Numerical Analysis on Deep Beam with Varying Shear Span to Depth Ratio

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***Abstract*—This research work aimed to investigate the shear capacity performance for three reinforced concrete deep beams model named as (DB01, DB02 & DB03) with different shear span to depth ratio. The grade of concrete is M40 and the grade of steel is Fe500. The deep beam is subjected to two point concentrated load to enable a better understanding of the effects of shear span–depth ratio, for this investigation ABAQUS FEA numerical software was used. The dimension of three test specimens (DB01, DB02 & DB03) is 1600 mm x200 mm x 600 mm. The effective span to height ratio l_0/h is 2.0; the shear span–depth ratio is 0.3, 0.6 and 0.9, respectively. The deflection of mid-span, the characteristics of the full process of shear capacity, the failure mode and the load deflection deformation curve were examined. The test results showed that the failure mode of deep beams (DB01) with small shear span–depth ratio is due to diagonal compression failure and the failure mode of deep beams (DB02 & DB03) is due to flexure - shear failure. From this numerical analysis the shear capacity of the deep beams varies when the difference in the shear span to depth ratio gets vary, it shows that when the shear span – depth ratio decreases it gets fail under diagonal compression and when shear span – depth increase it fails under the flexure – shear.**

***Index Terms*— ABAQUS FEA, Deep Beams, Flexural Strength, Shear span – Depth ratio.**

I. INTRODUCTION

In certain extreme situations, the designer may be called upon to deal with very low span /depth ratios. Such is the case in the structural members like pile cap, transfer girder, panel beam, strap beam in foundation, walls of rectangular water tank, shear wall etc. In such cases, where the depth of the beam becomes comparable to its span, the beam is referred to as a deep beam. A reinforced concrete member in which the total span or shear span is exceptionally small in relation to its depth is called a deep beam. Shear span is defined as the distance from the centre of one support to the nearest point of load application.

II. NUMERICAL ANALYSIS

ABAQUS is general-purpose software suitable for finite element analysis. It can be used for both static and dynamic problems. Abaqus software consists of three main products: Abaqus/CAE, Abaqus/Standard and Abaqus/Explicit. Abaqus/CAE is an interactive module that integrates the solver modules into CAE (Complete Abaqus Environment) for modelling, analysis, job management and offers inclusive tools for results interpretation and visualization.

A. Model Dimensions

Three deep beam members (DB01, DB02, and DB03) have been modelled in the abaqus. The dimension of the models for all three is 200mm x 600mm x 1600mm which is width x depth x span, the geometric dimension and reinforcement layout are shown in Fig 2.1-2.3 and Model specimen design parameters given in table 2.1.

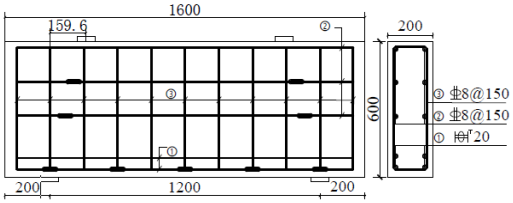

Fig 2.1 DB01 model size and reinforcement details

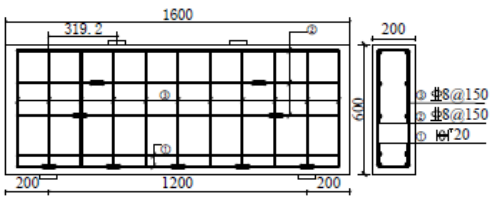

Fig 2.2 DB02 model size and reinforcement details

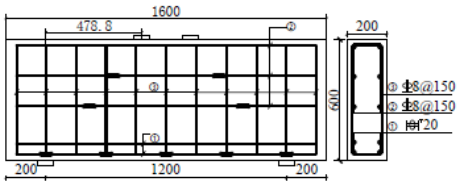

Fig 2.3 DB03 model size and reinforcement details

Component Number	b x d x l (mm)	Shear span depth ratio	l_{ef}/D ratio
DB01	200 x 600 x 1600	0.3	2
DB02	200 x 600 x 1600	0.6	2
DB03	200 x 600 x 1600	0.9	2

Table 2.1 Model specimen design parameters

B. Material Properties

Material properties like grade of material, density, young's modulus, poison ratio, yield stress and plastic strain for steel and concrete are given in table 2.2.

