Comparitive Study on Behaviour of Deep Beams

S. Raja Reddy, B. Sarath Chandra Kumar, A. Monica

Abstract: A Deep beam is having a greater depth comparable to the span length. According to Is.456-2000 provisions deep beam is defined as span to depth ratio less than 2.0 for simply supported beam and 2.5 for continues beams. This experimental setup consists of specimens of length 1200 mm X 200 mm X 600 mm, 1100 mm X 200 mm X 600 mm and 1000 mm X 200 mm X 600 mm. The flexural, shear, crack pattern of reinforced concrete deep beams with different l/D ratios. The width of bearing plate, depth, the percentage of tension reinforcement, and the percentage of vertical and horizontal shear reinforcement are constant under three-point loading using loading frame are tested. The experimental results show the Load V_s Deflection and crack width of the beam. The experimental results are compared with code results.

Index Terms: Bearing plate, crack pattern, flexural, shear, crack width.

I. INTRODUCTION

Infrastructure supports facilitates our daily lives concrete structures suffer from serious deterioration. Cracks are very common due to various chemical and physical phenomenon’s that occur during everyday use. Concrete shrinks as its dries, which can cause cracks. It can crack when there is movement underneath over the course of the season. Simply put too much weight on it can cause fractures. So deep beams are one of the useful structures to overcome the cracks with high/heavy weight. Generally deep beams are structural members that is constructed in tall buildings and they offend appeared as transfer girders and the strength of reinforced concrete deep beams its usually controlled by shear,rather than by flexure if normal amount of longitudinal reinforcement is used. The shear action in the beam web leads to diagonal compression and tension in a direction perpendicular. Therefore, a lot of research has been carried out on deep beams to study its structural behaviorboth experimental and analytical methods. The deep beams do not fail immediately due to the formation of diagonal cracks. Deep beams offend appears in high-rise building of wall. As pile caps, foundation walls, water tanks, bins, folded plate roof structures, floor diaphragms, shear walls and brackets or corbels.This investigation experimental results shows the Load versus Deflection and Stress V_s Strain. The experimental results are compared with analytical results by using ANSYS software for different L/D ratios.thebeam of different L/D were structured according to the code arrangement in IS 456:2000. L/D diminishes quality of the bar increments. Thestress appropriation chart it is seen that stress distribution over the depth is non-linear [1].An endeavor is made to predict the shear quality for concrete deep beams at ultimate stage[2]**.** Analyze down the conduct of deep beam using ANSYS programming. Redirection of beams increases as span to depth ratio decreases [3]. If percentage of tension reinforcement expands, shear quality and moment carrying capacity of deep beams. Disappointment of profound bars was chiefly because of diagonal cracking [4]. Lead trial look into is exhibited with respect to the flexural conduct of behavior of deep beams and steel fiber fibrous strengthened cement and within the sight of primary level steel bars. It must be noticed that utilizing SFRC, an expansion in the most maximum strength and ductility is observed compared to RC deep beams. It additionally must be noticed that although the quality of a RC bar can generally be expanded by utilizing higher-quality concrete or distinctive measurements or expanding the quantity of bars, and so on., an expansion in malleability is progressively hard to accomplish, and the utilization of strands is a simple way method to accomplish this target [5].Shear span-depth ratio proportion is the most imperative parameter that controls conduct and shear limit of RC deep beams. Concrete compressive quality has more impact on the shear strength of deep beams than shear reinforcement. Not withstand, the nearness of shear reinforcement is essential in controlling crack spread and giving flexibility to deepbeams [6].

II. RESEARCH SIGNIFICANCE

Deep beams are mostly used for the load bearing structures. The deep beam width does not take an active part in load bearing criteria and are mostly used in the industrial factories and main buildings. This paper is used for the length based research for the deep beams of successive lengths, the load bearing and crack patterns that are obtained in the deep beams are found and concluded for their results.

III. MATERIALS

A. Cement

OPC53 grade is used for the construction of deep beams. This grade was introduced in the country by BIS in 1987 and commercial production started from 1991. OPC 53 Grade cement is required to conform to BIS specification IS: 12269-1987 with the design strength for 28 days being a minimum of 53 MPa.

