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Behaviour of fibre reinforced beam column joint under cyclic loading

[1]A.Anjana, Department of Structural Engineering, Prathyusha Engineering College, Chennai.

[2]K.S.Divya, Department of Structural Engineering, Prathyusha Engineering College, Chennai.

Email id: anjanaashok07@gmail.com

Abstract - **In earthquake resistant design, it is important to ensure the ductility in the structure, i.e., the structure should be able to deform inelastically and dissipate energy without causing collapse. In frame structure, the bending moment and shear force are maximum in the junction area. So beam-column joint is one of failure zone. During earthquake large forces are applied on the Structure which leads to failure of the beam-column joint. Many researchers have done research on joints using different techniques, materials and introduced many repairing methods to enhance the resisting capacity of joints. From literature, it has been observed that glass fibres have enhanced many desirable properties of concrete. Hence, the fibrous material can be introduced in these joints to enhance joint property. The use of fibre reinforced polymer for structural strengthening and rehabilitation is becoming more popular due to its high strength to weight ratio, good fatigue life, good corrosion resistance and low maintenance cost. The fibre reinforced polymer laminates are introduced to enhance the flexural capacity and ductility. The addition of randomly distributed discrete fibres to the structural concrete increases its stiffness, ductility and load carrying capacity with reduced cracks. Fibres are effective in arresting both micro and macro cracks. In this study, we are going to prepare a glass fibre reinforced laminate and cure it for 18 hours, then it can be divided into small parts and added with concrete to increase the flexural capacity of beams. An experimental investigation is carried out on a concrete containing GFRP laminated parts in the certain range by weight of concrete. Material was produced, tested and compared with conventional concrete in terms of workability and strength.**

The present experimental investigation deals with the comparison study of fibre reinforced concrete with the conventional concrete. Here the cyclic loading is carried out to know about the load deformation characteristics of the specimen and also the other parameters such as ductility and energy absorption capacity are investigated.

Key words: Ductility, Fibre reinforced polymer laminates, Cyclic loading.

1. INTRODUCTION

Beam-column joint is an important component of a reinforced concrete moment resisting frame and should be designed and detailed properly, especially when the frame is subjected to earthquake loading. In RC buildings, portions of columns that are common to beams at their intersections are called beam-column joints. Since their constituent materials have limited strengths, the joints have limited force carrying capacity. When forces larger than these are applied during earthquakes, joints are severely damaged. Repairing damaged joints is difficult, and so damage must be avoided. Thus, beam-column joints must be designed to resist earthquake effects. Under earthquake shaking, the beams adjoining a joint are subjected to moments in the same (clockwise or counter-clockwise) direction. Under these moments, the top bars in the beam-column joint are pulled in one direction and the bottom ones in the opposite direction. These forces are balanced by bond stress developed between concrete and steel in the joint region. If the column is not wide enough or if the strength of concrete in the joint is low, there is insufficient grip of concrete on the steel bars. In such circumstances, the bar slips inside the joint region, and beams lose their capacity to carry load. Further, under the action of the above pull push forces at top and bottom ends, joints undergo geometric distortion; one diagonal length of the joint elongates and the other compresses. If the column cross sectional size is insufficient, the concrete in the joint develops diagonal cracks. This can be avoided by introducing fibres in the concrete. The fibre reinforced polymer laminates are introduced to enhance the flexural capacity and ductility. Fibres are effective in arresting both micro and macro The addition of randomly distributed discrete fibres to the structural concrete increases its stiffness, ductility and load carrying capacity with reduced cracks.

I. EXPERIMENTAL INVESTIGATION

In the experimental investigation, all the materials used for the production of concrete was tested and its values are within the specified limit

A.MATERIALS USED

a. CEMENT: Ordinary Portland cement type (grade 53) was used for this investigation and it is confirm to the IS 12269-2013. Physical properties of cement are given in the below table.

Table 1 Physical properties of cement

S.	PHYSICAL	RESUL

NO	PROPERTIES OF CMENT	T
1	Specific gravity	3.15
2	Initial setting time	35
3	Final setting time	450

b. FINE AGGREGATE:

River sand confirming to the code IS 383-1970 is used as fine aggregate. Physical properties of fine aggregate are given in the below table.

