INTELLIGENT ARCHITECTURE

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Part 1

Well, thank you very much for that introduction and welcome to you all to come here, to the University of Reading. We're very proud of our very rich, diverse student culture and I won't have time to talk to you all this morning, but on our way round the world in my lecture we will make some points about aspects of particular countries and there may be some of you that can add to what I say. On that last point on music, is anybody from China here? I am sure there are. Well, I'm off to Beijing on Saturday, but one of my last trips to China I was presented with a Chinese musical instrument called a *erhu*, but I can't find anyone even in London where I live, to teach me this, so if any of you Chinese people has some contacts either in Reading or London that know about the *erhu*, please let me know. Now I've got to move quite quickly this morning because you have a very busy programme and it sounds very exciting.

Intelligent Architecture - architecture is the art and science of building and of course it's very old and all of our civilizations, countries all over the world have particular things - we think about those countries in terms of their buildings and architecture. Buildings are important because surprisingly we spend 90% on average of our time in our lives in buildings, it's a lot, a lot. So obviously their impact on us on the inside of the building is very important. So, why 'intelligent?' Well as we will see in a moment, it's not a new thing intelligent buildings. They have been with us for centuries. But we do have quite a lot of cheap, bad building around as well. So how do you make a building intelligent? Basically we define that very simply by buildings that respond to the needs of the people within them. So our talk is going to start – we'll have the lights down now - by looking at the climates round the world. Because climate - could we take the lights down please? Thank you. Because climate obviously has a big impact on shaping peoples ideas about first of all about what they need and how we have buildings. So around the world here we see start from the cold regions, the ice caps, the tundras, mountains, continental climate, Mediterranean, sub tropical, the rain forest Savannah, steppes, deserts. When you think of those different areas around the world, those sorts of characteristics you immediately come to mind different things, they could be tents, they could be mud huts, or whatever.

And there we can see, you can pick out your places around the world and these different colours give you the different types, the cooler regions in the blues, the very light regions, the deserts and the forest regions in the deep greens. And you can see your patch on that map. And of course for centuries people around the world have shaped their buildings and architecture mainly governed by the climate that they actually live in. So, intelligent buildings, we basically want to know what is happening inside, immediately outside, you've got to know what the conditions are, what sort of work you are doing for example, and then you've got to decide the most efficient way of providing convenience, comfort, and also

the fact that the environment around you actually has an impact on your efficiency of working. So, you know how hot it is, how light it is, and so on, affects a degree - affecting us in a work situation. We are finding that increasingly, I've got a big program of research in this area. And of course, you want buildings and environments that will respond to your needs because over the course of a day, from morning to night, the time when you're sleeping your physiological system is changing, your emotional system is changing, we all have these diurnal rhythms. We need the environment to have some adjustment around those. Now, when we start thinking of buildings the human system is very interesting, and here we see the human skin is a very good model for how buildings should behave because the skin protects us when it's damaged – it's self-healing.

Part 2

OK? it protects us from moisture, it protects us from dirt, and so on. And of course the skin is very complex you get hair-cells, and inside the skin the fat cells which nourish the skin, and so on. And this is like a very simple way of thinking of the analogy between a building skin. We call this building fabric sometimes building skin - the skin of the building that's protecting the people inside from the external environment. So the human skin is a good starting point for thinking about what we want to do. The other thing is how do we deal with information, and the main thing is the human brain, very complex, different areas of the brain respond more sensitively to one thing than another, but we live through our senses. And our main senses are what we see, what we hear what we smell what we taste, what we touch, the five main senses. And so in a way, the buildings have got to provide the stimulus for us to actually respond to. If it's a boring environment you get bored and you get restless, you lose concentration.

