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Structural Behavior, Analysis & Design of Dapped-End Beams

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Abstract: *The flexure conduct of fortified cement dapped-end pillars (D-E) is relegated in this paper. Strengthened solid D-E pillars, that flopped in flexural have been investigated utilizing the ABAQUS programming. The ABAQUS model speaks to the nonlinearity, for example, post breaking malleable firmness of the solid, stress move transversely the broke squares of cement. The disappointment method of D-E shafts is exhibited genuinely well utilizing the present numerical model, and the greatest burden expected is close to the disappointment heap of test outcomes. In this investigation elucidated some of parametric examination, for example, shear length to profundity proportion (a/d), concrete compressive quality, and the fundamental D-E fortification on the conduct of the pillars. The fundamental steel sum has the most huge impact on the exhibition of flexural quality of RC D-E bars. Most extreme burden and uprooting for different kinds of flexural disappointments in bars have been spoken to. When all is said in done this examination exhibits that the D-E pillars flexural quality is affected by the previous parameters.*
Key words: *Finite element, shear span, Dapped-end beam, flexural Failure, ABAQUS software.*

I. Introduction

The D-E beams permit the development depth of a readied concrete floor or roof structure to be diminished, by recessing the supporting corbels into the depth of the beams supported [1]. They are for the most part utilized as a part of drop-in beams between corbels, as a feature of beam to-beam association and in suspended traverses between cantilevers, as appeared in figure (1) below. The utilization of D-E beams encourages the gathering of a precast concrete structure, because of the greater lateral stability of a protected D-E beam than that of a desolate beam supported at its bottom face [2]. The RC D-E beams are generally used in concrete bridge girders and prepared concrete buildings.

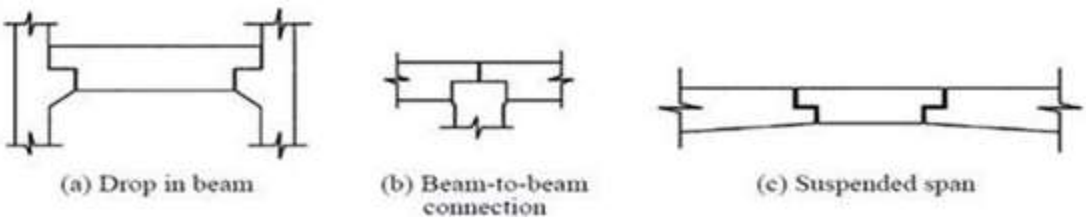

Figure 1 Cases of reinforced D-E beams

This paper is to study the ultimate flexural behavior of a D-E beams using ABAQUS software. For this purpose, three beams with span to depth ratio (1.2) were analyses in numerical solutions were gotten by this software [3]. The experimental and numerical modeling results are compared numerically and graphically.

II. Test information

Three reinforced concrete D-E beams were tested by Wen-Yao Lu et al, [4] with shear span-to-depth ratio more than unity under vertical load only. Variables considered were compressive strength of concrete, main dapped-end reinforcement, as well as horizontal and vertical stirrups.

Figure (2) shown that the D-E beam were formed on opposite ends of 3600mm, long rectangular prismatic beams. All the nibs had 500 mm, long and an overall height of, 260 mm. The reinforcement of the nibs contained from main bars, horizontal and vertical stirrups as shown in Figure (2). The sizes and amounts of the main bars, horizontal stirrups, vertical stirrups, and hanger bars in each specimen are listed in Table (1).

The main bars of the main body of the test beams consisted of 4-#6 straight bars. Shear reinforcement was provided within the middle and end span of the main body of the test beams to prevent premature failure. Dimensions of the main body of the specimen are itemized in Table (2).

The D-E beam was independently experienced by supportive the beam at one end of the D-E beam, and under the beam lowest face at the reverse end.

