Climate Change and How We Need to Change The Practice of Engineering

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It's always a pleasure to share my research experience. I pick this sort of a catchy title to send the message to young engineering professionals, this idea of climate change and how we need to change the practice of engineering.

I will share some background on climate change and the causes of it. This will cover Greenhouse gas effect. The carbon dioxide measurement in Hawaii is basically increasing continuously and this warming is actually a good thing for us. I mean too much of a good thing. Otherwise, we will not be able to live on this planet but more importantly, the question is, what effect it has on the environment? This is the key message I will be delivering.

Climate change is a type multiplier, and we need a new paradigm in practicing of engineering, and I'm going to share some of my ideas and experiences and research outcomes. This message called stationary is dead and you will know what stationary means after my speech. Hopefully, we can continue to practice engineering building up the infrastructure, the same way we have learned in school laws in how we do things in practice.

Basically, the climate change itself undermines the assumptions that we have been using historically, for management of water supply demand service. Now my focus will be primarily on water resources, also I'll touch on transportation, but it can apply to many areas of civil engineering in general.

The message I like to convey is that you need to come up with a new paradigm to plan projects under future conditions which is what we are not doing now. For the most part, we need to adapt the engineering curriculum to this concept that icon called resilient sustainability, the sustainability we've been talking about for decades but now we have to be resilient in doing that and you will see why because of this concept is non-stationary. The other important message I'm going to convey in this short time is, how do we deal with this deep uncertainty and I'm going to introduce this concept of dynamic adaptation.

The figure depicts the science of climate change, all these arrows going up signifies the increasing data behind every one of climate change factors and the arrows going down also indicate the variation of climate change. So these are all consistent with what is being predicted. In climate change science, the metrics that indicate where we are in terms of carbon dioxide global temperatures sea level and others.

This is the background in my speech and the fact is that we have a global scale in which we have already some indications about, more than a degree Celsius in warming on the planet. Since the pre industrial era this global warming is evident. Then, there's the sea level rising and it seems to be accelerating currently at the rate of 3.3 to 3.4 millimeters per year, which for low lying areas could be significant.

Climate change, basically alters the hydrological cycle and it is like a human on steroids, because of the increased energy that is on the planet is due to much of the climate change. About 90% of energy from climate change that comes as heat is absorbed by the ocean. So that's a big storage of heat and that could be something that causes changes in climate globally.

Our primary variables of interest in our planning of design is the temperature, precipitation is your procrastination in sea levels. As you all probably agree with me, it will have implications for ecosystems and human health, Water Management Energy, Agriculture economics and many more, including other sectors like transportation.

I have been looking at Sri Lankan data for some time on and off. I've been away from Sri Lanka for probably about 40-50 years but still I've been in touch with Sri Lanka on many occasions. Therefore, this is the work we did with my help on basically looking at trends in the map of Sri Lanka where about 20 stages and all the arrows are red, diamonds indicate the warming trend. These are all statistically significant and you have, in general, a variation of about point 1-5.2 degrees per decade and you probably all see that and the figures show that the sea had been warming continuously for each decade. You can see that the circle is becoming bigger and bigger, that means in every month, we are becoming warmer and warmer and I'm sure many of you who live in these areas like Colombo are feeling it.

So another aspect is you know what will happen to the sea level; As per 'Lena' we are surrounded by sea level rise. Lena is a wonderful tool from NASA that you can go to and globally look at the sea level rise rate. The point closest to Sri Lanka and you can see by 2100 we will have one meter or more depending on the greenhouse gas scenario emissions as shown in the figure. Warming is not going to stop and the sea level is going to rise continuously. And that's something we have to be cognizant on when we are planning or designing projects all along the coastline and I'll show you some examples of what's happening, or what could happen.

This particular side also tells you different scenarios which you can expect, let's say, half a meter one bit of sea level rise. Obviously, it all depends on the greenhouse gas scenarios but the current trend is not being enough to mitigate the greenhouse gases to slow down the warming. This two degree centigrade limit might be set up as not achievable by 2050 as someone wanted to. When you look at the scene of what happened in any kind of landscape there are what we call compounding effects of track multipliers. They could be sea level rise on the coastline.

These big storms like hurricanes which are known as cyclones in our part of the world also cause rising groundwater levels, particularly in coastal areas, because the highest levels been flooding due to potential changes in rainfall patterns. We saw all these threat multipliers, one research we are conducting is, what are the compounding effects of joint probabilities of this threat multipliers that we have to deal with many parts of the world. We wanted to see of climate change, where some figure show flooding in Florida, also in places like Miami Beach twice. In the West, there was a neighborhood that flooded for 60 days continuously just from tide which is rising and not having a significant effect on other neighborhoods.

But on the other extreme, you also have a drought, the western US is having an unprecedented drought, very low water levels in rest of the areas was having major implications for water supply for agriculture. Another issue was the hurricanes that come through that you never see very often, a New York subway being flooded due to a storm, for example, right now. The heart of the hurricane that came over from the west coast in Florida, had storm surges of 10 to 15 feet and flooding have implications for infrastructure and others.