So, to be happy, at this end of the scale, you want to have environments that are stimulating around us. Environments that are not stimulating make us glum, unhappy, not such a good mood. And we all have our experiences of those things. You've been in buildings which are dreadful, you've been in a buildings that are stimulating and you enjoy being in. And obviously if you are in an environment you enjoy being in, it puts you in a better mood to do your work and your studies. Now something else about consumption; we hear a lot about sustainability. Sustainability is controlling pollution, decreasing water consumption, decreasing energy consumption and also controlling waste. But as human beings, as soon as we are born we start producing waste. We put demands, we demand an environment to keep ourselves sufficiently hot or cool, and so each of us carry round a profile, a sustainability profile. When we look at how we can make a better world, and that means balancing the resources with the population we have, remembering the population of the world at the moment is about 6 billion, by 2050 it's going to be something like 9 or 10 billion. It's going to be a more taxing thing on the finite resources of the earth. When we start looking at consumption in buildings, we have actually measured buildings. The same kind of building, the same kind of use, in the same kind of situation, you know the difference in energy can be as high as 6 to 1, 6 to 1 difference – why, why 6 to 1 in very similar situations? You can insulate it very well, you can get it down to 3 to 1 but it's still a very big difference. An when you start

examining how people use things we see it's not the technical sides which is so important, as the lifestyles and the behaviour patterns of us individuals.

Some of us are tidy, some of us are untidy, some are very disciplined some people are not so disciplined and this reflects in things like energy and so on. So even if your architecture is intelligent and good, it also demands us as individuals to be responsive and responsible to these things. Now this is getting increasingly important and one of my research projects is about how we can use embedded technology in buildings to help you to save money in your home, and your offices, and at the same time be more conservative with the use of energy and water.

So the point of this slide is simply to show you that when you cost a building and this is an attitude, some of you are going to do international business I heard a few minutes ago, economics – we must get out of this idea of when you buy something, somebody says oh it's expensive. You have to look at the lifetime cost of buildings. In buildings the design and construction over the lifetime of the building is only 2 and a half % of the cost, maintenance about 4 and a half. The biggest costs of running the building are the people. So this university for example with all its buildings, we have about 15,000 students, we have about 4,000 staff so we have almost got a population approaching 20,000 here and it's that 20,000 people multiplied up by – well let's give you a salary, let's say that students have salaries, reckon up 20,000 salaries - that far exceeds all the building costs of the university. And it's the same in offices, so remember this point, it's people inside buildings and their salaries which are the big cost. If you can show a client that your better intelligent architecture can help you to save money by them performing better, you've got a very good case for being more sustainable, healthier buildings and also saving money.

Part 3

So let's now start looking round the world. We start at the Poles with igloos. And you can see here a gentleman with his igloo and we have all got a picture I am sure of what igloos look like, its rounded form to soften the flow of the winds, the very thick ice slabs that are made up, and you can see inside the igloo the animal skins put around to give a bit of insulation. The people sit on ledges high up and round and only a heating stove here is the only form of heat. So they rely on that little stove and lots of clothing to actually keep themselves protected. When we look at the performance of an igloo, you can see in terms of temperature here, this is the temperature in degrees Fahrenheit. And this is the time in a typical day, the weather temperature -10 to -30 and the temperature inside the igloo 27 to 39 depending on the height in the igloo. So you can see the impact of the igloo, the ice blocks there, no heating is to cause this actual warmth. Now if you live in conditions like this, these temperatures which to us here would be cold, in that situation, feel comparatively comfortable. So, we adjust our comfort levels according to our local environment, and the impact of the igloo is that.

We call this passive environmental control. Just the building itself, just the materials have an impact on temperature inside. If we now go to a hot region, here is an Indian house, in the American Southwest, mud hut here kind of thing. We can see again this time the temperature is still in degrees Fahrenheit, and you

can see a peak temperature there on the roof surface of 140. Ok? Outside air temperature 105, and inside the mud hut 75 also to 85 degrees. So, the impact of the construction of the mud hut has had this tremendous damping affect on the outside temperature and given a relatively comfortable band inside. So, what we make things of, how we shape them, has an impact on our environment.