C. Steps For Creating Model And Analyse

The deep beam model of 200 x 600 mm x 1600 mm of b x d x l has been created in the part creation. The elastic and plastic properties of the material were assigned to the created model of deep beam section. The values in Table 2.2 like young's modulus (E), Poisson's ratio, Density, yield stress, plastic strain of the concrete and steel has to be entered and to be assigned. The parts like deep beam, tension reinforcement, stirrups, and skin reinforcement want to be assembling all together. To create and configure analysis steps and associated output requests. The step sequence provides a convenient way to capture changes in a model. The step has been created for dynamic implicit. And interaction for deep beam wants to be done with steel reinforcement which is embedded in concrete. And also want to create the interaction between the loading support and concrete. One end of the specimen was constrained in X, Y and Z directions and the other end of the specimen was constrained X and Y direction. And in this displacement value has been given and we will obtain the force from applying the displacement.

The deep beam member was converted into a finite element model by using mesh module. A rectangular mesh of 25mm has been created for whole model. The job wants to be created and to be submitting for the analysis. And the status of the job should be monitor, if there an error occur need to be rectify the error.

Si. No	Properties	concrete	Steel
1.	Grade	M40	Fe500
2.	Density	2.5e-9 tonne/mm^3	7.85e-9 tonne/mm^3
3.	young's modulus	34600 N/mm2	210000 N/mm2
4.	Poison ratio	0.2	0.3
5.	yield stress	40 N/mm2	500 N/mm2
6.	Plastic strain	0	0

Table 2.2 properties of concrete and steel

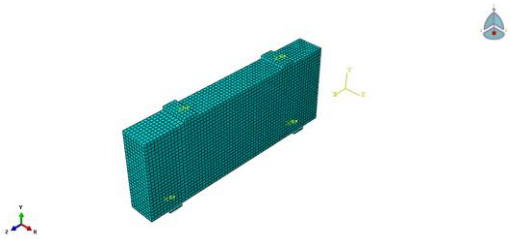

Fig 2.4 Meshing of the deep beam

III. RESULTS AND DISCUSSIONS

Three deep beam members (DB01, DB02, and DB03) have been modelled and were analysed using abaqus 16.0. The dimension of the models for all three is 200mm x 600mm x 1600mm, The stress and displacements representation of (DB01, DB02, and DB03) deep beam are given below in table 3.1. By this numerical analysis the results shows when the deep beam shear span to depth ratio decreases load carrying capacity increases. The shear span–depth ratio is the most important parameter that controls behaviour and shear Capacity of reinforced concrete deep beams.

b x d x l (mm)	Shear span depth ratio	Load 'N'	δ (mm)	Mode of Failure
200 x 600 x 1600 DB01	0.3	1.85E+06	3.15	Diagonal Compression
200 x 600 x 1600 DB02	0.6	1.82E+06	4	Flexural Shear Failure
200 x 600 x 1600 DB03	0.9	1.82E+06	6	Flexural Shear Failure

Table 3.1 Comparison of test results

A. Result of DB01 deep beam model

The stress, displacements, stress – strain &Force – displace representation of DB01 is shown in fig 3.1, 3.2, 3.3 & 3.4. The stress - strain values given in table 3.2 and Force – displacement value given in table 3.3.

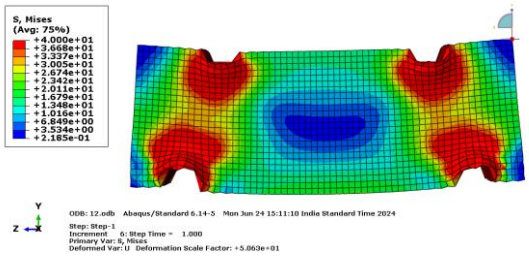

Fig 3.1 Stress representation of DB01deep beam

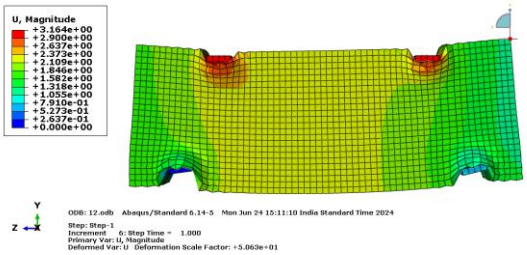

Fig 3.2 Displacement representation of DB01 deep beam.

