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"Advancement in Self Compacting Concrete: A Review of Last Few Decades"

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Abstract: *The development of self-compacting concrete started in Japan in the middle of 1980's with an aim to reduce durability problem in complicated and densely reinforced concrete structure due to lack of skilled labors and poor communication between designer and the construction engineer. The concept of Self compacting concrete (SCC) was purposed for the first time by the Prof. Hajimeokamura (1997), but the prototype was first developed in 1988 in Japan by Professor Ozawa (1989) at university of Tokyo. The last few decades is considered to be the era of the self-compacting concrete and thousands of research has been carried out. In India, the development of concrete possessing self-compacting properties is still very much in its initial stages. Over the past couple of years, few attempts were made using still the cost of production of such concrete is a challenging issue for the present concrete engineers. Hence, in the present paper an attempt is done to understand the effect of various types of mineral and chemical admixture (Rice husk ash, Meta kaolin) on the properties of SCC concrete with the cost by benefit analysis for the same. It is a basically an attempt to sum up the effect of various ingredients on the concrete by doing extensive literature review.*

Keywords- *Self compacting concrete, mineral admixture, chemical admixture, Rice husk ash, Meta kaolin*

I. INTRODUCTION

Concrete is considered to be one of the most important construction ingredient. But the problem like improper compaction, high level of noise pollution, lack of skilled labour etc. are considered to be the major source of destruction to the society. Thus, concrete that requires little vibration or compaction was been used in Europe since the early 1970s still the concept of the self-compacting concrete (SCC) was still an imaginary concept. In Europe it was probably first used in civil works for transportation networks in Sweden in the mid1990's.Basically, 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. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. SCC is a type of concrete that has the capacity to consolidate under its own weight. The current trend all over the world is to utilize the treated and untreated industrial by-products, domesticwaste etc. as a raw material in concrete, which gives an eco-friendly edge tothe concrete preparation process. This practice not only helps in reuse of thewaste material but also creates a cleaner and greener environment [1].It consists one of the very latest developments in concrete technology. With its excellent deformability, high fluidity, and better durability potential, it marks a milestone in the construction industry. SCC is a highly flow able, yet stable concrete that can spread readily into place and fill the formwork without a consolidation and without undergoing any significant separation [2].For the first time, The EC funded a multi-national, industry lead project "SCC" 1997-2000 and since then SCC has found increasing use in all European countries. Self-compacting concrete offers a rapid rate of concrete placement, with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure. SCC is often produced with low water-cement ratio providing the potential for high early strength, earlier remolding and faster use of elements and structures. The elimination of vibrating equipment improves the environment on and near construction and precast sites where concrete is being placed, reducing the exposure of workers to noise and vibration. The improved construction practice and performance, combined with the health and safety benefits make .SCC a very attractive solution for both precast concrete and civil engineering construction. In 2002 EFNARC published their "Specification & Guidelines for Self-Compacting concrete" which, at that time, provided state of the art information for producers and users. Since then, much additional technical information on SCC has been published but European design, product and construction standards do not yet specifically refer to SCC and for site applications this has limited its wider acceptance, especially by specifies and purchasers. In 1994 five European organizations BIBM, CEMBUREAU, ERMCO, EFCA and EFNARC, all dedicated to the promotion of advanced materials and systems for the supply and use of concrete, created a "European Project Group" to review current best practice and produce a new document covering all aspects of SCC. [3].Then after the usage of the SCC accelerated a lot and various inventions took place in last decade. Hence the present paper is an attempt to understand the various research taken place in the field and to have a brief review of it.

II. OBJECTIVES

The aim of the paper is to understand the mechanism lying behind the self-compacting concrete along with it to know the effect of various mineral admixture on the properties of SCC. The main objective of the research was as follows:

a. To understand the mix design of the self-compacting concrete.
b. To analyze the effect of various mineral admixture on the self-compacting concrete.
c. To review the various advancement in the field of Self compacting concrete in last decade.

III. MIX DESIGN OF SELF COMPACTING CONCRETE

The self-compacting concrete flows under the influence of gravity without segregation during which it and completely fills the formwork and spaces between the reinforcement without any need of induced compactions. For concrete to be self-compacting it should have filling ability, passing ability and. resistance against segregation.

