International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL STUDY ON SELFCOMPACTING RC BEAMS REINFORCED WITH POLY-VINYL MESH ON ALTERNATIVE PHASES AS SHEAR REINFORCEMENT

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Abstract - This research looked into the behaviour of an SCC reinforced concrete (RC) beam with a poly-vinyl mesh as an extra reinforcement. The use of PVC in concrete gave synthetics a whole new meaning in structural engineering. The purpose of examining the behaviour of PVC in structural members gives opportunity to observe benefit and feasibility of using PVC for wrapping reinforcement. In this research fly ash is used as mineral admixture for constructing SCC. The optimum percentage of flyash content is considered for this research .the fresh and hardened properties of SCC where tested and satisfied. A RC beam of conventional SCC is casted and compared with beam which is provided by double spaced reinforcement and PVC is wrapped on alternate phases of reinforcement. The mix design of SCC done As per IS.10262:2019 and EFNARC specifications. The test results for acceptance characteristics of self-compacting concrete such as slump flow, T50 cm slump flow test, V-funnel and L-Box are presented. The shear behaviour of RC beam is studied and compared with conventional SCC beam. Hence obtained similar results of conventional SCC.

***Key Words*: SCC (Self compacting Concrete), PVC (Poly Vinyl Chloride)**

1. INTRODUCTION

Concrete is the most common and widely used structural material in the construction area. It is more versatile but modern day engineering structures require more standard concrete owing to the huge applied load on smaller area and increasing adverse environmental aspects. This research looked into the behaviour of an SCC reinforced concrete (RC) beam with a poly-vinyl mesh as an extra reinforcement. The use of PVC in concrete gave synthetics a whole new meaning in structural engineering. The purpose of examining the behaviour of PVC in structural members gives opportunity to observe benefit and feasibility of using PVC for wrapping reinforcement

The properties of PVC are less rigid; has high impact strength; is easier to extrude or mould; has lower temperature resistance also less resistant to chemicals, and usually has lower ultimate tensile strength. Poly vinyl chloride mesh is used here to wrap the reinforcement for check the shear capacity that can be taken. Property enhancement by molecular orientation is known and some industrial examples have been produced for over thirty years. In more recent times, it has been applied to consumer products such as films, high strength garbage bags, some carbonated bottles etc.

Self-compacting concrete (SCC) has many benefits in of production and placement compared to traditional concrete, elimination of external or internal vibration for compaction, flowability, workability and pumpability, as well as increased bonding with congested reinforcement. The placement of SCC is easy and speed and requires less labour. The appearance, mechanical performance and durability of SCC can be considerably better than traditional concrete

2 .MATERIALS USED

2.1 Cement

Ordinary Portland Cement (53 grade) – SHARJAH CEMENTS confirming to IS 12269- 1987 was used for the experimental programme. Tests were conducted as per IS: 1489 (Part I). The properties of the cement are tabulated in Table.The various tests conducted on cement are fineness of cement , standard consistency test , specific gravity , initial and final setting time and compression test on mortar cube.

Table-1: PropertiesofOPC53grade cement

Properties	Test results	Technical reference
Specific gravity	3.12	IS4031(PART11):1988
Consistency (%)	30	IS4031(PART4):1988
Fineness ofcement (%)	4.7	IS4031(PART2):1996
Initial setting time (minutes)	78	IS4031(PART5):1988

2.2 Fine Aggregate

M – Sand was used as fine aggregate. Laboratory test were conducted on fine aggregate to determine the different physical properties as per IS 2386 (Part – III) – 1963 and IS: 383- 1970.The properties of fine aggregate are given in Table 3. 2. Test conducted on fine aggregate were grain sieve analysis, specific gravity, bulk density

Table-3: Properties of FineAggregate

Properties	Test results
Specific gravity	2.52
Fines modulus	3.84
Free surface moisture	Nil

2.3 Coarse Aggregate

Aggregate passing through 20 mm IS sieve and retained on 4.75 mm IS sieve is considered as coarse aggregate. Various tests on coarse aggregate were conducted based on IS: 2386 (Part I and Part III) – 1963 and IS: 383 – 1970.The properties of coarse aggregate determined as given in Table 3. 3. Tests conducted on coarse aggregate were grain sieve analysis, specific gravity, and bulk density.

