CONCRETE TECHNOLOGY

MODULE -5

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SPECIAL CONCRETES

LIGHT WEIGHT AGGREGATES

It is a type of coarse aggregate that is used in the production of lightweight concrete products such as concrete block, structural concrete and Pavement.

Light weight aggregates can be classified into two categories :-

i) Natural light weight aggregate.
ii) Artificial light weight aggregate.

Natural Light Weight AGGREGATE

1) PUMICE → These are rocks of volcanic origin which occur in many parts of the world. They are light in weight enough and yet strong to be used as light weight aggregate. The lightness is due to the escaping of gas from the molten lava when erupted from beneath the earth's crest. The bulk density of Pumice varies from 600 to 900 kg/m^3.

2) Diatomite → This is naturally occuring soft hydrated amorphous siliceous sedimentary rock derived from the remains of microscopic aquatic focalized plants called diatoms. It is also known as kieselguhr. The bulk density varies from 450 to 880 kg/m^3. Diatomite is used as a workability agent and

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also as one of the good Pozzolanic material.

3) Scoria → It is a highly vesicular, dark coloured volcanic rock and basaltic in nature. It is relatively low in density due to its numerous macroscopic vesicles. Bulk density varies from 1100 – 1500 kg/m³.

4) Volcanic cinders →

Cinders are mainly extrusive igneous rocks having numerous gas bubbles frozen into place as magma exploded into the air and then cooled quickly. The bulk density of cinders varies from 620 – 900 kg/m³.

5) Saw dust → It has been used as a light weight aggregate in flooring and in the manufacture of Precast Products. The bulk density varies from 300 – 400 kg/m³

Artificial light-weight Aggregate

① Cinder, clinker, coal breeze and bottom Ash.

The term clinker, breeze and cinder are used to cover the material partly fused or sintered particles arising from the combustion of coal. Cinder aggregates have also been used for making building blocks for partition walls, for making screeding over flat roofs and for plastering purposes.

2) Foamed slag → It is produced by rapidly quenching blast furnace slag, a by-product in the manufacture of pig iron. When the molten slag is rapidly agitated with a limited amount of water and the steam and gas and produced are made to get entrapped in the mass. Such a product is called foamed slag. It is used for manufacture of precast RCC lintels.

3) Bloated clay and shale → When certain clays and shales are heated to the point of incipient fusion (about), they expand or what is termed as bloat to many times their original values or volume on account of formation of gas within the mass at fusion temperatures.

4) Sintered Fly Ash (Pulverished Fuel Ash) –

low density aggregate is produced by dampening the fly ash with water and mixing it with coal slurry. It has high strength / density ratio and relatively low drying shrinkage.

5) Exfoliated Vermiculite – Raw Vermiculite is a micaceous mineral and has a laminar structure, but unlike mica, it expands (exfoliates) rapidly when heated. The raw ore

is dried, crushed and graded for sizes. The individual grades are then rapidly passed through hot burners, about, this causes the Vermiculite to exfoliate. The fully exfoliated vermiculite which may have expanded even as much as 30 times will have a density of only 60 to 130 kg/m^3. This concrete is used for insulating purposes. It is also used for in situ roof and floor screeds or for the manufacture of blocks, slabs and tiles which are used for sound insulation and heat insulation.

6) Expanded Perlite.
7) Thermocole beads.

LIGHT-WEIGHT AGGREGATE CONCRETE

Light weight aggregate concrete is prepared by using light weight aggregate or low density aggregate such as volcanic pumice, clay, slate, shale, scoria, and perlite. Concrete is considered to be light weight and the density is not more than 2200 kg/m^3, when compared to normal concrete which is 2300-2400 kg/m^3 and a proportion of the aggregate, should have a density of less than 2000 kg/m^3.

PROPERTIES

1). Particle shape and Texture of Aggregate.
The shape of the light weight aggregate used in concrete may be in cubical, rounded, angular or irregular shape. Textures may range from the fine pore, relatively smooth skins to highly irregular surfaces with large exposed pores.

2) Compressive strength :-

compressive strength levels commonly used by the construction industry for design strengths of cast-in-place, Precast or prestressed concrete is around 3000 to 5000 PSI which can be easily obtained by light weight aggregate concrete.