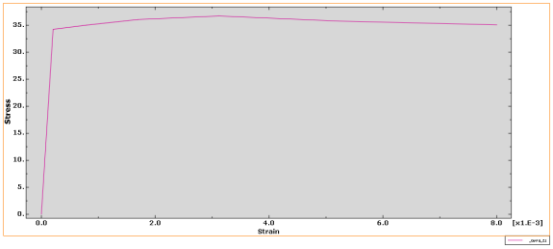

Fig 3.3 Stress Strain representation of DB01 deep beam

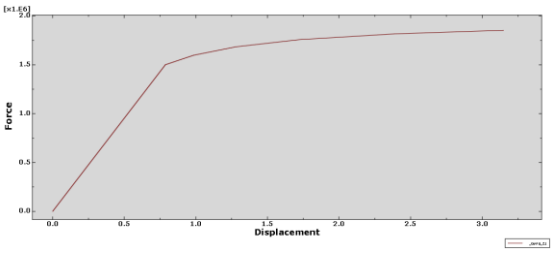

Fig 3.4 Force-displacement of DB01 deep beam

Si. No.	Stress (N/mm^2)	Strain
1.	0	0
2.	34.2397	0.000206
3.	35.025	0.000794
4.	36.058	0.001701
5.	36.7154	0.00312
6.	35.7629	0.005223
7.	35.0785	0.008

Table 3.2 Stress & Strain values of DB01 deep beam

Si. No.	Force (N)	Displacement (mm)
1.	0	0
2.	1.50E+06	0.7875
3.	1.60E+06	0.984375
4.	1.68E+06	1.27969
5.	1.76E+06	1.72266
6.	1.82E+06	2.38711
7.	1.85E+06	3.15

Table 3.3 Force & Displacement values of DB01 deep beam

B. Result of DB02 deep beam model

The stress, displacements, stress – strain &Force – displace representation of DB02 is shown in fig 3.5, 3.6, 3.7 & 3.8. The stress - strain values given in table 3.4 and Force – displacement value given in table 3.5.

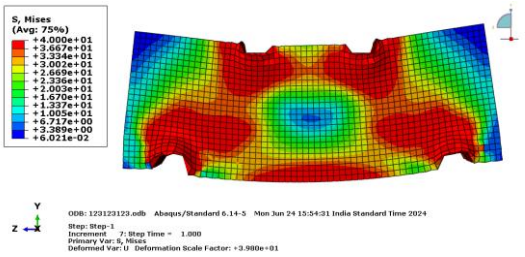

Fig 3.5 Stress representation of DB02 deep beam

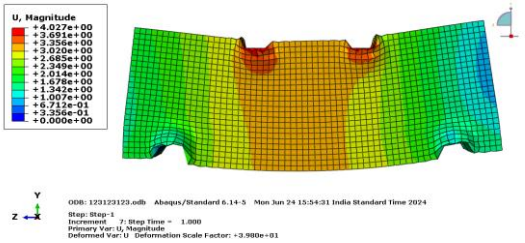

Fig 3.6 Displacement representation of DB02 deep beam

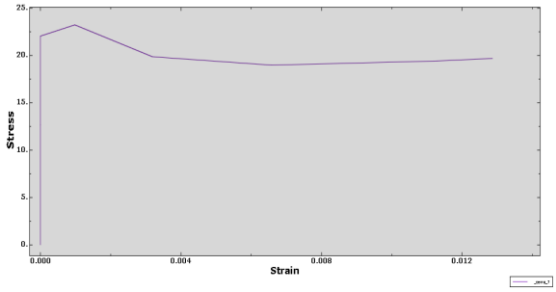

Fig 3.7 Stress Strain representation of DB02 deep beam

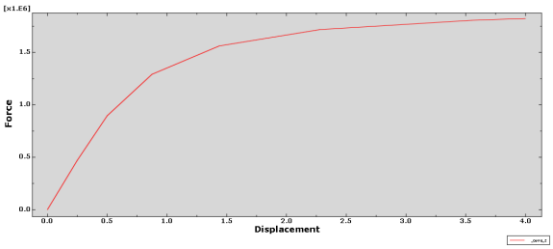

Fig 3.8 Force-displacement of DB02 deep beam

Si. No.	Stress (N/mm^2)	Strain
1.	0	0
2.	12.6695	0
3.	22.0485	0
4.	23.2332	0.000978
5.	19.8721	0.003185
6.	18.9795	0.006582
7.	19.6903	0.012866

Table 3.4 Stress & Strain values of DB02 deep beam

Si. No.	Force (N)	Displacement (mm)
1.	0	0
2.	470888	0.25
3.	895723	0.5
4.	1.29E+06	0.875
5.	1.56E+06	1.4375
6.	1.81E+06	3.54688
7.	1.82E+06	4

Table 3.5 Force & Displacement values of DB02 deep beam.

