Effect of Implementation of Magnetized Water To Improve The Strength Properties of Self-Compacting Concrete

A Satish[1], B Ganesh[2]
[1]Dept of Civil Engineering
[2]Associate Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract- *Water plays an important role in the concrete preparation. It plays an important role in workability and strength of concrete. A new technology known as magnetized water is used to increase the workability and strength of concrete. The magnetized water technology initiated in different countries for agricultural and other medical values and now it extends its application in construction industry. Magnetic water has been used in different fields like health care, dairy production, agriculture and oil industries. This experimental study involves the examination of magnetized water on the workability and strength properties of the concrete. Self-compacting concrete (SCC) is the concrete that flows through dense reinforcements and compacts under its own weight. A well graded SCC is highly flowable in nature which aids to its filling ability, passing ability and resistance to segregation. In this experimental analysis tests were carried on SCC of M30 grade made with magnetic water of 0.8 Tesla, in which sand is partially replaced with quarry dust and Glass Powder at 0, 10, 20, 30, 40 & 50% and 0, 5, 10, 15, 20 & 25% respectively, and cement with fly ash at 0, 10, 20, 30, 40 & 50%. The concrete mix was then tested in its fresh and hardened states at 7, 14 and 28 days and compared to conventional Self-compacting concrete.*

Keywords- Self compacting concrete, quarry dust, glass powder, fly ash, workability, compressive strength, split tensile strength test.

I. INTRODUCTION

Cement used in concrete is a mixture of complex compounds. Cement is a major industrial commodity that is manufactured commercially in over 120 countries. Mixed with aggregates and water, cement forms the ubiquitous concrete which is used in the construction of buildings, roads, bridges and other structures. In countries, even where wood is in good supply, concrete also features heavily in the construction of residential buildings. Production of concrete using Portland cement is popular all over the world. This is due to mainly low cost of materials and construction for concrete structures as well as low cost of maintenance. But high amount of energy is required for manufacturing of cement which emits carbon dioxide (CO_2) which is very harmful for the environment. In order to minimize this problem, we use the concept of supplementary cementitious material. Some of agricultural and industrial waste ash which was fulfilled the criteria as supplementary cementitious materials.

To make the SCC mix economical and environment friendly, a variety of materials have been experimented and analyzed in order to replace the constituent materials. The following materials have been used as replacements in the preparation of SCC. Glass is a transparent material which is found naturally when rocks high in silicates melt due to very high temperatures and cool rapidly before they can form a crystalline structure. Alternatively, they can be produced by melting a mixture of materials such as silica, soda ash, and $CaCO3$ at high temperature followed by cooling during which solidification occurs without crystallization.

Thermal plants usually generate Fly ash as residue when producing electricity through combustion of ground or powdered coal. Experiments show that this bi product can partially replace the cement in the production of concrete which improves both fresh and hardened states. Due to smooth and spherical shape of Fly ash particles the workability of fresh concrete increases which in turn lowers the water cement ratio, which later leads to higher compressive strength. Fly ash tends to delay the setting time of concrete but aids to the strength and durability of hardened concrete.

An experimental study on mechanical properties, such as compressive strength, flexural strength of self-compacting concrete (SCC) and the corresponding properties of self-compacting concrete were studied. The age at loading of the concretes for 7 and 28 days curing.

Making concrete structure without compaction has been done in the past. Like placement of concrete underwater by the use of term i.e., without compaction. Inaccessible areas were concreted using such techniques. The production of such mixes often used expensive admixtures and very large quantity of cement. But such concrete was generally of lower strength and difficult to obtain. SCC is a high performance concrete that consolidates under its self-weight, and adequately fills all the voids without segregation, excessive bleeding or any other separation of materials, without the need of mechanical consolidation.

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

1. To design and produce mix proportions for Self Compacting Concrete (SCC).
2. To evaluate the physical and chemical properties of SCC.
3. To obtain and compare the physical and chemical properties of self-compacting concrete.
4. To evaluate the physical properties and chemical properties of fly ash, quarry dust and glass powder.
5. To observe the literature review of self-compacting concrete using different industrial and agricultural waste materials.
6. To determine the various tests such as slump flow, L-box, U- box, V-funnel etc.

