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A REVIEW ON SELF-COMPACTING CONCRETE INCOPERATING ALCCOFINE

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Abstract - *Self-compacting concrete (SCC) is a highly engineered concrete with high fluidity without segregation. Self-compacting concrete is capable of filling every corner of form work under its own self-weight. The use of self-compacting concrete eliminates the need for external vibration; thereby unskilled labour problems are handled. On the other hand, the demand for cement has increased in large amount due to the rise in construction activities and to reduce this demand alternatives or replacements are used. One such replacement is the use of Alccofine in place of cement. This paper focuses on the comparison of the properties of SCC containing Alccofine as a partial replacement for cement. The fresh and hardened properties of self-compacting concrete mixes with different percentages of Alccofine (AF) as partial replacement of cement are also studied. Alccofine is a mineral admixture of ultrafine size which reduces the heat of hydration and increase the strength at all stages. The utilization of these treated industrial by-products as a partial replacement of cement helps to achieve an economical self-compacting concrete mix. Partially replacing cement with alccofine is very economical and can also help in the utilization of industrial wastes and in maintaining the ecological balance thus reducing the consumption of cement.*

Key Words: Self- compacting Concrete, Alccofine, compaction, Fresh properties, Mechanical properties

1. INTRODUCTION

Concrete is a mixture of cement, sand, gravel and water which when dries become hard and strong and is used as a material for building. Concrete is the most versatile heterogeneous construction material and leads to the infrastructural development of any nation. Civil engineering practice and construction works around the world depend to a large extent on concrete. It is the world's most widely used construction materials because of its properties. Almost all countries in the world are facing an acute decline in the availability of skilled labour in the construction industry, and hence the need of special concretes becomes very essential in this world where the use of concrete is just next to the water.

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. Vibratory compaction is noisy and deleterious to the health of construction workers, as well as an annoyance to people in the neighborhood. In remote areas it is difficult to find skilled workers to carry out the compacting work at construction sites. Another advantage of SCC is that the time required to place large sections is considerably reduced.

1.1 Self-compacting concrete

Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. To make durable concrete structures, sufficient compaction by skilled workers is required. A solution for the achievement of durable concrete structures independent of the quality of construction work is the employment of self-compacting concrete. The necessity of this type of concrete was proposed by Okamura in 1986. Self - compacting concrete (SCC) is a fluid mixture, which is suitable for placing difficult conditions and also in congested reinforcement, without vibration. In principle, a self -compacting or self -consolidating concrete must:

- Have a fluidity that allows self -V compaction without external energy
- Remain homogeneous in a form during and after the placing process and
- Flow easily through reinforcement

Compared with conventional concrete of similar mechanical properties, the material cost of SCC is more due to the relatively high demand of Cementation materials and chemical admixtures including high -V range water reducing admixtures (HRWRA) and viscosity enhancing admixtures (VEA). Typically, the content in cementation materials can vary between 450 and 525 Kg/m^3 for SCC targeted for the filling of highly restricted areas and for repair applications. Such applications require low aggregate volume to facilitate flow among restricted spacing without blockage and ensure the filling of the formwork without consolidation. The incorporation of high volumes of finely ground powder materials is necessary to enhance cohesiveness

and increase the paste volume required for successful casting of SCC. Self-compacting concrete or self-consolidating concrete (SCC) is a highly flow able, non-segregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation. When large quantity of heavy reinforcement is to be cast in a reinforced concrete member, it is difficult to ensure that the formwork gets completely filled with concrete. Thus, fully consolidation without voids or honeycombs through compaction by manual or mechanical vibrators is very impractical in this situation, it generates delays and additional cost in the projects and hence, the development of SCC.