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B. Fine aggregate

Itgenerally consists of natural sand or crushed stone with most particles passing through 0.375inch sieve. Table Ishows the details of fine aggregate used in the preparation of deep beams.

Table I:Sieve analysis of fine aggregate

IS Sieve size (mm)	Weight retained in (gm)	% of weight retained	% cumulative weight retained	% of finer
10mm	8	0.4	0.4	99.6
4.75mm	74	3.7	4.1	95.9
2.36mm	624	31.2	35.3	64.7
1.18mm	478	23.9	59.2	40.8
600	526	26.3	85.5	14.5
300	244	12.2	97.3	2.3
150	46	2.3	100	0
zone	II			
Total Cumulative % of Weight Retained			381.8	
Fineness modulus			381.8/100	
			3.81	

C. Coarse aggregate

Aggregates are the most mined material in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete, the aggregate serves as reinforcement to add strength to overall composite material. Coarse aggregate are particles greater than 0.19 inch but ranges between 0.375 and 1.5 inch in diameter. Table II shows the details of coarse aggregate used for the construction /casting of deep beams.

Table II:Sieve analysis of coarse aggregate

IS Sieve size (mm)	Weight retained in (gm)	% of weight retained	% cumulative weight retained	% passing
40	0	0	0	100
20	1078	35.93	35.93	64.07
12	1898	63.2	99.13	0.87
10	13	0.43	99.56	0.44
pan	11	0.36	99.92	0.08
Total Cumulative % of Weight Retained			347.41	
Fineness modulus			347.41/100	
			3.47	

D. Water

The water is collected from the nearby tap. The phvalue for the water is as good as it is used for the construction of concrete.

E. Reinforcement of Fe 500

The reinforcement provided for the deep beams are of Fe 500 with 12mm, 10mm, 8mm steel bars. Table III gives the detailed information about the reinforcement bars used in the construction of deep beams that are used for the testing.

Table III: Properties of steel

S.no	diameter of the bar (mm)	Yield stress (N/mm^2)	Ultimate stress (N/mm^2)	% Elongation
1	8	560.2	638.5	22.05
2	10	570.05	635.51	22
3	12	568.41	649.05	21.67

IV. EXPERIMENTAL WORK

A. Specimen details

A sum of 3 rectangular beams of size 200 mm wide, 600 mm deep were cast. Grade of concrete is M30.Three beams were tested over a simply supported spans of 1 m,1.1m,1.2m in three-pointloading.The materials used in concrete were tested before they cast to find out its properties. An ordinary Portland cement grade 53 has a specific gravity of cement 3.12. Specific gravity fine aggregate 2.57 and specific gravity of coarse aggregate was 2.6. Table IV gives the mix design details for the mixture. The slump used for the mixture is of 64 mm.

Table IV:Mix design

Grade of concrete	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	w/c ratio
M30	437.7	665.52	1127.58	0.45

B. Design of Deep Beam Specimens

Three deep beams were casted with same reinforcement but with different lengths of 1200mm, 1100mm, 1000mm and depth 600mm and width 200mm. Clear cover provided was 25mm. According to IS 456-2000,calculated load was 408kN, 427kN, 459kN and specimens were tested at a single point load and two supports of simplysupported on loading frame. Table V gives the information about the specimen details and compressive strength values for the mixture used in preparation of deep beams by cubes and cylinders.

Fig.1 and Fig. 2 shows the compressive strength increase in the cubes and cylinders respectively.

Table V:Specimen details

Specimen	Days of curing	Compressive strength (N/mm^2)
Cubes	7 days	29.2
	28 days	40.8
Cylinders	7days	870
	28 days	920

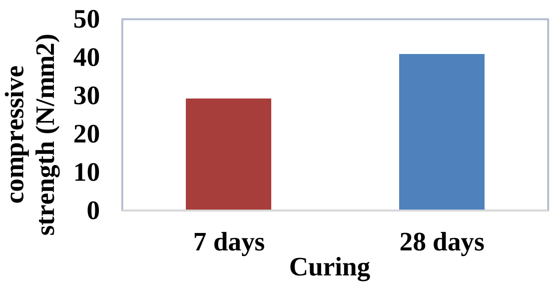

Fig. 1:Compressive strength of cubes

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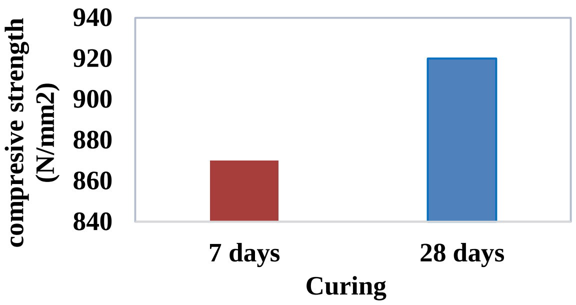

