

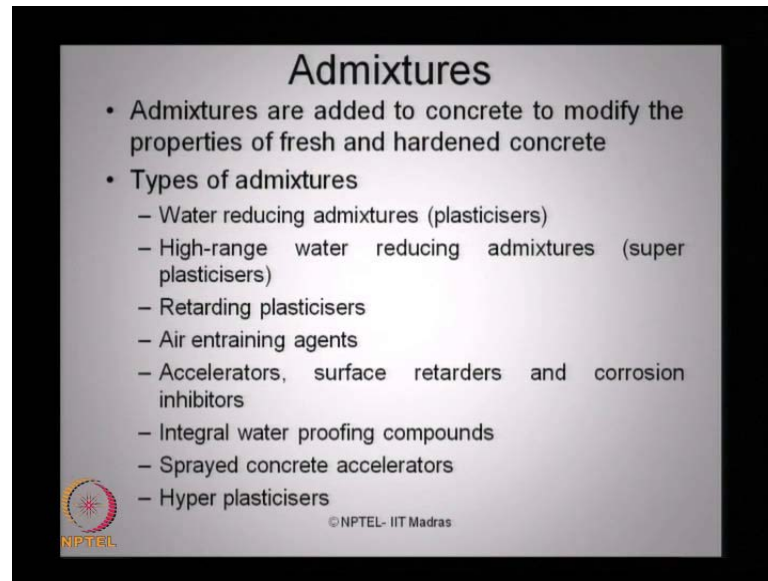
**Ocean Structures and Materials**  
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**Department of Ocean Engineering**  
**Indian Institute of Technology, Madras**

**Module - 3**  
**Lecture - 9**  
**Materials for Special Repair**

On the course on ocean structures and materials, it is clear for all of you that concrete is accepted as one of the famous and popular construction material for ocean structural systems. In addition to steel, as one of the major alternative for the construction material of ocean structural system, we will also see alternative materials other than steel and concrete, but there are problem associated with this material because international collar regulation do not very commonly support these two new kinds of composite materials.

Now, when you look concrete as one of the important and interesting, emerging material for construction in offshore structural systems, there are specific problems associated with concrete as a construction material. Though concrete is a good substitute in terms of strength point of view and service ability point of view, because concrete does not get deteriorated as it is becoming in case of steel because of the corrosive marine environment. But concrete also undergoes corrosive reaction because of the embedded reinforcement in concrete what we have discussed in previous lectures. In this lecture, we will talk about some special kinds of repair and the material attempted to do this repairs in particular for concrete structures that is going to be focus of this lecture.

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The slide is titled "Admixtures" and contains a bulleted list of information. The first bullet point states that admixtures are added to concrete to modify the properties of fresh and hardened concrete. The second bullet point, "Types of admixtures", lists ten categories: water-reducing admixtures (plasticisers), high-range water-reducing admixtures (super plasticisers), retarding plasticisers, air-entraining agents, accelerators, surface retarders, and corrosion inhibitors, integral water proofing compounds, sprayed concrete accelerators, and hyper plasticisers. In the bottom left corner, there is a circular logo with a starburst pattern and the text "NPTEL". In the bottom right corner, there is a small copyright notice: "© NPTEL- IIT Madras".

### Admixtures

- Admixtures are added to concrete to modify the properties of fresh and hardened concrete
- Types of admixtures
  - Water reducing admixtures (plasticisers)
  - High-range water reducing admixtures (super plasticisers)
  - Retarding plasticisers
  - Air entraining agents
  - Accelerators, surface retarders and corrosion inhibitors
  - Integral water proofing compounds
  - Sprayed concrete accelerators
  - Hyper plasticisers

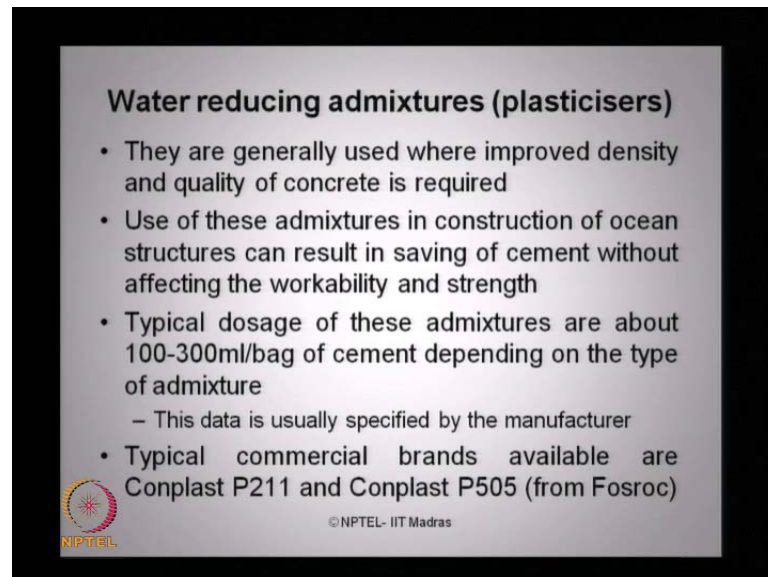
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So, we will speak about materials for special repair of ocean structures in this lecture. There are variety of materials available for special repair addressed to concrete structures in ocean structural systems. Top among them is a very common kind of material, which is called as admixtures. Admixtures are added to concrete to essentially modify the properties of fresh concrete as well as the characteristics of hardened concrete. There are different types of admixtures, which are available in the market which can be commercially available from different manufactures all over the country. They all have different functions; they all modified certain variety of properties to fresh concrete as well as hardened concrete. We will see them one by one in the list has been floated now.