II. REVIEW OF LITERATURE

This chapter discussed about the literature study on the body of works based on replacement of cement with fly ash and replacement of fine aggregate with quarry dust and glass powder in concrete design to pave the path for practical realization of this concept in the construction industry. The limited study available on self-compacting and ordinary concrete with quarry dust and glass powder is enclosed herein. This chapter deals with the review of literatures used in the project work and discusses about the different investigation for effective use of quarry dust and glass powder as replacement in general so far. In this part of the thesis, the various literatures that have been studied are presented in a chronological order dating back to 1980‘s when the development of SCC took place in Japan to the present times. Various research works done by the researchers of different parts of the world available in the form of literatures, here literatures available on the use of quarry dust and glass powder as partial replacement of fine aggregate and fly ash as partial replacement of cement is mentioned in the following Literature Review. The chapter also includes the motivation and objective of this research work.

SiriratJanjaturaphan and SupapornWansom (2010):They studied on, “The Pozzolanic Activities of Industrial Sugar Cane Bagasse Ash”. They find out the chemical composition of the Sugarcane Bagasse Ash and compared them with the other pozzolanic material that is, rice husk ash and concluded that the SCBA is suitable for the partial replacement of cement.

D. Mukharjee (2011):Has Study made on “Utilization of SCBA”. They described the various uses of SCBA in agriculture, construction, use of bagasse as fertilizers; in horticulture etc. their chemical and other fertilizing properties etc. also gave various options for utilizing bagasse ash in various fields.

YoukaiWanget al studied the effect of magnetic field on the physical properties of tap water and four types of magnetized water in the same condition and found that the magnetic field treatment changed the specific heat, evaporation amount and boiling point. She concluded that magnetic water can be utilized for power generation efficiency and to improve cooling.

MajidGholhakiet al analyzed the effect of using silica fume, metakaolin, rice husk ash and fly ash with different ratios of 10% and 20% by weight of cement in self-compacting concrete containing magnetic water of 0.8 Tesla and compared with a mix prepared with tap water. He concluded that the dosage of super plasticizer is reduced significantly. Also the results of hardened SSC show an improvement in mechanical and durability properties of concrete. The usage of silica fume with ratio 20% by weight of cement in self- compacting concrete containing magnetic water, increases the compressive and splitting tensile strengths by 48% and 35% respectively and decreases amount of water absorption by 55% at the age of 28days

Sagar W. Dhengare, Dr.S.P.Raut, N.V.Bandwal, AnandKhangan(2015):The utilization of industrial and agricultural waste produced by industrial processes has been the focus on waste reduction. Ordinary Portland cement (OPC) is partially replaced with finely sugarcane bagasse ash. The concrete mixtures, in part, are replaced with 0%, 10%, 15%, 20%, of SCBA respectively. In addition, the compressive strength, the flexural strength, the split tensile tests were determined. The mix design used for making the concrete specimens was based on previous research work from literature. The water –cement ratios varied from 0.44 to 0.63. The tests were performed at 7, 28, 56 and 90 days of age in order to evaluate the effects of the addition SCBA on the concrete. The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement.

K Meeravali, K V G D Balaji, T. Santhosh Kumar (2014):They studied on, “Partial replacement of Cement in Concrete with Sugarcane Bagasse Ash Behaviour in Hcl Solution”. In this paper concrete cubes are casted with different percentages of Sugarcane Bagasse ash replaced with cement by weight (i.e. 0%, 5%, 10%, 15%, 20%, and 25%), and this cubes are exposed to 5% HCL environment. Compressive strength of cubes for 7days, 28 days and 60days are observed.

Dinakar et al. (2008) talked about the trial consequences of durability properties of self-compacting concretes with high measure of replacements of fly ash. Eight proportions of different strength grades were designed at wanted fly ash contents of 0, 10, 30, 50, 70 and 85%, in comparison with five unique proportions of traditionally vibrated concretes at identical strength grades. The durability properties were concentrated through the estimation of porous voids, water absorption, corrosive assault and chloride permeation. The outcomes demonstrated that the high sum fly ash SCC showed higher penetrable voids and water absorption than the vibrated ordinary concretes of a similar strength grades. Nonetheless, in corrosive assault and penetrability contemplates the high volume fly ash SCC had essentially lower weight misfortunes and chloride ion diffusion.

