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ANALYSIS ON REACTIVE POWDER CONCRETE – AN ULTRA HIGH STRENGTH CONCRETE

SUKRAM PAL
Research Scholar
Sunrise University
Alwar, Rajasthan

DR. SANJEEV SINGH
Supervisor
Sunrise University
Alwar, Rajasthan

ABSTRACT: The paper deals with information concerning properties and technology of a new generation cementitious composite i.e. Ultra-High Performance Concrete. One of the most advanced Cementitious composites is the reactive powder concrete (RPC), belonging to a group of UHPC (Ultra High Performance Concrete). This material is often classified as so called low-temperature ceramics. The production of such composites has been made possible, first and foremost, thanks to the progress in mineral binder technology, increased availability of highly effective super plasticizers and wide recognition of influence of mineral additives on the microstructure and general properties of Cementitious composites.

KEYWORDS: Reactive Powder Concrete.

INTRODUCTION

Reactive powder concrete (RPC) is a generic name for a class of ultra high strength Cementitious composites. The production of very high strength concrete, maintenance and repair of structure and life cycle cost of structure plays and important role in its cost effectiveness and sustainability of Ultra High Performance Reactive Powder concrete (UHPRPC) n the design, planning and construction of buildings the principle of cost-effectiveness has Long been one of the principal demands made of civil engineers. Since the couple of decades this demand has been extended further and further to include the increasingly widespread social Requirement of Sustainability. While the cost-effectiveness factor is concerned purely with Economic optimization, the principal concern of sustainability also embraces ecological and social factors. Cost effectiveness and sustainability are by no means mutually exclusive. On The contrary, cost-effectiveness is an integral component of the concept of sustainability. Among the ecological objectives that aim at more sustainability are the minimal uses of non renewable resources, the guarantee of renewable resource regeneration and the Minimization of environmental impact from waste disposal and residues. In view of the Fact that construction produces approx. 70% of all material-flow in Indian Sinerio, it is Understandable that sustainability must be one of its particular concerns in order to achieve a Higher Success rate in Sustainability objectives. Accordingly, the decision as to which Materials are to be used for the construction project is particularly important. The increasing demand for sustainability in construction invariably extends the time frame which has to be analyzed. In addition to the classical life-cycle of the structure, a Comprehensive sustainability analysis has to take account of the production process of Building materials as the waste disposal after demolition. The aim of this paper is to make a qualitative statement about the behavior of (UHPRPC) with regard to sustainability. A comparison will be made between the behavior of (UHPRPC) and normal and high-strength concrete.

Many researchers around the world have developed Reactive Powder Concretes 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 “Ductal”. 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.

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REVIEW OF LITERATURE

Dili and Manu Santhanam (2005) developed two RPC mixes of 200MPa and 800MPa strength, which could be suitable for nuclear waste containment structures. The workability and durability properties were studied for the designed RPC mix. Also characterization of mechanical properties was carried out. The durability test carried out for the RPC mixes showed that the flow table test as per ASTMC 10916 was in the range of 120%-140% and the water and chloride ion.

Permeability is extremely low. These test results indicates the suitability of the designed RPC mix for nuclear waste containment structures. However, the suitability of RPC mix for use in nuclear waste containment structures with respect to resistance then penetration of heavy metals and other toxic wastes emanating from nuclear plants has to studied

Masami Uzawa, et al.,(2005) explored the practical applications of the reactive powder concrete with steel fibres with a high compressive strength of 200 MPa. Masami Uzama improved the already existing Reactive Powder Concrete (RPC) and a new material was proposed with simple curing process. This reactive powder composite material (RPCM) has high compressive strength and toughness inspite of simple curing techniques unlike RPC. This RPCM premix consists of (steel fibre reinforced ultra high strength mortar) cement, siliceous material quartz sand, special water reducer and high strength steel fibre (0.2mm diameter and 15mm length). The results showed that the RPCM has an extremely high fluidity and thus excellent self-compactability in the state of fresh mortar and when it is hardened, it had high levels of strength and toughness with a compressive strength of about 200 N/mm^2.

