THEORETICAL EVALUATION OF RC DEEP BEAM WITH WEB OPENING BY USING NONLINEAR FINITE ELEMENT SOFTWARE [ABAQUS]

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ABSTRACT: This examination went for analyzing the potential utilize reinforced concrete (RC) deep beams that had web openings by steel plates. Examinations were led to test thirteen deep beams under two point stacking with square openings. Each tried beam had a cross area of 100 mm x 400 mm and total length of 1000 mm. Two openings, one in each shear traverse, were set symmetrically about the midpoint of the slanted compressive strut. Test parameters incorporated the opening shape. It was presumed that the auxiliary conduct of deep beams that had openings was essentially subject to the intrusion level of the slanted compressive strut. In deep beam with openings, the first askew cracks showed up in the scope of 28% in experimental while the first cracking stress showed up in the scope of 30% in finite element software [abaqus]. The ultimate load close to the best and base corners of the openings. The nearness of unstrengthened openings diminished the mid-span deflection by (8%) for SQ, specimen, as compared with abaqus result.

Keywords: Reinforced concrete deep beams, square openings, , self-compacted concrete, abaqus nonlinear F.E analysis.

1.INTRODUCTION

RC deep beams are individuals in which an imperative share of the load is conveyed to the backings by compression struts joining the loads and backings. ACI 318-14, area 9.9 [1] characterizes that deep beams ought to be loaded on the loading and supporting focuses in a way that compression pushes can develop between theories loading and supporting focuses. For the past time, the deep beams have been composed by the slender beam semi-empirical strategies. All things considered, some expository reports and exploratory outcomes have determined that internal forces redistribution before disappointment, internal force components and shear strength in deep beams are entirely unexpected from those happened in slender beams. Openings are mostly built in deep beams to encourage ventilating, conductors, PC arrange links and power. The shear limit will be diminished If an opening intrudes on the characteristic loading way that joins the loading and supporting focuses [2,3]. There is no conspicuous outline technique for deep beams that have openings paying little heed to the essential impacts of these openings on the deep beam structural behavior.

Numerous researchers have contemplated the diverse main parameters involved, for example, cross sectional properties, shear span-to-depth ratio, web reinforcement amount, and opening area, shape and size in addition to concrete strength [4-6].

[7] tried 16 continuous deep beam examples that had rectangular openings, examining the size and area of the opening in addition to the impact of web reinforcement. Specifically, the creators took into consideration the openings within the outside shear span and within the interior shear span. They found that when the opening was set within the interior shear span, the most elevated load limit decrease took put. They additionally found that horizontal reinforcement was less compelling than that set vertically. [8] utilized inclined web reinforcement to propose a strut-and-attach model to assess the deep beam strength that had rectangular web openings. [9] tested 32 deep beam specimens that had rectangular openings. The specimens had different sizes of the opening, different concrete strengths, and the shear span-to-depth ratio ranged between 1 and 0.5. The authors concluded that the effect of concrete compressive strength significantly decreased in deep beams with openings in comparison with solid reference beams.

2.FINITE ELEMNTE MODELLING

2.1.Geometry of Specimens

Schematics of the test specimens are appeared in (Figure 1) in which all measurements are in (mm). The specimens had a viable span of 740 mm resulting in a ln/h ratio (span to depth ratio) of 1.85. All beams were tried under a/d of 0.75 keeping in mind the end goal to guarantee that deep beam activity will create. The beams were intended to bomb in shear before any flexural trouble. Two 16 mm deformed steel bars of fy= 614 MPa were given as strain reinforcement. Each 16mm bar had a nominal cross sectional territory of 201 mm^2. Two 4mm deformed steel bars with fy= 442 MPa and Ab = 12.56 mm^2 were given as compression steel reinforcement. At each end, compression steel reinforcement had 90o snare with a specific end goal to give adequate safe haven as appeared in (Figure 1,2). 4mm deformed bars dispersed vertically at 88mm and likewise divided at 155mm horizontally were accommodated the web reinforcement. The horizontal web reinforcement was longitudinal bars at the two sides of the beam though the vertical web reinforcement was in a type of stirrups. At top and bottom appearances of the beam, a reasonable front of 20 mm was maintained.