Mehta and Folliard 1995, Maeda et al. 2001):Reported that, the use of rice husk ash (RHA) in SCC is very limited. RHA is obtained by controlled burning of rice husks.RHA provides dramatic improvements in hardened properties and durability of concrete. Similarly the use of SCBA can also be used as a partial replacement of cement since it exhibits same chemical compositions as the alternative pozzolanic materials and effects might be observed when RHA is used in SCC.

Mehta and Monteiro(2006):The construction of highly congested reinforced concrete elements requires the fresh concrete mixtures to be very fluid. The risk of material separation in concrete is especially great for heavily reinforced structures with high placement heights and excessive vibratory compaction during consolidation. The cost of SCC could be reduced by 36% by incorporating BA along with the standard concrete ingredients.

Edwin Fernando et al (2014): Carried out an experimental investigation on self compacting concrete by replacing the fly ash as a filler material and copper slag as fine aggregate at a percentage of 5%, 10%, 15%, 20% and 25%. Mix design is done as per EFNARC specification by keeping water cement ratio of 0.40 all mix and super plasticizer was used to increase the flow properties. The fresh and hardened properties of concrete was tested as per the standards and compared for normal SCC and SCC with partial replacement of fly ash and copper slag. The result shows a marginal improvement in the replacement of cement by fly ash up to 40%.

Nileena et al (2014): Replaced the Ground Granulated Blast Furnace Slag and Granulated Blast Furnace Slag as filler material by the water cement ratio of 0.45. Six different mix proportions were prepared with a partial replacement of cement by GGBS at 30%, 40% and 50% and GBS at 30%, 40% and 50% as partial replacement of fine aggregate. Super plasticizer is used to achieve the selfcompactibility. The standard tests for fresh and hardened concrete was carried out and it was observed that only a small increase in compressive strength was achieved for 20% partial replacement of GGBS and GBS. But, ultrasonic pulse velocity shows an excellent result that there is no crack or undulations inside the specimen.

Srivastava et al (2012): Carried an experiment of addition of silica fume as a filler material to concrete in various stages. Cement is partially replaced by silica fume in varying proportions as per the mix design. The addition of silica fume increases workability, strength and durability, as well as resistance to cracks is improved. It was observed that there is an increase in compressive strength from 6% to 57% during partial replacement of cement by silica fume. Addition of silica fume improves the bond strength of concrete; however, modulus of elasticity of silica fume in concrete shows a similar result to that of conventional self compacting concrete.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Water
4. Quarry dust
5. Glass powder
6. Flyash

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. *Fine Aggregate*

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

3. *Coarse Aggregate*

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

4. *Quarry dust*

Quarry dust is a byproduct of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste..

5. *Glass powder*

Glass is a transparent material which is found naturally when rocks high in silicates melt due to very high temperatures and cool rapidly before they can form a crystalline structure. Alternatively, they can be produced by melting a mixture of materials such as silica, soda ash, and $CaCO_3$ at high temperature followed by cooling during which solidification occurs without crystallization.

6. *Fly ash*

Thermal plants usually generate Flyash as residue when producing electricity through combustion of ground or powdered coal. Experiments show that this bi product can partially replace the cement in the production of concrete which improves both fresh and hardened states. Due to smooth and spherical shape of Flyash particles the workability of fresh concrete increases which in turn lowers the water cement ratio, which later leads to higher compressive strength. Flyash tends to delay the setting time of concrete but aids to the strength and durability of hardened concrete. The flyash used for experimentation is obtained from Rajamahendravaram paper mill. It is found to be of Class F classification and is in accordance with IS:3812-2003.

7. *Magnetic water*

The water used throughout the experiment for preparation of concrete and for curing purposes is rampachodavarawater which is found to be in accordance with IS 456:2000 and] IS3025.

