**00:00:09 Michael Cornish**

Hello again and welcome to the Mechanics of Materials Podcast here at Imperial College London. Today we are talking with Professor Ambrose Taylor.

**00:00:18 Ambrose Taylor**

I'm Ambrose Taylor. I'm Professor of Materials Engineering. I'm an academic in the Department of Mechanical Engineering at Imperial College London.

**00:00:28 Ambrose Taylor**

And I'm Co-leader of the Imperial College Network of Excellence in Science and Engineering Research for Cultural Heritage.

**00:00:38 Michael Cornish**

So Ambrose, can you tell us a bit about this network?

**00:00:40 Ambrose Taylor**

The network links together the academics and researchers who work on the conservation of cultural heritage or have an interest in conservation, and also those whose research can be applied to conservation. They have the expertise that can help answer conservation questions. The academics and researchers at Imperial who are part of the research network work with cultural heritage organisations, but we also try and bring to the public what we do.

**00:01:15 Ambrose Taylor**

The research network has exhibited at the Great Exhibition Rd. Festival with an interactive exhibit looking at the science of art conservation. This highlighted the damage caused by light and handling by relative humidity changes, temperature changes, etcetera. And these are the sort of effects you can see in your own possessions. Your childhood toys, for example, where the plastic has gone brittle, or the rubber has become

**00:01:43 Ambrose Taylor**

sticky. The exhibit there was organised and run by a great team of academics, researchers and PhD students, some of whom are working in the area, but others who simply have an interest in art conservation and problem solving. They brought objects from their own lives, be it Lego models, toys, books, musical instruments that show damage

**00:02:06 Ambrose Taylor**

which had occurred overtime, but they've kept those objects because they mean something to them. The archives at Imperial College lent US scientific instruments and engineering tools, which reflected the craft and precision of the maker. So we had objects with historical value and social history value. We also showed research objects where we have worked with museums and art galleries.

**00:02:32 Ambrose Taylor**

For example, oriental lacquer that's been affected by light and relative humidity variations to give a cracked surface. Visitors could compare that with pristine lacquer.

**00:02:42 Ambrose Taylor**

And we could talk about how we accelerate aging to produce a surface that looks like it's had hundreds of years of light and damage, but that we can produce in months. This allows us to test consolidants to bind that cracked surface together and prevent pieces of the decoration being lost. The exhibit showcased the work going on across Imperial College to understand the degradation processes which occur overtime, to evaluate conservation treatments and to predict the future behaviour of both objects and those treatments. Visitors really connected with the work, because everyone has a favorite object that is dirty or cracked, and that strong engagement with the public was reflected by in-depth conversations about what being a custodian of an object means and how conservation matters. I will highlight another example of the work that's going on with the network. Consider 3D printing. It's a very useful and versatile tool for sculptors and artists.

**00:03:52 Ambrose Taylor**

And the museums use it as well for making display stands for objects. But there is a question over polymer choice. You can 3D print with many different polymers.

**00:04:06 Ambrose Taylor**

And sculptors are asking the museums which of the commercially available polymers they should choose to ensure the greatest longevity of their sculptures. The museums are not sure, so we're starting to work with conservators and curators to identify tests and recommend the best polymers to use for works of art.

**00:04:29 Michael Cornish**

Where does the funding come from and what is the project target?

**00:04:33 Ambrose Taylor**

The funding comes from the research councils, the EPSRC, the HRC and charities. There is also some funding from heritage organisations. In general, the work we do is not industrially funded because a company will not sell lots of a product intended for conservation, what we're doing is preserving objects for future generations. So the actual amount of material a company might sell or produce is actually relatively small, so hence industrial funding is not particularly relevant here. Why we work in cultural heritage is that cultural heritage is very valuable to the UK in economic terms due to the tourism it generates. Visitors spend millions of pounds in the UK and one of the biggest draws is the history and cultural heritage that is displayed in museums,

**00:05:35 Ambrose Taylor**

galleries and historic houses. Our work is aimed at future generations. It's to allow people to experience and enjoy the cultural heritage of the past and of the present as well. Because art is being produced all the time. Contemporary art uses contemporary materials.

