Case study of high strength concrete construction essay

In the text below I have tried my best and put in all of my efforts to create a document that might help other students even without any prior knowledge of the subject to understand the very important subject concrete with thorough understanding of the concrete. The text gives the basic knowledge of the lesser important concepts and has been written to depth for important and practical concepts. I have tried to create a document that shall be used to give lectures and cover the gap between a professor with in depth knowledge of the subject and a student who has just been introduced to the subject.

I am also thankful to my professors and friends for their support in completing this work. I hope the document acts as a mode of information rather than being a jigsaw puzzle and fulfill all the requirements for the formal submission.

Introduction: – Civil engineering is the oldest and the most basic streams of engineering. When we think of civil engineering the first thing that comes to mind is cement and construction, when we come down to the more uses of civil engineering we think of concrete. Concrete is not such a simple thing as it may look down to a non construction related person, it is due to the fact that it has so many practical uses, more than any construction material that it has a specialization of its own. So the study of concrete is very helpful or may be considered the most necessary studies for a civil engineer. Nowadays the study of concrete is considered as the backbone of the construction industry. This subject has its own specializations available for study is such a vast subject that for a construction industry or company the success is decided by its concrete engineers. The modern industry of the

today′s world relies completely on the construction of concrete structures. Concrete has experienced this great variety of use due to its marvelous properties that completely distinguish it from any of the rest of construction materials. The history of construction traces back to the times of Assyrians and Babylonians who first made the use of clay as a cementing material. The ancient forts and military buildings, the defense structures have witnessed a wide use of the concrete made of aggregates and lime as a binder. Construction of the pyramids in Egypt has also proved the use of lime and gypsum as a binder in the concrete works. The prominent scientists of the concrete study are Vitruvius who is believed to have the knowledge of chemistry of the cementitious lime. One of the remarkable ancient works is the pantheon, which consists of a dome spanning 43. 43m and is made entirely of concrete. The Romans also used suitable cements made of suitable limestone burned in kiln or were mixtures of lime and puzzolanic materials (volcanic, ash, tuff) combining into a hard concrete. Vitruvius′s work was followed by the researches made by M. Vicat of France. Joseph Aspedin of Yorkshire (U. K.) was the first to introduce Portland cement in 1824 formed by heating a mixture of limestone and finely divided clay in a furnace to a temperature high enough to drive off the carbonic acid gas. In 1845, Issac C. Johnson invented the cement by increasing the temperature at which the mixture of limestone and clay were burned to form clinker. This cement was the prototype of the modern Portland cement. From then onwards, a gradual improvement in the properties and qualities of cement has been made possible by researchers in U. S. A., U. K., France and Germany.

What exactly is concrete: – Concrete is a composite man-made material most widely used building material in the construction industry. It consists of a rationally chosen mixture of binding material such as lime or cement, well graded fine and coarse aggregates, water and admixtures (to produce concrete with special properties). In a concrete mix, cement and water form a paste or matrix which in addition to filling the voids of the fine aggregate, coats the surface of fine and coarse aggregates and binds them together. The matrix is usually 22-34% of the total volume. Freshly mixed concrete before set is known as wet or green concrete whereas after setting and hardening it is known as set or hardened concrete. The moulded concrete mix after sufficient curing becomes hard like stone due to chemical action between the water and binding material. It would be impossible to discuss all the aspects of this material in few pages and the discussion is confined to the general characteristics and quality tests necessary for its use by civil engineers and architects.

Most of the ancient structures and historical buildings had been constructed with lime concrete. With the advent of cement, the use of lime concrete has been confined to making bases for concrete foundations and roof terracing. The major factors responsible for wide usage of cement-concrete are mouldability, early hardening, high early compressive strength, development of desired properties with admixtures to be used in adverse situations, suitability for guniting, pumpability and durability. The simple reason for its extensive use in the construction of almost all civil engineering works is that the properties can be controlled within a wide range by using appropriate ingredients and by special mechanical, physical and chemical processing

techniques Buildingsâ€” from single storey to multistorey, bridges, piers, dams, weirs, retaining walls, liquid retaining structures, reservoirs chimneys, bins, silos, runways, pavements, shells, arches, railway sleepers are but a few examples of cement concrete applications.

