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SELF-COMPACTING CONCRETE USING ULTRAFINE NATURAL STEATITE POWDER REPLACEMENT OF CEMENT

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Abstract:
An experimental investigation was made on flow properties and compressive strength of self-compacting concrete (SCC) with ultrafine natural steatite powder (UFNSP) as replacement to cement. The tests were conducted on specimens with 5%, 10%, 15%, 20%, and 25% of replacement of UFNSP to the weight of cement and compared to the control specimens. The flow properties of all specimens were tested and checked for their limit with the existing guidelines. The compressive strength test was done on all specimens for strength of 7 days, 14 days, 28 days, and 56 days.The hardened samples were tested for their microstructural behavior and the elements Mg, Ca, and Si were mapped. Through mapping, the formations of M-S-H along with C-S-H are observed. The results show that the addition of UFNSP influences the flow property, by reducing the flow, and increases the compressive strength till 20% replacement. Further the addition of UFNSP increases the denseness of microstructure of the specimens thus resulting in the strength increment.

Keywords: SCC**,** Ultrafine natural steatite powder, Flow properties, Silica fume, Fly ash

1.Introduction

The self-compacting concrete (SCC), also known as self- consolidating concrete, is in the limelight for the last two decades in construction industry. Self-compacting concrete (SCC) is a concrete which can be placed and compacted into every corner of formwork purely by means of its self-weight by eliminating the need of external energy. Cement mortars prepared with steatite particles have been investigated for restoration of sculptures and other craft works. The steatite is mostly used in electrotechnics. Stabilization of protoen statite in steatite body is achievable by the development of small crystals . Improper selection of parameters led to undesired problems such as separation of the powder-binder mixture and formation of collapses and cracks on the structure of the moulded parts. The main objective of the project is to investigate on self compactive concrete and strength and durability by using different test method.To investigate the properties of SC concrete in rc slab element.

The mix proposition of SCC is about M70 grade of concrete. This is the problem mainly with heavily reinforced sections where a very high congestion of reinforcement is seen. In this case, it becomes extremely difficult to compact the concrete. Then what can be done to avoid honeycombing? The answer to the problem may be a type of concrete which can get compacted into every corner of form work and gap between steel, purely by means of its own weight and without the need for compaction. The SCC concept was required to overcome

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these difficulties. Now in our project we are(have) used replacement of (done replacement of/replaced) cement by volume by red mud and foundry waste. Because of red mud and foundry waste are solid waste.due to benefits of the use of this concrete.

A very limited work is reported from India, where the future for concrete is very bright due to scarcity of skilled man power, non-mechanization of construction industry,

Therefore, it can be said that SCC is still quite unknown to many researchers, builders, ready mix concrete producers, academia etc. Self compacting concrete is basically a concrete which is capable of flowing in to the formwork, without segregation, to fill uniformly and completely every corner of it by its own weight without any application of vibration or other energy during placing. There is no standard selfcompacting concrete.There fore each self-compacting concrete has to be designed for the particular structure to be constructed. flowability and resistance to segregation, self-compacting concrete may be proportioned for almost any type of concrete structure.

In the present research work, effect of UFNSP powder on setting time and strength development on cement is investigated. This experimental investigation is further supported by the scanning electron microscope images.Increasing the replacement level, arrested the micro cracks thereby improved the microstructure and showcased very less voids. The SEM images also indicated the formation of magnesium silicate hydrate gels which also contributed to the enhancement of durability properties.

2 Literature Review

Many researchers have studied about the Self Compacting Concrete Using **STEATITE** Powder Replacement of Cement. "Behaviour of concrete partially replacement of cement by steatite and polypropylene fiber. (Dr. T. Bhagavathi pushpa and S. Rajesh Kumar., 2016)"

[1], The interest in the use of fibers for the reinforcement of composites has increased during the last several years. Use of fibers show considerable improvement in tensile properties of concrete and also reduce shrinkage and cracks. In this study, the results of the Strength properties of concrete, setting time and pozzolanic activity of cement using polypropylene fiber and steatite have been presented.