**00:05:55 Ambrose Taylor**

Multi material artworks may mix plastic, rubber, metals, etc.

**00:06:02 Ambrose Taylor**

And instinctively, you know that plastics will degrade as they get old, rubber goes hard or become soft and sticky plastics go brittle and crack or transparent plastics go cloudy. And that can happen over relatively short periods of time.

**00:06:21 Ambrose Taylor**

But if we want future generations to see these objects, we need to understand how and why they are degrading. Then we need to do something to reduce the rate at which that damage happens, and ideally stop that damage occurring. That's where science engineering can help to understand what is happening and help conservators choose how to conserve those objects.

**00:06:48 Michael Cornish**

How does this research fit into sustainability?

**00:06:50 Ambrose Taylor**

If you go to a museum, you'll see many beautiful objects and many cultures, some old, some modern but all of them

**00:06:58 Ambrose Taylor**

handmade and unique. But even mass produced objects are a snapshot of cultural heritage which need collecting and hence need preserving.

**00:07:08 Ambrose Taylor**

Cultural heritage is something that is very difficult to replace. A replica can never have the same impact as the original. Conserving that originality has great value. We go to museums because we want to look at the real thing. Picture in a book or an image on the Internet. Even a 3D scan can never quite capture the essence of that object. So if objects degrade then they can become too fragile to display.

**00:07:37 Ambrose Taylor**

And that is a great loss to museum visitors and to our collective history. Part of conservation is to control the environment that a work of art is exhibited in. We don't want all of our cultural heritage locked away in glass boxes, we don't want to simply store objects away for future generations.

**00:07:58 Ambrose Taylor**

Our generation wants to see those objects, to enjoy them and learn from them.

**00:08:04 Ambrose Taylor**

If you take an example, if we take a painting in a house, it's displayed on a wall. It's exposed to variations in temperature,

**00:08:16 Ambrose Taylor**

variations in relative humidity, often exposed to direct sunlight, and we can choose to ignore the factors that make it dirty. Smoke from fires, cigarettes, nicotine dust.

**00:08:31 Ambrose Taylor**

Those can be cleaned off, which is a separate consideration, but those temperature and relative humidity variations can be severe.

**00:08:40 Ambrose Taylor**

That can affect the integrity of the painting, causing cracking and eventually loss of the paint that makes up the image. That means that object loses its value, is able to teach us less. So if we consider the environment in a house that might be unheated for some of the time, for example, in winter when it's unoccupied,

**00:09:02 Ambrose Taylor**

it can get very hot in summer.

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The relative humidity may vary from very wet to very dry. Those changes cause expansion and contraction.

**00:09:13 Ambrose Taylor**

Especially of a wooden panel, a sheet wood.

**00:09:17 Ambrose Taylor**

There will be differences in expansion and contraction. Due to the wood grain, that movement causes damage and that causes cracks.

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Our house is a relatively uncontrolled environment, but museums and galleries have temperature and relative humidity control.

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The temperature and relative humidity control are kept within a narrow band to minimise damage to the objects there. There is an underlying annual variation, but on a day-to-day basis they're fighting against the weather.

**00:09:53 Ambrose Taylor**

Hot and dry or cold and wet days.

**00:09:56 Ambrose Taylor**

And the presence of visitors on a wet day will increase relative humidity, your wet clothing, and they also increase temperature. And what happens? It takes a lot of energy to maintain those ideal conditions for that museum. That exhibition for sustainability, what we need to do is try and reduce the amount of energy we need to keep some sort of control. But we need to reduce the overall energy demand.

**00:10:27 Ambrose Taylor**

There's a need for energy saving on both cost and environmental grounds. So the question then comes, what is a safe range of temperature and relative humidity and how quickly do you need to respond to any changes in relative humidity by visitors coming in, say?

**00:10:43 Ambrose Taylor**

And those factors make a big difference to energy consumption and hence sustainability. What we're trying to do is to predict when damage will occur to an object, and how fast that damage will grow?

**00:10:57 Ambrose Taylor**

And hence what are the safe conditions that it can be displayed in to minimize energy use.

