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STUDY ON STRESS STRAIN BEHAVIOUR OF FLY ASH SELF COMPACTING CONCRETE UNDER AXIAL COMPRESSION WITH OR WITHOUT CONFINEMENT

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ABSTRACT:

Analytical models for the full stress–strain relationship of confined and unconfined concrete in compression are required for the numerical simulation of the structural behavior of reinforced concrete structural elements. The experimental work was done to observe the effects taking place during replacement of the pond ash on fresh and solidified properties of SCC. Replacement of fly ash by weight of fine aggregates in various percentages such as 20%, 40%, 60%, by weight of cement is replaced as a mineral admixture to attain self-compacting concrete properties to predict flow behaviour. It is recognized that the stress-strain behavior of concrete under uniaxial compressive loading is influenced by the concrete constituents. A special type of concrete, i.e. self-compacting concrete (SCC) incorporating high-volume fly ash, has different constituents to that of conventional concrete. To investigate the effectiveness of transverse steel on M 40 grade concrete under monotonically increasing axial compression. The behavior of SCC cylinders confined by circular hoops and square prisms by rectilinear hoops with different volumetric ratios and spacing were compared under axial compression. The effects of the test variables such as volumetric ratio, spacing and shape of cross section on the behavior of SCC specimens are presented and discussed. The results revealed that the more the volume of confinement steel, more the increase in peak stress and deformability. The super plasticizer by 1% weight of cement is used to increase the workability of SCC. This replacement had proved to have some economic benefits as well as time effective techniques in concreting for the future.

I. INTRODUCTION

Sustainability is a major issue affecting the activities of concrete industries around the globe, because concrete is not a sustainable construction material for a variety of reasons. The main concern with using of concrete is that it requires a significant quantity of cement, the production of which generates CO2 emissions, which contribute to the greenhouse gas effect Attempts have been made to seek alternative construction materials with a smaller environmental impact, by reducing the amount of cement. One of these is the use of high-volume fly ash to partially replace cement content in the production of construction materials In previous research, a special type of concrete i.e. self-compacting concrete (SCC) was produced by incorporating high-volume fly ash to substitute the cement content in the range of 50–70% by weight. The influences of high-volume fly ash on short-term and long-term properties are noted To support the utilization of this type of concrete as a structural element, a reliable stress-strain relationship must be determined carefully. Complete stress-strain behavior of concrete is a very important characteristic from which fundamental parameters in the analysis and design of structural concrete elements can be developed It has been shown by previous researchers that the complete stress-strain behavior of concrete under uniaxial compressive loading is affected by the type of concrete being investigated. used recycled saturated coarse aggregate to substitute normal coarse aggregate at various percentages in the production of concrete. They confirmed that due to the low elastic modulus of recycled coarse aggregate compared to normal aggregate, the recycled aggregate concrete exhibited greater strains under similar stresses compared to the normal concrete. The effect of aggregate type on the stress-strain behavior was also suggested by Da et al The descending part of the complete stress-strain curve showed a sudden drop (no softening behavior) for concrete with corals as the substitute for aggregates. The no softening behavior of the descending part of the stress-strain curve was similarly observed in concrete with different types of cementitious material; i.e. Geo polymer Concrete The amount of coarse aggregates in SCC is lower compared to conventional concrete. On the other hand, the amount of fine particles, including cement, is higher in SCC This proportion of ingredients in SCC could be expected to give a different behavior to the stress-strain relationship.

An inclusion of high-volume fly ash to substitute a large quantity of cement in SCC may give further distinction to the behavior. The difference in the stress-strain behavior due to the difference in concrete composition could be explained by various fracture mechanisms at the meso- and macro-level, as suggested by Relatively

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higher and lower amounts of fine and coarse particles in SCC, compared to normal concrete, will affect the arrangement of particles of hardened concrete, which influences the stress distributions and concentrations via particle contacts, eventually triggering micro cracking in the weak bonding between aggregates and cementitious material. The micro cracking is accountable for the nonlinear stress-strain behavior in the pre peak region. Some of the micro cracks propagate and develop into stabilized cracks in a localized fracture zone, which affects the softening response in the post peak region Several models have been suggested to represent the complete stress-strain behavior of concrete under uniaxial loading Three of these were selected for the purpose of assessing the suitability of the models to capture the stresss train behavior of SCC incorporating high-volume fly ash.