IV. MIX DESIGN

Self-compacting concrete mix does not have any standardized test methods or specified mix design procedure to follow. It shall satisfy the total performance criteria for the concrete in both the fresh and hardened state. This section describes mix design methodology by the European Federation of National Association representing for concrete (EFNARC) technique and fine-tuned by using different guidelines to get the mix with the required fresh and hardened properties. Here we are designing self-compacting concrete having minimum compressive strength of 30MPa.

V. RESULTS AND DISCUSSIONS

In this chapter results of various tests conducted on fresh SCC mixes and hardened concrete are listed and analyzed to check if the mixes prepared met the required standards.

5.1 FRESH CONCRETE TESTS

As per EFNARC guidelines the following are the preferred testing methods for various characteristics of SCC:

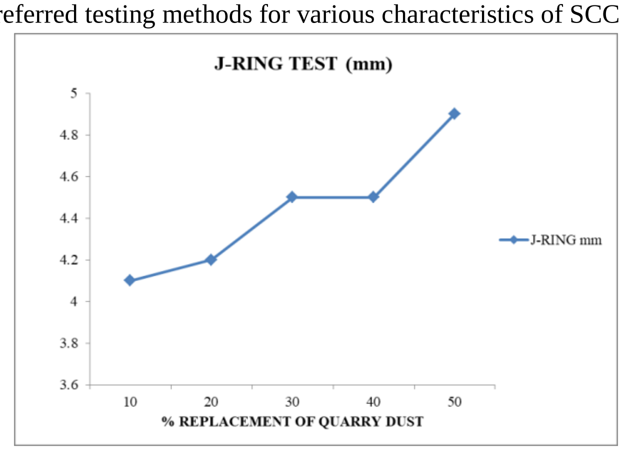

Fig 5.1 Variation in J-Ring test results with percentage replacement of quarry dust

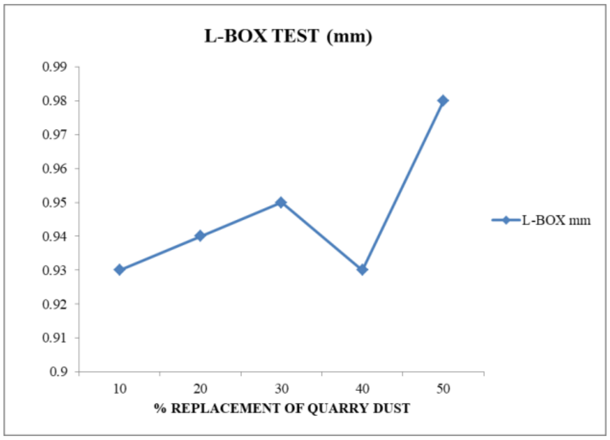

Fig 5.2 Variation in L-Box test results with percentage replacement of quarry dust

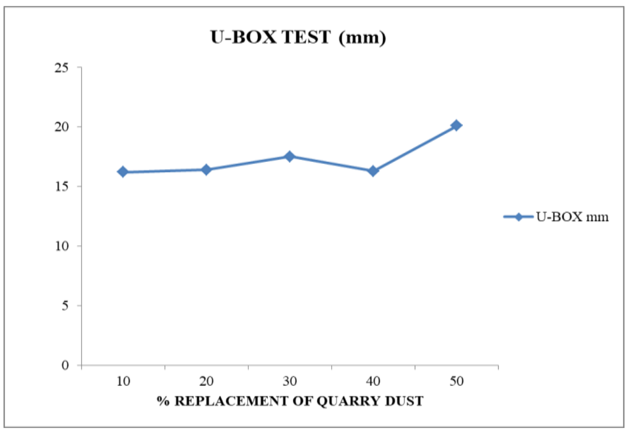

Fig 5.3 Variation in U-Box test results with percentage replacement of quarry dust

