Presenter: **Associate Professor Pippa Conolly - *2018***

Title: What is engineering about? – People, design and the virtue of being unseen. (14:07)

Time	*Dialogue*
00:09	Hello there. My name's Pippa Conolly and I'm going to talk to you a little bit about my life as an engineer and some of the things I have done. First of all … what woke you up this morning? Was it your body clock? Was it an alarm clock or a more analogue version? Was it your smart phone or was it something like that? There you are. There's an engineer already, had an involvement in your daily life. You got an electronic engineer, electrical engineer, mechanical engineer, process engineer. All of them working away to make that little thing that wakes you up.
00:40	I'm an Associate Professor here at Monash and I'm involved in a number of different things including a lot of industry engagement work. Basic to my background is Civil Engineering. I'm currently involved in lecturing some Civil Engineering. So you've woken up. Got out of bed. You haven't fallen through the floor? Guess what a Structural Engineer has been making sure that you haven't fallen through the floor. Material Engineers have helped the Structural Engineer. Walk across the floor, perhaps go to the bathroom. Turn the light on … arh there's the Electrical Engineers, the Power Engineers.
01:09	You might go to the toilet. Waste water engineers. Probably not the most glamorous of engineering but absolutely one of the most fundamental. Turn the shower on. There's your hydraulic engineers. Had your shower, you are going to put some clothes on. You think "engineers?" What have engineers got to do with that? Production engineering, transport engineering. You have to get all those clothes to you. Ok you might have some breakfast. Open the fridge. Imagine where you would be without a fridge? So you got to that point and you're thinking, OK there are engineers all around.
01:37	Leave the house and there is even more. Environmental engineers, transport engineers, traffic engineers, public transport engineers, so they're everywhere. Now you probably have never met any of these people and you don't really know them, but do you really know what they do? So I guess I'm going to try and illustrate that with an example. So first of all I'm going to try and tell you a little bit about the process of engineering. So what an engineer does is focus on optimization and improvement. To do that you've got to figure out what your problem is. So the first thing you do is ask questions. Lots and lots of questions.
02:14	So all those little kids that ask "Why? ...What? …Why? ... What?" are budding engineers. So ask lots of questions. Work out what the problem is and once you have figured out what the problem is, identify the constraints. What are the things that are going to have an impact on how you design something? So work through all of the constraints and then you need to make some assumptions. So make some assumptions based on those constraints, all the questions you have asked. Now you can get to the exciting stuff.
02:43	Start to explore the possibilities. The what if's? How about? Start to think laterally. Create some options. Come up with some ideas and at that point you test the ideas. Work out which ones are the good ones. Go back to your client or the person who has set you the problem and try and figure out which one they are going to like the best, but you don't stop there. They'll give you some input. You go through the whole process again, and so it's always about optimisation, improvement. The whole time getting better. If you want to keep an engineer busy then give them a problem with no deadline. It will keep them happy for ages.

Time	Dialogue
03:21	So how do engineers cater for all of the possible effects that can happen? The example I am going to give you today as about a project I worked on over twenty years ago. And I have worked on a lot of different projects. All sorts of places but this is one that really really stands out. It's in New Zealand. It's the museum of New Zealand, Te Papa Tongarewa, known as Te Papa for short or Treasure House. So it's sited right there in Wellington, and for those of you who know all about your New Zealand geography it's that little red dot there. It's at the bottom of the North Island just before you get to South Island and it's in that bay that you can just see there on the slide.
04:00	So that's basically looking right out to the ocean and that keeps on going pretty much to Antarctica. So what I'm going to talk about today is how we actually got that museum to happen. So first we identified you know what the project was and I was fortunate to work with a team of engineers and other people. One of the myths that around the place is that engineers aren't "people" people. Well … yes engineers aren't the best in a lot of social situations, not all of them but … that's not their forte, however to get any engineering problem solved you need to work with people.
04:41	And they're not the people you know, you know the people you work with every day but people from different area. So they will be people from a client, other engineers, they will be people doing all sorts of different things on your project. You have to work with them to get a solution. Back to Te Papa. We are on site and looking at the constraints. Now this site it has the most unbelievable constraints that you could come across and this is why it really stands out. First of all it is in one of the most highly seismic areas in the world and it is on a major fault line.
05:14	So the fault line runs just behind the site. On that basis alone most people wouldn't choose to build there. On top of that it is right in one of the windiest areas you could possibly find almost anywhere in the world. On top of that you have reclaimed land. So the site has been made by chucking truckloads of dirt onto the site and just leaving it there and letting it settle over time. So not very strong and in fact in an earth quake liquefraction will happen which some people might know what that is, but those who don't, an earthquake hits and basically the ground turns to soup.
05:51	You've got tsunami and seiching. So a tsunami is because of the location. You can have an earthquake anywhere in the area and a tsunami happens it will hit the site face on. The other thing you get with a tsunami is seiching, which is the precursor to a tsunami. The land starts to fall away. Just like when you are on the beach and the sand is fall away from your feet before the wave comes in. So basically you have all that happening. On top of that, as if you needed any more, there is basically a three storey concrete building in the middle of your site that you are not allowed to demolish.
06:23	So quite a lot of things going on on that site so you are thinking who on earth figured out that this was quite a good site to buy? Well it is quite a stunning location. The Government decided that they wanted to buy it. They set the budget and the time frame so then you get the political imperative, the budget imperative, add them all together, … big problem. So a team of engineers binds everyone else together. So how did we overcome all of those constraints? First thing there is that concrete building. The three storey concrete building. Not sure if you can spot in the slide that it is sitting on rail bogies?
07:01	Now the reason for that is good old Kiwi ingenuity. Oh let's just move the building. Three storey concrete, that doesn't matter. So what they did was chopped off the columns. Slid some rail bogies underneath it. Put down some rail tracks down the site and some went across the road and just moved it. Moved the whole building across the site and it is now a boutique hotel called the Museum Hotel. A very nice place to stay in Wellington. Next thing all that pea soup for the ground what are we going to go with that? So of course another solution you wouldn't really generally think about.

