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Mechanical and Durability Properties of Hybrid Fiber Reactive Powder Concrete Using Silica Fume and Quartz Powder

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ABSTRACT: Adding fibres to concrete greatly increases the toughness of the material. The use of fibres also alters the behaviour of the fibre matrix composite after it has cracked, thereby improving its toughness. Secondary cementing materials like Reactive Powder can be used to partially replace cement because of pozzolanic nature. Materials like quartz powder best suit to sand due to its physical and chemical properties, fineness etc. Also these materials are known to increase durability, resistance to sulphate attack. Our main aim is to study the materials Reactive powder, Quartz powder, Silica Fume are best suitable for preparing durability of concrete for M30 Grade. In cement replaced by silica fume and quartz powder with various percentages like 5%, 10%, 15% and 20%. And additional strength purpose using crimped steel fibres and polypropylene fibres with various percentages like 0.5%, 1%, 1.5% and 2%. In this study mechanical properties like compressive strength, Split tensile strength and Durability properties like Acid attack test, Sulphate attack test, Alkalinity attack test, Rapid Chloride permeability test and Water permeability test and Young's modulus test can be accomplished. And the comparative study of normal concrete and fibres concrete.

KEYWORDS: Compressive strength, Rept, Alkalinity, Acid Resistance, Permeability, Crimped Fibres, Polypropylene Fibres, quartz Powder, Silica Fume.

I. INTRODUCTION

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement that hardens over time. Most concretes used are lime-based concretes such as Portland cement concrete or concretes made with other hydraulic cement such as cement found. However, asphalt concrete which is frequently used for road surface, is also a type of concrete, where the cement material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer.

The first testing of silica fume in Portland cement based concretes was carried out in 1952. The biggest drawback to exploring the properties of silica fume was a lack of material with which to experiment. Early research used an expensive additive called Fumed Silica, An Amorphous form of Silica made by combustion of Silicon Tetrachloride in a Hydrogen-Oxygen Flame. Silica Fume on the other hand, is a very fine pozzolanic, Amorphous material, a by-product of the production of elemental Silicon or ferrosilicon alloys in electric arc furnaces. Before the late 1960s in Europe and the mid-1970s in the United States, Silica Fumes were simply vented into the atmosphere.

Crimped steel fiber are low carbon, cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, enhanced flexural reinforcement, improved shear strength and increase the crack resistance of concrete. PSI Crimped Steel Fiber complies with ASTM C1116, Standard Specification for Fiber Reinforced Concrete and Shotcrete and ASTM A820, Type I, Standard Specification for Steel Fibers for Fiber Reinforced Concrete. These steel macro-fibers will also improve impact, shatter, fatigue and abrasion resistance while increasing toughness of concrete. Dosage rates will vary depending upon the reinforcing requirements and can range from 25 to 100 lbs/yd³ (15 to 60 kg/m³).

Polypropylene Fiber Reinforced Concrete The capability of durable structure to resist weathering action, chemical attack, abrasion and other degradation processes during its service life with the minimal maintenance is equally important as the capacity of a structure to resist the loads applied on it. Although concrete offers many advantages regarding mechanical characteristics and economic aspects of the construction, the brittle behaviour of the material remains a larger handicap for the seismic and other applications where flexible behaviour is essentially required.

Recently, however the development of polypropylene fiber-reinforced concrete (PFRC) has provided a technical basis for improving these deficiencies. This paper presents an overview of the effect of polypropylene (PP) fibers on various properties of concrete in fresh and hardened state such as compressive strength, tensile strength, flexural strength, workability, bond strength, fracture properties, creep strain, impact and chloride penetration. The role of fibers in crack prevention has also been discussed.

Quartz, most common of all minerals is composed of silicon dioxide, or silica, SiO₂. 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 luster 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 colored by impurities. Rock crystal is a colourless form of quartz occurring in distinct crystals. Rose quartz is coarsely crystalline and colored 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.

