Ocean Structures and Materials
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Module - 3
Lecture - 11
New materials for coastal embankments 2

Ladies and gentlemen, today we will discuss the eleventh lecture on third module on the course Ocean Structures and Materials under the braces of NPTEL, IIT Madras.

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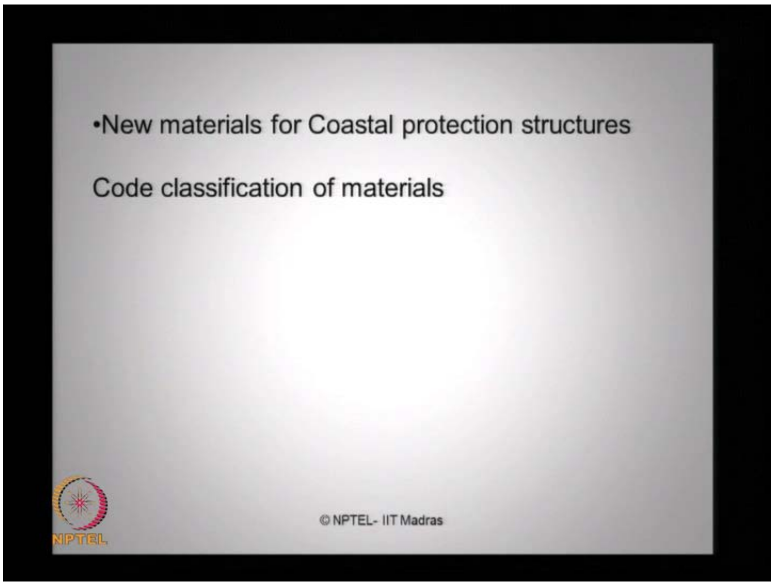

In this lecture, we will discuss new materials which are applied and used for coastal protection structures, and also we discuss some code classification of materials, how they have been selected and recommended by various international codes for offshore applications.

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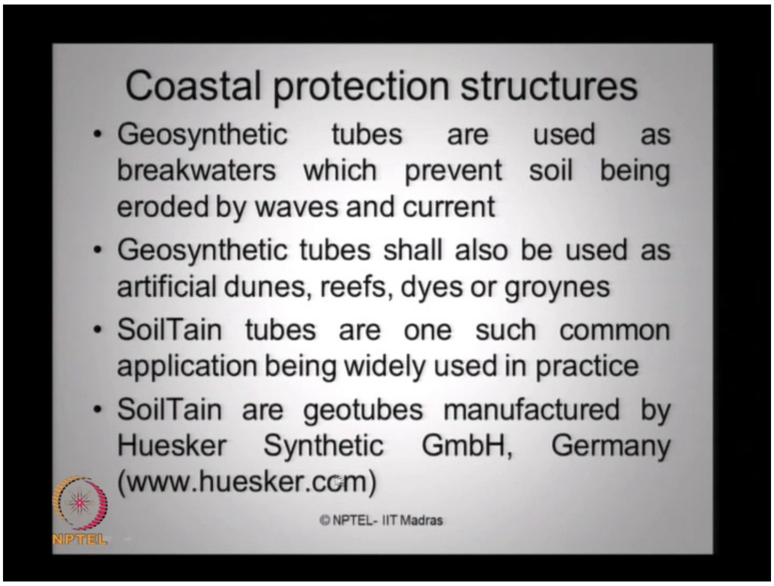

Let us first talk about different new methods and materials being applied for coastal protection structures. Geosynthetic tubes, as we saw in the last lecture, are also more frequently being used as breakwaters, which prevent soil being eroded by waves and current. Geosynthetic tubes shall also be used as artificial dunes, reefs, dyes or groynes. In this lecture, I will show a case study photograph where the width of the groynes is been extended using a geosynthetic tube. SoilTain tubes are one of the most such common application being widely used in practice. SoilTain are nothing but geotubes which are manufactured by Huesker synthetic GmbH, Germany where we can see the references from this specific website.

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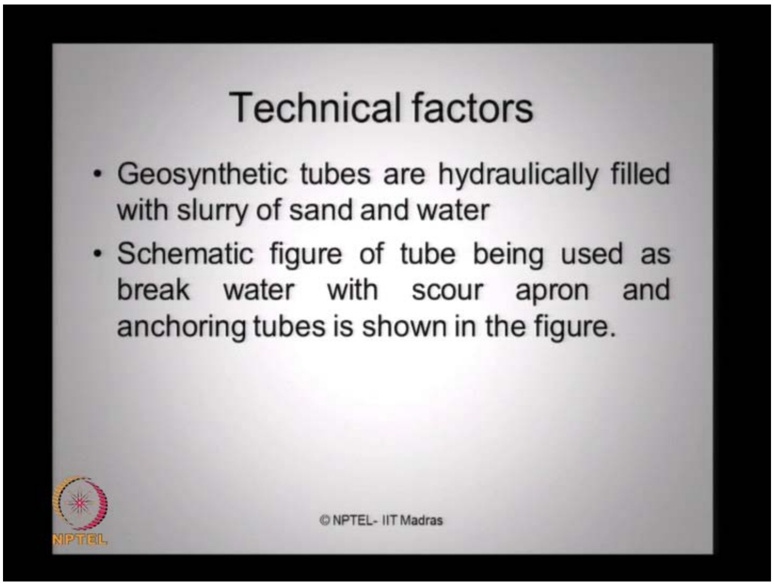

Now let us see those technical factors, which will govern or which will show advantages of using new materials like geotubes for coastal protection structures. Geo synthetic tubes are hydraulically filled with slurry of sand and water. The schematic figure of tube being used as breakwater with scour apron and anchoring tubes will be shown in to a following figure.

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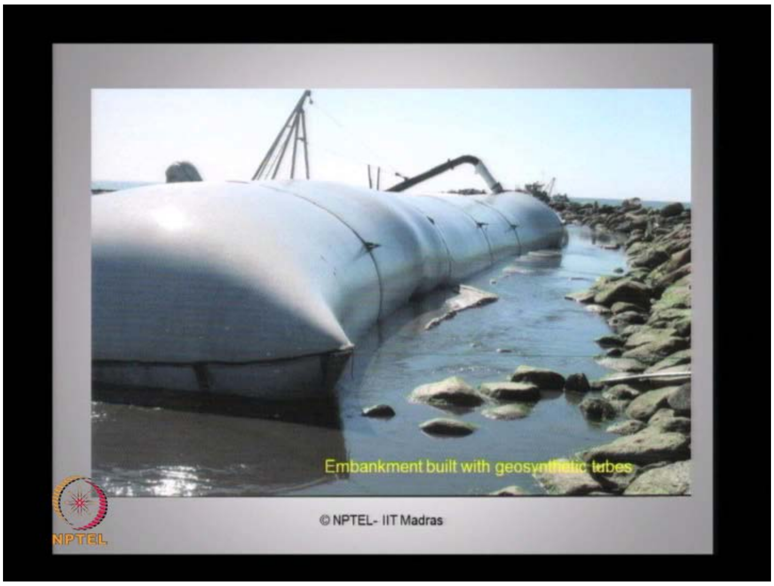

We can see here, this is geosynthetic tubes, which is filled with slurry and sand which is acting as at temporary breakwater along the groynes. The embankment which is built with the geosynthetic tubes is what you see in the photograph.