Table-4: PropertiesofCoarseAggregat*e*

Properties	Test results	Technical reference
Specific gravity	2.69	IS2386(PART3):Clause 2.4.2
Free surface moisture	Nil	IS383(PART3):1970
Finenessm odulus	4.25	IS383(PART3):1970 table 2

2.3 Water

Water is required to wet the surface of aggregate to develop adhesive quality as the cement paste binds quickly and satisfactorily to the wet surface of the aggregates than dry surface. It is commonly accepted view that any portable water is suitable to be used in concrete making. It should have inorganic solid less than 1000 ppm and should be free from injurious quantities of alkalies , acids ,oils, salts, sugars, organic materials, vegetable growth or other substance that may be harmful to bricks, stones, concrete or steel.

2.4 Admixture

Admixtures are defined as a material other than water, hydraulic cement, aggregates and fiber reinforcement, used as an ingredient of concrete or mortar, and added immediately before or during its mixing.Chemical admixtures are used to increase the quality of concrete during their entire process

They fall into the following categories.

- Air entrainers
- Water reducers
- Set retarders
- Set accelerators
- Super plasticizers

MASTER RHEOBUILD 1126ND is an admixture of a new generation based on modified poly carboxylic ether. The product has been developed for utilize in high performance concrete where the highest durability and performance is required. Master Rheobuild 1126ND is free of chloride & low alkali. It is compatible with all types of cements. Master Rheobuild 1126ND has a different chemical structure from the other superplasticisers.At the beginning of the mixing process it initiates the same electrostatic dispersion mechanisms the other super plasticisers, but the side chains linked to the polymer back bone generate which greatly stabilizes the cement particles' ability to separate and disperse. Rich in drance provide physical barrier (along side the electrostatic barrier) between the cement grains. With this process, flowable concrete with reduced water content is obtained.

Table 4 Properties of Master Rheobuilt

Aspect	Dark brown liquid
Relative density	1.24±0.02 at 25°
pH	≥6
Chloride iron content	<0.2

2.5 Poly Vinyl Chloride Mesh (PVC Mesh)

Vinyl mesh fabric is an open weave, durable and flexible fabric. Use coated mesh in a variety of applications from tennis court screens, garden tarps, barrier fabric and muchmore .Vinyl coated polyester open mesh fabrics, or PVC-PES Mesh, are strong and durable fabrics, a popular choice in tensile fabric and membrane architecture. The base material comprises of a woven high tenacity polyester base fabric grid and a flexible plasticised PVC coating which protects the grid from all sides. It is possible to apply coatings or lacquers, for example, dirt repellent surface lacquers, to enhance the performance of these mesh fabrics. There are certain mesh openings available. PVC Coated Mesh

(PCS) consists of two components: liquid vinyl (PVC) compound and knit polyester scrim. PVC is applied to mesh and is heat cured. Like our laminate products, the PCS products contain anti-bacterial heat stabilizers agents, mildew inhibitors, UV and heat stabilizers heat stabilizers

Table 5 Properties of PVC

SL. NO.	Chemical Composition	Result
1	Silica(SiO_2)	18.59
2	Iron Oxide(Fe_2O_3)	3.04
3	Alumina(Al_2O_3)	4.56
4	Calcium Oxide(CaO)	60.34
5	Magnesium oxide(MgO)	1.92
6	Total sulphur(SO_3)	2.89
7	Potassium oxide (K_2O)	0.64

3.7 Flyash

Flyash is a fine powder that is a byproduct of burning pulverized coal in electric generation power plants. Flyash is a pozzolanic material, a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water, flyash will be change in the similar form of Portland cement. As per IS 3812: 2003, the generic name of the waste product due to burning of coal or lignitein the boiler of a thermal power plant is pulverized fuel ash. Pulverized fuel ash can be flyash, bottom ash, pond ash or mound ash. Fly ash is the pulverized fuel ash extracted from the fuel gases by any suitable process like cyclone separation or electrostatic precipitation.

