Study OnDeep Beam With Web Openings

Meenakshy S[1], Dr. K Subha[2]

Abstract— RC deep beams are structural elements loaded as beam in which significant amount of load is transferred to the support by compression thrust line joining the loads and reactions. As a result the strain distribution is no longer considered linear and shear deformation become significant when compared to pure flexure. The provision of opening in the web of deep beam is usually required to accommodate essential services such as air conditioning ducts and electricity cables or to provide accessibility such as doors and windows. Several studies are done for providing openings in the deep beam. This paper deals with to find the exact position, size shape of the openings.

Index Terms— Static Structural Analysis, ANSYS 16.2, Deep Beam, Openings In Deep Beam.

1 Introduction

Deep beam as a structural element loaded as a simple beam in which significant amount of load is transferred to the support by compression thrust joining the load and the reaction. As a result, strain distribution is no longer considered as linear shear deformation become significant when compared to pure flexure.

The behaviour of deep beams is significantly different from that of beams of more normal proportions, requiring special consideration in analysis, design and detailing of reinforcement. Because of their proportion they are likely to have strength controlled by shear on the other hand their strength is likely to be significantly greater than the predicted by theoretical equations. Stresses in the deep beam can be evaluated using 2D analysis

Floor slab under horizontal loads short span beam carrying heavy loads and transfer girder are the example of deep beam. Deep beam is a beam having large depth to thickness ratio and shear span to depth ratio less than 2 for concentrated load and 5 for distributed load .because of the geometry of the deep beam their behaviour is different from slender beam or inter mediate beam. By using RC deep beam as the transfer girder, it can provide more space at lower floor. This is because of the high strength of the RC deep beam, it can carry higher loads from above, and thus the column below it can be removed. There will be more space below when the columns were removed.

The shear behaviour of deep beams is very complex and there is still no agreement on the role of size effect in shear due to lack of information. Deep beams are classified as no flexural members, in which plane sections do not remain plane in bending. Therefore, the principles of stress analysis developed for slender beams are neither applicable nor adequate to determine the strength of deep beams.

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An important characteristic of deep beams is their high shear strength. The greater shear strength of deep beams is due to internal arch action, which transfers the load directly to a support through concrete struts. The reinforcement acts as a tie and, hence

RC beams are analogous to steel trusses. Deep beams are also classified as disturbed regions, which are characterized by nonlinear strain distribution. Elastic solutions of deep beams provide good description of their behaviour before cracking. However, after cracking major redistribution of strains and stresses takes place and the beam strength must be predicted by nonlinear analysis.

Shear is more predominant in RC deep beam so that here my study concentrated about the shear strength behaviour RC of deep beam.

2 LITERATURE BACKGROUND

KhalafIbrahemMohammad(2007) responses of reinforced concrete deep beams with web openings under monotonic load conditions I carried out in this study.

HawrazKarim M. Amin, V.C. Agarwal, Omar Q. Aziz(2013) this paper carried out to study the effect of opening sizes and locations on the shear strength behaviour of reinforced concrete deep beam without web reinforcement

NishithaNair(2015) The present study is to determine the effect of opening in deep beam using strut and tie model approach. Experimental investigation is done on 7 deep beam with various position opening as per strut and tie formation.

HaiderMufeedAlsaeq(2014) This research aims to investigate how to increase the structural strength of reinforced concrete deep beam with large openings. Two approaches are under consideration; the first is the effect of steel reinforcement bars near the opening edges, and the second is attaching CFRP layers around the opening...

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3 MODEL GENERATION

Ansys 16.2 is used to model the deep beam with web openings. The cross section of the beam is 200 x 400 mm and the length is 800 mm

3.1 Concrete

"SOLID 65" is used to model the concrete. It is used for 3-D modelling of solids with or without reinforcing bars and capable of cracking in tension and crushing in compression. The element is defined by 8 nodes having three degrees of freedom at each node. Translations of the nodes in x,y and z-directions.