- Filling ability- It is the ability of SCC to flow into and fill completely all spaces in the formwork by its own weight. It gives us idea about the fluidity of concrete.
- Passing ability-It is the ability of concrete mix to pass through obstacles like narrow sections aggregate particles. It gives us idea about the flow through tight openings such as spaces between steel reinforcing bars without segregation and blocking.
- Resistance to segregation- Segregation resistance of self-compacting concrete is its capability to retain homogeneity in the distribution of ingredient in fresh state during both static and moving condition i.e. during mixing, transportation and placing. It is dependent on viscosity of mix at fresh state.

The basic principle of producing Self consolidating concrete is as follows:

- Limiting the coarse aggregate content in self-compacting concrete reduces internal stresses between aggregates.
- Addition of super plasticizers can reduce water demand of highly fluid concrete while imparting workability and resisting segregation.
- Self-compacting concrete has tendency to segregate to high workability. This problem can be overcome by adding higher proportion of mineral admixture self-Compacting concrete.

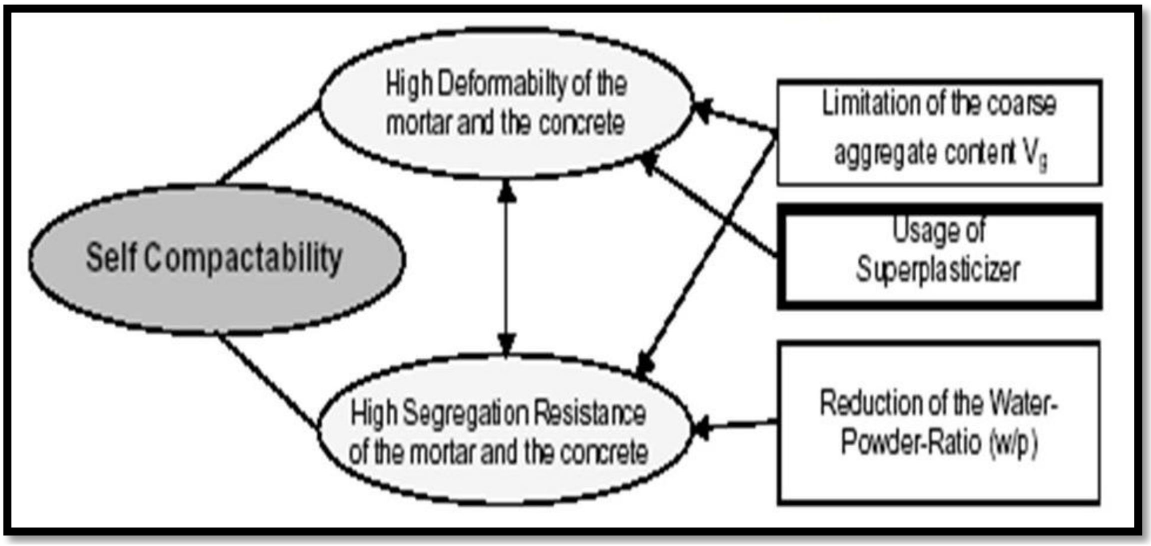

Figure 1: principle of self-compacting concrete

Hence from above figure is clear that in order to obtain SCC we need to follow the above three steps. Along with that the other important point to be noted is that all material available in market cannot be used for producing SCC. It is found that SCC is very sensitive to the property of the materials used. It is very necessary to have uniformity of the property.
The various research has been carried out for the mix deign of self-compacting concrete. Few of them are as follows:

- PRASANT BHUVA et al made an attempt to develop SCC involving various ranges of cements and fly ash, with appropriate quantity of Super plasticizer and VMA (Viscosity Modifying Agent). They concluded that the optimum dosage of Super plasticizer can be calculated using Marsh Cone test. Further, they proved that SCC containing higher cement materials have high compressive strength.
- HARDIK UPADHYA et al concluded that the quality, density as well as the compaction of theconcrete which were the main parameters that cause deterioration inconventional concrete was reduced with the new concept of SCC. They alsomentioned that it can be a boon considering improvement in concrete quality,significant advances towards automation and concrete construction processeswith shortened construction time and lower construction cost and with muchimproved working conditions with reduced noise levels.