Ah now we are going to the Mediterranean, I have spoken to some people from Cyprus and Greece already. And this is fairly typical in the Mediterranean regions, of fairly heavy construction. White surfaces, lots of over-ledges where there is shade, and you can see the seat here where somebody can come out, be outside, but be in the shade where it is much cooler of course than being directly in the sun. And it's these simple things that have guided architecture through the ages as opposed to the modern day, this is a factory where they produce CDs in South Wales and you can see the big feature here is a lot of glass. And glass of course, the inside the temperature goes up and down very quickly with outside, so you need lots of air conditioning. So all this is air conditioned. So, this is an example of an active environmental control system. Active environmental control where you use lots of mechanical, air conditioning, and so on. Now of course when you have these systems in they consume a lot of energy, so we really want to see how far we can stretch using the passive solution, the material solution, compared to using these kinds of systems.

So the pattern is, that across day and night – in the daytime we're hotter in the night time, we're cooler and we have various degrees of controlling for our conditions, from the natural conditions here to the microclimate around the building the structure, the actual materials and then finally the mechanical controls, the ventilation and the air conditioning. What we are aiming to do is to minimise the use of these. And rather do more round here – and that the first main ingredient of intelligent architecture.

Now go to Turkey – anybody from Turkey here? No, nobody from Turkey, has anybody been to Turkey? Oh somebody from Turkey – which part of Turkey? Oh you went to Turkey. Did you go to Cappodocia? In the middle? No, well Cappadocia, those who have not been, it's a fascinating place because you get all these natural volcanic forms, *tufa* as they say in Turkey. We talk about Goroma, one of these places, it is one of the main places where you can see these places where people can still live inside the volcanic structure. They did that centuries ago and kept very, very cool.

Part 4

And here's a dramatic example of a fortress up at the top here, which was turned into a monastery in the 7th century and there the monks feel very cool and refreshed. It's a natural formation from the volcanic structure.

Here are some examples from China, Quianlong in China, underground cave villages. Are you aware of those? And over here the burial grounds in Siwar in Egypt – anyone from Egypt? Egypt, nobody. Anybody been to Egypt? Right, but you haven't seen the burial grounds? Again, its ingenuity – how people have used their imagination to control and have a comfortable existence. Now some people in parts of Africa – there are certain types of baobab tree. There are many types of

baobab tree, and it has been known that people have lived in trees, not only animals but people. There are many types of baobab tree and they don't all – there are some more examples there.

Now back to Cappadocia and you can see this gentleman here living inside this structure, with his television set, electricity and he's very happy with his way of life. One of the chapels built in the volcanic formations, it could just be like going to Italy and going into the beautiful old fresco buildings, or in Greece you have these as well. But this is inside this volcanic structure which is really very beautiful. And gives us evidence of course that people really were using these places to live in. And if you go to Turkey you can book yourself into a hotel in one of these places, so remember more interesting.

Now – animals. Part of my own school, we have a department called Biomimetics and biomimetics think of the word bio-mimetics, bio-mimicry – it's the imitation of nature. Plants and animals. Now I can only show you a little bit here but they have a lot we can learn from. We might be looking at spider's webs, here in close-ups, we might be looking at living cells, but they can tell us a lot about structure and about efficiency of construction. Here's two types of spiders, this one and this one. I am not a spider expert but immediately you can see from their webs, here, that they are very much like buildings. They're very much like tents, tent-like structures and the thing about animals is they automatically seem to know how to build things economically, with the minimum stress. So remember animals and plants – we can learn a lot from.

Here are the weaver birds in South Africa, anyone here from South Africa? Wasps. Nests. And see the development here of this primeval house, this woven house in Africa, and look that's been developed aesthetically into this rather beautiful house here. It gives the shade, protection and so on. Now we were going to look at the ants, termites. There are many kinds of ants but we will concentrate on the termites, and there are many kinds of termites. The termites are really very interesting and you would be surprised to know that we even have a British Termite Society even though we don't have many termites here. There is always a society for something.

Now look at this – anybody from Australia? Yes. You recognise these. Well can you tell us what the distinctive thing is in this picture here. Yes, that's right, you are both saying the point. They're all facing the same direction, see, and if you look at the temperature curve here – I get all this data from the University of Cambridge, there is a lady professor there who specializes in termites. And she gave me this data, and you can see in this direction here you get the lowest temperature. So the termite has evolved to give themselves the most comfortable conditions. Now that's the Compass termite, but there are these others. Anyone from Tanzania? No.