Self – consolidating concrete has recently been used in the pre – cast industry and in some commercial applications, however the relatively high material cost still hinders the wide spread use of such specialty concrete in various segments of the construction industry, including commercial and residential construction. In order to meet the performance requirements the following three types of SCC are available.

i. Powder type of SCC: This is proportioned to give the required self-compatibility by reducing the water-powder (material<0.1mm) ratio and provide adequate segregation resistance
ii. Viscosity agent type SCC: This type is proportioned to provide self-compaction by the use of viscosity modifying admixture to provide segregation resistance. Super plasticizers and air entraining admixtures are used for obtaining the desired deformability.
iii. Combination type SCC: This type is proportioned so as to obtain self-compatibility mainly by reducing the water powder ratio, as in the powder type, and a viscosity modifying admixture is added to reduce the quality fluctuations of the fresh concrete due to the variation of the surface moisture content of the aggregates and their gradations during the production.

The self-compactability of fresh concrete depends mainly on its ability to flow through obstacles. The method for achieving self-compactability involves not only high deformability of paste or mortar, but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars. Okamura and Ozawa have employed the following methods to achieve self compactability:

a. Limited aggregate content
b. Low water-powder ratio
c. Use of super plasticizer

Highly viscous paste is required to avoid the blockage of coarse aggregate when concrete flows through obstacle. When concrete is deformed, paste with a high viscosity also prevents localized increases in the internal stress due to the approach of coarse aggregate particles. High deformability can be achieved only by the employment of a super plasticizer, keeping the water-powder ratio to be very low value. Poly-carboxylate type of super plasticizer is suitable for SCC. Self-compacting concrete has been used in many practical structures since 1990. Currently, the main reasons for the employment of self-compacting concrete can be summarized as follows:

1. To shorten construction period
2. To assure compaction in the structure: especially in confined zones where vibrating compaction is difficult
3. To eliminate noise due to vibration: effective especially at concrete products plants. Also, SCC is applied to tunnel lining for preventing the cold joint.

1.2 Alccofine

Alccofine is ultrafine size and essential in terms of reducing heat of hydration and increases strength at all stages. Alccofine in place of cement shall be very economical, help in the utility of Industrial wastes and in maintaining the ecological balance thus reducing the consumption of cement. Alccofine is a micro fine material of particle size much finer than other hydraulic materials like cement, fly ash, silica. Alccofine is manufactured in India. There are two types of Alccofine and they are Alccofine 1203 which is an alccofine with low calcium silicate and are used in high performance concrete and the second one Alccofine 1101 is an Alccofine with high calcium silicate and are used for injection grout in underground tunnels and soil stabilization. The technical benefits of using an Alccofine are the following:

i. Improved workability and cohesiveness and reduced shrinkage- Having better particle size distribution compared to other supplementary cementatious materials, which provide a dense matrix pore structure resulting in better workability, cohesiveness and superior volume stability (shrinkage).
ii. Better retention of workability- Offering better compatibility with cement and certain chemical admixtures, its physical/chemical structure on hydration improves the workability retention properties of fresh concrete.
iii. Reduced segregation- Ultrafine slag improves particle packing in the cementitous paste by filling cement particle voids by virtue of proper distribution of particles, whereby it reduces the bleed water and results in more homogeneous concrete with reduced segregation
iv. Improved flow ability- The material has better particle packing, which results in improved rheology resulting in improved flow ability.
v. Improved durability- Resulting in a dense pore structure, which restricts the ingress of chloride and sulphate ions, this green material, unlike other equivalent material, makes concrete more alkaline,

thereby protecting the reinforce steel in concrete and providing a durable structure.

vi. Improved strength- Ultrafine slag results in the formation of a dense pore structure, and in-built $Ca(OH)_2$, due to cement hydration, provides an increased secondary hydrated product resulting in improved strength gain at early as well as later stages.
vii. Retention of alkalinity- Ultrafine slag has lime content of about 34 per cent that, during hydration, helps retain higher alkalinity in pore solution, thereby mitigating corrosion.
viii. Improves resistance to chemical attack- Because of its finer pore structure and chemical stability, it is substantially more resistant to chloride diffusion. Thus it reduces the penetration of chlorides in concrete and protects embedded steel from corrosion. CaO available in alccofine contribute to maintain $Ca(OH)_2$ as buffer in pore solution, which helps to maintain pH of pore solution
ix. Reduces heat of hydration
x. Lowers permeability

2. REVIEW OF LITERATURE

Literature review that has been carried out to understand the concept behind the topic and to further plan the experimental programme for further research is discussed below.