Concept of high strength concrete: – Concrete due to its versatile properties is used for many heavy and medium or low cost constructions. So the concrete used in these works is not entirely same. Thus for more important and demanding works a concrete with higher strength is needed. This concrete can be given extra strength by various methods. Usually any concrete which falls in a grade over M65 is considered or called high strength concrete. This M65 signifies a compressive strength of 65N/mm2 after 28 days.

This strength apart from other methods can be reached by REINFORCING the concrete with other materials of higher strength. Reinforcing means the mixing the concrete mix with other materials. The materials most commonly used are steel, bamboo, wire mesh, sticks etc. These materials provide those properties to the concrete that the concrete itself lacks. The concrete so reinforced becomes so strong that no other material can be compared to it. Also the strength to cost ratio of this is very less as compared to any other material available in the market.

RCC and concrete: – RCC and concrete are the same thing but for the fact that RCC has some reinforcement provided to the mix and the plain concrete is just a mix of cement sand and water along with aggregates. The reinforcement is placed where the structure has to be built and concrete is

later put on it and both of these bond together to form a high strength concrete. The most common reinforcing material used is steel in the form of steel bars and wire mesh. So the wire mesh or the steel bars are easy to place and the main work then lies in properly preparing the concrete mix. So we shall now study the preparation of the concrete mix.

Preparation of concrete: – The concrete is fairly easy to manufacture. The preparation of concrete is a stepwise process. Its preparation involves storage of materials namely sand aggregate, cement, water. After that follows batching of materials which is a process of measurement of materials by different, convenient methods. Then falls the process of mixing which is a vital process; the most of properties depend on the mixing conditions and the type of mixing done. Mixing is the process of mixing the materials, batched before and preparing the final concrete mix or paste. The concrete so prepared is now needs to be transported to the site of use. This is done by using pans, wheel bar rows, transit mixers, chutes, bell conveyers, pumps, tower crane and hoists etc. Now that the concrete has been brought to the site it needs to be placed such that it gains maximum strength as easily as possible. So the placing is also a very vital process of the concreting operation. Now that the concrete has been placed we now have to make sure that no voids are left in the placed mix. Compacting the concrete mix makes sure that the concrete gains fullest of its strength. Then remains finishing of the concrete work done to make sure that it looks good aesthetically. Then the concrete needs to be cured to check the development of cracks and control the heat of hydration.

The details of each of these processes are as follows:

Storing of materials: – Storing of materials is controlled so that the materials do not get deteriorated. The materials stored on sites are cement, aggregate, sand, water, steel and any other admixtures. The cement should be stored very carefully as the cement is the second most costly material after steel which is used in lesser quantities; cement easily attracts any moisture in the air and hardens and gets useless for the construction purpose. The cement should be stored in air tight rooms free of moisture and rodents. The bags of cement should be placed at least 30 cm apart from the walls and at least 20 cm above the floor level this is done by making a temporary platform of wood or other cheap material. The cement bags should be placed one over other to a maximum height of 1. 5m. The cement bags should be used on the first in first out basis. These bags should be kept covered at all times with a suitable plastic cover.

Then comes the aggregates, the aggregates should be so stored that these are distinguishly stored according to their size. These should either be kept completely moist or completely dry this helps to better understand the water cement ratio and provides a strict control over this vital ratio.

Then comes sand, sand does not need much special attention while storing but sand so stored should be checked regularly for increase in the moisture content and hence bulking.

The water used for adding to the cement or concrete is usually potable water and the water should be kept clean and free of any vegetation and any kind of visible materials and sand etc.

Batching: – The batching of materials is a simple process of measuring the quantity of the materials to be used for the concrete mix. This is done by two methods namely by weight and by volume. The materials while mixing need to be proportioned properly so that the desired strength and properties can be achieved. This has to be done strictly to ensure the desired properties. In the former category all of the ingredients are measured by weight. But this system has a drawback that the moisture content alters the weight of the materials and this has to be adjusted after experiments and mathematical calculations.