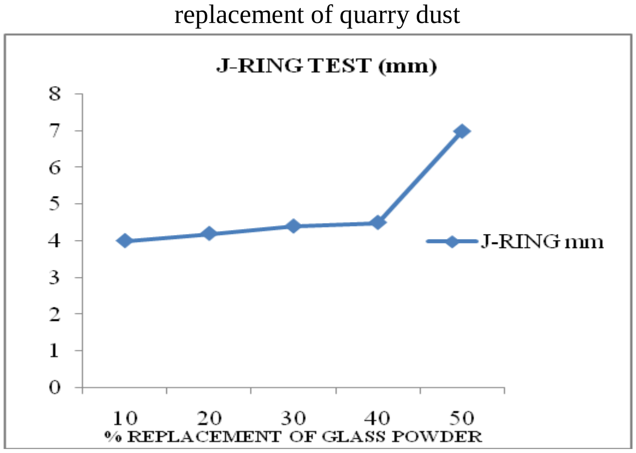

Fig 5.4 Variation in J-Ring test results percentage replacement of glass powder

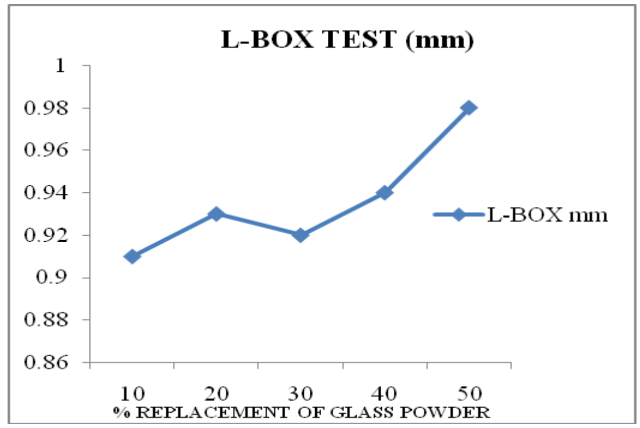

Fig 5.5 Variation in L-Box test results percentage replacement of glass powder

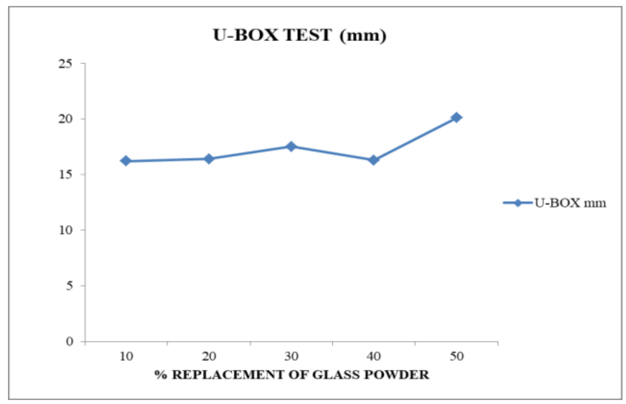

Fig 5.6 Variation in U-Box test results percentage replacement of glass powder

5.2 SCC prepared with magnetic water and fly ash replacing cement:

This mix is prepared with magnetic water and Fly ash replacing cement at 10, 20, 30, 40 and 50%. Various tests were conducted on fresh concrete and following are the results obtained from the tests.