2.1 Studies on self-compacting concrete

Xie *et al.* (2002) presented the preparation technology of high strength self- compacting concrete (SCC) containing ultrapulverised fly ash (UPFA) and super plasticizer (SP).Various parameters of concrete were selected namely good workability, high mechanical properties and high durability and SCC was developed. There was low slump loss in the fresh SCC mixture. The workability of high strength SCC containing UPFA and SP can be evaluated by the method of combining slump flow and L-box test. Slump flow was 600-750 mm. Flow velocity of L-box test was 35-80 mm/sec.

Cengiz (2005) used fly-ash with SCC in different proportional limit of 0%, 50% and 70% replacement of normal Portland cement (NPC). He investigated the strength properties of self-compacted concrete prepared using HVFA (high volume fly ash). Concrete mixtures made with water-cementitious material ratios ranged from 0.28 to 0.43 were cured at moist and dry curing conditions. He investigated the strength properties of the mix and developed a relationship between compressive strength and flexural tensile strength. The study proved that it is possible to convert an RCC (zero slump) concrete to a workable concrete with the use of suitable superplasticizer.

Kumar (2006) reported the history of SCC development and its basic principle, different testing methods to test high-flow ability, resistance against segregation, and passing ability. Different mix design methods using a variety of materials has been discussed in this paper, as the characteristics of materials and the mix proportion influences self-compact ability to a great extent, also its applications and its practical acceptance at the job site and its future prospects have also been discussed. Orimet test was performed, the more dynamic flow of concrete in this test simulates better the behavior of a SCC mix when placed in practice compared with the Slump-flow variation. The Orimet/J-ring combination test shows great promise as a method of assessing filling ability, passing ability and resistance to segregation.

Miao (2010) conducted a research on developing a SCC with cement replacement up to 80% in all the mixes and examining its fresh properties. Result show that the fly ash acts as a lubricant material; it does not react with super plasticizer and produce a repulsive force and the super plasticizer may only act on the cement. As a result, the larger the amount of fly ash contained, lesser the super plasticizer needed.

Shashikanth, Dr.V.Mallikarjuna Reddy(2016), This study demonstrates that metakaolin (MK) & Micro Silica(MS) can be successfully used as an admixture in the preparation of self-compacting concrete (HSSCC). In order to prepare suitable mix proportions for different grades of MK based HSSCC, investigations were undertaken replacing cement with 0%, 10%, 20%, 30%, 40% of MK As per the European guidelines for Self-compacting concrete, slump flow test, V-funnel test and L-box test have been carried out on fresh properties of MK based HSSCC. The compressive strength, split tensile strength and flexural strength of the specimens have been analyzed for 7-days and 28 days curing. From the study it is observed that workability decreases with increase in Metakaolin. Whereas mechanical properties such as Compressive strength, Split tensile strength and Flexural strength test increase with increase in metakaolin up to 20% and decreases from 30% to 40%. Non Destructive Test is also conducted to assess the quality of concrete in the hardened state.

Netravati T Shepur *et al* (2014), the main objective of the paper is to investigate the strength of Self-Compacting Concrete by fibrous material Polypropylene fiber with varying percentages of Metakaolin (mineral admixture). The mix design which was carried out in the study is Nan su method .Investigations are made to study the Flexural, Compressive and Tensile properties of concrete for 7 days and 28 days of curing and optimum result is obtained for different percentages of Metakaolin 10%, 20% and 30%. The investigation carried out in this work shows that the introduction of 20% of Metakaolin (MK) in concrete will yield better strength compared to other percentages of Metakaolin added. The addition of Metakaolin and polypropylenes results to higher

strength. This paper reviews the properties of hardened state of self-compacting concrete.

S. Shrihari, Seshagiri Rao (2015), in the present paper M40 grade of SCC was considered with different replacement of sand with G.B.F.S. Further it is studied that the effect of MetaKaolin on the properties of GBFS self-compacting concrete, the studies include the effect of GBFS and MetaKaolin on the fresh and hardened mechanical properties of SCC made with GBFS and MetaKaolin The fresh properties and compressive strength of self-compacting concrete is improved as percentage of GBFS increases with constant MetaKaolin (%). The study has revealed that using MetaKaolin in the replacement of river sand with GBFS gives better flow properties and compressive strength in comparison to only GBFS.

