Building Materials III

Lecture 4

Polymer Concrete

In the previous lectures, we have looked into polymer concrete. It is most commonly used in making swimming pool beddings because it is very efficient waterproofing. It is also used widely in the making of drainage lines and pipes. Polymer concretes are a type of concrete that use polymers to replace lime-type cements as a binder. In some cases the polymer is used in addition to Portland cement to form Polymer Cement Concrete (PCC) or Polymer Modified Concrete (PMC). When we talk about Polymer as a binder, they are fine aggregates and coarse aggregates with water. In this case, instead of the lime type binding and use of cements, we use Polymers. Cement and concrete can be used in various ways to suit various purposes, in this case not only can we form Polymer concrete but we can also form Polymer Cement concrete by adding cement to the whole mixture. It can also be called as Polymer Modified Concrete. Polymerization happens either by Gamma radiation which is not so popularly used. Rather, chemically initiated means is what is mostly used. This is by using thermal catalytic method, adding 3% by weight benzoyl peroxide to the monomer as a catalyst. This is how a polymer is induced. The impregnation is aided by drying the concrete at a higher temperature by evacuations and soaking in the monomer under pressure. Back and forth brings in the impregnation of the Polymer. Moving on, thermoplastic Polymers may be used but that is not typically used because thermosetting resins are used as the principle polymer component due to their high thermal stability and resistance to a wide variety of chemicals. More than thermoplastic polymers, thermosetting resins are used. Polymer concrete is also composed of aggregates. Besides being impregnated by polymer, besides using cement in some cases, it does have the usual aggregates such as silica, quartz, granite, limestone and other high quality material. The aggregate must be of good quality, free of dust and other debris and dry. Failure to fulfill these criteria can reduce the bond strength between the polymer binder and the aggregate. Not only does it make the concrete weaker, it forms a characteristic where the polymer binder and the aggregate do not bond efficiently.

We will now talk about the properties of Polymer concrete, the exact properties depend on the mixture, polymer aggregate used, etc, but with mixtures used - The binder is more expensive than cement. This is one of the reasons it is not used so extensively. Significantly greater tensile strength than unreinforced Portland concrete, since plastic is stickier than cement and has reasonable tensile strength. You can have a cement mortar but the tensile strength of a Polymer impregnated concrete is much better than the under reinforced Portland concrete, simply because Polymer adds plasticity and this plastic is stickier than general Portland cement. Similar or greater compressive strength to Portland concrete is achieved. Much faster curing

methods. Good adhesion to most surfaces, including to reinforcements. Good long-term durability with respect to freeze and thaw cycles. It also has good resistance against corrosion.

Polymers obviously relate to lighter weight. Slightly less dense than traditional concrete, depending on the resin content of the mix. May be vibrated to fill voids in forms. Voids are generally formed in the case of concrete formation but this can be vibrated in order to form forms. Allows the use of regular form-release agents in some applications. Product hard to manipulate with conventional tools such as drills and presses due to its density. Recommend getting pre-modified product from the manufacturer. Small boxes are more costly when compared to its precast counterpart however pre cast concretes induction of stacking or steel covers quickly bridge the gap. Obviously the cost is also on the higher end. Being water resistant, it is used largely in the making of underground drainage pipes and various types of lining, in terms of tunnels, etc. The various uses of Polymer concrete is based on these properties. It may be used for new construction or repairing of old concrete. Let's say we have construction, it may be Polymer concrete construction or normal concrete construction. In order to repair both of it, you can use Polymer concrete. It doesn't necessarily have to be previous Polymer concrete used material. The low permeability and corrosion resistance of Polymer concrete allows it to be used in swimming pools, sewer structure applications, drainage-channels, electrolytic cells for base metal recovery and other structures that contain liquid or corrosive chemicals. It is especially suited to the construction and rehabilitation of manholes due to their ability to withstand toxic and corrosive sewer gases and bacteria commonly found in sewer systems. Sewer systems, other than having to deal with general drainage, it also deals with toxic material from factories and such. The use of Polymer concrete to create manholes is the best solution for these cases. Unlike traditional concrete structures, polymer concrete requires no coating or welding of PVC-protected seams. It can also be used as a bonded wearing course for asphalt pavement, for higher durability and higher strength upon a concrete substrate. In case of roads and highways, it can be used as a bonded weathering force for the asphalt pavement along these roads. Polymer concrete has historically not been widely adopted due to the high costs and difficulty associated with traditional manufacturing techniques. Not only traditional manufacturing techniques but handling on site, the ways in which it could be compacted, tested; all require high quality equipment that are specifically used only for Polymer concrete. This is the reason it is not used widely. However, recent progress has led to significant reductions in cost, meaning that the use of Polymer concrete is gradually becoming more widespread. Obviously in the future and the reduction in costs allows more usage of Polymer concrete.