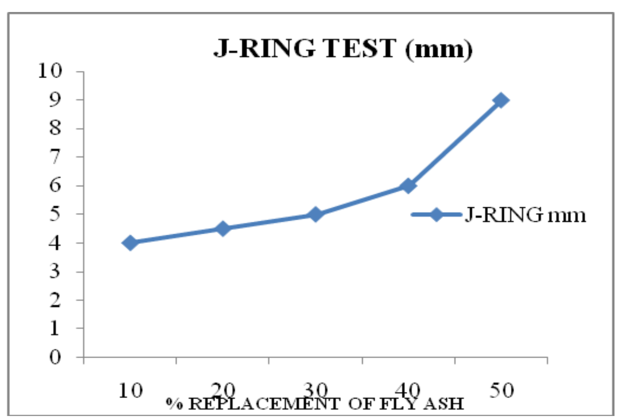

Fig5.7 Variation in J-Ring test results percentage replacement of fly ash

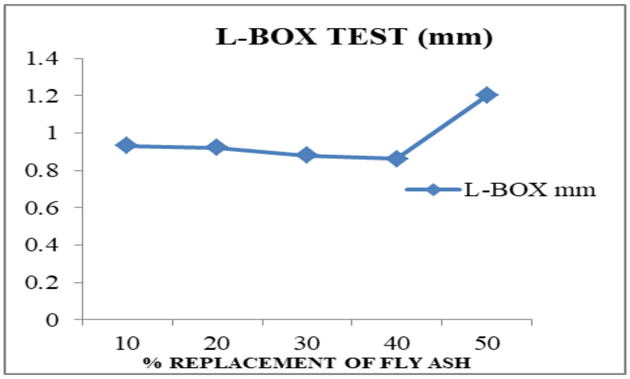

Fig 5.8 Variation in L-Box test results percentage replacement of fly ash

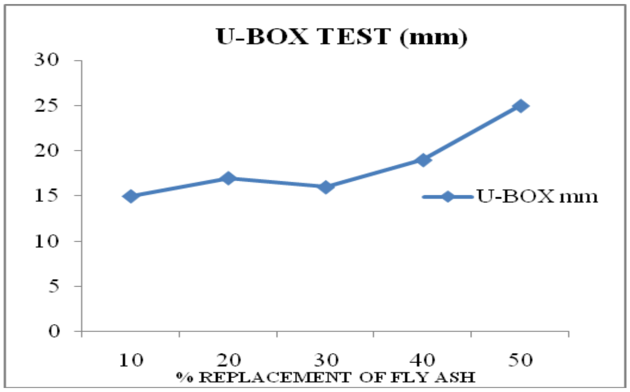

Fig 5.9 Variation in U-Box test results percentage replacement of fly ash

From Graph we can see that there is a significant increase in the flowability of SCC when prepared with Magnetic Water when compared to normal SCC. The graph also shows the effects of magnetic water on SCC mixes with varying replacement quantities.

In case of J-Ring all the replacement categories performed similar to M SCC mix except for the mix in which flyash is partially replaced at 40% in cement.

In case of L-Box from the above graphs we can see that magnetic water improved the passing ability of SCC and had the best effect on SCC mix in which fine aggregate is partially replaced with quarry dust.

In case of U-Box From the above graphs it is clear that magnetic water positively affected all the mixes improving their filling and passing abilities compared to conventional SCC.

5.3 HARDENED CONCRETE TESTS:

Compressive Strength and Split Tensile Strength tests were conducted on SCC after proper curing at the ages of 7, 14 and 28 days.

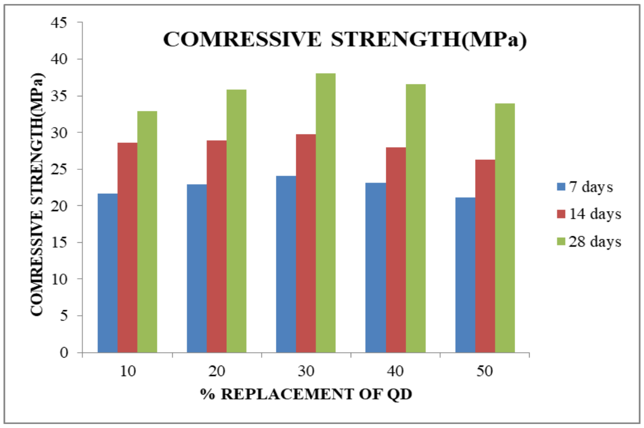

Fig 5.10Variation in compressive strength results percentage replacement of quarry dust

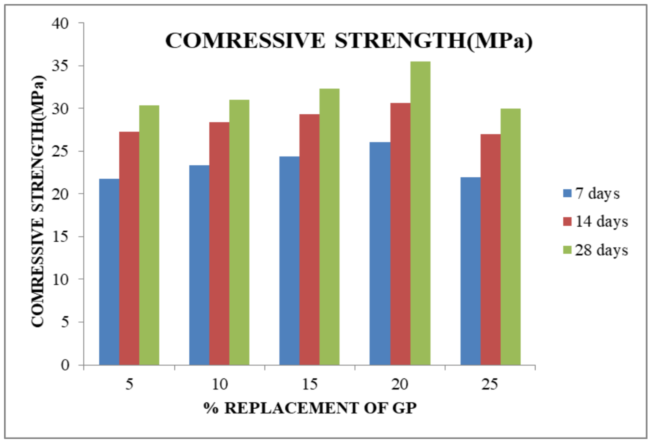

Fig 5.11 Variation in compressive strength results with replacement of glass powder