The later uses the measuring the materials by volume and is less preferable to the above method. This is for the reason that the sand content varies greatly in volume by the moisture content. This variation is harder to account for accurate measurement.

Mixing: – The process of mixing of various ingredients of concrete in specified proportion is termed as mixing of concrete. Objectives of mixing: the quality and strength of concrete depends upon proper mixing. The object of mixing is to coat the surface all aggregate particles with cement paste and to obtain concrete of uniform color and required consistency.

Methods of mixing:

Hand mixing: – the process of mixing the ingredients of concrete by manual labor is called hand mixing. It is adopted for small and unimportant and where quantity of concrete used is small. Hand mixing method requires more cement (10%) than machine mixing for obtaining the same strength of concrete.

Machine mixing: – The process of mixing the ingredients of concrete by a machine is called machine mixing.

In case where a large quantity of concrete is to be produced, hand mixing becomes costly even if the labor is cheap. The machine maxing becomes essential. The concrete can thus be produced at a faster rate and at lesser cost. The quality of concrete by machine mixing is also better.

Transportation of concrete: – The process of carrying concrete mix from the place of mixing to the final position of deposition is called transportation of concrete. Transportation of concrete mix is very important because in transportation, time factor is involved. The mix has to be transported as soon as possible.

Precautions in transportation: – concrete should be transported as quickly as possible to the formwork within the initial setting time of cement.

Efforts should be made to prevent segregation.

Transportation cost should be as low as possible.

The concrete mix should be protected from drying in hot weather and from rain during transportation.

No water should be lost from the mix during transportation.

Methods of transportation: -The following are the modes of transportation of concrete:

Pans- in this method concrete is transported in iron pans manually.

Wheel barrows- steel wheel barrows with 70L capacity with pneumatic tires are used for moderate distances.

Truck mixers or tipping lorries- this is used for longer distances of travel. In this a truck or lorry having a mixer built into it is used to carry concrete.

Other methods are:

Chutes

Belt conveyers

Tower cranes

Pumps

Formwork: – The temporary construction used as a mould for the structure for the structure in which the concrete is placed and in which it hardens is called formwork or shuttering.

It includes all the surfaces in contact with concrete and all necessary supporting members. The part of formwork which consists of sheeting and its immediate supporting or stiffening members is called form. The part of formwork which supports the forms usually for a large structure is called false work. It is yet another important process for concreting.

Compaction: – Compaction of concrete is a process of eliminating the entrapped air in concrete and achieving maximum density. The importance should not be under estimated. The strength of concrete is reduced by about

40% by presence of only 5% voids. The compaction reduces voids to a minimum. The compaction is done by doing external work on the concrete.

Finishing: – finishing may be defined as the process adopted for obtaining a true, uniform concrete surface. The importance of finishing is inevitable. It is to keep the concrete surfaces free from undulations. The vibrating or hand tamping of a concrete leaves a slightly rough surface. Finishing of concrete surface is therefore important. The choice of concrete finishing depends upon the ultimate use of the component and desired aesthetic effect.

Curing: – The process off keeping the concrete moist to enable it to gain strength is called curing. It is name given to procedure used for prompting the hydration of cement. The concrete hardens because of hydration i. e. the chemical reaction between water and cement. This reaction depends on the presence of water. Although there is sufficient water at the time of mixing yet it is necessary to ensure that the water is retained to enable the chemical reaction to continue.

Methods of curing: – The various methods of curing are

Shading of concrete work.

Covering the concrete surface with gunny bags or hessians.

Sprinkling of water.

Ponding method.

Membrane curing.

Steam curing.

Of these, ponding covering of concrete surface with gunny bags or hessians are the most commonly and very widely used.

Proportioning of concrete mixes: – Proportioning of a concrete mix means determining the relative amounts of materials required for batches of concrete of required strength. This process is generally called as design of mix.