The top among the list is what we commonly use as water-reducing admixtures. This commercially called us plasticisers. There can be high range water-reducing admixtures which are commercially called as super plasticisers. There can be retarding plasticisers. We can also used air entraining agents as additional admixtures in concrete. There can be accelerators, surface retarders, and corrosion inhibitors which can be also used while concrete is being pore in the form work when it is green. There can be also an integral water proofing compounds that can be added to fresh concrete when the concrete is being late. There can be also sprayed concrete accelerators with a specific application purposes on concrete structures. We can also use what we called hyper plasticisers in concrete.


So, ladies and gentlemen, there are varieties of admixtures which are recommended by commercial manufactures of these admixtures at various levels in terms of fresh as well as hardened concrete. Some them are essentially used for a repair or some of them can also be used routine part of the construction activity as well.

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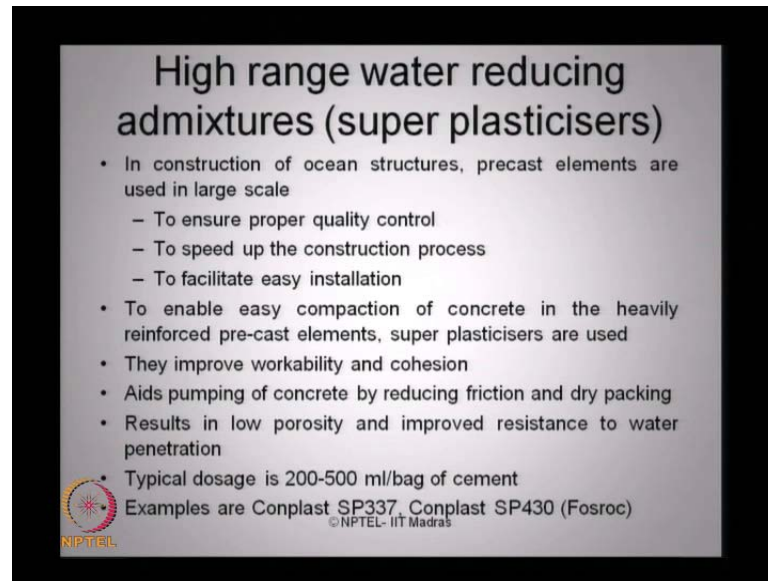
**Water reducing admixtures (plasticisers)**

- They are generally used where improved density and quality of concrete is required
- Use of these admixtures in construction of ocean structures can result in saving of cement without affecting the workability and strength
- Typical dosage of these admixtures are about 100-300ml/bag of cement depending on the type of admixture
  - This data is usually specified by the manufacturer
- Typical commercial brands available are Conplast P211 and Conplast P505 (from Fosroc)

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If you look at the water reducing admixtures which are commonly called as plasticisers, they are generally used where improved density and improved quality of concrete is required. Ladies and gentlemen, both these properties are very vital as well as concrete is consider in ocean environment, because I want to have higher density of concrete as well as the quality of concrete should be at its best. Use of these admixtures in construction of ocean structures can result in saving of cement without affecting the workability and the strength of concrete. Typical dosage of these admixtures, which are called as plasticisers, are about 100 to 300 milliliter per bag of cement depending on the type of admixtures. Generally manufacturers advise or recommended this dosage depending upon variety and chemical composition of the plasticisers. The typical commercial brands which are available in market are conplast P211 and conplast P505 both of them are from fosroc chemicals. So, these are examples coated in the slide other than these there are variety of plasticisers are available in the market which are generally used to improve the quality and certain characteristics of concrete when they have been used. Essentially, they are used as water reducing admixtures.

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**High range water reducing admixtures (super plasticisers)**

- In construction of ocean structures, precast elements are used in large scale
  - To ensure proper quality control
  - To speed up the construction process
  - To facilitate easy installation
- To enable easy compaction of concrete in the heavily reinforced pre-cast elements, super plasticisers are used
- They improve workability and cohesion
- Aids pumping of concrete by reducing friction and dry packing
- Results in low porosity and improved resistance to water penetration
- Typical dosage is 200-500 ml/bag of cement

Examples are Conplast SP337, Conplast SP430 (Fosroc)

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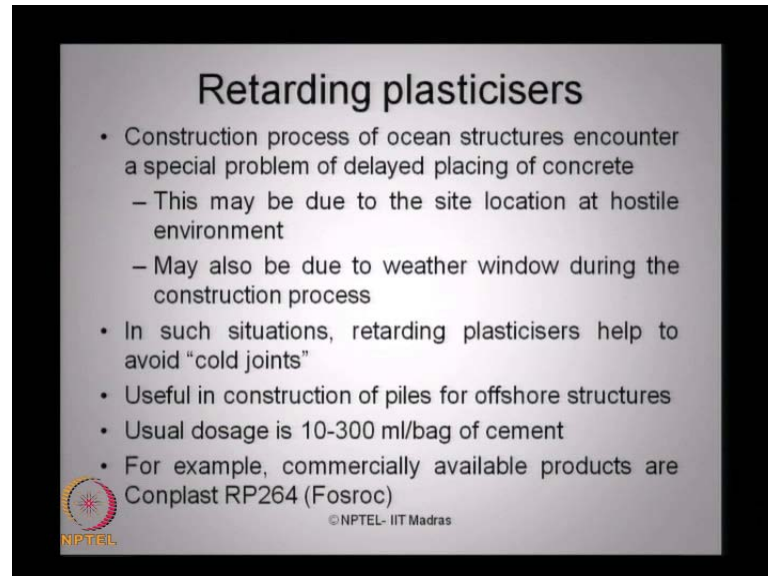
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We can also use high range of water reducing admixtures, which are called as super plasticisers in the commercial brands. In construction of ocean structures, precast elements play a very major role, because they have been used in large scale. There are many reasons why precast members are preferred to ensure construction as per the ocean system structures are concerned. Because to ensure proper quality control, as they are fabricated and erected in the lab control environment. To speed up the construction process prefabricated precast elements can be easily made available on any specific modular dimension which can be used to increase the speed up the construction process as well, and above all it facilitates easy installation of the platform. As we all understand installation of offshore structures becomes a major task as the mass of the structure is very large and they are got to be installed in a very high coastal environment.