Table 1 Details of dapped-ends

Number of Beam	a	d	(a/d)	fc'	Hanger reinforcement		Main dapped-end reinforcement		Vertical stirrups		Horizontal stirrups	
	2 mm	2 mm	-	MPa	Stirrups	Avh mm^2	Bars	As mm^2	Stirrups	Av mm^2	Stirrups	Ah mm^2
1	310	260	1.2	32.5	3#4	760.1	2#7	774.2	4#3	567.1	2#3	283.5
2	310	260	1.2	32.5	2#4	506.7	2#6	573.0	3#3	425.3	2#3	283.5
3	310	260	1.2	32.5	2#4	506.7	2#6	573.0	2#3	283.5	2#3	283.5

Table 2 Details of dapped-ends

Number of Beam	Main Bars	H mm	b mm	a mm	Shear reinforcement End	Shear reinforcement Middle
1	4#6	600	200	310	#3@150 mm	#3@250 mm
2	4#6	600	200	310	#3@150 mm	#3@250 mm
3	4#6	600	200	310	#3@150 mm	#3@250 mm

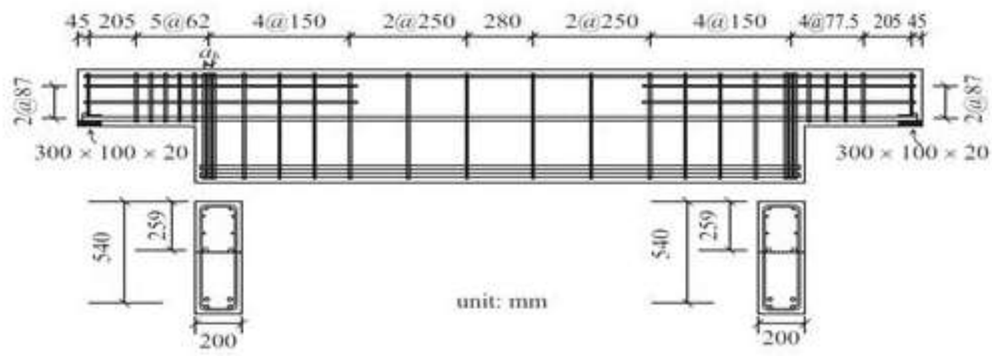

Figure 2 Typical specimen

III. Numerical Analysis And Nonlinear Solution Technique By Abaqus Software

Numerical studies were achieved using ABAQUS matched against tested results [4]. In this paper we principally concentrated on the flexural failure on RC D-E beams under vertical load as it were.

3.1. Concrete Damage Plasticity Model

The concrete damage plasticity model is a continuum, plasticity-based, damage model, which assumes two main failure mechanisms: the tensile cracking and the compressive [5]. The model uses the yield function proposed by Lubliner et al [6] and modification by Lee and Fenvas [7].

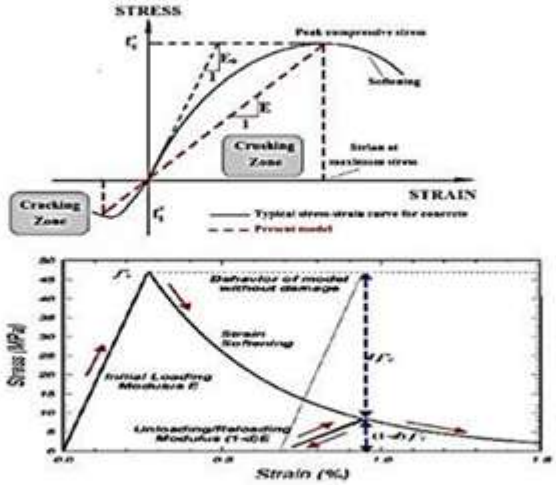

Figure 3 CDP Model for compression & tension

3.2. Steel Bar Model

Steel of both main and transverse has acted as the embedded part and the average stress-strain behavior of mild steel bar using bilinear model shown in figure below [8]:

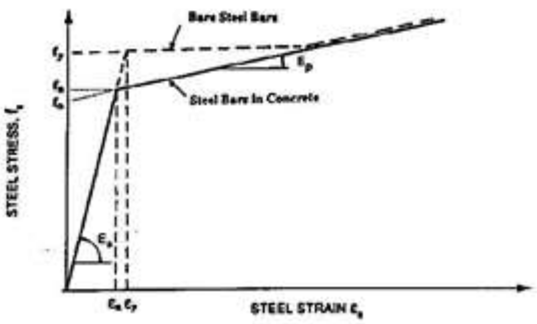

Figure 4 Average stress-strain relationships of steel reinforcement using bilinear model

3.3. Material Property for Concrete

Table 3 property for concrete

Property	**Value**
Density (kg/m3)	2400
Young Modulus (Pa)	26794e6
Poison's Ratio	0.20
Dilation Angle	38
Eccentricity	0.1
FB0 / FC0	1.166

3.4. Properties for Mild Steel

Steel reinforcement density is 7850 kg/m^3 and E_c= 210000x106 Pa, and the υ=0.3. Truss elements are rods that can convey as it were tensile or compressive loads. They have no resistance to bending; consequently it can be demonstrated as a truss.

