AN EXPERIMENTAL STUDY ON THE EFFECT OF INDUSTRIAL WASTE ON COMPRESSIVE STRENGTH OF SELF COMPACTING CONCRETE

DISSERTATION

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SUBMITTED BY

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DECLARATION

I declare that the research thesis entitled "**AN EXPERIMENTAL STUDY ON THE EFFECT OF INDUSTRIAL WASTE ON COMPRESSIVE STRENGTH OF SELF COMPACTING CONCRETE**" is the bonafide research work carried out by me, under the guidance of MR. **MOHD KASHIF KHAN**, Associate Professor, Department of Civil Engineering, Integral University, Lucknow. Further I declare that this work has not previously formed the basis award of any degree, diploma, associate-ship or other similar degree or diplomas, and has not been submitted anywhere else.

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Certified that the thesis entitled "**AN EXPERIMENTAL STUDY ON THE EFFECT OF INDUSTRIAL WASTE ON COMPRESSIVE STRENGTH OF SELF COMPACTING CONCRETE"** is being submitted by **MOHD ABDUL QADIR** (1901431016) in partial fulfillment of the requirement for the award of degree of Master of Technology in Structural Engineering at Integral University, Lucknow, is a record of candidate's own work carried by him under my supervision and guidance.

The results presented in the thesis have not been submitted to any other University or Institute for the award of any other degree or diploma.

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TABLE OF CONTENTS

CONTENTS Page No

CHAPTER -1 INTRODUCTION

CHAPTER -2 LITERATURE REVIEW

LIST OF TABLE

LIST OF FIGURES

CHAPTER -1

INTRODUCTION

1.1 Self-Compacting Concrete

Self-compacting concrete (SCC) is a special type of concrete which can be placed and consolidated under its own weight without any vibration effort due to its excellent deformability, and which at the same time is cohesive enough to be handled without segregation or bleeding. Self-compacting concrete (SCC), which was initially introduced in Japan, is a unique type of concrete that can flow and fill into every corner of formwork, even in the presence of congested reinforcing, entirely by its own weight and without the use of vibrating compaction, tamping, or other techniques. As the name implies, self-compacting concrete is identical to regular concrete. SCC behaves differently than standard composites due to the addition of extra admixtures (super plasticizers and viscosity modifying admixtures) and varying proportions of composite ingredients SCC has a large amount of extra cementitious ingredients, up to 70% of the overall powder volume. Fly ash, silica fume, blast furnace slag, and other additional materials are commonly used. SCC saves time, labor, and energy because it does not require compaction. A nice surface polish is also achieved. The high powder content of self-compacting concrete (SCC) distinguishes it. The water-powder ratio is the most essential metric in SCC, while the water-cement ratio is largely neglected. Fly ash content, sand-aggregate ratio, paste %, types of admixture utilized, and so on are all essential characteristics. The aggregate content of SCC is lower than that of traditional concrete, which necessitates the use of vibratory equipment. In SCC, the degree of coarse aggregate packing is roughly 50%. When concrete deforms, it's to lessen the interaction between coarse aggregate particles. The fine aggregate packing in SCC mortar is roughly 60%, limiting shear deformability when the concrete deforms. The viscosity of the paste in SCC, on the other hand, is the highest among the other forms of concrete due to the lowest water-powder ratio. This property is crucial in preventing segregation.

Test on Self Compacting Concrete

- **Slump flow test**. The slump flow test is used assess the horizontal free flow of self-compacting concrete in the absence of obstructions. The test method is based on the test method for determining the slum. Recommended limit (760mm – 850mm (SF-3)

- **V Funnel Test**. V funnel test on self-compacting concrete is used to measure the flow ability. But the follow ability of concrete is affected by its other properties as well which may affect the flow ability of the concrete during testing. Recommended limit (Less than 8.0 sec.)

- **L Box Test**. This test assesses the flow of the concrete and also the extent to which it is subjected to blocking by reinforcement. Recommended limit (Between 0.8 to 1.0)

- **U Box Test.** U Box test is used to measure the filing ability of self-compacting concrete. U box test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Sometime the apparatus is called a "box shaped" test

- **Fill Box Test.** Fill box test is also known as 'Kajima test' is used to measure the filling ability of self-compacting concrete with a maximum aggregate size of 20 mm

1.2 Fresh Concrete

Brittleness, weak tensile strength, poor resistance to impact strength, fatigue, low ductility, and low durability limit the use of concrete as a structural material to some extent. It is also quite limited in its ability to handle dynamic loads induced by explosions. Brittleness in structural members is corrected by adding reinforcement (or) pre-stressing steel to the tensile zone. However, it has little effect on the fundamental properties of concrete. It's simply a technique for achieving the desired result by combining two components. The basic problem of low tensile strength and the requirements for high strength persist, and several types of reinforcing materials are being used to address it. Fibers are commonly used in concrete to prevent cracking caused by shrinkage of the plastic and drying shrinkage. They also limit the permeability of concrete, resulting in less water bleeding. Concrete with certain fibers has higher impact, abrasion, and shatter resistance.

1.3 Materials and Mix Proportions

Self-compacting concrete primarily consist of cement, fine aggregate, coarse aggregate, fly ash, silica fume, admixture and water.

1.3.1 Coarse Aggregate

Coarse aggregate is defined as aggregate that is maintained on the 4.75 mm IS sieve and contains only as much fine material as is allowed by the specification.

One of the following types of coarse aggregates could be used.

(i) Crushed gravel or stone, which is made by crushing gravel or hard stone.

(ii) Uncrushed gravel or stone formed by natural rock disintegration.

(iii) Gravel or stone that has been partially crushed as a result of combining the first two categories.

The nominal size of graded coarse aggregate is used to describe it. 40 mm, 20 mm, 16 mm, 12.5 mm, and so on. Because aggregate is generated by natural disintegration of rock or mechanical crushing of rock or gravel, many of its qualities are derived from the current rock. Chemical and mineral composition, petrographic description, specific gravity, hardness, strength, physical and chemical stability, pore structure, and color are all examples of these qualities. Other characteristics of the aggregate that are not present in the source rock include particle form and size, surface texture, absorption, and so on. All of these characteristics could have a significant impact on the quality of concrete in both its fresh and hardened forms. The above description of concrete as a mix of hydraulic cement, aggregates, and water excludes a fourth component, admixtures, which are commonly employed in modern concrete formulations.

Fig.1.3.1 coarse aggregate

1.3.2 Fine Aggregate

The majority of the aggregate passes through a 4.75mm filter and contains only as much coarser particles as the standards allow. Sand is commonly thought to have a size limit of roughly 0.07mm. Silt is defined as material with a thickness of 0.06 mm to 0.02 mm. Clay refers to even smaller particles. Sand, silt, and clay are found in this soft deposit. Loam is a mixture of clay and sand in roughly equal proportions. One of the following types of fine aggregates could be used:

(i) Natural sand, which is fine aggregate formed by natural rock disintegration or that has been deposited by stream and glacial forces.

(ii) Crushed stone sand, which is fine aggregate made from crushing hard stone.

(iii) Crushed gravel sand, or fine aggregate produced by natural gravel crushing.

(iv) IS: 383-1970[4] has divided in the particle size distribution based on the particle size distribution. Four grading zones for fine aggregate gradually, the grading zones grow more difficult. From grading zone, I to grading zone IV, the grain becomes finer.

Fig.1.3.2 fine aggregates

1.3.3 Cement (Binder Materials)

Cement is a building material that sets, hardens, and adheres to other materials. Materials in order to bind them together. Joseph Aspdin of England invented the first ordinary Portland cement. PPC, in addition to OPC, can be utilized as a binder material with a fly based of up to 35 percent. Portland cement is made from calcareous elements like limestone or chalk, as well as argillaceous materials like shale or clay, with a 3-5 percent gypsum addition (retarder).

Different Types of Cement

Ordinary Portland **Cement** (OPC) ...

Portland Pozzolana **Cement** (PPC) ...

Rapid Hardening **Cement**. ...

Extra Rapid Hardening **Cement**. ...

Low Heat **Cement**. ...

Sulfates Resisting **Cement**. ...

Quick Setting **Cement**. ...

Blast Furnace Slag **Cement**.

Portland Pozzolana Cement (PPC)

Portland Pozzolana Cement is a type of Blended Cement that is made by intergrading OPC clinker with gypsum and pozzolanic materials in certain proportions, or by grinding OPC clinker, gypsum, and Pozzolanic materials separately and thoroughly combining them in specific proportions.

Portland Pozzolana Cement, or PPC cement, is a type of cement made from pozzolana. Pozzolanic materials are used as one of the key ingredients in the production of these types of cement. Between 10 and 30 percent pozzolanic material should be utilized in the preparation. The cement's strength is lowered if the % is surpassed.

Pozzolana is a natural or synthetic substance that contains reactive silica. It's also known as siliceous or siliceous and aluminous material, which has little or no cementitious qualities on its own but will chemically react with calcium hydroxide in finely divided form and in the presence of moisture at room temperature to generate cementitious compounds. Pozzolana must be finely divided because only then can silica interact with calcium hydroxide (liberated by the hydrating Portland Cement) in the presence of water to generate stable calcium silicates with cementitious characteristics.

The pozzolanic materials commonly used are:

- Volcanic ash
- Calcined clay
- Fly ash
- Lica fumes

1.3.4 Fly Ash

Fly ash is a valuable ingredient that makes concrete stronger, more durable, and simpler to work with. It is derived from coal combustion. Fly ash helps cementitious compounds develop, which improves concrete's strength, impermeability, and durability. In concrete, there are two types of fly ash: Class F and Class C.

Class F

In plastic concrete, it reduces bleeding and segregation. Increases ultimate strength, reduces drying shrinkage and permeability, lowers heat of hydration, and reduces creep in hardened concrete. Improves permeability and has unique self-hardening properties. Particularly effective in pre-stressed concrete and other wet cement pastes that shrink when moisture evaporates from their tiny pores. The surface tension of the remaining water tries to pull the pores together as moisture is lost in these microscopic pores, resulting in a loss of volume over time. Shrinkage reduction admixtures (SRAs) are meant to reduce the surface tension in these pores, hence lowering the effects of drying shrinkage. It's worth noting that the type of aggregate used and the qualities of the cement itself can have an impact on the degree of cracking that occurs. When shrinkage testing, it's crucial to test local project-specific materials. Cracking is also affected by curing. The top of a slab tends to dry out and shrink first, while the bottom areas retain a higher moisture content. Shrinkage Reducing Admixtures, which change the way water migrates through the concrete and result in a more uniform moisture profile

Fig.1.3.4 Fly ash

1.3.5 Silica Fume

Silica fume, commonly known as micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide, silica (CAS number 69012-64-2, EINECS number 273-761-1). It's an ultrafine powder made up of spherical particles with an average particle diameter of 150 nanometers that's collected as a by-product of silicon and ferrosilicon alloy manufacture. The most common use is as a pozzolanic substance in high-performance concrete. It's sometimes mistaken for silica fumed (also known as pyrogenic silica, CAS number 112945-52-5). The production process, particle properties, and application domains of fumed silica, on the other hand, are all distinct from those of silica fume.

Silica Fume: Early Strength and Reduced Permeability

Silica fume can contribute significantly to concrete's early-age strength. A pound of silica fume generates roughly the same amount of heat as a pound of Portland cement and has three to five times the compressive strength. The basic pozzolanic reaction and a micro filler effect are two ways that silica fume enhances concrete. The use of silica fume increases concrete bonding and reduces permeability, as well as combining with the calcium hydroxide created during the hydration of Portland cement to increase concrete durability. The great fineness of silica fume allows it to fill small spaces between cement particles as a micro filler. When compared to traditional concrete, this significantly reduces permeability and enhances the paste-to-aggregate connection.

Fig.1.3.5 silica fume

1.3.6 Admixture

Admixtures are powdered or liquid components that are mixed into concrete to give it properties that aren't possible with standard concrete mixes. A material other than cement, water, and aggregates that is utilized as an ingredient in concrete that is added to the batch just before or during mixing to affect the freshly mixed, setting, or hardened qualities is referred to as an admixture.

They are:

Type A: Water-reducing **admixtures**.

Type B: Retarding **admixtures**.

Type C: Accelerating **admixtures**.

Type D: Water-reducing and retarding **admixtures**.

Type E: Water-reducing and accelerating **admixtures**.

Type F: Water-reducing, high range **admixtures**.

Type G: Water-reducing, high range, and retarding **admixtures**.

Chemical admixtures are used to minimize construction costs, adjust the properties of hardened concrete, ensure concrete quality during mixing, shipping, putting, and curing, and solve certain problems that arise during concrete operations. Chemical admixtures are added to concrete to improve its quality during the mixing, transport, placing, and curing processes.

Fig.1.3.6 admixture

1.3.7 Water

The amount of water in concrete affects a variety of attributes in both fresh and hardened concrete, such as workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage, and cracking potential. Water is an important component of concrete because it plays an active role in the chemical reaction between cement and water. Because it aids in the formation of the strength-giving cement gel, the quality and quantity of water must be carefully monitored. All contaminants should be removed from the water, and it should be safe to drink

CHAPTER -2

LITERATURE REVIEW

2.1 General

This section contains a survey of the literature on steel and glass fiber concrete. Several tests on enhancing the flexural strength of concrete have been carried out by a range of researchers over the last few decades. The current literature review survey focuses on the flexural strength of reinforced concrete employing steel and glass fiber.

