Building Materials III
Lecture 5

Wimpey No Fines

Here we have a house, this is a house in Britain. A social housing done by the government during post-war times. This is called Wimpey No-fines houses. Wimpey was a construction company that did social housing. No-fines comes from the name no-fines concrete. We looked at no-fines concrete, it simply means that fine aggregates aren't used. During post-war times, a social housing solution was proposed by Wimpey construction house, using no-fines concrete. A large set of houses were completely done due to no-fines house. What makes no-fines house very efficient or a solution to such a big form of social housing. We will be looking into no-fines concrete and how this came about. If you take a look at this picture, no-fines concrete means there is no sand. There is this very capillary or locked form of aggregates which seemingly allow capillaries or spaces in between allowing water to permeate through it. Usually, we look at concrete as a way of repelling moisture or keeping water away. In this case, it allows water, let's see if it is useful or not.

No-fines concrete is a method of producing light concrete by omitting the fines from conventional. No-fines concrete as the term implies is a kind of from which the fine aggregate fraction have been omitted totally. This concrete is made up of only coarse aggregate, cement and water. Very often only single sized coarse aggregate, of size passing through 20mm retained on 10mm, is used. No-fines concrete is becoming popular because of some of the advantages it possesses over the conventional concrete. The single sized aggregated make a good no-fines concrete, in addition to having large voids and hence lighter in weight, also offering architecturally attractive look. When looking at this picture, it gives a rugged look. Let's say for the first time in making concrete, it adds an aesthetic value. The usual proportion of cement to aggregate is 1:10 in case of heavy aggregate or 1:6 in case of light aggregate. The amount of water should be just sufficient to give coating of cement paste on all particles. Sand or fine aggregates is what makes it plastic. We need to make sure that just the right amount of water is added to make sure it doesn't slump off too much. Too little water may leave loose aggregate inside the concrete and too much of water may cause the cement paste to flow and segregate. It is better to wet the aggregate before adding cement and water. A little bit of wetting such that you can judge the level of water added and how it is going to set.

The concrete should be mixed thoroughly till all the particles are coated. You add water slowly, mix it thoroughly to make sure all the particles are coated, this will immediately make the aggregates lock amongst themselves and thus form the no-fines aggregate. Properly prepared concrete will not segregate during placing. It does not need any watertight forms also. It should not be rammed but only rodded to remove large cavities. While the water is being added, usually ramming or contacting is what is done to make it segregate properly. In this case, only rodding, such that the capillaries fill up evenly as practiced. This concrete cannot be easily cut away afterwards and all fixtures, etc, should be placed in the green state. Even though it has a lot of aesthetic and efficient uses, it does have some restrictions and limitations as well. This concrete cannot be cut as you can see, the person is holding a bit of the no-fines concrete, obviously you cannot have fixtures added to it. These should already be added to it in the green state. It has no resistance to penetration of water and suitable rendering may be applied on its external surface. In case you want a particular set of the no-fines concrete to be resistant to water, suitable finishing or damp roofing or ways to lock the water should be applied. Otherwise, this water permeability is actually used in many ways in terms of no-fines concrete.

Properties - it does not segregate because it forms immediately after the locking formation. The density varies with the grading of aggregates. The absence of fine aggregates makes an important character for strength and grading. Water cement ratio of this concrete varies from 0.38 to 0.52. It's strength increases with time because it set immediately and the lock or interlocking forms have reduced. It increases with time accordingly. There is very little cohesiveness, necessitating longer duration of formwork removal. What happens is, as much as it sets, the fact that it cannot set on its own without that external support is very clear. The form work that is done to support it should be used for a longer time than usual concrete. Shrinkage of this concrete is lower than normal concrete because there is no fine aggregate compacting or moving out. The shrinkage is lesser than normal concrete and its thermal expansion is about 0.6 to 0.8 than normal concrete. Whatever fine aggregate is imparting in terms of character to concrete is all kind of reduced in this no-fines concrete forms. Thus, the uses of no-fines concrete.