Fly Ash:

Fly ash is also known as “pulverized fuel ash” is one of the coal combustion products and is composed of the fine particles that are driven out of the boiler with the flue gases. Fly ash is captured by electrostatic precipitators or particle separator equipment before the flue gases reach the chimneys of coal fired power plants. Depending upon the source and makeup of the coal being burned but all fly ash includes substantial amounts of silicon dioxide (SiO_2), aluminum oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal bearing rock strata Coal Fly Ash is classified as hazardous waste under Resource Conservation and Recovery Act (RCRA).Two classes of Fly Ash are defined by ASTM C618:

Figure: 1. Fly Ash

PRODUCTION AND CLASSIFICATION OF FLYASH:

A thermal station is a power plant in which the prime movers steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle. The greatest variation in the design of thermal power stations is due to the different fossil fuel resources generally used to heat the water. Some prefer to use the term energy center because such facilities convert forms of heat energy into electrical energy Certain thermal power plants also are designed to produce heat energy for industrial purposes of district heating , or desalination of water, in addition to generating electrical power. Globally, fossil fueled thermal power plants produce a large part of man-made CO_2 emissions to the atmosphere, and efforts to reduce these are varied and widespread.

Self -compacting concrete:

The concept of compacting and recognition of its contribution to obtain desirable properties of concrete is not novel. This technique has been adopted to maintain moisture and temperature conditions in a freshly placed compendious mixture to allow hydraulic cement hydration and pozzolanc reactions to occur so that the potential properties of the mixture may develop. In earlier stage though it has not received proper attention but nowadays it is found to be one of major concern in the study of concrete performance. However the concept of self-compacting has been developed and now been in practice to eliminate some problems occurred in case of traditional compacting. According to the definition provided in American Concrete Institute (ACI) Terminology guide self-compacting is “supplying water throughout a freshly placed cementations mixture using reservoirs, via pre-wetted lightweight aggregates, that readily release water as needed for hydration or to replace moisture lost through evaporation or self-desiccation From this definition two major objectives of objectives of self-compacting can be identified as maximizing hydration and minimizing self-desiccation along with its accompanying stresses which may cause early-age cracking. The principal contribution of self-compacting results in the reduction of permeability that develops from a significant extension in the time of compacting. Self-compacting reduces plastic shrinkage cracking and settlement. Also a life-cycle cost reduction was estimated when internally cured high performance concrete is used instead of normal concrete. So far different materials has been self-compacting such as super Absorbent Polymers(SAP),Wood Powder, crushed return concrete aggregates, rewetted light weight aggregates(LWA) expanded shale,clays, and slates.

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Figure 2 Self-compacting machine

II. METHODOLOGY

Concrete technology has made tremendous strides in the past decade. The development of specifying a concrete according to its performance requirements, rather than the constituents and ingredients has opened innumerable opportunities for producers of concrete and users to design concrete to suit their specific requirements. One of the most outstanding advances in the concrete technology over the last decade is "self-compacting concrete" (SCC). Self-compacting concrete is a highly flow able, stable concrete which flows readily into places around congested reinforcement, filling formwork without any consolidation and significant segregation. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as that of traditional vibrated concrete. The use of SCC eliminates the need for compaction thereby saves time, reduces labour costs and conserves energy. Furthermore use of SCC enhances surface finish characteristics.

SCC PRODUCTION

Production of SCC requires more experience and care than the conventional vibrated concrete. The plant personnel would need training and experience to successfully produce and handle SCC. In the beginning, it may be necessary to carry out more tests than usual to learn how to handle SCC and gain the experience.