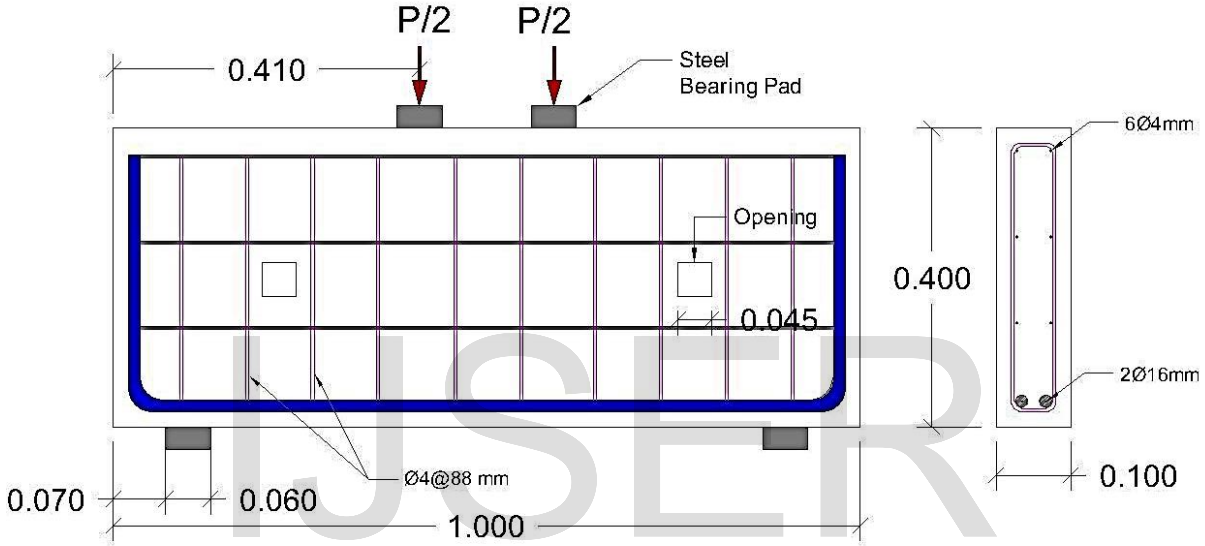


Figure. 1. Details of beam with square openings

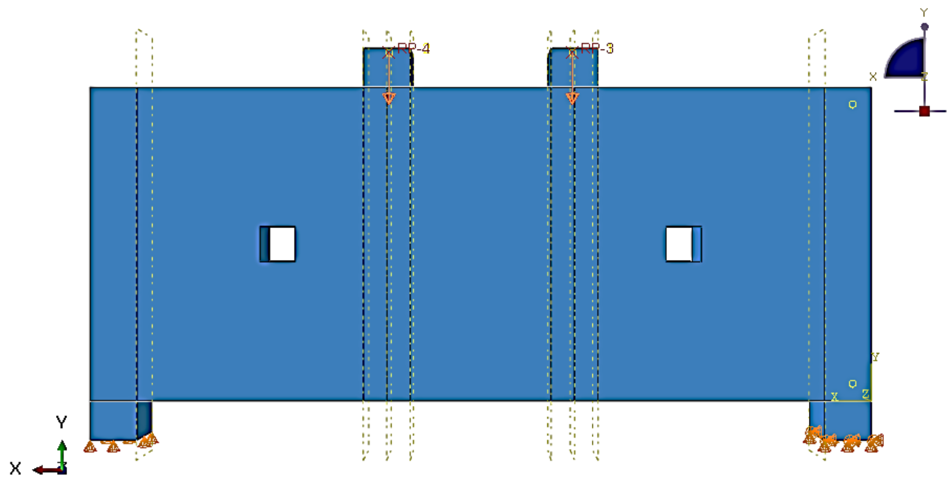


Figure. (2). Beam with square openings by abaqus

2.2.Boundary Conditions and Mish of Finite Element

As shown in (Figure 3), the right hinge support was considered as a roller by constraining the y-direction (Uy=0). While the left support was considered as a hinge support by constraining a single line of steel bearing plate nodes along the width of the beam soffit in the x- y and z-directions (i.e. Ux =Uy=Uz=0). Across the width of the top surface of the beam, as shown in (Figure 3), the external loads were distributed at center of the steel bearing plate and having coupling kinematics constrain..