3.5. Modeling and Meshing

In this study, three dimensional numerical models of RC D-E beam were established, and the some substances concerned with modeling is addressed as follows.

- Elements type
- Material property

- Assigning sections
- Defining step
- Interaction between elements
- Specify boundary conditions and load
- Meshing
- Assigning job
- Evaluating the results

The numerical recreation of a reinforced concrete structure requires an exact model of the structural components and its constituent individuals going about as a composite made up of concrete and steel. A drawing of each section is created separately with ABAQUS, which can then be extruded in any direction; this is why a 3D solid element in "modeling space" using deformable type for beam was created. In order to develop concrete beam, 20-node continuum solid element was used.

The used element has three degrees of freedom at each node, translations in the nodal x, y, and z directions. It is talented of plastic distortion, cracking in three orthogonal directions, and crushing. Concrete beam necessary partitions (of size 3600 x600 x200) are made to facilitate load application and meshing.

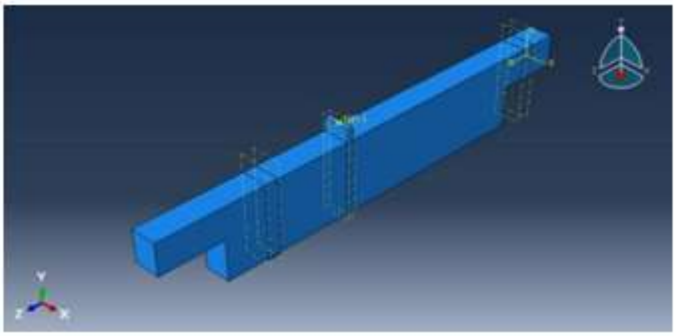

Figure 5 Solid model for concrete Dapped-End beam

The main steel reinforcement of size 3510 mm is modeled as two node beam elements connected to the nodes of adjacent solid elements.

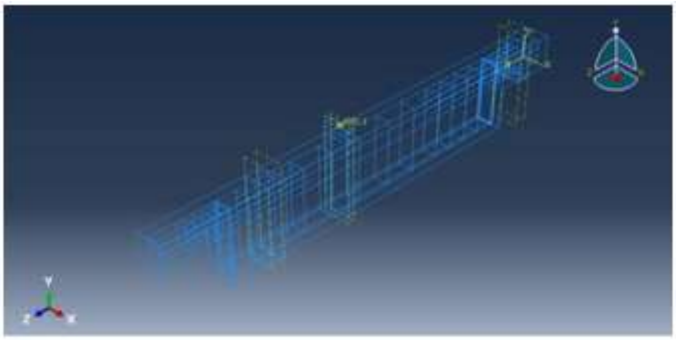

Figure 6 Reinforcement model for concrete Dapped-End beam

After assembling and assigning the properties, an input file is created which is then imported to create an orphan mesh. An orphan mesh contains nodes and elements but no geometry. This is useful for creating surfaces on concrete to apply load and also for applying boundary condition on nodes. The beam is simply supported, all the nodes at a distance of 50mm from both the edge of the beam is retrained to move along Y direction at one side and on the other side it is restrained to move in X and Y direction as shown in Figure. Meshing is the process of generating nodes and elements. A mesh is generated by defining nodes and connecting them to define the elements.

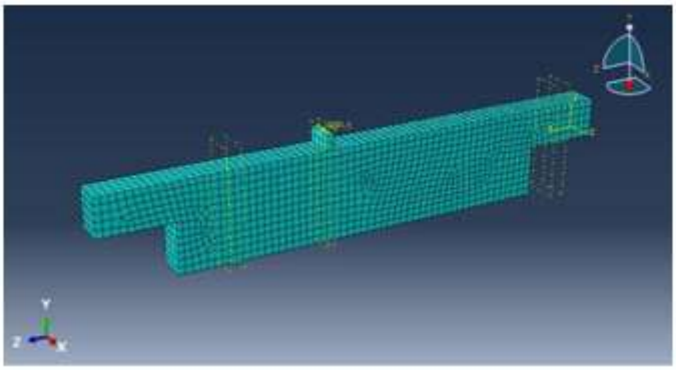

Figure 7 Meshing of concrete Dapped-End beam

To solve any type of finite element problem, the relevant job analysis should be established. After this stage the extracted answers is visualized analytically and graphically.