2.2 Review of studies on flexural strength of concrete using fibers

F. A Mustapha, A. Sulaiman, R.N. Mohamed, S.A. Umara (2020)[1] "Fly ash and silica fume effects on self-compacting high-performance concrete." The slump flow of the respective SCHPC is within class SF1, indicating strong filling ability; all SCHPC mixes meet the passing ability class PA2 standard; and the V-funnel flow time for all respective SCHPC is within viscosity class VF2. At 28 days curing age, a Portland-fly ash-silica fume blend of 40% PC; 50% FA; 10% SF attained a maximum compressive strength of 87.06 MPa, which is 5% greater than the control specimen's 82.39 MPa, and the cement content of this mixture is only 235.00 kg/m3.

Heba, A. Mohamed (2011)[2] "Effect of fly ash and silica fume on self-compacting concrete compressive strength under various curing conditions." This work describes an experimental program for describing the influence of curing conditions on SCC with various percentages of FA and SC in order to determine the best percentage of FA, SC, or their combination in terms of concrete compressive strength. The following primary conclusions can be formed based on the given results. Until 30% FA, the higher the proportion of FA, the higher the values of concrete compressive strength. However, the highest value of concrete compressive strength is obtained from mix containing 15% SF. SCC mixes with 15% SF as a replacement of cement content give higher values of concrete compressive strength than those with 30% FA by about 12% and 10% for 550 kg/m3 and 450 kg/m3 concrete mix with 15% SF yields the maximum compressive strength rating. For 550 kg/m3 and 450 kg/m3 cement content, SCC mixes with 15 percent SF as a cement replacement produce higher concrete compressive strength values than those with 30 percent FA by roughly 12 percent and 10%, respectively. For all test cases, specimens cured in water for 28 days have the maximum compressive strength, while air cured specimens have the lowest compressive strength. SCC containing 10% FA and 10% SF had the highest concrete compressive strength of all the SCCs tested.

Mehran Khan, Majid Ali (2019)[3] "Fly ash, silica-fume, and coconut fibers improve concrete behavior." When compared to PC and CFRC, the workability of various FA-SPC and FA-SCFRC blends is reduced by up to 66 percent -100 percent. The elastic modulus, compression strength, compression total energy absorbed, and compression toughness index of the best FA-SCFRC, FA10-SCFRC, are increased by 40%, 35%, 68 percent, and 22%, respectively, over CFRC. In comparison to CFRC, the best FA-SCFRC, FA10-SCFRC, has an increase in flexure strength, flexure total energy absorbed, and flexure toughness index of 5%, 95%, and 19%, respectively. Split-tension toughness, split-tension strength, and split-tension total energy absorbed

Wongkeo, W. Thongsanitgarn, P. Ngamjarurojana, A. Chaipanich (2014)[4] "Self-compacting concrete with high levels of fly ash and silica fume: compressive strength and chloride resistance." The effects of high calcium fly ash and SF as a binary and ternary blended cement at high volume replacement on SCC characteristics were explored in this research. The apparent densities of all SCC when including FA and SF were not significantly different, based on these findings. The apparent density of binary and ternary mixed Portland cement, however, seems to be somewhat lower than Portland cement control at all w/b. SCC incorporating FA had a greater volume of permeable pore space (voids) and higher water absorption than Portland cement. The amount of permeable pore space (voids) and water absorption of SCC containing FA were larger than those of Portland cement control, and this trend continued as FA concentration increased. In both binary and ternary mixed Portland cement, the action of SF appears to reduce voids and water absorption of SCC. At all test ages, SCC compressive strength dropped with increasing FA concentration and was lower than SCC control. After 7 days, the compressive strength of SCC including ternary blended Portland cement rose with increasing SF percentage and was greater than SCC using binary blended Portland cement at the same replacement level. When employing high calcium fly ash and SF as ternary blended cement at large volume cement replacement, very low chloride ion penetrability may be achieved.

H.Y. Leung, J. Kim, A. Nadeem, Jayaprakash, jaganathan, M.P. Anwar (2016)[5] "Sorptivity of fly ash and silica fume-containing self-compacting concrete." Surface water absorption and sorptivity are reduced when OPC is partially replaced by FA and SF in SCC. When just fly ash is used to partially replace OPC, the drop in sorptivity is obvious when FA is used to replace more than 20% of OPC. The reduction in water absorption is greater when both FA and SF are used in SCC blends than when FA is used alone. This suggests that the SF impact is substantially greater than the FA effect. When both FA and SF are included in SCC mixtures, the 28-day cube strength of SCC is increased. There is no evident link between sorptivity and cube strength after 28 days**.** The quantity of mineral admixtures and other environmental conditions influence the behavior of SCC's surface water absorption and compressive strength. Concrete strength over a longer length of time may be a more accurate predictor of concrete durability.

Rabar H. Faraj, Aryan Far H. Sherwani, Lamyaa Hama Jafer, Dalya F. Ibrahim (2020)[6] "Rheological behavior and fresh characteristics of self-compacting high strength concrete using recycled PP particles and mixed fly ash and silica fume." There is no consistent association between RPPP concentration and SFD in any category of mixes. The SFD of a mixture combining 10% RPPP and 10% SF is the greatest. Furthermore, mixes containing 10% SF showed larger SFDs than those without SF, owing to the increased requirement for superplasticizer in combinations containing SF. SF2 is the classification for mixes containing 0% SF. With the exception of combinations containing 10% RPPP, the T50 SFT was significantly reduced as plastic content increased, owing to the light weight nature and smooth surface of PP plastics, which requires less time to flow than natural rough aggregates. Furthermore, the addition of SF increased the superplasticizer need, resulting in lower SFT in SF-containing mixes compared to non-SF-containing mixes. For both sets of mixtures, the VFT steadily declined as the RPPP content increased. Furthermore, increasing the quantity of superplasticizer in the combinations with 10% SF resulted in a further drop in the VFT of concretes. The viscosity classes VS2/VF2 can be applied to any combination. • When comparing combinations containing 10% SF to mixtures containing 0% SF, mixtures containing 10% SF perform better in terms of passing ability. The ability to pass through steel bars improves when the quantity of replacement is very modest. Due to the tendency of bleeding, the passing ability is reduced if the substitution level is greater than 10%. The results of the rheometer test revealed that the percentage of plastic content and torque values did not have a systematic relationship. The mixes with 20 percent plastic content (SF0P20 and SF10P20) exhibit the maximum torque values for both groups of concretes, whereas the combinations with 40 percent plastic content show the lowest torque values. The addition of SF, on the other hand, lowered the torque value by increasing the viscosity of the mixes. The findings of the applied models demonstrate that the SCHSC has a shear thickening behavior, which was clearly reduced by increasing the RPPP content, as the c/ and n values were lowered as the plastic content was increased. • By enhancing the RPPP content, the power of SCHSC was dramatically reduced. The addition of SF, on the other hand, enhances compressive strength regardless of the plastic content. Overall, the results show that the limits of EFNAR's fresh qualities of SCC may be addressed by synthesizing SCHSC with PP particles. From a practical standpoint, this product can be quite beneficial in terms of adaptability and long-term viability. As a result, the problem of disposing of plastic garbage can be partially addressed.

A. Ferhat Bingol, Iihan Tohumcu (2013)[7] “Effects of various curing regimes on the compressive strength parameters of self-compacting concrete with fly ash and silica fume." In the fresh condition, all of the tested concrete mixes had adequate self-compacting qualities; moreover, the FA series outperformed the SF series in terms of workability. When it comes to self-compacting qualities of fresh SCC such slump-flow, V-funnel T50 time, L-box ratio, and

U-box ratio, concrete mixes with FA replacements are more successive in enhancing all of them. (2) An increase in the SF replacement % resulted in an increase in compressive strength, whereas an increase in FA content had the opposite effect. The best compressive strength was found in SCC mixtures with 15% SF substitution of cement component. The results of fresh and hardened concrete tests demonstrated that SCC may be made using SF and FA and had acceptable SCC qualities. (3) Standard cured specimens yielded the greatest compressive strength values (cured in water for 28 days). Increases in compressive strength were seen as the water curing time was extended. Compressive strength was reduced by air curing, and air cured specimens had the lowest strength values of all groups. (4) For the steam curing regime, the best results were achieved from a 55 percent FA replacement group curing at 70 C for 16 hours. The compressive strength of this group was 95 percent that of conventionally cured specimens. At steam curing applications, both the SF and FA replacement groups developed higher strength than the control group without any mineral additive.

H.A.F. Dehwah (2012)[8] "Corrosion resistance of self-compacting concrete with quarry dust powder, silica fume, and fly ash." M4 specimens had the shortest time to reinforcement corrosion commencement (350 days), followed by M2 (230 days), M3 (130 days), and M1 (35 days) specimens. M5 specimens had the shortest time to reinforcement corrosion onset (20 days). In the early phases of exposure to a 5 percent NaCl solution, the corrosion current density on steel in all SCC specimens was very low, but it increased with increasing exposure time. Steel specimens from the M1, M3, and M5 series showed signs of corrosion activation. Even after more than two years of exposure to a 5 percent NaCl solution, it was not found in M2 and M4 specimens. In SCC specimens adding quarry dust powder or fly ash, the chloride permeability was moderate, whereas it was low in specimens incorporating silica fume plus quarry dust powder. In all SCC specimens, the chloride content dropped increasing depth. M2 specimens had the lowest diffusion coefficient, whereas M5 specimens had the greatest diffusion coefficient. The performance of SCC created with 8% QDP and w/c 0.38 or 8% QDP + 5% SF and w/c 0.4 was superior to that of specimens made with other methods. examined the quantities of QDP or FA Structures constructed with these materials have a longer service life due to the longer time to corrosion onset and reduced corrosion rate. It is advised that easy-to-find QDP be used to make SCC, especially in areas where neither silica fume nor fly ash are readily available. In constructions exposed to chloride-bearing environments, M2 (8 percent QDP, w/c 0.38) and M4 (8 percent QDP + 5 percent SF, w/c 0.4) are recommended.

Raharjo.Da, Subakti.A, Tavio (2013)[9] "On the compressive strength of mixed concrete using fly ash, silica fume, and iron slag." It is possible to draw the formula for SCC compressive strength at 28 years of concrete age. SCC Compressive Strength 28 Days = 40.848 + 3.100395 cement - 0.587366 water - 2.69854 sand - 3.19724 stone crush + 0.544276 silica fume + -1.93886 fly ash + 0.830342 iron slag + 1.724703 viscocrete SCC Compressive Strength 28 Days = 40.848 + 3.100395 cement - 0.587366 water - 2.69854 sand - 3. (Kg) Because the correctness of some of the results in this study is debatable due to the ambient temperature, air moisture, scale of measuring materials, and other factors, this formula must be proven using other compositions for subsequent research.

H.A.F. Dehwah (2011)[10] "Mechanical characteristics of self-compacting concrete with quarry dust powder, silica fume, or fly ash." All SCC specimens had increasing compressive strength and pulse velocity with age. SCC specimens produced just with QDP had higher compressive strength and pulse velocity than those prepared solely with SF and QDP or FA. M2 specimens had the highest compressive strength and the fastest pulse velocity, whereas M5 specimens had the lowest. Split tensile and flexural strength data followed the same pattern as compressive strength data. The M2 specimens had the highest split tensile and flexural strength, whereas the M5 specimens had the lowest. Some of the mechanical parameters studied, such as compressive strength, pulse velocity, split tensile strength, and flexural strength, showed a strong association. In conclusion, the mechanical characteristics of SCC with QDP were comparable to or better than those of SCC made with either SF + QDP or FA alone. In places where SF and FA are not accessible locally and must be imported from other regions, using QDP alone results in considerable cost savings.

Burak Felekoglu (2007)[11] "Utilization of high volumes of limestone quarry wastes in concrete industry (self-compacting concrete case)". Incorporating QLP at the same cement content reduced the need for superplasticizer and enhanced the SCCs' 28-day compressive strength.

The strength values were reduced when large volumes of cement were replaced with QLP.