Fig. 2: Compressive strength of cylinders

Table VI gives the brief information about the dimensions of the Deep beams that are casted and tested for their strength proportions.

Table VI: Deep beam detailing

Specimen	Length (mm)	Width (mm)	Depth (mm)
Beam 1200	1200	200	600
Beam 1100	1100	200	600
Beam 1000	1000	200	600

C. Tests on Deep beams

The specimens casted were tested on loading frame having 2000kN capacity. The 3 specimens were tested at simply supported end conditions with single point load. In this experiment deflection, crack pattern, stress-strain curves were noted. A comparative study was made between all the 3 specimens. The specimen test setup was as shown Fig. 3.

Fig.4 shows the reinforcement bars setup in the deep beam

Fig.5 and Fig.6 shows the details of reinforcement provided in deep beams.

Fig. 3: Loading Frame with Deep Beam

Fig. 4: Casing of steel reinforcement

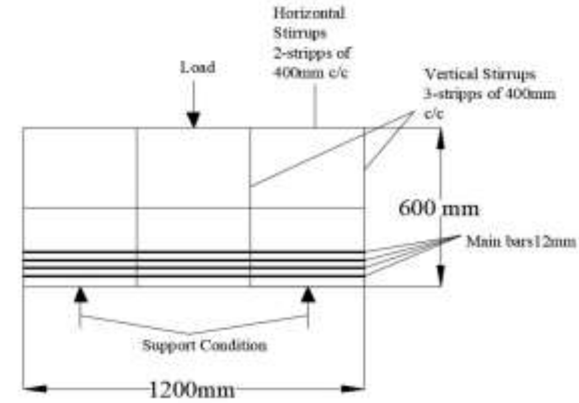

Fig. 5: Sectional Diagram of Deep Beam

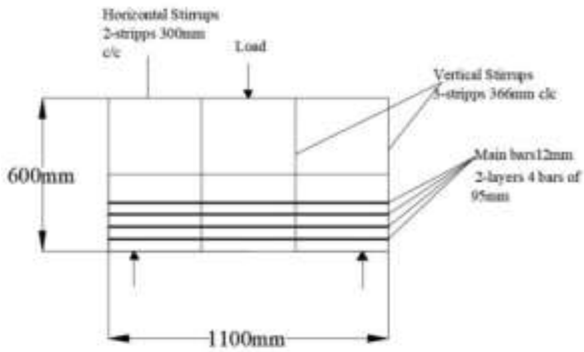

Fig. 6: Sectional Diagram of Deep Beam

D. Cracks produced in Deep beam

The beam after loading a small crack observed at the load of 330.1kN which is called first crack or flexural crack, crack formed below middle to near to the load cell shown. The pattern of flexural cracks and After the application of the complete bearing load the shear cracks begins to form near the supports below the neutral When beam was developing shear cracks it was observed that load that shows in device is 562kN. Fig. 7 and Fig. 8 shows the shear cracks are formed at an angle of 45 degrees and the shear crack pattern for 1200mm and 1100mm deep beams respectively.