To enable easy compaction of concrete in the heavily reinforced precast elements high range water admixtures are called a super plasticisers are generally added to concrete. It improves the compaction of concrete in reinforcement dense shuttering. On the other hand, they also improve workability and cohesion between the aggregates. It also aids pumping of concrete by reducing friction of flow and dry packing. It results in low porosity and improved resistance to water penetration, which is very important to protect the reinforcement from corrosion environment like sea environment. Typical dosage is about 200 to 500 milliliters per bag of cement. The commercial brands available for


example, in the market of conplast SP337 and conplast SP430 which can be commonly used as super plasticisers for marine structural systems.

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**Retarding plasticisers**

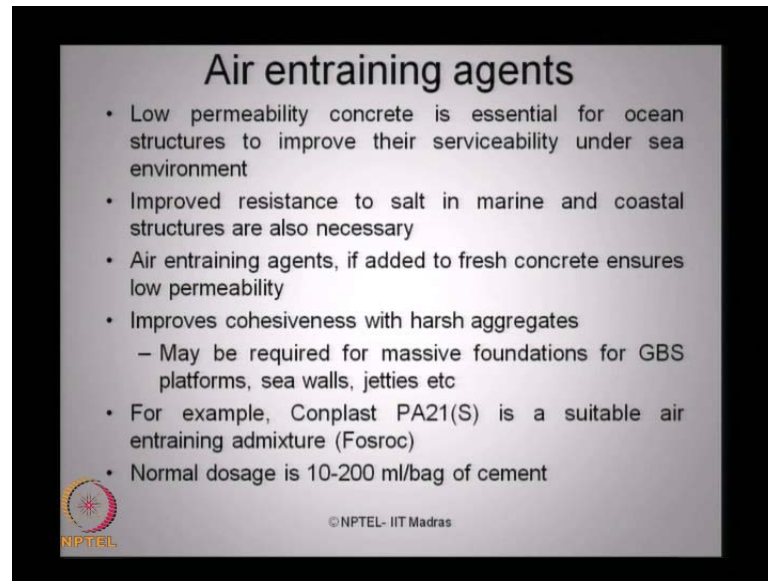
- Construction process of ocean structures encounter a special problem of delayed placing of concrete
  - This may be due to the site location at hostile environment
  - May also be due to weather window during the construction process
- In such situations, retarding plasticisers help to avoid "cold joints"
- Useful in construction of piles for offshore structures
- Usual dosage is 10-300 ml/bag of cement
- For example, commercially available products are Conplast RP264 (Fosroc)

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If we look at the next variety of admixture, which is also commonly recommended in the construction of ocean structural systems, we talk about retarding plasticisers. Ladies and gentlemen, as the name retarding suggest the constructing process of ocean structures encounters a very special problems which can be addressed to delayed the placing of concrete. The concrete once it is green need to be placed in the formwork with in a specific period of time depending upon the admixtures what to add. If we really want to delay the placing of concrete then you need to add certain chemical adventured to concrete, which retards the setting time or it gives to the enough time to place the fresh concrete.


Now in ocean structures, this is a very special requirement because it may be due to the site location at coastal environment, may also be due to the weather window during the construction process cannot take place. In such situations, retarding plasticisers help us to avoid what we technically called cold joins. It is useful in construction of piles in offshore structures. The usually dosage of retarding plasticisers added to fresh concrete is about 10 to 300 milliliter per bag of cement. The commercially available brands of retarding palsticisers for example are conplast RP264, which is also from Fosroc chemicals.

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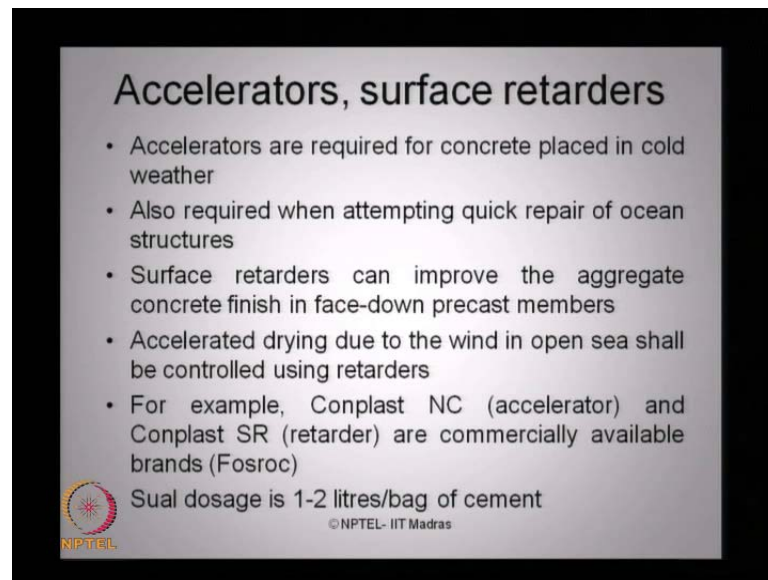
**Air entraining agents**

- Low permeability concrete is essential for ocean structures to improve their serviceability under sea environment
- Improved resistance to salt in marine and coastal structures are also necessary
- Air entraining agents, if added to fresh concrete ensures low permeability
- Improves cohesiveness with harsh aggregates
  - May be required for massive foundations for GBS platforms, sea walls, jetties etc
- For example, Conplast PA21(S) is a suitable air entraining admixture (Fosroc)
- Normal dosage is 10-200 ml/bag of cement

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Coming to the usefulness of air entraining agent, which can be added admixtures to fresh concrete, low permeability concrete is an essential demand for ocean structural system, because it improves the service ability under sea environment. The improved resistances to salt in marine and coastal structures are also important for this kind of structural system. Air entraining agents, if added to the fresh concrete ensures low permeability to concrete. It also in addition improves cohesiveness with harsh aggregates; it may be required as a fundamental requirement for massive foundation, for example, for gravity based structures, sea walls, jetties etcetera. For example, Conplast PA21(S) is a suitable air entraining admixtures which is manufacture by Fosroc. The normal dosage of this air entraining agent is varies from 10 to 200 ml per bag of cement depending upon the recommendation given by the manufacturer.