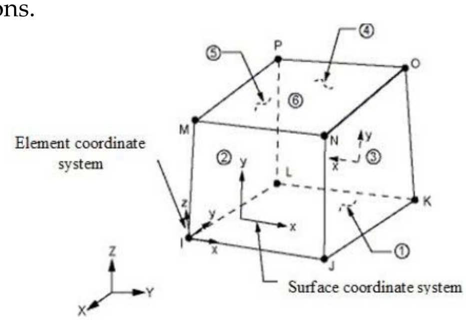

Fig.1 Geometry of solid 65

3.2 rebar

"LINK 8" is used to model the behaviour of steel reinforcement. It is a uni axial tension-compression element with three degrees of freedom at each node. Translations of the nodes in x,y and z direction

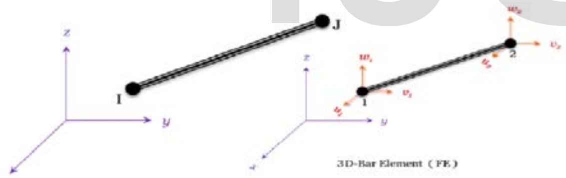

Fig.2 Geometry of link 8

4 LOADING AND BOUNDARY CONDITION

Boundary conditions are the support condition. One end is hinged and other end is simply supported.
Centre concentrated load is applied as line load. This load on concrete is applied based on maximum principle compressive strength theory for brittle material, according to this the failure is initiated when principle stress in concrete exceeds the compressive strength. Here 90% of failure load is applied to the whole models it is about 110KN

TABLE1: Material properties

material no:	element type	material property
1	Solid 65	Density = 2400 kg/m^3
		Young's modulus E = 2.236 e4 MPa
		Poisons ratio = 0.15
		Tensile ultimate strength = 3.13 MPa
		Compressive ultimate strength = 20 MPa
2	Link 180	Density = 7850 kg/m^3
		Young's modulus = 2e5 MPa
		Poisons ratio = 0.3

sl.no	type of reinforcement	details of reinforcement
1	Main steel	4-12 mm dia bars (Fe 500)
2	Vertical stirrups	2 legged 8 mm dia at 140 mm c/c

TABLE2: Reinforcement details

5 RESULTS AND DISCUSSION

To predict the behaviour of deep beam with opening, following parameters are studied

1. Shape of opening in deep beams.
2. Beam with two openings
3. Beam with different size of opening

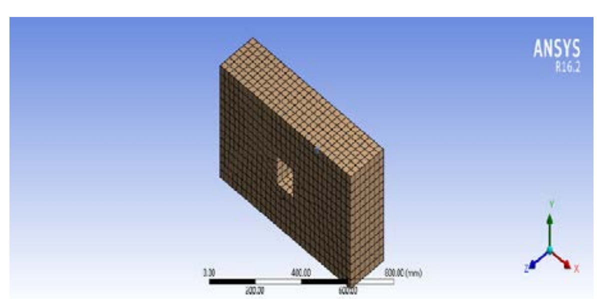

Fig.3 Typical model of deep beam with web opening

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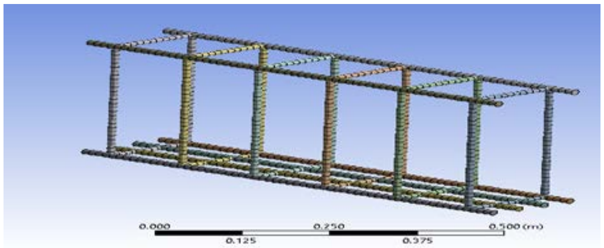
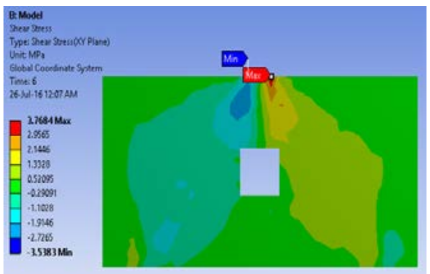
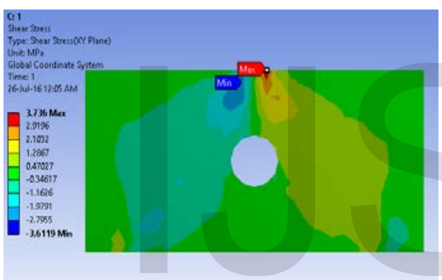
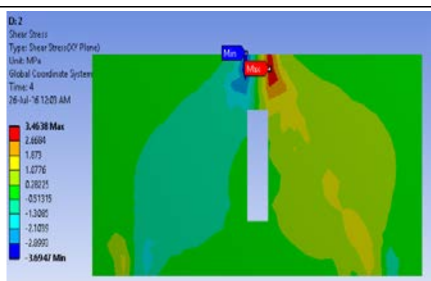