Part 5

Here we go to a very popular one. This particular termite here, if you look at a cross-section of the termitery you can see the termites are here and they generate a lot of heat. Heat rises, hot air rises, comes down, loses heat with the outside, cools down, comes down again. So it develops a natural circulation, natural

ventilation, air conditioning system to keep itself reasonably comfortable. There's another example there. I think that's a particularly beautiful one.

So back to humans, and we've talked about fairly heavy weight buildings in the Mediterranean and the North Pole, but of course there are many nomadic tribes. Anybody from the Sahara? No – less likely but it is a possibility. Well, tents of course for nomadic tribes are necessary because they move around. They herd and they have to go to different places through the year, that's the way they live. So they have to have structures that they can take up and down very easily, and also keep them in a sensible material that protects them. This goats material which expands when it gets wet so it doesn't let the moisture in, and at the same time gives the shade and goes down, dilates, when it's not raining and lets little airflow patterns go through the structure. So the structures are really lovely.

Anybody from Sudan? We do have students from Sudan, yes, I had one two years ago. Now Mongolia – anybody from Mongolia? Well Mongolia is interesting and I have just updated my lecture from last year because I got some books with more pictures of the *gers*, yurts or *gers*, and you see they're very well insulated. Here you can see very tightly closed doors and if we look back at the pictures of the Mongolian landscape – there we are. 80% of people in Mongolia live in *gers,* and of course they are great horse riders, camels and so on. While you are here, if you have not seen the film 'The Story of the Weeping Camel', if you've not heard of that yet, do go and see it. It's a wonderful film, fascinating, I won't tell you all the story but if you see that advertised – 'The Story of the Weeping Camel' I do advise you to go and see it. It takes place in Mongolia and it is fascinating.

You see, living inside there, with the television inside the *ger.* Of course transportation of these things is important and you can see this is a really royal one, and this is Genghis Khan's coronation in 1206, and you can see Genghis Khan here, and this is a very beautiful *ger* where he is receiving all of the people to celebrate. So *gers* aren't just for poor people, *gers* are the architecture of Mongolia for all people, and they have these simple things, good insulation, good ventilation and compact space. And it works very well for them.

Now the challenge in the present century, and last century, in the 20th century, was how we could use and develop this architecture and the thing that has helped us to do that is the advancement in materials, new materials. Now this is the Arctic City of 1952 designed by Ralph Erskine and Frei Otto. Ralph Erskine died recently in London, he was from Sweden originally. Frei Otto is still alive in Frankfurt in Germany – anybody from Germany here? No. I've had the good fortune of working with Frei Otto at odd times. Their idea was 'how could we make a city in the Arctic comfortable?' and you can see their idea was to actually build normal buildings into the ground, and then put a lightweight cover over which you could see through. That was the principle of the idea. But at that time in 1952, these materials weren't advanced enough, they couldn't withstand the snow loading, the wind, they still weren't strong enough.

Part 6

So in 1982 I had the good fortune to work with Frei Otto in Canada, anybody from Canada? No. This is the Athabaska River and it's -30, -40 in winter, pretty cold and in fact they use the river as a roadway in winter, because the ice is so thick. So this is a very cold region, and people if they get a job in the region, their families often didn't want to go, because of the weather conditions, so we thought about how we could use the Arctic City idea, but now we actually had materials where we could do it. So this is a chlorofluorine material, a lightweight material that you can see through, and it's something like 60 metres high, its 35 hectares and it houses 10,000 people in normal buildings. What happens is, of course, this material is very strong. If you take a knife and try and put through it, it won't do it, you can't cut through it. It's very strong indeed and the wind is good, takes the snow loading and so on. The temperature in here, -30 outside, 0 degrees in here, and then normal buildings here. So we can actually produce a sort of European climate there called the mesoclimate there, the Artic climate here, the Canadian climate outside there but the 0 degrees here European, people can live and work there, 10,000 people at a time.