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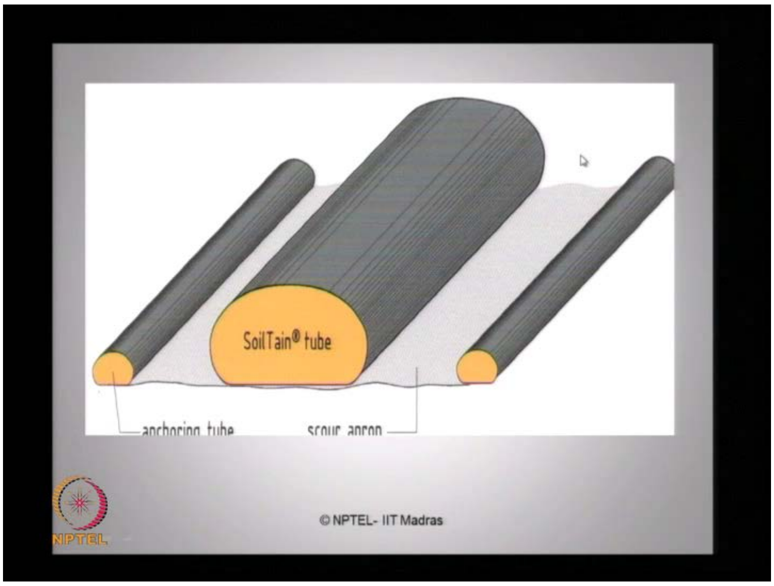

We can see a another photograph which show a schematic view of how the geo synthetic view can be used in addition to an anchoring tube and a scour apron as they are require in case of breakwater. So, we can see here that a new novel material like geo synthetic tubes which has been started applications in break waters as anchoring tubes as well as covering aprons to protect soil erosion along the be soil.

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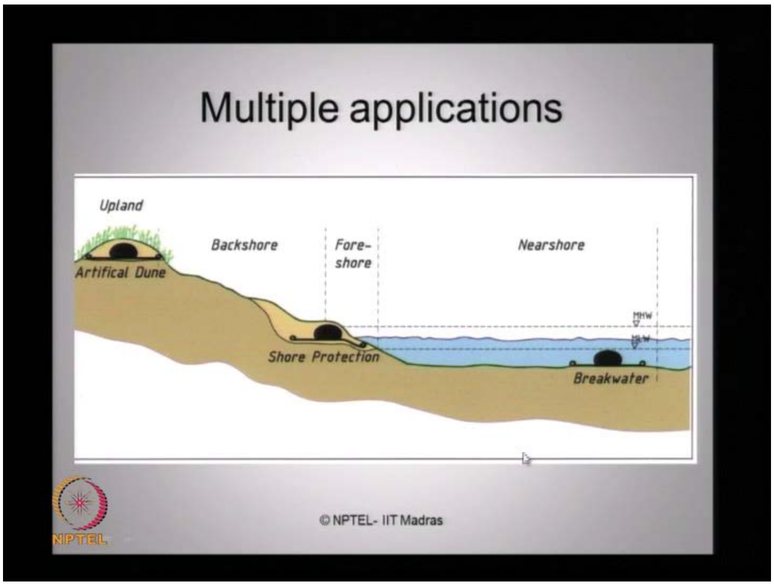

They also have multiple applications as you see in the literature. For example, we can also have breakwaters, which are submerged below the low tail level using geo synthetic tubes. As you see in the figure, which can be in near shore application. For a foreshore, application lines can again use them as shore protection as you see in this location in case you want to protect them backshore, we can also use them as artificial dunes, which are covered with rubble mounded moss which are again cover with beautiful with nature of legislation on the upland. So, geo synthetic tubes in the recent practices have been applied to as an attempt to try in submerge breakwaters, as shore protection structural systems and also for artificial dunes, so that they have multiple applications in the recent parts.

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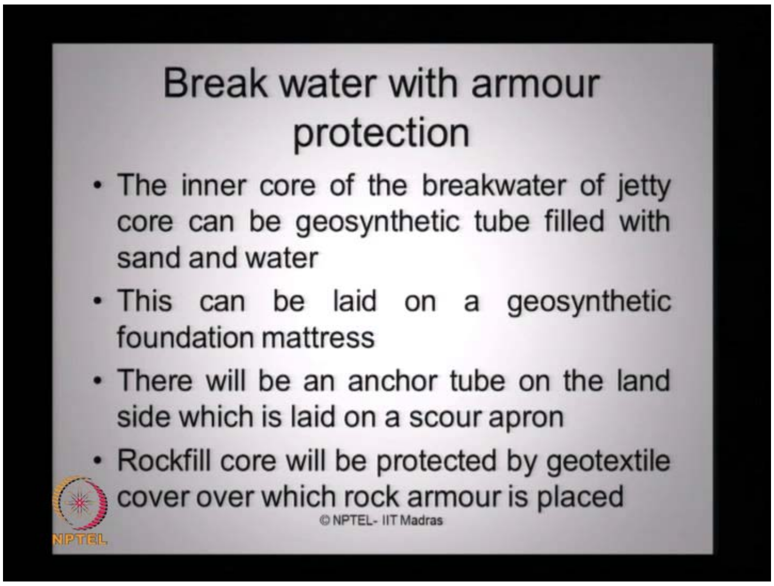

Let us look at the breakwaters with armour protection which is being recently attempted with geo synthetic tubes. The inner core of the breakwater of jetty can be geo synthetic tube, which is filled with sand and water. This can be laid on a geo synthetic foundation mattress, they drain away they eroded water. There will be an anchor tube on the land side which is laid on a scour apron. The rock fill core will be protected by the geotextile cover over which the rock armour is placed.

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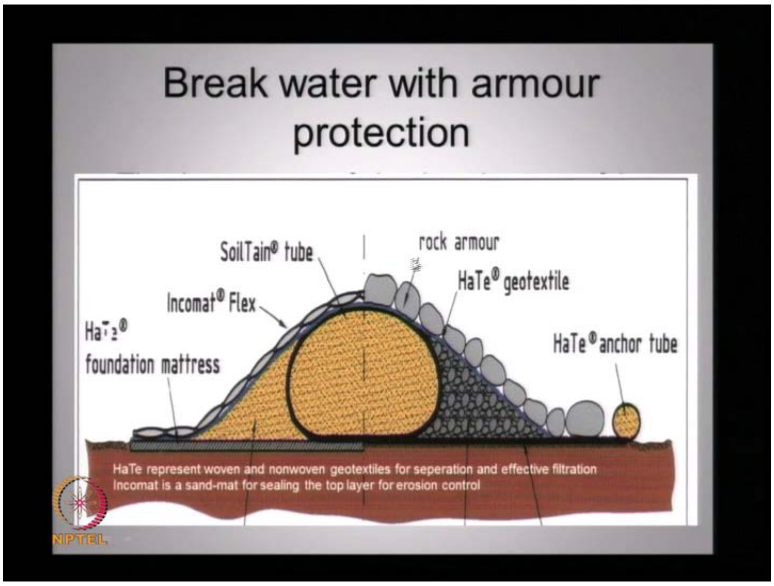

Ladies and gentlemen, this is one of the recent application which has been used in Australia. This is a geo synthetic tube which is cover by a rock armour as you see in the top and below the rock armour which is covers a geo synthetic layer, you have got a geo textile. H a T e is the branded name of the geo textile, which is actually represent woven and nonwoven geo textile for separation and effective filtration of the water when they fly over and flow over this arrangement. On the anchor side, you got H a T e, which is specially woven and nonwoven textile which is provide as an anchor tube whereas, on the other end you have got the foundation mattress which is being laid using again H a T e nonwoven fabric. The incomat flex is again a sand mat, which is used for sealing a top layer for erosion control.

If you want to control the erosion on this downward slope, I have to provide sand mat, seals of the top layer and protects the top layer from the further erosion. This is one of the reason combinations of geo synthetic tubes which have been used for breakwater with armour protection as you see on one side using a rock armour.