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**Accelerators, surface retarders**

- Accelerators are required for concrete placed in cold weather
- Also required when attempting quick repair of ocean structures
- Surface retarders can improve the aggregate concrete finish in face-down precast members
- Accelerated drying due to the wind in open sea shall be controlled using retarders
- For example, Conplast NC (accelerator) and Conplast SR (retarder) are commercially available brands (Fosroc)

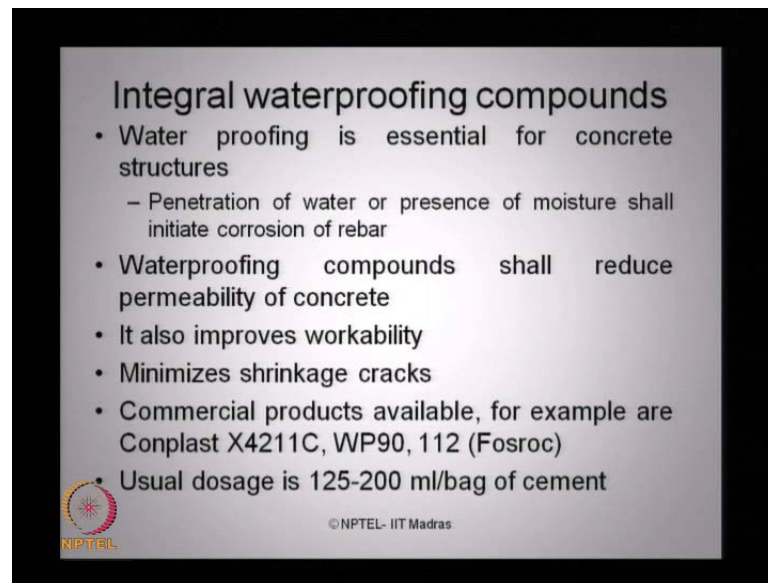
Sual dosage is 1-2 litres/bag of cement

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Coming to accelerator and surface retarders which can be also used as admixtures in the construction of concrete structures of ocean structures systems. Accelerators are essentially required for concrete placed in cold weather. As we all understand, in ocean environment, the weather window varies drastically. During the construction process, if the weather window varies unsuitably for the construction process then the accelerators are required to be used in concrete to place it during cold weather. They are also required when attempting a quick repair on ocean structures.


Ladies and gentlemen, we all understand like coastal structures of statistic importance for example, jetties used by navel based etcetera, the repair time available or shut down time available of the jetties are very less. One has to therefore undergo or undertake repair of these kinds of structural systems in the quick possible time, in that cases we might to be add accelerators when we are attempting quick repairs of offshore structural systems. The surface retarders can improve the aggregate concrete finish in the face down of precast members. Accelerated drying due to the wind in open sea shall be controlled using these kind of retarders. Therefore, they allow enough moisture to be available for concrete have a fresh finish. For example, Conplast NC which is an accelerator and conplast SR which are retarder are commercially available brands manufacture by Fosroc which can be used for marine environment comfortably. Usual dosage is about 1 to 2 liters per bag of cement.

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**Integral waterproofing compounds**

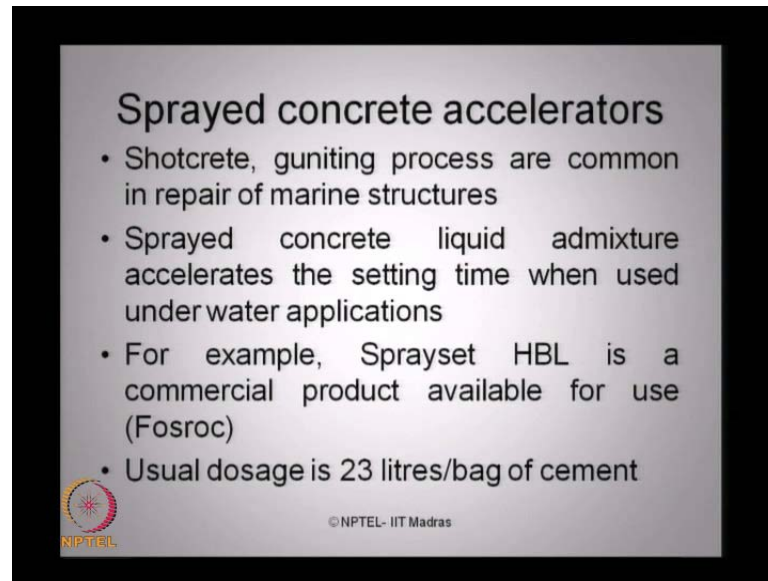
- Water proofing is essential for concrete structures
  - Penetration of water or presence of moisture shall initiate corrosion of rebar
- Waterproofing compounds shall reduce permeability of concrete
- It also improves workability
- Minimizes shrinkage cracks
- Commercial products available, for example are Conplast X4211C, WP90, 112 (Fosroc)
- Usual dosage is 125-200 ml/bag of cement

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If we talk about integral waterproofing compounds, which are also added as admixtures to concrete in the fresh concrete are the following. Water proofing is the fundamental requirement for the concrete structures, because penetration of water or presence of continuous moisture shall initiate corrosion of reinforcement present in the rebar. Waterproofing compound shall therefore, reduces permeability of concrete, therefore it protects concrete by not permitting water to penetrate through the concrete which can result in corrosion of rebar that is embedded in concrete. It also off course improves workability of concrete, it minimizes shrinkage cracks and commercial products available for integral water proofing are Conplast X4211C, WP90, WP112 etcetera. All these are commercial brands available from Fosroc chemical which can be comfortably used as water proofing compounds for concrete to improve on the permeability or to minimize the shrinkage cracks resulting from the laying of concrete. Usual dosage is about 125 to 200 m l per bag of cement.




