

**Introduction to Civil Engineering**  
**Prof. Ravindra Gettu**  
**Department of Civil Engineering**  
**Indian Institute of Technology, Madras**

**Lecture – 01**  
**What is Civil Engineering?**

So, welcome to this course on Introduction to Civil Engineering, this is the first lecture where we are going to talk about What Civil Engineering is, what is the purpose of the career and what kind of work civil engineers do. My name is Ravindra Gettu, I am a professor of civil engineering at IIT Madras. So, what is Civil Engineering? Civil engineering involves facilities, installations that people generally use, so this means that the profession involves finding out what is required and making it happen.

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### The Field of Civil Engineering



The civil engineering profession involves analysis, planning, design, construction and maintenance of different types of facilities for government, commerce, industry and the public.

These include high-rise office towers, factories, schools, airports, tunnels and subway systems, dams, canals, and water purification and environmental protection facilities, such as solid waste and wastewater treatment systems.

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So, it includes the analysis, planning, design, construction and maintenance that is the whole life cycle of different facilities that people use. So, these could be government facilities, these could be for businesses, industries like factories, shop floors and so on and facilities that are used by the general public like bridges, roads and other such installations.

So, here we see some examples of facilities that are created manage by civil engineers, high rise buildings, office, towers, residential buildings, factories, schools, airports and other transportation facilities like tunnels subways and also other systems which are needed for providing drinking water and also for treatment of sewage dams, canals, water purification systems and others that we need for protecting the environment.

We want to make sure that the sewage that is created from all these townships and offices are treated properly before they go back into the environment. So, this would be a broad definition of what is the field of civil engineering.

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## What Civil Engineers Do



Civil engineers coordinate the needs of society, with technical and economic feasibility.

Civil engineers are concerned with the impact of their projects on the public and the environment.

Civil Engineering is a broad discipline that unifies a number of aspects of engineering and sciences.



Koshy Varghese

And the purpose of civil engineers in society is that they coordinate the needs of society. So, broadly when we talk about civil engineering it is a response to what society wants or society needs. So, civil engineers coordinate the needs of society, they see what is required and make it happen within the limits; within the feasibility that is technical and economic. Technical meaning what? It is doable it is possible with the technology that we have here, it is possible with the resources that we have here manpower or raw materials.

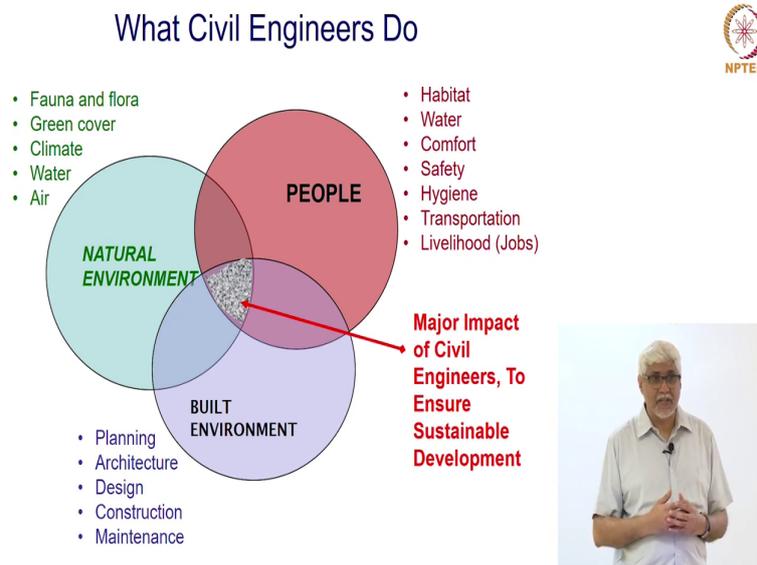
And civil engineering always is determined or the scope of civil engineering is mostly determined by economics it is cost also, because somebody has to pay for these facilities and it is the public which directly or indirectly pays for these facilities. So, that is there are limitations there are constraints due to the economics. Civil engineers are concerned about the impact because what we do as a civil engineer affects people directly.

So, the impact of the projects on the public is very very important and also we have to go habit, we have to be in equilibrium with the environment. So, we do not want to create something that spoils the environment and make takes it to a point that it is not renewable or if it cannot be returned to it is original state.