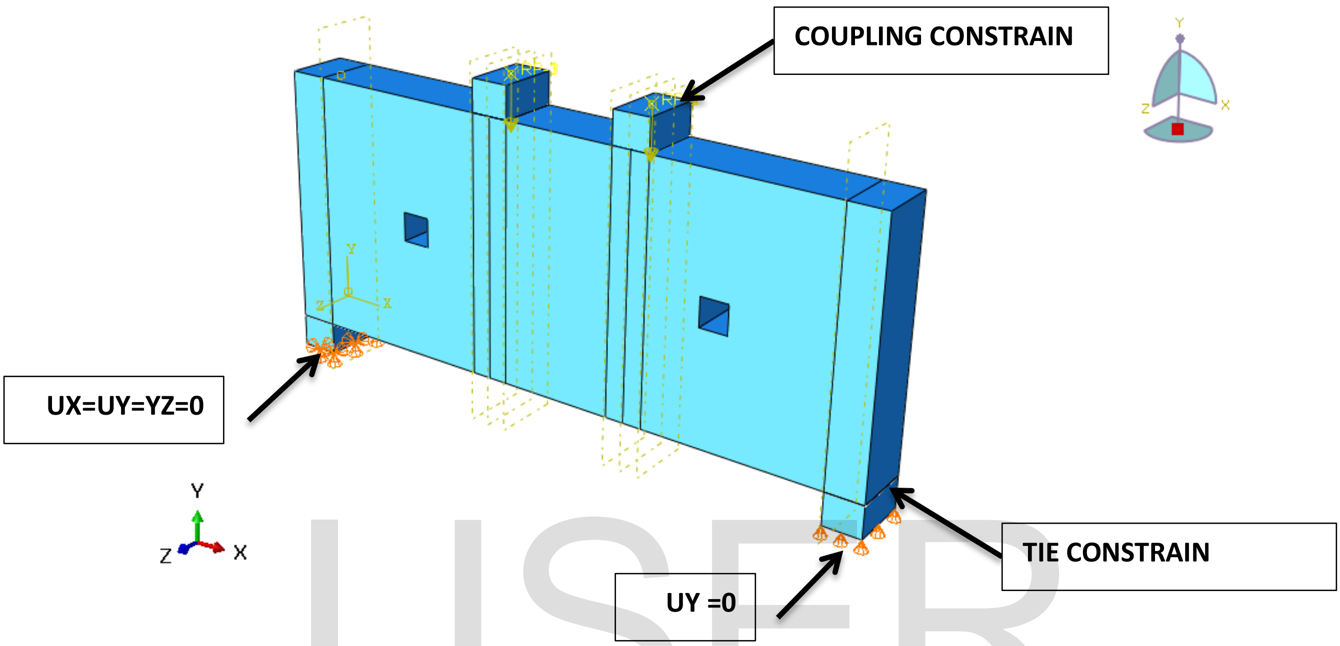


Figure 3. Boundary Condition of RC Deep Beam

The finite element meshing of steel bearing plate (60x30x100) mm at loading and supporting regions and concrete for the deep beam with opening are shown in (Figure 4, a-b). By using 3d stress – quadratic [21 nodes] to idealize the nonlinear behavior of concrete and steel material during analysis. Also for steel of reinforcement, the wire parts idealization with cross section have been used and abaqus stress family as a truss. Abaqus user manual [11].