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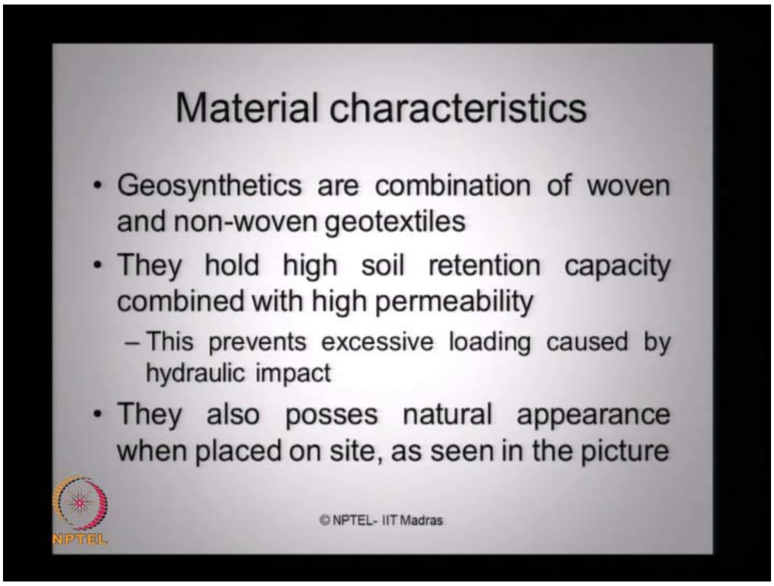

Let us quickly look at the different material characteristic, which has been used in modern construction practice for a coastal protection structure. Geo synthetics are combination of woven and nonwoven geo textiles. They actually hold a very high soil retention capacity combined with very high level of permeability. This prevents excessive loading caused by hydraulic impact on such structure. They also possess natural appearance when placed on site as you seen in the photograph.

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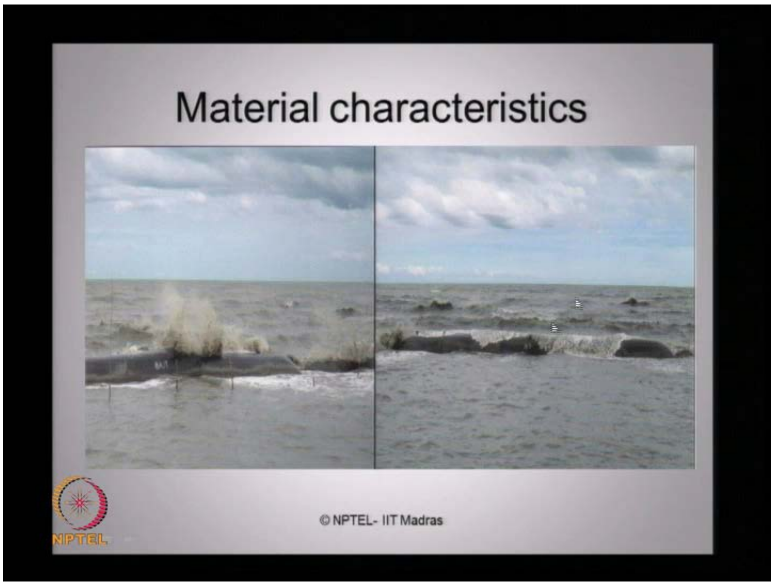

Now I got geo synthetic tubes, which has been placed on a site and they actually merged with elevation sea surface what you see in the gray color. So they get amalgamated in nature, so that you may not use in notice then the artificial layer which has been provide as the protection layer for the coastal site as they get merged with the sea states.

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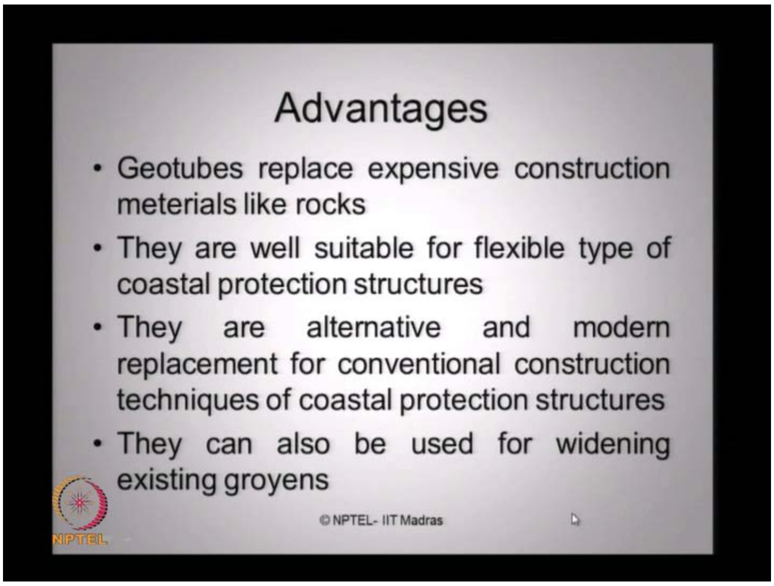

There are salient advantages of using these kind of new materials as coastal protection structures. Geo tubes replace an expensive construction material like rocks; that is the one important advantage again by using a geo textiles for coastal protection system. Secondly, they are very well suitable for flexible type of coastal protection structures. Ladies and gentlemen, in this last lecture, we saw a specific site which has a very requirement of soil pore pressure which demands a very flexible system. In such cases, I cannot use a gravity type rubble mounded system which does not dissipate energy at all because of its rigidity; however, geo tubes has found extensive replacement, because they are very flexible type of coastal production structure. They are alternative and modern replacement for conventional construction techniques for coastal protection structures in the recent past. They can also be used for widening existing groyens, which is also one of the great advantages.

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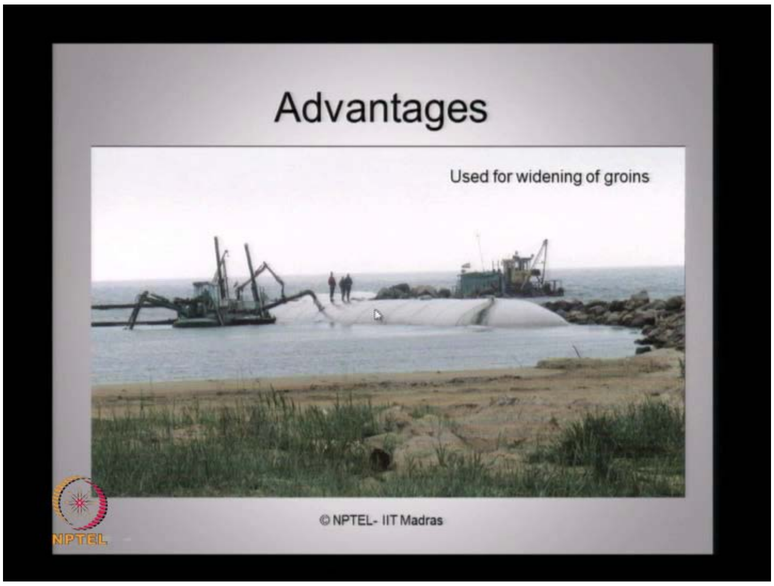

There is photograph here, which has been taken on a site where the existing drawing seen here has attempted to be widened using geo tubes.

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The next application of modern construction material in ocean structures is actually dewatering of dredged material. We will talk about dredging in a separate module later; however, when the dredge material is collected, it is very important that the dredge material should be content completely with dewatering arrangement. There are new methodologies, which can be used for dewatering the dredged sludge using geo textile tubes, which we will see now in detailed application. Again the applications are recommended and been as you see in the specific website of huesker.