Applications typically will be Marine works, Prefabricated structural elements, Pre-stressed concrete, Nuclear power plants, Sewage works and desalination plants, Waterproofing of

structures and numerous industrial applications. We have looked at the typical characteristics of Polymer concrete and its direct application. Apart from this, it is also put into the making of Prestressed concrete, because of its strength; Pre-fabricated structures as well and Nuclear power plants. We talked about toxicity and how it can withstand all that corrosion. Nuclear power plants also seem to be served by Polymer concrete. Applications - we talked about swimming pools, as to how Polymer concrete forms a very good bedding layer for swimming pools.

There are also various types of Polymer concrete. The thing about these types are varying the ways it is compacted, various types of concrete can be formed in order to suit many ideal conditions. Here we look at a few types of Polymer concrete - Geopolymer Concrete, Polymer modified concrete and Fiber reinforced Polymer concrete. Briefly looking at them, Geopolymer concretes are polymer concrete with inorganic polymers and have substantial elements to be considered environment friendly compared to other concretes. It is always a necessity or its become a necessity of the present field to look towards energy efficiency or conservation of energy. Every material, every type of construction, every mode of construction is looking towards energy and its conservation methods. Using inorganic polymers facilitates this. Polymer modified concrete is cement concrete with polymers and it becoming popular for ease of handling and economic feasibility. On one hand we have cement concrete and on the other we have Polymer impregnation. Putting the two together adds the ease of handling and workability of normal Portland cement concrete as well as the lightweight and other corrosion handling ability of Polymer concretes. Fiber reinforced Polymer concrete, Polymer concrete reinforced by fibers helps enhance its properties to many folds. Glass, carbon, hemp, sugarcane are some of the fibers used in fiber reinforced concrete.

Ready Mix Concrete

Let's consider this scenario of making concrete. The aggregates, water and cement are usually accumulated on site and put together to form concrete. There are various things that happen here, you need the place in order to do this. You need to have the sufficient size of the place in order to be able to carry this out. To be able to solve this and in case of mass constructions where a separate site cannot be allocated for the setting or making of concrete. Ready mix concrete is a very good solution. Ready mix concrete is manufactured in a factory or a batching plant. What happens is, there is a centrally located plant where the concrete is actually mixed, typically it's mixed on the way and set on site or its usually taken to the site and then mixed and set directly. This is a typical way of doing it but the main process of actually mixing takes place in a centrally located plant. This helps in a precise mixtures being composed allowing specialty concrete mixtures to be developed and implemented on construction sites. The first ready-mix factory was built in 1930s but the industry did not begin to expand significantly until the 1960s

and it has continued to grow since then. Ready-mix concrete is often preferred over on-site concrete mixing because of the precision of the mixture and reduced work site confusion. You don't need to allocate a separate portion of the site for the mixing of concrete. Also, you can control to great precision and extent, the mixing and proportioning of concrete making. Ready-mix concrete or RMC as it is popularly called, refers to concrete that is specifically manufactured for delivery to the customer's construction site in a freshly mixed and plastic or unhardened state. As I said, it is done at a centrally located plant and then the mixing or unhardened state of the cement is sent to the site and then it is set. Concrete itself is a mixture of Portland cement, water and aggregates comprising sand and gravel or crushed stone. We have looked at how concrete is made. Ready-mix concrete is bought and sold by volume-usually expressed in cubic meters. This is how it is handled economically, it is bought in volumes. Ready-mix concrete is manufactured under controlled operations and transported and placed at site using sophisticated equipment and methods. We saw that it can be controlled to precise effects, so the transportation and placing equipment have to be sophisticated in order to maintain the same level of precision. We will look at some of the properties of Ready-mix concrete.