- G. De SCHUTTER et al discussed about the transport properties and durability of SCC in their Belgium research project. They compared SCC with traditional concrete (TC). They concluded that the water permeability of SCC is less as compared to TC for the same water/cement ratio, water absorption of SCC is similar to the values obtained from TC, gas permeability of SCC is lower than TC and resist to freezing and thawing in combination with de-icing salts is same for SCC and TC.
- CHRISTIAN DUTTA et al carried out the research work to compare the Splitting tensile strengthand Compressive strength values of self-compacting concrete with normal concrete specimens and examined the bonding between the coarse aggregate and the cement paste using the Scanning Electron Microscope. Cylinder specimens were tested for Splitting tensile and Compressive strength.The water – cement ratios varied from 0.3 to 0.6 while the chemical admixtures, were adjusted for obtaining the self-compatibility of the concrete. The splitting tensile strength increased by approximately 30%, whilst the compressive strength was around 60% greater. In addition, the SCC tensile strengths after 7 days were almost as high as those obtained after 28 days for normal concrete.

IV. MINERAL ADMIXTURE IN SELF COMPACTING CONCRETE

The usage of mineral admixture in the traditional as well as self-compacting concrete has been increased tremendiously inlast decade. The various review of the work done in this field is as follows:

- NANAK J PAMNANI et al mentioned in their study to determine the optimum dose of Super plasticizer in order to minimize the trials and labour the Marsh cone test can be used. In his paper, the PCE based Super plastizers used were Glanium Sky 784 (SP1), Viscocrete 20HE (SP2) and Glanium B276 Suretec(SP3). Different dosages of Superplasticizers were used for finding the flow values of the mixes. They concluded that for a selected water cement ratio i.e. 0.32, the optimum dose are 1.2%, 1.3% and 1.1% for SP1, SP2 & SP3 respectively, all the three SPs are compatible with the cement used for the project. And also added that Marsh cone test can be effectively used as useful tool for optimization of doses of Super plasticizer.
- N.R.RAJIWALA et al concluded that SCC provides good finishing as compared to normal concrete without any external mean of compaction, by addition of 15% of fly ash in the mix, maximum compressive strength of SCC can be obtained as compared to addition of 25%, 35%, 45% and 55% cement replacement by fly ash, maximum tensile strength for SCC can be obtained by addition of 15% of fly ash in mix as compared to addition of 25%, 35%, 45% and 55% cement replacement by fly ash, the maximum flexural strength for SCC can be achieved by addition of 15% of fly ash in mix as compared to addition of 25%, 35%, 45% and 55% cement replacement by fly ash , the maximum pull out strength for SCC can be obtained by addition of 15% of fly ash in mix as compared to addition of 25%, 35%, 45% and 55% cement replacement by fly ash. Further, they proved that SCC provides good durability properties compared to the ordinary concrete.
- N. BOUZOUBA et al focussed in their research about production and evaluation of self-compacting concrete (SCC) incorporating high volumes of fly ash. They investigated to make SCC more affordable and economical for the construction market by replacing high volumes of Portland cement by fly ash. The mixture proportion used was water to cementitious materials ratio of 0.32, and cement and fly ash contents of 155 and 215 kg/m3 respectively. They concluded that such concrete is flowable, cohesive and develops a 28-day compressive strength of approximately 35 MPa. The results are compared to those obtained with a conventional control concrete.They determined that the compressive strengths ranging from 15 to 31 MPa, and from 26 to 48 MPa, at 7 and 28 days, respectively. And in terms of mix design cost, the economical SCC that achieved a 28-day compressive strength of approximately 35 MPa was made with 50% replacement of cement by fly ash, and with a water-to cementitious materials ratio of 0.45.
- P. RAMANATHAN et al focused in their research to incorporate the use of mineral admixtures in Self compacting concrete. The admixtures used were fly ash, silica fumes and ground granulated blast furnace slag. They carried out an experimental investigation on mechanical properties like compressive strength, flexural strength and split tensile strength of SCC containing different mineral admixtures and also fresh properties like slump, L- box, U-box, T50 were carried. They replaced cement content with 30%, 40%, 50% mineral admixtures andperformance were measured and compared. They concluded that the flow and filling ability of SCC were improved with involvement of admixtures. It was further observed that with the use of mineral admixtures in SCC, the amount of Super plastizers was reduced, to achieve a given fluidity. They concluded that cost effective SCC can be achieved by involving the mineral admixtures.
- S. WANSOM et al suggested that the pozzolanic activity of RHA paste is sensitive to the unburnt carbon content in the range of 6-8% weight and especially sensitive to amorphous SiO2 content. Thus, it is very important to check the chemical content of rice husk used for producing concrete.
- M.A.AHMADI et al in their research focused to determine the usefulness of Rice Husk Ash (RHA) in manufacturing SCC. The cost of concrete was considerably reduced by replacement of cement with waste materials like RHA. In their research, they fixed the proportions of coarse aggregates and fine aggregates, while water/powder ratio and Super-plasticizer dosage was adjusted by trial and error they concluded that RHA has