So, the impact has to be positive on the people who are using these facilities, on this at the same time it should not be negative or extremely negative on the environment. So, this equilibrium or this balance is always kept in mind by the civil engineering. Civil engineering unifies many fields, later during this course we will talk about different disciplines or specializations and see what each of these specializations talks about.

In the next lecture I will give a brief introduction to each of these specializations. So, we use the sciences we use maths, physics, chemistry, sociology, ecology to create manage these different facilities that civil engineers have to take care of.

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So, we can so what I said can be put in this form graphic form, we have people we respond to the needs of the people, we create facilities that would be called the built environment. But all this has to happen in coordination with or along with in conjunction with the environment without spoiling the environment.

What are the things that what are the aspects of factors that could be important? When we talk about people civil engineering concerns where they live that is the habitat. We want a comfortable place where people can live, we want to provide facilities like water, drinking water is a facility or a requirement of everyone. In general they should be comfortable.

So, the place given for people to live and work should have proper ventilation, should have proper lighting and they should be able to be comfortable when they are living there or working there. Safety is important; safety against any type of threats people the environment

natural hazards suppose there is an earthquake, suppose there is a cyclone or a hurricane we want to make sure that our facilities keep people safe.

Similarly, if there is a flood in a city we do not want the buildings to be unsafe, people inside the buildings in our facilities that civil engineers create, they should be safe. Hygiene is important; so that means, that pollution waste water is treated mitigated well. People have to move within cities from one city to other, city to rural areas back and forth so transportation is very very important.

Nowadays we spend a lot of time moving people and goods back and forth. So, it is very important that transportation facilities are good and people waste as little time as possible, spend as little time as possible in moving from one place to the other. Finally and very importantly especially in a country like India the construction sector or the civil engineering sector provides a lot of jobs. Civil engineering facilities are not only important for doing the job but also civil engineering creates a lot of job.

Construction provides a lot of jobs especially for unskilled people. In India it is the largest sector that provides jobs and livelihood for people who are not very highly skilled. So, these are the important aspects as far as people are concerned. So, we have to address a civil engineers what whatever we can as much as we can all of these aspects.

Then we have the natural environment, so all this has to happen within the world that we live in and this means that the environment has animals, plants, insects, birds and so on. We have flora and fauna that we do not want to destroy we do not want to take up their space too much. But we have to live within the same ecosystem the green cover is important how much of the earth how much is the land that we use green we want to keep it as green as possible. We do not want to use up everything and therefore we will hurt the environment and hurt ourselves in the bargain.

Climate can also change we talk a lot about climate change, we talk about the ozone layer, where industries even construction activities emit substances, emit gases and so on which can alter the climate and affect the whole earth including us. Water in air pollution is very

important we want to keep the air and water as pure as possible for us and for the other beings that are there on the earth along with us.

So, we have to manage what people want, without harming the environment because from the environment we are taking the natural resources we are using up space and we are emitting things that could hurt the environment. So, we need this balance. Along with this balance is what we create as the built environment, what do we construct all the facilities we construct we can put together as the built environment. It is the environment that we live in working that we have created within the natural environment or the earth that we live in.

So, here we have to do things properly, starting off with planning we have to plan much ahead of time and properly what are the requirements that we have, what are the installations that we want. Architecture becomes very important and later on you have a lecture on architecture and how it is developed how architecture leads to the structures that we construct.

We have to design; design means coming up with an optimum way of executing what we have planned ok. So, design is where we have all the sciences on our hand, we have all the technologies, we decide which to use how to use in an optimum way. Optimum in the sense of raw material usage time and costs and provide what people want. The construction is executed by civil engineers. So, we have to make sure that the design is implemented, something is planned and designed. Now, the civil engineer has to make sure that what is designed is actually constructed ok, so that is where the execution becomes very very important.

And finally most of the structures that we build have to last for a very long time, see a bridge in a city has to last at least for hundred years and this means that we have to maintain take care of these facilities repair them if necessary ok. So, this is the whole system that we have to consider, we have people we have the natural environment and we are building this environment to satisfy the requirements of people without hurting the natural environment.

So, the major impact of civil engineering is where all this comes in, to avoid conflicts, to make sure that everything is done without hurting the environment too much, without it being

too expensive, but responding to what people need ok. So, this diagram tells you where we are working in as a civil engineer and where the major impact is.

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## History of Civil Engineering

Humans adapted cave shelters to protect themselves of weather and harsh environment, and used tree trunks to cross rivers, demonstrating the ancient age of civil engineering.



