terms of its physical properties. And when we talk about the physical properties of stone—let us say here sandstone—there is a discussion on water absorption, what kind of texture it has, its mineralogy and occurrence. What is the structure like? How much is the hardness?

What is the color? What is the porosity? What is its compressive strength? So, these are very scientific and technical details. Nonetheless, I am just putting them here so that if somebody among you is interested in these in-depth details, then you could do some surveys or look at catalogs and at least be aware that we have to keep these kinds of aspects in mind while selecting stones.

We will see some of these properties like you know about hardness or MOH in the case of tiles also. So stone is also used as tiling material. So there are some properties that you will see in tiles as well. So when we talk about granite, it is an igneous stone and it is considered to be an ideal stone for use in flooring and in food preparation areas. And then sandstone is a sedimentary stone and it is primarily composed of loose grains of quartz sand and it is usually rough in texture and it comes in a variety of colors.

Limestone is another sedimentary stone and it's quite interesting. It also has very interesting color pigments. It is formed from calcite and sediment and it comes in many earthen colors like I was telling and it's quite extensively used in construction. Marble is a metamorphic stone. It can be polished as well.

It is characteristically soft and is easily scratched or edged by acids. And there are countless types of marbles that are, you know, available around the world also in India. Then there is slate, there is quartzite. These are other examples of metamorphic rocks. And marble is considered as an ideal stone wherever carving is to be achieved.

The formation of stones defines their individual characteristics. Stones with a finely packed grain structure are considered ideal for carving, like what we are talking about with marble. While the grain structure and a few other factors make them easy to quarry. Stones come in a variety of colors that we just talked about. These colors are influenced by the color of the predominant mineral within their composition, as well as edges in minerals and grain size.

So, these are all technical specifications. Igneous rocks generally have very stable pigments, while they are quite unstable in sedimentary rocks. The widest range of colors is found in metamorphic rocks. So, when we talk about marble, it comes in a wide range of colors. And so, we can pick and choose based on the usage of the stone, the type of project, the lifespan we are looking at, how the budget is defined, and whether it is to be used in a food preparation area, which is slightly wet, or in a dry area, etc.

There are also stone types based on surface finishes, and some of the most common or popular finishes are listed here. So, there is a polished finish, something known as a honed finish, an acid-wash finish, and a saw-cut finish. There is also a brushed finish that you will come across while working with stones. Then, there is the flamed finish, which is very interesting. There is a split-faced finish and also a tumbled finish.

Some of the images that you see on the screen highlight some of these finishes. So, there is this polished finish over here. And then there is this honed finish. This is the saw-cut finish. There is this acid-wash finish and so on.

So, yeah, to understand them in detail, we'll take another lecture altogether. And since we know interior design is a very vast course, it's very difficult to cover everything, but I'm just trying to put an overview in place. This is the split-face finish that we see over here, and then this is the tumble finish. If we talk about the geographical distribution of stones, especially Indian stones over here, this is a sort of inventory that I have tried to put together. So, starting with which part of the country we are procuring that stone

from, and then what are the particular kinds of stones that are used, and what are the examples in which we see their applications—that is being put together over here.

So, if we talk about South India, the stones used are granitoids, and we will see lots of examples of ancient temples where these are used. And if I talk about the North, we see a lot of use of red and yellow sandstone. We see references to Mughal architecture there. Then, if we talk about West India, we also see very interesting, popular, and famous examples—Ajanta and Ellora caves and the Buddhist architecture from that time period. We also see Somnath Temple from Gujarat and the use of meiolite limestone in Gujarat, as well as basic volcanic rocks in the case of Ajanta and Ellora.

Now, if we go towards Odisha, we see the use of Khondalite gneiss, and it is quite commonly used in this part of the country. So, now when we talk about the machines, you know, which are used for cutting the stone, there are different sizes of blades available with these machines, and they are used for cutting purposes. So, 14 inches, 16 inches, 18 inches, all the way up to 54 inches. These are the cutting machines with various sizes of blades that we see. 14 and 16 inches are combined on one machine for cutting stone, and 18 and 20 inches are another combination on one machine used for cutting stone.