Materials:

M40 Self Compacting Concrete design mix was used in the study. The materials consisted of 53 grade Ordinary Portland Cement confirming to IS 12269-1987 natural river sand belongs to zone II and crushed stone coarse aggregate of maximum size 20 mm confirming to IS 383- 1970, Type II fly ash obtained from Vijayawada thermal Power station confirming to IS: 3812, potable water for mixing and curing, super plasticizer admixtures (SP) and viscosity modifying agent (VMA) with satisfy the adequate fresh properties of SCC. To obtain the desired fresh properties and strength, several trial mixes were made and then the final mix proportion was determined after satisfying fresh and hardened properties. proportions and 28 days cube Compressive Strength. The properties of unconfined concrete were obtained by testing plain Cylindrical and Square specimens. Mild steel of grade 250 MPa with a 6mm diameter was used as lateral reinforcement.

Testing Procedure

The axial displacement of the specimens was recorded over a gauge length of 200mm using two dial gauges were attached on the two opposite faces of the specimen. The experimental setup is shown in Fig.2. The specimens were loaded in 1000 kN capacity strain controlled universal testing machine. The monotonic concentric compression was applied at a very slow strain rate. The load was applied from zero to failure. The time taken to complete each test ranged from 30 minutes to 50 minutes depending on the degree of confinement.

Figure3: Experimental Set up

Table1: Typical Chemical characteristics of fly ash

Constituents	Percentage
Carbon	2.10
Volatile matter	0.147
Fe2O3	8.83
MgO	0.84
Al2O3	27.73
SiO2	58.9
P2O5	0.17
SO3	0.24
K2O	0.79

Table2: Physical characteristics of fly ash

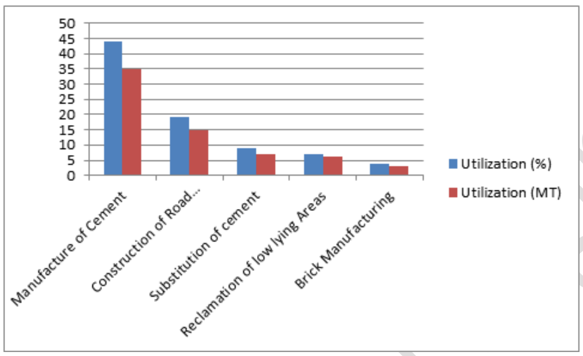
Colour	Percentage
Dry density, kg/m3	Light gray
Optimum moisture content ,%	1.208 g/cm3
Permeability m/sec	30
Liquid limit %	40.89
Plastic limit %	Non –plastic
Specific gravity	2.54

STATUS OF UTILIZATION OF FLY ASH:

Fly ash has got various applications in several areas and hence treated as by-product and not as a waste. Due to pozzolanic property, it is used as raw material for cement manufacturing. Some of the other major areas of current fly ash utilization are back filling in opencast mines, reclamation of low lying areas, stowing in underground mines, manufacturing of bricks, construction of road and embankments, structural fills.

Table3: Share of fly ash in various sectors

Area of Utilization	Utilization (%)	Utilization (MT)
Manufacture of Cement	44	35
Construction of Road Embankments	19	15
Substitution of cement	9	7
Reclamation of low lying Areas	7	6
Brick Manufacturing	4	3



Graph1: fly ash in various sectors

III. DESIGN PROCESS:

The key fresh properties of SCC are the filling ability, passing ability and segregation resistance. These three properties must be satisfied regardless of the sophistication of the mixture design and other considerations such as cost. Among other fresh properties, plastic shrinkage, unit weight and air content are noteworthy.