**Bhimbetka caves, Madhya Pradesh**  
(<http://www.mptourism.com/tourist-places/bhimbetka-caves-rock-shelters.html>); 30,000 year old paintings



I will spend a little bit time on the history of civil engineering, looking at some landmarks and I will give examples of as much as possible of India. We can guess that human beings started off being civil engineers very early in the development of mankind. We can assume that people lived in caves in shelters that they made and probably adapted them, they chose the shelters or caves which were safe from wild animals which were saved from floods and rain and sun and probably adapted them to make sure that they were safer and more comfortable ok.

So, this would be probably the first civil engineering accomplishment, where to live in a safe manner. Probably when they found or discovered or invented a small bridge by making a tree

trunk fall across the river or placed it across the river, that would have been the first bridge as a civil engineering. So, the origin of civil engineering surely goes back to the time when people started moving around and human beings started to behave similar to what we do today.

There is lot of evidence of people living in caves sheltered areas this is an example of the Bhimbetka caves in Madhya Pradesh, where 30,000 year old paintings have been found. So that means that people have been living or had lived there 30,000 years or more. So, there is evidence all over the world that people lived in caves and these caves had to be protected or they chose caves that were well protected. So, this is the start of civil engineer as a provider of habitat, where people lived, how safe can we make that.

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## History of Civil Engineering

Humans adapted cave shelters to protect themselves of weather and harsh environment, and used tree trunks to cross rivers, demonstrating the ancient age of civil engineering.



**Living tree root bridges of Meghalaya**  
(<https://mymodernmet.com/india-s-fascinating-tree-roots-bridges-grow-stronger-every-year/>)



I talked about bridges this is a very interesting phenomena that you see in places like Meghalaya again in India, where trees or branches or roots of trees are used to make bridges. Possibly the early human saw that these roots could be moved and tied and then made to do a bridge. Similarly a trunk or a series of trunks of trees could be put across the river and moved. These are even today used by people in the picture you can see people crossing this bridge made out of living tree roots. Where the tree roots are tied together and sort of engineered to cross the river or the stream and to provide a path.

So, the roots are all tied together and trained made that they form like a bridge and people use it. So, like it is a like a living bridge and again you see that the early civil engineer or human being also a thought of how to use what is around them to create facilities for themselves to be living in a comfortable way and to move from one place to the other.

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## History of Civil Engineering

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Houses, streets and drains of Mohenjodaro (<https://theindusvalleycivilization.weebly.com/houses.html>); 3,000 BCE



We have evidence very early in our civilization of entire cities being built; this is the example of Mohenjo-Daro. Where people establish cities, here in this picture you see part of houses you can see the walls being built that were made with bricks and between the houses there is a street there is a paved street and in the middle of the street there is a drain. So, you can see that people a lot of people will probably living there, they had an organized planning of where to live and where the habitats would be and from move to one place to the other they had streets well designed they had paving. So, that they could walk safely probably their animals and carriages could also moved safely.

And they also thought that their sewage the storm water should be directed in a certain way not haphazard everywhere, but along the drain and this drain would probably go somewhere and this was even about 3000 years Before the Current Era. So, about 5000 years from now; 5000 years back from now this existed ok. So, people have spent a lot of time effort and energy putting together technologies available at that particular period of time, to provide these habitats and places to live.

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## History of Civil Engineering

Humans adapted cave shelters to protect themselves of weather and harsh environment, and used tree trunks to cross rivers, demonstrating the ancient age of civil engineering.



**Sanchi Stupa**  
(<https://www.jagranjosh.com/general-knowledge/the-sanchi-stupa-facts-at-a-glance-1455779247-1>); Oldest stone structure in India, commissioned by the emperor Ashoka, in the 3rd century BCE



The oldest structure in India is the Sanchi Stupa and here you see a nice image of this which was commissioned by the emperor Ashoka in the 3rd century, before the current era and here we see a structure that is made by assembling stone pieces. So, that means the stone had to be identified the material had to be a setting, it had to be designed and for this design the stones had to be cut to a certain shape assembled to make these make the Stupa and there are carvings on the Stupa which are very elegant. The image here is the Stupa as it is today reconstructed, but originally we can imagine that it would have been very very similar. So, this is from the 3rd century before the current era.

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## History of Civil Engineering

Humans adapted cave shelters to protect themselves of weather and harsh environment, and used tree trunks to cross rivers, demonstrating the ancient age of civil engineering.