II. LITERATURE REVIEW

P. C ,Laplante (1985): From the results obtained on the seven field concretes under study, it is evident that silica-fume concrete exposed for 4-6 years to severe environmental conditions behaved as satisfactorily as the corresponding concrete without silica fume. No strength losses were noticed as in the case of a very high-strength concrete (85.4 MPa at 28 days) cast 4 years ago. It appears, however, that silica-fume concrete seems to suffer somewhat more from field placing and curing conditions than no silica-fume concretes. It is interesting to note that, after 4 - 6 years of field exposure, these field concretes exhibit very low chloride-ion permeability, almost in the range of latex-modified concrete, or polymer-impregnated concrete. All seven concretes will be cored every 3 years as part of the long-term performance research program of silica-fume concrete

WidodoKushartomoa(2012): After the experiments were carried out and comparing of RPC with glass powder of 10%, 20% and 30%, conclusion can be made as follows. The maximum of average of compressive strength value that can be achieved in this study is 136 MPa for the RPC with glass powder of 20%. The RPC with glass powder of 20% indicates also the maximum of average of split tensile strength value of 17.8 MPa and the average of flexural strength value of 23.2 MPa. The use of glass powder of 20% of the mass of cement in this study is quite good to substitute the quartz powder in the RPC in order to improve its mechanical behavior.

M. Pankaj(2013): The following main conclusions can be drawn from the laboratory investigations:
Analyzing the results of the hybrid mixes in the fresh state, considering the summary amount of the fibers, it can be concluded that for the fibers volume ratio higher than 1.4% the mixes did not satisfy the passing ability requirement for the SCC. The mixes containing 0.9% of 38mm PP fibers should be analyzed as conventional concrete; A slight influence of hybrid fibers on compressive strength of the SCC matrix was noted;

A significant and proportional to Of increase of flexural tensile strength and toughness with the increase of steel fibers volume ratio was observed. The flexural behaviour of the SCC matrix reinforced with only polypropylene fibers was less predictable

W. Kushartomo (2014): After the experiments were carried out and comparing of RPC with glass powder of 10%, 20% and 30%, conclusion can be made as follows. The maximum of average of compressive strength value that can be achieved in this study is 136 MPa for the RPC with glass powder of 20%. The RPC with glass powder of 20% indicates also the maximum of average of split tensile strength value of 17.8 MPa and the average of flexural strength value of 23.2 MPa. The use of glass powder of 20% of the mass of cement in this study is quite good to substitute the quartz powder in the RPC in order to improve its mechanical behavior

III. EXPERIMENTAL MATERIALS

Cement

Cement is a binder material, which is used to binds the other material together. Ordinary Portland Cement of 53 grade manufactured by Zuari company confirming ISO 5001:2011 is used. The main benefit is the faster rate of development of strength. The specific gravity of cement is 3.00 and fineness modulus is 225kg/m³

Aggregates

After cement, the aggregate is the basic material used in any concrete to comprise the body of concrete for increasing the strength to the material quantity, and to minimize the consequential volume change of concrete. The fine and coarse aggregates generally occupy 60% to 75% of concrete volume and strongly influence the concrete freshly mixed and hardened properties, mixture proportions and economy.

Coarse aggregates:

In this research investigation crushed grained aggregate of 20mm size was used. The specific gravity of coarse aggregate is 2.72.

Fine aggregates

The quantity of the fine aggregate important is main to fill the voids present in coarse aggregate. In this research natural sand was used as fine aggregate. The specific gravity of sand is found to be 2.7

Silica fume, also known as **microsilica**, (CAS number 69012-64-2, EINECS number 273-761-1) is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete. Silica fume is an ultrafine material with spherical particles less than 1 μm in diameter, the average being about 0.15 μm . This makes it approximately 100 times smaller than the average cement particle. The bulk density of silica fume depends on the degree of densification in the silo and varies from 130 (unidentified) to 600 kg/m^3 . The specific gravity of silica fume is generally in the range of 2.2 to 2.3. The specific surface area of silica fume can be measured with the BET method or nitrogen adsorption method. It typically ranges from 15,000 to 30,000 m^2/kg .

