Course Name: Building Materials as a Cornerstone to Sustainability

Professor: Dr. Iyer Vijayalaxmi Kasinath

Department of Architecture,

School of Planning and Architecture, Vijayawada

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Lecture 01

Bioluminiscent paints

So, dear students, we will start our next session today and today we will look at bioluminescent paints. Now, bioluminescent paint is an innovative material and it has a lot of uses and we are yet to explore its full potential. So, what are bioluminescent paints? This luminescent paints, it is derived from materials that emit light. They find their origin in pigments, crystals or compounds integrated into paint formulations. Their working principle involves absorbing ambient light to energize luminescent particles, releasing stored energy as visible light in darkness. With applications ranging from safety signage to artistic expression and improved low light visibility, luminescent paints utilize phosphorescent materials for prolonged light emission and fluorescent materials for immediate light release.

Future trends include ongoing research for enhanced durability and versatility coupled with integration into smart technologies for dynamic illumination control. Now, the consequences of excess artificial lighting go far beyond the deprivation of starry sky viewing. They are also a source of disturbance for biodiversity. Artificial lighting anyways is a burden on the environment because of the amount of energy they consume.

So, sometimes there can even be a modification of the prey and predator systems in biodiversity areas which are sensitive areas and it can even cause disturbance of reproduction or migration and things like that. This is beyond the amount of wastage of energy. Now, faced with this issue, more and more officials, they are mobilizing modulation of public lighting or complete shutdown of neighborhood part of the night. So, it is not a choice that people have anymore in sensitive areas. In this context, luminescent paint offers an alternative solution.

So, phosphor and paints. Let us look at the types of luminescent paints. So, we have three types of luminescent paint. One is the fluorescent paint. The other type is the phosphorescent paint.

And third type is the radioluminescent paints. Now fluorescent paints, they emit immediate light upon exposure to light. When it is very dark and some light falls on that place, they emit light immediately. Now these are suited for situations where instant visibility becomes crucial. Whereas phosphorescent paint emit light for an extended period after exposure and they prove ideal for applications which require prolonged visibility.

And in contrast radioluminescent paints they incorporate radioactive materials that emit light when exposed to radiation. They do not require external light exposure and offer continuous illumination. Here I am going to show you a small clip of how this kind of light works. So, you can see here the concept of how these luminescent light works. Let us look at bioluminescence.

Bioluminescence is the production and emission of light by living organisms. This occurs through chemical reaction involving luciferase, luciferin and oxygen, common in various marine organisms, fungi and some insects. This kind of lighting can be very useful and they can cause very less harm to the environment. Their functions include attracting mates, deterring predators and luring prey. Bioluminescent organisms have specialized cells or organs called photophores.

Some deep sea creatures use bioluminescence for camouflage in the darkness. Scientists explore the potential of bioluminescence for various applications including lighting. A lot of research needs to be done in this domain. Let us look at now the characteristics of these kinds of lights. Now bioluminescent organisms - This type of paint contains living bioluminescent organisms such as bioluminescent algae or fungi.

These organisms emit light as a result of enzymatic reactions involving luciferase enzymes and luciferin molecules. When these substances come into contact and react with oxygen, they produce light. We can also have synthetic bioluminescent chemicals. So, some bioluminescent paints use synthetic chemicals that mimic the natural bioluminescent reaction. These chemicals typically include synthetic luciferase and luciferin molecules.

They can be engineered to produce light when mixed together or when triggered by very specific conditions. Now, how does bioluminescent paint work? We have what is called as luciferase reaction. So, bioluminescent paints function by utilizing the luciferase reaction which is a chemical process that emits light without generating heat. The bioluminescent proteins in these paints they produce light when they react with oxygen. And they convert chemical energy into light energy resulting in the glowing effect of the

paint.

Some bioluminescent paints are derived from specific types of luminescent bacteria. Algae with bioluminescent properties are another source used to create these specialty paints. While certain fungi species are also utilized in the production of bioluminescent paints. Here, we can see an example of how these bioluminescent paints, the organisms in it can emit light and there is no energy external source of energy required for this. Just the movement of a person triggers the light.

Now let us look at the characteristics. Phospholuminescence. So, these paints they absorb ambient light and emit it in low light conditions. In general, if you look at the characteristics of these paints, they are quite durable because they contain living organisms which multiply. Illumination time is that which is actually required and that also gives us energy efficiency.

They are very versatile and it is up to our imagination how we could use it and you can have these in variety of colors. Based on your creativity, you can integrate these because they have the potential for integration with smart technologies for dynamic control. A lot of research is still focused on improving their longevity and resilience. And the most important aspect from environmental point of view is that they harness ambient light and reduce our reliance on external energy sources. These also come with certain limitations.

Now, the intensity and duration is one of the limitations. Bioluminescent paints may not provide the same intensity and duration of light as conventional artificial lighting methods. The glow may be relatively dim and the duration may be limited. When we look at the environmental factors, bioluminescence is influenced by environmental conditions such as temperature and humidity. Extreme conditions might affect the performance of bioluminescent paints.