Steatite powder and polypropylene are used as a replacement for cement.Cement is replaced with steatite powder by 30%, 25%, 20%, and 15%, mass of cement and 0.5 % of polypropylene fiber by weight of concrete isconstantly added for all mixes. Ordinary Portland cement of 53 grade is used. The strength properties will be compared with the conventional concrete for curing periods of 7, 14 and 28 days. The grade of concrete used in this project is M30 "Mechanical properties of self -compacting concrete containing silica fume and steatite powder (Padmanapam and N. Sakthieswaren., 2015)"[2],SelfCompacting Concrete which flows under its own weight and homogeneity while completely filling any formwork and passing around congested reinforcement. The experimentation is performed in M30 grade concrete, by nansu method for the volume fractions of Natural Steatite Powder were 0 to 15% by weight of cement content with 1.8% of conplast 430 as super plasticizer in SC The compressive strength, Split Tensile Strength and Flexural

Strength are being determined. "Properties of green concrete containing quarry rock dust and marble sludge powder as fine aggregate. (M. Shahul Hameed and A. S. S. Sekar., 2009)" [3], Green concrete capable for sustainable development is characterized by application of industrial wastes to reduce consumption of natural resources and energy and pollution of the environment.Marble sludge powder can be used as filler and helps to reduce the total voids content in concrete. Natural sand in many parts of the country is not graded properly and has excessive silt on other hand quarry rock dust does not contain silt or organic impurities and can be produced to meet desired gradation and fineness as per requirement. Consequently, this contributes to

improve the strength of concrete. Through reaction with the concrete admixture, Marble sludge powder and quarry rock dust improved pozzolanic reaction, micro-aggregate filling, and concrete durability. This paper presents the feasibility of the usage of quarry rock dust and marble sludge powder as hundred percent substitutes for natural sand in concrete. An attempt has been made to durability studies on green concrete compared with the natural sand concrete. It is found that the compressive, split tensile strength and durability studies of concrete made of quarry rock dust are nearly 14 %
more than the conventional concrete.The concrete resistance to sulphate attack was enhanced greatly. Application of green concrete is an effective way to reduce environment pollution and improve durability of concrete under severe conditions.
"Self-compaction high performance green concrete for sustainable development (M. Shahul hameed and A. S. S. Sekar., 2010)" [4], SelfCompacting Concrete (SCC) as the name implies that the concrete requiring a very little or no vibration to fill the form homogeneously. SCC is defined by two primary properties:
Ability to flow or deform under its own weight and the ability to remain adjusting the price of environment resources to elevate concrete's price, which will be helpful for protection of the environment and will promote the homogeneous while doing so. A sustainable industrial growth will influence the cement and concrete industry in many respects as the construction industry has environmental impact due to high consumption of energy and other resources. One important issue is the use of environmental-friendly concrete ("green concrete") to enable worldwide infrastructure growth without affecting the environment. The potential environmental benefit to society of being able to build with green concrete is huge.
Suitable environmental cost of producing concrete into the current price by advancement of concrete technology. The problems of sustainable development should be considered on the societyeconomy- technology level.
Fresh properties and basic strength characteristics, such as compressive strength, splitting tensile strength, with crusher rock and marble slurry dusts are the main focuses in this research. "Development of Self Compacting Concrete, Goodier, Nov 2003 (L V A Seshasayi, et al ., 33rd Conference on OUR WORLD IN CONCRETE & STRUCTURES: 25-27 August 2008 Singapore)" [5], This paper outlines a history of SCC from its origins in Japanto the development of the material throughout Europe. Europe are discussed, together with a look at the future for the material in Europe and the rest the world. The history and development of SCC can be divided into two key stages; its initial development I japan in the late 1980s and its subsequent introduction into Europe. SCC was developed from the existing technology used for high workability and underwater concretes where additional cohesiveness is required.The main barrier to the increased use of SCC in the UK and Europe seems to be the lack of experience of process, and the lack of published guidance, codes and specifications. "Experimental Methods on Glass Fiber Reinforced Self compacting Concrete (Deepak Raj A, et al IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN: 2278-1684)" [6], The purpose of this study is to investigate the workability and mechanical properties of plain SCC and GFRSCC. The laboratory testing included slump flow test, L-Box test, sieve segregation resistance test, density test, ultrasonic pulse velocity test, compressive strength test, splitting tensile strength test, and flexural strength test. With reference to the obtained test result we conclude that the addition of glass fibers does not affect the filling ability, passing ability and segregation resistance of the SCC.The glass added is maximum 1% of glass fiber in all sizes. "Effect of Polypropylene Fibers on Fresh and Hardened Properties of SCC at elevated temperatures (Arabic Nawwaf Saoud AL Qudi, et al., Australian Journal of Basic and Applied Science, 5(10): 378- 384,2012)" [7], This research present the result from an experimental study on the optimum amount of Polypropylene (PP) to be used in SCC to prevent spalling when exposed to elevated

temperatures.