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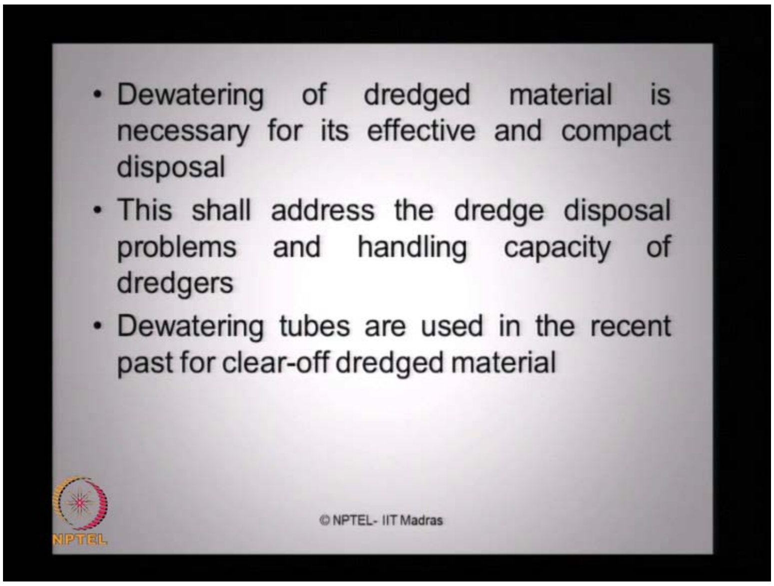

Dewatering of dredged material is very important for its effective and compact disposal, because dredging is again a serious manners in case of bridge (( )), but however disposing the dredge the material is also equally important. When the dredge material is volumeness because of water content present in it then the compact of disposal becomes a serious issue. So, it is very important that dewatering of this material should be carried out for its compact disposal. This shall address two problems, one - the dredge disposal problems. Secondly, the handling capacity of dredgers, because if the volume of dredge sledge is very high and a cumulative, you need to have large capacity of dredges which are to be higher on the site.

So, if you are able to dewatering the dredge sledge and make it compact then dredge disposal problem can be addressed in a very effective manner as well as the handling capacity of dredges can also be relatively reduced. Therefore, it is interesting that the recent past one can see dewatering tubes have been used for clearing off the dredged material.

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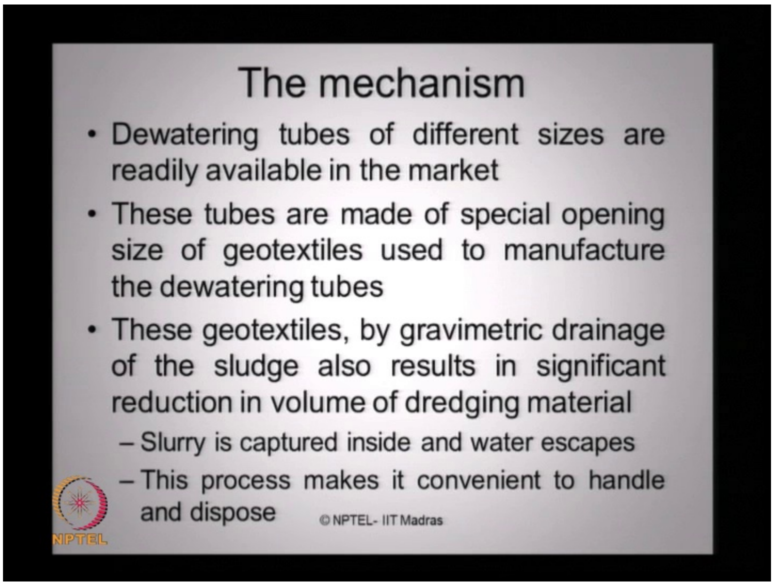

Let us quickly see how this mechanism works. The mechanism consists of placing dewatering tubes of different sizes, which are readily available in the market. These tubes actually are made of special opening size of geo textiles which are used to manufacture the dewatering tubes. These geotextiles, by gravimetric drainage of the sludge also results in significant reduction of volume of dredging material. However, you are interesting to know slurry is captured inside a geosynthetic tube and water escapes from the tubes by the narrow pores present in the geotextile layer. This process makes it convenient to handle the dredge and dispose it in a very compact manner.

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This is the photograph of a typical dewatering tube as you see here which has been laid we will talk about the mechanism now.

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There are different stages of operation when you want to carry outing dewatering of dredge material. It is a four stage of process as now understand. The first stage is filling of the geotextile tube; the geotextile tube is filled up with processed dredging material which you want to dewater. The geotextiles confines the solids only. During this process, the water is escaping from the tube a filter cake of the dredging sludge is formed at inner surface of the geotube. Since the geotextile enable water to drain completely, but retain solid during this process there is a possibility that the formed cake gets completely dried, so a thorough dewatering happen in the second stage.

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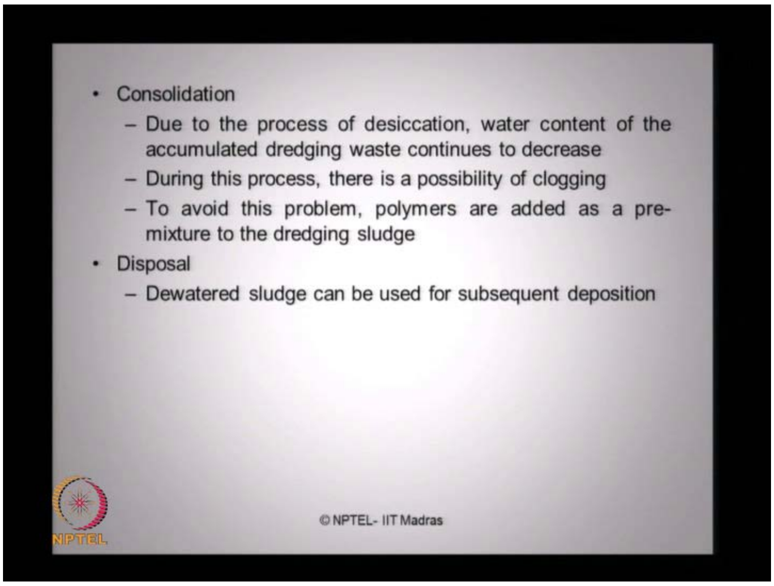

In third stage, we have a consolidation process where due to the process of desiccation, water content of the accumulated dredging continues to decrease from the geotube. During this process, there is a possibility of clogging. To avoid this problem, there are certain polymers are added as a pre-mixture to the dredging sludge, before the sludge is filled in geo synthetic tubes. Then the fourth stage is disposal of this dewatered sludge, which can be used for subsequent deposition.

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You can see here from this photograph before geo tubes are filled with dredging sludge for dewatering a drainage base as you see here need to be prepared. The figure clearly shows the preparation of a water collection tray which is got different drainage arrangement from where the drained water is taken away from the site and such arrangements are provided as long as periphery and its corner of the drainage bases.

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This is the very interesting photograph taken on site where the geotube drainage water is clearly seen, we can see here only the drain sludge is noted and the water has been completely percolated and drained of from the content.

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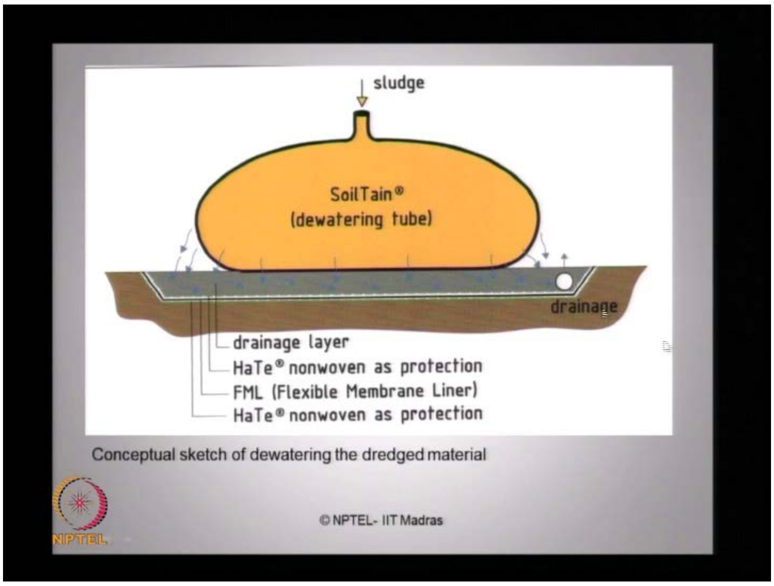

This is a schematic conceptual sketch which shows how dewatering takes place from the dredged material. When you fill it in the dredge sludge dewatering tube because of the pore present in the tube, the water gets exit out from the tube which compacts the sludge and forms a cake inside. This water which is escaping from the dewatering tube passes through a drainage layer which is again laid over a nonwoven geotextile layer as a protection, and there is a flexible membrane layer which is housed between a nonwoven layers to protect the flexible membrane layer. And this is a drainage arrangement what is see here which is drains out the water from the dewatering tube. Of course, there are extensive numbers of dewatering drains available separately on a drainage area which is exits out this water and collected later and then dispose of safely.