**00:11:05 Michael Cornish**

How do Mechanical Engineers contribute to this project? Can you give any specific examples?

**00:11:11 Ambrose Taylor**

What we as Mechanical Engineers are doing is trying to understand how objects respond to environments.

**00:11:18 Ambrose Taylor**

The stresses and strains can cause damage and fracture.

**00:11:24 Ambrose Taylor**

And we conserve objects to prevent a loss of their value. For example, if we look at an object, be it a piece of Oriental lacquer, furniture or a painting, what we have is something that has a detailed image on the surface, for example, that might be characters in a landscape or a portrait. Overtime sunlight variations in relative humidity cause expansion and contraction of the surface and so cracks are made.

**00:11:54 Ambrose Taylor**

Well, if you go to a museum and look at objects, you'll see those cracks, but they tend to be fine, narrow cracks and they don't detract from that glorious image that the artist intended. However, if we allow those cracks to grow, they'll widen, they will deepen, and that surface will start to flake off.

**00:12:14 Ambrose Taylor**

If we start to lose sections of that surface, we lose the artist's hand. We lose their work, and we start to get holes.

**00:12:23 Ambrose Taylor**

So we need to understand what causes the damage and how to maintain it without repainting. We want to conserve what's there, not replace it, and you can think of it like this. If you think of a layer of paint on a backing material, for example fabric, if you stretch that backing, instinctively you know that the paint, which is relatively stiff and fragile, is going to crack. Bits will fall off, and that's what's happening with these objects. So the aim is to consolidate to reinforce the surface and prevent the widening of cracks and the losses.

**00:13:04 Ambrose Taylor**

It can be argued that working with cultural heritage is more difficult than working with industry. Industry might want the highest properties for a particular material. They might want the highest toughness.

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For example, if an adhesive doesn't fail, then perhaps that is the problem solved. For cultural heritage,

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if the material you use is too tough, then what happens is the original object will fail before that repair material you have used. So you want to reinforce the object but not do too much, so that actually that repair material

**00:13:47 Ambrose Taylor**

you've used is the one that fails, if the object sees those high stresses again, whatever you use, whatever material you use that needs to be inert, it has to not damage the object and the treatment needs to be reversible, so that future generations can undo what has been done. So it becomes a very challenging and very interesting problem.

**00:14:11 Michael Cornish**

Are there any other specific details of how you think the creation and display of art into the future might change?

**00:14:19 Ambrose Taylor**

Perhaps one of the major changes is that visitors are going to be encouraged to handle objects now, not necessarily objects themselves, but replicas of those objects we can readily manufacture via 3D printing and other processes. A copy of a particular object so that an object can be handled. That replica can be handled because actually

**00:14:45 Ambrose Taylor**

many objects were originally designed to be used to be handled. They're quite tactile objects, and when a work of art is in a glass case,

**00:14:56 Ambrose Taylor**

that tactile sensation is lost. Other work that's been going on at Imperial College has been to look at how we can add to the displays in museums, art galleries, etcetera, using interactive exhibits, for example, digital technology and sound to help give the visitor an impression of the environment that those objects were originally intended for,

**00:15:24 Ambrose Taylor**

and how the original purchaser or the original user would interact with those objects to create a greater context for those objects.

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Some of the other work that's been going on at Imperial College has been to help the museums look at what's happening underneath the surface of a painting, for example, because, of course, an artist, when they make a painting, prepare the canvas, there'll be an underdrawing. And then as they paint that painting, there will be changes.

**00:15:57 Ambrose Taylor**

Right, the work of art will evolve and using X-rays and other techniques, museums can image what's happening underneath that finished surface. But because you've got multiple layers, it can be very hard to extract the information from just one layer because the images are all effectively overlaid.

**00:16:21 Ambrose Taylor**

So there's been work going on at Imperial, using artificial intelligence to analyse those images and work out which parts of the image correspond to which step in that process of making that work of art, which can give curators a real insight into how the artist worked and how they evolved from their initial sketch to go to that final finished piece of art.

**00:16:52 Michael Cornish**

Well, Ambrose, thank you very much for coming in to speak with us today. We are very excited to see where this research leads in the future.