There's an idea we had for a tent city. Tents are very interesting because you can actually roll the material up and on a winter's night you can roll them down, keep protected, keep the light out, keep it all very cosy. In the summer day you can roll it up, let the light in, let the air in and so on, very fresh. So tent cities are really quite an interesting idea, tents are structures as we call them.

And then, we move from Canada, we went to Saudi Arabia, anybody from Saudi Arabia? Ah, right. Diplomatic club? Riyadh? Yes OK. So, ah you recognize this kind of picture? Now, this snaking building here, with these materials, these lightweight materials around the outside, of course Saudi Arabia gets very hot, over 50 degrees in the summer and near desert regions, very dry, sandstorms and all sorts of things. A very testing climate. And of course the old idea we have of people travelling on camels, and coming to an oasis is sort of in our mind. It was the thought that this could be a kind of oasis, that was the kind of idea.

We looked at the plan of this, the idea was that we would build this wall, very thick, of stone from this region, and around it we would have lightweight structures where they would have banquets and entertainment and greet people and so on. So people could do the work, and actually concentrate in the cool part which was air-conditioned as well. And then, have their banquets and so on in the round parts. Nice combination of heavyweight material and lightweight material.

There is inside the diplomatic quarters. And this leads us to the idea, that of course you can tune buildings. You can choose materials to be opaque not letting light in, to be transparent to light like glass or translucent like this, about 10% translucent, to let some light in. And the degree of light you have in a space psychologically is extremely important.

Now just a quick survey of some nice jobs, projects that were done mainly by Frei Otto and some of his German colleagues. This is the pavilion at the World Fair 1967. That's '71, Cologne. That's the Pink Floyd Festival, 1978. And here we have the prophet's Holy Mosque in Medina. If you keep your eye on that bit a

moment, supporting the structure here just keep on that. If you look at the next picture you can see this is very, very beautiful - and you can see that the lighting and the air has been built into the column, lighting here, and the air coming through the column. So the lighting and that is all part of that support system for the tent. That's what we call integrated design. How we use parts of the structure to do more than one function to actually deliver air, to control the lighting as well as support the system.

Part 7

So we now move to Pakistan, any people from Pakistan? No, right, not this time. This is Hydrabad, and what do you notice here? You notice all these shapes, these are what we call wind towers or bagis and they work like this. The heat of the day heats up the feature here, the chimney, as it were, the wind scoop, the tower, and the warmth comes through, heats up the air, so the air goes up like that. At night, clear night skies, it's very cold, all this cools down the air becomes heavier, and it goes down like that. So you've got a natural ventilation system, and these things are very common in Dubai. Anybody from Dubai? In Persia, or Iran I should say, anybody from Iran? Have you seen this kind of feature in Iran. I've got some pictures here from Iran somewhere – there we are. This is the ice house at Kirmun, have you seen that? Yes, they're very beautiful aren't they? Very old, but that's the point. That when we say air-conditioning of buildings or refrigeration, it goes back a long way. Often people say – ah, it was at the end of the 19th century in America, and it started then. But it started way before then.

So these things work in a very simple way, there we are – these chimneys either sid, give these ventilation effects, this goes over the water here or the food supplies, and cools them down by convection over and you get quite cool water. So the essence of air-conditioning and refrigeration has been with us for centuries. There's another example in Yatz Same idea.

Now Syria. Anybody from Syria? Damascus? No, well these buildings in Damascus here, see how close they were together. This wasn't an accident it was partly to actually let the buildings shade each other. In Morocco, Marrakesh, you can see this market place or souk here, and of course the market you do buy things, but it's also a social place where you to meet your friends and so on as well. But of course it's very hot in Morocco, in Marrakesh and you can see this simple rafter roof, it just gives enough shade here for these people to stop and talk and be quite comfortable which they couldn't do when they were outside. You can see the planners in the town have thought about these things. Water and greenery. When we see green things we feel a bit fresher. When we see water, or hear water, if it's moving water as well, it is also refreshing. So sometimes you see things which make you feel, even though you've not gone into the water, you still feel better. There is another shady area in Marrakesh and Hassan Fathy there, an architect who died a few years ago was responsible, an Egyptian architect, who did a lot of very interesting architecture and beautiful things.