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**Sprayed concrete accelerators**

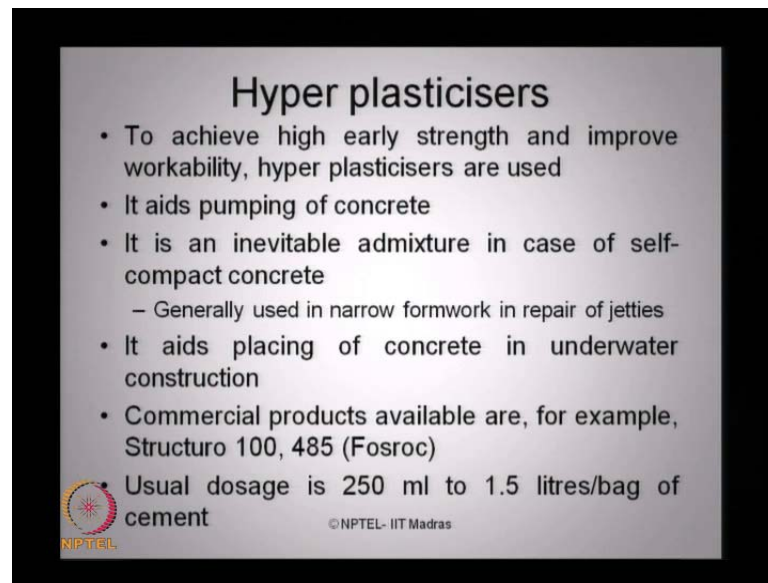
- Shotcrete, guniting process are common in repair of marine structures
- Sprayed concrete liquid admixture accelerates the setting time when used under water applications
- For example, Sprayset HBL is a commercial product available for use (Fosroc)
- Usual dosage is 23 litres/bag of cement

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If we talk about sprayed concrete accelerators, which can also be used as chemical admixtures in fresh concrete, in particular to ocean structural systems. Shotcrete and guniting process are highly common in the repair of marine structures. We all understand the marine structures repair invokes state of our condition and requirement for inevitable them because of list shutdown time. And of course availability of material and state of our repair technology need to be applied to these repair methodologies, because of shut down time of the marine structures which are as strategic importance may not be available for a longer duration.


So, shotcrete is one of the important admixtures which being used for concrete repairs. So, sprayed concrete accelerators can be liquid admixtures which accelerates the setting time when used for underwater applications. For example, spray set HBL is a commercial product available for used manufacture from Fosroc. The usual dosage of sprayed concrete accelerators varies is about 23 liters per bag of cement.

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**Hyper plasticisers**

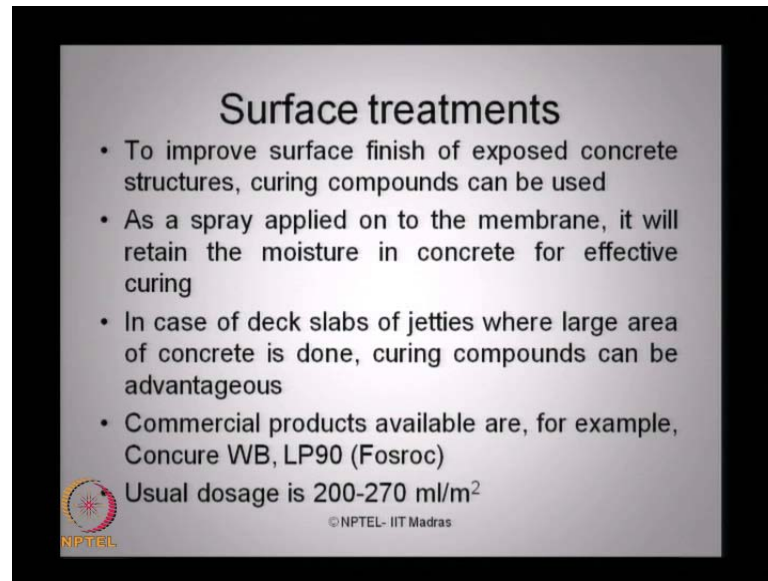
- To achieve high early strength and improve workability, hyper plasticisers are used
- It aids pumping of concrete
- It is an inevitable admixture in case of self-compact concrete
  - Generally used in narrow formwork in repair of jetties
- It aids placing of concrete in underwater construction
- Commercial products available are, for example, Structuro 100, 485 (Fosroc)
- Usual dosage is 250 ml to 1.5 litres/bag of cement

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If we talk about hyper plasticisers, which are also used as admixtures in concrete, they are generally used to achieve high early strength and improve workability of concrete. It aids basically pumping of concrete as we understand batching plants cannot be located as close to the construction site in offshore as well as coastal structures. So, therefore, there may be essentiality of pumping of large volume of concrete when the construction of these kinds of structures do happen. Therefore, aid pumping of concrete hyper plasticisers is generally added to the raw concrete.