3) Density :- The fresh density of light weight concrete is a function of mixture proportions, air contents, water demand, particle density, and moisture content of the lightweight aggregate.
ACI 213 definition of structural grade lightweight concrete that has an equilibrium dry density ranging between 90 to 115 lb/ft^3

4) Absorption :- light weight concrete absorbed very little water and thus maintained their low density.

5) Internal Curing :- They are used for better

internal curing because of better hydration of the cementitious fraction provided by moisture available from the slowly released reservoir of absorbed water within the pores of the light weight concrete.

6) Thermal conductivity :-

The thermal conductivity of concrete depends mainly on its density and moisture content but is also influenced by the size and distribution of the pores, the chemical composition of the solid components their internal structure of light weight concrete. As the lightweight concrete is low in density and moisture content is more due to pores, the thermal conductivity of this concrete is less when compared to normal concrete.

7) Fire Resistance :- When tested according to the procedures of ASTM E 119, structural lightweight concrete slabs, walls and beams have demonstrated greater fire endurance periods than equivalent thickness members made with concrete containing ordinary aggregate.

CHARACTERISTICS

1. There should be uniformity in properties and composition.
2. The aggregate should have a low specific weight to ensure worthwhile savings in the structure, in accordance with the appropriate ASTM specifications.
3. Notwithstanding the desirability of having surface characteristics to provide a good bond, the aggregate should have a minimum of large external voids but a large number of smaller well dispersed voids throughout the particles.
4. Individual pieces of aggregate should be strong enough to withstand handling and mixing.
5. The particles should bond well with cement and not react chemically to cement.
6. The aggregate should be suitably graded for the intended use, in accordance with the appropriate ASTM specification.

USES

1. Screeds and thickening for general purposes especially when such screeds are thickening and weight to floors roofs and other structural members.

2. Screeds and walls where timber has to be attached by nailing.

3. Casting structural steel to protect its against fire and corrosion or as a covering for architectural purposes.

4. Heat insulation on roofs.

5. Insulating water pipes.

6. Construction of partition walls and panel walls in frame structures.

7. Fixing bricks to receive nails from joinery principally in domestic construction.

8. General insulation of walls.

9. Surface rendered for external walls of small houses.

10. It is also being used for reinforced concrete.

WEIGHT OF LIGHT WEIGHT AGGREGATE CONCRETE

The weight of the light weight aggregate concrete is around 115 pounds per cubic foot whereas the weight of the normal weight concrete is 145 pounds per cubic foot.

NO-FINES CONCRETE

No-fines concrete is a light weight concrete made up of only coarse aggregate, cement and water by omitting fines (sand or fine aggregates) from normal concrete.

Advantages

1. No fines concrete is a light weight concrete i.e density is about 25 to 30% less than the normal concrete due to no fine aggregates, thus self weight of structure is less.

2. As it does not have sands or fine aggregates it has less drying shrinkage compared to normal concrete.

3. It has better thermal insulating characteristic than normal concrete and thus it is useful for construction of external wall.

4. As it has no fine aggregate, the surface area required for cement coating is reduced considerably. So, quantity of cement required gets reduced per cubic meter compared with normal concrete. So, it is economical.

5. Light weight concrete has no effect on quality due to segregation of coarse aggregates as it has no fine aggregates. Thus it can be dropped from heights.

6. No fines concrete can be compacted without the need of any types of concrete vibrators and can easily done by tamping with rods.

LIMITATIONS

1. As there is no fine aggregates to fill the voids in this concrete, it has high permeability than normal concrete. Thus it is not a good idea to construct reinforced concrete with no fines concrete, as the reinforcement can easily get corroded.

2. To make this concrete impermeable, extra coat of masonry plaster is required which increase the cost.

3. No fines concrete can not be tested for workability by using tests for normal concrete such as slump or compaction factor test.

MIX-PROPORTION OF NO-FINES CONCRETE

No fines concrete is generally made with the aggregate / cement ratio from 6:1 to 10:1. Aggregates used are normally of size passing through 20 mm and retained on 10 mm.