Then again, if we talk about this set, 24 and 30 are combined together, and 36, 42, and 54 can be seen on one machine for cutting stone. So, these are all technical details, and when we work with the industry on the ground, we get to know how these are used. Then there is also a lathe machine. It comes in both small and large sizes and has been used extensively during the construction of temples. For example, for making the shikharas of the temples—the towering structures that we see—we can create different forms, whether round or truncated, for making columns or different kinds of artifacts.

There are also small cutting machines, you know, which vary in size from 14 inches to 30 inches. They are also used for different purposes. Then there are drill machines that are used extensively while working with or on stone. There are some standard drills with varying sizes of drill bits, which are part of the drill machine. Then there is a diamond drill, you know, for jali making, which is very extensively used in temples and construction related to religious structures.

Then there is diamond spiral drill for making you know diverse kinds of patterns and different kinds of placements. Then we also see machines like a chain pulley, there is a polish machine and there is also handle. So we have some hand tools, some power tools and some machines and a permutation and combination of these is used depending on the scale and purpose and the application of stone and what is the project like. There are some hand tools which are like used commonly and you will see them across the length and breadth of India. Somewhere the nomenclature may vary, but mostly these are the kinds of hand tools which are associated with, you know, making in stone.

So, of course, there is a hammer which is Hathaudi and it is used for applying force. Then there is Cheedaan which is used for breaking stones apart into smaller pieces. There is kath khuaan which is you know for measurements and alignments. Then there is adhiyaan which is used for cutting. There is Athaadhi, which is used for cleaning the surfaces.

There is also Guthdhi, which is used for making edges. And the smaller size Guthdhi is called Chaiyanaa. Then there is, you know, Taankanaa, which is used for giving forms and detailing. There is a smaller size available in Taankanaa, which is called Taankani. There is Kaanast, which is used for filing.

So all the files that we see. They are used quite extensively and then we see over here Bapdhaa which is used for making grooves and slits. These are some of the hand tools and some of the pictures of those which are shown on the screen. Again over here there is a huge variety and there are different small and big sizes that we see over here. This is master craftsman Jeenabhai who was explaining these tools to us when we were having this discussion on the tools related to the stone and its making.

Now we have also moved to CNC and CAM which are like computer numerical controlled machines and computer aided manufacturing. So not everything is happening by hand tools and power tools. There is a lot of automation happening now. And there's a lot of use of CNC machines even for making of temples, etc. So this is a paradigm shift and this is a very, very, you know, popular scenario now that, you know, there is a lot of use of CNC and CAM.

So I always discuss this that how do we achieve this ecosystem between handmade and mechanization and if we have to really see the timelessness of stone and if we have to

really look at the temples which are historically very famous, their craftsmanship is quite intricate and very exquisite compared to what we achieve from a machine. But it depends how much time do we have for production, what does the client want and what is the project like. These are again some more images and it's a completely mechanized and automated system. Now we can also classify stone in terms of usage. And there are two broad categories.

There are building and veneer stones. And we see a lot of use of laterite, granite, sandstones, and limestones under the building and veneer stone category. And these stones that are used for masonry purposes can be termed as building stones. And the ones which are used for cladding are termed as veneer stones. So they are used according to the purpose for which they are being used.

And then there is also another category, which is sculpture and object carving stones. So, both hard and soft stones can be used for these purposes, and they include granite, sandstones, limestones, marble, and slate. Now, depending on the use, the scale, and where it is to be procured from—what the available source is—the selection can be made accordingly. But these are primarily for sculptural purposes or for utilitarian objects. So, if we continue with sculpture and carving stones across India, here we have tried to put up this inventory in place—like which part of the country and what type of stone we commonly find there—and then what are some examples from history where we see these applications.

So, let us say Tamil Nadu, Andhra Pradesh, Kerala—we see granite, basalt, and also metamorphic gneiss, and we find examples of rock-cut temples and some other sculptural applications as well. If we talk about Odisha, then of course we see Khondalite and the example of the Konark Temple. We still see some traces of sculpting in this part of the country. So, these are all diverse applications and typologies that are put together. So, in terms of sedimentary rocks, while sculptural and carving-related applications are concerned, we see Rajasthan, Uttar Pradesh, and Gujarat, and there is a lot of use of sandstone.

There is a lot of use of sandstone actually across India. So, whether it is Madhya Pradesh, West Bengal, Orissa, Bijapur and Makrana. So, sandstone is used in large quantities and we see the application here in Rajasthan primarily like architectural elements and then in Madhya Pradesh figure sculpting, in Orissa very intricate carving

etc. So, these are some traditional uses of stones and when we talk about sculptural and architectural carving, we see examples in traditional architecture, in sculptures, in Vastu Vidya, in Shilpa Shastra.