It is an inevitable admixture, in case of self compact concrete. Generally, they are used in narrow formwork, for example, in repair of jetties. It also aid placing of concrete in underwater construction very fast. The commercial products available for hyper plasticisers are for example, structro 100, structro 485 which are manufacture by Fosroc chemicals. The usual dosage recommended by the manufacture is about 250 ml to 1.5 liters per bag of cement.


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**Surface treatments**

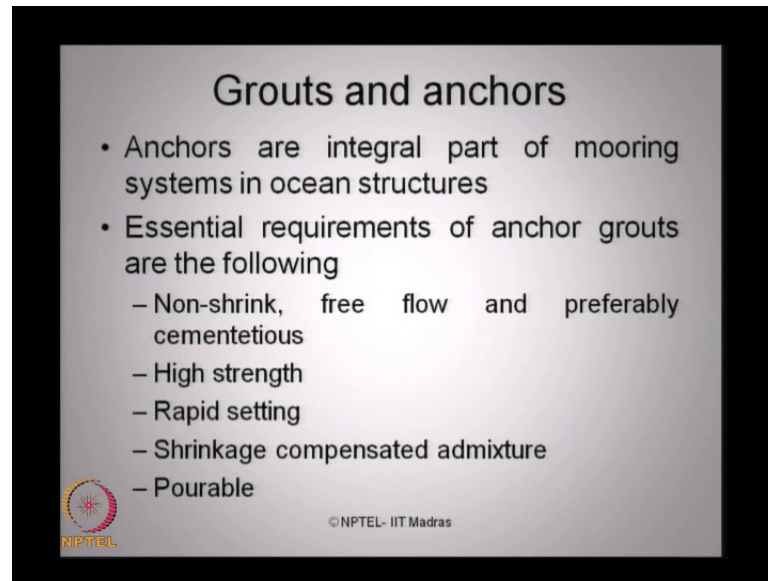
- To improve surface finish of exposed concrete structures, curing compounds can be used
- As a spray applied on to the membrane, it will retain the moisture in concrete for effective curing
- In case of deck slabs of jetties where large area of concrete is done, curing compounds can be advantageous
- Commercial products available are, for example, Concure WB, LP90 (Fosroc)

Usual dosage is 200-270 ml/m<sup>2</sup>

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If we look at the surface treatments, which are also equally important for maintaining the integrity of offshore structures, and to improve the load carrying capacity as well as service ability of these kind of structures in marine environment. They are required to improve the surface finish of exposed concrete structures curing compounds can be used as surface treatment. As a spray applied on to the membrane, it will retain the moisture in concrete for effective curing. In case of deck slabs of jetties where large area of concrete is to be caused, curing compounds can be advantageous. The commercial products available in the market are for example, concrete WB and LP90 both of them manufactured from Fosroc chemicals. The usual dosage of surface treatments admixtures is vary from 200 to 270 milliliter per square meter area of application.

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The slide is titled "Grouts and anchors" and contains a bulleted list of requirements for anchor grouts. The requirements are: Anchors are integral part of mooring systems in ocean structures; Essential requirements of anchor grouts are the following: Non-shrink, free flow and preferably cementitious; High strength; Rapid setting; Shrinkage compensated admixture; and Pourable. The slide also features the NPTEL logo in the bottom left corner and the copyright notice "© NPTEL- IIT Madras" in the bottom right corner.

### Grouts and anchors

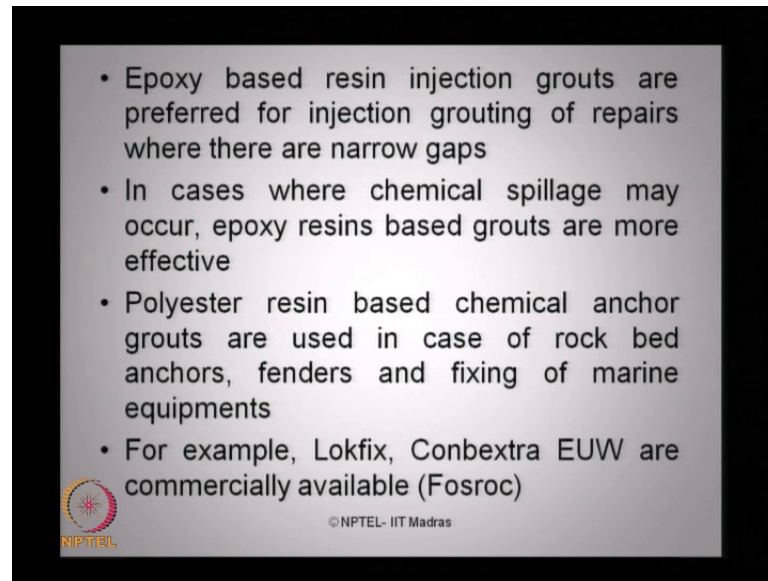
- Anchors are integral part of mooring systems in ocean structures
- Essential requirements of anchor grouts are the following
  - Non-shrink, free flow and preferably cementitious
  - High strength
  - Rapid setting
  - Shrinkage compensated admixture
  - Pourable

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If we look at the grouts and anchors and admixtures related to grout and anchoring processes, anchors are integral part of any mooring systems provided in ocean structures. The essential requirements of anchors and grouts are the following. It should be non shrink, it should be free flowing and preferably the material should be cementitious. It is because of the basic reason that cementitious products have a good bonding with the concrete as a parent material where the repair is being attempted.

Alternatively they should also have the high strength, because the anchor grouts are very important to impose upon the axial pull and axial push to the bolts or the members through which they are grouts it. It should also requested that these kind of admixtures to ensure rapid setting of these cementitious material in quick possible time. They should be having specific characteristics of shrinkage compensated admixtures, and they should be available in pourable models. They should not be a solid material, because the compaction of grouts material in a narrow hole available for the bolts becomes a difficult issue.