Richard and Cheyrezy (1995) developed an ultra high strength ductile concrete with the basic principles of enhancing the homogeneity by eliminating the coarse aggregate and enhancing the microstructure by post-set heat treatment. In addition, the ductility and tensile strength of concrete is increased by incorporating small, straight, high tensile microfibres. Two types of concretes are developed and designated as RPC 200 and RPC 800. These concretes had exceptional mechanical properties, which resulted in elimination of reinforcement, and reduction of materials resulting in reduction of self-weight resulting in cost savings. The concrete finds its applications in industrial and nuclear waste storage silos.

Harish.K.V, et al., (2008) investigated an ultra high performance concrete at CSIR-SERC., Chennai. It was found that the selection of ingredients and curing regime plays a major role in the enhanced performance of UHPC. It was found that addition of silica fume increases the strength of concrete due its high pozzolanic activity. In addition, the types of curing regime was (normal water, hot water, hot air) recommended to achieve high mechanical properties. A mix proportion has been developed by optimizing the volume of ingredients and curing regime to produce ultra high strength concrete of 193MPa.

Cwirzen.A.(2007) studied the influence of curing regime on the mechanical properties of ultra high performance concrete. Nine different curing methods were tried with variation in heat treatment, variation in water to binder ratio, with variation of filler materials like silica fume and fine quartz. The microstructure of the specimens was investigated by electron microscope and mercury intrusion porosimeter scan. Results revealed that increase in heat treatment periods decreases the hydration processes and refine the microstructure. This results in higher compressive strength. The scanning electron microscope investigation revealed the formation of one hydration rim around anhydrous cement particles and the presence of a hollow shell in all investigated specimens.

Teutsch, et al. (2014) observed a ductile fracture behavior in UHPC mixtures with short fibres. Compared to unreinforced UHPC mixtures, the tensile tests showed that addition of short discontinuous fibres leads to a change in loading capacity and fracture behavior. A higher service load and a continuous load carrying behavior due to a finely distributed crack development were observed, i.e. higher loads were achieved at same displacements. The changes in the matrix composition of the UHPC mixtures (no short fibres) probably do not influence the bonding characteristic significantly and hence no significant differences in the progression of the load-displacement curves obtained by the tensile tests were observed.

Naaman.A.E. (2012) suggested the use of the nomenclature "High Performance Fibre Reinforced Composites" (HPFRC) describing them as having a combination of high strength and toughness-ductility. In 1987 paper presented at an IABSE conference in Paris, Naaman described the typical tensile response of strain-hardening FRC composites, and provided a theoretical formulation to achieve strain-hardening behavior. The terms 'strain-hardening' and 'strain-softening'" were not used but instead the terms "high performance" and conventional fibre reinforced concrete were used.

MODIFICATION OF THE MATRIX MICROSTRUCTURE

Setting of reactive powder concrete in the environment of water vapour and at elevated temperature, as in the case of traditional Cementitious materials, brings about changes in its microstructure. In most reported studies two types of hydrothermal treatment are used. In the first one, low pressure steam curing at about 90◦C, accelerates the processes of cement hydration and enhances the pozzolanic activity of the other ingredients. Elevated temperature causes increase in SiO2 solubility, regardless of its form (amorphous – silica fume or crystalline – ground quartz). The positive effect of this treatment is related to the appearance of additional quantities of C-S-H phase, which directly entails reduction of the composite porosity. Moreover, according to Staquet, the rise of temperature during cement hydration is beneficial from the standpoint of the shrinkage reduction, especially if it contains a huge amount of binder.