And other than that, they are also used in kitchen products. There is the traditional use of stone, which is seen in architectural elements. Some products for ceremonies and ritualistic purposes, accessories for personal use and some products for public use. And then today in contemporary times is some shift and we see that this stone is used again for, you know, varied purposes. Of course, for products which could be kitchen products or, you know, furniture products, ritualistic products, personal accessories, even furniture and fixtures.

And within the architectural applications, we see, you know, the folk elements, formal temple elements and then also sculptures which are both traditional and contemporary. So, we see all these kinds of uses. There is also a lot of cladding that happens, you know, with stone in the contemporary times. So, that is another application. These are some of the contemporary examples of furniture in stone and some images that have been put.

You know, this is seating. This is also seating. These are some tabletops in stone. Again, some chairs, some garden seating over here, etc. Then, you know, there are some wall finishes that we see in stone.

These are some examples from Gujarat. And we see more basalt and sandstone used over there. This is also a wall in basalt and some more examples of that. So, very interesting walls and wall junctions and joinery details at the corner, etc. These are applications of stone in traditional floors.

So there are traditional floor-laying methods, and you know, we see a center stone and some loose stones which are put around it and then residues. Then there are more examples of stone flooring. These are again from Gujarat, and we see this flooring in a mosque in Ahmedabad. And then here in Adalaj, again flooring in Jami Mosque in Ahmedabad, Gujarat. More examples of that.

And this very interesting flooring in a palace which has a pattern and design to it. This is Sarkej Roza, very very famous from Gujarat. Then there was this stone craft cluster at Ambaji where we had visited as a team and it was very interesting to see how they

are applying stone. Just like we do wood turning, like we use a lathe machine and we turn the sections of wood on that lathe, there is also stone turning possible and these very interesting sections and rings that they were using in a very contemporary manner. you know, in the temples and some elements of temples.

Some explorations in stone I would like to show you and they are primarily sourced from CEPT University in Ahmedabad and I was a part of these organizing team of the workshops that were being organized and we were trying to explore stone as a material and trying to see what could be the interesting ways of experimenting with it. So, this is again the work done by the researcher designer Purna and here basically there are attributes such as you know recyclability, reusability, circularity that we were trying to just you know capture and then create some applications of stone. So, whenever we work with stone there are always leftover pieces. So, can we use them as you know also like modularity if I talk about leftover pieces and modules. Can we use those modules and then we can we design some joinery and put these pieces together and create partitions out of it or storage units out of it etc.

So, those kinds of explorations we were doing and then with these modules we using different permutations and combinations, there could be different explorations, right? So, it could be a partition screen, it could be a walling system, it could be a storage unit, it could be a different way to put like a sculptural lamp or something. So, these kinds of explorations we did during those workshops and based on this learning, I am still continuing to do these kinds of experiments here at IIT Roorkee also. So these are some of the renders from that experiment.

Again, you know, this is another exploration. So we can bring in these kinds of attributes, foldability, portability, modularity, and then we can try to put things in a very different permutations combinations and have different explorations from the same pieces of modules or units that we organize and reorganize and create new experiments. So before the experiment was actually done in stone, there were also some kinds of models that were prepared. Again, this is another way of putting things together. So this is exploration number 11 and 12.

So within a partition system also, how could we play with the scale and expense and where is it to be installed? What kind of space will it be put in? What is the volume, etc. ? So, more examples, more explorations, more configurations, more permutations

and combinations. So, there is a planar element and there is a columnar element and how we put them together.

So, there is horizontality and verticality and then we put something like this together in place. There was an attempt to also do costing because you know this experiment was happening with industry experts so it was good to have an idea and You know, also what was the total weight of the product. So let's say 600 kg and then the total cost. It gives some idea how much cost goes to the karigar, how much goes to the, you know, transportation part of it.

What are the dimensions? How many pieces of stones are used? How much is the time that goes into making of these prototypes? So this was a very useful learning experience. So, continuing more in terms of discussing explorations in stone, there are different kinds of stones that could be used even you know these kinds of grooves and lines could become a part of design vocabulary and it is quite possible to create finishes and textures despite it being a natural stone and it having its own granular structure and veins and everything.