Besides, when we look at the cost aspect, the production and incorporation of bioluminescent materials can be expensive. This can impact the cost effectiveness of using them on a large scale. When we look at their color ranges, bioluminescent light, they often fall within a very narrow color spectrum, limiting the variety of colors that can be achieved compared to traditional lighting. Bioluminescence relies on the sensitivity of light sensitive organisms or materials. So, exposure to ambient light may affect their performance.

When we look at the application very specifically, bioluminescent paints have very specific applications and may not be universally suitable for all lighting needs. There are certain current technology challenges. The technology is still in a very early stage and

ongoing research is needed to address existing limitations in order to optimize their performance. Let us now look at the applications along with certain examples. Here you can see that we can use these kinds of light emitting paints for aesthetic purpose to create certain patterns in graffitis.

We can also use them for illuminating dark and dingy corridors. And we can also have them for safety purpose to guide people to a particular route. Besides these, we can use them for certain artistic expressions. Now, artists have used bioluminescent paints to create captivating and unique pieces that emit an ethereal glow. Using these paints can cause a lot of drama.

So, these paints have been used by artists to create patterns without actually having a larger canvas. There is no limit to the scale because these lights can be used on any surfaces. In architecture, these paints are incorporated to produce stunning environmental and aesthetic effects. In architectural design, sky is the limit to use these paints. These paints can be applied on the facade of the building or on the interiors.

Instead of creating larger murals, these paints can be used which will give a different effect during day and will give a different effect during night for the same space. And that way this can produce stunning aesthetic effects. Besides these are all environmentally friendly. These paints can also be used for emergency signages. So, bioluminescent paints, they are used to create visible emergency signs and markings in low light conditions.

For example, in a wildlife sanctuary, it is not advisable to have artificial light along the roads when someone has to travel at night because the artificial lights can impact the biodiversity of the place and the animals there. They are very sensitive to the circadian cycle and having bright lights at night can impair their growth, psych and also their reproductive cycle. Under such conditions, bioluminescent paints can be very effective. So, here you can see how the bioluminescent paint can actually guide people along the road even at night times. So, in places where it is not appropriate to use artificial light, these paints become very effective.

Well, certain safety precautions have to be incorporated. So, industrial and military sectors utilize these paints for enhanced visibility and safety measures. The glowing effect provides clear guidance which is much needed. So, these paints can be used in very remote areas on isolated roads where there is absolute darkness at night and there is no facility for any artificial lighting. In such places, using these lights can offer a lot of safety and there can be many contexts under which this can be used.

One can be along the woods where man movement is needed, but there must not be artificial light. These can be along highways which are isolated and which lack artificial lighting. So, let us now look at another interesting thing where engineers have created plants that glow. So MIT engineers had taken a critical first step towards making that vision into a reality. By embedding specialized nanoparticles into the leaves of a watercress plant, they induced the plants to give off dim light for nearly four hours.

They believe that with further optimization, such plants will one day be bright enough to illuminate a workspace. To create their glowing plants, the MIT team turned to luciferase, which is an enzyme that gives fireflies their glow. Luciferase acts on a molecule called luciferin causing it to emit light. Another molecule called coenzyme A helps the process along by removing a reaction by product that can inhibit luciferase activity. The MIT team packed each of these three components into a different type of nanoparticle carrier.

The nanoparticles, which are all made of materials that the US Food and Drug Administration classifies as generally regarded as safe. They help each component get to the right part of the plant. They also prevent the components from reaching concentrations that could be toxic to the plants. What are the advantages of using these? So, the advantages are they offer sustainable and energy efficient lighting solutions reducing the reliance on electricity.

They also have certain disadvantages. This include that the technology is still relatively expensive and requires proper maintenance to sustain its luminescence. So, even though this technology can be very sustainable and then this technology can propel us towards carbon neutrality, but this technology is still in its very nascent stage and a lot of research is required. If we look at the ongoing innovations researchers are exploring new methods to enhance the brightness and durability of bioluminescent paints. Because as of now the intensity of the paint is good enough for things like guiding people and when it is extremely dark these paints shine by contrast. But these paints do not have brightness as much as an artificial lighting.

However, beyond all this the focus will always remain on creating eco-friendly version with reduced environmental impact because the regular paints that we use are high in BOCs, are chemically laden and on a long run they do not benefit the environment in any way. Using these kinds of paints gives us the added advantage of incorporating lighting in the paints. So, bioluminescent paints have diverse applications from enhancing artistic expression. So, artistic use in graffitis, in murals to create patterns.

These are also used in architectural design. I would say architectural and planning design; they are used again for the aesthetic aspects to also put forward a particular idea

or a concept. Besides, these are also used for from safety point of view. So, from safety point of view these can be used on isolated abbeys on highways, along trekking paths. This can also be used in sanctuaries, sanctuary roads. And one of the last uses is these can be used as signages especially where there is a need for signage in the dark when signages are needed in dark areas.

Including railway stations or again sanctuaries and so on. So, they may have a lot of applications to serve critical safety needs. But addressing environmental considerations, ongoing research aims to advance their capabilities and sustainability. So bioluminescent paints have a lot of scope in architecture, especially because they are environmentally sustainable and they do not cause any harm to human health. But a lot of research needs to be done in this domain to bring bioluminescent paint into mainstream architecture.

So, with this we will stop this class on an innovative building material which is bioluminescent paint and we will take up another interesting topic in the forthcoming class.