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Experimental Investigation on Reactive Powder Concrete using Silica Fume and Different Fibers

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ABSTRACT

Reviews of several literatures have made to understand the behaviour reactive powder concrete. The reactive powder concrete has properties like reduction in aggregate size, enhanced mechanical properties, reduction in aggregate to matrix ratio. The durability of RPC was better than HPC, such as abrasive wear, water absorption, corrosion, chloride ion diffusions are lower than HPC. RPC having the reduction in the total quantity of material consumed and the use of recycled materials in Ductile. RPC

Provides improve seismic performance by reducing inertia loads with lighter members, allowing larger deflection with reduced cross section and providing higher energy absorption. The extremely low levels of water and chloride ions indicates the potential of RPC as good material for storage of nuclear waste. Rpc concrete can be used in construction of nuclear plants because of its high impermeable nature.

Key words: Silica Fume, Steel Fibers, Polypropylene Fiber, Compressive Strength, Split Tensile.

1. INTRODUCTION

Concrete is a composite material consist of mainly water, aggregate, and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture. A solid mass that can be easily moulded into desired

Shape can be formed by mixing these ingredients in certain proportions. Over The time, a hard matrix formed by cement binds the rest of the ingredients together into a single hard (rigid) durable material with many uses such as buildings, pavements etc., the technology of using concrete was adopted.

Earlier on large-scale by the ancient romans, and the major part of concrete technology was highly used in the roman empire. The coliseum in rome was built largely of concrete and the dome of the pantheon is the world's largest unreinforced concrete structure. After the collapse of roman empire in the mid-18th century, the technology was repowered as the usage of concrete has become rare. Today, the widely used man made material is concrete in terms of tonnage.

REACTIVE POWDER CONCRETE

Reactive powder concrete (rpc) is a high strength, new generation concrete, formed from a special combination of constituent materials. The composition of reactive powder concrete includes cement (ordinary portland cement), fine sand, silica fume, quartz powder, and high tensile steel fibers. Reactive powder concrete is grouped under ultra-high- performance concrete. This type of concrete has enhanced mechanical and durability properties. This concrete has a very high compressive strength of 200 mpa which can be improved further by introducing steel pellets up to 800mpa. This new family of concrete has improved ductile behavior with a Flexural strength of 25mpa to binder 40mpa. These performances are due to the improved microstructure properties and highly discontinuous pore structure.

Also, the toughness index of this concrete is high when compared with the Ordinary confined concrete. There is almost no carbonation and chloride ion penetration and near zero sulphate attack. Moreover, the resistance to abrasion is near to rock. The net effect is a maximum compactness and highly disconnected pore structure. There is also no shrinkage or creep, which makes the material very suitable for application in prestressed and prefabricated structures. The high strength and easiness to produce using customary industrial tool by casting injection, and extrusion makes it suitable for prefabricated structural applications many researchers around the world have developed reactive powder concrete that could be classified, as ultra high performance concrete (uhpc). This technology of producing rpc is covered in one of many patents in the range of uhpc known as "ductile".

This material has a capacity to take high load, deform and support flexural and tensile load, even after initial cracking. Characterization of materials used in rpc has progressed to such an extent that the use of rpc in full-scale structures is distinctively visible on the horizon. Research and observations to date indicate that rpc has the potential to expand its usage in new forms that have been considered impossible until recently. In here, a general introduction about high strength reactive powder concrete is done.

The properties of such concrete show a substantial improvement over conventional concrete of low or medium strength. High strength reactive powder concrete is a concrete which has an extremely low water to cement ratio (i.e., less than 0.26), higher content, optimum packing density to eliminate capillary pore and provide an extremely dense matrix. It is a high strength material formulated from a special combination of combination of constituent materials which include portland cement, silica fume, fine aggregate, high-range water reducer and water. The material has the capability to sustain deformation and resists flexural and tensile forces, even after initial cracking.

MECHANICAL PROPERTIES OF RPC

Reactive powder concrete (rpc), which is uhpc, lies at the front in terms of innovation, aesthetics and structural efficiency. This new concrete type has compressive strengths of 150-230 mpa depending on the type and number of fibers used. Rpc has an ultra-dense microstructure as ultra-high strength concrete. Rpc based on the densest packing theory with heat curing is investigated and it is observed that it exhibits compressive strength of more than 200 mpa with great ductility. Reactive powder concretes are characterized by a high silica fume content and very low water to cement ratio. Very fine granulometry sand and heat treatment are optimized to obtain excellent mechanical and durability properties. In order to increase concrete ductility and flexural strength, metallic fibers can be added. Currently, to achieve excellent mechanical behavior, some special techniques and raw materials must be adopted in the preparation of rpc.

2. METHODOLGY:

To study the strength characteristics of concrete with the reactive powder concrete materials like silica fume, quartz powder, super plasticizers, and steel fibres with varying percentages of mix and first design mix done for m20 concrete. Collect all materials and tests should be conducted for materials to verify the properties with respect to the respective is code. Then by doing weight batching cast the cubes of size 150mm*150mm*150mm and cylinders of size 300mm depth,150mm diameter, after 24 hours remoulding the cubes and cylinders then it is allowed for curing in water at 7days,14days, and 28days.then conduct tests on cubes and cylinders at 7days,14 days, and 28days and compared the normal concrete with reactive powder concrete. Estimates the cost concrete and compare both select the which one is the cost effectiveness and economically.

3. MATERIALS USED:

The different types of materials used in this investigation give below.

CEMENT: ordinary Portland cement 53 grade cements conforming to IS: 169- 1989.the result of tests included on cement are as fallow.