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The photograph now you see here is a geotube, which is filled with dredging material which is ready for dewatering arrangement. This is place on the drainage layer as you see here for dewatering and all these pores what you see here these are all nothing but the escape roof for drained water to come out from the drainage layer. As we understand in recent development of material which can be used for coastal protection structure as we saw in the last two lectures; interestingly modern material like geosynthetic has been widely applied and being practiced with different innovative design methodology is for coastal protection system. Now the fundamental question comes, how the code classified in different material for offshore and ocean structures.

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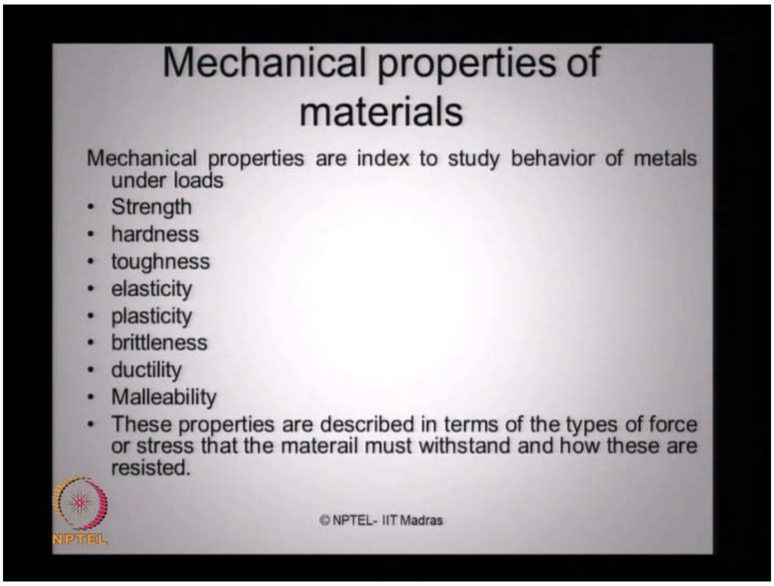

If you look at the coastal classification essentially looking at the property of the material the mechanical engineering point of you are very important. The mechanical properties are considered to be important indices to study behavior of metals under different load combinations. If you look at the different properties which are very important for selection of material as recommended by the codes, let us try to understand what are those properties which are important or the properties based on which code classify material for construction purposes in marine environment. The foremost property what code generally looks at while classifying a material is a strength. Followed by which is hardness, toughness, elasticity, plasticity, brittleness, ductility and malleability. These properties are of course, described in terms of the types of forces or stress that the material must withstand and how these are resisted upon.

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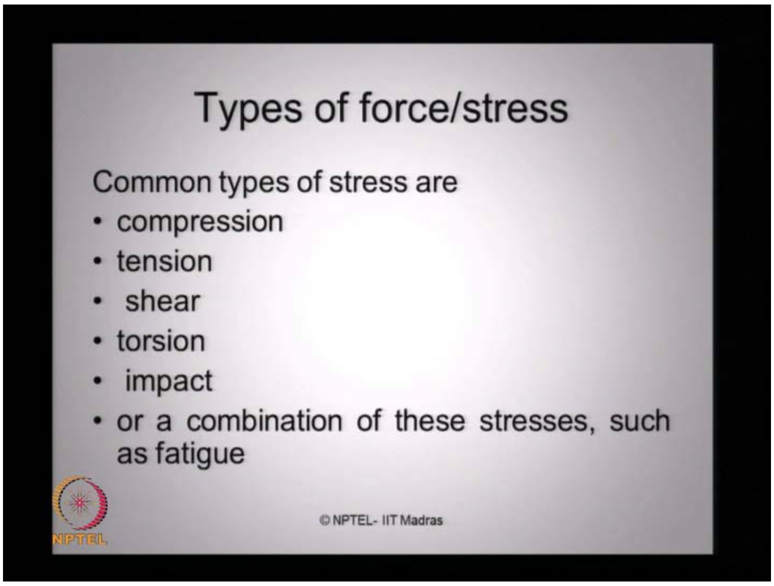

There are different types of forces and stresses that act on material, when they are housed in construction for offshore structure. Common types of stress which are see in material are the following - compression stresses, tensile stresses, shear, torsion, impact or a combination of these stresses such as fatigue.

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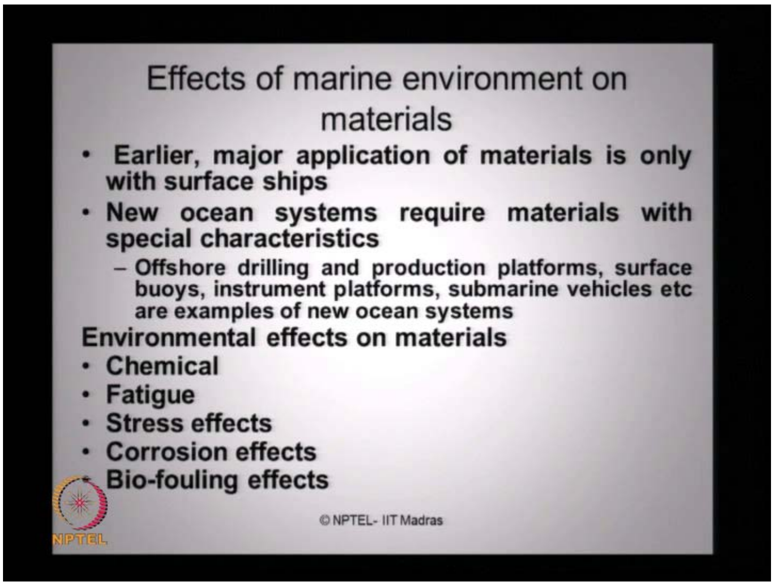

Now let us see quickly what are the effects of marine environment on these materials, because it is important to know what are the consequences of the marine environment on these materials, if you really know how to select the material for construction techniques in marine environment. Earlier if you look at the literature, major application of materials is only with surface ships. However, the new ocean systems, they require and start demanding material with special characteristics. We are seen such example in the past few lectures, where geosynthetic, geotubes, geotextile, woven textile and geotextile are used for coastal protection structure and saline embankment.

So, offshore drilling and protection platforms have been in the constant innovation for placing them in ultra- deep waters. Surface buoys which have been also been currently used for wave energy generation devices. Instrument platforms have been used for constantly monitoring the performance of offshore structure under different sea state. Submarine vehicles, autos AOVs, ROVs etcetera are very classical examples of new ocean systems which demand new type of construction material with special characteristics. If you summarize environmental effects on materials very quickly, we will understand that the environment has serious effects and materials like chemical attacks and fatigue problems, stress effects, corrosion effects, bio-fouling effects these are some serious of chronological problem which environment imposes on materials in marine structures.