Hossein Sasanipour, Farhad Aslani, Javad Taherinezhad (2019)[12] "The impact of silica fume on the durability of self-compacting concrete made from waste recycled concrete aggregates". Silica fume enhanced the workability of SCCs while also improving their fresh characteristics. The mixtures that did not include silica fume, on the other hand, had acceptable fresh qualities and enough passing ability. It is feasible to combine the usage of recycled aggregates with the qualities of fresh SCC. The compressive strength of concrete built using recycled particles reduced due to their porosity and excessive water absorption. SCC's water absorption increased when recycled aggregates were replaced. There was also an increase in water absorption when the replacement of CRAs increased. Water absorption reduced by 7 to 12 percent in various combinations after silica fume was added. Pulse velocity in concrete containing RCAs can be lowered due to porosity in recycled aggregates. The decrease range, on the other hand, is tiny and minimal. The pulse velocity, on the other hand, dropped when the silica fume was replaced, which might be attributable to its lower specific gravity than the cement. The pulse velocity range, on the other hand, is suitable for all blends. The electrical resistivity was not appreciably affected by replacing 25% of the aggregates with recycled aggregates. Electrical resistivity decreased as the number of RCAs replaced increased due to the porosity in recovered aggregates. Electrical resistance was greater in silica fume-containing blends than in other mixes. The results revealed that silica fume enhanced electrical resistivity and raised it greatly, which might be related to the improved interface transition zone and filled the porosity of the recycled aggregates' surface. The use of recycled aggregates resulted in an increase in TCHP and a decrease in SCC resistance to chloride ion penetration. Silica fume, on the other hand, was particularly successful at reducing TCHP and controlling chloride ion penetration. The porosity of the surfactant is being improved. The most important aspect in this decrease might be improving the porosity of the surface on recycled aggregate. Because of the presence of silica fume, regulating the mobility of ions in mixes containing silica fume reduced the temperature of the solutions in comparison to other mixes, which increased resistance to chloride ion penetration.

Vahab Naderi Zarnaghi, Ali Fouroghi-Asl, Vahid Nourani, Hongyan Ma (2018)[13]

"On the pore microstructure of silica fume-containing lightweight self-compacting concrete." With the MIP approach, the fractal dimensions of pores in small and big diameter ranges can be determined and distinguished; however, the range of tiny and large pores of LWSCC in this study differs from the prior research definition for standard concrete. 30–65 nm and 75–11,190 nm are the dimensions of the tiny and big pores, respectively. The fractal dimensions of microscopic pores were discovered to be smaller than those of big pores. As the degree of hydration rises, the number of big pores shrinks and becomes more scattered, resulting in an increase in the fractal dimension. The results revealed that mixes containing 5% SF had a larger fractal dimension than other quantities, and the pore structure of LWSCC is optimum at this level. The formulas link compressive strength and water penetration depth to the fractal dimension, presenting a linear function with R2 = 0.8036 and R2 = 0.7063, respectively, with a nearly excellent correlation coefficient. The fractal dimension boosts both compressive strength and water penetration depth. Finally, a mathematical model connecting fractal dimension strength and penetration depth was presented. The following linear equation can be used to represent the relationship between critical (dcr) and threshold (dth) pore diameters: dcr 14 0:5904 dth 10:071. dcr 14 0:5904 dth 10:071. Critical pore sizes have a higher correlation relationship with compressive strength than threshold pore diameters.

Walid E. Elemam, Ahmed H. Abdel Raheem, Mohamed G. Mahdy, Ahmed M. Tahwia (2020)[14] "Self-consolidating concrete fresh characteristics and compressive strength optimization". With increasing fly ash %, fresh parameters of self-consolidating concrete such as slump flow, L-box (H2/H1) ratio, and segregation index improve, whereas 28-day compressive strength of the concretes decreases. With an increase in silica fume %, the diameter of the slump flow and the L-box (H2/H1) ratio drop. However, increasing the silica fume concentration improves SCC's segregation resistance and increases its 28-day compressive strength. When limestone powder is used to substitute cement, it has a negative influence on the L-box (H2/H1) ratio and 28-day compressive strength, but it improves segregation resistance. Using existing methods, SP doses may be estimated and optimized to reduce the risk of bleeding and segregation. Fly ash substitution offers a lot of potential for lowering SP consumption and achieving the required slump flow. Increased SF content, on the other hand, increases SP demand. The use of a central composite design reduces the number of trials required to get significant results. The established models may be utilized to simplify the SCC optimization test method. Response surface methodology (RSM) may be used to build strong relationships between responses and the component materials of self-consolidating concrete, and analyses of variance can be used to assess the effects of factors and their interactions on responses. The findings also show how optimization tools may be used to determine the best values for variables to obtain certain response outcomes.

Ahmet Benli, Mehmet Karatas, Yakup Bakir (2017)[15] “An experimental investigation of the mechanical characteristics and sorptivity of self-compacting mortars containing fly ash and silica fume under various curing regimes." When compared to the SF series, all of the mortar mixes tested have adequate fresh self-compacting qualities. In addition, the FA series scored better with workability attributes. FA-containing mortars had significantly greater viscosities than control mixtures and SF-containing mortars. At 28 days, the compressive strength of binary mixes of FA10, FA20, and control sample performed better for air curing, whereas compressive strength of binary mixes SF and ternary mixes of SF and FA had the greatest values for water curing when compared to other curing regimes. Compressive strength of all SCMs performed better for water and wet sack curing at 180 days than for the other two curing regimes. In comparison to the other three healing regimes, the flexural strength of control, binary blends of SF except percent 14 of SF, had the greatest for LPWC at the age of 28 days. The increase in SF content resulted in a rise in compressive strength; however, the increase in FA content had the opposite effect on compressive strength. The increase in compressive strength was driven by an increase in the SF content ratio; the increase in FA content had the opposite effect. At the age of 28 days, the maximum flexural tensile strength values were achieved from binary SF mixes and ternary SF and FA blends for all curing regimens. When flexural tensile strength was measured at 180 days, binary SF blends except SF14 and ternary FA10SF6 blends performed better for self-curing (LPWC) than other curing regimes. Compressive strength increases as the water curing time increases. Despite the fact that air curing reduced compressive strength, all air cured samples for all groups had the lowest strength values. The sorptivity coefficient values of SCMs with FA rose as the FA and SF content increased, whereas the sorptivity coefficient values of SCMs with SF declined. When the sorptivity data are compared to compressive strength of samples cured in water at the age of 28 days, binary and ternary mixtures of SCMs with high sorptivity values often demonstrate poor compressive strength.

Hasan Salehi, Moosa Mazloom (2019)[16] "Ground granulated blast-furnace slag and silica fume have opposite impacts on the fracture behaviour of self-compacting lightweight concrete." When compared to the SCLC control mixes, the examined cement replacement materials increased the need for superplasticizer doses, while MW improved the workability of all SCLC mixes. MW reduced the slump flow duration by around 17 percent and increased the ultimate diameter of the slump flow of all the mixtures by roughly 9%. The compressive strengths (Fc) of samples with 5% and 10% SF were around 18% and 30% greater than the control samples, respectively. Using MW might boost these numbers by around 7% and 3%, respectively. However, when 10% and 20% GGBFS were used in SCLC mixtures, Fc fell by around 6% and 8%, respectively, whereas MW increased this characteristic by about 17 percent and 11 percent. As a result, the mechanical qualities of the mixes comprising 10% SF and MW were the best, whereas the mechanical properties of the mixes containing 20% GGBFS and tap water were the worst. The initial fracture energy improved by 19 and 24 percent when silica fume (SF) concentration rose from 0 to 5% and 10% of cement weight, respectively. When the content of ground granulated blast furnace slag (GGBFS) was raised from 0 to 10% and 20%, however, it reduced by 11% and 19%, respectively. With larger concentrations of GGBFS and SF, the growing rate of fracture energy caused by the usage of MW in SCLC mixes was reduced. The use of MW raised the fracture energy of specimens containing 10% and 20% GGBFS by around 23 and 17 percent, respectively, but the use of MW only increased this parameter by about 9% and 6%, respectively, in the case of specimens containing 5% and 10% SF. In other words, MW was more effective in GGBFS-containing mixtures than in SF-containing combinations. Fracture toughness (KIC) values dropped by 7% and 13% in SCLC mixes including 10% and 20% GGBFS, respectively, and rose by 14% and 18% in SCLC mixes containing 5% and 10% SF, respectively. MW increased the KIC of SCLC containing 10% and 20% GGBFS about 15% and 12%, and it increased these values about 6% and 3% for SCLC containing 5% and 10% SF, respectively. As mentioned earlier, MW was more effective in the mixes having GGBFS compared to the ones including SF. Based on size effect method (SEM), it can be stated that SCLC behavior approached the strength criterion when the GGBFS content increased, and it approached to linear elastic fracture mechanics (LEFM) criterion when the SF content increased. All of the SCLC specimens, with or without MW and comprising any types of additional materials (SF and GGBRS), were in the region of nonlinear fracture mechanics, according to the brittleness number (b) achieved in this study. SCLC has an effective length of fracture process zone (Cf) that is within the usual concrete range. In the same compressive strength, SCLC is slightly more ductile than conventional concrete. Furthermore, Cf was affected by the additive material content; for example, using SF in SCLC mixes reduced concrete ductility, while using GGBFS increased it. It's worth mentioning that using MW instead of tap water improved ductility.

T. Rajah Surya, Prakash, N Parthasarath (2020)[17] “Self-compacting concrete's compressive strength at increased temperatures." The compressive resilience of self-packing (SCC) concrete at increased temperatures was investigated in this work. For 7 and 28 days of healing, the compressive capacity of controlled self-compacting concrete was determined to be 25.16 N/mm2 and 39.68 N/mm2, respectively. The mean resilience capacity of self-compacting concrete was 39.68 N/mm2 after 28 days of controlled curing. The maximal compressive capacity of self-packing concrete at extreme temperatures was reported to be 38.43 N/mm2 at 200 °C and 19.3 N/mm2 at 800 °C. In comparison to the controlled concrete, the percent variation of resilience strength of self-packing concrete at 200 °C, 400 °C, 600 °C, and 800 °C was determined to be 3.15 percent, 10.88 percent, 43.39 percent, and 51.36 percent, respectively. Under a 7-day controlled healing condition, the mean resilience might of self-packing concrete was 25.16 N/ mm2. The maximum amplitude resilience strength of self-packing concrete was discovered at 200 °C (23.35 N/mm2), while the minimum value was recorded at 800 °C (10.95 N/mm2). In comparison to the controlled concrete, the percent variation of resilience strength of self-packing concrete at 200 °C, 400 °C, 600 °C, and 800 °C was determined to be 7%, 16.09 percent, 50.07 percent, and 51.36 percent, respectively. The test findings demonstrate a decrease in strength as the temperature rises. It was discovered that when temperature rose, compressive capacity decreased. At 600 °C and 800 °C, there was also a significant loss in strength. The surface colour of the specimen changed at 200 °C, 400 °C, and 600 °C. Furthermore, at 800 °C, concrete spalling was detected along with a change in surface color. The strength bearing capacity was diminished as the temperature rose.

Fereshteh Alsadat Sabe, Nicolas Ali Libre, Mohammad Shekarchi (2012)[18] “Mechanical and durability qualities of self-consolidating high-performance concrete with natural zeolite, silica fume, and fly ash." Because of the large surface area of its structure, the superplasticizer requirement of the SCHPCs containing 10% and 20% natural zeolite was 0.8 percent and 1.6 percent (percent binder) greater than that of the control mix. The addition of silica fume increased the superplasticizer requirement for 0.6 and 1.1 (percent binder) in mixtures containing 10% and 20% silica fume, respectively. Fly ash, on the other hand, reduced the need for superplasticizers to some extent. Natural zeolite at a 10% replacement level increased compressive strength from 62 MPa for the control mix to 64.5 MPa (at 28 days), however natural zeolite at a 20% replacement level reduced compressive strength by 8% (at 28 days). Silica fume was the most efficient mineral additive for increasing compressive strength; at the age of 28 days, the compressive strength of the mixes containing 10% and 20% silica fume rose to 75.5 and 79.5 MPa, respectively. The 28-day compressive strength was increased to 67 and 81 MPa by replacing 10% and 20% of the cement with 10% and 20% fly ash, respectively. The addition of all mineral admixtures increased the electrical resistivity of concrete mixes significantly, especially at later ages. The addition of natural zeolite and fly ash to concrete mixtures increased electrical resistance by almost the same amount at all ages. The 90-day resistivity of concrete mixtures with 10% and 20% natural zeolite or fly ash rose from 8.4 kX cm for the control mix to 30 and 50 kX cm. S10 and S20 mixes had resistivities of 54 and 231 kX cm, respectively, at this age. This might be due to silica fume's increased pozzolanic reactivity. Silica fume was shown to be the most efficient mineral additive in reducing final absorption. At 10% and 20%, replacing cement with silica fume reduced final absorption from 4.5 percent to 2.76 percent and 2.57 percent, respectively. Natural zeolite and fly ash were also used to reduce final water absorption, but these mineral additives were not as efficient as silica fume. The addition of 10% fly ash or natural zeolite reduced final absorption by up to 20%, whereas the addition of 10% silica fume lowered final absorption by 39%. The effective diffusion coefficients for 4.3 10.12 and 4.9 10.12 m/s2 were found to be reduced by including 10% and 20% natural zeolite, respectively. In terms of minimizing chloride diffusion, fly ash was shown to be less efficient than natural zeolite. The effective diffusion coefficient was reduced by 10% and 20% fly ash, respectively, from 7.9 10.12 to 4.7 10.12 and 3.2 10.12 m/ s2. The effective diffusion coefficient for 5.6 10.12 m/s2 was lowered by 10% silica fume, and additional increases in silica fume concentration did not enhance chloride diffusivity considerably.