Filling ability: Filling ability is defined as the ability of fresh SCC to flow into and fill the spaces within the formwork under self-weight at unconfined condition It is associated with the formability, self-leveling capacity, and finishing ability of SCC. The filling ability is an essential property of SCC to achieve self-consolidation capacity. This property is crucial for concrete placement with proper casting technique. The filling ability primarily depends on the aggregate content, W/B ratio, binder content and HRWR dosage of concrete A good filling ability can be achieved by limiting the coarse aggregate content and increasing the amount of cementing materials, while adding a proper dosage of HRWR.

Passing ability: Passing ability is defined as the ability of fresh SCC to flow through tight openings or spaces confined by steel reinforcing bars Where structures are heavily reinforced, a good passing ability of SCHPC enables it to be placed and consolidated through dense reinforcing bars without any aggregate blockage. The factors affecting the filling ability also influence the passing ability of concrete. In addition, the passing ability depends on the number and spacing of the reinforcing bars. A good passing ability can be achieved by increasing the filling ability of fresh concrete and by limiting the segregation of coarse aggregates.

Segregation resistance: The segregation resistance of SCC refers to its ability to remain uniform during and after placement without any loss of stability due to bleeding, mortar separation and coarse aggregate settlement In particular, the distribution of aggregates becomes non-uniform if SCC does not possess sufficient segregation resistance. This might affect the properties and durability of concrete. A study has reported that the water absorption and chloride penetration of SCC can be affected under poor segregation resistance (Daczko 2002). A good segregation resistance can be attained in SCC by a proper mixture composition. An increased amount of cementing materials, a small nominal maximum size of aggregate, a limited content of well-graded coarse aggregates, and a low W/B ratio should be used to achieve good segregation resistance In addition, the segregation resistance of SCC can be improved by using VEA

IV. RESULTS AND DISCUSSIONS

Concrete is a construction material widely used in the infrastructure development, the properties of concrete may change after exposure to high temperature. Hence, it is important to understand the behaviour of concrete materials under elevated temperatures. It is essential that the structural engineers should have idea on mechanical properties of concrete subjected to high temperatures. The variations in the mechanical properties of concrete after exposed to high elevated temperature are to be investigated. When concrete is exposed to high temperature, strength and stiffness on concrete reduces significantly, due to loss of moisture, dehydration of cement paste and decomposition of aggregate. Due to these changes in the micro-structure of concrete, compressive, tensile and bending strength of the concrete is significantly reduced. To examine and repair the fire affected concrete members, it is essential to understand the effect of temperature on the mechanical properties of concrete, especially the stress-strain behaviour which

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determines the behavior of structural members under different loads. The stress strain relationship of conventional and high performance concretes (SCC) under elevated temperature may be different, due to the changes in the material properties. It was found from the literatures that the information is lacking on the stress-strain behaviour of SCC exposed to elevated temperatures. SCC can be made using suitable chemical and mineral admixtures which are available in the market. In the present study, an attempt has been made to understand the behaviour of SCC made with different mineral admixtures (FA, SF and MK) under elevated temperature. They varied the temperature from room temperature to 800°C. It was reported that compressive strength of SCC in hot state decreased with increase in temperature. They reported that the loss of strength depended on the grade of concrete, especially when the temperature was below 400°C. They found that higher grades of SCC were susceptible to higher loss of strength.

Fresh properties of SCC:

In order to find workability, tests like slump flow, T50 slump, V-funnel, L-box and U-box conducted for every percentage of replacement fly ash such as 20 %, 40 %, and 60 %. rom the test results, we can notice that as replacement increases time taking was increased for the flow ability. The entire experimental programme used to define the fresh and hardened properties of the SCC. The test results for fresh properties are given below.

V FUNNEL TEST:

This test measures the ease of flow of the concrete; shorter flow times indicate greater flow ability. For SCC a flow time of 10 seconds is considered appropriate. The inverted cone shape restricts flow, and prolonged flow times may give some indication of the susceptibility of the mix to blocking. After 5 minutes of settling, segregation of concrete will show a less continuous flow with an increase in flow time.