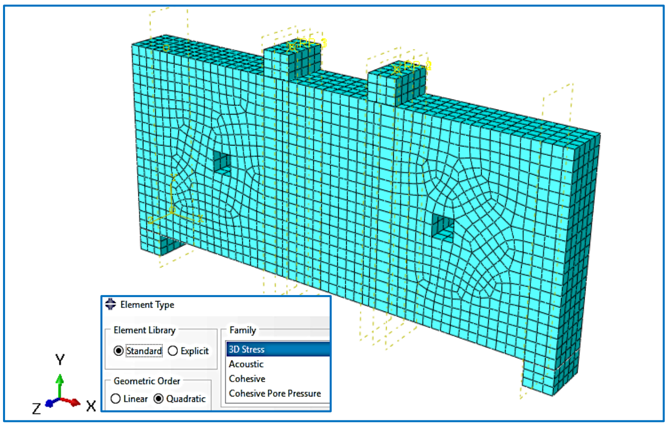


Figure (4,a). Meshing of RC Deep Beam

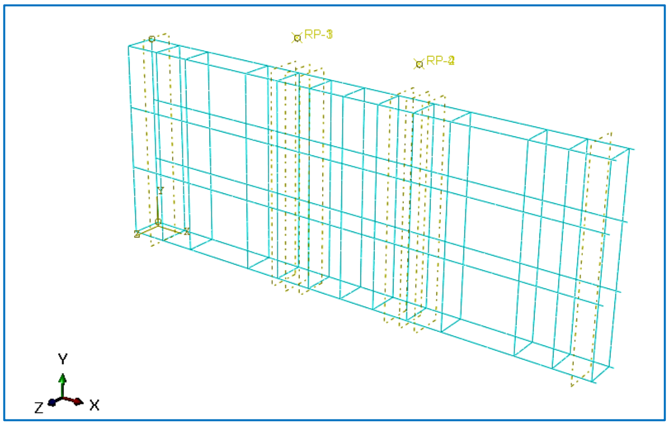


Figure (4,b). Meshing of cages

2.3. Material Properties

Self-compacted concrete compressive strength was 40 MPa. Khattab S. at al. [10]. Table 1 list the parameters of abaqus for concrete material.

Table 1. Parameters for concrete material

Concrete density	**Plastic parameter**		**Plastic parameter**				
23,530 N/m3	**E- N/m2**	**Poison's Ratio**	**Dilation angle**	**Eccentricity**	**fbo/fco**	**k**	**v**
	2.35E+10	**0.2**	**30^0**	**0.1**	**1.16**	**0.667**	**0**
Comp. behavior range value	**Yield Stress N/m2**	**Yield Strain**		**Tension behavior range value**	**Yield Stress N/m2**	**Cracking strain**	
	10500000-1111509.034	**0-0.011958241**			**3727130.263-1503924.841**	**0-0.001301094**	

And steel reinforcement parameters list in table 2. As shown below:

Table 1. Parameters for reinforcement bars material

Steel Density	**Poison's Ratio**	**E- N/m2**
7800 N/m3	**0.3**	**2.09E+11**
Plastic	**Yield Stress N/m2**	**Plastic Strain**
	350000000- 645000000	**0-0.5**

3. RESULTS AND DISSCUSION

3.1 Loads capacity comparing [experimental vs numerical test]

the examined deep beam with abaqus failed because of concrete strut failure. (Figure 5) shows the Von Mises stress distribution and failure load esteems . And comparing the result with experimental test (SQ) by Khattab S. at al. [10] . In deep beam with openings, the first askew cracks showed up in the scope of 28% in experimental while the first cracking stress showed up in the scope of 30% in finite element software [abaqus]. The ultimate load close to the best and base corners of the openings.