Just one or two more pictures which are very old. This is from Dubai, and Oman, and you can see these facades of buildings. And what I would like to point out to you here is these holes in the building, they have a purpose. They are there to let the air come through, but how beautiful they are. Different patterns like a mosaic

in the wall. So you can combine function – letting the air in - with beauty, with aesthetics. So we must always remember that although we're doing very practical things in building architecture buildings we can still have something very beautiful. In this case here this is from the Ivory Coast, but there are many examples of these *mashrabia* constructions, and there were also social influences. In many of these countries women were not allowed to go public. They were usually kept behind the scene a bit, and this was a way that women could look out, people couldn't see them looking out, and they could look out and feel comfortable from men gazing in, besides the air and so on. It may be unthinkable but it's still, I think in certain countries around the world we see now when we are talking about cultures around the world today very much more in a global environment, there are still very big differences in how women are treated around the world and the architecture was again used in a way, to enforce certain things in a particular culture. Very nice and comfortable there – coffee space. This is Hassan Fathy's architecture.

Part 8

Now I'd like to say something a little bit about the light in buildings, and light is important, daylight, we can't, we've got no light in this space, you're only here for an hour, so it probably doesn't matter too much. But if when you are working in normal job or living at home, lots of light. You like to see the view, and also the colour. Now this is actually reflecting some paintings by an English painter, Turner, called an Impressionist, and if you mist your eyes slightly, what Turner managed to do, was to actually show the diffusion of light in the atmosphere. This is a train, one of the early rocket trains, from about 1836, coming down the railway here, and steam coming out into the atmosphere. It's also raining, and of course all of these factors give you this kind of misty haze. How he did this, people don't know, it's what we call Impressionist painting. Impressionist painting very common in France, Spain, Italy at this time. He was our only English painter that did this to this degree. Impressionist painting is about how you sense the things around you, you know, things which aren't objects like, you know, that's the piano, that's the table, things which were mists and hazes and so on.

Now it's very difficult to put a science, reasoning behind this but there were many attempts to do so. And you can see that in the painting schools, this is the Dutch school, Dutch painting, the window was very important. Letting in the light - and the window in buildings, we have a very large research project on this, of how we can design different envelopes of the buildings which are responsive to daylight, sound, air, protecting from the sun, giving nice views and vision outside. So, this part of the building has lots of different things, connection with the outside world. Your sense of time, the light changes through the day. All of these things are important factors that affect. And in modern buildings, the window positions are actually prime positions, people say, oh can I go and sit near the window area, not right in the centre part of the building. They want to look out in sum. So - windows very important. In history.

And the use of space, this is a painting by Stainbech again from the Dutch school, and it shows the people here coming through, these people having a discussion. This space is organized so that you know some dark spaces where it's very

private, open daylight spaces, which are very public, and so we think of space in these different ways. Private space, semi-public space, social space, and very public space. And usually the light has an important part to play - but also how you shape spaces through there.

Now, anybody from France? Yes, you know this building? Have you been there? You haven't been there, ok. Nice to have someone from France. Le Corbusier was actually a Swiss architect, he did work a lot of the time in France, and he was French-speaking of course, and he built this chapel in Ronchamp in Eastern France in about 1950, 50-ish. What do you notice about these pictures? Anything particular? Any characteristic that strikes you? Well, look at the windows, all different shapes. Narrow, horizontal, vertical, squarish, rectangular and so on, all different shapes. So, what on earth was he thinking about? Well a church is for what? For praying, sanctity, peace. You want a nice, a special nice space in there. And the light he produced is there. This is kind of not the best picture I'm afraid, but I think you can see, get the impression, this is really lovely, and you can see the light guided through these windows, beautifully done, this is particular example of very sensitive use of light, and that's done by, tuning the windows, these openings here, have been thought about extremely carefully. That is another example of intelligent architecture, and here's a more modern one, anybody from Denmark? 1976 from this church by Utzon, Utzon was the architect who designed the Sydney Opera House, and you can see that the light coming in - you can't see the window - it's let in very discretely to give this sort of almost up-in heaven type of feeling and this rather relaxed, quiet spiritual environment below. So, this is part of matching the requirement of a building, a church in this case, with designing that architecture to be responsive to that particular need, people in church praying and so on.