According to IS 3812-1981, there are two classification of Fly Ash

- Grade I flyash, which are derived from bituminous coal having fractions SiO2+ Al2O3+Fe2O3 greater than 70 %.
- Grade II Flyash which are derived from lignite coal having fractions SiO2+ Al2O3+ Fe2O3 greater than 50 %

Table 6 Physical Properties of Class F Flyash

SL. NO.	Physical property	Test Result
1	Colour	Grey
2	Specific Gravity	2.3

Table 7 Chemical Composition of class F Flyash

SL. NO.	Chemical Composition	Result
1	Silica(SiO_2)	62.5
2	Iron Oxide(Fe_2O_3)	3.5
3	Alumina(Al_2O_3)	23.4
4	Calcium Oxide(CaO)	1.8
5	Magnesium oxide(MgO)	0.34
6	Total sulphur(SO_3)	1.2
7	Potassium oxide (K_2O)	0.95

3. EXPERIMENTAL STUDY

3.1 SPECIMEN DETAILS

Beam of size 150 mm x 200 mm x 1250 mm was used for the experiment.

Table 8 Reinforcement Details

Main Reinforcement	Anchor Bars	Shear reinforcement
2#8mm	2#6mm	8mm dia @180mm c/c

3.2 TEST SET UP

Two point bending test provides values for the modulus of elasticity in bending Ef , flexural stress σ f , flexural strain εf and the flexural stress – strain response of the material. This test is very similar to three points bending flexural test. The major difference being that with the addition of fourth bearing points is put under maximum stress as opposed to only the material right under the central bearing in the case of three point bending.

This difference is of prime importance when studying brittle materials, when the number and severity of flaws exposed to the maximum stress is directly related to the flexural strength and crack initiation. Compared to the three point bending flexural test, there are no shear forces in the four point bending flexural test in the area between the two loading pins. The four point bending test is therefore particularly suitable for brittle materials that cannot withstand shear stress very well. It is commonly used apparatus to characterize fatigue and flexural stiffness of asphalt mixtures.

Beams have a same total length of 1250 mm, same width of 150 mm and same depth of 200 mm. The longitudinal reinforcement is calculated using IS 456-2000 code [24] to obtain shear failure and is equal for all beams. The main lower reinforcement is 2-6 mm in diameter and 8 mm diameter stirrups. The steel cover used is 25 mm. All beams using Self Compacting Concrete. Normally curing can be done using jute bags with room temperature for 28days.The compressive strength of the concrete mix was measured after 28 days using standard cubes. The mean compressive strength (cube) for the mix was 37.25 MPa.

The shear strength of the specimens was tested using a 30 ton loading frame. A dial gauge was attached at the bottom of the beam to determine the deflection at the centre of the beam. For the testing of the specimen the supports are provided at a distance of 130 mm from the edges of the beam. The effective span of the beam is taken as 990 mm in the case of 1250 mm beam. A proving ring of 500 kN is connected at the top of the beam to determine the load applied.

The shear strength of the beam is tested as a three point loading system using a hydraulic jack connected to the loading frame. The behaviour of beam is carefully observed from beginning to the failure. The loading was stopped when the beam was just on the end of collapse. The first crack propagation and its development are observed keenly. The values of load verses deflection are noted directly and further the plot of load vs. deflection is performed which is taken as the result. The load in kN is applied with uniformly increasing the value of the load and the deflection under the different loads is noted. The applied load is increased up to the breaking point or till the failure of the material.

4. RESULTS

4.1 Load Deflection Behaviour

Due to increase in the load, deflection of the beams emerge, up to certain level the load v/s. Deflection graph will be linear where load will be directly proportional to deflection. Due to further increase in the load, the load value will not proportional to deflection, when the deflection values increases as the strength of the materials goes on increasing material loses elasticity and undergoes plastic deformation. The deflection and the corresponding load, of SCC beam with alternate placing of PVC mesh reinforcement is compared with SCC beams with conventional reinforcement arrangement.