Time	Dialogue
07:39	That's a 25 ton weight with a red circle around it. Heading at very high speed to the ground because it has been dropped from the top of those columns. So what they did was drop the weight on the site repeatedly, so 25 tons until the ground was fully consolidated and much stronger. So again not a classic solution. In effect every single time when that weight hit the ground there was a mini earthquake. So yes quite an unusual thing to do and also you wouldn't have been able to do that right in the city centre even though you are right on the edge of the city.
08:16	Next solution, base isolators. So this is probably one of the major ones that differentiate this building and of course the other constrain that I didn't mention is a 250 years design life. Most projects you would design for 50 years so this building was designed for a 250 year design life. So that means that every single thing you design the probability of something going wrong gets higher. So you need to design for heavier loads, for heavier earthquakes forces, much higher forces. That sort of thing. The solution to the earthquakes was a base isolating the building.
08:52	The Base isolators that you can see in the image there with red arrows on them, they look fairly innocuous. They are actually a very very sophisticated bearing. So they are layers of rubber and steel with cores of lead. Now this was designed by a New Zealand engineer, William Robertson in New Zealand and using a team of engineers globally working on it to actually get the right composition for those base isolators. So effectively it completely isolates the movement from the earthquake.
09:24	So imagine that the earthquake is coming and everything is moving around and moving around quite significantly and the building just moving a tiny little bit and that then protects all the artefacts. So inside this building are the most valuable treasures New Zealand has so none of them can be damaged and so that's the way that that is achieved. The other thing to consider in terms of design life is how much of your design life do you actually want to cater for? Do you want the building to be 100% usable after a significant event like an earthquake?
09:58	Do you want it to be repairable or do you want it to be in a condition where everyone's' got out safely and you will demolish and start again? That's make a big difference to what you design for. So the next solution we are looking at is a very aggressive site because you are right on the ocean there, salt laden air and it's very very corrosive. Most the time a with a 50 year design life you design for things to last that long. 250 years is a completely different thing so materials engineering was really really significant in this so we had to do a lot of research into concrete.
10:36	Now those panels you can see on the outside of the building, each individual panel is a piece of concrete and there were lots of different colours of concrete. The concrete is either polished or left as it is. No reinforcement. Again unusual so the panels had to be designed the largest size they could be without putting any reinforcement in because the reinforcement was at risk of splitting the panel apart when it corrodes. The actual design of the concrete mix was one of the things that I was very heavily involved in.
11:00	So it was like doing a very fancy recipe. Of course we had to test it. We didn't actually get the joy of testing it like a cake mix. So we just had to keep testing it. So lots and lots of testing of the concrete until we got it right. That was certainly a very iterative process. The other thing that you can see off to the side there is the bracket that is holding up the panels. Each one of those panels has four of those brackets and they are made of grade 316 stainless steel. Grade 316 stainless steel is the highest grade of stainless steel that you can get.
11:36	Very expensive. Very durable. It's about the only thing that can cater with that salt laden environment. So here it is on site. Now I haven't mentioned how we dealt with the seiching and the tsunami. So the seiching and tsunami we dealt with by putting all of the valuable artefacts on the first floor of the building. So designing all the things that were effectively expendable or could be moved on the ground floor because the thing about a tsunami is you get a warning.

Time	***Dialogue***
12:07	Anyone who lives in New Zealand will know when you are school you get taught how to react when you get a tsunami warning. You have time. Basically that was designed that if there were people on the ground floor you would take them over out of the building to higher ground or you would go up to the first floor and the ground fool you would assume would be inundated. So you got things like the car park, café and the childcare centre which is potentially a bit controversial but yes they would be the first people you would be moving.
12:36	So that’s how the building dealt with that. Again a little bit lateral. Another significant benefit is probably the primary factor designed for is safety. Engineers get things wrong, you kill people. You do not want to kill anybody and particularly with structural engineering if the building falls down there’s a good chance you are going to kill people. So one of the major things this project delivers is safety.
13:01	If you live in wellington and if you know that there is major aftershocks happening then the safest place to be is in that building because it has been designed for probably some of the highest loads of any of the building in the whole of New Zealand, but certainly Wellington has been designed for. So this is the building finished. You can see it’s got lots of different shapes which is clearly architecturally diverse. There is a lot more I could talk about but I could go on for ever.
13:28	So I guess I really wanted to illustrate is engineering is about problem solving. It’s about solving a problem using the information you’ve got and coming up with a solution to meet all of those criteria. So if you know people that you come across and particularly younger people looking at what they might study, where they might go, just say to them if you are interested in problem solving, have capability in maths, science something like that; “Have you thought about engineering?”
13:59 14:07	If you’ve got someone who has always asked that question; Why? … How does it work? … How is it put together? Think about engineering. All I can say now is thank you very much for your time.