TABLE 3.1. RESULTS OF CEMENT

Si.no	Property	Required as per IS 1489-1	VALUE
1.	Fineness	<10%	7%
2.	Specific gravity	3.1-3.16	3.16
3.	Initial setting time	30MINS	32MINS
4.	Final setting time	<600MINS	500MINS

FINE AGGREGATE:

The sand obtained from Saradha river near anakapalle is used as fine aggregate in this project investigation.. The sand used in this confirmation to zone-1 according to BiS. Sand which passed on 4.75mm sieve & retained on 150microns sieve are used.

Silica fume: Silica fume is a by-product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor.

Table 3.2. properties of silica fume

	Physical properties of silica fume		Chemical properties of silica fume	
s.no	properties	results	Properties	results
1.	Physical state	Micronized powder	Silica(sio2)	99.920%

2.	odour	odorless	Alumina(al2o2)	0.031%
3.	colour	white	Ferric oxide(fe2o3)	0.012%
4.	Pack density	0.77 gm/cc	Calcium oxide (Cao)	0.000%
5.	PH of 5% solution	6.91	magnesium oxide (MgO)	0.000%
6.	Moisture	0.055%	Potassium oxide(k2o)	0.002%
7.	Oil absorption	54ml /100gms	Sodium oxide(na2o)	0.004%
8.	Appearance	White colour powder	Loss on ignition	0.001%

Figure: silica fume

Super plasticizer; Super plasticizer is indispensable for the creation of Self Compacting Concrete. The role of sp is to import a high degree of flow ability and deformability however the high amounts generally with Self Compacting Concrete can lead to a high extent of segregation. Complast sp430 is utilized in this project.

Figure; super plasticizer

Steel Fibers: The steel Fibers are used for this experiment is gotten by cutting the locally available steel binding wires. Binding wires are nominally used to bind steel reinforcement together. The steel Fibers that would be used for this test will be cut into small pieces of 35mmto 50mm (2 inches) and they will have a diameter of 0.498mm, their aspect ratio will be 100.

Figure: steel Fibers

Quartz powder: Quartz, most common of all minerals is composed of silicon dioxide, or silica, SiO_2. It is an essential component of igneous and metamorphic rocks. The size varies from specimens weighing a metric ton to minute particles that sparkle in rock surfaces. The lustre in some specimens is vitreous; in others it is greasy or glossy. Some specimens are transparent; others are translucent. In pure form, quartz is colourless, but it is commonly coloured by impurities. Rock crystal is a colourless form of quartz occurring in distinct crystals. Rose quartz is coarsely crystalline and coloured rose red or pink. Smoky quartz occurs in crystals ranging from smoky yellow to dark brown. Amethyst, a semiprecious variety of quartz, is purple or violet.

Figure: quartz powder

Table 3.3. properties of quartz powder

	Physical properties of quartz powder		**Chemical properties of quartz powder**	
S.no	**parameter**	**value**	**parameter**	**value**
1.	Appearance	white	Ignition (%)	0.12
2.	odour	none	SiO2 content (%)	97.12
3.	Melting point	1710 c	Fe2O3 content (%)	0.13
4.	Boiling point	2230 c	CaO content (%)	2.16
5.	hardness	7	Moisture€ (%)	0.07
6.	Specific gravity	2.65	Organic matter	Negligible

4. RESULT AND OBSERVATIONS;

A. Compressive strength of cube

The cube specimens were tested on compression machine of capacity of 1800KN.the machine was cleaned and the specimen was placed in such a manner it was given load on opposite sides equally. All the concrete specimens were tested in a 1800KN capacity compression testing machine. Concrete cube of size 150mm×150mm×150mm is placed on the compressive testing machine and grip firmly between top and bottom plates. Apply the load at the rate of 140 kg/sq.cm/minute till the specimen failed. Note down the ultimate load at the failure of specimen, when the load is applied. divide the ultimate load by the area of specimen, then compressive strength has been calculated.

➢ **Compressive strength observations of cube specimen**

S.no	Age of specimen	Normal concrete n/ mm2	Reactive powder concrete n / mm2
1	7days	14.22	15.01
2	14days	16.44	17.99
3	28days	21.25	23.75

B. Testing of a cylinder for spilt tensile strength:

The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as spilt tensile strength of concrete. This test is compression-testing machine by placing this cylinder specimen horizontally, so that its axis is horizontal between the plates of the testing machine. The load is applied uniformly at a constant rate until failure by splitting along the vertical diameter takes place. Load at which the specimen failed is recorded. Test is performed as per IS :5816-1970. The following relation used to find out the split tensile strength of the concrete.

Picture of split tensile test

- **Compressive strength observations of reactive powder concrete cube specimen**

S.no	Age of specimen	Normal concrete n / mm2	Reactive powder concrete n / mm2
1	7days	1.708	2.24
2	14days	1.994	2.09
3	28days	2.137	1.90

5. CONCULUSION

The presented results showed that it is feasible to produce reactive powder concretes from locally materials applying reactive powder concretes principles and packing density theories. The 28-day compressive strength and the theology of the normal and of the reactive powder concretes appeared to be comparable. A compressive strength of 22.38 MPa, indirect tensile strength of 2.24 MPa, flexural strength of 9.2MPa were approached for steel fibers reactive concrete samples of 910 kg/m3 cement content and 230 kg/m3 silica fume (NRPC2). The use of fine sand whose grain size is (<600 m) improves the compressive strength due to the more dense microstructure of the cement matrix. RPC without fibers is a brittle material and fails suddenly and violently.

Finally, it can produce an economic RPC using locally available materials in Iraq, in order to manufacturing a pre-cast ultra-high strength concrete with ultra-mechanical properties (RPC). Further improvement of the mechanical properties of normal and reactive powder concretes could be achieved by, for instance, incorporation of locally fibers or non-fibers either in both concretes or only in the transition zone. In this case a more detailed study is needed.

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