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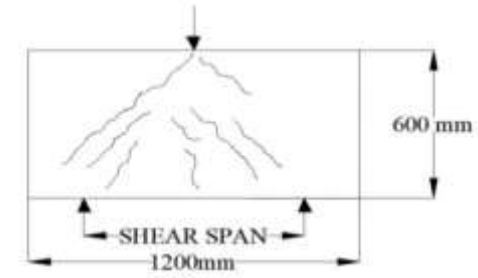

Fig. 7: Shear crack Pattern

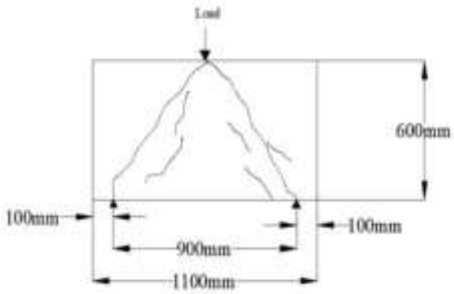

Fig. 8: Shear crack pattern

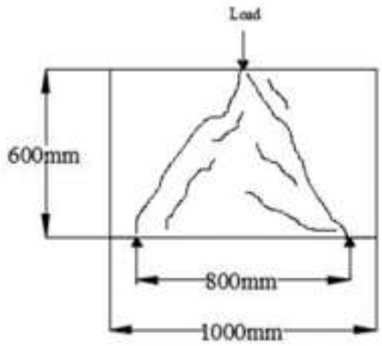

Fig. 9: Shear crack pattern

V. RESULTS AND DISCUSSION

Load vs deflection

The Deep beams are tested under loading frame for the crack to develop on the surface of beam to determine the load bearing capacity of the deep beams which are of different length but with same breadth and height.Fig. 4 shows the Load versus deflection curve for the deep beam of 1100mm length and Fig. 9 shows the load versus deflection curve for 1200mm length.

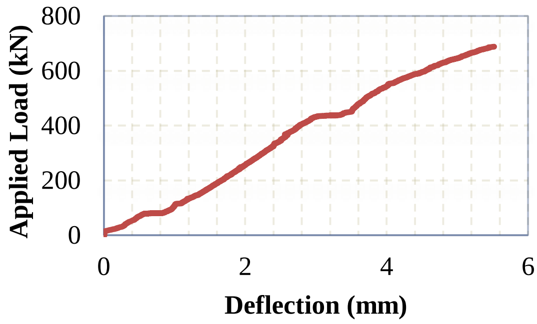

Fig. 9: Load versus deflection graph for 1100mm length

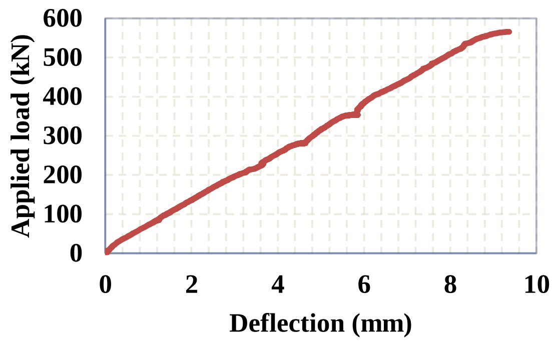

Fig. 10: Load versus deflection graph for 1200mm length

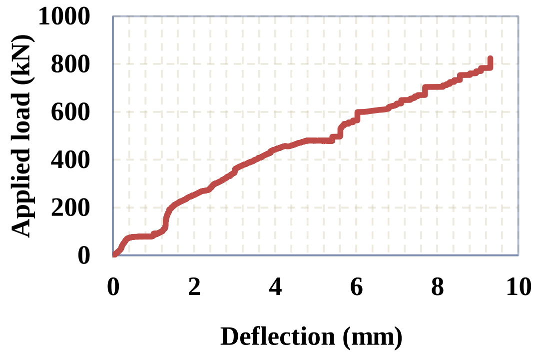

Fig. 11: Load versus deflection graph for 1000mm length

Fig. 10 and Fig. 11 show the load versus deflection graphs for the deep beams respectively.

Table: VII shows the experimental results and analytical results and compared for their strengths.

specimen	Analytical load (kN)	Experimental First crack (kN)	Ultimate load (kN)
Db- 1000	290	640.3	837
Db-1100	260	490.7	688
Db-1200	210	330.2	565.9

Note: Deep beam

Fig. 12 shows the comparison of experimental and analytical values for deep beams of lengths 1000mm, 1100mm and 1000mm respectively.