Polypropylene Fibers

The raw material of polypropylene is derived from monomer C_3H_6 which is purely hydrocarbon. Its mode of polymerization, its high molecular weight and the way it is processed into fibers combine to give polypropylene fibers. The fibers are manufactured either by the pulling wire procedure with circular cross section or by extruding the plastic film with rectangular cross-section. They appear either as fibrillated bundles, mono filament or microfilaments. The properties of these three types of PP fibers are given the fibrillated polypropylene fibers are formed by expansion of a plastic film, which is separated into strips and then slit. The fiber bundles are cut into specified lengths and fibrillated. In monofilament fibers, the addition of buttons at the ends of the fiber increases the pull out load. Further, the maximum load and stress transfer could also be achieved by twisting fibers.

Crimped steel fibers

It is low carbon, cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, enhanced flexural reinforcement, improved shear strength and increase the crack resistance of concrete. PSI Crimped Steel Fiber complies with ASTM C1116, Standard Specification for Fiber Reinforced Concrete and Shotcrete and ASTM A820, Type I, Standard Specification for Steel Fibers for Fiber Reinforced Concrete. These steel macro-fibers will also improve impact, shatter, fatigue and abrasion resistance while increasing toughness of concrete. Dosage rates will vary depending upon the reinforcing requirements and can range from 25 to 100 lbs/yd^3 (15 to 60 kg/m^3).

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 luster 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 colored by impurities. Rock crystal is a colourless form of quartz occurring in distinct crystals. Rose quartz is coarsely crystalline and colored 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.



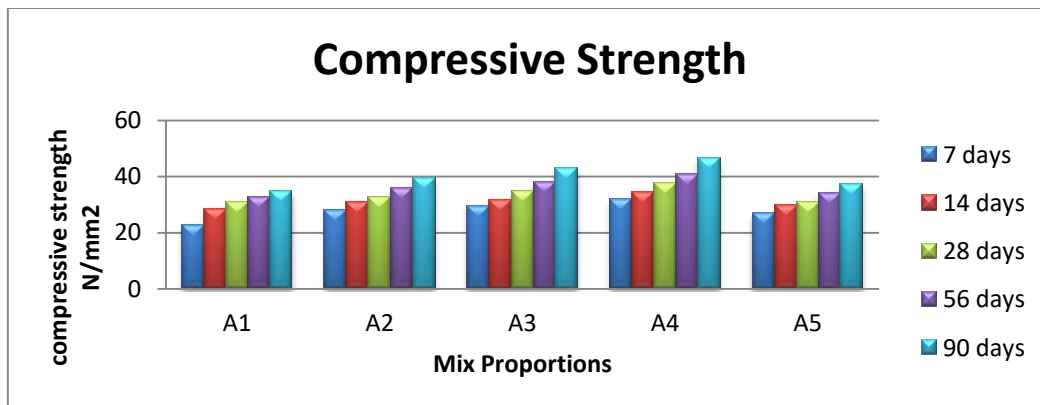
Experimental Procedure

Mix Proportion	Proportions of Supplementary materials
A1	100% cement
A2	5% silica fume, quartz powder and 0.5% crimped steel fiber, polypropylene fiber
A3	10% silica fume, quartz powder and 1% crimped steel fiber, polypropylene fiber
A4	15% silica fume, quartz powder and 1.5% crimped steel fiber, polypropylene fiber
A5	20% silica fume, quartz powder and 2% crimped steel fiber, polypropylene fiber