Table 2 Physical properties of fine aggregate

S.NO	PHYSICAL PROPERTIES OF COARSE AGGREGATE	RESULT
1	Sieve analysis	2.522
2	Specific gravity	2.68
3	Bulk density	1402kg/m^3

c. COARSE AGGREGATE:

Aggregates are tested as per code IS 383-1970**.** Physical properties of coarse aggregate are given in the below table.

Table 3 Physical properties of coarse aggregate

S.NO	PHYSICAL PROPERTIES OF COARSE AGGREGATE	RESULT
1	Sieve analysis	2.522
2	Specific gravity	2.68
3	Bulk density	1402kg/m^3

d.WATER:

Ordinary tap water is used for mortar preparation. Water should be clean and free from organic materials and deleterious amounts of dissolved acids, alkalies, and salts.

e. GLASS FIBRE REINFORCED POLYMER:

Glass fibre (or fibre glass) is a material consisting of numerous extremely fine fibres of glass. Glass fibres are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fibre-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fibreglass".

Table 4 physical properties of Glass fibre

PROPERTIES	E-GLASS
Colour	White
Technical data of fibre	E-glass,610gsm
Tensile strength(Gpa)	3.5
Modulus of elasticity	73.5
Density(g/cc)	2.57

f. Mix Proportion:

A mix design for M30 grade concrete was done as per IS 456 – 2000. The water to cement ratio in the production of concrete is taken as 0.45 weight % of cement.

Table 5 Mix Proportion

CEMENT(kg/m^3)	FINE AGGREGATE(kg/m^3)	COARSE AGGREGATE(kg/m^3)	WATER(kg/m^3)
413.33	770.089	1054.024	186
1	1.86	2.55	0.45

GFRP REPLACEMENT TO THE WEIGHT OF COARSE AGGREGATE

1% GFRP = 1054.02 × (1/100) = 10.540 kg/m^3

1.25 % GFRP = 1054.02 × (1.25/100) = 13.175kg/m^3

III. EXPERIMENTAL WORK

A.CASTING AND CURING OF GLASS FIBRE REINFORCED POLYMER CONCRETE

The test specimens are cast in cast iron steel moulds. The moulds were applied with oil in the inner surfaces for easy removal of specimens after demoulding. The concrete is placed in the mould in three layers of equal heights and placed on the vibration table for proper compaction. After 24 hours, the specimens are demoulded and placed in water tank for curing till the age of testing to be done. The dimension of the test specimen is 150mmx150mmx150mm.

B. COMPRESSIVE STRENGTH TEST

All the cubes were tested under drying condition, after drying the surface of the specimens containing moisture in it. For each mix proportion three cubes were tested at 28 days using compression testing machine of 3000kN capacity. The tests were carried out at a uniform rate stress level with the specimen properly placed and centered in the testing machine. Load was applied gradually with the help of hydraulic pumps until dial gauge reading just get reverses its direction of motion. The reverse of needle indicates the total failure load of specimen. The dial gauge reading is noted at the instant of failure, which is ultimate load of specimen. From that the compressive

strength of the cube is calculated by dividing the cross sectional area of cube specimen from ultimate load. The compressive test results are given in the table below

SPECIMEN DETAILS	WEIGHT OF THE SPECIMEN(kg)	ULTIMATE LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)
GFRP -1%	8.160	764	33.96
GFRP -1.25%	8.215	792	35.20

C. SPECIMEN DETAILS

SIZE OF T-BEAM

Flange of t-beam = 200mmx150mm

Web of t-beam = 150mmx125mm

IV. CONCLUSION

The experimental work consists of testing three t-beams with different percentage of glass fibre reinforced polymer. The flange portion of t-beam has a cross section of 200 mm x 150 mm with an overall height of 1000 mm and the web portion has a cross section of 150 mm x 125 mm with cantilever length 800 mm. Here the t-beam is casted and kept for curing. After that cyclic loading has to be carried out to know the flexural strength of the beam and the other factors such as ductility and energy absorption capacity.

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