IV. Comparison Of Experimental And Analytical Results

4.1. Load-Deflection Relationship

The present Abaqus model are plotted in below based the corresponding relationships drawn from the selected previous experimental investigations [3]. For the D-E beam B1, the maximum loads from the numerical model and the tested beam are 430kN and 425 kN respectively, and the ultimate deflection are 8.25mm and 10mm respectively. For D-E beam B2 the maximum loads from the numerical model and the tested beam are recorded as 345kN and 350 kN, respectively, and ultimate displacement are 8.76mm, and 9.8mm, respectively.

For D-E beam B3 the maximum loads from the numerical model and tested result are recorded as 333kN and 325 kN, respectively, and ultimate displacement are 8.1mm, and 7mm, respectively. With reference Figure (8) and Figure (9) deflections at beam soffits under bad positions given by the previous experimental tests [4], and those computed by the present finite element model are very close to each other. The ratios between the experimental and theoretical deflections at ultimate load are 1.21, for beams B1, and 1.11, for B2, and 0.86, for B3 respectively.

The load displacement curves for the beam from the current numerical model concur great with the selected test results [4].

The little divergent that can be noticed from plots can be attributed to the micro-cracks that present in the concrete for the tested beam and could be produced by drying shrinkage in the concrete and/or handling of the beam. The assumption of perfect bond between the concrete and steel reinforcing bars is assumed in the numerical model that not real for he tested specimens.