This much flooding is a medical concern and the picture shows Houston streets were flooded for days and then more recently in Pakistan another same kind of climate we never used to have. We need to think about that when we planned, you know, engineering projects in the future. On the occurrence of extremes, I just want to point out the category of storms coming on shore in Florida, not too long ago it's still going through a state of a major storm event and these things are happening more and more frequently. It’s expected to be stronger and more frequent in the future, particularly the major storms and the climate change.

When you look at the, the cost of these events, what we call billion dollar disasters. They're increasing significantly and this might be the result of development, without any planning and that is a sign that we are going to have more and more losses in the future. One aspect that we should think about which is not really happening in Sri Lanka, in my opinion, is this whole idea of floodplain management if you dig major river basins in Sri Lanka, every one of the basins will be flooded now more and more frequently. But I think we need to think about floodplain management in the context of climate change and that's something I've been trying to promote in Sri Lanka for some time.

The other aspect we don't talk much about as a civil engineer is this crown water. So what inclusion effect, in particularly along the coastline, we have this situation the saltwater inclusion will basically affect high rise buildings, other buildings. This salty water coming in and affecting the foundations and maybe even piles that you construct. This video I'm showing from YouTube is on a collapse of building in Miami Beach, and you will see that this poor building has collapsed and everybody was wondering what the engineers had done. So, this is what happened after the building collapse everybody was wondering we don't build engineering buildings or design buildings to collapse like that but what is happening on the ground is probably the main culprit.

This whole word inclusion due to sea level rise, basically corroded the foundation, and since something that might be sort of like a thread on the ground that we don't know about and that's something we need to think about. This whole concept of stationary at a non-station or it is something Professor Fernando mentioned that I've been doing research on lately. Traditionally, in engineering practices we assume station ID is not constant but the basic laws and patterns will remain the same, the path climate is an indication so when we designed for the future. We assume this probability of extreme still remain the same through time. The idea is the past is a key to the future and we use the concept of return period that many of you engineers might be very familiar with. Now on the non-stationary, the probability distribution basically will be changing with time and basically lifting up with time, because of this trend we might experience in the future. There are many challenges in analyzing and we have done some research on how to plan for the four projects on the future conditions this.

Basically, in this case the past is not a good indication of the future and we need to think about what could happen in the future, can we extend this trend into the future. Those are some of the challenges. So we have a situation of dynamic return period that I will explain that in two minutes. In other words the return period as a fixed quantity cannot be used for planning anymore in this paradigm.

This is an example of sea level rise again. When designing bridges or old way infrastructure, the dynamically changing extreme probabilities will require you to have a new paradigm for planning and design. The graphic go through all the details of that, the return period will actually decrease if you design well. For example, it will have maybe a 50 year return level auditor area by 2040. In other words, your level of protection is decreasing. It’s same with another location, this is for the sea level rise on the west and flooding on the right. In other words the return period concept that we've been using as engineers for generations, will not work anymore in this kind of setting.

We've done research, I'm not going to go to all the math on this but we have redefined the return period as what we call expected waiting time. We have come up with other definitions of how we plan for changing frequency of flooding in the future and have come up with this return period concept where we can determine what we need to design for today, in order to deal with these changing conditions in the future.
Also, another concept that we are looking for is the risk based concept. This is the risk formula for non-stationary day and one of the things that I have is what was developed for the National Climate Assessment in the United States. So, under stationary day with your design life your risk is going to increase that is natural, under stationary. But under non stationary you're going to have a higher risk even for the same design life. So we have come up with ways of, If you specify let's say 50%, what you need to design for, so this risk based design is an approach that could

be expanded to incorporate damage in terms of monetary terms.

One thing we have done is to come up with this concept of adaptation portfolio and what are the things that we could do in the future. I'm now going to go through each one of those so that is something that we have developed for the state of South Florida area, what are the options we can use again, keeping in mind this concept of manifestation. So the concept that I want to promote, dynamic Adaptive Path, is what we have worked with the Dutch on. The whole idea is that we are in an existing situation with highly vulnerable conditions and we have had that for generations. There's no change in that we still have an aging infrastructure, but we have this current situation but the future is not in stationery, and due to climate change.

It is uncertain because prediction of climate change is not easy and we have what we call a situation of deep uncertainty. So how do we plan for that kind of uncertain future. So, the approach is basically looking at different adaptation pathways and looking at tipping points. So, this concept of dynamic adaptation or dynamically adaptive pathways is a wonderful technique that we should think about in dealing with non-stationary climate change in engineering. One example we looked at is Miami, for example, we looked at various options or portfolio of measures. Basically elevating the roadways and houses so the idea here is like how to face these solutions in and we came up with this pathway concept.

At sea level rise magnitude we need to resort to another measure in this set. Finally, I want to leave with five resilience principles.

So, compared to what we have been doing, working in engineering in the past we need to think, have a systems approach we can't just isolate one area and need to look at the environment and other aspect of a project, which you might already be doing.

We also need to think about beyond design events, because I think we are going to have a higher stronger event in the future and we need to look at those as well.

Number three is we need to think about how we design a project using this concept to remain functioning. Just because you fail once, maybe the project does not need to be abandoned how we make sure. They can be used at all design the project in a way that they can be enhanced or rebuild very easily. Improve the recovery capacity by also looking at social and financial capitals, working with the community. And then basically how do we remain in the future by looking at this concept like stationary.

I will stop here and take questions.