Mehmet Gesoglu, Erhan Guneyisi, Erdogan Ozbay (2007)[19] "Properties of self-compacting concretes prepared from fly ash, blast furnace slag, and silica fume in binary, ternary, and quaternary cementitious blends". Mineral admixtures improved the filling and passage capabilities of SCCs by increasing the H2/H1 ratio in the L-box. Mineral admixtures also enhanced the T50 slump flow time marginally, notably in concretes containing silica fume. In terms of V-funnel flow duration, however, only the ternary application of PC + FA + S met the EFNARC's approval requirements. Using any of the mineral admixtures in the creation of SCCs reduced chloride ion permeability, resulting in better concrete durability. S. was discovered to be the most efficient mineral admixture on chloride ion permeability. When compared to the control Portland cement concrete, the sorptivity of SCCs reduced as mineral admixtures were added. Mineral admixture use in the ternary (PC + S + SF) and quaternary (PC + FA + S + SF) lowered the sorptivity index of SCCs, but increasing the replacement amount of mineral admixtures had no effect on the sorptivity index. Because of their low water permeability, all manufactured concretes may be categorized as chemically resistant. When compared to control concretes, adding any mineral admixtures reduced the water permeability of SCCs. The compressive strength of concretes containing FA was found to be lower in general. Binary (PC + SF and PC + S) and ternary (PC + S + SF) SF and S blends, on the other hand, have comparable compressive strengths. With increased cementitious materials content, mineral admixtures improved the electrical resistivity of the concretes. The concrete containing 45 percent S and 15 percent SF had the highest electrical resistance (18.9 kohm cm) of all 22 concretes. When FA and S were utilized in binary mixes, the free shrinkage of the SCCs was decreased, but the drying shrinkage was raised. The simultaneous usage of mineral admixtures, on the other hand, considerably reduced the SF's negative effects. The multi objective optimization of SCC mixes yielded the following ideal design parameters with 0.823 desirability: cement 183.4 kg/m3, fly ash 5.2 kg/m3, ground granulated blast furnace slag 196.2 kg/m3, silica fume 64.1 kg/m3, and the quantity of superplasticizer 5.2 kg/m3. The following SCC qualities were attained using the above-mentioned ideal mix proportions: T50 slump flow time is 4.57 seconds, slump flow diameter is 73 cm, H2/H1 L-box height ratio is 0.812, V-funnel flow time is 6 seconds, compressive strength is 63.9 MPa, electrical resistivity is 18.7 kohm cm, sorptivity index is 0.056 mm/min0.5, chloride permeability is 239 C, ultrasonic pulse velocity is 4999 m/s, and water permeability is 14

Halit Yazici (2008)[20] “The influence of silica fume and high-volume Class C fly ash on self-compacting concrete mechanical characteristics and chloride penetration" According to test results, high-performance SCC may be achieved with a high-volume FA component, particularly with a 10% SF substitution. These mixes have strong mechanical qualities, freeze–thaw resistance, and resistance to chloride penetration. Furthermore, these mixes offer significant environmental and economic advantages. These combinations have a lower heat of hydration and shrinkage than SCC mixtures prepared with high-volume Portland cement. Incorporating FA and/or SF into SCC improves chloride penetration resistance dramatically. All mixes have a far lower chloride penetration depth than Portland cement SCC. After 90 cycles, the chloride penetration depth of a control combination using only Portland cement as a binder is 19 mm. With 60 percent FA and 10% SF substitution, this value dropped to 9.5 mm. Replacement of FA without SF resulted in a loss in both early and final compressive strength, whereas 10% replacement of SF resulted in a favorable effect on compressive strength at all FA content and ages. At 28 days, the compressive strength of the HS30 and HS40 mixes outperformed the control combination. Furthermore, test findings show that 90 days after replacing 10% SF with 60% FA (HS60), 68.2 MPa compressive strength may be reached. This mixture contains just 180 kg/m3 of cement. The modulus of elasticity is unaffected by 10% SF substitution up to 50% FA replacement. The modulus of elasticity decreased as the FA concentration increased. While solely FA replacement without SF results in a 30% reduction in modulus of elasticity, FA content results in a 30% reduction in modulus of elasticity. After freezing and thawing, the residual compressive strength of both FA and FA + SF replacements surpassed the residual compressive strength of the control mixture. Increased FA content, on the other hand, resulted in a lower residual splitting tensile strength ratio for FA SCC after 90 freeze–thawing cycles, but residual splitting tensile strength of FA SCC mixes is higher than control mixtures at all FA concentrations with the addition of SF.

A.R. Esquinas, J.I. Alvarez, J.R. Jimenez, J.M. Fernandeza (2018)[21] "Durability of self-compacting concrete built from coal-fired power plant non-conforming fly ash". A study of the durability of three kinds of SCCs was conducted in this study. The first SCC was a mix with SF (SCC-1), the second was a mix with NCFA (SCC-2), and the third was a mix with a 1:1 (by volume) mixture of both components (SCC-3) (SCC-12). It is noticed that all of the mixes meet the EHE-08 guideline's self-compacting requirements. Because SF has a finer and more consistent grain size distribution than NCFA, the fresh state density in SCC-1 is somewhat greater than in SCC-12 and SCC-2. The bulk densities of the mixtures varied by a wider margin (1–2%) than their skeleton densities (0.6–1%). This is related to the definition of both densities, which causes variations in bone density to be masked. SCC-2 has the highest open porosity, followed by SCC-12 and SCC1. These findings are consistent with the MIP, since the NCFA (SCC-2) mix has a larger proportion of holes above 10 lm than the SF (SCC-1), which has a higher percentage of pores less than 10 lm, resulting in a finer porous structure. The addition of 50% NCFA (SCC-12) to the mix resulted in a porosity and microstructural density that is intermediate. The somewhat higher water absorption by immersion in SCC-2 is explained by the above-mentioned characteristics. All of the mixes may be utilized in structural elements exposed to extremely hostile conditions with appropriate durability according to the results of the capillarity absorption analysis and the limitations imposed by the CYTED's DURAR network. Because the mixes had a penetration of more than 30 mm in all situations, it is plausible to assume that they have great compactness and are waterproof based on the findings of water penetration under pressure. According to ASTM C 1202, all of the mixtures are in the poor penetrability to the chloride ion category. In terms of chloride ion concentration as a function of depth, all of the mixes attained a concentration of less than 0.05 percent for depths more than 23 mm, indicating that the reinforcements would be unaffected if the cover was greater than this value. As a result, the mix's safety margin is larger than 20 mm, compared to EHE-08's mandated cover (45 mm). SCC-2 has a larger carbonation depth than SCC-12 and SCC-1, owing to the greater amount of portlandite formed during setting and, on the other hand, the less fine porous structure of SCC-2. The results reveal a safety margin of about 25 millimeters. Because the CO_2 concentration in the ambient is 0.04 percent, 125 times lower than the CO_2 concentration in the carbonation chamber, the reinforcement will be covered by the cover with the three mixes. In terms of SO_3 penetration, SCC-1 was the mix with the lowest value, followed by SCC-12 and SCC-2. The finer and denser porous structure in the SCC-1 and SCC-12 mixes will result in a significant drop in SO3 ion concentration compared to SCC-2, and hence decreased sulphate diffusion and penetration depth. Neither blend displays any signs of wear or degeneration after the exposure duration. Under the curing conditions utilized in this study, the deformation of the mixes caused by shrinkage was stabilized at 450 days. The pozzolanic activity of the SF, the drying process, and the influence of the porous structure caused SCC-1 to shrink more than the SCC-12 and SCC-2 samples. SCC-12 behaves in a middle ground between the other two blends. In short, when it comes to shrinkage, SCC made using NCFA from coal-fired power plants outperforms SCC-1. In conclusion, by substituting all or part of the SF with NCFA from coal-fired power plants, an SCC with excellent durability against aggressive agents and shrinkage may be obtained.

A.R. Esquinas, R. Otero, J.R. Jimenez, E.F. Ledesma (2018)[22] "Mechanical behavior of self-compacting concrete made with non-conforming fly ash from coal-fired power plants" To evaluate an NCFA-like filler in SCC, a comparative research of three SCC mixes was conducted; in the first (SCC-1), a commercial SF was used as a reference; in the second (SCC-12), a 1:1 mix of SF and NCFA was used; and in the third (SCC-2), solely NCFA was employed. comply with the EHE-08's specifications SCC-12 (2.421 kg/dm3) and SCC-2 (2.397 kg/dm3) had somewhat lower densities in the fresh condition than SCC-1 (2.441 kg/dm3), which is due to the SF's finer and more consistent particle size distribution compared to the NCFA. As a result, it is possible to obtain an SCC by substituting NCFA from coal-fired power plants for natural SF in order to achieve mechanical behavior that exceeds the Spanish Code on Structural Concrete's minimal requirements (EHE-08).

Erhan Guneyisi, Mehmet Gesoglu, Suleiman Ipek (2015)[23] "Fresh and rheological behavior of nano-silica and fly ash blended self-compacting concrete" SCC combinations including NS and FA were able to attain slump flow diameters ranging from 700 to 800 mm. When NS was used in SCC manufacturing, the slump flow diameter reduced, however when FA was used, it grew. At all FA replacement levels, the use of NS in SCCs enhanced both slump flow and V-funnel flow times. Slump flow and V-funnel flow times were reduced when FA was used in SCC production. The L-box height ratio was similarly influenced by NS and FA. The L-box height ratio fell as the NS content increased, while the L-box height ratio increased when the FA content increased.

T. Ponikiewski, J. Golaszewski (2014)[24] "The effect of high-calcium fly ash on selected properties of self-compacting concrete" The addition of fly ash in the mix could make it less self-compacting, especially if only a minor amount of superplasticizer was added. If the ash is ground or used as a cement element, the effect is reduced. Furthermore, the use of ash improves the self-compacting mix's stability (resistance to segregation). The compressive strength of concrete made with high-calcium fly ash and without the inclusion of the ash is comparable to that of analogous concretes. The study demonstrates that grinding high-calcium fly ash or using it as a cement constituent, especially in multi-component cement, can reduce the ash's negative impact on self-compacting mix flow.

Neelam Pathak, Rafat Siddique (2011)[25] "Properties of self-compacting-concrete containing fly ash subjected to elevated temperatures" Despite the fact that fly ash affects the strength, SCC can still be produced with sufficient strength. All of the high volume fly ash concretes met the requirements to be classified as SCC, and their fresh qualities, such as workability, were in line with European recommendations [39]. The produced SCC was resistant to segregation and had superior flowability and passing ability. The rate of splitting tensile strength loss is larger than the rate of compressive strength loss at high temperatures. Due to the departure of bound water, the splitting tensile strength continued to drop in a similar manner as it did between 20 and 100 C, equivalent to a considerable mass loss. A minor reduction of strength was noticed between 20 and 200 C.

2.2 INFERENCES

- Maximum compressive strength of 87.06 MPa was achieved by Portland cement, fly ash and silica fume blend of 40% PC, 50% FA & 10% SF at 28 days.

- The increase in the replacement percentage of SF resulted in increases in compressive strength of SCC while the increase of FA content affected the compressive strength inversely.

- The compressive strength of SCC decreases with the increase of tyre rubber from 5% to 15%

- The compressive strength of SCC increases with the increase of Marble Powder from 0% to 15% then start decreases

- The use of RHA, the compressive strength of SCC decreases from 5% to 20%.

2.3 RESEARCH GAP

- On the basis of the above literature review various work has been done so far on the compressive strength of SCC with fly ash and silica fume.

- For the comparison of combined effect of compressive strength of marble powder and other waste materials such as rice husk ash, tyre rubber and lime is not well defined.

2.4 Objectives

- To study the compressive strength of SCC with lime and fly ash as fine material.
- To study the compressive strength of SCC with replacement of rice husk ash and marble powder as industrial waste fine material.
- To study the compressive strength of SCC with tyre rubber for coarse aggregate.

CHAPTER -3

EXPERIMENTAL WORKS AND METHODOLOGY

3.1 Material Testing

Before starting any research work some preliminary test or work has to be done in lab or at site. The detailed experimental procedure is discussed below:

- Collecting all the basic materials like cement, sand and aggregate as per Indian Standard Specification.
- Finding all the basic properties of cement, sand and aggregate by performing basic tests on it.
- Getting cement: sand: aggregate ratio by defining w/c ratio by IS 10262-2019 mix design procedure.
- Casting of concrete cubes without addition of fibers of size 150mm×150mm×150mm for performing different tests of 7 and 28 days.

3.1.1 TEST ON FINE AGGREGATE

SPECIFIC GRAVITY

Specific gravity is defined as the ratio of unit weight of substance to the standard substance at standard temperature i.e. 4^{o}C. This test is performed with the help of pycnometer.