IV. EXPERIMENTAL RESULTS

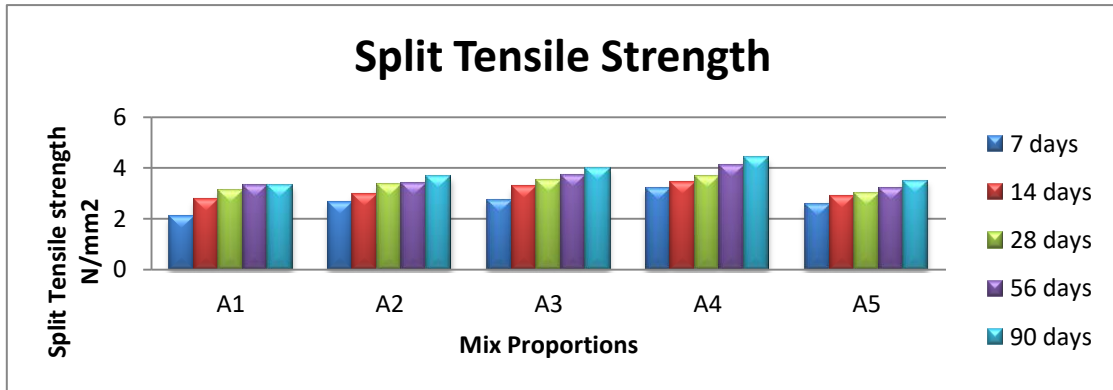
Compressive Strength:

Mix Proportions	Compressive strength N/mm ²				
	7-Days	14-Days	28-Days	56 days	60 –Days
A1	22.76	28.53	30.92	32.56	34.76
A2	27.76	30.68	32.51	35.65	39.47
A3	29.63	31.52	34.76	38.15	42.76
A4	31.73	34.15	37.65	40.79	46.73
A5	26.85	29.69	30.78	33.94	37.35



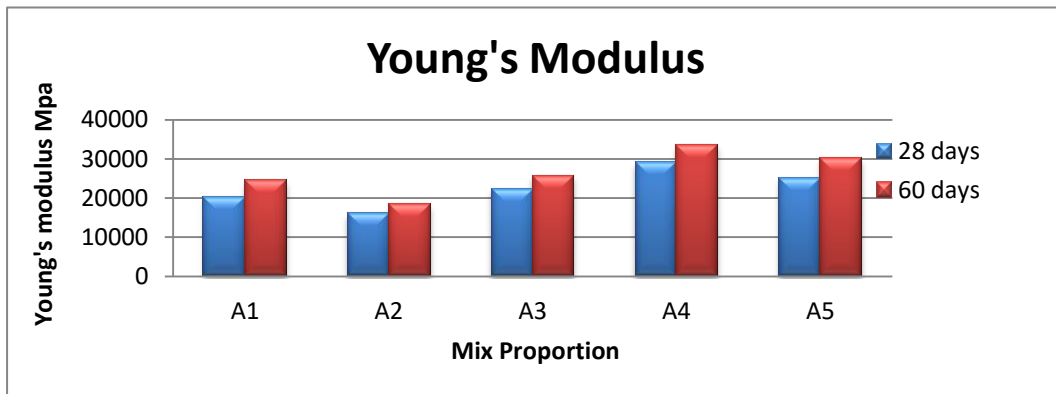
Split Tensile Strength:

Mix Proportions	Split Tensile strength N/mm ²				
	7-Days	14-Days	28-Days	56 days	90 –Days
A1	2.1	2.78	3.10	3.29	3.30
A2	2.65	2.98	3.35	3.40	3.68
A3	2.74	3.25	3.53	3.72	3.97
A4	3.20	3.45	3.68	4.1	4.43
A5	2.59	2.89	3.01	3.21	3.5