Quality assured concrete, this is one of the very basic advantages of having ready-mix concrete. Every mix of concrete is the same and is not varied because of confusion on the site or because of atmospheric conditions because it is at a centrally located plant. Concrete is produced under controlled conditions using consistent quality of raw material. High speed of construction - speed of construction can be very fast in the case RMC is used. Speed of construction drastically increases because pre orders are placed based on how much concrete is necessary. Everything is pre-ordered and it can be easily accounted for. Reduction in cement consumption by 10-12% due to better handling and proper mixing. When you mix on site, obviously there is a lot of cement that goes into it. You have to adjust and variate until you reach your desired level. Since this is a template and it is being done regularly, 10-12% is being reduced in cement use. Further reduction is possible if mineral admixtures or cementitious materials are used. We know that certain different types of catalysts or admixtures can be used, this gives a lot more freedom in terms of centrally located plants. Versatility in uses and methods of placing: the mix design of the concrete can be tailor made to suit the placing methods of the contractor. The contractor without any restrictions can actually acquire tailormade proportions and mixes that can be used for varied types of constructions.

Here in this picture, you can see a plant where there is a truck that picks up the mortar that is ready and mixed. Usually you might have noticed in many cases, especially on highways, we have trucks that do the mixing on the way. This is called transit or transport mixing. We will look into that, this is one of the ways in which it is mixed and time is also saved. Conservation of

energy and resources because of saving of cement. Environment pollution is reduced due to less production of cement. Making cement on site causes hydration, releases a lot of heat, has a lot of energy involved, so, environmental pollution is reduced. With better durability of structure, their overall service life increases and there is saving in life-cycle cost. Eliminating or minimizing human error and reduction in dependency on labour. When it is something you do on a regular basis or a regular template, lots of things can be controlled precisely, that minimizes human error in turn and also reduces dependency on labour. Timely deliveries in large as well as small pores. This is facilitated in case of Ready-mix concrete. Furthermore, the properties - no need for space for storing the materials like coarse and fine aggregate, cement, water and admixtures. What happens is, a contractor or the person who requires concrete makes a pre order, then the materials are sourced then and there as per the order, directly sent into the various process, mixed and concrete is given. Basic necessity of storage, looking into qualities is all being reduced at site quality itself. No delay due to site based batching plant erection/dismantling. When you prepare concrete on site, you have to erect the equipments, etc. This is all reduced drastically, there is no depreciation of costs. Reduced noise and air pollution, less consumption of petrol and diesel and less time loss to business. These are all added advantages in case of Ready-mix concrete.

Here in case of Ready-mix concrete, the mix is very important. It can be done in two or three ways- Transit-mixed or Transport mixed as I mentioned, also known as Truck-mixed. Concrete materials are batched at a central plant and are completely mixed in the truck in transit. Let's say the plant is few kilometers away from the site, the materials are basically mixed and then put into the truck in a large mixer. This happens while the truck travels from the place of plant to that of the site, there is time saved and also, the mixing is done perfectly and is given on time. Frequently the concrete is partially mixed in transit and mixing is completed at the jobsite. This helps in thorough mixing of the concrete. Transit-mixing keeps the water separate from the cement and aggregates and allows the concrete to be mixed immediately before placement at the construction site. You can see the things that facilitate when compared to normal concrete. This method avoids the problems of premature hardening and slump loss that result from potential delays in transportation or placement of central-mixed concrete. Furthermore, shrink mixed is used to increase the truck's load capacity. The mix of concrete is shrunk such that the truck is able to carry more load. If you notice, the concrete is mixed and added to truck, it gives a certain amount of volume. When you use the concrete mix that has a little bit of shrink, the truck is able to carry a better load or rather a larger load and makes it more feasible in terms of economics. This makes it more feasible in terms of economics. This retains the advantage of transit-mixed concrete. In this case, concrete is partially mixed at the plant to reduce or shrink the volume of the mixture and mixing is completed in transit or at the jobsite. As I said, it should be shrunk so that more volume can fit into the truck. Only partial

mixing is done. Ready-mixed concrete is often remixed once it arrives at the jobsite to ensure that proper slump is obtained. Apart from being partially mixed, completely transit mixed, it is also remixed at the site to make sure it thoroughly done and that there is no slump. However concrete that has been remixed tends to set more rapidly than concrete mixed only once. This can be advantageous as well as disadvantageous. This can be varied and used as per the specific requirements.