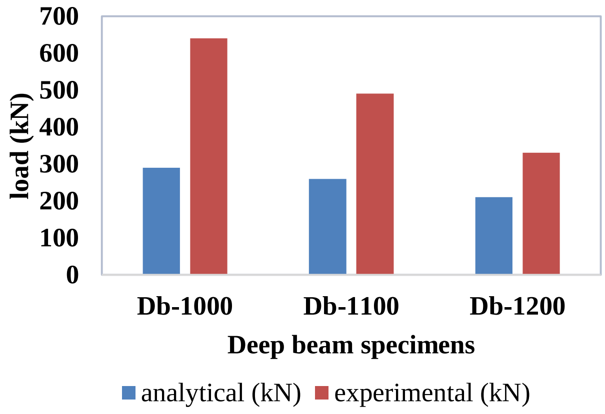

Fig. 12: Experimental results of first crack results

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VI. CONCLUSION

The following conclusions are drawn from the results that are obtained for the deep beams for different lengths that area used in this paper

1. The Load obtained for the deep beam of length 1000mm is 837kN and is more when compared to other deep beams and concluded that theload obtained by the deep beams experimentally is more compared to the load calculated by using code.
2. The deflection obtained for the 1000mm length beams is also satisfactory when compared to other beams.
3. The crack obtained in this deep beam is less when compared to other beam and the width of crack is about 6.78mm and the first crack obtained at 640.3kN load.
4. As per the experimental work the load obtained is very high compared to analytical work, which was calculated as per Is code.

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REFERENCES

1. Niranjan, B.R. and Patil, S.S., 2012. "Analysis of RC Deep Beam by Finite Element Method" *International Journal of Modern Engineering Research (IJMER)*, Vol-*2*(6), pp.4664-4667.
2. Kumar, K.K., Ramadass, S., Philip, V., Kumar, K.K., Ramadass, S. and Philip, V., "A Study on Concrete Deep Beams Using Nonlinear Analysis". *International Journal*, Vol-*2*, pp.57-64.
3. Sabale, V.D., Borgave, M.D. and Joshi, P.K., 2014. "Non-linear finite element analysis of deep beam". *International Journal of Engineering Research and Technology*, Vol-5, p.3.
4. Suresh, D.G. and Kulkarni, S., 2016. "Experimental study on behaviour of RC deep beams". *International Research Journal of Engineering and Technology (IRJET)*, Vol-6(2).pp.4
5. Campione, G., 2011. "Flexural behavior of steel fibrous reinforced concrete deep beam". *Journal of Structural Engineering*,Vol- *138*(2), pp.235-246.
6. Ismail, K.S., 2016. "Shear behaviour of reinforced concrete deep beams" *(Doctoral dissertation, University of Sheffield).*
7. Niwa, J., 1995. "Nonlinear finite element analysis of deep beams". 10th annual lecture on" FEM Analysis of Reinforced Concrete Structures".
8. Zhang, N., Tan, K.H. and Leong, C.L., 2009. "Single-span deep beams subjected to unsymmetrical loads". *Journal of structural engineering*, Vol-*135*(3), pp.239-252.
9. Patel, R., Dubey, S.K. and Pathak, K.K., 2014. "Effect of depth span ratio on the behaviour of beams". *International Journal of Advanced Structural Engineering (IJASE)*, Vol-*6*(2), p.3.
10. Al-Saidy, A.H., Klaiber, F.W. and Wipf, T.J., 2004. "Repair of steel composite beams with carbon fiber-reinforced polymer plates". *Journal of Composites for Construction*, Vol-*8*(2), pp.163-172.
11. Liu, J. and Mihaylov, B.I., 2016. "A comparative study of models for shear strength of reinforced concrete deep beams". *Engineering Structures*, Vol-*112*, pp.81-89.
12. Sanad, A. and Saka, M.P., 2001. "Prediction of ultimate shear strength of reinforced-concrete deep beams using neural networks". *Journal of structural engineering*, Vol-127(7), pp.818-828.
13. Asin, M., 1999 "The behaviour of reinforced concrete continuous deep beams Amsterdam", *The Netherlands: Delft University Press*.p. 168
14. Correia, J.R., Branco, F.A., Silva, N.M.F., Camotim, D. and Silvestre, N., 2011." First-order, buckling and post-buckling behaviour of GFRP pultruded beam, Part 1: Experimental study" *Computers & Structures*, Vol-89(21-22), pp.2052-2064.

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