Young's Modulus

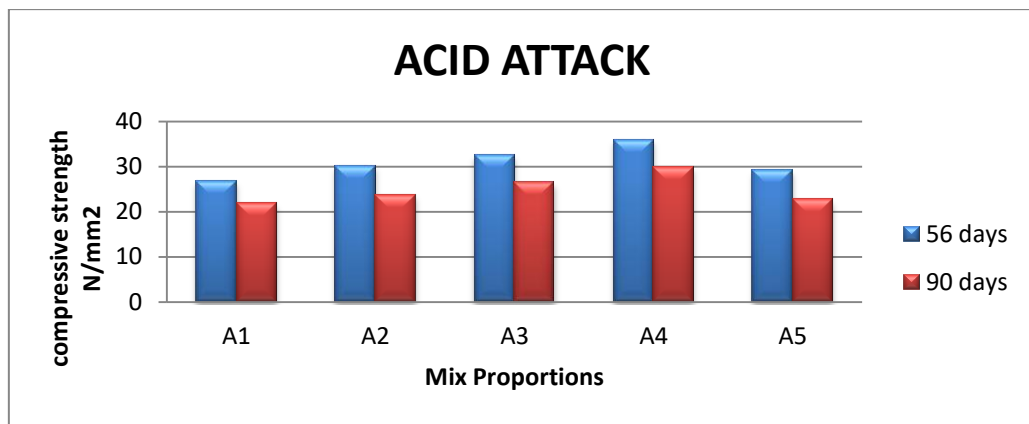
Mix Proportions	Young's Modulus at 28 days (Mpa)	Young's Modulus at 60 days (Mpa)
A1	20347.2	24416.54
A2	15972.16	18367.9
A3	22314.7	25661.9
A4	29166.6	33541.59
A5	24999.7	29999.6





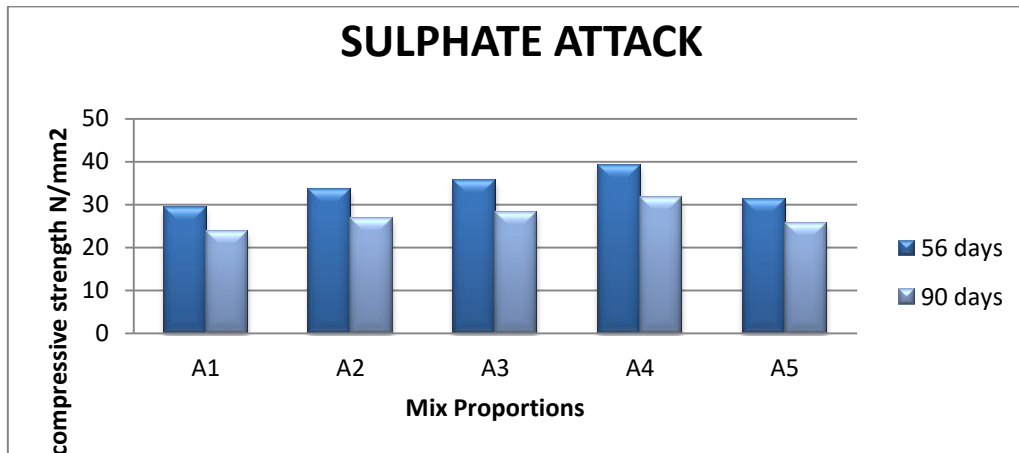
Acid Attack Test:

Mix proportions	Compressive Strength (N/mm ²)	
	56 days	90 days
A1	26.73	21.87
A2	30.15	23.73
A3	32.40	26.42
A4	35.95	29.86
A5	29.15	22.67



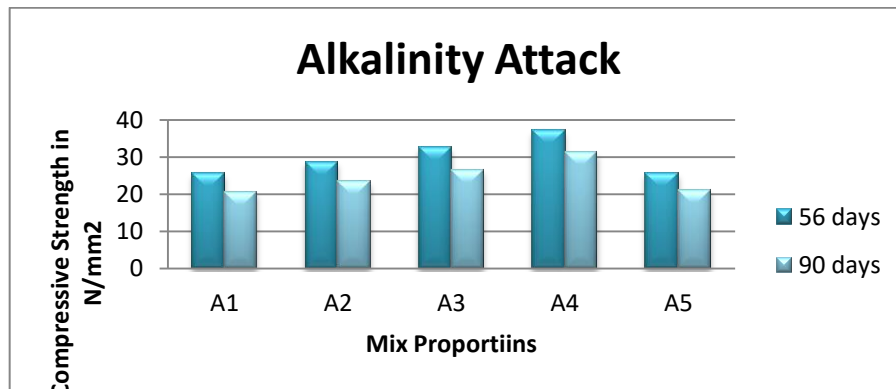
Sulphate Attack Test :