**Varaha Cave, Mahabalipuram**  
([https://en.wikipedia.org/wiki/Varaha\\_Cave\\_Temple](https://en.wikipedia.org/wiki/Varaha_Cave_Temple)); dating from the late 7th century CE



This evolved the construction evolved and here we see an image of a Mandapa or cave close to where madras is situated or Chennai situated in Mahabalipuram. So, those of you who are around here I certainly urge you to visit Mahabalipuram, this is one of the caves there called the Varaha Cave or Varaha Mandapa which is from the seventh century of the current era.

So, the technology architecture evolved that stone could be carved into pillars and you could have a space created an interior space created where people could live it is not just the cave anymore. But a cave that has been modified or when there was no cave it was just a huge piece of rock that was carved out into the habitat that people wanted.

And this later evolved as an assembly of different elements, here you see columns that is the vertical members the pillars and then you see the roof. Now, where this was not possible people would make an element that will form the function of the column and find what will

give the roof and build on top of it and so on. So, the history has evolved from the cave and the trunk of the tree being a bridge to something that we live today, also as this same type of civil engineers that possibly lived at those times.

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## History of Civil Engineering

*Some milestones from historical documents:*

- Around 2550 BCE, Imhotep, the first documented engineer, built a pyramid for King Djoser located at Saqqara Necropolis (Egypt).
- Earliest examples of a scientific approach to physical and mathematical problems applicable to civil engineering: Archimedes in the 3rd century BCE, including Archimedes Principle and Archimedes' screw; Brahmagupta, an Indian mathematician, used arithmetic in the 7th century CE, for excavation (volume) computations.
- The first engineering school, The National School of Bridges and Highways, France, was opened in 1747.
- The Department of Civil Engineering at the Indian Institute of Technology Roorkee is the oldest in India; established in 1847, as Roorkee College.

<http://www.thecivilengg.com/History.php>



Here are some snippets or some notes from a history, the images that I showed you before we do not know the names of these people we do cannot pinpoint who these people were. But from historical documents there are some things that we know for certain. For example, it is said there are around 2550 before the current era this is more or less at the after the fall of Mohenjo-Daro and properly Harappa. There was an engineer imhotep in current Egypt who built a pyramid in what is called the Saqqara Necropolis. So, this is the first documented name at least of a civil engineer somebody who built a pyramid ok, certainly they were many many more before and after him. But it is interesting to know this is the first name that we know of a civil engineer.

In the third century there is evidence that people started using science scientific principles in construction and building. All of you know Archimedes, in the third century BCE the Archimedes principle and the Archimedes screw were invented by him and they were used a lot in construction. In the seventh century we know that Brahmagupta and Indian mathematician used arithmetic for calculating excavation volumes, to see how much excavation had to be done and this is in the range of where I talked about the Sanchi Stupa and the cave temples and so on.

So, at that time in India elsewhere in the world people were using scientific methods for construction to find out how to construct in an optimum way, so that they could plan the resources and probably costs that were required. The first formal school of civil engineering started in France, the national school of bridges and highways called the Ecole Nationale de Patisserie say.

That is they said that at that time civil engineering at least in France was called the engineering of bridges and roads or bridges and highways, these were the important aspects that were given to civil engineering. A lot of time and even now in Europe architecture or buildings are not are not considered as part of civil engineering, they are considered more as architecture. But in India we consider all built environment as the realm of civil engineering.

In India the oldest school of civil engineering or the department of civil engineering is in the current Indian institute of technology in Roorkee. It was started a hundred years after the school in France in 1847 ok. So, these are some aspects of the formal way that we have documented civil engineering in our country and elsewhere.

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## A Civil Engineering Professional



*A civil engineer should be one who:*

- Enjoys problem solving and giving action to one's ideas
- Has curiosity about how things work and how to improve them
- Is interested in improving the environment and reducing negative impact
- Is socially aware and wants to help people live better
- Is creative, yet practical



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So, now that we have talked about what is civil engineering, what does a civil engineer do, what would be the ideal characteristics of a civil engineer, who should be a civil engineer are you going to be a good civil engineer. So, a civil engineer is should be one who enjoys problem solving, who wants to provide solutions and wants to take action on his or her ideas, conceiving something that will be for the good of society for the good of people and acting on it.

