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# A REVIEW ON MECHANICAL PROPERTIES OF HIGH STRENGTH SELF COMPACTING CONCRETE

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**Abstract—**High strength self compacting concrete is a fluid mixture suitable for congested reinforcement. It should posses a good balance between the deformability and suitability. This is being used in increasing volume in recent years due to its mechanical properties durability properties than conventional concrete. In this review the High strength self compacting concrete with different minerals used and their performances were presented. By adding admixtures like silica fume, fly ash and quarry dust will decrease the flow ability, to improve this super plasticizers were added. The successful utilization of silica fume, fly ash and quarry dust could turn this waste material into valuable resources. This paper presents the results of an experimental work of high strength self compacting concrete with silica fume, fly ash and quarry dust and super plasticizer and their mechanical properties.

**Keywords—** self compacting concrete, silica fume, fly ash, quarry dust, mechanical properties

## I. INTRODUCTION

The purpose of High strength self compacting concrete is one of the most important development in the building industry. The purpose of using this concrete is to decrease the human risk. The properties of high strength self compacting concrete differ from conventional concrete.

**Venkat Rao (2013)** observed that the growth of population, industrialization and increasing urbanization needed the demand for infrastructure. Concrete plays an important role in creating infrastructure very significant and fulfill the need of construction industry. The concrete have increased its utility at every stage of construction due to its flexibility, suitability and adoptability. In conventional concrete, through vibration workability may be achieved but it is not possible to get full compaction. Inadequate compaction forms the large number of voids. The voids in the concrete reduces the strength and durability of concrete. The contribution of self compacting concrete satisfies requirement. European federation (EFNARC) gave design specifications, guidelines to produce and use high quality self compacting concrete. Concrete in the fresh state decides the characteristics of self compacting concrete. The fresh concrete should posses the filling ability, passing ability and resistance against segregation. The fresh concrete is tested by slump flow Test, V-Funnel test, L-Box test. Higher water binder ratio leads to volume change, permeability and cracks. Therefore lower water binder ratio need to produce the dense, impermeable and durable concrete. Lower water binder ratio reduces the corrosion on steel reinforcement. The super plasticizers had made it easy to produce the concrete with lower water/binder ratios and it makes a high strength and high performance self compacting concrete . The concrete with low water/binder ratio reduces the intensity of damage by resisting the impact of magnesium sulphate.

**Gaywala N R (2011)** ascertained that, self compacting concrete with fly ash decreased Permeability and increased density by long term pozzolanic action. It is more resistant to sulphate attack and

 

reduced shrinkage because fly ash ties with lime. The maximum compressive strength, tensile strength and flexural strength were obtained by 15% of fly ash replacement with cement.

**Ahmed Fathi (2013)** proposed that**,** self-compacting concrete is the concrete mix that has ability to resist the segregation and to flow under its own weight and not by the vibration. By reducing the aggregate contents and increase the cement amount as well as the addition of chemical admixture such as super plasticizer, we can achieve the required mix. The increase in cement content will lead to increase in total cost. To avoid this problem the cement replacement material can be used. Fly ash, microwave incinerated rice husk ash and silica fume are the famous type of cement replacement material to replace the cement content in the concrete and can increase the workability properties of self compacting concrete mix. All self compacting concrete mixes showed acceptable slump flow value of 650-768 mm that posses a good deformability. The self compacting concrete mixes gave values within the range of 0.8 to 1.0 in L-box test. To achieve the fresh properties, microwave incinerated rice husk requires more water than silica fume. The highest compressive strength and split tensile strength was achieved in 5% silica fume and 30% fly ash with concrete mix. Where as all cement replacement material mixes resulted in high flexural strength, which was due to the negligible bleeding and high cohesiveness. The performance of microwave incinerated rice husk to replace the cement depends on the burning degree which will affect the microstructure of the binder.