L BOX TEST METHOD:

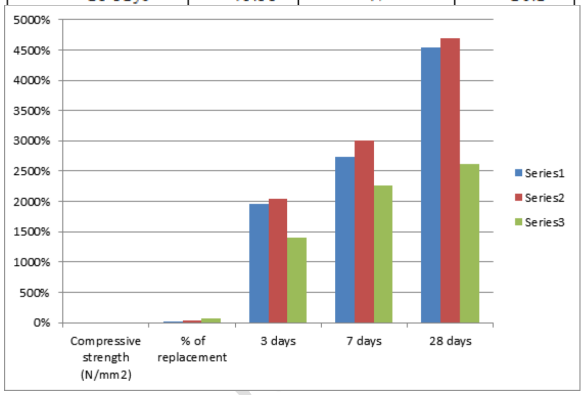
If the concrete flows as freely as water, at rest it will be horizontal, so H2/H1 = 1. Therefore the nearer this test value, the „blocking ratio", is to unity, the better the flow of the concrete. The EU research team suggested a minimum acceptable value of 0.8. T20 and T40 times can give some indication of ease of flow, but no suitable values have been generally agreed. Obvious blocking of coarse aggregate behind the reinforcing bars can be detected visually.

Test	Limits	20 %	40%	60%
Slump flow	650-800 mm	680 mm	620 mm	725 mm
T 50 slump flow	2-6 sec	5.78 sec	5 sec	5.2 sec
V-Funnel	6-12 sec	6 sec	6 sec	8 sec
L-Box (H_2/H_1)	0.8-1.0	0.9	0.8	0.8
U-box (H_2-H_1)	0-30 mm	29 mm	10 mm	0 mm

Table4: Test Results for SCC

Table5: Compressive strength of M 40

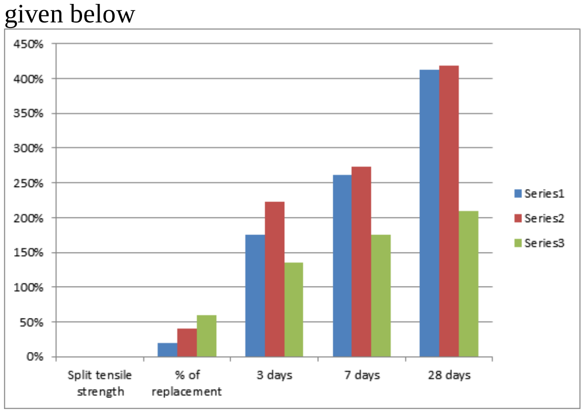
% of replacement	Compressive strength (N/mm²)		
	20%	40 %	60%
3 days	19.6	20.5	13.96
7 days	27.4	30	22.6
28 days	45.33	47	26.2



Graph2: Compressive strength of M 40

Split tensile test:

Split tensile (ductile) quality strength test cylinder specimens are cast by changing the confinement in the form of hoops. For 20% replacement 0.267% of confinement provided by 2 hoops similarly for 40 % confinement of 0.330% of 3 hoops, 60% replacement confinement 0.412% of 4 hoops for 60 % replacement during testing, specimen failed totally. And strength decreases as the percentage of replacement increases. Results are given below



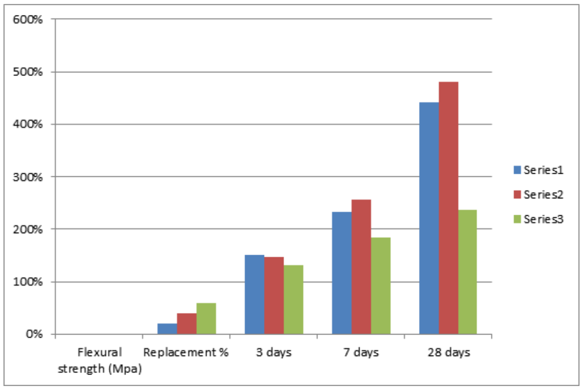
Graph3: Split tensile strength M40

Flexural strength

The destructive test on beams of specimens of standard sizes 150x700 mm. By differentiating the confinements at 0.026% for 20% replacement, 40% replacement with confinement 0.0465% similarly 60% replacement with 0.0631% provided Average mean of 2 beams taken for curing period of 3, 7 & 28 days for every replacement At 60 % replacement taken a long time to settle more than 30 hours.