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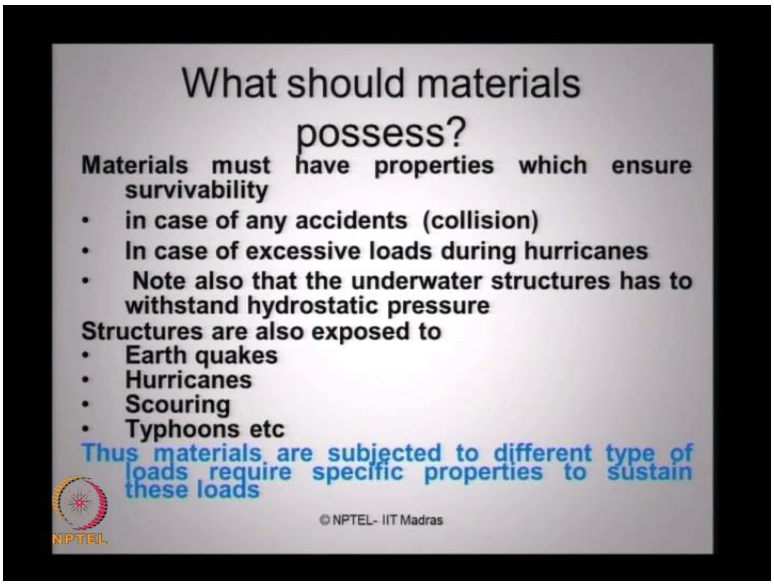

Therefore, the fundamental question that comes to the mind is what should those basic properties which is to be possessed by the material. You may wonder why we are talking about the property of materials as we got to address the coastal communication. Ladies and gentlemen, it is very important to understand first let us see those characteristics which are vital for selection of material then we see how the code classified them based on these characteristics. So, let us have a fundamental question to be answered what should the materials possess to qualify it for marine application. The materials must have the following properties, which ensure basically the survivability of the materials; in case of any accident that is for an example, in case of any collision, in case of excessive loading due to hurricanes or during un force in events. Note also that the underwater structures have to withstand very high hydrostatic pressure.

Ladies and gentlemen, it is interesting for all of us to understand and agree the structures are also exposed to the combination of earth quakes, hurricanes, scouring, typhoons etcetera when they are placed in marine environment. Therefore, these materials are subjected to different type of loading require specific properties to sustain these loads; hence it is very common to agree upon that the specific property cannot applied on average all kinds of material. So that material selection must be thoroughly based on application on which the material got to be used for marine environment, because the forces, the sea state, the conditions and the effect of environment on the material differ as have been used in different location.

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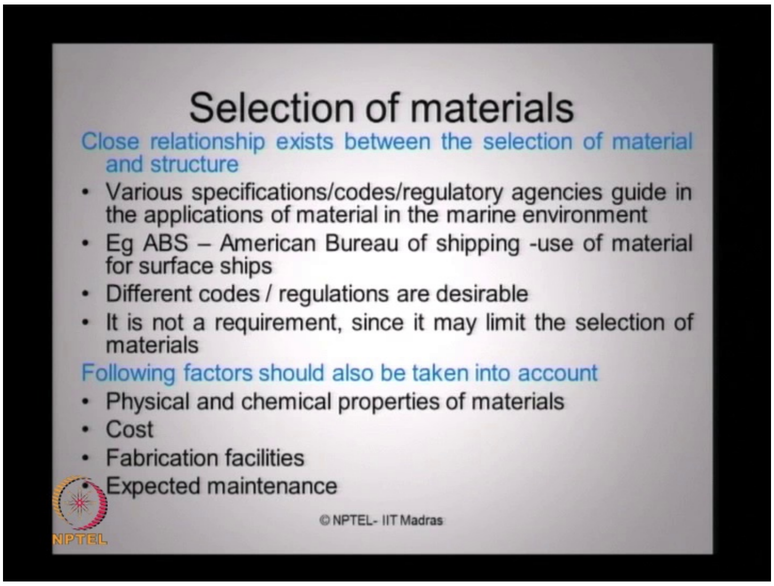

Let us look at the selection of materials now very quick the first module we discuss about this detail, but to have the advantage of viewer we summarizing it fast in this lecture. So, we also cross co related this with international code and selection criteria given by the international codes. Ladies and gentlemen, we all agree thatclose relationship exists between the selection of material and the type of structure where in used in construction. Various specifications, codes, regulatory agencies are used only as a guide in the applications of material in the marine environment. For example, ABS which American Bureau of shipping; this recommends use a material for surface ships. Different codes regulations are desirable, so that one can consult the wide variety of course application of them in offshore structure. However, it is not a requirement since it may be a limit of selection of materials. So, the following factors should be considered while we select material for marine applications. Physical and chemical properties of materials, cost factor, fabrication facilities, expected maintenance, may be important factors which we consider before we select the material for offshore applications.

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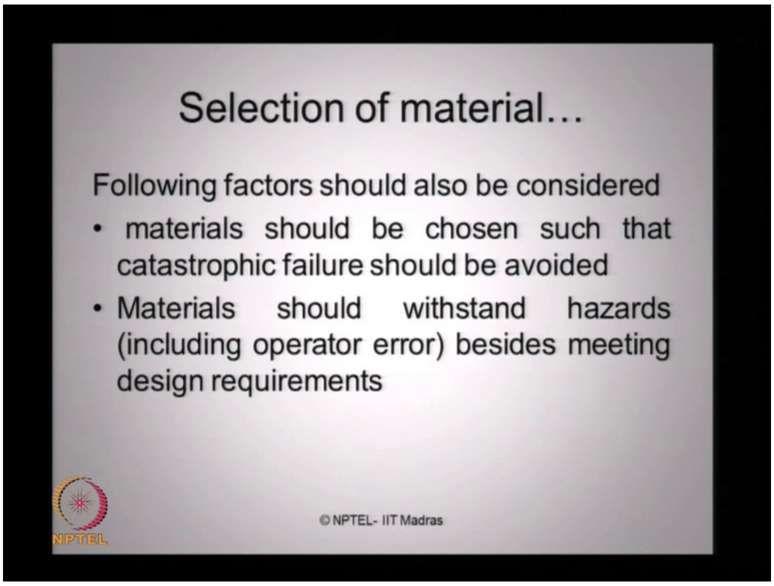

In addition, ladies and gentlemen, following factors should also be considered. Materials should be chosen such that the catastrophic failure should be avoided. Materials should withstand hazards including operation error besides meeting the design requirements.

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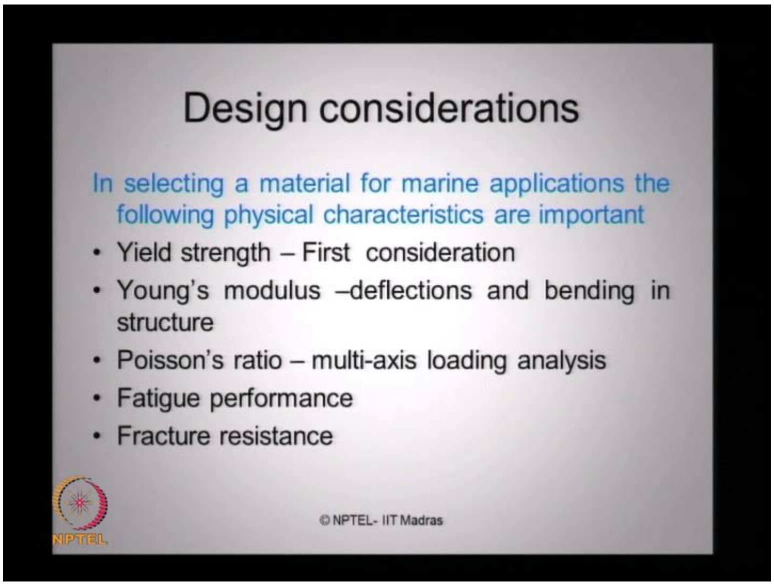

Now let us quickly summarize, what are those design considerations which one must understand before selecting material for marine application based on international codes. In selecting a material for marine applications, the following physical characteristics are very important in design point of view. For example, yield strength is the fore most consideration one must think of. Secondly, will be Young's modulus, because this will govern the extent of deflection in blending moments coming to the structural system. Of course, Poisson's ratio is very important as we are talking about multi-axis loading analysis for offshore structures. Fatigue performance is important because there is always high probability, the forces get reversed though the magnitude may not be higher, but the cycle of reversal is very high in the random scenario in sea states. We also have to have the enough fracture resistance of the material as one of the important consideration for using it in offshore structures.