**Muhammad Nouman Haral (2013)** inferred that, an alternative binder in the construction industry is natural pozzolan. Nowadays environmental aspects have become a major concern of many in the construction field . The cement industry contaminates the environment pertained to substantial amount of $CO_2$.It is essential to control the entire process of cement production by minimizing the amount of $CO_2$ introduced to environment. The introduction of supplementary cementitious materials, this can be achieved. The supplementary cementitious materials increase from one day to another and from one application to another because of the demand and the subsequent added-cost. Self compacting concrete should have higher quantity of binder,a higher fine aggregate content and lesser amount of coarse aggregate content. Hence it is essential to incorporate chemical admixtures such as super plasticizers to keep proper workability and viscosity aspects into consideration of self compacting concrete. To achieve fresh concrete properties, higher quantities of finer particles are added. The application of Natural pozzolan as an alternative binder in self compacting concrete mixes up to 20% provide flow able mix. The determination of optimum poly carboxylic ether dosage for various pastes can be found from modified marsh cone test. The flow-ability of the pastes and mixes increases with the increase in Poly carboxylic ether dosage. The slump flow increase with the increase in volume fraction of paste of higher binder content. Higher water volume causes the risk of segregation and settlement of aggregate. The value of $T_{500}$ decreases with the increase in the paste volume fraction and water binder ratio.

**Mostafa Jalal (2015)** explained that, high strength concrete is one of the classification of high performance concrete. The grade above M60, concretes refers to high strength concrete. High strength and durability properties achieved by reducing porosity, in homogeneity, micro cracks in concrete . The reduced sizes of structural member, increased building height in congested areas, early removal of form work, in prestressed concrete construction makes greater span-depth ratio, early transfer of prestress and application of service loads can be achieved by using high strength concrete. Reduction of corrosion of steel and attack of aggressive chemicals can be done by Low permeability characteristics of high strength concrete. This permits the use of high strength concrete in nuclear power plants, bridges, marine structures and places of extreme climatic conditions. High strength concrete reduces maintenance and repair cost. By combining the BIS method , ACI methods for concrete mix design and the available literatures simplified mix design procedures are formulated. Some times the mix proportion should be modified to meet the desired workability and strength criteria, by adjusting the % replacement of cement by SF, % dosage of super plasticizer solid content of binder, air content and unit weight by means of trial batches to optimize the mix

 

proportion.Based on the above formulated mix design , mix proportions are arrived for M80 and M100 grades of concrete and by replacing 0, 2.5, 5, 7.5, 10, 12.5 and 15% of the mass of cement by silica fume. The increased percentage of silica fume content decreases the workability of concrete. The cement replacement by silica fume 10% is the optimum percentage for M80 and M100 grades of concrete. The maximum compressive, split tensile and flexural strength and elastic modulus are achieved by the optimum percentage of cement replacement by 10% silica fume.

**D.W.S. Ho (2002)** reported that, the fresh concrete flow under its own weight over a long distance without segregation and without using vibrators there by achieving proper compaction known as self-compaction. It should have plastic viscosity together with a low yield stress approaching as a Newtonian fluid. High powder content and the incorporation of surface-active agents, such as super plasticizers cause the self-compaction. A by-product in the production of concrete aggregates during the crushing process of rocks is known as granite fines. The granite fines are referred as quarry dust. The introduction of quarry dust to concrete mix is limited due to its high fineness. Addition of quarry dust to fresh concrete would increase the water demand and consequently the cement content for given workability and strength requirements. Utilization of quarry dust in self compacting concrete could turn this waste material into a valuable resource and it saves the cost. Quarry dust requires a higher dosage of super plasticizer for similar yield stresses and other rheological properties. The higher fineness of granite fines could promote durability problems, such as alkali silica reactions.

**Prajapati Krishnapal (2013)** found that, the most revolutionary development in concrete industry is Self-Compacting Concrete. It has advantages like faster construction, reduction in size for concrete sections, better durability, suitable for congested reinforcement. Therefore this concrete becomes popular in the construction industry. The self compacting concrete is developed by using various percentages of fly ash ( 10%, 20% and 30%) by weight of cement as partial replacement of cement. The fresh properties of self-Compacting Concrete are been assessed by using the methods such as $T_{500}$ time, V funnel and , L-box test as per EFNARC specification. The poly carboxylic ether is used as water reducing admixture. The cement is replaced by fly ash up to 30% (10%, 20% and 30%) by weight of cement and quantities of the fine aggregates and coarse aggregates are kept constant. The fine aggregate is kept approximately 37% by weight of concrete. The coarse aggregate is kept approximately 34% by weight of concrete. The water binder ratio is kept 0.40 and 0.45 by weight. The mixes thus prepared follow the EFNARC guidelines. The addition of Fly ash decreases the addition of super plasticizer content for same and better workability. The addition of Fly ash results is decrease in 7 days and 28 days of compressive strength. The 28 days compressive strength is decreased and the fly ash content is increased to 30%. However all the mixes have good 28 days compressive strength. Therefore, it is possible to produce a good performing self compacting concrete using locally available Fly ash.