C. Result of DB03 deep beam model

The stress, displacements, stress – strain &Force – displace representation of DB02 is shown in fig 3.9, 3.10, 3.11 & 3.12. The stress - strain values given in table 3.6 and Force – displacement value given in table 3.7.

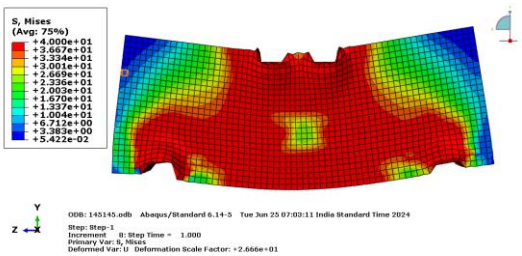

Fig 3.9 Stress representation of DB03 deep beam

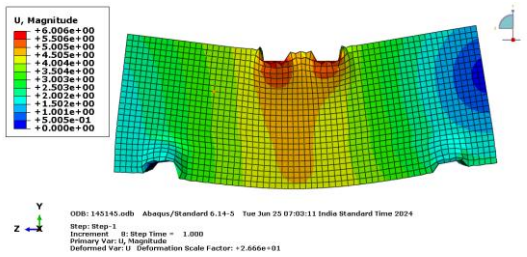

Fig 3.10 Displacement representation of DB03 deep beam

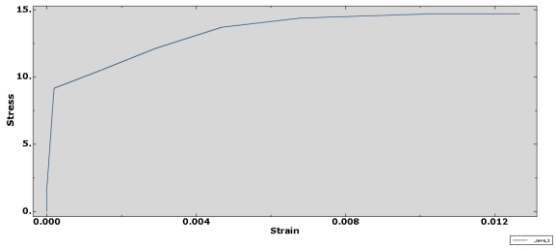

Fig 3.11 Stress Strain representation of DB03 deep beam

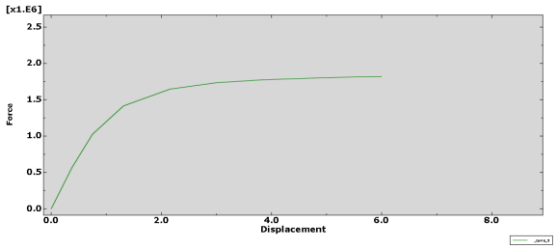

Fig 3.12 Force-displacement of DB03 deep beam

IV. CONCLUSIONS

- Thus, the modelled deep beam (DB01, DB02 & DB03) with varying shear span–depth ratio with assigned specifications and loading, material properties has been numerically analysed in Abaqus software.
- The test results showed that the failure mode of deep beams (DB01) with small shear span–depth ratio is due to diagonal compression failure and the failure mode of deep beams (DB02 & DB03) is due to flexure - shear failure. From this numerical analysis the shear capacity of the deep beams varies when the difference in the shear span to depth ratio get vary, it shows that when the shear span – depth ratio decreases it get fail under diagonal compression and when shear span depth increase it fails under the flexure – shear.
- By this numerical analysis when shear span to depth decreases the load carrying capacity has been increased and when the shear span to depth ratio increases the load carrying capacity has been decreased.

Si. No.	Stress (N/mm^2)	Strain
1.	0	0
2.	1.78199	0
3.	9.16163	0.000189
4.	12.1319	0.002913
5.	13.7061	0.004689
6.	14.6925	0.010229
7.	14.6872	0.012665

Table 3.6 Stress & Strain values of DB03 deep beam

Si. No.	Force (N)	Displacement (mm)
1.	0	0
2.	565458	0.375
3.	1.42E+06	1.3125
4.	1.65E+06	2.15625
5.	1.73E+06	3
6.	1.81E+06	5.10938
7.	1.82E+06	6

Table 3.7 Force & Displacement values of DB03 deep beam

V. REFERENCES

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