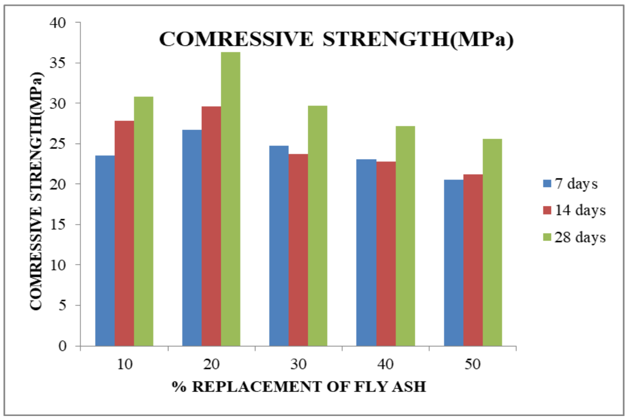

Fig 5.12 Variation in compressive strength results with replacement of fly ash

VI. CONCLUSIONS

This study was carried out to investigate the influence of quarry dust and glass powder as replacing fine aggregate and fly ash replacing cement, on fresh and hardened properties of SCC. Following conclusions were inferred from the test results:

- The utilization of quarry dust and glass powder in Self-Compacting Concrete provides additional environmental as well as technical benefits to all related industries. Partial replacement of cement with fly ash as mineral admixture and filler in SCC reduces the cost of making SCC.
- The inclusion of quarry dust and glass powder does not affect the flow parameters at lower replacement levels. The passing ability in terms of L box ratio, U box difference in height and J ring are within acceptable limit for self-compacting concrete
- The workability of concrete increased significantly for the same water-cement ratio when compared to control mix due to the use of Magnetic water of 0.8 Tesla in preparation of self-compacting concrete (SCC) of M30 grade,
- The compressive strength increases by 12.1% and split tensile strength by 11.97%.
- It was found that 11.5% of super plasticizer dosage was reduced by the employment of magnetic water in SCC.
- Partial replacement of sand at 10, 20, 30, 40 and 50 % with quarry dust resulted in steady improvement of Compressive and Split tensile strength upto 30% but at 40 and 50% the SCC mix failed.
- The compressive strength and split tensile strength effectively increased by 17.25% and 17.41% at 30% replacement for 28 days when compared to conventional SCC, therefore it is recommended.
- When fine aggregate was partially replaced with Glass Powder at 5, 10, 15, 20 and 25 % the Compressive strength and Split tensile strength improved upto 20% replacement but beyond the mix is failed.
- The compressive strength and split tensile strength effectively increased by 12.4% and 12.84% at 20% replacement for 28 days when compared to conventional SCC and it is the recommended replacement percentage.
- From the results it is evident that better results were obtained in replacing sand with quarry dust in terms of strength and economy when compared to glass powder.
- When Cement was replaced with Fly ash there was an increase in compressive and split tensile strength for 10% and 20% replacements but did not attain target strengths at 30% and 40%.

REFERENCES

[1] IS 10262 (2009) Indian Recommended guidelines for concrete mix design.

[2] IS 456 (2000): Plain and Reinforced Concrete – Code of practice [CED 2: Cement and Concrete]

[3] IS 2386-1 (1963): Methods of Test of Aggregates for Concrete, Part I: Particle Size and Shape [CED 2: Cement and Concrete

[4] IS 383 – 1970: Indian Standard "Specification for coarse and fine aggregates from natural sources for concrete"

[5] "CONCRETE TECHNOLOGY" Theory and practice, a text book by M.S.Shetty, 2005.

[6] De Schutter, G, 2005, „Guidelines for Testing Fresh Self-Compacting Concrete‟,

[7] September, European Research Project: Measurement of Properties of Fresh Self-

[8] Compacting Concrete.

[9] Dina Sadek, M, Mohamed El-Attar, M &Haitham Ali, A 2016, „Reusing of marble and granite powders in self-compacting concrete for sustainable development‟, Journal of Cleaner Production, vol. 121, pp. 19-32.

[10] Dinakar, P, Babu, KG & Manu Santhanam 2008, Durability properties of high volume fly ash self-compacting concretes, Cement & Concrete Composites, vol. 30, pp. 880-886.

