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Studies on Strengthening of High Performance Self Compacting Concrete

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Abstract: Self Compacting Concrete (SCC) has more attention because of its ability to compact without the need of internal or external vibration. The placing of normal conventional concrete is difficult in reinforcement confinement places and also the strength of the concrete is low when it is subjected to severe exposure condition. In order to overcome these effects the admixtures were used in the concrete to increase the strength and durable properties of the concrete. Self-Compacting Concrete (SCC) is one of the concrete which makes use of admixture to increase the flow ability of the concrete without any additional vibration. As the concrete is flowable, it has good workability. SCC has more workability and by the addition of mineral admixture like fly ash and silica fume, the concrete will attain more strength and durable, so that the concrete will behave as Self Compacting High Performance Concrete (SCHPC).The aim of the study is to determine the flexural behavior of the self-compacting high performance concrete. In this present work the various literatures related to SCC with different mineral admixtures was studied and the best among them was chosen for the future work

Keywords: - Self Compacting Concrete, Fly ash, Silica fume, Superplasticizer, Viscosity Modifying Admixture

1. INTRODUCTION

Self-Compacting Concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight.In other words it is a relatively new product that sees the addition of super plasticizer and a stabilizer to the concrete mix to significantly increase the ease and rate of flow. By its nature, SCC does not require vibration. It achieves compaction into every part of the mould or formwork simply by means of its own weight without any segregation of the coarse aggregate. It has been developed in Japan and Continental Europe and is now being increasingly used in UK where, apart from health and safety benefits, it offers faster construction times, increased workability and ease of flow aroundheavy reinforcement.
The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. The main advantage is in the elimination of mechanical compaction. Uses of SCC can also helpin minimizing hearing-related damages on the worksite that are induced by the vibration of concrete. Another advantage of SCC is that the time required to place large sections is considerably reduced.

Self-compacting high performance concrete (SCHPC) is defined as a new generation of concretes on the basis of the concepts of self-compacting concrete (SCC) and of high performance concrete (HPC). A method for proportioning SCHPC aims at fulfilling the self-compact ability requirements of SCC (filling ability, passing ability, and segregation resistance), and of high compressive strength and good durability of HPC. To realize this goal, a high volume of Portland cement, a very high dosage of chemical admixtures, i.e. super plasticizer (SP) and Viscosity Modifying Admixtures (VMA), and reactive Mineral Admixtures (MA), e.g. Silica Fume (SF), are used. The performance of SCHPC is highly improved by using SF however it is expensive due to the limited availability especially in developing countries.

Mixture proportions for SCC differ from those of ordinary concrete, in that the former has more powder content and less coarse aggregate. The High Range Water Reducing Admixture (HRWRA) helps in achieving excellent flow at low water contents and VMA reduces bleeding and improves the stability of the concrete mixture. An effective VMA can also bring down the powder requirement and still give the required stability. Moreover, SCHPC almost always includes a mineral admixture, to enhance the deformability and stability of concrete.

2. ADVANTAGES OF SCHPC

Self-Compacting High performance Concrete possess various numbers of advantagesbecause of its fluidity nature.Some of the advantages are listed below.

1. Improved quality of concrete and reduction of onsite repairs
2. Faster construction times
3. Improvement of health and safety is also achieved through elimination of handling ofvibrators
4. Possibilities for utilization of dusts, which are currently waste products and which are costly to dispose of.
5. Ease of placement results in cost savings through reduced equipment and labor requirement.