The strength of no-fines concrete is dependent on the water/cement ratio, aggregate cement ratio and unit weight of concrete.

The water/cement ratio for satisfactory consistency will vary between a narrow range of 0.38 and 0.52. If too low water/cement ratio is adopted the paste will be so dry that aggregates do not get properly smeared with paste which results in insufficient adhesion between the particles.

On the other hand, if the water/cement ratio is more, the paste flows to the bottom of the concrete, particularly when vibrated and fills up the voids between the aggregates at the bottom and makes that portion dense. This condition reduces the adhesion between aggregate and the paste becomes very thin.

No standard method is available like slump test or compacting factor test for measuring the consistency of no-fines concrete.

No fines concrete when conventional aggregates are used may show a density of about 1600 to 1900 kg/m^3, but when no fines concrete is made by using light weight aggregate the density may become 360 kg/m^3. The compressive strength varies from 1.4 MPa to about 14 MPa.

HIGH DENSITY CONCRETE

High density concrete is a concrete having a density in the range of 6000 to 6400 kg/cum. High density concrete is also known as heavy weight concrete. High density concrete is mainly used for the purpose of radiation shielding, for counterweights and other uses where high density is required.

TYPES OF RADIATION IN HIGH DENSITY CONCRETE AND THEIR HAZARDS.

1) Electro-magnetic waves.
2) Nuclear Particles.

Shielding Ability

1. It has sufficient capacity to absorb the radiation both of neutron and gamma rays, reducing the radiation to a very weak state.

2. It has good mechanical properties as strength and durability.

3. It is used for radiation shielding and its initial and maintenance cost is relatively low.

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DISADVANTAGES

1. The use of concrete as shielding against radiation needs more space.

2. The weight of shielding concrete is very high in the range of 3360 to 3840 kg/m³.

CHOICE OF AGGREGATES

Some of natural commercially used aggregates are as follows.

1. Barite
2. Magnetite
3. Ilmenite
4. Limonite
5. Haematite
6. Chromite
7. Manganese slag.

PROPERTIES

1. The strength of the concrete measured on standard cylinders has been found 42 MPa at 28 days for a water / cement ratio 0.58 and 24 MPa at water / cement ratio 0.9.

2. The density of this concrete for a mix of 1:4.6:6.4 with water / cement ratio of 0.58 has been found as 3700 kg/m³.

3. The coefficient of thermal expansion of barite concrete measured in the range of temperature of 4°C to 38°C is found about

twice that of normal concrete.

4. The modulus of elasticity and poisson's ratio of high density concrete and normal concrete are approximately the same.

5. Shrinkage of high density concrete is about 1/4 to 1/3 of the normal concrete.

6. Concrete made with barite aggregate does not stand well to weathering.

7. No entrained air should be permitted in this concrete.

FIBRE REINFORCED CONCRETE

It can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete uniformly dispersed suitable fibres.

The fibres that are used are steel fibres, polypropylene, nylons, asbestors, coir, glass and carbon.

NECESSITY OF FIBRE REINFORCED CONCRETE

1. It increases the tensile strength of concrete.
2. It reduce the air voids and water voids

the inherent porosity of gel

3. It increases the durability of the concrete

4. Fibres such as graphite and glass have excellent resistance to creep while the same is not true for most resins.

5. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibres to concrete would act as crack arrested and would substantially improve its static and dynamic properties

FACTORS AFFECTING

1. Relative fibre matrix stiffness.
2. Volume of fibres.
3. Aspect ratio of the fibre.
4. Orientation of fibres.
5. Workability and compaction of concrete.
6. Size of coarse aggregate
7. Mixing.

Different types of fibre reinforced concrete

1. Steel fiber Reinforced concrete.
2. Polypropylene Fiber Reinforced Cement mortar & concrete.
3. GFRC Glass fiber Reinforced Concrete.
4. Asbestos fibers.

5. Carbon fibers.

6. Organic fibers.

POLYMER CONCRETE

It is a composite material in which the aggregate is bound together in a matrix with polymer binder.

In polymer concrete thermoplastic polymers are used, but more typically thermosetting resins are used as the principal polymer component due to their high thermal stability and resistance to a wide variety of chemicals.