"Rapid Chloride Permeability Test on Self-Compacting High Performance Green Concrete (M. Shahul Hameed, V.Saraswathi and A.S.S. Sekar.,2011)"[8], Self-compacting concrete (SCC) is one of the most significant advances in concrete technology in the last two decades.SCC was developed to ensure adequate compaction through self-consolidation and facilitate placement of concrete in structures with congested reinforcement and in restricted areas. Marble Sludge Powder (MSP) can be used as filler and helps to reduce the total voids content in concrete. Consequently, this contributes to improve the strength of concrete. An experimental investigation has been carried out to study the combined effect of addition of MSP and crusher rock dust (CRD) on the durability of self-compacting high performance green concrete SCHPGC. This paper aims to focus Chloride Permeability study of (SCHPGC) made with name implies that the concrete requiring a very little or no vibration to fill the form homogeneously. SCC is defined by two primary resistance of the SCC.

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3. Design Methodology

The main objective of the project is to investigate on self compactive concrete and strength and durability by using different test method.To investigate the properties of SC concrete in rc slab element.

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Upon the partial replacement of cement with flfly ash in self compacting concrete, the specimens developed good resistance to water absorption, rapid chloride penetration and permeability . Incorporation of ultra-fifine natural steatite powder (UFNSP) in SCC developed good mechanical properties and reduce segre gation up to 25% addition of steatite content SCC were produced successfully beyond which it could not meet certain parameters of SCC. And in terms of strength, the optimum strength was achieved at 15% addition of steatite in SCC mix after which the strength starts to reduce but up to 25% of steatite content in SCC mix has better strength that the control specimen. Hence in this durability study the optimum percentage of steatite as addictive is kept as 25%. However, to enhance the durability of the concrete, flfly ash is introduced in this study along with the UFNSP. Fly ash is added as a fifiller

4. Materials and Experiment

For producing the self-compacting concrete trial and error method based on European guidelines (EFNARC) was used. The 1st few trials end up with the negative results whereas after adopting the recommended guidelines in the 4th trial SCC was produced successfully and the mix proportions were obtained accordingly. The control specimen of self-compacting concrete was produced with the total cement content of 525 kg/m3 and the final mix ratio adopted for the study is 1:1.8:1.9 with the water powder ratio of 0.46. For test specimen fly ash is replaced with cement in 10%, 20% in both replacement level UFNSP is added in various percentage like 0%, 5%, 10%, 15%, 20%, 25% to the weight of cement. compressive strength of the hardened specimens was tested on cubes of size 150 mm × 150 mm × 150 mm conforming to specification of Indian Standard (IS) 10086: 1982 and the tests were carried out in accordance with IS 516: 1959 (reaffirmed 2004) in hydraulic compression testing machine of 2000 kN capacity. The microstructural behavior of the specimens is studied by

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
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Volume 14, Issue 2 | April 2023 Pages 13-21

scanning electron microscopy. Samples for scanning electron microscopy (SEM) analysis are taken near the surface (0-1 mm depth) of specimens. Microstructural studies utilized SEM (ZEISS) equipped with EDAX analyzer for microstructural observations of the surfaces, which is coated with evaporated copper for examination. SEM analysis is done at a maximum magnification of 1000x with energy 20 keV and a high resolution of 3.5 nm. For this analysis, samples of size 10 mm cubes were cut witha saw cutter.

5. Production of SCC

To produce controlled mix the following steps were taken during the batching process and Mixing process.

I. All the materials were kept ready inside the laboratory one day prior to casting.

II. The fine aggregate was tested for moisture content before the time of casting, and if there any change in moisture content corresponding correction was made in required water/powder ratio to produce the mix.

III. And to reduce the temperature effects the mixing of concrete was done in the early morning.

IV. One of the key aspects in production of SCC is proper mixing sequence and duration of mixing. For this purpose, the mixing sequence recommended by khayat et al. Based on that the mixing sequence and the duration was as fallows.

By using this method, the mix developed was noted to be highly workable and does not shows bleeding or segregation. And the cement paste is also found to be blended well with the coarse aggregate is followed for producing homogeneous mixes. As per this procedure initially the aggregates were mixed homogeneously in pan mixture for 0.5 min then form the entire water content

50% is added and mixed for another 1 min. Followed by that the aggregates were allowed to absorb water without disturbing for another minute. Afterwards,the total powder content was added and mixed for another 1 min finally the higher end superplasticizer and viscosity modifying agent were added with the remaining 50% of water is added to the pan mixture and mixed for another 3 more minutes and left undisturbed for another 2 min and the mixing is continued for final 2 min to obtain the SCC.