Aerated Concrete

We will move on to another type of concrete. This is very interesting in the way it is formed and facilitates a lot of uses. It is called Aerated concrete. You can imagine Aerated drink, it is formed pretty much the same way. Autoclaved aerated concrete, a lightweight, precast foam concrete building material invented in the mid-1920s that simultaneously provides structure, insulation and fire- and mold-resistance. AAC products include blocks, wall panels, floor and roof panels, cladding (facade) panels and lintels. Unlike most other concrete applications, AAC is produced using no aggregate larger than sand. We noticed in other sands, we had more fine aggregates, we also had aggregates that were polymers. In this case the only aggregate that will be used is sand and nothing larger than that. Quartz sand, calcined gypsum, lime(mineral) and/or cement and water are used as a binding agent.

When AAC is mixed and cast in forms, several chemical reactions take place, giving AAC its light weight 20% of the actual weight of Portland cement concrete and thermal properties. Aluminium powder reacts with calcium hydroxide and water to form hydrogen. Once it is mixed, hydrogen is formed. The hydrogen gas foams and doubles the volume of the raw mix creating gas bubbles up to 3mm, in diameter. At the end of the foaming process, the hydrogen escapes into the atmosphere and is replaced by air. We have aerations or small capillaries. This is replaced by air. When the forms are removed from the material, it is solid but still soft. Its kind of lightweight, soft, has air bubbles in between which is why it is called Aerated concrete. After this, it can be cut easily into blocks or panels and placed in autoclave chamber for 12 hours. During this steam pressure hardening process, when the temperature reaches 190 degree celsius, 374 Fahrenheit, and the pressure reaches 8 to 12 bar, quartz sand reacts with calcium hydroxide to form calcium silicate hydrate, which gives AAC its high strength and other unique properties. Apart from being lightweight and being able to cut easily, the formation of calcium hydroxide results in high strength and other unique properties of AAC. Because of the relatively low temperature used AAC blocks are not considered fired brick but a lightweight concrete masonry unit. After the autoclaving process, the material is ready for immediate use on the construction site. Physical feature itself shows that it's very lightweight and can be very finely cut and precisely done.

Properties are improved thermal efficiency, Porous structure allows for superior fire resistance, workability allows accurate cutting, which minimizes the generation of solid waste during use. Resource efficiency gives it lower environmental impact in all phases of its life cycle, from processing of raw materials to the disposal of waste. Light weight saves cost and energy in transportation labour expenses and increases chances of survival during seismic activity. It also reduces the overall cost of the project. Environment friendly as I said, reduces at least 30% of the environment waste produced. There is a decrease of at least 50% of the greenhouse gas emissions. Every form of concrete has greenhouse gas emissions. There is a 50% reduction in terms of ACs. When possible, using autoclaved aerated concrete is a better choice for the environment. Energy saver, apart from being environment friendly, it also saves a lot of energy.

Great ventilation - this material is very airy and allows for the diffusion of water. This will reduce the humidity within the building. ACC will absorb moisture and release humidity; this helps to prevent condensation and other problems that are related to mildew. Obviously, air pockets lead to non-toxiccity. Also, quick assembly in case of neatly cut blocks. Lightweight material and easy to work with, the assembly is much more quicker and smoother.

We will look into the various uses of Aerated concrete because of the various manifold of advantages it offers. The reduction in the dead weight of the construction materials using lightweight concrete, could result in a decrease in cross-section of concrete structural elements. AAC blocks can be used in both non-load bearing and load bearing walls. Aerated concrete blocks can be applicable in construction engineering in terms of foundation, pipeline backfilling, roof insulation, etc, but also get some application result in infrastructure facilities. It has applications for both general construction industry as well as Infrastructure facilities.