And looking at the problems that people have in cities and elsewhere and seeing, how can we provide a solution within the resources that we have. A civil engineer should have curiosity about how things work, why do they work as they are and can we improve them everything can be improved right. Every with every year the way we live in improves changes now how can we improve it, within again the constraints that a civil engineer has.

A civil engineer should also be interested and certainly be careful about spoiling the environment, we want or we would like civil engineers to be those who improve the environment and reduce the negative impact of civilization humankind our built environment. It is going to have impact we want the impact to be the least.

And if we can recover from mistakes done in the past harmful impact that we have created in the past all the more better. A civil engineer should be socially aware because from the beginning I have been saying that civil engineering is a response to the needs of the people.

So, civil engineers to has to understand endeavor to understand what do people need and have to be aware of the requirements needs of society and make things better for people. T here are always conditions which can be improved as we develop as more people start to habit the world we need to improve conditions for everyone. So, a civil engineer has to have this purpose to make things better for people.

Finally and very important we feel that a civil engineer should be creative yet practical. What does this mean? In India we have a term called Jugaad which means that you improvise sometimes it is not something that we recommend be the basis of civil engineering. But sometimes you have to improvise you have to be creative to provide a solution. A civil engineer may not have all the time in the world to give every solution that they can sometimes you have to be improvising, you have to react fast you have to be creative using the tools that we have resources that we have that is why a civil engineer also has to be practical.

The materials that we use the systems that we use are very economical; suppose you make it very costly nobody will use it. A very common construction material that we use is concrete, today the cost of concrete is just about 2 rupees a kilogram ok. That is why it is so popular, that is why it is so extensively used. If we make the same concrete as 5 rupees construction would stop as of today. So, it is very important that the civil engineer is creative yet practical; practical within the constraints that the civil engineer has.

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## Career Paths for Civil Engineers



*The possibilities for Civil Engineers are endless:*

- Government and public sector organizations
- Industry: design, construction and operation
- Engineering management, Policy and Planning
- Consultancy for design, quality assurance, testing, ...
- Education
- Research and development
- Marketing and Business management
- Computers
- Law
- Medicine
- In combination with other experts, e.g., economists, geologists

[https://www.google.com/url?sa=t&rc=1&q=&esrc=s&source=web&cd=12&ved=2ahUKEwjTs8PKxejjAhUQ73MBHZpCCacQFjALegQIAxAC&url=https%3A%2F%2F1.cdn.edl.io%2F4R1zL3qpJOCsYu10A03zhvCoKonyYxWe9t2Z95baBgHLYW9W.ppt&usq=AOvAw2FD\\_LIMMq2-4X92Xh9ZTxZ](https://www.google.com/url?sa=t&rc=1&q=&esrc=s&source=web&cd=12&ved=2ahUKEwjTs8PKxejjAhUQ73MBHZpCCacQFjALegQIAxAC&url=https%3A%2F%2F1.cdn.edl.io%2F4R1zL3qpJOCsYu10A03zhvCoKonyYxWe9t2Z95baBgHLYW9W.ppt&usq=AOvAw2FD_LIMMq2-4X92Xh9ZTxZ)



What are the jobs possible for a civil engineer? It is endless there are all sorts of jobs that could be possible for a civil engineer. Firstly, lot of civil engineers work for the government and public sector organizations. So, they are involved in planning of projects, analysis of what should be done looking at time and costs preparing contracts, executing managing the construction overseeing contractors and workers. And then finally seeing if it has been done properly and through the life of the structure or the facility maintain it rehabilitated at the end of the day end of the life of the structure probably go to demolition as well.

Similarly, in industry when you have factories companies which are running with a lot of people machinery products coming in and out, again design is important. Where to put up a place how we should function, what facilities it will require, what loads it will handle, how many people will go in and out all this is required for designing the facility properly. Again

the construction make sure that the design is implemented correctly a design is a plan design is the end of a plan.

Now, this has to be realized and this means that the construction has to be done properly and then the whole facility has to be operated like a train station. The train station has to go on working it is the job of the civil engineer does not finish as soon as the train station is constructed. Trains have to run day in and day out people have to go in and out everything has to be safe and everything has to function according to a schedule, similarly everything else every other facility.

There are lot of people who are involved in the management the engineering management, how to do all these things that I have discussed in a proper way. Managing the resources, we have time constraints a project has to be finished in a certain amount of time, we have certain resources especially money, we want a certain quality and we want the construction to be safe. So, all this has to be managed well, so that the project is executed well.