Polymer concrete is also composed of aggregates that include silica, quartz, limestone, granite etc.

USES

1. The adhesive properties of polymer concrete allow repair of both polymer and conventional cement-based concretes.

2. It can also be used as a bonded wearing course for asphalt pavement, for higher durability and higher strength upon a concrete substrate and in skate parks.

3. It is used in swimming pools, drainage channels, electrolytic cells for base metal recovery and other structures that contain liquids or corrosive chemicals.

4) It is especially suited to the construction and rehabilitation of manholes due to their ability to withstand toxic and corrosive sewer gases.

TYPES

1. Polymer Impregnated Concrete (PIC)
2. Polymer Cement Concrete (PCC)
3. Polymer Concrete (PC)
4. Partially impregnated and surface coated polymer concrete

POLYMER IMREGNATED CONCRETE (PIC)

It is a pre-cast conventional concrete, cured and dried in oven or by dielectric heating from which the air in the open cell is removed by vacuum.

Mainly the following types of monomers are used :-

1. Methyl Methacrylate (MMA)
2. Styrene.
3. Acrylonitrile.
4. t-butyl styrene.
5. Other thermoplastic monomers.

POLYMER CEMENT CONCRETE

It is made by mixing cement, aggregate, water and monomer.

The monomers used are :-

1. Polyester-styrene.
2. Epoxy-styrene.
3. Furans.
4. Vinylidene chloride.

HIGH PERFORMANCE CONCRETE

It is defined as concrete with strength and durability beyond those obtained by normal means.

COMPOSITION

The composition of high polymer concrete consists of the following materials.

1) Cement
2) Water
3) Fine aggregate
4) Coarse aggregate.
5) superplasticizer
6) Cementitious materials (slag, fly ash, silica fume, GGBFS) etc.

FEATURES

1. Compressive strength > 80 MPa even upto 800 MPa.

2. High durability.

3. Water binder ratio (0.25 - 0.35)

4. Reduced flocculation of cement grains.

5. low bleeding and plastic shrinkage.

6. Discontinuous pores.

7. stronger transition zone at the interface between cement paste and aggregate.

8. little micro-cracking.

9. low heat of hydration

10. Powerful confinement of aggregates and smooth fracture surface.

SELF COMPACTING CONCRETE

It is defined as fresh concrete that flows under its own weight and does not require external vibration to undergo compaction.

MATERIALS USED

The main ingredients used are :-

1. cement

2. Aggregates.
3. Water.
4. Mineral admixtures.
5. Chemical admixtures.

PROPERTIES

1. Filling Ability → This property of the concrete is the ability to flow under its own weight without any vibration provided intentionally.

2. Passing Ability → The ability of concrete to maintain its homogeneity.

3. Segregation resistance → This is the resistance of the concrete not to undergo segregation when it flows during the self compaction process.

TESTS

1. Filling Ability tests. → It is further divided into 4 tests.

* Slump flow test
* T50 cm slump flow
* Orimet

* V-funnel Test.

2. Passing Ability tests → It is further divided into 4 parts:-
* L-Box Test.
* J-Ring Test.
* U-Box Test.
* Fill-Box Test.

3) Segregation Resistance tests → It is further divided into 2 parts:-
* V-funnel test at T5 minutes
* GTM screen stability Tests.

Advantages

1. The permeability of the concrete structure is decreased.
2. SCC enables freedom in designing concrete structures.
3. The SCC construction is faster.
4. The problems associated with vibration is eliminated.
5. The concrete is placed with ease, which results in large cost saving.
6. The quality of the construction increases.
7. The durability and reliability of the concrete structure is high compared to normal concrete structures.

DISADVANTAGES

1. There is no globally accepted test standards to undergo SCC mix design.
2. The cost of construction is costlier than the conventional concrete construction.
3. The use of designed mix will require more trial batches and lab tests.
4. The measurement and monitoring must be more precise.
5. The material selection for SCC is more stringent.

APPLICATIONS

1. Construction of structures with complicated reinforcement.
2. SCC is used for repairs, restoration and renewal construction.
3. Highly stable and durable retaining walls are constructed with the help of SCC.
4. SCC is employed in the construction of raft and pile foundations.