6. Sampling

Standard steel mould is used to produce the test specimen for the durability study. For each test three samples per mix were casted, cured, and tested the average value of the three specimens were considered for each test. Cube specimens of 100 mm size were casted for various test like sorptivity and water absorption. Disk specimens of 100 mm diameter and 50 mm were casted for rapid chloride penetration test. For the Bulk diffusion test specimens of size 20 cm height and 10 cm diameter were casted.

Fig 1 Preparation of specimen

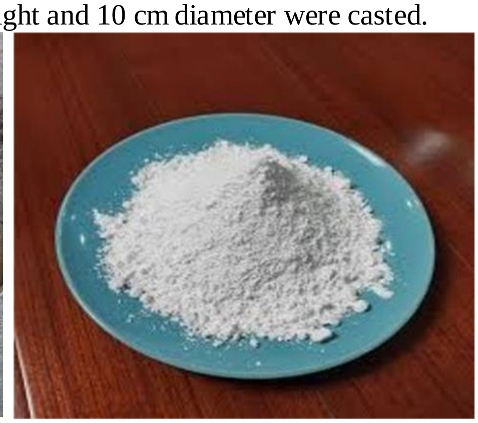

Fig 2 Steatite Powder

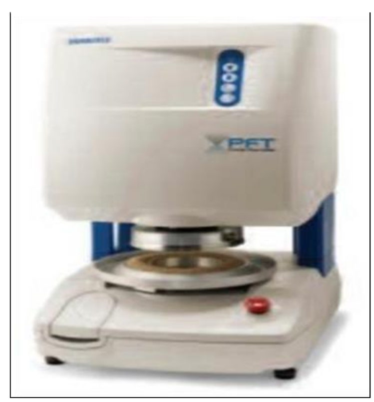

Fig 3 Steatite Powder flow Tester

NATIONAL JOURNAL ON INFORMATION AND COMMUNICATION ENGINEERING
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Volume 14, Issue 2 | April 2023 Pages 13-21

Specific Gravity of cement : 3.14 Specific Gravity of fine aggregate : 2.64 Specific Gravity of coarse aggregate: 2.74 The manufacturing of recycled concrete block: According to practice of professional concrete block producers, the whole mixture was subjected to the mechanical compaction machine in order to provide a later higher load bearing capacity and aesthetics to the new block. From the machine, the new blocks were covered with a plastic sheet for 24 hours to prevent rapid hardening. After 24 hours, the concrete blocks were cured in water (immersed) for 26 days. Then they were taken out of the water for surface drying for one day before the laboratory testing. The manufacturing process of the new block Concrete waste has been procured from the demolished site. The demolished waste was transported, crushed and segregated. Several tests on segregated concretes were conducted in the laboratory such as water absorption, sieve analysis, crushing value test, impact value test, and abrasion test, workability and crushing strength of natural &demolished waste by making cubes. The demolished waste should be sieved through a set of IS sieves to obtain a fitness of fine aggregate which was also replaced. To study the partial replacement of demolished waste in fresh (new) concrete, effect of demolished waste has been observed on the strength of concrete, by casting more than180 cubes of size 150mm in the laboratory using two no minimal mixes M15 & M20 (1:2:4 & 1:1.5:3). An effect of partial replacement of demolished waste has been made here to compare the strength of concrete. The same quality and required quantity of cement and fine aggregate have been used for both the nominal mixes, replacing fresh coarse aggregate by 0%, 25%,
50%, 75% and 100% demolished waste aggregate concrete for both mixes have been prepared and cubes were caste. Seven days and 28 days compressive strength of the cubes have been obtained. Ordinary Portland cement (53 grades) has been used in both the mixes.

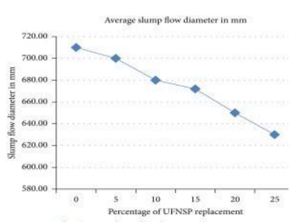

Fig 4 Result of slumpcone


Fig 5 Testing of slumpcone

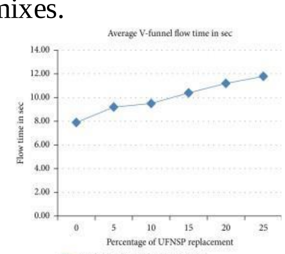

Fig 6 Result of V funnel


Fig 7 Testing of V funnel

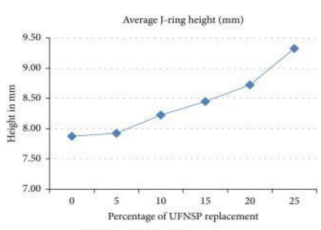

Fig 8 Result of JRing Test


Fig 9 Testing of JRing


Fig 10 Casting samples


Fig 11 Compression Testing

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Volume 14, Issue 2 | April 2023 Pages 13-21