3. LITERATURE REVIEW

The influence of cement and expansive additive types in the performance of self-stressing and self-compacting concretes for structural elements was studied. The influence of different parameters was evaluated by the addition of expansive additives which results is compressive strength reduction. It was observed that the reduction in compressive strength was mainly due to the total expansion of cement which depends on alumina and sulphate content of cement. The addition of additives promoted increased values of slump for similar w/c ratio and superplasticizer content. (Carballosa et al. 2015)

The effect of antifoaming admixture on High-Performance Self-Compacting Concrete was highlighted. The influence of the admixture type on pore size distribution, compressive strength and frost resistance of HPSCC at constant water to cement ratio, type and volume of aggregate, and volume of cement paste was examined. The results showed that admixtures influence the properties of HPSCC and modification of anti foaming agent effect impacts the air content and workability of HPSCC. (Beata. 2015)

The physico-mechanical properties of high performance concrete using different aggregates in presence of silica fume was observed. Four different concrete mixes with the same cement content and different w/c ratios were designed using normal dolomite aggregate, air-cooled slag by-product and two different types of iron ore aggregates. High performance concrete can be achieved using superplasticizer to reduce the water/cement ratio and physic-mechanical properties of coarse aggregate and hardened concrete was studied. The results showed that addition of 10% silica fume developed a stronger cement matrix. (Salah et al. 2014)

The investigation on the effect of specimen shape on residual mechanical properties of polypropylene (PP) fibre self-compacting concrete (SCC) exposed to elevated temperatures was discussed. Various types of fibers were used in cylindrical and cubical shapes of concrete specimen and air cooling was done in the room temperature before testing. Thermal shock induced by cylindrical shape air cooling caused more severe damage to concrete with greater losses in compressive strength than those with cubical shapes. (Arabi et al. 2014)

The effect of tension lap splice on the behavior of high strength self-compacted concrete beams was discussed. The effect of reinforcement bar diameter and ratio, splice length and casting position on the beam flexural behavior was observed. Ultimate capacity, deflection, crack pattern and mode of failure have been recorded and test results showed that the splice length with different values of bar diameter showed variations in strength and had been compared with proposed values in the Egyptian code of practice. (Azab et al. 2014)

The behavior of self-compacting fiber reinforced concrete containing cement kiln dust was investigated. The effect of reinforcing SCC with Polypropylene fiber was examined. A comparison was carried out among the behavior of SCFRC mixtures, tensile strength and shrinkage. Slump flow and L-box were performed and the results showed that shrinkage of SCC was reduced due to PPF inclusion. (Adam et al. 2014)

The effects of fly ash and TiO_2 nanoparticles on rheological, mechanical, micro structural and thermal properties of high strength self-compacting concrete has been studied. The various parameters such as Strength enhancement and durability-related characteristics were investigated. It was found that the addition of FA as a natural pozzolana can improve the rheological, mechanical and durability properties of concrete at higher ages and also helped in saving the energy. (Mostafa et al. 2013)

The methods of rehabilitation or strengthening of these zones should be reliable, effective and economical was foccused. Some of the most recent issues and findings using UHPFC as a repair material were discussed. The excellent repair and retrofit potentials in compressive and flexure strengthening was obtained with Ultra High Performance Concrete (UHPFC) and it possesses high bonding strength and bond durability. (Bassam et al. 2013)

The development of self-compacting concrete using contrast constant factorial design was examined. It was observed that if adjustment of the four factors namely. cement content, water to powder ratio, fly ash content, and super plasticizer will increase the compressive strength of self-compacting concrete (SCC). It was concluded that the interactions of the parameters of a couple effect of Cement with SP, w/p with SP, FA with SP, and C with FA and SP in a full quadratic model was the only significant effects and the underlying assumptions of the analysis were satisfied. (Kamal et al. 2013)

The mechanical and fresh properties of high-strength self-compacting concrete containing class C fly ash was studied. A high-strength self compacting concrete (HSSCC) mix of 100 MPa compressive strength was designed following the available guidelines for normal-strength self-compacting concrete. It was found that with an equivalent w/b ratio, HSSCC develops considerably higher compressive strength compared to that of CVHSC. Experimental results were compared with some of the available codal provisions in order to assess the applicability of the existing criterion to HPSCC. (Allan et al. 2013)