1. A = wt. of pycnometer + water = 1530 gm
2. B = wt. of pycnometer + wt. of fine aggregate + water = 1846 gm
3. C = saturated surface dry wt. = 500 gm
4. D = wt. of oven dry aggregate = 488 gm

Specific gravity = $\frac{D}{C-(B-A)}$ = $\frac{488}{500-(1846-1530)}$ = 2.65

WATER ABSORPTION TEST

1. C = saturated surface dry wt. = 500 gm
2. D = wt. of oven dry aggregate = 488 gm

Water absorption = ($\frac{C-D}{D}$)*100 = $\left(\frac{500-488}{488}\right) * 100$

W.A = 2.1 %

SIEVE TEST

Sieve Analysis of the fine aggregate is carried out in the laboratory as per IS 383:1870. The sand is first sieved through 4.75mm sieve to remove any particle greater than 4.75 mm sieve and then washed to remove the dust. For performing the sieve test 1kg of fine aggregate is taken. The fine aggregates used for the experimental work is locally procured and comply according to IS383: 2016 Table 9 clause 6.3 with grading zone I.

GRADING OF FINE AGGREGATE

IS Sieve Size	Weight retained(gm)	Cumulative weight Retained(gm)	Cumulative % Weight Retained	Cumulative % Passing
4.75mm	67	667	6.7	93.3
2.36mm	123	190	19.0	81
1.18mm	204	394	39.4	60.6
600 µm	285	679	67.9	32.1
300 µm	255	934	93.4	6.6
150 µm	60	994	99.4	0.6
PAN	5	999	99.9	0

3.1.2 TEST ON COARSE AGGREGATE

SPECIFIC GRAVITY

The aggregate most of which are required on the 4.75mm IS sieve and contain only that much of fine material as is permitted by the specifications are termed as coarse aggregate

Total weight of coarse aggregate taken = 2000 gm

1. A1 = wt. of aggregate + weir bucket in water = 2354 gm
2. A2 = wt. of bucket in water 1115 gm
3. B = wt. of aggregate in saturated surface dry condition = 1994 gm
4. C = wt. of oven dry aggregate = 1990.5 gm

Specific gravity = = $\left(\frac{C}{B-(A1-A2)}\right)$ = $\left(\frac{1990.5}{1994-(2354-1115)}\right)$

Specific gravity = 2.64

WATER ABSORPTION TEST

1. B = wt. of aggregate in saturated surface dry condition = 1994 gm
2. C = wt. of oven dry aggregate = 1990.5 gm

Water absorption = ($\frac{B-C}{C}$)*100 = $\left(\frac{1994-1990.5}{1990.5}\right) * 100$

W.A = 0.2 %

SEIVE TEST

Total weight of coarse aggregate taken = 5000 gm

Table 3.5: Sieve Analysis of coarse Aggregate

IS Sieve Size	Weight retained(gm)	Cumulative weight Retained(gm)	Cumulative % Weight Retained	Cumulative % Passing
16 mm	62	62	1.24	98.76
12 mm	1388	1450	29	71
10 mm	1770	3220	64.4	35.6
4.75 mm	1756	4976	99.52	0.48

From the above tables and results obtained by sieve analysis, it is confirmed that the nominal size of coarse aggregate is 10 mm according to IS 383:1970. Fineness modulus of coarse aggregate

= Summation of % retain on sieve size (16mm, 12mm, 10mm, 4.75mm)/100

= (1.24+29+64.4+99.52)/100

= 1.95

3.1.3 TEST ON CEMENT

NORMAL CONSISTENCE TEST

The basic aim is to find the water content required to produce a cement paste of standard consistency as specified by the IS: 4031(Part 4)-1988[32]. The principal is that standard consistency of cement is that consistency at which the Vicat plunger penetrates to a point 5-7mm from the bottom of Vicat mould.

The procedure adopted for the test is as following:

(i) Weigh approximately 300g of cement and mix it with a weighed quantity of water. The time of gauging should between 3 to 5 minutes.

(ii) Fill the Vicat mould with paste and level it with a trowel.

(iii) Lower the plunger gently till it touches the cement surface.

(iv) Release the plunger allowing it to sink into the paste.

(v) Note the reading on the gauge.

(vi) Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm.

Consistency of Cement:

Weight of Cement = 300gm

Weight of water 37 % of cement = 111gm

Gauging time 3 to 5 minutes

Initial Reading = 4mm

Final Reading = 10mm

Vicat apparatus Reading = 7mm O.K (in between 5 to 7 mm)

The amount of water required as a percentage by weight of dry cement was 37%

INITIAL AND FINAL SETTING TIME OF CEMENT

Initial setting time is that time period between the time water is added to cement and the time at which 1mm square section needle fails to penetrate the cement paste, placed in the Vicat's mould 5mm to 7mm from the bottom of the mould. Final setting time is that time period between the time water is added to cement and the time at which 1mm needle makes an impression on the paste in the mould but 5mm attachment does not make any impression.

The apparatus required are Vicat's apparatus conforming to IS: 5513-1996, [33] Balance, whose permissible variation at a load of 1000gm should be +1.0gm, gauging trowel conforming to IS: 10086-1982[2].

Initial Setting time of the Cement:

Weight of cement = 400gm

Weight of water, according IS: 456 = 0.85 x c x 400

Where c = Consistency of cement = 0.85 x 37 100 x 400

Weight of water = 126gm

Initial reading = 3 mm

Final Reading = 9 mm

Penetration of plunger up to from the bottom of mould = 6mm O.K (between 5to7mm)

The initial setting time was found to be 32 minutes.

COMPRESSIVE STRENGTH OF CEMENT

The compressive strength of cement is a very vital criterion to be considered in the field of concrete technology. Hence, it becomes important to perform required test for compressive strength of cement. Strength testes are not made on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement.

The test procedure adopted in the present study is as follows:

(i) Take 200gm of cement and 600gm of sand i.e. ratio of 1:3 and mix them dry thoroughly.

(ii) Add water at rate (P/4 +3%, where P is % of water required for preparing of standard consistency) to the dry mix of cement and sand and mix thoroughly for a minimum of 3 minutes and maximum for 4 minutes to obtained a mix of uniform color. If even in 4 minutes' uniform color of mix is not obtained reject the mix and mix fresh quantities of cement, sand and water to obtain a mix of uniform color.

(iii) Place the thoroughly cleaned and oiled (on interior face) mould on the vibrating machine and hold it in position by clamps provided on the machine for the purpose.

(iv) Fill the mould with the entire quantity of mortar and vibrate it for 2 minutes at a specified Speed to achieve full compaction. Three cubes sample were made of same specification.

(v) Remove the mould from the machine and keep it in a place with temp of 27 20C and relative humidity of 90% for 24 hours.

(vi) At the end of 24 hours remove the cube from the mould and immediately submerge in fresh clean water. The cube is taken out of the water only at the time of testing.

(vii) After curing of 28 days, place the test cube on the platform of a compressive testing machine without any packing between the cube and the plates of the testing machine. Apply the load steadily and uniformly, starting from zero at a rate of 35N/mm2 /minute.

The value of compressive strength at 28 days found from compression test was 43.2N/mm2 which is satisfactory when compared to the standard value as per IS: 8112:1989[33] i.e. 43N/mm2. Thus, it is evident that the cement used satisfied the compressive strength criteria of 43 grade cement.

Table 3.6: Physical Properties of Portland pozzolana Cement

Characteristics	Observed value
Normal consistency	37%
Initial setting time	32 minutes
Specific gravity	2.88
Compressive Strength at 28 days	43.2MPa

3.1.4 MIX DESIGN PROCEDURE (IS 10262: 2009) [35]

In order to design a concrete of a particular strength, firstly we need to decide the constituents of concrete mix such as cement, fine aggregate, coarse aggregate, admixtures etc. The material's optimum quantity is taken to achieve the required performance. Other criteria such as workability are also kept in mind while designing. The procedure of mix design adopted in current study is given below:

CONCRETE MIX PROPERTIONING FOR M40 GRADE

(1) Stipulations for Proportioning

(a) Grade designation : M40

(b) Type of cement : PPC Conforming to IS 8112, 1989[2]

(c) Maximum nominal size of aggregate : 10mm

(d) Minimum cement content : 450Kg/m3

(e) Maximum water-cement Ratio : 0.40

(f) Slump Flow Class : SF 3 (Slump Flow 760 mm - 850 mm

(g) Passing Ability by L-Box Test : Ratio of h2/h1 =0.8 -1.0

(h) V-Funnel Flow Time : Class VI (flow time <=8 sec)

(i) Exposure condition : Severe (for reinforce concrete)

(j) Method of concrete placing : Manual

(k) Degree of supervision : Good

(l) Type of aggregate : Crushed Angular aggregate

(m) Maximum cement content : 450kg/m3

(n) Chemical admixture type : superplasticizer

(2) TEST DATA FOR MATERIALS

(a) Cement used : PPC Conforming to IS 8112, 1989[2]

(b) Specific gravity of cement : 2.88

(c) Chemical admixture : Sulphonated Naphthalene Polymers

(d) Specific gravity of:

(1) Coarse Aggregate : 2.6

(2) Fine Aggregate : 2.5

(e) Water absorption:

(1) Coarse Aggregate : .22 %

(2) Fine Aggregate : 1.66%

(f) Sieve analysis:

(1) Coarse Aggregate : 10mm aggregate IS: 383-1970[4]

(2) Fine Aggregate : Conforming to grading zone II of table 4 of IS 383-1970[4]

(3) Target Strength for Mix proportioning:

$f'ck = fck + 1.65s$

Where $f'ck$ = Target average compressive strength at 28 days.

fck = Characteristic compressive strength at 28 days.

s = Standard deviation.

Standard deviation s = 5 from table 1 IS: 10262-2009[29]

Target Strength = 40 + 1.65x 5 = 48.25 MPa

(4) Selection of Water Cement Ratio:

From Table 5 of IS 456, maximum water –cement ratio =0.45

Adopt water-cement ratio as = 0.4

0.4 , hence O.K.

(5) Selection of Water Content:

Form Table 4 IS: 10262-2019[29], maximum water content for 10mm aggregate = 197.64

(6) Calculation of Cement Content:

Cement =494.1 kg/m3

Air content =0.8

Super plasticizer =1.5% by mass of cementous materials

(7) Selection of Admixture:

=1.5/100*494.1

8.2kg/m3

(8) Selection of Fine Aggregate Content:

Powder content =550 kg/m3

Fine required = total powder – (fly ash + cement)

=550 – (0+549)

1kg/m3

Fine aggregate has 10% materials < .125mm

F.A = 1/.1*100 = 1000kg/m3

(9) Selection of Course Aggregate:

Vca = (1-air content) – (vol. of water + vol. of cement + vol. of fly ash + vol. of admixture + vol. of F.A)

= (1-0.8) – (197.64/1*1000 + 549/3.15*1000 + 8.2/1.08*1000 + 1000/2.65*1000

= .985 – (.756)

= .229 = .23m3

Mass of C.A

= Vca*S.G*1000

= .23*2.64*1000

= 607.2 kg/m3

(10) Calculation of vol. of powder content:

Vol. of P.C = vol. of PPC + vol. of fly ash + vol. of portion of F.<.125

= 549/3.15*1000 + ½.65*1000

= .174

(11) Mix Proportion:

Cement = 549kg/m3

Water = 194.64kg/m3

Fine Aggregate = 1000kg/m3

Coarse Aggregate = 607.2kg/m3

MIX PROPORTION = 1: 1.82: 1.10

3.1.5 CASTING, MIXING AND CURING OF CONCRETE

Once the mix design and all the required tests on ingredients of concrete are done and their suitability is found satisfactory, the task of casting cubes was taken up. The available laboratory equipment's were utilized in accomplishing the experimental program. The guidelines in IS10262:2019[35] were strictly followed in mixing. Coarse aggregate was washed a day before casting to make it silt free and the laid to dry. On the day of casting, coarse aggregate remained satisfactory moist so that it does not absorb any further water from the mix i.e. the design of water cement ratio is carefully regulated. The moulds used for cubes, beams were of steel having an internal dimension of 150mm X 150mm X 150mm for cubes. The cement coarse and fine aggregate and indusrials waste. For each batch of design mix the three cubes are made. The mould was removed after 24 hours and the specimens were kept immersed in a clear water tank for curing. After curing the specimens in water for a period of 7days and 28 days the specimens were removed out and allowed to dry under shade.

3.1.6 Specimen for Compressive Strength

This test gives us an idea about all the characteristics of concrete. With the help of this test we can check that whether Concreting has been done properly or not and compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates

Procedure of Test

For this test mainly 150mm * 150 mm * 150 mm cubes are used

- Clean the mounds properly and apply oil inside the cube frame
- Fill the concrete in the molds in layers approximately 50mm thick
- Level the top surface and smoothen it with a trowel
- The concrete cubes are removed from the moulds between 16 to 72 hours, usually this done after 24 hours. Remove the specimen from water after specified curing time and wipe out excess water from the surface. Take the dimension of the specimen to the nearest 0.2mm and then place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast. Align the specimen centrally on the base plate of the machine. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
- Apply the load gradually without shock and continuously at the rate of 140 $kg/cm^2/min$. till the specimen fails
- Record the maximum load and note it.

Fig Cube testing

CHAPTER – 4

RESULTS AND DISCUSSION

4.1 GENERAL

4.1.1 CALCULATION FOR COMPRESSIVE STRENGTH OF CONCRETE

Table 4.1 for compressive strength of mix with lime as replacement of cement.