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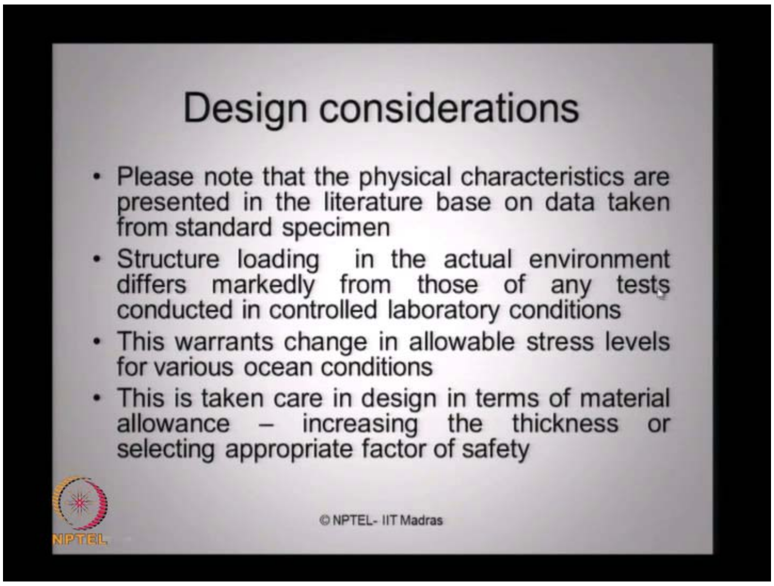

Kindly note that the physical characteristics which are, given in the literature are based on the data taken from a standard specimen; however, the specimen what you use for construction may differ the structure loading in the actual environment differs markedly from those of any tests requirements and test conditions conducted in a controlled laboratory conditions. So, what does it mean? How does it affect the selection of materials? Most importantly this warrants change in allowable stress levels for various ocean conditions; however, one easy and simple methodology which has been used in the design is that, we can increase the thickness of the material or selecting appropriate factor of safety can handle this kind of changing allowable test level which are cost because of various ocean conditions. That is one of the interesting design requirement which we generally follow the design of offshore structure while selecting material basically for them.

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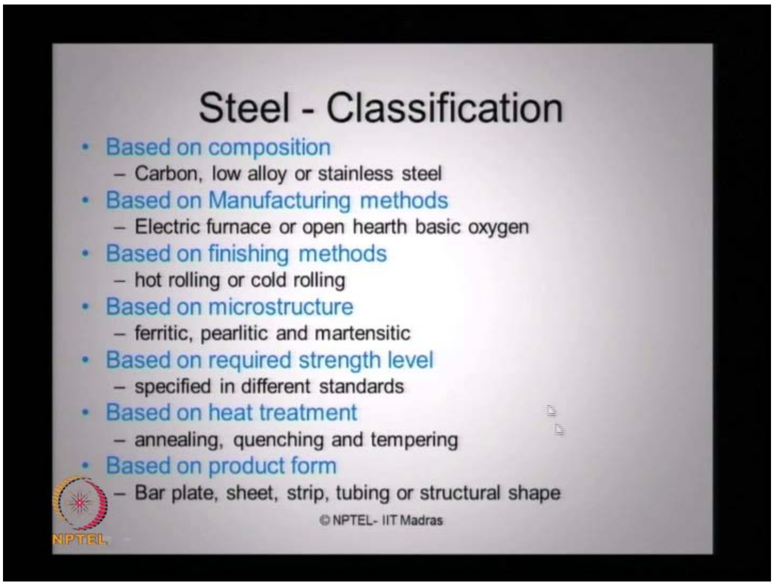

Steel has been a very predominantly common material which has been successfully used in offshore selection materials. It is based on composition, steel are classified as carbon, low alloy or stainless steel. Based on manufacturing methods, like electronic furnace or open hearth basic oxygen material manufacturing method we can classify steel. Based on finishing one can classify, it as hot rolling or cold rolling. Based on microstructure as ferritic, pearlitic, and martensitic one can classify steel. Based on required strength level specified in different standards we can specify and classify steel for applications. Of course, based on heat treatment like annealing, quenching and tempering one can classify steel. And of course, very famously, very commonly steel is also classified based on the product form as bar, plates, sheets, strips, tube or any other structural shape which are very commonly used for marine applications.

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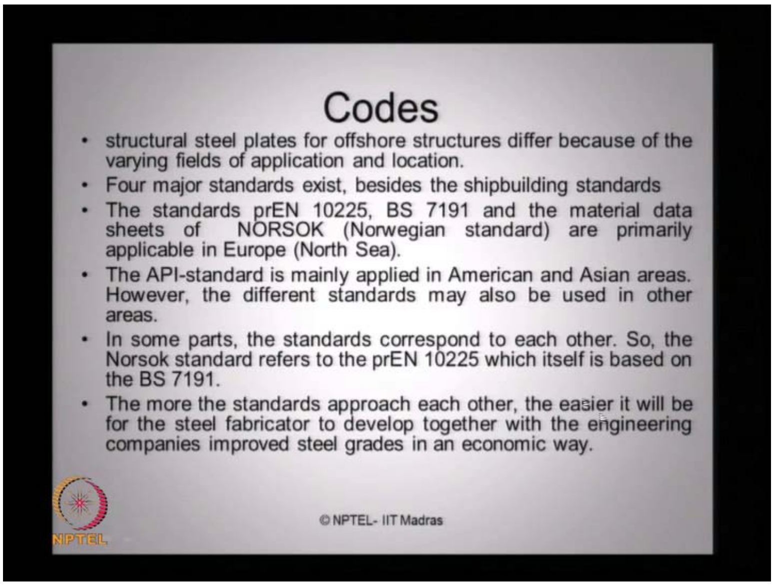

Now ladies and gentlemen, finally, we looked at the codes, what is the recommendation given by the codes, how international codes advise engineers to select material for marine environment. Structural steel plates for offshore structures differ because of the varying fields of application and location. Four major standards exist, besides the shipbuilding standards for selection of structural steel plates for offshore construction. The standards like prEN 10225, BS 7191 and the material data sheets of NORSOK are primarily applicable in Europe and Norway or North Sea which can be used as one of the primary code reference for selection of material. However, American petroleum institution standard can also be used essentially and predominantly in American and Asian areas. Different standards may also be used in different areas; there is no water type requirement of selecting a specific standard for specific location. In fact, in some parts, the standards correspond to each other; in some class, some of them refer to the same argument repeatedly. For example, the NORSOK standard refers to the prEN 10225 which itself is based on the BS 7191.

So, there has been mutual agreement between different international codes which has been used commonly for selection of material for offshore structures. More interestingly as an engineers, we must agree that more the standards approach each other more commonly and agree upon, it is easier that the steel fabricator to develop together with an engineering companywhich can use or which can result in improved steel grades in a more economical manner. So, it is always advisable and better to have a mutual and common agreement of certain properties of material to be used for offshore structure which has been agreed upon by different codes as listed here.