So how do we put together these two pieces? What kind of color pigments do we select? How do we achieve this overall color combination? So all of it is actually a part of these explorations and then it becomes a job of the designer to even look into details like this, putting two pieces of stone together and in what color pigments will they look best along with the functionality of course. Now, I was talking about some case studies, you know, that we will discuss case studies.

So, there is this house which is made out of stone and this is a case study from Rajasthan and, you know, Jodhpur specifically and was constructed in 2018. This is from one of the studio exercises that, you know, I coordinated a studio here and this was at the B.Arch third year level and one of the students work is what I am presenting here. So this exercise, you know, it involved a very thorough documentation. of understanding what are the details and what is the construction process and talking about the climate of Rajasthan, specifically Jodhpur, what kind of stone is available there and then how it is actually used in the construction of this house. So, the details were also mapped focusing on foundation, you know, wall filling, doors and window frames.

All of that, the student had gone to the site, mapped it, and tried to understand the entire construction process. These were the inventories that our student Kimaya had generated using the framework I had provided during the studio. Starting, of course, with the drawings—what is the plan—and then the stone on the site, how the wall filling is done. Then there is the chimney, the entire construction process, openings, all of that, then the roof slabs. The sections, window and door casings, stairs.

So all of these details were documented on-site. And we see the sandstone and granite exterior here. So we also tried to create a framework where we put things in a very systematic manner. When we document this house, what do we see as matter, resources, or physical properties? So, of course, we see the use of stone here.

And then, of course, it's in a very hot region, and the climatic concerns must be addressed. So there are thick walls with high thermal mass. Because of that, there is some cooling within the interior or inside space. So this kind of consideration was there, and we tried to put things together systematically. And what structural aspects can be seen, whether load-bearing or non-load-bearing?

Is it, you know, in terms of arches or an arcuated system? So, that documentation was also being done, and those details were being mapped. So, Here, the stone is not only used for walls, which are load-bearing, but also for roofs, stairs, cupboards, doors, window casings, and even in the foundation. And wherever the roof length is more than 20 feet, a steel I-section is installed in between along the shorter side to help support the roof.

So, this kind of, you know, structural detail was also noted. Then, what are the surfaces? What is the protective coating like? What are the decorative aspects that we see within the spaces? So, even that kind of detail is there. For example, the plaster, you know, lime plaster is used, and wherever the cladding is used with stones such as sandstone or granite. What are the architectural elements?

So, door and window frames, cladding for exteriors. What is the typology of the building? So, it's a residential building. Are there any aspects of craftsmanship or workmanship over here? So, of course, there is.

Involvement of the craftspeople and the stone makers who could be seen on site, and they are involved in a lot of work at different scales in different capacities. Then, what

are the natural building materials that are put together in this house? There is stone, slate, mud, and mortar, which are used for the construction of this house. Are there any environmental aspects? Of course, we were talking about the region and how hot it is, and then how the temperature was sort of reduced to give some kind of thermal comfort within the space.

So, those kinds of details were also recorded. These are some of the images that were put in that inventory. Here, you can see them in a zoomed-in format. So, from footing to wall filling to the section—this is inside, and this is outside—and we can see this thick wall with an air cavity, and therefore, the thermal lag increases, and here it is cooler than outside. Yeah, so more of the images.

These are the casings of the window and door. We see the stairs. This is a roof slab, and how the joinery is done and how they are fixed together. This is a section. So here, you see the wall.

This is the lintel, and these are the roof slabs. Over here is the image of that. And we were talking about the expanse, which is larger than 20 feet. And then, what is done over here on the shorter side. We spoke about it a few slides ago.

More images from the site. And this is like the floor finish. The exterior cladding. Yeah. And now, from Rajasthan, we go to Odisha and see Krushi Bhavan.

This case study you will probably see in other lectures also. We are trying to understand interior architecture through different lenses and in different dimensions. And this one case study actually explains several of these dimensions, and I find it a very interesting and benchmark case study. So, it will probably get repeated in some lectures, but the details may, of course, be different, and the focus of discussion may vary. So, again, it is by Studio Lotus, and here we see the use of stone to quite an extent.