S.NO	Cement (kg)	Lime (%)	F.A (kg)	C.A (kg)	W/C	Admixture (%)	V-Funnel Test (Sec)	L-Box Test			Compressive strength(MPa)		
								H1	H2	Ratio H2/H1	7 days	28 days	
1	7.2	10	14.56	8.8	.40	1.8	6.86	4.7	15.5	3.29	11.37	17.49	

2	**6.8**	**15**	**14.56**	**8.8**	**.40**	**1.8**	**6.40**	**6.4**	**14**	**2.18**	**12.6**	**19.38**	
3	**6.4**	**20**	**14.56**	**8.8**	**.40**	**1.8**	**6.28**	**4.4**	**18.5**	**4.20**	**10.5**	**16.15**	

Table 4.2 for compressive strength of mix with fly ash as addition of cement

S.NO	Cement (kg)	Fly Ash (%)	F.A (kg)	C.A (kg)	W/C	Admixture (%)	V-Funnel Test (Sec)	L-Box Test			Compressive strength (MPa)	
								H1	H2	Ratio H2/H1	7 days	28 days
1	8	10	14.56	8.8	.40	1.8	5.32	4.6	27	5.86	19.8	30.46
2	8	15	14.56	8.8	.40	1.8	8.38	5	17	3.4	22.37	34.41

3	8	20	14.56	8.8	.40	1.8	8.36	4.2	18	4.3	18.7	28.76

Table 4.3 for compressive strength of mix with lime as replacement and fly ash as addition of cement.

S.NO	Cement (kg)	Lime (%)	Fly ash (%)	F.A (kg)	C.A (kg)	W/C	Admixture (%)	V-Funnel Test (Sec)	L-Box Test			Compressive strength(MPa)	
									H1	H2	Ratio H2/H1	7 days	28 days
1	6.8	15	15	14.56	8.8	.40	1.8	7.80	4.4	27	6.13	22.43	34.50

Table 4.4 for compressive strength of mix with lime as replacement and fly ash and silica as addition of cement

S.NO	Cement (kg)	Lime (%)	Fly ash(%)	Silica (%)	F.A (kg)	C.A (kg)	W/C	Admixture (%)	V-Funnel Test (Sec)	L-Box Test			Compressive strength(MPa)	
										H1	H2	Ratio H2/H1	7 days	28 days
1	6.8	15	15	1	14.56	8.8	.40	1.8	9.1	3.9	17	4.35	20.0	30.76
2	6.8	15	15	1.5	14.56	8.8	.40	1.8	9.5	4.2	25	5.95	22.66	34.86

S.NO	Cement (kg)	Lime (%)	Fly ash (%)	Silica (%)	Tyre Rubber (%)	F.A (kg)	C.A (kg)	W/C	T50 cm (sec)	Admixture (%)	V-Funnel Test (Sec)	L-Box Test			Compressive strength(MPa)	
												H1	H2	Ratio H2/H1	7 days	28 days
1	8	15	15	1.5	2	14.56	8.8	.40	5.5	1.8	8	3.9	29	7.43	21.43	32.96
2	8	15	15	1.5	4	14.56	8.8	.40	4	1.8	6.6	5.2	21	4.03	20.3	31.23
3	8	15	15	1.5	5	14.56	8.8	.40	3.5	1.8	5.8	6.9	24	3.47	20.2	31.07

Table 4.5 for compressive strength of mix, Fix the lime, fly ash as 15% and silica 1.5% and addition of tyre rubber as 2%, 4% & 5%

Table 4.6 for compressive strength of mix, Fix the lime, fly ash as 15% and silica 1.5% and addition of rice husk ash as 2%, 4% & 5%

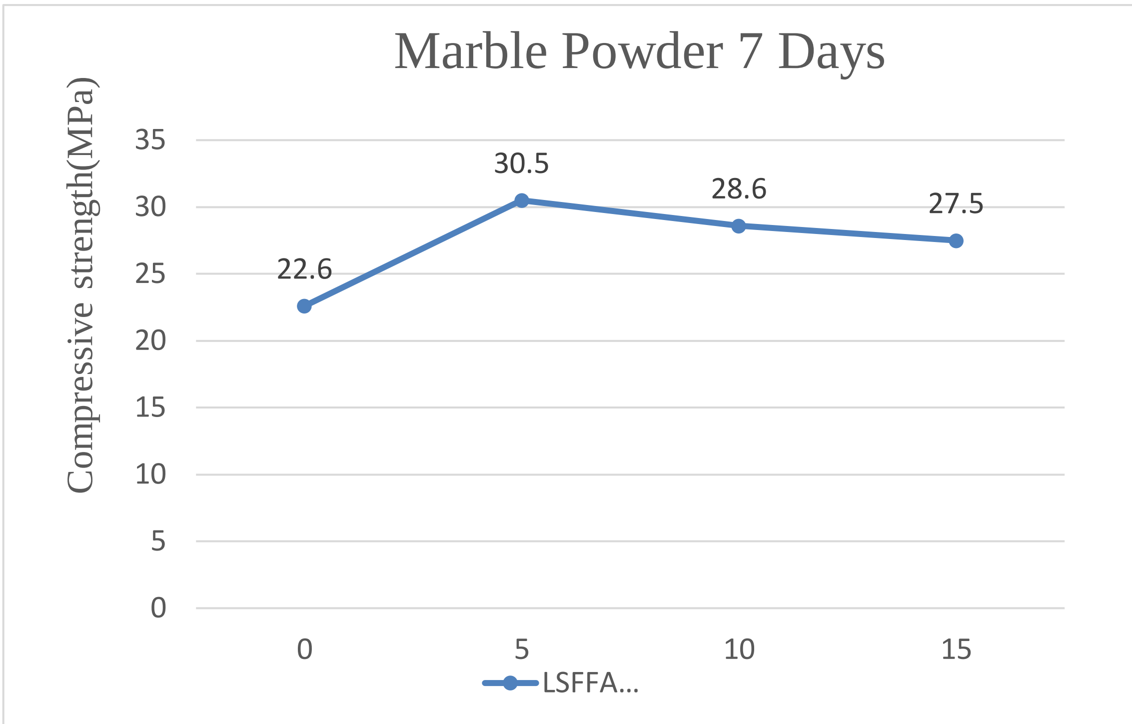
S.NO	Cement (kg)	Lime (%)	Fly ash (%)	Silica (%)	Rice husk ash (%)	F.A (kg)	C.A (kg)	W/C	T50 cm (sec)	Admixture (%)	V-Funnel Test (Sec)	L-Box Test			Compressive strength (MPa)	
												H1	H2	Ratio H2/H1	7 days	28 days
1	8	15	15	1.5	2	14.56	8.8	.40	6	1.8	6.4	4.2	28	6.3	22.73	34.96
2	8	15	15	1.5	4	14.56	8.8	.40	4.5	1.8	6.0	5	18	3.6	19.2	29.53
3	8	15	15	1.5	5	14.56	8.8	.40	5	1.8	6.2	6.4	22	3.4	17.5	26.92

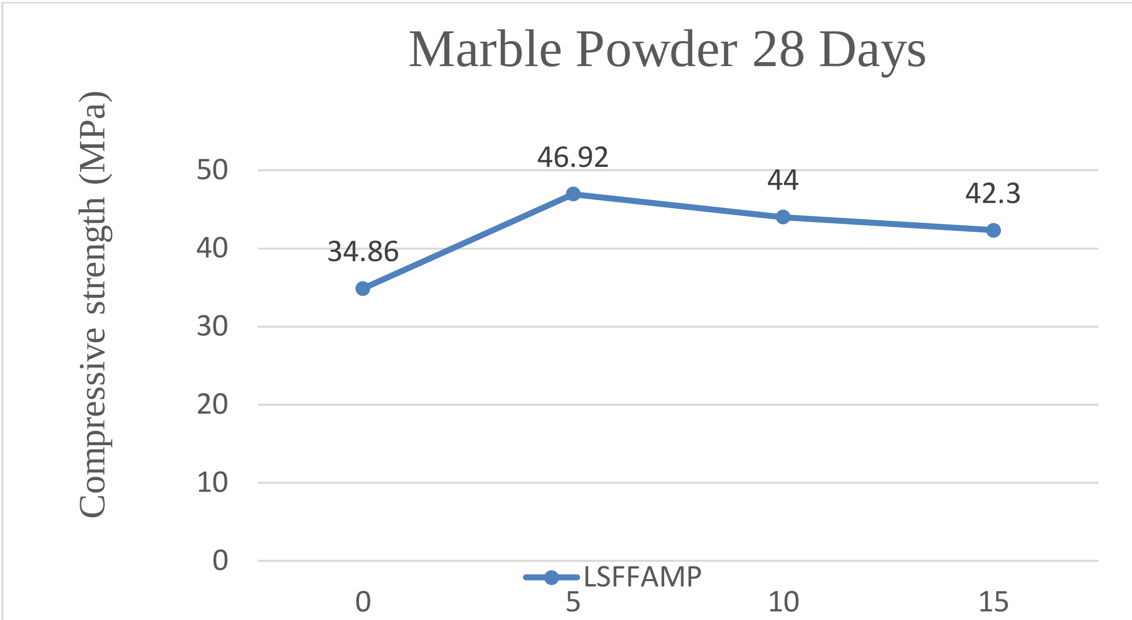
Table 4.7 for compressive strength of mix, Fix the lime, fly ash as 15% and silica 1.5% and addition of marble powder as 5%, 10% &15%

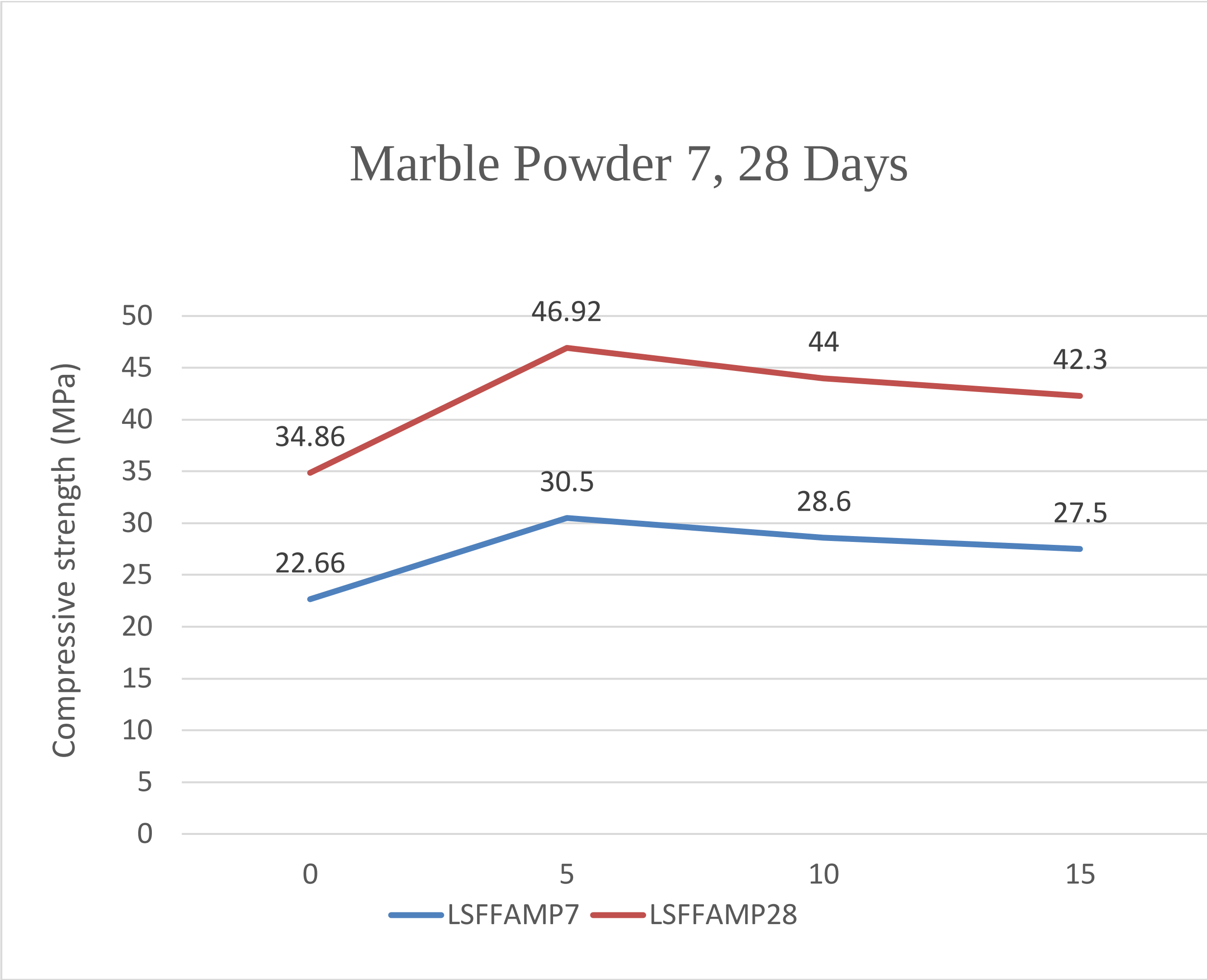
S.NO	Cement (kg)	Lime (%)	Fly ash (%)	Silica (%)	Marble (%)	F.A (kg)	C.A (kg)	W/C	T50 cm (sec)	Admixture (%)	V-Funnel Test (Sec)	L-Box Test			Compressive strength(MPa)	
												H1	H2	Ratio H2/H1	7 days	28 days
1	8	15	15	1.5	5	14.56	8.8	.40	6.4	1.8	7.2	4.6	27	5.86	30.5	46.92
2	8	15	15	1.5	10	14.56	8.8	.40	5.8	1.8	6.9	5	17	3.4	28.6	44
3	8	15	15	1.5	15	14.56	8.8	.40	5.6	1.8	6.5	4.2	18	4.3	27.5	42.30