Sometimes engineers have to be involved in the policy as well, policy meaning what are the rules that are required, what type of materials can be used where, what type of structures should come up with, how can we construct without hurting the environment and then plan for all this. So, there is a lot of management, if somebody becomes a civil engineer and says that I do not want to work at the construction site I am not interested in doing things by myself.

I would rather oversee supervise and manage there is a lot of scope there is a tremendous scope in engineering management planning policy and so on. There are also others who become consultants, consultants who are those who can work with different organizations and different clients to provide solutions these solutions could be designing. So, these consultants are experts in a certain area and when somebody wants something to be built they would approach them and say can you design this for us according to our needs. So, there are design consultants there are people who have specialize in quality.

As I said what we construct as civil engineer should last for a long time, should respond to the needs of people. So, this means we need quality high quality construction and operation. So, for this there are people who specialize in what is called quality assurance and quality control. So, they would even before the project starts look at how to ensure that the project will be done with high quality materials, high quality technology and end up in a high quality structure or facility.

They can also do testing, so this is what we call third party testing and this becomes very important when you have disputes. Say the contractor has done something the owner requires that. Now, instead of either of them testing because they have a vested interest, they could be a third party consultant who do the test and say that yes this material is good no this material was not good was not what the requirements were for.

Then we have a lot of civil engineers in education as myself who teach train the future civil engineers and also in a place like IIT Madras the professors do a lot of research probably more research than actually teach because things have to change civil engineering as we discussed before has to respond to the needs of people. So, it has to keep changing so that means, we have to find out new techniques new materials new systems new processes that are better or prove will provide better results that to what we have been used and also to respond to new needs that have come up.

See long time back we did not design for earthquakes or seismic activities properly in every zone. But after the recent earthquakes now we know that we have to design for these lateral movements of the earth that we might experience at certain areas. So that means, the way of designing the technologies have to change certain things that we did before in a certain place are not valid anymore. So, these are things that we have to adapt to that means research is required.

We want materials to be more eco friendly now what are called green materials or sustainable technologies; this was probably not that important in our list of things to do as civil engineers 20 25 years back. But now we are more concerned we want this to happen in a systematic

way. So, again research and development is required, research is where something new comes up development is where this is taken into practice.

So, this is also an important space that civil engineers can work in. Marketing and business management again a civil engineer would be very much adapted to our technology in civil engineering and help market it or administrator. So, there are a lot of civil engineers who go on to do an MBA who go on to specialize in marketing and an India in India it is very common for somebody from an IIT to go to an IIM to get to; get a masters in business administration or any equivalent.

So, our students talk about cracking cat, which is the entrance exam to going to these business schools. So, lot of civil engineers have gone on to become excellent managers, business administrators and help marketing help run businesses especially those in related to civil engineering and the sector.

Computers are needed everywhere and computer science and techniques are very much necessary for civil engineering. We have several of our faculty members who specialize in computer based systems, design, analysis, optimization for civil engineering purposes. So, there is a lot of computer science which can be used in civil engineering and there is hardly anything that we do in civil engineering that does not require a computer today.

So, it is very important also that people who have become civil engineers, but have an inherent interest for computers and information technology can also find a very important role in civil engineering. There are sectors which seem to be very different from civil engineering, but also civil engineers have a role. For example, in law suppose there is a court case where somebody is deciding whether a building was constructed properly or not where the bridge had the right design or not.

There could be a court case and they would look for an expert, there are needs for several experts possibly and again a civil engineer is very much useful. This is becoming more and more important in our country it was already important in many countries like the United

States of America, where a lot of civil engineers were involved in litigation and court cases being expert witnesses giving their opinions and in India now also this is increasing.

Because we are having a lot of construction there is a lot of construction going on, they could always be mistakes they could always be disputes and civil engineers could play an important role in settling these disputes, in arbitration resolving a problem between different parties could also be taken care of with the advice or the expert opinion of a civil engineer.

Civil engineers can work in combination with many other experts as well. For example, economics. Financing of projects is a very important thing how to finance properly, so that benefits are there for everyone involved. So, engineers work together with economists on policy in type of projects how projects should be run on the other hand they could work with geologists to see which structures could come up, where will earthquakes occur which slopes are stable and that you can construct. So, there are many areas where civil engineers work in combination with experts from other fields.