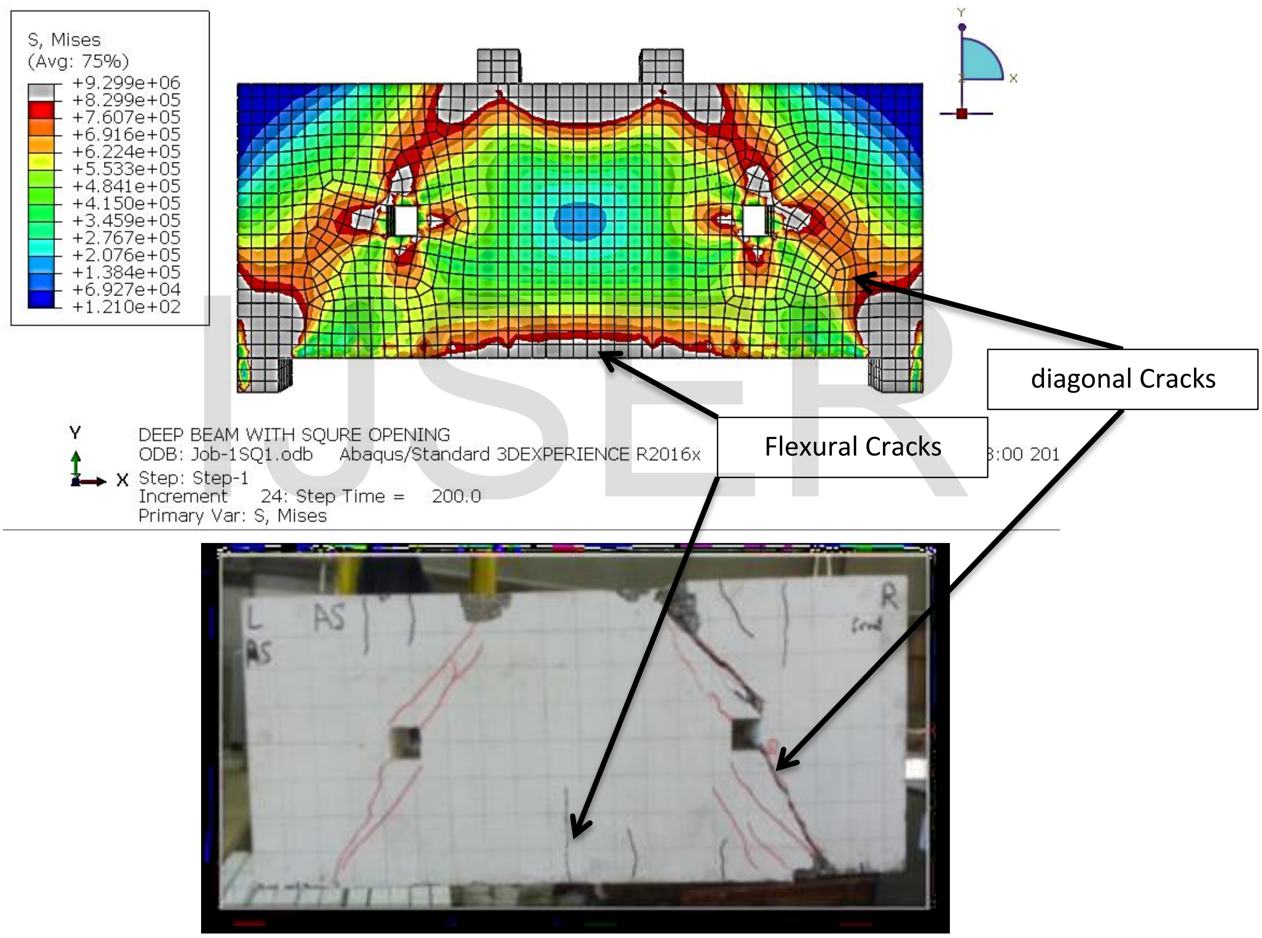
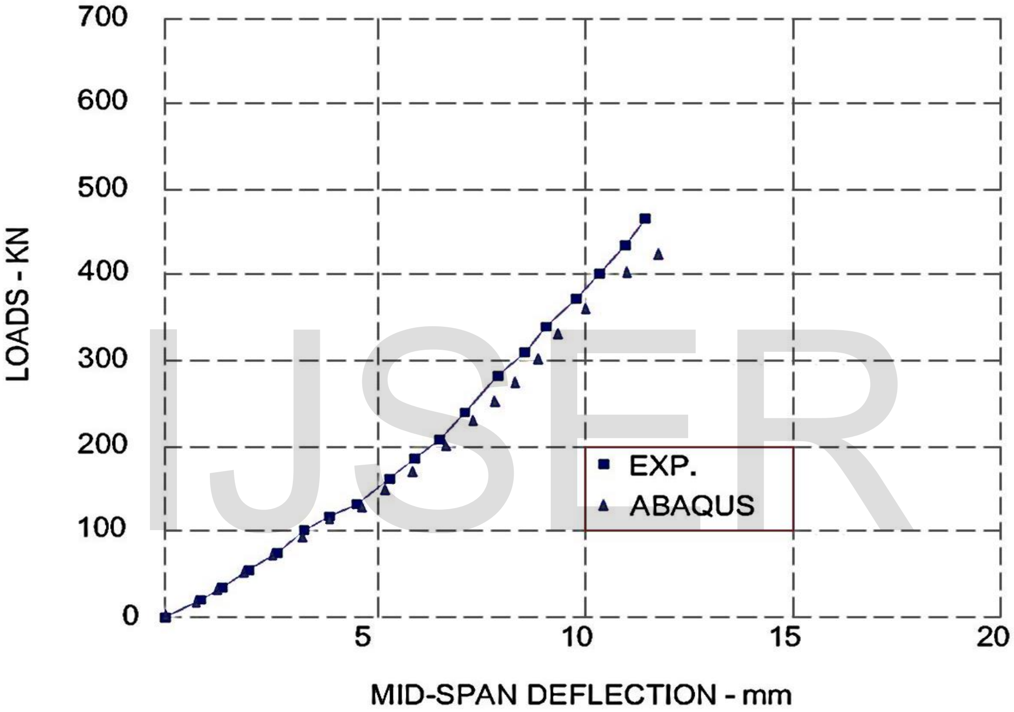