the effects on mechanical properties at an age after 60 days. According to the results obtained from the research , SCC mixes shows strength about 12% to 20% more than normal concrete, SCC mixes shows higher compressive strength than normal concrete i.e. 31% to 41% and Modulus of Elasticity for normal concrete is 9% to 17 % more than in SCC. Thus, it was found that with increase in RHA content, the Modulus of Elasticity reduces. It was also concluded that the specimens with 20% replacement by RHA have best performance.

- NDIGUI BILLONG et al found that when Meta kaolin was replaced by part of RHA in binder with lime, then absolute density was increased and grind ability of binder was decreases. Also mixture with 25% metakaolin and 75 % RHA gives better results in terms of initial setting time, flexural strength and compressive strength. They found that SCC mixes showed maximum compressive strength of about 19 MPa at 28 days and thus, metakaolin and RHA both together improves the fresh and mechanical properties of SCC
- Md. SAFIUDDIN et al founded that the filling and passing ability criteria were fulfilled for the SCCmixtures, except few concretes with a lower w/b ratio and the RHA contentgreater than 15-20%. The orimet and inverted slump cone flow times increasedwith lower w/b ratio and higher RHA content, and thus, indicated a reduction inthe filling ability of concrete. Further, no sign of segregation was observedwithout RHA, but it existed in presence of RHA containing concrete mixes, though the bleeding was significantly reduced. They concluded that RHA contentwas 10-15% based on the results of filling ability , passing ability , segregationresistance , unit weight and air content .
- MD NOR ATAN et al mentioned in their study toinvestigate the compressive strength and flexural strength of SCC incorporatingraw rice husk ash, individually and in combination with other types of mineraladmixtures as partial cement replacement. The additives used were finelimestone powder (LP), pulverized fuel ash (FA) and silica fumes (SF). The resultconcluded that 15% replacement of OPC with RRHA, 30% replacement with twomineral additives components (LP/RRHA), 45% replacement with three mineraladditives components (LP/SF/RRHA), produces comparable compressivestrength as the control mix and improved flexural strength. The 30% replacementof OPC with two mineral additives components (FA/RRHA), 45% replacementwith three mineral additives components (FA/SF/RRHA), produces comparablecompressive strength and flexural strength as the control mix. The studymentioned that the use of RRHA results in better performance in flexure than thatin compression.

V. CONCLUSIONS

- Self-compacting is considered to be the one of the most consumer friendly concrete and the usage of it has been accelerated in last few decades. The usage of such concrete in construction results into more durable as well as economical concrete.
- Establishment of standard mix design procedure and appropriate testing methods isessential for widespread use of SCC. Most of Indian researchers have followedEuropean guidelines for testing SCC. Other countries are adopting these guidelineswith slight modifications as per their local conditions.
- The usage of mineral admixture in the self-compacting concrete results into effective production concrete with great reduction of the cost.
- The chemical admixtures is considered to be one of the most important component of the self-compacting concrete. It is not at possible to produce concrete without poly carboxylic or naphthalene based chemical admixture.
- Rice husk ash is agro waste whereas flyash is industrial waste from thermal powerstation. Utilization of these waste products as cement replacement will not only helpto achieve economical SCC mix, but it is envisaged that it may improve themicrostructure and consequently the durability of concrete. This provides solution todisposal problems and other environmental pollution created by these waste.
- Addition of fly ash in SCC increases filling and passing ability of concrete, whereasrice husk ash imparts viscosity to concrete improving segregation resistance ofconcrete mix. From this experimental study it can be inferred that fly ash and RHAblend well improving overall workability, which is the prime importantcharacteristics of SCC.
- Flow ability of mortar is directly influenced by the composition of the concrete. Especially sand content influences the flow spread by affecting the free water inmortar mixer. \
- According to most of the researcher the addition of pozzolana like rice husk ash, fly ash, metakaolin silica fumes etc. into the concrete canimprove the mechanicalproperties of specimens at longer duration.
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