Fig.4 Element used for reinforcement in the finite element model

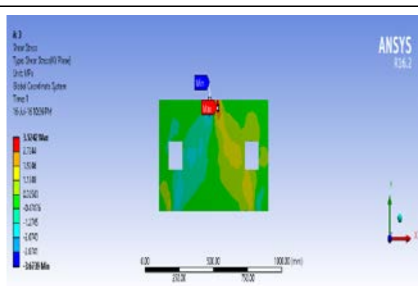
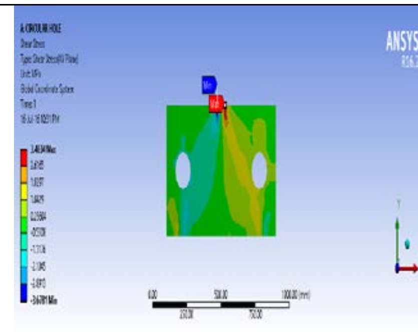
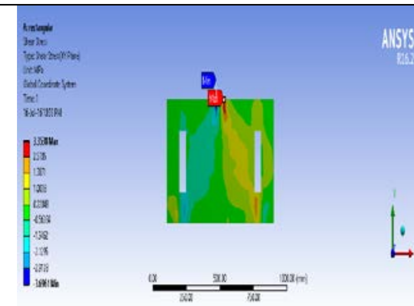
5.1 Beam with openings in the centre

TABLE3: beam with different shape of hole

Beam specimen	Shear stress diagram obtained from the software
Beam with square opening	
Beam with circular opening	
Beam with narrow rectangular opening	

5.2 Beam with openings away from the centre

TABLE4: beam with hole away from the centre

Beam specimen	Shear stress diagram obtained from the software
Beam with square opening	
Beam with circular opening	
Beam with narrow rectangular opening	

6 OPTIMIZATION

To achieve an optimal design, design variable such as dimensions of its parts can be varied, with the constraint that allowable displacement and allowable stress cannot be exceeded. An optimum is achieved by analyzing a trial design, making helpful changes, reanalyzing, and repeating the cycle until convergence. The objective function is usually subject to constraints, such as limits on displacement or stress at several locations, and limits on design variables. Many optimization algorithms have been devised and the iterative process until convergence can be automated, and provision for it appears in Ansys software.

Minimum shear stress is considered as main objective function while optimization. Three points were obtained having minimum value of shear stress. From this optimum position of hole is obtained.

6.1 Position Of Opening If One Opening Is Provided

TABLE5: Optimization results for position if two square opening are provided

	Point 1	Point 2	Point 3
Beam with square openings	66.875mm(along length)	100.63mm	168.13mm
	54.375mm(along depth)	89.375mm	106.88mm

There are three points are obtained where the shear stress is minimum. The best position of opening 0.28l-0.41l from the edge to the centre of the openings along the length and 0.23D-0.36D from the top to the centre of the hole along the depth

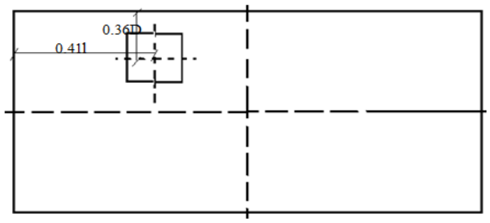


Fig.5 Position of hole

6.2 Size of opening

TABLE6: Optimization results for size of opening

	Point 1	Point 2	Point 3
Beam with square opening	107.13mm (along length)	74.375mm	172.63mm
	92.73mm(along depth)	61.875mm	108.38mm

Optimization results show that the best size of opening where the shear stress is minimum about 1-5% of total area of the beam