Part 9

Now John Tindall addressed the British Association in 1856 and we talked about old things and new things. And 'lightpipes' is used in modern terminology, modern technology but in fact he spoke about them in 1856. He had this idea of using mirrors to guide the light through the building. And this is done fairly commonly today. This is a 'light scoop' which takes in light, and goes into the building and down again. Indirect, instead of just beaming straight in it actually gets deflected into the building in a pathway. Here is the light scoop for … anybody going to take a guess? Didn't take long for the guess. Yes, the light scoop for the Hong Kong Shanghai Bank in Hong Kong. I saw this building at the 23rd level when I was there, but I'm going again in November so hopefully I will see the complete thing.

Sound – I won't spend a lot of time on this. The same argument is about sound – how we listen to things. Now the critical thing here, speech of course. Speech is a bit easier, music very difficult. Composers like Wagner designed opera houses to shape the sound in the space much better and people in the later times, the last century, 1952 was the Berlin Philharmonic Concert Hall. Anyone from Berlin? Germany? No. Well, the Berlin Philharmonic Orchestra here, a world famous orchestra and wonderful surroundings for bouncing the sound around. So just like taking light into the building, how do you distribute the sound? This is the sound source, how you bounce it round the building again depends on the shape

of the building, it depends on the materials. In concert halls wood, plaster, are very important. The same principle.

The Centre Pompidou in Paris was notable, because in 1976 this was, this building, ah, notable for putting the structure, the pipes, the services on the outside of the building. Before we used to disguise them, hide them. This was saying 'why hide them? You can use this as part of your architectural expression.

There was the site in Paris for the new Institute for Research, co-ordination, acoustics and music and I show you this because it led to the design of music spaces which are rather different. This open space where you don't have recognised seating, you take your own cushion or box or something, and you can alter the size of the space and you can alter the texture of the walls. These can be actually tuned. As you can see here, you can turn these elements round and they can either be soft and absorb the sound, or they can be hard, and reflect the sound. We have a friend from France – do you like the building? You like it? Yes. It has created a great social life around Centre Fauborg hasn't it? A lot of activities going on, people visiting and so on.

So now to the last part of the lecture some innovations – the use of glass to actually direct sound into buildings. You can see this glass here as got all these little shapes inside which help you to select the sunlight which you need, and the sunlight that you don't need. When it's in summer it closes off, when it's in winter it lets more light in. These windows here let the air move through the glass. They are pieces of glass like this, but instead of the air just being static the air actually moves though. By doing that you actually save an enormous amount of energy, and that really is very important.

Likewise this floor system also saves energy. You don't have any heating or cooling. You take outside air, run it round the building, and you tune the mass of the building and the air supply to cover most of your environmental conditions. If it got very cold, or very hot, you could then put a bit of heating in but most of the year these buildings run on their own; they are actually fully passive buildings. There's an example of the floor.

Types of glass – all sorts of glass. Glass is getting quite complex. You can put things in the middle of the glass to increase reflection, you can have elements, you can have electrical glass, electro-chromic glass, alter the voltage and you can alter the transparency across the glass.

Part 10

And you can have glass you can see from here the heat value, the heat loss value here is very low for some glass, used to be up here. By selecting your glass carefully, you can actually not lose very much heat. So, glass buildings are ok. And the Digital Age. We now have very complex building management systems in buildings to control all areas of the building. Touch sensors, so that you, as individuals, can have something by the side of your desk, and you can register your mood, your expression, your satisfaction, as you go through the day. And we, that data is very important for us to understand and follow.

Understanding convection around the body and using infra-red thermography to actually see exactly how things are heated, what's losing heat, what's gaining heat, and so on. So our case study is now quickly through, Frankfurt, the commercial bank, which uses a lot of the ideas I've spoken about this morning, very high building, not the highest building. The highest building is in Taipei, the Building 101, 2003 at the moment, but there will be another one higher than that soon I'm sure. And again using natural ventilation in the building and only using heating and cooling in extreme conditions. Again, planned use of materials, use of plants, all very important. The Debis Building, Berlin, similar approach, lot of glass, see the glass. The advantages of the glass is, it's very flexible, you can do a lot with it and it lets in the light, and people like daylight in the buildings, that's the big advantage.