Mix Proportions	Compressive Strength N/mm ²	
	56 days	90 days
A1	29.35	23.78
A2	33.46	26.76
A3	35.63	28.27
A4	39.2	31.65
A5	31.19	25.80



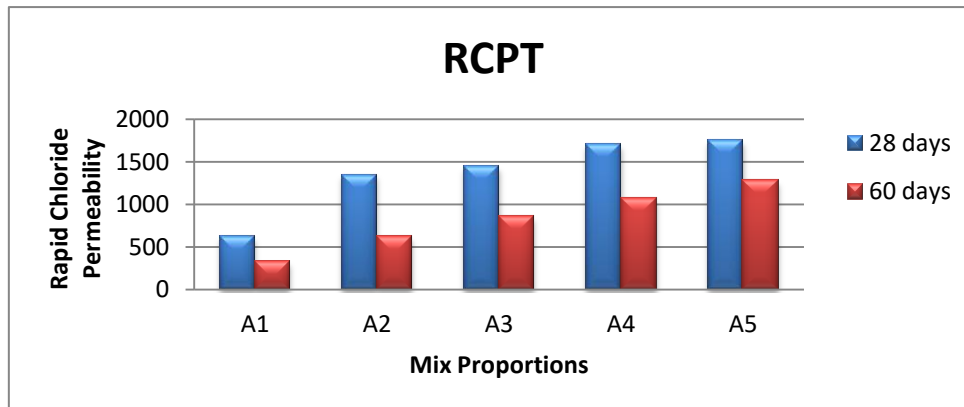
Alkalinity Attack Test :

Mix Proportions	Compressive Strength N/mm ²	
	56 days	90 days
A1	25.54	20.65
A2	28.70	23.40
A3	32.55	26.52
A4	37.15	31.21
A5	25.46	21.21



Rapid Chloride Permeability Test

Mix Proportions	RCPT for 28 days (Mpa)	RCPT for 60 days (Mpa)
A1	624.6	332.1
A2	1348.2	617.4
A3	1443.6	863.1
A4	1699.2	1073.7
A5	1753.2	1283.4



V. CONCLUSION

- Crimped Steel Fibers are used low carbon cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, improved shear strength crack resistance of the concrete.
- Poly propylene fibers capability of durable structures to resist weathering action, chemical attack, abrasion and other degradation. The roll of fibers in crack prevention.
- Quartz was most common of all minerals is composed of silica dioxide it is an essential of igneous and metamorphic rock.
- Silica fume is made by combustion of silicon tetra chloride in a hydrogen oxygen flame. It is a very fine pozzolanic amorphous material.
- In this investigation for M30 grade of concrete it can be calculated that the cement can be replaced up to 5%, 10%, 15% and 20% of silica fume and quartz powder and crimped and poly propylene fibers are using additional strength purpose up to 0.5%, 1%, 1.5% and 2%.
- Compressive strength of concrete having more strength on 1.5% fibers+ 15% silica fume and quartz powder when compared normal concrete and remaining percentages.
- Split tensile strength of concrete having more strength on 1.5% fibers+ 15% silica fume and quartz powder when compared normal concrete and remaining percentages.
- Acid attack test is having more strength on 1.5% fibers+ 15% silica fume and quartz powder when compared normal concrete and remaining percentages. In this investigation 56 days compressive strength is more than the 90 days strength.
- Alkalinity test is having more strength on 1.5% fibers+ 15% silica fume and quartz powder when compared normal concrete and remaining percentages. In this investigation 56 days compressive strength is more than the 90 days strength.
- Sulphate attack test is having more strength on 1.5% fibers+ 15% silica fume and quartz powder when compared normal concrete and remaining percentages. In this investigation 56 days compressive strength is more than the 90 days strength.
- Modulus of elasticity of concrete according to stress-strain curve 28 days of strength increase 1.5% fibers+ 15% silica fume and quartz powder when compared normal concrete and remaining percentages.
- Durability of concrete as Rapid Chloride Permeability Test at 28 days chloride penetration is more than 56 days.

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