In proportioning a concrete mix, one has to choose suitable proportions of all the ingredients of concrete i. e. cement, aggregate and water so as to give concrete its desired properties both on the plastic as well as in hardened stage with the maximum economy.

Grades of concrete: – concrete id graded according to its compressive strength. As per IS 456: 2000 the concrete mixes are designated into fifteen grades. The various grades of concrete are given in the table below:

Group

Designation

Compressive Strength (N/mm2)

Ordinary concrete

M10

10

M15

15

M20

20

M25

25

Standard concrete

M30

30

M35

35

M40

40

M45

45

M50

50

M55

55

M60

60

High strength concrete

M65

65

M70

70

M75

75

M80

80

Concretes of compressive strength lesser than 20MPa may be used for lean concrete bases and simple foundations for masonry walls.

Grades lower than M20 should not be used in reinforced concrete works.

Grades lower than M30 should not be used in post tensioned prestressed concrete.

Grades lower than M40 should not be used in pre tensioned prestressed concrete.

There are two types of concretes based on the method of proportioning:

Ordinary concrete (normal mix concrete)

Controlled concrete (design mix concrete)

Ordinary concrete (normal mix concrete): – The concrete in which the proportions of cement, aggregates and water are determined by adopting nominal concrete mixes and no preliminary tests are performed is called ordinary concrete. It is only used when it is not possible to use controlled concrete. It may be used for grades M20 or lower if designed mix concrete cannot be used for some reasons. The proportions of the ingredients are specified by the engineer usually without testing the materials. There is no guarantee that a M20 nominal mix with adopted proportions (say 1: 4: 8) will have a 28 days cube strength of 20N/mm2.

IS 456: 2000 suggests the proportions of materials required for nominal mix concrete as shown in the table below:

Grade of concrete

Total quantity of dry aggregate per 50 kg of cement (kg)

Proportions of fine aggregate to coarse aggregate by wt.

Maximum quantity of water per 50kg of cement (liters)

M10

480

Generally 1: 2 but upper

34

M15

330

Limit is 1: 1. 5 and lower

32

M20

250

Limit is 1: 1. 25

30

Controlled concrete (design mix concrete): – The concrete in which the proportions of cement, aggregate and water are determined by conducting preliminary tests for the design of mix is called controlled concrete. A design mix concrete is preferred over a nominal mix concrete for durability, strength and economy.

Reinforced cement concrete: – RCC or reinforced concrete cement is yet another type of high strength concrete. As explained when reinforcing

materials of higher strength are added to the concrete it becomes reinforced cement concrete.

The main feature of adding this reinforcement is that it makes the concrete very strong even in tension; otherwise in which concrete is very weak. This happens due to the bonding between reinforcing materials and the concrete mix.

The concrete so prepared is used for many purposes such as piers, bridges, flyovers, dams, slabs, arches etc. The strength of same proportions of materials of concrete when reinforced yields more than twice the strength as it would otherwise.

IS codes help us design structures of RCC by considering various norms and limits of safety and other factors. These tell us what extra provisions are needed to be made in certain conditions. The normally used reinforcements are steel bars which are explained in detail as under:

Steel bars are available in the market in various sizes which are the measure of the diameter of the bar. These sizes range from 6 mm to 24 mm for general purpose. Other larger and specialized sizes are also available for special constructions. These bars are cast of steel formed by addition of about 1% of carbon content to iron while it´s manufacturing. This steel is very hard and is very ductile. Traces of other materials are also added to this steel to modify suitable properties.

These bars are of two types based on the process of manufacturing or final properties:

TMT- thermo mechanically treated bars

Sal- ordinary ribbed bars.

TMT: – this is a product of the new age and has evolved as a result of scientific research over the years in the fields of metallurgy and other related field such as metallurgy and the properties of metals. These bars as the name suggests are mechanically treated to make stronger. These are first heated to a temp of 1400C (red hot) and then cooled suddenly which makes it stronger. Then these bars are also ribbed which makes them stronger at bonding. These bars are available in the market and are preferred over the other plain or ribbed or SAL bars.