S.NO	Mix Details	Replacement of UFNSP %	Average Slump Flow Diammeter in MM	Average Vfunnel Flow Time in (sec)	Average J-Ring Height (mm)
1	SCC	0	710	7.90	7.88
2	SCC5	5	700	9.20	7.93
3	SCC10	10	680	9.50	8.23
4	SCC15	15	672	10.40	8.45
5	SCC20	20	650	11.20	8.73
6	SCC25	25	630	11.80	9.33

Table 1 Result of Flow Table

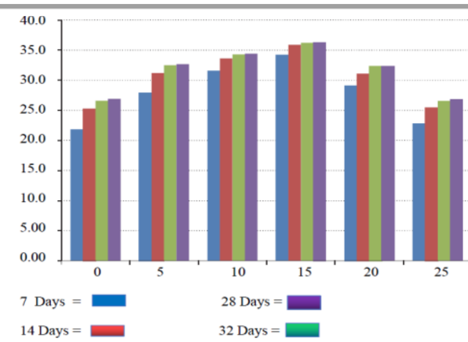

Fig 12 Compression Test On Hard Concrete Test At Different Age

7. Compression Test On Hard Concrete Test At Different Age

The compressive strength is tested on hardened concrete and The strength attainment of SCCCS, SCC5, SCC10, SCC15, SCC20, and SCC25 was 82%, 86%, 92%, 94%, 90%, and 86%,respectively, on 7 days and 95%, 96%, 98%, 99%, 97%, and 95% on 14 days. Through this, the SCC5 and SCC10 specimens are attaining 90% and above of designed strength on 7 days, which may be a notable parameter The 7 days' test shows that the SCC5,SCC10, SCC15, SCC20, and SCC25 has strength increment of about 28.21%,44.50%, 56.88%, 33.35%,4.59%, respectively, when compared to SCCCS. From the From the results on 14 days' test it was evident that the SCC5, SCC10, SCC15, SCC20,and SCC25 have strength increment of about 23.47%, 33.30%, 42.07%,22.71%, and 0.67%, respectively, in comparison with SCCCS. The 28 days'compressive strength for SCC5, SCC10, SCC15, and SCC20 has strength gain of about 22.18%, 28.95%, 36.09%, and 21.43%, respectively. The SCC25 specimens have a strength reduction of about 0.38% on 28 days in comparison with SCCCS. The 56 days' compressive strength for SCC5,SCC10, SCC15, and SCC20 has strength gain of about 21.38%, 27.88%,34.94%, and 20.33%, respectively. The SCC25 specimens have a strength reduction of about 0.37% on 56 days in comparison with SCCCS. Through the observations it was evident that until 14 days the strength of all replacement specimens increases. From 28 days the strength of SCC25 is almost similar to that of SCCCS and there is very little strength loss for SCC25 on 28 and 56 days' tests. The strength gain is due to the presence of right proportion of MS-and C-S-H [20]. The concrete attains its strength through the UFNSP; the reason behind this is the presence of Mg and reduced particle size of UFNSP,which facilitates the intrusion of particle in cement matrix [11–14]. The higher hydration rate is the main cause of early age strength attainment [21]. From the result it was clear that the strength attainment can be achieved until 20% replacement. The specimen with 25% UFNSP replacement is almost equal to and little lesser than SCCCS specimens on 28 days and 56 days.

8. Conclusion

From the present study it can be concluded that the replacement of UFNSP in self-compacting concrete system can have an influence on the work ability, flow of fresh concrete, compressive strength of hardened concrete,and micro structural properties. There was decrease in flow properties of SCC with increase in addition of UFNSP. The entire replacement percentage exhibits safer limit for the SCC, but the specimens with 25% of UFNSP replacement reach the limit where the typical limit ends, which confirms that further replacement is not possible in terms of flow properties. The early age strength attainment is seen in samples SCC5,SCC10, SCC15, and SCC20 even on 7 days' test where more than the target strength is achieved. The maximum strength is achieved in SCC15 specimens. The strength enhancement is seen on all replacement specimens, wherein the strength of SCC25 specimens is almost equal to that of SCCCS. The micro structures

Volume 14, Issue 2 | April 2023 Pages 13-21

of SCC10, SCC15, and SCC20 are denser and show denser magnesium hydroxide which has an effect on strength improvement.Further magnesium and silicate are mapped, which shows the dispersion over the surface and forms denser structures.

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