Construction of external load bearing walls, Construction of small retaining walls, damp roof material, Construction of temporary structures. These are very common uses of no-fines concrete. Some advantages based on characteristics and uses - No-fines concrete exhibits less drying shrinkage as compared to ordinary concrete. Movement of water due to the capillary action is negligible in this type of concrete. Water doesn't get trapped. It does allow water to permeate through it. But the general problem or the general damage done to concrete by moisture or water is when water gets trapped between the concrete. That doesn't happen because the capillary action does not happen in this case. Due to its lightweight nature, it is used in lightweight concrete construction work. It is lightweight because of no fines and locking forms, this aids in lightweight constructions. Thermal insulating characteristic of no fines concrete is better than conventional concrete. This is why it is used in the construction uses where external walls are temporary structures. This is because the thermal capability of these no-fines concrete walls are much better than normal concrete. Furthermore, the advantages would be, this type of concrete results in saving of material requirement. Obviously, there is no fine aggregate, so that eliminates the use of fine aggregates, its cost, its transport and every other form of factor that affects fine aggregates. The density of this type of concrete is about 25% to 30% lesser than the conventional concrete. Therefore, it exerts less pressure on formwork. The density is much lesser, it exerts less pressure on formwork. Even though the formwork is required for a longer period of time, the pressure exerted by the concrete as such on form work when compared to conventional concrete is much lesser. Segregation property of this type of concrete is very low. We discussed that one of the properties and advantages of no-fines concrete is that there is no segregation as such. Therefore, it can be dropped from a considerable height without the danger of segregation. No special equipment is needed for compaction of this concrete. Full compaction can be achieved by simple rodding operation.

When this is compacted, it can actually be transported from one point to another without damaged even in case it's dropped. No special equipment is required in case of compaction of this concrete. This form work is more than enough. As stated earlier, this compaction is not necessary, just rodding is more than enough. Other advantages are - highly permeable to water, it absorbs rainwater and facilitates its natural runoff. A concrete being permeable to water opens up a lot of advantages in terms of water permeability, in terms of moisture absorbing rainwater and it facilitates a natural runoff. Instead of having an actual slope to have the water runoff in terms of rain, what happens is actually the water passes directly through the no-fines concrete making it very easy and also helpful in collecting ground water. It reduces the risk of flooding during heavy rain. When you have the pavement or the outer area surrounded by no-fines concrete, it simply acts as a layer through which water can pass through the ground. It quickly redirects rainfall runoff from roads and walkways. It reduces pollution in storm water due to filtering action. This is another thing, water when it flows off in case of rain water, it does have a lot of impurities, so we have to actually have to pass it through various levels of filtration, but in this case no-fines concrete traps all these impurities or any form of pollution. Lower cost due to lower cement content. There is formation of cement with reaction to water but there is fine aggregate, this reduces the cement content that reacts and therefore the cement content is used much lesser. The better insulating characteristics than conventional concrete because of the presence of large voids.

You can see water in the picture when you pour water over no-fines concrete, the water passes through directly. Obviously, there are some limitations when compared to any other type of concrete. Due to absence of fine aggregates, this type of concrete lacks cohesiveness while in plastic state. When we are actually setting or mixing it, the plasticity is totally absent in the case of no fines concrete because there is no sand. Therefore, it requires a long time for formwork removal. It is more permeable than conventional concrete. Therefore, walls constructed with no fines concrete needs an extra cost of mortar from durability point. Generally, reinforcement is not recommended in this type of concrete. However, if it is required to used reinforcement, then apply a thin layer of cement paste on the reinforcement before using it. Directly adding reinforcement, does not help the form to lock. We have to add a little cement in order to add a little plasticity to adjust this form of concrete, only then will it improve the bonding of steel with concrete and also resistance to corrosion. These are some limitations and there are no standard tests because it's a simple formation method. Only by proper visual inspection and trial & error method, one judges its workability. This is also a big limitation in terms of no-fines concrete. We will now talk about Wimpey No-fines house. This is another example where the no-fines concrete was used. You can see the actual wall, the balcony wall done in no-fines concrete. We rarely find this in other types of buildings. This was actually widespread, followed during the post-war period, done exclusively by the government of Britain. There were a lot of problems with respect to Wimpey No fine houses, not because of the no-fines concrete but because of the windows as such.