The second type of heat treatment applied to RPC materials is autoclaving process, which is often conducted at 250◦C. These conditions, in addition to the changes also taking place at lower temperatures, cause the appearance of crystalline forms of hydrated calcium silicates. The phases which are usually encountered in materials subjected to such treatment are tobermorite $C_5S_6H_5$ and xonotlite C_6S_6H. There are some contradictory reports concerning the impact of crystalline phases on the mechanical properties of the material. However, some researchers observe a clear increase in both compressive and tensile strengths. Moreover, the crystallization of calcium silicate hydrates in the free spaces of the material (pores and micro cracks) reduce the porosity and thereby heal its structure. Inappropriate conduction of steam curing and autoclaving can lead to decrease of the mechanical properties and durability of the composite. The following should be listed among the adverse phenomena that can be ascribed to heat treatment of Cementitious materials: formation of microcracks as a result of improperly chosen initial period of setting, delayed ettringite formation, and decreased specific surface area of hydrated calcium silicates, leading to a deterioration in their adhesion to the inclusion.

Extensive research completed by the author concerning the impact of initial curing conditions on the mechanical properties of matured RPC composites allowed establishing the best parameters both for low-pressure steam curing and for autoclaving. The research was focused on: the time of initial setting as well as the temperature and time of isothermal heating. The test results showed that the best mechanical properties of the steam cured materials were obtained when the initial setting period lasted for 6 hours and the temperature was 90◦C. The influence of time of isothermal heating, verified in temperatures ranging from12 to 48 hours, was negligible from the standpoint of mechanical properties. In the case of autoclaving the best temperature for isothermal heating was 250◦C. Both the initial setting time, studied within the range 0 to 24h, and time of isothermal heating (12 to 48 h) were the factors which did not bring about significant changes in mechanical properties of the material. According to the author's test results the best curves for hydrothermal treatment, in terms of manufacturing technology and the subsequent mechanical properties of RPC composites, are shown in Fig. 1.

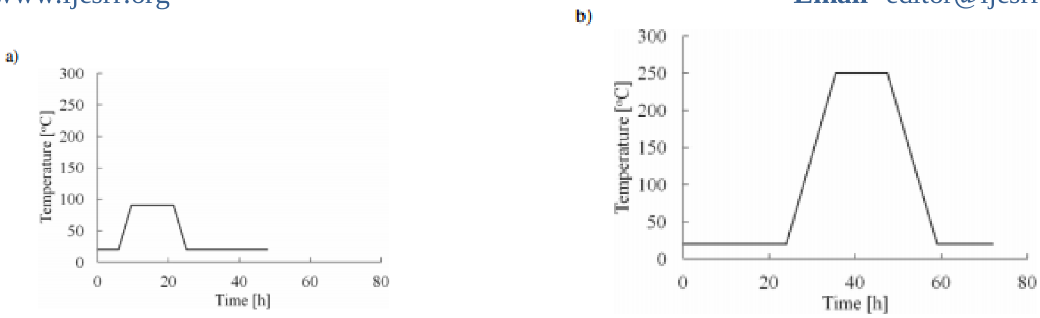

Fig. 1: Optimal curves for (a) steam curing and b) autolaving of reactive power concretes

OBJECTIVE OF THE STUDY

The aim of this research program is to find the suitability of Reactive Powder Concrete for prefabricated structures especially angle sections. The first step of this thesis will be to characterize the material property of RPC mix. The mix proportion suggested by CSIR-SERC, Chennai, will be taken into consideration for preparing the RPC mix. In addition, the mechanical property of the RPC structural components prepared from the recommended mix proportion will be studied.

In the present study, the materials are characterized and a mix proportion will be formulated by trial and error from the already available literature, for preparing the RPC mix at CSIR-SERC, Chennai. In addition, the mechanical properties of the RPC specimens prepared from the recommended mix proportion were studied in addition to the study of RPC structural components.

CONCLUSION

At present reactive powder concrete is one of the most modern technologies of the cement matrix composites. Its development can be attributed to the observed general tendency to interfere into the nanostructure of all materials, including cement-based composites. The application of components with a colloidal particle size (super plasticizer or, silica fume) influence directly the structure and properties of C-S-H phase, which is one of the main factors leading to obtaining such outstanding RPC's mechanical properties.

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