And you can see, when you are designing the outside of a building, there are lots of aspects to consider there, in terms of altering the facade to protect, to shade, fire control and all sorts of things, safety - and now terrorism even. Reflective glass panels there to give light to the building. Now over to Holland, in Utrecht. This is an old building, refaced using a new facade and using what we call a double façade, so a very thick space, of which you could do all of your environmental control and get a nice comfortable environment inside. The same idea in this building in Germany, and in the Potsdam Plaza back in Berlin. That's another façade. That's back, so common. And there in Japan, anybody from Japan here? No, one person, do you know this place? No, no, right, well you could see that it was intended to be green, to give you the impression that this was a very natural green environment. An interesting idea, I haven't been to it, but this is the designer, the Atago Building.

And Florida in America, superstores with forests in between the glass, those plants are actually in the glass, and I think you all know where that is, Hong Kong. And the Shanghai Bank there, I haven't got the Bank of China, I'm afraid. This is some of the plant room for that building. And this is partly as the bank was being constructed. The air-conditioning in the floor, the facade of the building, and some of the options. When you are designing you have to consider many different possibilities for designing the building. Testing the air diffusers, all of those air diffusers for the air. That's the air system, and you can see this lady here sitting, the air coming up from here, but her dress is still in place, it's not been disturbed by the air from the floor.

City of London, this is the Lloyd's building, you can go and see this in Leaden Hall Street in London when you are here. And this is the where all the insurers come, all the shipping incidents around the world are registered here in this building. Very big atrium, you see, very busy. And each of the decks has a different insurance company. This is the façade of the building - I've used this for the cover of my book on intelligent buildings - different types of glass, external glazing system, triple layered solar glass, ventilated on the inside cavity to actually give a very nice controlled environment. Also, the services on the outside of the building again, giving this architectural expression. Inside the building, the people doing their work and you can see each of these desks has its own control system. Like this, each one has its own individual ventilation, its own lighting control, and so on, from there.

Part 11

I think we can miss those. And now back to Paris to, you know this building, the Institute du Monde Arabe, no? This is a nice building by Jean Nouvelle in 1987, and if we start looking in that building, you can just see Notre Dame over here, and you can see this interesting structure here, different on that side. This is on the south side. We look at the building. It looks like a sort of mosaic, and if you come closer into the building and closer, you see that this is open, that's closed. Each of these little irises here, act like the eye. They open and shut with photo electric cells, and you can control the lighting and heat gain in the building very nicely. That's at night.

And then, I think my last example is going to New Caledonia in the Pacific. I don't think there will be anybody from there, here today probably. And you can see these beautiful wooden structures here like this. And they protect the museum, this is the design of a museum. From the winds, and the tempestuous kind of weather that can occur sometimes in the region. And they have actually used iroko wood, structures here, which is slatted like this. And then behind these is the museum, you see a bit of the museum there, which comes in behind there. Very beautiful structures. So, this is combining passive control again, with minimum amount of active control. And there is the museum at night, lit up, protected by these structures. There is a cross section, there is the structure protecting the museum over here. And this means you can have practically natural ventilation most of the time, natural ventilation, no fans or that.

Those are, these are a few things that have happened mainly in Britain in the last few years. The Future Systems Building, the use of turbines mounted into the building structure. That is the 'Z' project for London with again turbine structures. This is the Phoenix Central Library in America, solar protection here, and this is the Houston Menell Collection, art collection, a beautiful shaped construction you can see how carefully it has been designed to control the sun but again aesthetics, nice aesthetic. And so, that's the last part and over the time that I have been speaking to you, I have spoken a lot about how we control systems, how we use materials, how we need to be sustainable. We need to keep the energy down, the water down, and how we can do the architecture. At the same time, meeting the requirements of us all as people. Thank you.