So, laterite and Khondalite are the locally available stones found there, and it was constructed in 2018. And it's actually for the government of Odisha, and the entire project is a very interesting demonstration of how the government can encourage construction in a very... local style, creating this ecosystem of employing local makers and then creating a design vocabulary that is very rooted in the culture and place. So, a lot of the materials, palette, and details we see here are local and very rooted in the culture of this place. So, it gives a sort of identity.

So, we see the primary entrance pathway lined by laterite. And then we also see the stone used for cladding as well as flooring. And we see a lot of terrace farming in this entire project. And over 100 highly skilled artisans or craftspersons came together to facilitate this vision. So, like the ecosystem I was talking about.

And We see a very profound use of traditional art and craft of Odisha and all the communities of makers involved in creating a project like this. And their folklore and mythological stories are depicted through this built form. Yeah, so these are some of the images and concepts sourced from Studio Lotus itself. And here, we also tried to put things in a very systematic fashion.

So, what is the matter? And what is the matter, as in what material has been used, or what are the resources and what are the physical properties? Again, the structural aspects—column-beam structure—and then clay bricks and stone are used over here. And there is this very interesting, you know, ikat work that you see in Odisha. It's a traditional weave. And that has been, you know, demonstrated.

That has been demonstrated on the facade of the building. So, that's very interesting. It's like a brick facade, and it looks like a weave. And some of the traditional crafts are used, such as Dhokra, which is, you know, related to metal. So, we see lots of screens, animal figurines, and foliage.

We see very good motifs over here, which are used in the interior spaces. Also, some kind of plaster and texture that has also been custom-made. Architectural elements that we see over here, and, you know, what are the functions of this building? It's a government building, and it's open to the public. What are the aspects of craftsmanship? And again, what is the aspect of the environment that we see over here?

So sustainability in terms of procuring everything that is locally available was kept in mind. And also, there are passive cooling strategies employed in this entire building. We will see those in detail in one of the lectures later, discussing how those techniques have been employed in this kind of project. And here you see the details. This is the demonstration of ikat weave but using stone and clay bricks.

This is the custom-made interior plaster and texture that I was talking about, and these are the natural color pigments because the source is the natural stone which is being put

together. Some more images. These are the drawings sourced from the architects themselves. It's open source.

They are available on their website. Then this is the third case study, continuing with the experimental explorations and applications in stone that we were talking about earlier. There are some prototypes that have been put together. This is quite interesting. So groups were made, and the group had students from diverse backgrounds.

It also had, you know, some researchers, designers, and faculty, and they were trying to explore together. So, starting with the human spinal cord, what is the anatomy? How does the joinery happen between, you know, different parts of the human spine? And can we learn from that joinery and try to use stone again? In terms of a modular system, and then create permutations and combinations of those modules, and then design something which could be sculptural, or it could be a shelving or storage system, or it could be a partitioning system as well as a parapet, etc. So, these were the modules, and then by understanding the joinery—how they are put together—these different kinds of applications are achieved. So, this was quite interesting.

Even like, what kind of joinery should happen here—whether it is mortise and tenon or dovetail—that is very important. So, we started with mortise and tenon, which is like tongue and groove, but when we actually produced this, you know, on-site because stone is very, very heavy. So, it was buckling—this element over here was buckling—and because of that, we had to revise the mortise and tenon into the dovetail joinery. So that, you know, the fixing becomes stronger, and the weight is counterbalanced, and it does not buckle or tumble. This was another one where, again, these modules of stones were used.

It was slightly experimental also, in the sense that it is not a linear plane, or it is not, you know, a simple use of stone. It is curved, and we created this kind of a wall which also had some kind of inlay work, and so it could create a pattern of life of a tree. So, this one here—we have different details here that we see in the drawings. So, where is the first course? Where is the second course? The assembly is shown over here. This was another one where, again, these modules were used, the joinery was designed, and again, you know, it was put together in the form of a partition screen with interesting details like contrasting stone with some kind of an inlay work, etc.

And then this was also another prototype. Module 1, module 2, this is module 3, 4, and 5, and how do we assemble them and put them together again as a partitioning system. So, this is case study 4, and we are talking about stone and modularity. We talked about modularity earlier also, but this one particularly talks about these attributes and also tries to understand that the term modularity evolved during the last decade of the 20th century. And it became evident in interdisciplinary fields.