[11] Ding, Y, Liu, S, Zhang, Y & Thomas, A 2008, The investigation on the workability of

[12] Fibre cocktail reinforced self-compacting high performance concrete, Construction and Building Materials vol. 22, pp. 1462-1470.

[13] Domone, PL 2007, „A review of the hardened mechanical properties of self-compacting concrete‟, Cement & Concrete Composites vol. 29, pp. 1- 12.

[14] R. Malathy, N. Karuppasamy and U. Vinitha, "Effect Of Magnetic Field Exposure Time On Fresh And Hardened Properties Of Magnetic Water Concrete," ukieri concrete congress.

[15] P. Srinidhi, "Comparitive Study On Concrete Materials Using Normal And Magnetized Water," International Research Journal of Engineering and Technology (IRJET), vol. 6, no. 4, 2019.

[16] H. Okamura and M. Ouchi, "Self-Compacted Concrete," Journal advanced concrete technology , vol. 1, no. 1, pp. 5-15, 2003.

[17] T. Suresh, V. Vijayan, T. Sathanandham and K. Sivanesan, "Experimental Investigation of Self - Compacting Concrete," International Journal of

Engineering Research & Technology (IJERT), vol. 2, no. 12, 2013.
[18] R. Sharma and R. A. Khan, "Fresh and mechanical properties of self-compacting concrete containing copper slag as fine aggregates," Journal Of Materials And Engineering Structures, Vol. 4, Pp. 25-36, 2017.
[19] A.A. Aliabdo, A.E.M.A. Elmoaty, A.Y. Aboshama, Utilization of waste glass powder in the production of cement and concrete, Construction and Building Materials. 124 (2016) 866–877.
[20] Ahmed Omran, ArezkiTagnit-Hamou, Performance of glass-powder concrete in field applications, Construction and Building Materials 109 (2016) 84–95.
[21] Ana Mafalda Matos, Joana Sousa Coutinho, Durability of mortar using waste glass powder as cement replacement, Construction and Building Materials 36 (2012) 205–215.
[22] Concrete Technology by M S Shetty.
[23] C. Venkatasubramanian, The influence of combination of crushed waste glass powder (GP) and ground granulated blast furnace slag (GGBS) as a partial replacement in cement, on the behaviour of mechanical and durability properties of concrete, Construction and Building Materials 156 (2017) 739–749.
[24] E. Anastasiou, K.G. Filikas, M. Stefanidou, Utilization of fine recycled aggregates in concrete with fly ash and steel slag, Construction and Building Materials. 50 (2014) 154–161.
[25] EsraaEmam Ali , Sherif H. Al-Tersawy, Recycled glass as a partial replacement for fine aggregate in self compacting concrete, Construction and Building Materials 35 (2012) 785–791.
[26] IS 456: 2000, recommended code of practice for plain and reinforced concrete, Bureau of Indian Standard, New Delhi.
[27] IS 10262- 2009, Recommended guide lines for concrete mix, Bureau of Indian Standard, New Delhi.
[28] M.M. Younes, H.A. Abdel Rahman , Magdy M. Khattab , Utilization of rice husk ash and waste glass in the production of ternary blended cement mortar composites , Journal of Building Engineering 20 (2018) 42–50.
[29] NurulHidayahRoslan , Mohammad Ismail , Zaiton Abdul Majid , SeyedmojtabaGhoreishiamiri , Bala Muhammad , Performance of steel slag and steel sludge in concrete, Construction and Building Materials 104 (2016) 16–24.
[30] Specification and Guidelines for Self-Compacting Concrete by EFNARC, 2005.
[31] V. Subathra Devi, B. K. Gnanavel, possibility of replacing the conventional aggregates by steel slag,
[32] Wang Qiang, Yan Peiyu, Yang Jianwei, Zhang Bo , Influence of steel slag on the mechanical properties and durability of concrete , Construction and Building Materials 47 (2013) 1414-1420.
[33] Jian-xin Lu, Zhen-huaDuan, Chi Sun Poon, Fresh properties of cement pastes or mortars incorporating waste glass powder and cullet, Construction and Building Materials 131 (2017) 793-799.