The investigation on the self- compacting concrete with different types of steel fibers in order to determine the behavior of flexural strength was done. The straight and hooked end steel fibers were used in SCC and it was compared with Normally Vibrated Concrete (NVC). It was found that the increase in volume of fiber ratio increases the flexural behavior of self-compacting concrete when compared with the normal concrete according to the type of fibre used. (Pajak and Ponikiewski. 2013)

the bond properties between reinforcement and high strength self-compacting concrete as well as conventionally vibrated high-strength concrete was investigated. The bar grade, diameter, bond length, concrete type and their effects were determined by means of pull out tests and post-yield slip behavior of different steel concrete types was determined. The concrete with different grades and difference in ductility bars showed diameter reduction due to axial tensile stress. This stress affected their bonding performance. (Ashtiani et al. 2013)

The high performance self-compacting concrete modified by High-Calcium Fly ash was studied. The cement was replaced by High Calcium Fly ash and it was also used as an additive agent to the concrete. It was found that the raw calcium fly ash showed negative influence. The various parameters such as rheological properties, compressive strength and flexural strength tests have also been studied with variations in HCFA as a replacement of cement in concrete mix and the test results showed that there is no effect in change of fly ash fineness on properties oh HPSCC mixtures. (Ponikiewski and Golaszewski 2013)

The strength parameters of self-compacting concrete containing fly ash and dolomite powder was investigated. The cement was replaced by fly ash and dolomite powder in different percentages. The 7^{th}, 28^{th} and 90^{th} days compressive strength with water powder ratio of 0.33 was studied and various tests were conducted. The results showed that the use of fly ash in self-compacting concrete reduced the bleeding and segregation and increased the filling ability of concrete. The dolomite powder increased the segregation resistance of concrete. It was overall concluded that that the overall increase in workability occurred when the fly ash and dolomite powder were blended well together. (Deepa and Paulose 2013)

The use of linen fibers in reinforced self-compacting concrete (SCC) was reviwed. Three circular slender columns were casted using both plain and linen fiber reinforced SCC to determine the hardened properties and mesostructural characteristics along the column heights. The various tests on fresh and hardened concrete were carried. It was found that the addition the workability of SCC was reduced due to the addition of linen fibers and the hardened properties did not vary significantly along the height of the column. (Ahmed 2013)

The self-compacting fibre reinforced concrete in prestressed precast beams was examined. The nine pre stressed I-beams of different flange dimensions was used and shear evaluation was analyzed under different conditions. The fibres act as a additional reinforcement to stirrups and it was found that the Steel fibers control not only the appearance of cracks but also their propagation. The cracks created in concrete without steel fibers were smaller when compared to the concrete with steel fibers. (Cuenca and Serna 2013)

The high performance composite cementitious systems were analyzed. The compressive strength, tensile strength, gas permeability and rapid chloride ion penetration was investigated. The replacement of 8 to 12% SF by cement yielded the optimum strength, permeability and chloride ion penetration value. The applicability of artificial neural network for the prediction of compressive strength, tensile strength, gas permeability and chloride ion penetration obtained using artificial neural networks have a good correlation between the experimentally obtained values. (Mohammad Iqbal Khan 2012)

The effect of different fibers on the residual behavior and flexural toughness of self-compacting high performance concrete after exposure to high temperature was studied. The two types of fibers namely micro polypropylene fiber and macro steel fiber was used. The hybrid fibre self-compacting high performance concrete showed good mechanical properties when compared to mono fibre reinforced self-compacting high performance concrete. The micro polypropylene fibre mitigates spalling but did not show effect on mechanical properties. (Ding et al. 2012)

The self compacting fibre reinforced concrete beams was analyzed to determine its flexural fatigue strength and failure probability. The steel fibers were used in different ratios in SCFRC beams and various tests such as compressive strength and flexural strength tests were conducted. It was found that the better fatigue performance was found in SCFRC and due to the initialization of first crack the failure was occurred. (Geol et al., 2012)