Figure 5. The Von Mises stress distribution by abaqus and the result with experimental test (SQ) by Khattab S. at al. [10]

3.2 Load-Deflection curve comparing [experimental vs numerical test]

(Figures 6) demonstrates the load versus mid-span deflection curves. In deep beam with square opening, the load deflection bend was generally straight at the first steps of the loading till the presence of the first cracks inclining cracks for deep beams with openings. From that point onward, the curves began to twist somewhat. The nearness of unstrengthened openings diminished the mid-span deflection by (8%) for SQ, specimen, as compared with abaqus result.



Figures 6. The load versus mid-span deflection curves

In general, the openings in deep beams led to decrease the ultimate shear strength and mid-span deflection when compared with the reference deep beam that had no openings by using finite element software as shown in (Figure 7). And this fact appear clearly of experimentally work introduced by Khattab S. at al.

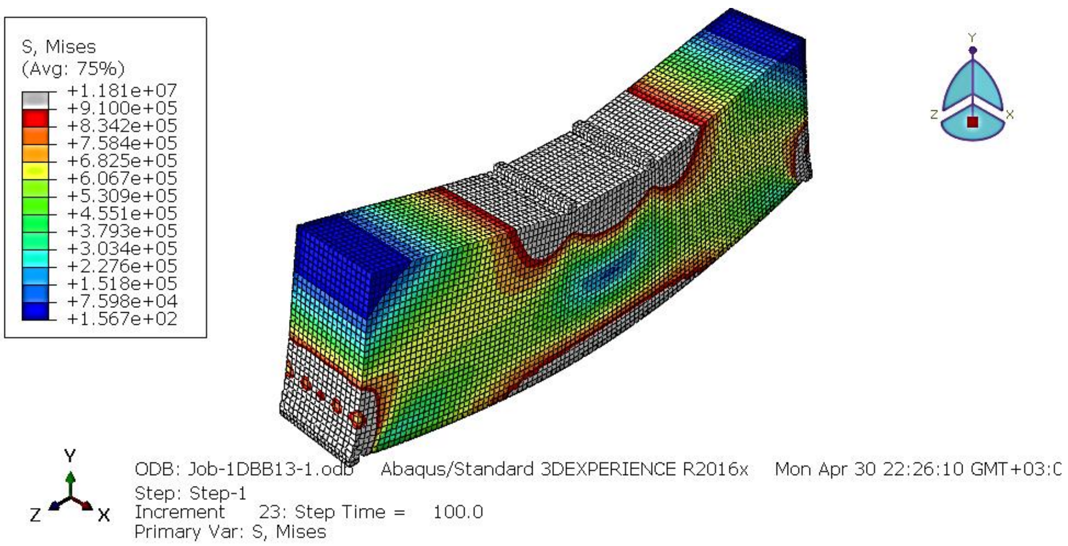


Figure 7. the reference deep beam by present study.

The presence of unstrengthened openings decreased the mid-span deflection by (30%) for SQ specimen, as compared with REF beam [experimental work].

4. Notation

fb0/fc0 The ratio of biaxial compressive yield stress to uniaxial compressive yield stress.

K The ratio of the second stress invariant on the tensile meridian to that on the compressive meridian for the yield function.

V The viscosity parameter (relaxation time).

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