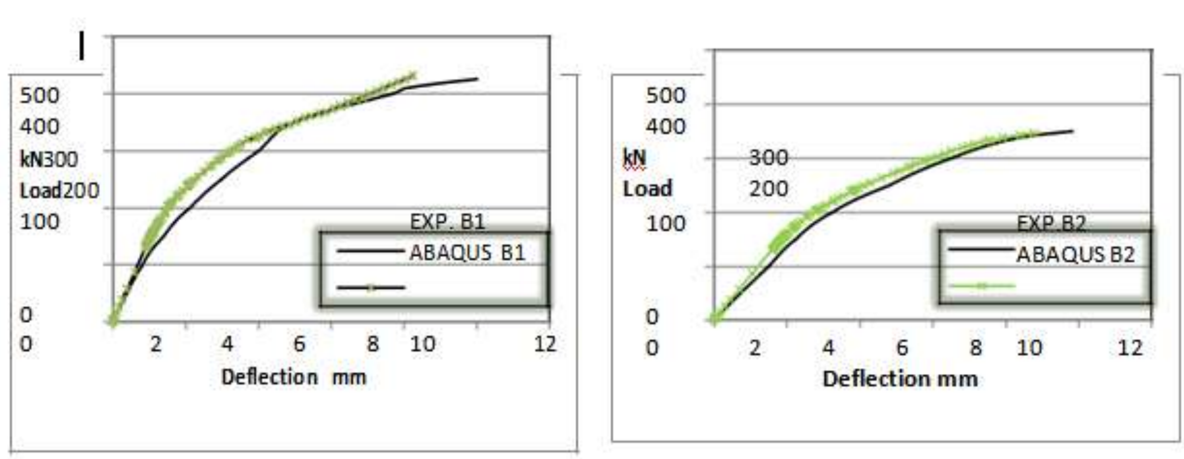

Figure 8 Experimental [4], and numerical load-deflection behavior for B1and

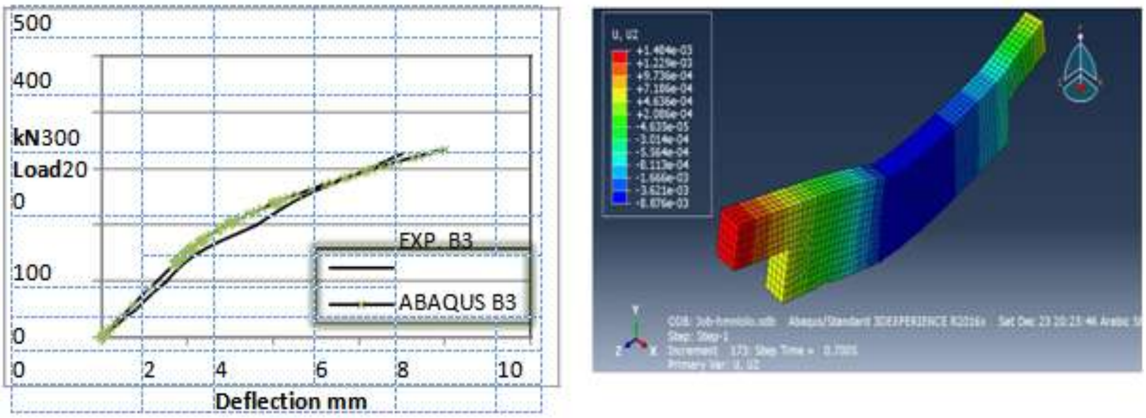

Figure 9 Experimental [4], and numerical load-deflection behavior for B3

4.2. Stress Distribution

The performance of D-E beam B3 is reflected suitable, both at service and maximum loads. For all beams the general process of cracking is comparative. The first crack initiates at the corner at all stage of loading. This crack transmitted at about 45^o to the horizontal. It reaches to the entire height of the nib. As of now extra inclining tension cracks ocure in the beam in the opposite edge and in the full depth of the beam. At hight stresses for the last load step are appeared for the beams in Figure (10) where the maximum stress location in the reinforced concrete D-E beams as dictated by the current numerical model as shown in figure below.

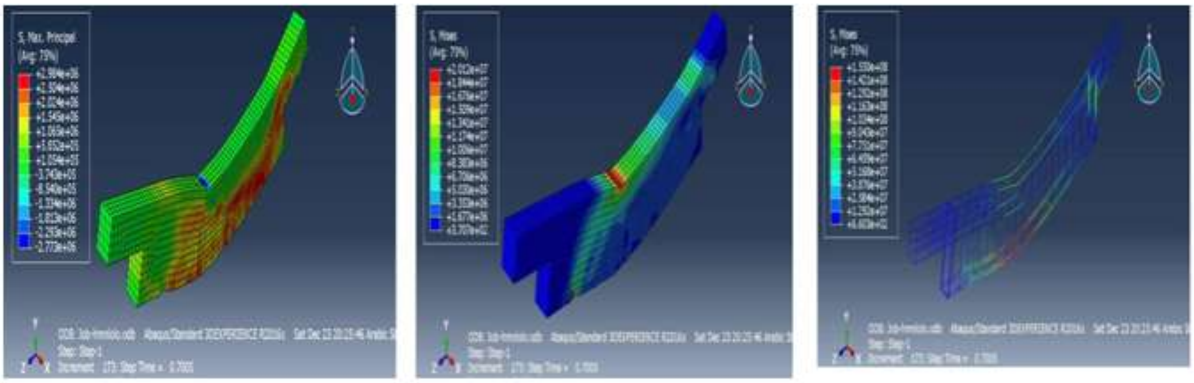

Figure 10 Deflection and stress distribution of D-E beam 3

V. Parametric Study

Utilizing the analytical model that confirmed against previous test results for reinforced concrete D-E beam, a parametric study is conducted to beam B3 only, to evaluate the effects of (a/d) ratio, (f'c), and the major D-E reinforcement.

5.1. Effect of Shear Span to Depth Ratio

Figure (11-A), Demonstrations influence of the (a/d) ratio on the ultimate load for D-E B3. It is realized that the maximum strength of the specimen decline with increasing the (a/d) ratio. The maximum strength, of specimen B3 diminished as of 375kN for the ratio of (a/d) =0.8, to 270kN for (a/d) =1.5. This decrease in the total strength is due to the cracks across depth of the nib of the beam, because when the shear span increases the flexural behavior becomes the controller instead of the shear failure, and cracks in the re-entrant corner of the beam developed.