2.2 Studies on Self-compacting concrete with Alccofine

M.S. Pawar, A.C. Saoji (2013), in this study, the use of Alccofine powder to increase the amount of the fines and hence achieve self – compatibility is done. The study focuses on comparison of the properties of SCC containing Alccofine with that standard one. The main variable is proportion of Alccofine keeping cement, fly ash, water, coarse aggregate, fine aggregate and super plasticizer contents constant. SCC mixes with Replacement of SCC by 15% constant Fly ash by weight of cement and varying percentage of 0% to15% Alccofine by weight of cement with optimum dosage of super-plasticizer (SP) and viscosity modifying agents (VMA) & to develop different combinations of SCC Mixes. In order to study the effect on properties of SCC with different percentage of Alccofine, SCC's is tested for fresh and hardened Properties. The study concludes that Fresh and Harden properties of SCCs with Alccofine are enhanced than that of SCC without Alccofine and Fresh and Harden properties of SCCs with 10% Alccofine are superior to SCCs with 5% and 15% of Alccofine. The paper suggests Alccofine can be a very good replacement for cement with respect to economy, strength and the considerations of availability of resources.

Arjun .B *et al* (2015), in the present investigation an attempt has been made to study the rheological and strength characteristics of self-compacting Concrete (SCC) mixes by using Metakoilne (MK) and Alccofine (AF) as industrial by-product. The utilization of these treated industrial by-products as cement replacement help to achieve an economical SCC mix. Further the adding Metakoline and Alccofine significant influence in improving the properties viz: rheology, setting time and compressive strength. The best approach is to develop a performance based specification of conventional and SCC mixes with Replacement of SCC by 10% constant Metakoline by weight of cement and varying percentage of 9% to14% Alccofine by weight of cement with optimum dosage of super-plasticizer (SP) and viscosity modifying agents (VMA) & to develop different combinations of SCC Mixes . Further the rheological properties are Slump flow, V-funnel time, L-box; U-box J-Ring etc. and the Hardened properties of developed SCC Mixes in the laboratory after 7 & 28 days curing are studied

S. Kavitha *et.al* (2016) investigates that alccofine and GGBS combination can be used in the SCC as the strength enhancer. Mix design for SCC was carried out by Nan-Su method and substantial result of characteristics of fresh and hardened concrete and effect of alccofine by keeping the GGBS percentage constant on rheological properties and strength properties were investigated. Result of the study made on self-compacting by replacing cement by 30% using GGBS and alccofine content varied from 5%, 10%, 15% and 20%.The workability tests are carried out for the mixes NSCC, PM1, PM2, PM3 and PM4 with a replacement of cement with GGBS and alccofine. The test specimens for determining compressive strength, split tensile strength and flexural strength for concrete were permitted to cure in water for 7, 14, and 28 days. The improvement in properties of concrete like compressive, splitting tensile strength and flexural strength at 28 days was observed with increase in alccofine dosage. Finally the conclusion has been drawn that alccofine and GGBS combination can be used in the SCC as the strength enhancer.

3. CONCLUSIONS

Self - compacting concrete (SCC) is a fluid mixture, which is suitable for placing difficult conditions and also in congested reinforcement, without vibration. Alccofine can be a very good replacement for cement with respect to economy, strength and the considerations of availability of resources. The Alccofine in place of cement shall be very economical and can also help in the utility of Industrial wastes and in maintaining the ecological balance thus reducing the consumption of cement. And hence this technology conserves energy and reduces greenhouse gas emissions through decreasing the demand for products made from energy intensive manufacturing processes. Workability characteristics of self - compacting concrete with Alccofine at different percentages satisfies EFNARC recommended values. Compressive strength mainly depends upon the percentage of alccofine based on this its high pozzolanic nature to form more dense of Calcium silicate hydrate (C S H) gel. Alccofine is easy to use and can be added directly with cement, ultrafine particle of Alccofine provide better and smooth surface finish.

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