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## Inspirational Projects



### Bandra-Worli Sealink (2009)

- Built over Mahim Bay in Mumbai. 8 lane wide; 5.6 km long; 3.8 km lies over the sea.
- Reduces travel time from more than an hour to just 7 minutes as 29 traffic lights are avoided. Supports roughly 1,25,000 vehicles a day. Saves about Rs 100 crore/year in vehicle operating costs.
- Cost of Rs 350 crore escalated to Rs 1634 crore on completion.



I am going to quickly look at some inspirational projects some great projects and explain why at least I think that they are important. We start off with a project from India the Bandra worli Sealink those of you who have been to Bombay and would have seen this and probably use this to cross the Mahim Bay. So, it is an 8 lane wide bridge 5.6 kilometers long and what is important in this structure is that it cut travel time from 1 hour to 7 minutes 29 traffic lights were avoided. About 125000 vehicles use it today and in terms of savings it is estimated that about rupees 100 cores a year in vehicle operating costs are saved.

So, this was a landmark structure in our country where transportation was eased peoples movement in a major city as Mumbai was facilitated by the construction of this structure. It is an elegant structure it is a cable stayed bridge and there are very nice images that show the beauty of this structure. Also I have a note at the bottom which says that the cost increased almost five times. So, this also brings out the fact that a civil engineering project may not be

exactly going as per as the plan. So, there are things that we have to take care of and sometimes if we do not plan well we might end up spending more and that means that we have to justify it and ensure that things go well.

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## Inspirational Projects



### Burj Khalifa (2010)

- Over 828 m and more than 160 stories tall. Has broken many world records.
- Consumed 330,000 m<sup>3</sup> of concrete, 39,000 tonnes of steel rebars, 83,600 m<sup>2</sup> of glass, and 22 million man-hours.
- **Total project cost US \$ 20 billion (tower cost \$ 4.2 billion)**
- 100 year design life. Total built-up area of about 6 million sq. ft.; nearly 2 million sq. ft. of residential space and over 300,000 sq. ft. of office space



N. Subramanian, NBM&CW Jan. 2010

In the project the Burj Khalifa the tallest building in the world is again an engineering marvel over 800 meters height 160 stories high. It is broken lot of world records in terms of material alone you will see the numbers 330000 cubic meters of concrete; 39000 tons of steel reinforcement bars for the concrete, concrete has to be reinforced we will talk about it more in detail 83000 square meters of glass in the facades.

So, in most new buildings now you see glass on the facade and the Burj Khalifa is not an exception, 22 million man hours that is 22 million hours of people were used in the

construction. So, you can imagine the effort in managing all this, making sure that everything runs according to schedule and is done properly.

The cost was about 20 billion US dollars and it was designed for a hundred year lifespan. Now, most structures which respond to people's needs were people generally use would have now a design life of at least hundred years and this is no exception. The built up area was six million square feet and it is also now become the symbol of Dubai where it is located.

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## Inspirational Projects



### Palm Island Trilogy

- Three islands Palm Jebel Ali, Palm Jumeirah and Palm Deira were created to solve Dubai's beach shortage.
- They add 520 km to the existing 60 km of beaches in Dubai.
- The first two consisted of 100 million m<sup>3</sup> of rock and sand whereas Palm Deira will comprise of 1 billion. All materials were quarried in UAE itself.

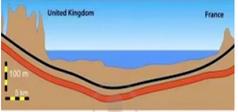


Also close to Dubai another engineering marvel was construction of land where there was no land. So, Dubai wanted more of coastline wanted more of land, so they just created islands and these islands are so big that in the Google map or the satellite image you can see this. So, these are large structures they added about 522 kilometers of coastline to that of Dubai, the first two islands used 100 million cubic meter of rock and sand.

So, in the sea islands were constructed and on these islands have come up buildings houses hotels and so on. So, civil engineering is so powerful that you can create space for living and in this case on the sea and where there was no land.

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### Inspirational Projects



Wikipedia

#### The Channel Tunnel (1994)

- 50.5 km undersea tunnel linking England with northern France. At its lowest point, it is 75 metres (250 ft) deep.
- Two rail tunnels and a service tunnel.
- **The Channel Tunnel was completed at a cost of \$21 billion.**
- In the first five years of operation, trains carried 28 million passengers and 12 million tons of freight through the tunnel.



Civil engineering also can take you under the sea and this is a very good example of the channel tunnel linking England to France a 50 kilometer tunnel going under the sea linking the two land masses, the lowest point is about 75 meters. So, it goes under the sea to a maximum depth of 75 meters it costs about 21 billion us dollars and it saved or it helped 28 million passengers just in it is first five years, 12 million tons of cargo went through the tunnel in the first five years.