The prediction of deep beam failure related to tensile bar and web reinforcement percentage variations was determined. High strength self-compacting deep beams were tested and strains were measured with the loads applied incrementally. The results showed that the strain distribution is no longer parabolic at ultimate load condition. The failure due to crushing of concrete at nodal zones was observed when tensile steel reinforcement increased. The crack length was in the range of 0.24-0.6 times the height of the section. The number of cracks with reduced crack length was obtained with increase in tensile bar percentage. (Mohammadhassani et al. 2011)

The investigation was made on Self Compacting concrete (SCC) with two types of cement content. The three types of mixes with different percentages of fly ash and silica fume was used. The first consists of fly ash, the second with silica fume and the third with the mixture of fly ash and silica fume. The nine cylinder specimens were casted and cured. The various tests like Slump test and V-funnel test in fresh concrete and compressive strength on hardened concrete was carried out. It was found that the higher values of compressive strength were obtained in SCC with 15% of silica fume rather than 30% and it was obtained from water cured specimens. (Mohamed 2011)

A mechanical behavior of High Performance Self Compacting Concrete was presented under drying. During drying competitive effect occurs which controls the evolution of mechanical behavior. The quality of the binder paste determines this effect. Uniaxial compression and bending tests were carried out on samples. It was observed that uniaxial compressive strength increases while it's bending strength decreases with air drying. The micro cracks was induced due to the higher sensitivity of bending strength subjected to drying and in case of accelerated drying, micro cracking affects the uniaxial compressive strength. (Yurtdas et al. 2011)

The experimental analysis of strength, toughness and durability characteristics of High performance concrete with Czech metakaolin was observed. The high performance concrete (HPC) with metakaolin including basic physical characteristics, mechanical and fracture-mechanical properties, durability characteristics, hydric and thermal properties and chloride binding characteristics was measured. The results showed that the replacement of 10% of metakaolin by Portland cement gave better improvement in strength and does not significantly impair substantial properties and it was found that the physical properties and heat transport and storage properties were very similar to normal HPC. (Eva et al. 2010)

The fresh and hardened properties of SCC made with different aggregate and mineral admixtures were studied. The effect of two mineral admixtures namely fly ash and limestone powder and two types of coarse aggregates limestone and olivine basalt was tested on fresh and hardened SCC. The effect of mineral admixtures on fresh properties was more dominant than the effect of aggregate type. Limestone powder and limestone aggregate combinations had superior fresh and mechanicalproperties compared to basalt-incorporated mixtures. (Selcuk and Ali. 2010)

The Chloride resistance of high-performance concretes subjected to accelerate curing was discussed. After curing, the strength and chloride penetration were measured. The concrete with silica fume (SF) or ternary blends of SF and ground granulated blast-furnace slag (GGBFS) exhibit improved chloride penetration resistance compared to those of plain Portland cement concretes. In addition, chloride penetration resistance of Portland cement concrete was adversely affected by accelerated curing. (Hooton and Titherington. 2004)

SUMMARY OF LITERATURES

The research articles published by various authors were discussed and it was concluded that most of the mineral admixtures such as fly ash, various types and sizes of fibers, silica fume and metakaolin were used in SCC in varying percentage to improve the strength of the concrete. It shows that the mineral admixture plays a significant role in increasing the performance of the concrete in various means. Among that silica fume and fly ash were considered as most efficient one. Hence silica fume and fly ash will be used in SCC for experimental investigation of RC beam.

CONCLUSION

This paper reviewed the existing research work on Self Compacting Concrete (SCC) with various types of admixtures. The SCC with different types of mineral and chemical admixtures possessed greater strength and enhance good flow ability and workability. It also showed that the durability property of the SCC was also increased which helps in increasing the service life of concrete structures. From the literature it is evident that the use of Fly Ash and Silica fume will exhibit good characteristics in both fresh and hardened state of SCC.

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