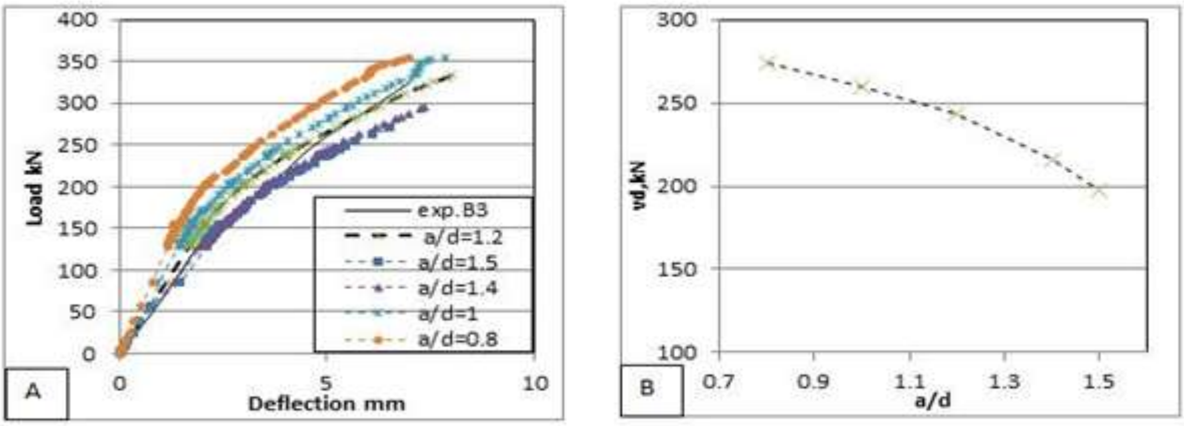

Figure 11 Experimental [4], and numerical load-deflection behavior for different value of (a/d) ratio for beam (3)

5.2. Effect of Compressive Strength

The current numerical model was utilized to show the effect of compressive strength on the behavior of D-end beam. The concrete compressive cylinder strength was varied in the range of 32.5, 48.6, and 62.9 MPa. The other parameters are kept the same for beam B3. The influence of (f'c) on the performance of D-E beam is shown in figure (12-A). The maximum load of D-E beams increases with the increase of the concrete compressive strength. The maximum load, of the D-E beam increases from 333kN for f'c =32.5 MPa to 492kN for f'c =62.9 MPa. The increasing of failure load is almost slightly diverging from compressive strength. The load deflection behavior is illustrated in Figure (12-B) for altered estimations of concrete compressive strength.

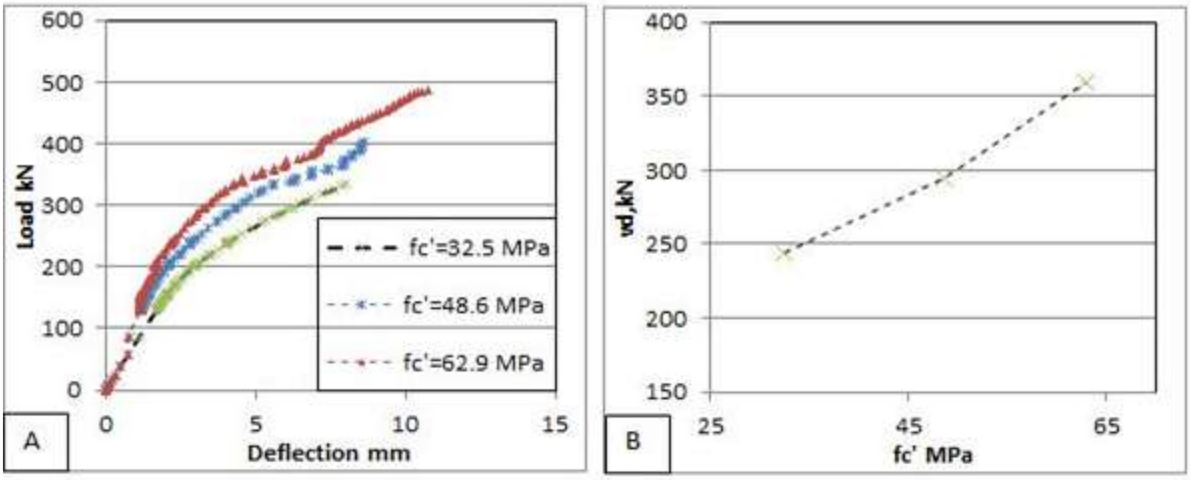

Figure 12 Experimental [4] and numerical load-deflection behavior for different value of (f'c) ratio for beam (3)

5.3. Effect of Main Dapped-End Reinforcement

The main D-E steel amount (ρfy) is one of the most significant factors effecting on the performance of flexural strength of RC D-E beams. The analytical models adopted the following values of (ρfy), (3, 4.88, and 7MPa) as illustrated in Figure (13). The specimen Flexural strength increases with the increasing the amount of main D-E reinforcement. Higher flexural strength values are predicted for larger (ρfy) values.