So, instead of using a ferry instead of having to ship things between England and France, now people could use this tunnel and just drive through and have a train passing through. Again

you can imagine the difficulties the challenges of having a tunnel that is going under the sea. Obviously, it should go correctly in the direction that you want it should not leak it should not collapse, you have all this mass of water on top of it and you have the soil all set the support, so again very very challenging inspirational structure.

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## Inspirational Engineers



### M. Visvesvaraya (1860-1962)

- He implemented an extremely intricate system of irrigation in the Deccan area. He also designed and patented a system for raising the storage in a reservoir without causing any damage to the dam.
- He designed a flood protection system for the city of Hyderabad and a system to protect Visakhapatnam port from sea erosion.
- He supervised the construction of the Krishna Raja Sagar Dam across the Cauvery River. This created the biggest reservoir in Asia, when it was built in 1924.



Wikipedia



People also have been very inspirational I will start with M Visvesvaraya who is said to be the best or the most famous civil engineer of our country. So, he was involved in irrigation structures flood protection structures, he implemented the irrigation system in the Deccan area designed a system for having storage in a reservoir or increasing the storage in a reservoir without causing damage to existing dams.

For the city of Hyderabad he created a flood protection system and for the port of Visakhapatnam he made a system to prevent the port from getting eroded by the sea. He

personally supervised the construction of the Krishna Raja Sagar dam across the Cauvery river and when it was built it was the biggest reservoir in Asia. So, we look up to him as Indian civil engineers to see how we can keep this legacy going.

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## Inspirational Engineers



### Fazlur Khan (1929-1982)

- Considered to be the Einstein of Structural Engineering for his innovative use of structural systems that remain fundamental to modern skyscraper construction.
- His most famous buildings are the John Hancock Center and the Willis Tower (formerly Sears Tower), which was the world's tallest building for several decades.
- His design innovations significantly improved the construction of high-rise buildings, enabling them to withstand enormous forces generated on these super structures.



Wikipedia



There are many people around the world that we can look up to one other person is Fazlur Khan who made who became famous as in structural engineering and who was even called the Einstein of structural engineering. For his innovative use of structural systems his famous buildings were the John Hancock Centre and what is called now is the Willis Tower earlier it was called the Sears Tower and for a long time it was the tallest building in the world.

And he came up with the system where he used bundles or tubes of steel, these were large tubes which made up the whole structure and with this steel buildings could be made very very tall, they could be strong they would not deflect or move or sway and provide the space

that we required. So, for a long time tall buildings were made along according to his method of construction, this has now been transferred to the new hybrid systems of construction where you have concrete and steel like at the Burj Khalifa. But for a long time the methods of Fazlur Khan were used for all the tall buildings of the world.

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## Inspirational Engineers



### Stephen Bechtel (1900 -1989)

- His imagination was fired by grandiose projects - the more seemingly impossible the better.
- Primary manager in the building of Hoover Dam in the early 1930s. In the course of five years workers excavated 3.7 million cu. yds. of rock and poured 4.4 million cu. yds. of concrete.
- His company built pipelines and power plants in the Canadian Rockies, across the Arabian desert and through South American jungles. His portfolio even includes an entire city (Jubail, Saudi Arabia). Bechtel built in 140 countries and on six continents.



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In terms of management a name that is very important is Stephen Bechtel, who was a construction manager per excellence. He always it is said wanted to take a projects that everybody said was impossible, he wanted to make the impossible better and durable he was the main manager in the Hoover Dam. The Hoover Dam was built in the 1930 in the united states, excavation of 3.7 cubic million cubic yards of rock they pored 4.4 million cubic yards of concrete massive structure in a very remote area to provide water.

His company which is even today existing and very popular build pipelines power plants in the Canadian Rockies, built structures in the Arabian desert and in the South American jungles. In a variety of environments he even has had built an entire city the city of Jubail in Saudi Arabia. Overall Bechtel was involved in construction in 140 countries and 6 continents. So, he was a construction manager who could execute anything everywhere practical.

So, I will stop there for now and what we have seen in this lecture is what civil engineering is broadly about, what civil engineers have to do what has been done and what we can look forward to. I will see you in the next lecture where we will talk about the different specializations of civil engineering and give examples of what these specializations do and deliver.

Thank you.