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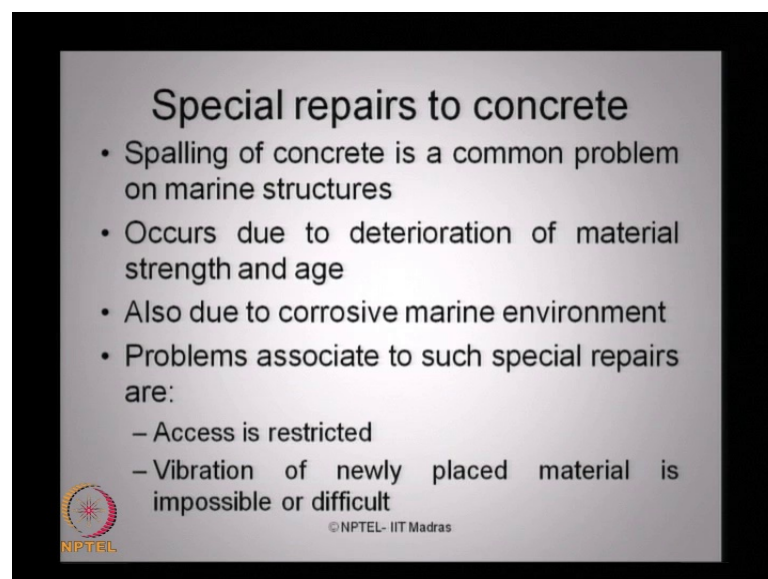


- Epoxy based resin injection grouts are preferred for injection grouting of repairs where there are narrow gaps
- In cases where chemical spillage may occur, epoxy resins based grouts are more effective
- Polyester resin based chemical anchor grouts are used in case of rock bed anchors, fenders and fixing of marine equipments
- For example, Lokfix, Conbextra EUW are commercially available (Fosroc)

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Epoxy based resin are also injection, injected and used as a injected grouts. They are generally preferred for injection grouting of repairs where there are narrow gaps on the surface of concrete. In cases where chemical spillage may occur, epoxy resins based grouts are more effective. Polyester resin based chemical anchor grouts are specifically used in case of rock bed anchors, fenders and fixing of any marine equipment. For example, Lokfix, Conbextra EUW are commercially available brands are manufacture from Fosroc chemicals which can be used as anchor grouts in common terminologies.

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### Special repairs to concrete

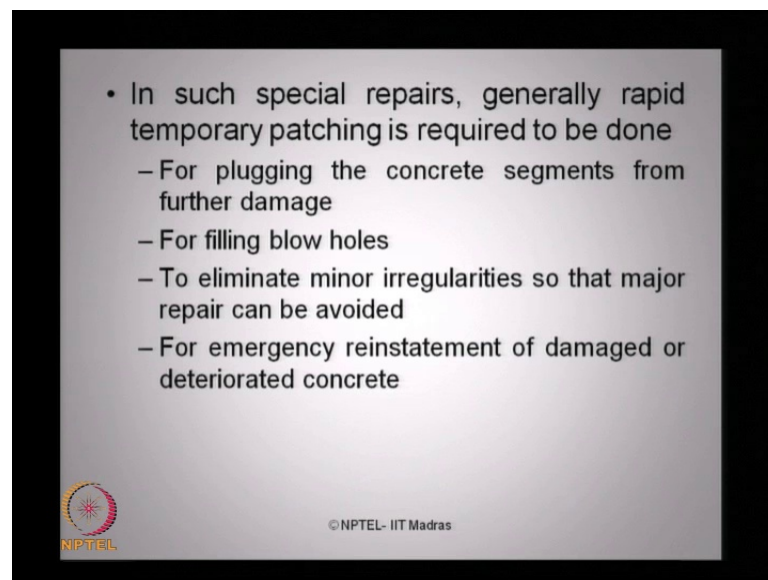
- Spalling of concrete is a common problem on marine structures
- Occurs due to deterioration of material strength and age
- Also due to corrosive marine environment
- Problems associate to such special repairs are:
  - Access is restricted
  - Vibration of newly placed material is impossible or difficult

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If we talk about special repairs, concrete spalling of concrete is a very common problem, which is normally seen on marine structures. Marine structures are exposed to severe environment which are corrosive and chemical in nature because of the presents of the salt and because of the continuous moisture present in the surface. Especially in case of splash snooze and tidal snooze the members are piles are subjected to severe corrosive environment and they result in spalling of concrete. It is essentially occurring due to deterioration of material strength and age when the re bar starts corroding, it expands the multi phased volume which will cause external pressure on the cover of concrete, which makes the cover of concrete is fall down from the parent member what we called as spalling of concrete.

Generally, it occurs as the indication of deterioration of material strength and because of long age of concrete in a sea environment. It can be also be due to corrosive marine environment, because of the rebar expand there is a possibility that spalling of concrete may follow the expansion of rebar's. The problem associated to such special repairs are the access to such kind of repairs is generally restricted or vibration of newly placed material could become impossible or essentially difficult to do the repair.

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In such special repairs, generally rapid temporary patching is done, because it is essentially to be carried for plugging the concrete segments from further damage. It is also required for filling the blowholes. It is required to eliminate minor irregularities, so

that major repairs in the structures or in the member can be avoided in near future. Therefore, the emergency reinstatement of the structures of damaged part of the structures or deteriorated concrete is a special repairs need to be carried out in a very small possible time what we called us temporary patching.