These Wimpy no-fines houses have been retro-fitted in many ways but the basic or the underlying no-fines concrete is very much intact which shows that no-fines concrete is very much used and it has a lot of advantages. This is retro-fitted, rather a very recent example of the no-fines housing. The no-fines housing was a construction method and series of house designs produced by George Wimpey company and intended for the mass production of social housing for families, developed under the Ministry of Works post-World War. Emergency Factory Made Program, no-fines refers to the type of concrete used-concrete with no fine aggregates. No-fines houses were built with a ten-inch (254mm) concrete shell cast in situ. Not only was it used for walls but very extensively used for slabs for the whole structure. The concrete for the entire outer structure was cast in one operation using reusable framework. Another added advantage in terms of time consumption.

The ground floor was concrete - the first floor was made with traditional timber joists and floorboards. Interior walls were a mixture of conventional brick and block work construction. To weatherproof the structure, the external facade was rendered.

Fiber Reinforced Concrete

Another very interesting type of concrete and contrasting to the no-fines is Fiber-reinforced concrete. If you look at what capability fiber-reinforced concrete offers in the building industry. We will look at its properties, its uses, its origins etc, and another interesting example of the building. Fiber-reinforced concrete, concrete as you see it's been made with different types of aggregates, used with polymers, air bubbles and so there is also a way of using it with reinforcements. Fiber-reinforcements is one way of using reinforcements in concrete.

Plain Portland cement is a brittle material. The strength of concrete in tension is much lower than in compression. A growing tensile crack in plain concrete can very soon lead to failure. In the presence of reinforcement, the tensile load is transferred to steel. RCC - reinforced cement concrete which was so widely used, uses steel reinforcement but an alternative to this that adds to the plasticity is Fiber-reinforcement. An alternative to increasing the load carrying capacity of concrete in tension is the addition of fibers. Fibers are added to these concretes to make it better. Fibers can be natural fibers as well as artificial fibers. Well-dispersed fibers in the concrete act to bridge the cracks that develop in concrete. The biggest factor of cracking is controlled with the use of dispersed fiber, very controlled dispersed fibers in the use of concrete is practiced. The incorporation of fibers in a cement matrix leads to an increase in the toughness and tensile strength, and an improvement in the cracking and deformation characteristics of the resultant concrete. The ultimate strength in concrete is improved by adding fibers, this makes it a very interesting type of concrete and also a very useful one.

Fiber-reinforced concrete - FRC, as it is called, is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers - each of which, lend varying properties to the concrete. In addition, the character of fiber-reinforced concrete changes with varying concretes, fiber materials, geometrics, distribution, orientation and densities.

The concept of using fibers are reinforcement is not new. Fibers have been used as reinforcement since ancient times. Horse hair has been used in a lot of building materials, especially in mud construction, etc. This is a way of using natural fiber. This is what is being researched and taken further into development and artificial fibers are being used now. The health risks associated with asbestos were discovered, there was a need to find a replacement for the substance in concrete and other building materials. By the 1960s, steel glass and synthetic fibers such as polypropylene fibers were used in concrete.

We will go through a brief history, this is one of the Pavilion exhibitions that were conducted during the time of Le Corbusier. The office of Le Corbusier was supposed to make a design for this Pavilion. Le Corbusier was apparently not available, one of his architects Xenakis was the one who did it. This is actually a Pavilion that uses sound as an inspiration and is the prime of music converted into architecture. This is a very documented and modern use of fiber-reinforced concrete. This is called the Philips Pavilion and was done for the company Philips to exhibit their lights in the form of acoustic measures.

The Fiber types are discussed below - the steel fibers can be straight, twisted, hooked; this is the most commonly used. Glass Fibers are generally straight. Natural Organic and Mineral Fibers which we talked about - wood, cotton, bamboo and rockwool are used. Furthermore, Polypropylene Fibers - plain, twisted, fibrillated types. Synthetic fibers - Kevlar, Nylon and Polyester were used.