Table7: Flexural strength M40

Replacement %	Flexural strength (Mpa) 20%	40%	60%
3 days	1.51	1.47	1.321
7 days	2.33	2.57	1.85
28 days	4.425	4.80	2.365



GRAPH4:Flexural strength M40

V. CONCLUSION:

Concluded that the results of confined circular and square M40 grade SCC specimens subjected to axial compression. A comparative study of existing stress-strain models for normal strength concrete is also reported. The following conclusions are derived based on the experimental results.

- An increase in volume of transverse reinforcement directly improves both the strength and ductility of confined SCC. The increase in strength was found to be 24% at 0.912% volume of transverse steel and 42% at 1.824% volume of transverse steel for circular sections.
- The ductility i.e. the ratio of the strain at peak stress of confined concrete to the strain at peak stress of corresponding unconfined concrete, varied from 21% to 51% for 0.912% to 1.824% of volumetric ratio for circular specimen.
- Circular sections with circular hoops as confinement are more effective than square sections with rectilinear confinement. The percentage increase in strength was 42% and 30% for circular sections and square sections respectively at 1.824% volume of transverse steel.

The different experimental programmes are conducted such as compressive quality test, split tensile strength and flexural strength for cubes, cylinders & beams that are carried out on the specimens to calculate the strength and durability properties of prepared concrete specimens and results obtained from the experimental programmes.

- By observing the experimental results 40% replacement is optimum. As a part of using pond ash, we noticed settlement undergoes long time to settle.
- After that 60 % replacement of any by-product was not good for usage.
- By providing the confinement at different percentages use to increase strength at 28 days.
- The results of confinement show that there is an increase in the volume of transverse confinement tends to increases the strength and ductility of concrete.

References:

1. Cusson D. and Paultre P.“Stress-Strain model for confined high strength concrete”, ASCE Journal of Structural Engineering, 2001, 121 No. 3, 468-477.
2. .Mugurama H., Nishiyama M., and Watanabe F. “Stress strain curve for concrete with a wide range of compressive strength”, Procedings of Symposium on High Strength Concrete, Lille hammer, Norway, 1993, pp. 314- 321
3. Mehta P. K., Conference Proceedings of the International Workshop on Sustainable Development and Concrete Technology, Edited by K Wang, Beijing, China, 2004, pp. 3-14
4. Balakrishnan B., Awal A. S. M. A., Flow Properties and Strength Behaviour of Masonry Mortar Incorporating High Volume Fly Ash. International Journal of GEOMATE, Vol. 12, Issue No. 3 (SI. No. 31), 2017, pp. 121-126.
5. Jayaprithika S., Sekar S. K., Stress-strain Characteristics and Flexural Behaviour of Reinforced Eco-friendly Coconut Shell Concrete Construction and Building Materials, Vol. 117, 2016, pp. 244-250
6. Da Y., Yu H., Ma H., Tan Y., Mi R., Dou X., Experimental Investigation of Whole Stres-sstrain Curves of Coral Concrete. Construction and Bilding Materials, Vol. 122, 2016, pp. 81-89
7. Samani A. K., Attard M. M., A Stress-strain Model for Uniaxial and Confined Concrete Under Compression. Engineering Structures, Vol. 41, 2012, pp. 335-349
8. Gergely A. Sik, Salem G. Nehme, and Cecília Sik-Lanyi, 2012, The optimization of Self Compacting concrete (SCC), production scheduling- specially the effect of fine aggregate, IACSIT International Journal of Engineering and Technology, Vol. 4, No. 4,