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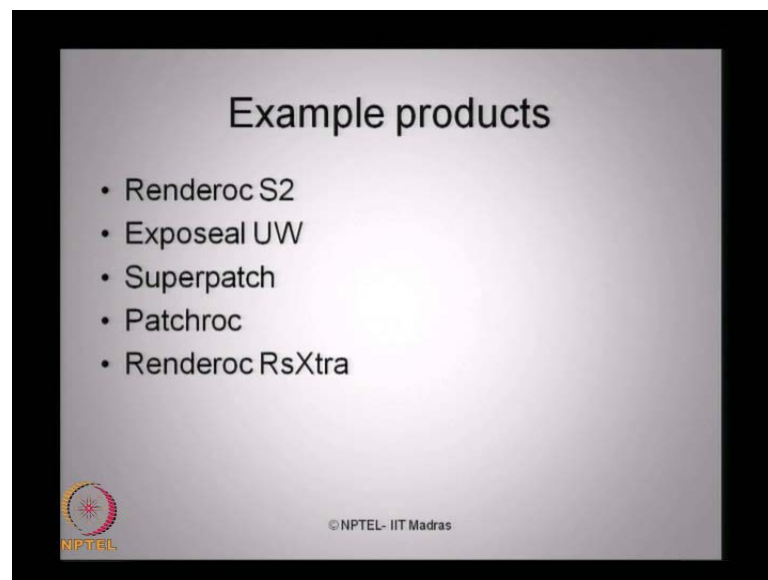


If we look at the special requirements of materials for attempting such repair on concrete structures in marine environment, the material should have a proper structural grade. As we understand, the parent grade of the concrete used in marine environment is generally very high. The basic grade of concrete, which recommended ocean environment, is M 45. So, the material should also have an higher grade of structural grade of concrete, and if it is cementitious materials. Remember very important point, the repair attempted in concrete structure in marine environment is not a cosmetic task, but it is a functional task. The member has to undertake the same load carrying capacity or the stresses and the combination of loads for which they have to be design.

So, there is no compromise on the load carrying capacity of the material, even though the materials are partially failed, because of some penetration of moisture, because of corrosion of rebar etcetera. All the special requirement of the materials of such repairs to ensure that after repair the structural member should remain functional as it was earlier. So, repair attempted in a concrete structures in marine environment are not a cosmetic treatment.

The best way or the best choice of engineers to use special materials for such repair is, it should be light-weight grade in a pre-packed mode, that's what the people would prefer, because it should also be able to get portable to the site to be used easily. The material should be used for such repair for remain as anti washout material; it is very important requirement of material and special repairs. The material should remain non-shrinking compound; the material should have high strength and preferably it should remain cementitious material. Off course epoxy based materials are also used for special repairs material, but cementitious material are generally preferred, because they get integrally modeled with parent concrete where the repair is being attempt it. It should enable crack sealing completely, and it should have a rapid setting characteristic, if it is used for special repair. It should also have a special characteristic called waterproof plugging.

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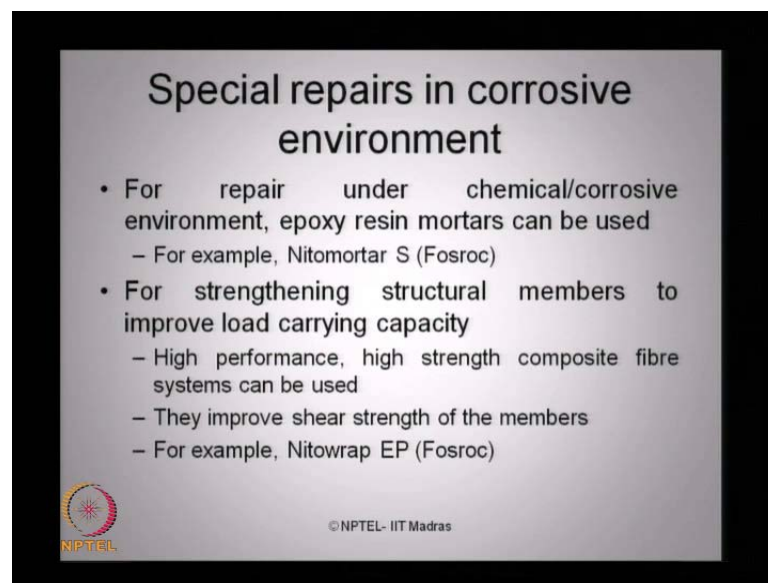


If we look at some example products which carry the above requirements which can be used as material for special repairs in marine environment, then the list follows Renderoc S2, Exposeal underwater – UW, super patch, and Patchroc, and Renderoc RsXtra which are all manufacture by Fosroc chemicals in India. So, ladies and gentlemen, in this lecture, we saw special materials which have been used for repairing concrete structures in marine environment. Of course dosage of these kinds of admixtures which have been recommended for using or for repair of concrete structures are generally recommended by the manufacture themselves.




There is no standard regulation international coral provision which we recommended for these kinds of materials for any specific application in marine environment. Therefore, all these materials, all the update on these materials depends on the latest research and developments and various companies, and manufacturing organization which manufacture chemical admixtures, which can be used for a special repairs in concrete structures in particular to marine environment.

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**Special repairs in corrosive environment**

- For repair under chemical/corrosive environment, epoxy resin mortars can be used
  - For example, Nitomortar S (Fosroc)
- For strengthening structural members to improve load carrying capacity
  - High performance, high strength composite fibre systems can be used
  - They improve shear strength of the members
  - For example, Nitowrap EP (Fosroc)

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If we look at the special repairs attempts in corrosive environments, for repair under chemical or corrosive environment, epoxy resin mortars are generally recommended. For example, nitmortar S manufacture by Fosroc can be a good alternative for attempting repair under chemical or corrosive environment, which is generally a marine environment. For strengthening the structural members to improve their load carrying capacity, high performance, high strength composite fiber systems can also be used. They improve the shear strength of the members; in addition they can also improve the strength axial compression bending strength of the members. The commercial product available in the market which a nothing but a composite fiber system is Nitowrap EP manufacture by Fosroc which can be also used in corrosive environment.

Thank you.