4.2 CALCULATION OF COMPRESSIVE STRENGTH:

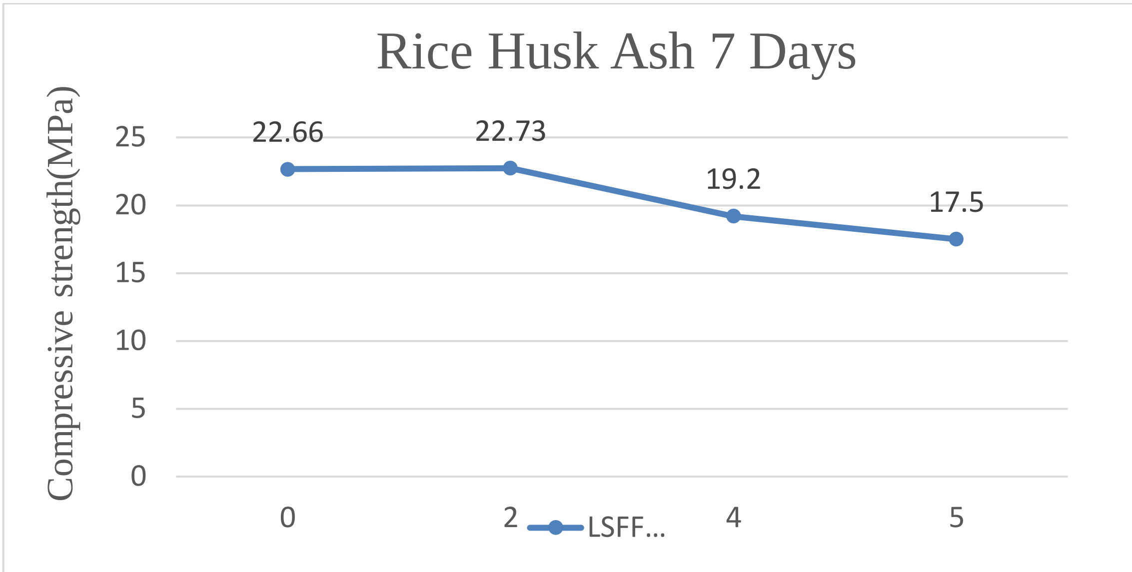
Compressive strength of cube = $\boldsymbol{Load\ at\ Failure(N)/Surface\ area\ of\ cube\ (mm2)}$

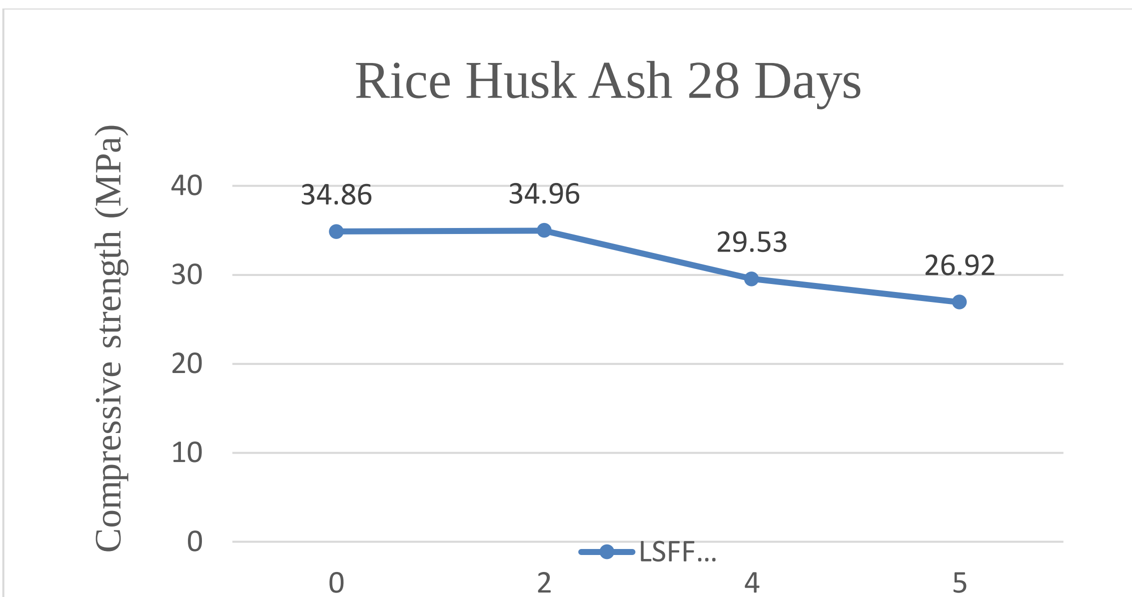


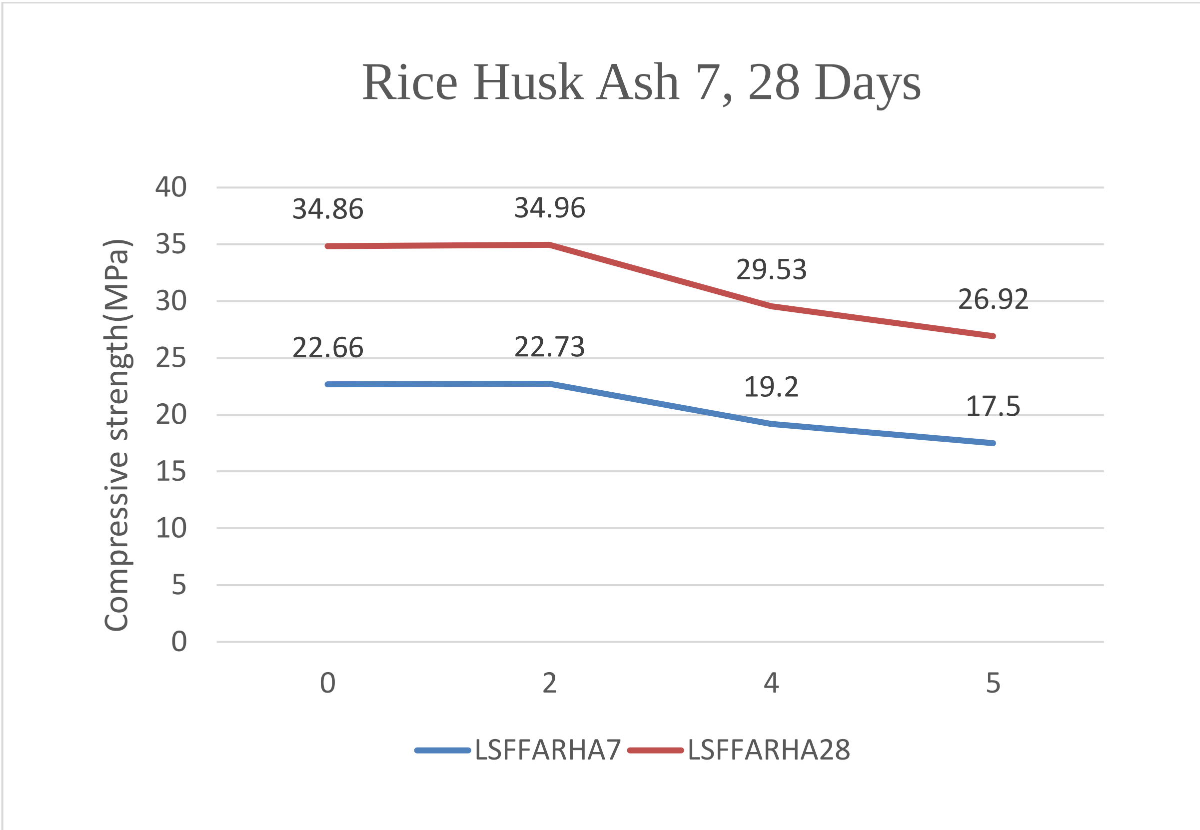

Marble Powder 28 Days
Compressive strength (MPa)
50
40
30
20
10
0
46.92
44
42.3
34.86
LSFFAMP
0
5
10
15

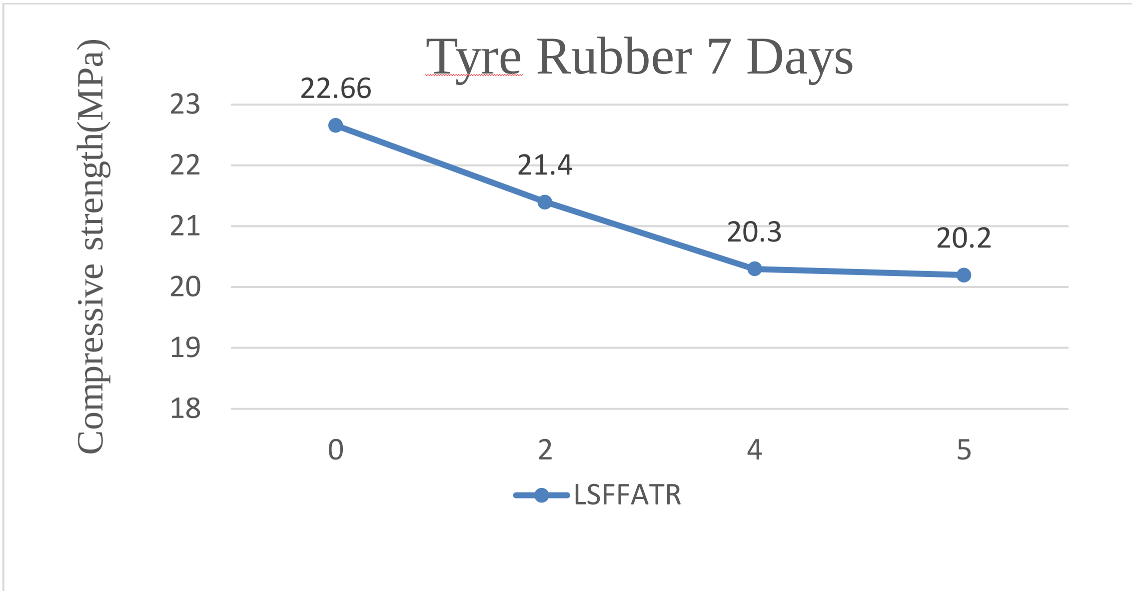


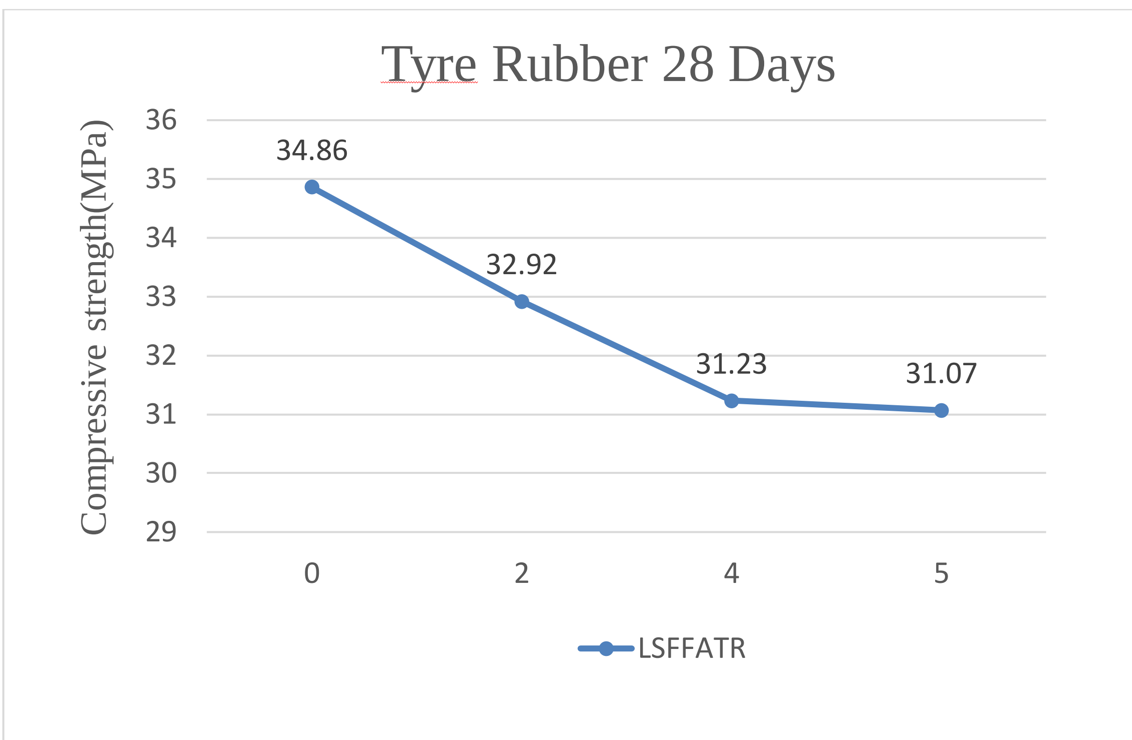
Marble Powder 7, 28 Days
Compressive strength (MPa)
50
45
40
35
30
25
20
15
10
5
0
46.92
44
42.3
34.86
30.5
28.6
27.5
22.66
0
5
10
15
LSFFAMP7
LSFFAMP28