**Rahul Dubey (2012)** developed that, the self compacting concrete has more powder content, less coarse aggregates, high range water reducing super plasticizer and small dosage of viscosity modifying agent . Self-compacting concrete has to posses high flowing ability when it is being cast and high viscosity when it is at rest, in order to prevent bleeding and segregation. To achieve above properties super plasticizers were used. Trial mixes were prepared by varying the dosage of super plasticizers from 2% to 12% of cement material with an increment of 2% to achieve required strength. Self compacting characteristics in fresh state of mix proportion with varying dosages of super plasticizers slump flow test, V-funnel flow test and L-Box test were performed according to the procedure proposed by EFNARC. The filling ability of self compacting concrete can be determined by Slump Flow test. The filling ability and passing ability can be determined by L-box test. The addition of super plasticizer upto 4% gives good strength. Addition of super plasticizers up to 8% increases the compressive strength at all ages but the increase was marginal. The setting time was increased with increase in dosage of super plasticizers .On addition of super plasticizers more than 10% ,the mix was not set even after 11 days.

**K.S. Johnsirani (2013)** proposed that, a concrete which can be placed and compacted under its self weight without vibration effort and at the same time cohesive enough to be handled without segregation is considered as self-compacting concrete. It contains super plasticizer, high content of fines and viscosity modifying agent. The use of super plasticizer maintains the fluidity. The resistance against bleeding and segregation is attained by using high fine content and super plasticizer. The use of blast furnace slag fly ash and quarry dust in self compacting concrete reduces the super plasticizer dosage. Self compacting concrete may result in up to 40% faster construction than using normal concrete. The use of mineral admixtures improved the performance of self compacting concrete in fresh state and also reduces the use of viscosity modifying agents. Passing ability, filling ability and segregation resistance are well within the limits only when water/binder ratio is 0.4.The compressive strength and split tension strength had shown higher strength when replacement of admixture is 25% of finest materials. Beyond that limit the hardened properties of concrete decreases.

**M.Iyappan (2014)** ascertained that, self compacting Concrete is one of the category of high performance concrete characterized by ability to spread and self consolidate under its own weight without bleeding and segregation. Among the various manufactured nano materials such as nano silica, nano alumina, nano titania, nano zirconia, nano $Fe_2O_3$ etc, the addition of Nano Silica (NS) enhances the possibility for the reaction with Calcium Hydroxide (CH) to develop more strength. Self compacting concrete with partial replacement of cement by nano silica in three different percentage such as 2%,4%,6% and hardened properties were found. Mix design was designed by ACI Mix Design method. The water Cement Ratio is 0.32 and the mix ratio is 1:2.05:2.3.The nano silica has large surface area which improves the compressive, flexural and split tensile strength at early ages and reduced porosity and water absorption when compared with conventional concrete. The nano silica about 4% in self compacting concrete gives more acid resistance compared with conventional concrete due to reduced porosity.