The types of Fiber we saw, Steel - you can see the hooked type of fibers are used. Glass fibers are straight fibers. The properties of Fiber-reinforced concrete are manifold. Obviously the first and foremost being the Modulus of elasticity. It becomes more plastic because of the fibrous content present throughout the concrete. Flexure was supposed to be increased by 2.5 times using 4 percent fibers. Toughness again is about 10 to 40 times better than that of plain concrete . Splitting Tensile Strength - usually, it was compressive strength that was increased by varying the type of concrete. In this case the tensile strength is increased much more.

Compressive strength - the presence of fibers may alter the failure mode of cylinders, but the fiber effect will be minor on the improvement of compressive strength. Impact resistance for fibrous concrete is generally 5 to 10 times that of plain concrete. Making it fibrous and evenly distributed, make sure that it is at least 5 to 10% times more impact resistant. You can see in this picture, only after large amounts of impact was it able to crack and only upto an extent, without causing that much damage as well. Corrosion is also resisted to a great extent. We will be talking about how the fiber or the characteristics of the fiber affect the particular fiber-reinforced concrete. Type of fiber, the material and the texture, the volume concentration of the fiber, aspect ratio of the fiber, Orientation of the fiber in the matrix as some important ways in which the fiber affects the type of concrete. Some advantages - we looked at Nylon fibers and Polypropylene fibers - these help improve mix cohesion, improve the freeze-thaw resistance, improve resistance to explosive spalling in case of a severe fire, improved impact resistance and abrasion resistance. Helps increase resistance to plastic shrinkage during curing, improves structural strength, reduce steel reinforcement requirements, improves ductility, reduces crack widths and controls the crack widths tightly, thus improving durability.

Steel fibers can improve the structural strength, can reduce the steel reinforcement requirements, reduce crack widths and control the crack widths tightly, thus improving durability. Helps improve impact and abrasion resistance and also improves freeze-thaw resistance. The most primary applications of Fiber-reinforced concrete is not domestic architecture or residential architecture or even mass construction. It is used for more infrastructure kind of architecture - runways, aircraft parking and pavements. Tunnel lining and slope stabilization. Blast resistant structures - FRC is a very good blast resistant concrete, thin shell, walls, pipes and manholes are also applications. Dams and Hydraulic structures.

You can see how Fibrous concretes can be shaped because of the plasticity and modulus elasticity that it can offer. The photo you just saw was of Heydar Aliyev Center by Zaha Hadid Architects.

Zaha Hadid Architects

Let's look at how this form was arrived. Zaha Hadid architects were appointed as architects of Heydar Aliyev Center following a competition in 2007. The Center designed to become the primary building for the nation's cultural programs breaks from the rigid and often monumental Soviet architecture that is so prevalent in Baku, aspiring instead to express the sensibilities of Azeri culture and the optimism of a nation that looks to the future.

This was built in Russia. The design of the centre establishes a continuous, fluid relationship between its surrounding plaza and the building's interior. You can see that the overall form is fluid and is also structural in its character. The plaza as the ground surface; accessible to all as part of Baku's urban fabric, rises to envelop an equally public interior space and define a sequence of event spaces dedicated to the collective celebration of contemporary and traditional Azeri culture.

One of the most critical yet challenging elements of the project was the architectural development of the building's skin. You can look at the skin, this was actually enabled better by the fiber-reinforced concrete system. The space frame system enabled the construction of a free-form structure and saved significant time throughout the construction process. The two most important materials used were glass fiber-reinforced concrete and glass fiber-reinforced polyester. Fiber-reinforcement was an important element. We just discussed various Fiber-reinforced concrete and glass was one of them. This is the direct application of glass fiber-reinforced concrete in a project by Zaha Hadid. This allows for the powerful plasticity of the building's design while responding to very difficult functional demands related to a variety of situations - plaza, transitional zones and envelopes. You can see in the picture, how fluid the form is. Fiber-reinforced concrete is the way to facilitate this. We looked at two different applications and how these concretes enabled them.