Modularity is being used in a lot of designs. We tried to incorporate this aspect in our Indo-German workshop and some prototypes that we made during the exercise while we were focusing on pavilion designs. So, we were trying to develop a modular system using stone. Also, we tried to understand joinery and how the pieces are put together. So here, modularity was employed because it leads to the evolution of a new system in architecture.

Transportation becomes easy, and some kind of experiment can be done here. And of course, it started with the idea of standardization and cost-effectiveness. So, we also published an article on this, and the literature and all the supplemental data that you see on the screen can be referred to later in great detail. We did talk about the evolution of modularity and how it became an important aspect of industrial design. So, some more details about it, and then we were trying to focus completely on stone as a material. We see some references where stone modules have been discussed, and stone is a very complex material. Getting it to the construction site is cumbersome, and transportation is not easy.

So, to some extent modularity tries to you know mitigate those. So, we started with that premise and then we started understanding these primary concerns like bulkiness associated with stone and then how to try to you know come to a scale where the cut pieces or the leftover pieces could be compiled together using the different aspects of modularity and some other attributes. Yes, so again we were trying to also think about the joinery because the modules have to be put together. And then how can we reduce errors while using modularity as an approach? So this was our exercise.

And we started thinking about this modular use of stone as a new and sustainable alternate, which can be easily replicable. And then we can also, you know, combat the issues related to transportation. So we designed an experiment. It was a joint exercise.

The Indian and German students came together and the pavilion or micro architecture was the focus, which was to be designed in stone using modularity as an approach.

And the essential volume that we were trying to achieve was four meter by four meter by four meter. And actually, this is designed and it's there in a workshop with our industry partner. Trivedi Private Limited in Gujarat and we are going to install it soon within the IIT Roorkee campus and we discussed greatly on site in the workshops how will the assembly happen how can we have very uniform and consistent pieces in stone whether it should be done you know handcrafted or a CNC machine should be used So we did use BIM simulation model, we did use CNC and we also had some of the hand finish incorporated in it. So those details we were able to cover on site thanks to the support from the industry partners.

So, when I said Indo-German exercise, RWTH Aachen University and IIT Roorkee, they were involved in this exercise. And we were thinking about cylindrical disc modules and stone pin components like I showed on the previous slide. And we were trying to achieve different dimensions of It was a concern how to handle the weight and there will be lots of pieces that will be put together to create this pavilion. So the calculations happen, how many pieces will be used, what is the weight and you know, so these are the

pin joinery system that we were talking about and these are the discs its entire module system in place and there was also a need to design proper grooves you know how the fitting of these pieces happens so the grooves were also designed to accommodate all these modules and these are the components again and I was talking about the CNC machine cutting for consistency in the modules, for easy fabrication and you know to have precision. So sandstone was used for this kind of a prototype. It's light. It's available in varieties.

We had the options of colors. It was readily available, you know, in the workshop in Gujarat where we were doing this experiment and was slightly cheaper. So we went with the sandstone as discussed with the structure experts and as well as our industry experts. And then we tried to put this... micro architecture in place.

Now, it was inspired by the Sanchi Stupa, you know, which is a World Heritage Site, and we were trying to create an enclosure inspired by the Sanchi Stupa. Of course, we

started the inspiration here and then began designing this enclosure using these stone modules, designing their courses one after the other, and trying to put them together. So, this is like one render or one iteration of that, which could be used as a reading space, an exhibition space, or a tea pavilion. So, the permutation and combination of these modules can generate different kinds of prototypes and different spaces. That was the idea behind this pavilion design—using stone as the main building material and capitalizing on the idea of modularity. So, this was the entire experiment, and we focused quite a bit on the modularity aspect.

So, there is a lot of detail over here. I am not reading out everything because I am just telling the main idea. So, I did tell you about the BIM simulations also before we could achieve the final design. Yeah, this is another render of the same experiment that you see. And we, of course, started with technology, but we also had hand-holding support from the carriers or the craftspersons on site.

And it was a very, very interesting pavilion, actually, and it was a huge learning curve for everybody involved. And I'm going to just... Showcase this very, very interesting quote: 'One might regard interior architecture as history arrested in stone.' So, stone is a very, very crucial material when we talk about interior architecture. Next, we will talk about tiles, and there are some references that are being put here. You can refer to them later if you want more in-depth information. There are some e-books as well.

Thank you so much. I'll see you next time.