**H.A.F. Dehwah(2012)** described that, a concrete that is able to consolidate itself without vibration, fills all recesses, spaces and voids, even in highly congested reinforced concrete members and it is expected to flow freely without any segregation of its constituents to form nearly a level surface is self compacting concrete. It requires a higher proportion of fine materials, incorporation of chemical admixtures and high range water reducer with commonly used filler materials. Filler materials include fly ash, quarry dust powder, blast furnace slag, silica fume and quartzite powder. Self compacting concrete eliminates consolidation work that results in reducing the efforts and cost of placement, shortening of the construction time, and therefore improves the productivity. Self compacting concrete also leads to a reduction of the noise during casting, better working conditions, and the possibility of increasing the placing times in inner city areas. Trial mixtures were prepared with different proportions of fillers, namely quarry dust powder, silica fume + quarry dust powder and fly ash. By the rational mix-design method these mixtures were designed and the proportioning of materials was carried out on weight basis. By conducting the slump flow test, V-flow test, U-box flow test and L-box flow test the flow characteristics of the trial mixtures were evaluated. The maximum compressive, flexural, split tensile strength was obtained in mix design with (8% quarry dust powder, water/binder = 0.38) specimens. The mix incorporating quarry dust powder alone gives better strength than prepared with silica fume plus quarry dust powder or fly ash alone. This indicates that 8–10% quarry dust powder alone as a better filler than fly ash or silica fume plus quarry dust powder. The use of quarry dust powder alone results in a significant cost saving in regions where silica fume and fly ash are not available locally.

**Caijun Shi (2015)** explained that , mix design is a critical step to obtain high quality self compacting concrete. A good self compacting concrete mixture design method should consider, widely applicable, strong robustness for variable raw materials, technical requirements, sustainability and cost.There are various methods available for mix design of self compacting concrete,such as

EFNARC "Specification & Guidelines for Self-Compacting concrete", ACI method empirical design method , Compressive strength method , close aggregate packing method, mixture design method based on statistical factorial model , mixture design method based on rheology of paste model . Silica fume and quarry dust were observed to improve the mechanical properties of self compacting concrete because of the pozzolanic action of silica fume. It has been indicated that self compacting concrete having silica fume have higher compressive strength,split tensile strength and flexural strength. As the water cement ratio reduces and cement content increases, strength increases in self compacting concrete made with silica fume and self compacting concrete made with quarry dust.

**P. Vinayagam (2012)** explained that, High Strength Concrete refers to concretes of grade above M60. High strength and durability properties become reality for Conventional concrete by reducing porosity, in homogeneity and micro cracks in concrete. The use of high strength concrete reduces size of structural member, increased building height in congested areas and early removal of formwork.

**Priyanka P.Naik (2013)** observed that, self compacting concrete is a highly workable concrete that can flow through densely reinforced and complex structural element under its own weight and adequately fill all voids without segregation, excessive bleeding, excessive air migration or other separation of materials and without the need of vibration or other mechanical consolidation**.**

**J. M.Srishaila (2014)** observed that, a sustainable industrial growth in the construction industry in all aspects, has environmental impact due to high consumption of energy, which results in increase liberation of carbon dioxide ($CO_2$). Thus, by partially replacing cement by mineral admixtures such as silica fumes, an effort is being made to reduce the global warning and also as these mineral admixtures are usually the industrial wastes, these materials can be safely disposed by blending them with cement.

## II. CONCLUSION

In the present review, study of self compacting concrete using cement replacement material such as Silica Fume, Fly Ash and Quarry Dust the following conclusions were arrived. Because of extreme fineness and very high amorphous silicon dioxide content, silica fume and fly ash is a very reactive pozzolanic material and quarry dust act as a filler material which cause the densified concrete. Hence self compacting concrete with silica fume with quarry dust shows the good result in both tension and compression. A simplified mix design procedure for high strength self compacting concrete using silica fume , quarry dust powder and super plasticizer is formulated by combining ACI methods of mix design , EFNARC "Specification & Guidelines for Self-Compacting concrete" and available literatures on high strength self compacting concrete. The optimum percentage of cement replacement by silica fume and fly ash is 20% for achieving maximum compressive, split tensile and flexural strength.The use of silica fume in high strength self compacting concrete reduces the workability.The partial replacement of quarry dust also decreases the workability due to variation of particle size ,bulking parameter .Hence high strength self compacting concrete requires the higher dosage of super plasticizers. The dosage of super plasticizer beyond 4% of mix proportion affect the strength. The more amount of using silica fume and quarry dust cause alkali silica reaction which promote durability problems. The optimum percentage of silica fume and quarry dust gives the best results and also it reduces the cost and reduces the environmental pollution. Finally, using the industrial waste of silica fume, fly ash and quarry dust is valuable resource and reduces the human risk.

 

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