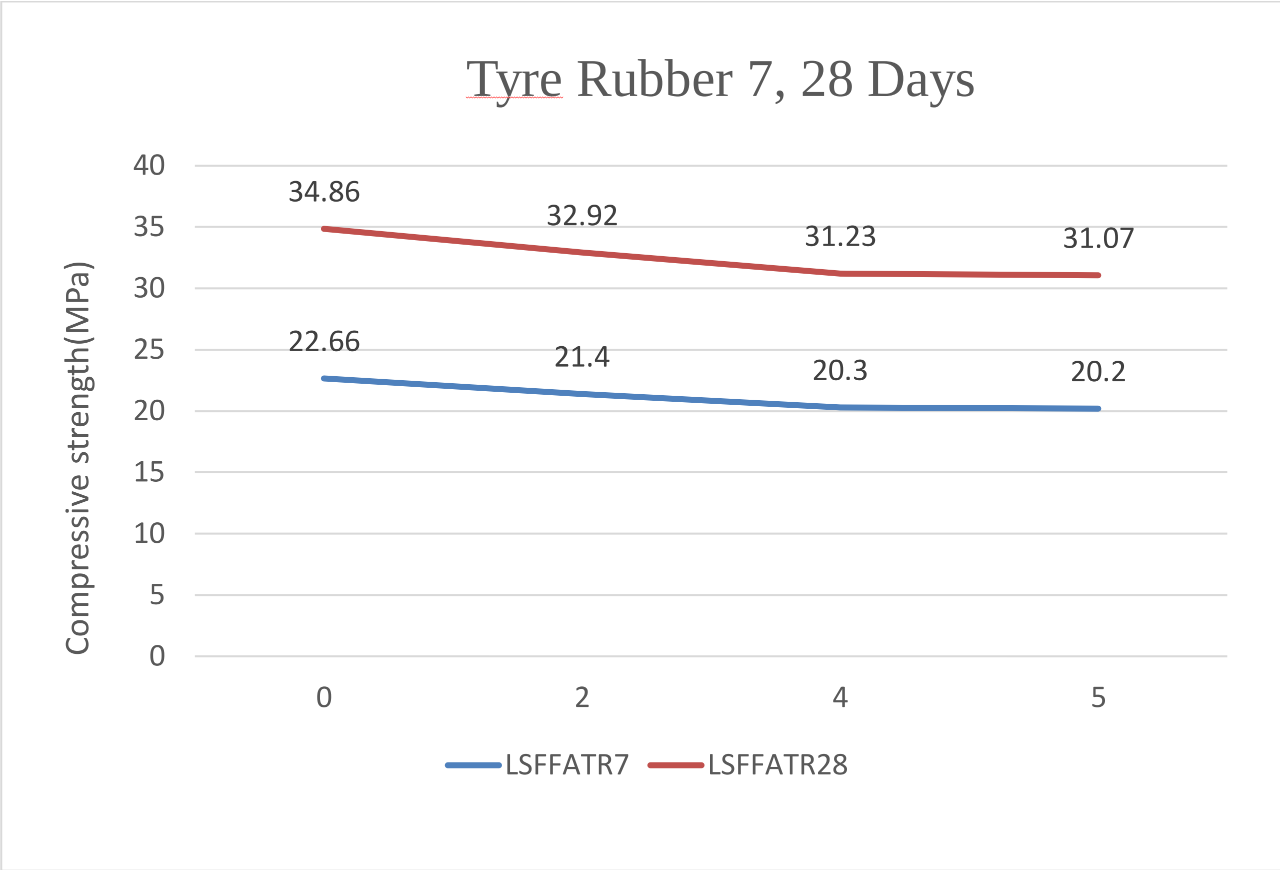

Rice Husk Ash 7 Days
Compressive strength(MPa)
25
20
15
10
5
0
22.66
22.73
19.2
17.5
0
2
4
5
LSFF...


Rice Husk Ash 28 Days
Compressive strength (MPa)
40
30
20
10
0
34.86
34.96
29.53
26.92
0
2
4
5
LSFF...

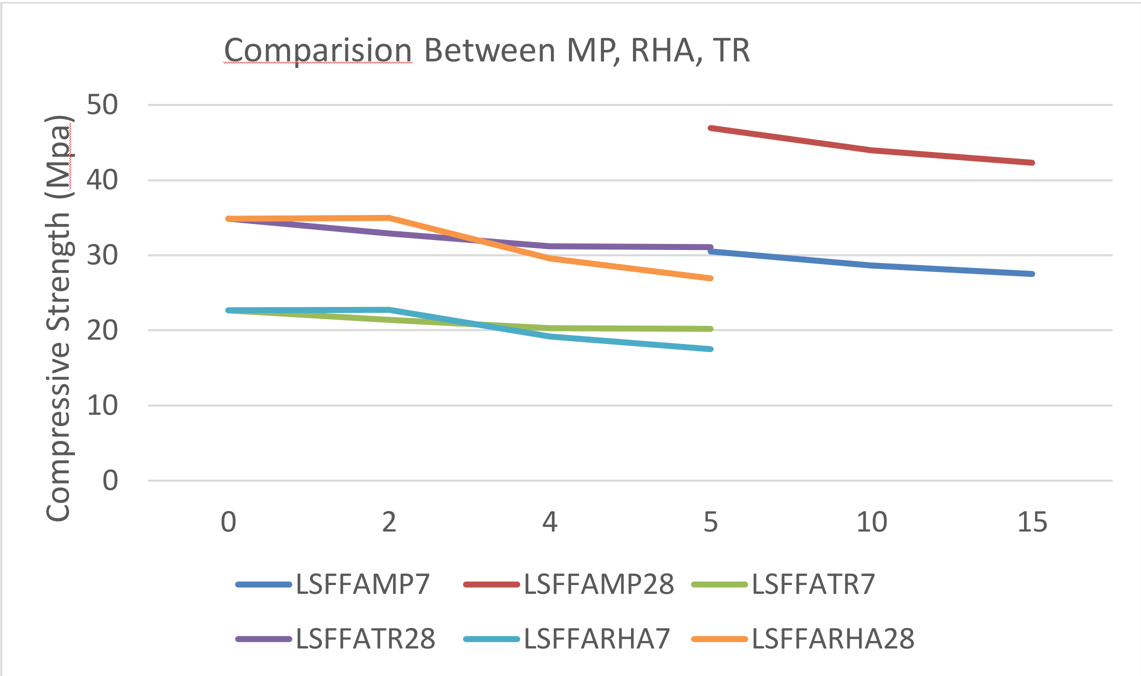

Rice Husk Ash 7, 28 Days
Compressive strength(MPa)
40
35
30
25
20
15
10
5
0
34.86
34.96
29.53
26.92
22.66
22.73
19.2
17.5
0
2
4
5
LSFFARHA7
LSFFARHA28


Tyre Rubber 7 Days
Compressive strength(MPa)
23
22
21
20
19
18
22.66
21.4
20.3
20.2
0
2
4
5
LSFFATR


Tyre Rubber 28 Days
Compressive strength(MPa)
36
35
34
33
32
31
30
29
34.86
32.92
31.23
31.07
0
2
4
5
LSFFATR



Tyre Rubber 7, 28 Days
Compressive strength(MPa)
40
35
30
25
20
15
10
5
0
34.86
32.92
31.23
31.07
22.66
21.4
20.3
20.2
0
2
4
5
LSFFATR7
LSFFATR28



Comparision Between MP, RHA, TR
Compressive Strength (Mpa)
50
40
30
20
10
0
0
2
4
5
10
15
LSFFAMP7
LSFFAMP28
LSFFATR7
LSFFATR28
LSFFARHA7
LSFFARHA28

CHAPTER - 5

CONCLUSIONS

The compressive strength of cubes was increase a lit bit after addition of Rice Husk Ash by 2% then decreasing further increase of Rice Husk ash.

The compressive strength of cubes was decrease after addition of Tyre Rubber.

The compressive strength of cubes was increase considerably on adding of 5% Marble Powder and increase in the percentage of Marble Powder then the compressive strength was decreased but found higher than the controlled cubes.

CHAPTER – 6

REFERENCES

- Burak Felekoglu; Utilization of high volumes of limestone quarry wastes in concrete industry (self-compacting concrete case), February 2007
- Mehmet Gesoglu, Erhan Guneyisi, Erdogan Ozbay; properties of self-compacting concrete made with binary, ternary and quaternary cementitious blends of fly ash, blast furnace slag, and silica fume, May 2007
- Halit Yazici; The effect of silica fume and high volume class C fly ash on mechanical properties, chloride penetration of self-compacting concrete, January 2008
- Mehmat Gesoglu, Erhan Guneyisi, Erdogan Ozbay; Properties of self-compacting concrete made with binary, ternary, and quaternary cementitious blends of fly ash, blast furnace slag, and silica fume, November 2008
- Hiba A. Mohamed; Effect of fly ash and silica fume on compressive strength of self-compacting concrete under different curing conditions, June 2011
- Neelam Pathak, Rafat Siddique; Properties of self-compacting concrete containing fly ash subjected to elevated temperatures, December 2011

- H.A.F. Dehwah; Mechanical properties of self-compacting concrete incorporating quarry dust powder, silica fume or fly ash, July 2011
- H.A.F. Dehwah; Corrosion resistance of self-compacting concrete incorporating quarry dust powder, silica fume and fly ash, September 2012
- Freshet Al-Sadat sabet, Nicolas Ali Libre, Mohammad Shekarchi; Mechanical and durability properties of self-consolidating high performance concrete incorporating natural zeolite, silica fume and fly ash, February 2013
- A. Ferhat Bingol, Ilhan Tohumcu; Effect of different curing regimes on the compressive strength properties of self-compacting concrete incorporating fly ash and silica fume, April 2013
- Raharjo.D, Subakti.A, Tavio;Mixed concrete optimization using fly ash, silica fume and iron slag on the SSC's compressive strength, may 2013
- Wongkeo, Pailyn Thongsanitgarn,Athipong Ngamjarurojana,arnon chaipanich;compressive strength and chloride resistance of self-compacting concrete containing high level fly ash and silica fume, July 2014
- T. Ponikiewski, J. Golaszewski; The effect of high calcium fly ash on selected properties of self-compacting concrete, October 2014
- Erhan Guneyisi, Mehmet Gesoglu, Suleiman Ipek; Fresh rheological behavior of Nano silica and fly ash blended self-compacting concrete, July 2015
- H.Y. Leung, J.kim, A. Nadeem, Jayaprakash Jaganathan, M.P. Anwar; sorptivity of self-compacting concrete containing fly ash and silica fume, March 2016
- Ahmet Benli, Mehmet Karatas, Yakup baker; An experimental study of different curing regimes on the mechanical properties and sorptivity of self-compacting mortars with fly ash and silica fume, March 2017
- A. R Esquinas, R. Otero, J.R. Jimenez, E.F. Ledesma; Mechanical behavior of self-compacting concrete made with non-conforming fly ash from coal fired power plants, June 2018

- A.R. Esquinas, J.I. Alvarez, J.R. Jimenez, J.M. Fernandez; Durability of self-compacting concrete made from non-conforming fly ash from coal fired power plants, September 2018
- Vahab Naderi Zarnaghi, Ali Fouroghi Asl, Vahid Nourani, Hongyan Ma; On the pore structures of lightweight self-compacting concrete containing silica fume, November 2018
- Mehran Khan, Majid Ali; Improvement in concrete behavior with fly ash, silica fume and coconut fibers, January 2019
- Hossein Sasaniour, Farhad Aslani, Javad Taherinezhad; Effect of silica fume on durability of self-compacting concrete made with waste recycled concrete aggregates, July 2019
- T. Rajah Surya, M. Prakash, K. S Satyanrayanan, A. Kenneth Celestine, N. Parthasarathi; Compressive strength of self-compacting concrete under elevated temperature, March 2020
- Walid E. Elemam, Ahmad H. Abderlraheem, Mohamed G. Mahdy, Ahmad M. Tahiwia; Opyomizing fresh properties and compressive strength of self-consolidating concrete, march 2020
- F.A. Mustafa, A. Sulaiman, R.N. Mohamed, S.A. Umara; The effect of fly ash and silica fume on self-compacting high performance concrete. April 2020
- Rabar H. Faraj, Aryan Far H. Sherwani, Lamyaa Hama Jafer, Dalya F. Ibrahim; Rheological behavior and fresh properties of self-compacting high strength concrete containing recycled PP particles with fly ash and silica fume blended, July 2020