Table 9 Deflection and Corresponding Loads

Deflection (mm)	Control specimen(KN)	Alternative phased double spaced(KN)
0	0	0
0.5	9.11	9.22
1	19.25	20
1.5	28.01	28.22
2	38.02	39.22
2.5	48.77	49.33
3	48.77	49.33

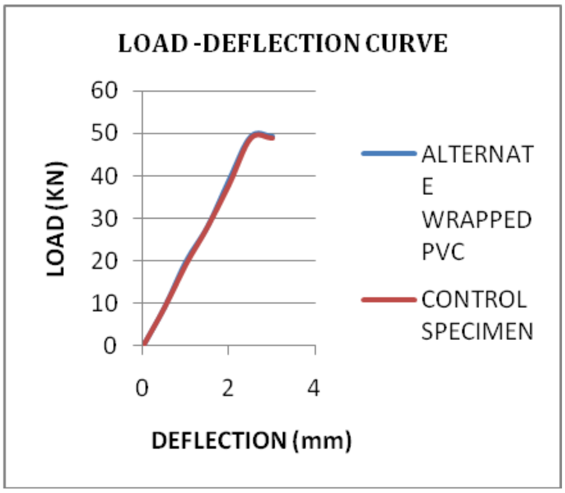

Fig. 1 Load Deflection Curve

4.2 Ultimate Load Carrying Capacity

The ultimate load carrying capacity of PVC mesh beams were found to increase as the the placement of mesh changes like full phase is more better, because of contribution by PVC Mesh in load carrying capacity. As compared with conventional SCC beam the PVC Mesh beam has same strength or some slight variation. When PVC mesh beam is placed in full phase doubly reinforced, the ultimate load carrying capacity of beam is slightly higher. A special type of load vs. deflection behavior is observed because of using PVC Mesh as reinforcing material. From the result it was found that the PVC reinforced beam with full phased with doubly reinforced exhibit as same load or slightly greater than carrying capacity of control SCC beam.

4.3 First Crack Load

The first shear cracks were formed at bottom surface in the maximum moment region at the mid span of the beams when the applied load was approximately increased. As the applied load increased, the cracks began to spread out through the length of the beams and became perpendicular towards the neutral axis beams. These values vary among different beams depending on transverse reinforcement ratios (ρt) and spacing of the stirrups for each group. In the under reinforced section beam, the member approaches failure due to gradual reduction of compression zone, which shows cracks developed at the soffit and progress towards the compression face. It can be observed that the cracks in the control specimen are mainly shear and the specimens with PVC in fully and alternate wrapped also mainly shear.

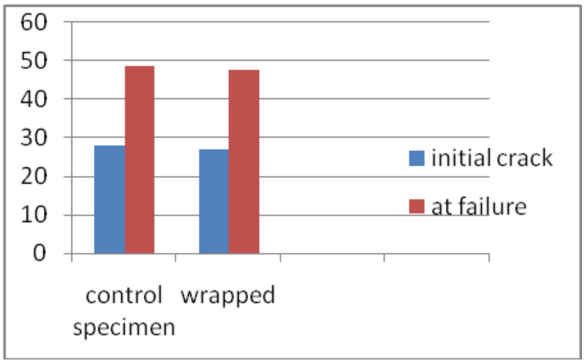

Fig 2 initial crack load and final load of specimen

4.4 Ductility

The ratio between the deflection at ultimate load and the deflection at yielding load of the RC beams was defined as ductility index .The rate of increase in the ductility index from beam without PVC Mesh reinforcement to that with alternate phase of mesh was higher. Moreover, a significant increase or same in the ductility index was observed when using of PVC mesh compared to that of control beam .The load deflection curves show that the ductility of the specimen increases with changing the placement like fully wrapped.

4.5 CRACK PATTERN AND CRACK LOAD

The first flexural cracks were formed at bottom surface in the maximum moment region at the mid span of the beams when the applied load was approximately increased. In the under reinforced section beam, the member approaches failure due to gradual reduction of compression zone, exhibiting and cracks, develop at the soffit and progress towards the compression face.

The modes of failure of beams are as follows

- All Reinforced concrete beams failed in shear zone
- After the first crack load, the reinforcement started yielding and more number of cracks have formed in the shear zone and extended towards the point loads with increment in loads.

Fig 3 crack in fully wrapped double spaced

5. CONCLUSIONS

An experimental study looked into the behaviour of self-compacting reinforced concrete beams withPVC Meshes. One conventional beam and three PVC beams are casted. These beams were tested using two-point loading.

- When PVC s are kept in the tension zone of reinforced concrete beams, they also carry tensile pressures.
- While comparing with conventional SCC beams the wrapped one shows greater strength
- PVC is also utilised as a supplementary reinforcing material in RC beams when increased strength and reduced deflection and cracking are required.

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