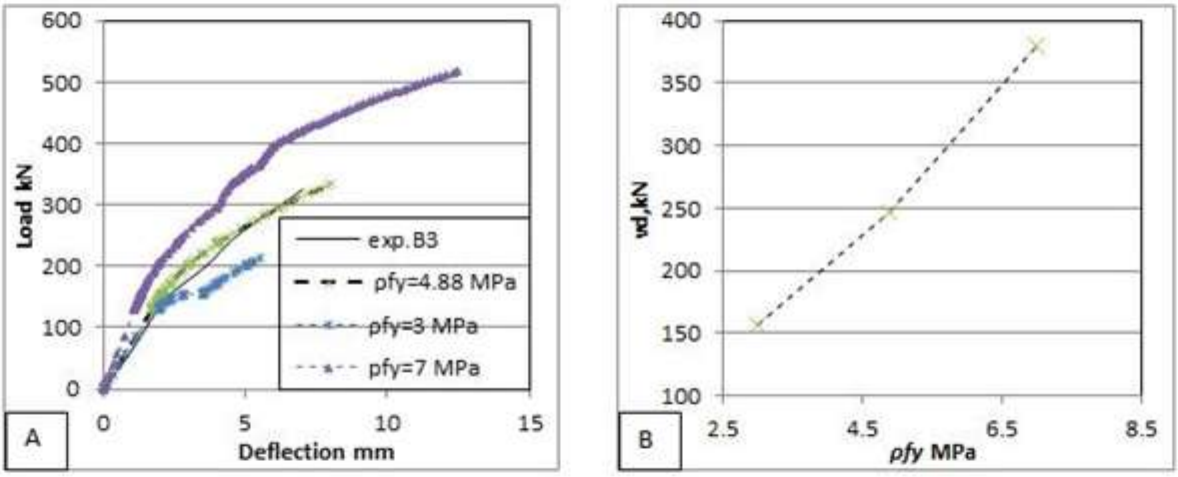

Figure 13 Experimental [4] and numerical load-deflection behavior for different value of (ρfy) ratio for beam (3)

On the other hand the deflection values in the earlier load applications are the same but when load increases further the difference begins to increase, especially for (ρfy) =3MPa, due to the small amount of area of reinforcement in the beam.

In general the main D-E reinforcement yielded before achieving the maximum capacity and the load-deflection curve for analytical models is faintly diverse from the experimental curve.

VI. Conclusions

- A numerical model has been established to pretend the load-deflection performance of the RC D-E beams under vertical load. The model considers the linearity and nonlinearity material properties for concrete and mild steel. The numerical model related well with the results of previous data [4].
- The studies using this model has been carried out to inspect the effects of (a/d), concrete compressive strength, and the amount of the main reinforcement on the performance of the RC D-E beams.
- The estimated loads of the RC D-E beams by the present numerical models at various steps were observed to be in great concurrence with the experimental results [4].
- The failure mode of D-E beams is demonstrated fairly well using the present numerical model, and the maximum load expected is very near to the failure load of test results [4].
- In this study, selected three from twenty four D-E beams with (a/d) ratio above unity were tested.
- The shear strength of D-E specimens increases with increase in compressive strength of beam. With smaller (a/d) ratio of D-E beams, there is larger rigidity and maximum capacity of D-E beams.
- The ultimate load of D-E specimens increases with increase in compressive strength of beam.
- And also the outcome had shown that the flexural strength increases with the increasing of the major D-E reinforcement.

NOTATIONS

a = shear span defined, estimated from the focal point of the support to the focal point of the hanger bars.
ab = width of hanger bar zone.
Ah = the horizontal stirrups area.
As = the main bars area.
Av = the vertical stirrups area within shear span.
Avh = area of the hanger bars.
b = the D-E width.
d = effective depth of the D-E.
fc- = compressive strength of concrete.
L1, L2 = Distances between load and supports, Vdv,tet = .
RC=Reinforced concrete.
D-E=Dapped end.

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