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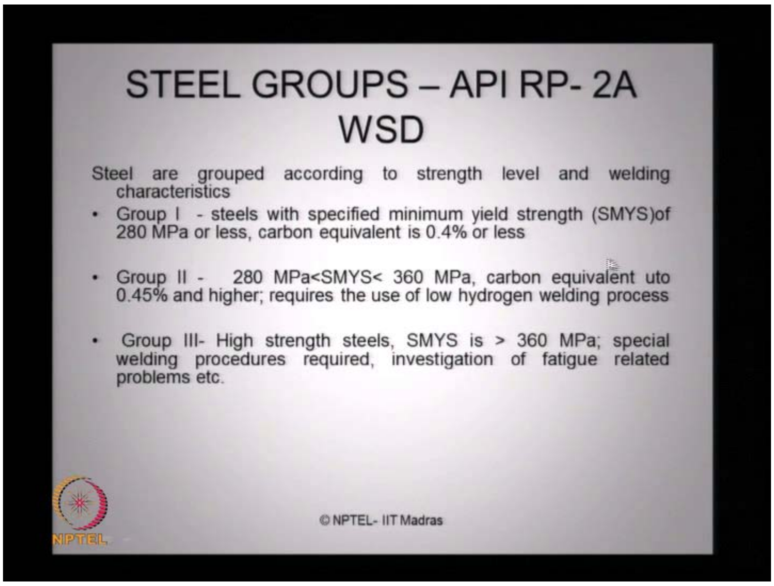

Now the fundamental question which comes to our mind is how codes classify steel for offshore applications. Steel groups are done using API RP 2A working system design method. Steel are grouped according to the strength level and welding characteristics. For example, group 1, group II and group III. Group I, steel specified minimum yield strength of 280 MPa or lesser than that and also the carbon equivalency is about 0.4 percent. Talk about group II, it varies from 280 to 360 mega pascal, the carbon equivalents is about 0.45 or higher. Whereas, group III is meant for high steel strength whose yield strength is higher than 360 mega Pascal, of course, you have to recommend certain special welding procedures, if you want to investigate fatigue related problems in this particular type of steel.

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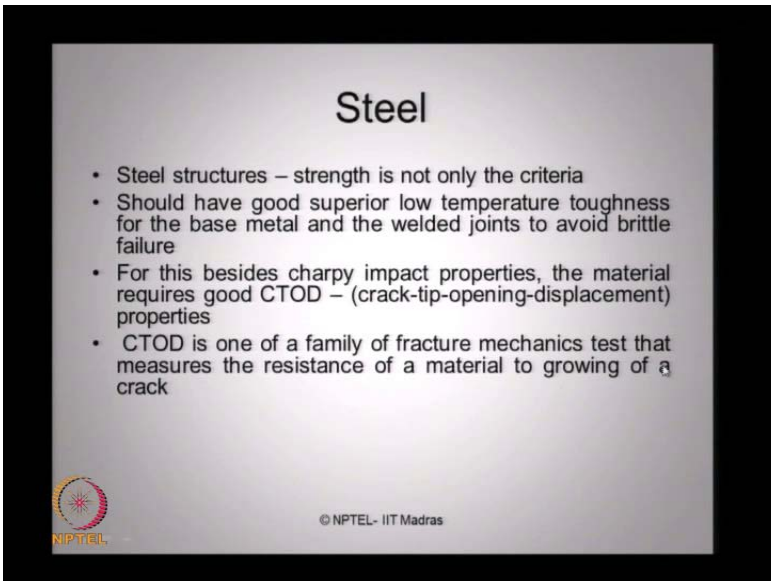

Steel structures are most commonly used offshore structural system. Strength is not only the criteria steel structure should also have superior low temperature toughness for the base metal and the welded joints to avoid essentially what we see as brittle failure. For this besides charpy impact properties, the material should also possess good CTOD capacity. CTOD is nothing but crack -tip-opening-displacement characteristics. CTOD is one of the important properties of a family of fracture mechanics that measures the resistance of a material to growing of a specific crack or to see how crack propagate when it is already initiated.

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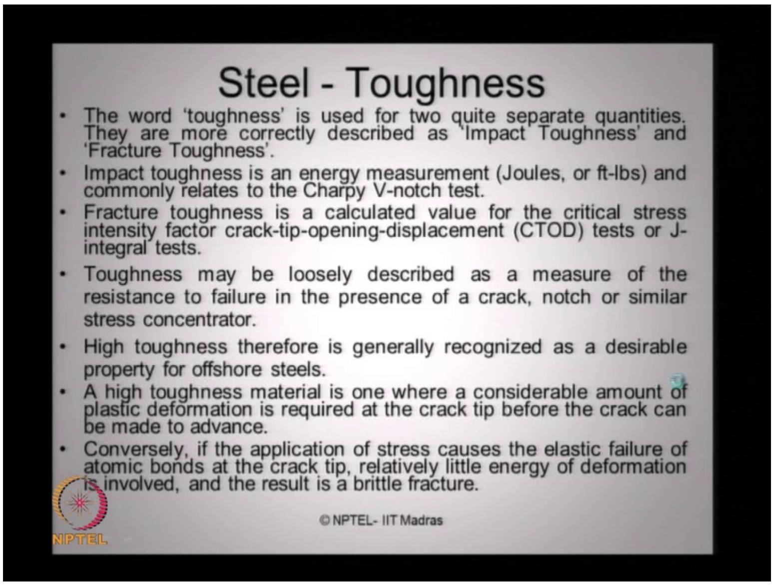

Let us look at the toughness of the material steel for application of offshore structures. The word toughness is used to quite understand two different formats; one is impact toughness, other is fracture toughness. Impact toughness is an energy measurement, which is generally given in joules or ft- bounds and commonly relates to the Charpy V-notch test. Whereas the fracture toughness is calculated value based on the critical stress intensity factor crack-tip-opening-displacement tests or what we call J-integral tests in the literature. Toughness may be loosely described as a measure or capacity of the resistance to failure in the presence of crack, notch or similar stress concentrators. High toughness therefore is generally recognized as a desirable property for offshore steels. A high toughness material is one where a considerable amount of plastic deformation is required at a crack tip before the crack can be made to advance further. Conversely, if the application of stress causes elastic failure of the atomic bonds at the crack tip, relatively little energy of deformation is involved and therefore, the resulting failure will be a brittle fracture.

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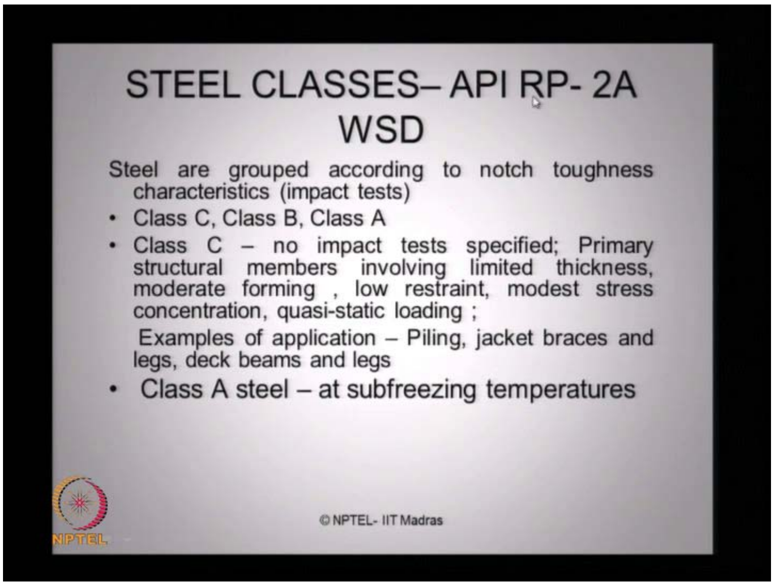

Steel also classified based on API RP 2A using WSD. Steel are also grouped further based on the notch toughness characteristics or the impact test as class A, class B, and class C. Class C do not recommend any impact test specified in the literature of API RP. They are used by primary structural members which involves limited thickness, moderate forming, low restraint, modest stress concentration and generally applicable location where quasi-static loading. Some examples are pilling, jacket braces and legs, deck beams and legs etcetera. Whereas, class A steel can use even at subfreezing temperatures that is a wide range of variety of three classification of steel, which are grouped essentially on the notch toughness requirement as recommended API RP for steel selection for offshore structures.

Thank you.