SAL: – these are the traditional bars which were first tested by forming corrugations or ribs. The ribs on these are helical in shape. These are less strong than the other types of bars (TMT). These bars are manufactured from steel with 0. 8-1. 2% of carbon content in iron. These bars are brittle and less ductile. So these are nowadays moving out of market. These are not used in any of the engineering works. The cost of these is not considerably less than the TMT bars. These bars are available in sizes ranging from 8mm to 26mm. these bars make a weaker bond than TMT and should not be used for any important works.

Design of RCC: – RCC structures need quite a lot of mathematical analysis to be done before the values of final construction are received. The maximum amount of steel that can be added to the structures is 4% of the cross sectional area. The slabs and beams designed of RCC are categorized into two parts- singly reinforced structures and doubly reinforced structures.

Singly reinforced structures are those in which the steel reinforcement is added to the lower side of the beam or the slab that bears tension.

Doubly reinforced structures are those in which the steel reinforcement is added to both- upper and lower side of the structure for cases of variable tension and compression values; or extra strength is required for higher load values or when the dimensions of the member to be cast are limited due to some reason or other. These kinds of things make the RCC structures backbone of the construction industry. These RCC structures with steel are also very safe for shear and torsional forces too.

Alterations of properties of concrete (Admixtures): – The concrete has its certain properties that sometimes are needed to be changed, for this reasons other materials other than the basic ingredients are added to the concrete while mixing. These materials are called admixtures.

These are categorized into several divisions:

Accelerators

Retarders

Water-reducing admixtures

Air-entraining admixtures

Plasticizers

Some common examples of admixtures are fly ashes, silica fume, rice husk ash, metakaolin.

Now details of these types of admixtures

Accelerators: – Accelerators are the chemicals used to accelerate the setting and hardening of concrete. Accelerators are added to concrete to:

Increase the rate of hydration and hence to increase the rate of strength development.

Reduce the setting time.

E. g. of accelerators- calcium chloride, triethenolamine etc.

Retarding admixtures (Retarders): – Retarders are the chemicals used to delay the setting and hardening of concrete. Retarders slow down the chemical process of hydration so that concrete remains plastic and workable for a longer time than a concrete without retarder. E. g. of retarders are sugar, calcium sulphate, skimmed milk, ammonium chloride, calcium borate, calcium tartarate, mucic acid etc.

Water reducing admixtures: – These are used to:

Increase the workability of freshly mixed concrete without increasing water cement ratio.

Maintain workability with reduced water cement ratio.

Sugar in addition to acting as a retarder, improves the workability of concrete also. Carbohydrates and organic acids are other examples of water reducing admixtures.

Air entraining agents: – Air-entraining admixtures are used to entrain air in form of very small disconnected air bubbles in concrete. The air bubbles (approximately . 01 to. 25mm dia) act as flexible ball bearings and modify the properties of plastic concrete. It also modifies the properties of hardened concrete.

Plasticizers: – Plasticizing admixture is a substance which imparts very high workability with a large decrease in water content (at least 20%) for a given workability. It also permits the use of lower water cement ratio for the same workability.

Materials used as plasticizers:

Anionic substances such as lignosulphonates.

Nonionic surfactants such as hydroxylated carboxylic acid.

Other products such as carbohydrates.

Calcium, sodium, and ammonium lignosulphonates are mostly used as plasticizers.

Plasticizers are used in the amount of 0. 1 to 4% by weight of cement.

A 0. 5% concentration of plasticizer by weight of cement can:

Increase the 28 days compressive strength by 30% with 20% reduction in water cement ratio.

Increase slump from 25 to 100mm.

Require 15% less cement.

Uses: these can be used where a high degree of workability is required in situations like:

Deep beams.

Column and beam junctions.

Tremie concrete.

Pumping of concrete.

Thin walls of water retaining structures with high percentage of steel reinforcement.

This was it about the case study of high strength concrete. I have tried my best to give the best approach possible to every aspect of any concept. Still humans will keep making mistakes so that they can learn from them. Thanks.