6.3 Position Of Opening If Two Openings Are Provided

TABLE7: Optimization results for position if two square opening are provided

	Point 1	Point 2	Point 3
Beam with square opening at the at the edges.	100.63(from the edge along the length)	168.13mm	201.88mm
	100.63((from the edge along the depth)	123.13mm	66.875mm

If two square openings are provided the exact position of openings 0.28l to 0.41l from one of the edges to the side of the opening along the length and 0.3D-0.4 D from the top of the beam to centre of the opening. Where l is the total length and D is the total depth. This is in the top corners

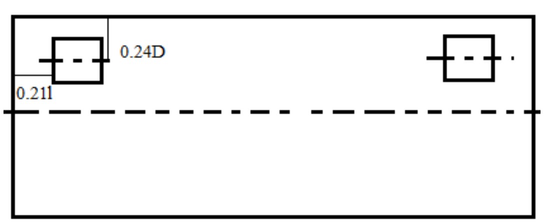


Fig.6 Beam with two square openings

TABLE8: Optimization results for position if two circular opening are provided

If two circular opening are provided the exact position of openings 0.0.7l to 0.08l from one of the edges to the side of the opening along the length and 0.34D-0.36 D from the top of the

	Point 1	Point 2	Point 3
Beam with circular opening at the edges.	69.143(from the edge along the length)	65.964mm	59.606mm
	61.346(from the edge along the depth)	58.525mm	57.115mm

beam to centre of the opening. Where l is the total length and D is the total depth. This is in the top corners.

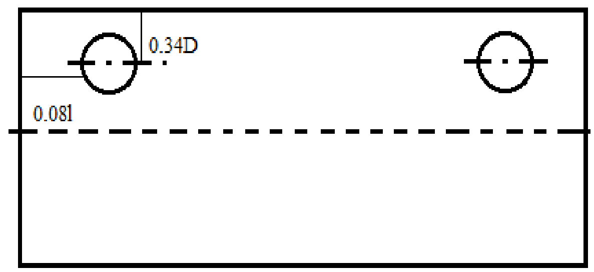


Fig.7 Beam with two circular opening

TABLE9: Optimization results for position if two rectangular opening are provided

If two rectangular opening are provided the exact position of openings 0.17l to 0.28l from one of the edges to the

	point 1	Point2	Point3
Beamwith rectangular opening at the edges.	105.63mm(from the edge along the length)	230.63mm	36.88mm
	59.167mm(from the edge along the depth)	53.75mm	3.75mm

side of the opening along the length and 0.29D-0.36D from the top of the beam to centre of the opening. Where l is the total length and D is the total depth. This is in the top corners.

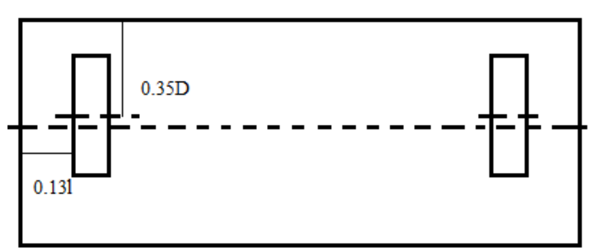


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Fig.8 Beam with two rectangular openings

7 CONCLUSION

On the basis of the finite element analysis, the following conclusions can be made

- The best shape of the opening with minimum shear stress is narrow rectangular as compared to square and circular.
- The best size of opening where the shear stress is minimum is about 1-5% of total area of the beam.
- The best position of square opening 0.28l-0.41l from the edge to the centre of the openings along the length and 0.23D-0.36D from the top to the centre of the hole along the depth
- If two square openings are provided the exact position of openings 0.28l to 0.41l from one of the edges to the side of the opening along the length and 0.3D-0.4 D from the top of the beam to centre of the opening. Where l is the total length and D is the total depth. This is in the top corners
- If two circular openings are provided the exact position of openings 0.0.7l to 0.08l from one of the edges to the side of the opening along the length and 0.34D-0.36 D from the top of the beam to centre of the opening. Where l is the total length and D is the total depth. This is in the top corners.
- If two rectangular openings are provided the exact position of openings 0.17l to 0.28l from one of the edges to the side of the opening along the length and 0.29D-0.36D from the top of the beam to centre of the opening. Where l is the total length and D is the total depth. This is in the top corners.

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