

## **Investigation of Effective Parameters on Nonlinear Behavior of R.C. Deep Beams by Finite Element Method**

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### **Abstract**

This paper investigate influence of various parameters on the nonlinear behavior of R.C. deep beams. Reinforced Concrete deep beams are one of the structural element that used in dams, offshore piers, rectangular tanks, bridges, floors, diaphragms and high rise buildings. Definition of deep beam by various codes is based on span to height of beam ratio. Generally, span to height ratio of deep beams required not to be greater 2.5. In this paper, three deep beams which have been tested in laboratory already, have been analyzed with various number of element by a nonlinear layered finite element program. In the nonlinear analysis section, results include vertical load versus vertical displacement curve, crack pattern, cracking load and ultimate load. For investigating deep beams behavior, a parametric study used to investigate size-effect phenomenon, tension and compression strength of concrete, yield strength of reinforcement (bar), amount of longitudinal and vertical reinforcement, location and percentage of opening. Also, a new method proposed for placing reinforcement cage in the shear failure area and analytical results compared to experimental results. Results comparison show that nonlinear layered finite element method can be used for investigating of R.C. deep beams with high accuracy.

**Key words:** Deep beam, Reinforced concrete, Nonlinear analysis, Finite element, Ultimate strength.

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[ ] Leonhardt (1966)

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Subedi (1988)

[ ] Arabzadeh (1992)

[ ] Kotsovos (1988)

(1992)

[ ] Paiva and Siess

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(.)

NONLACS2

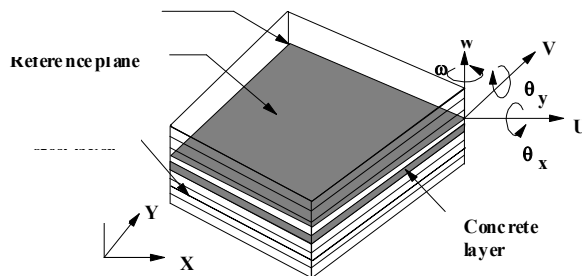
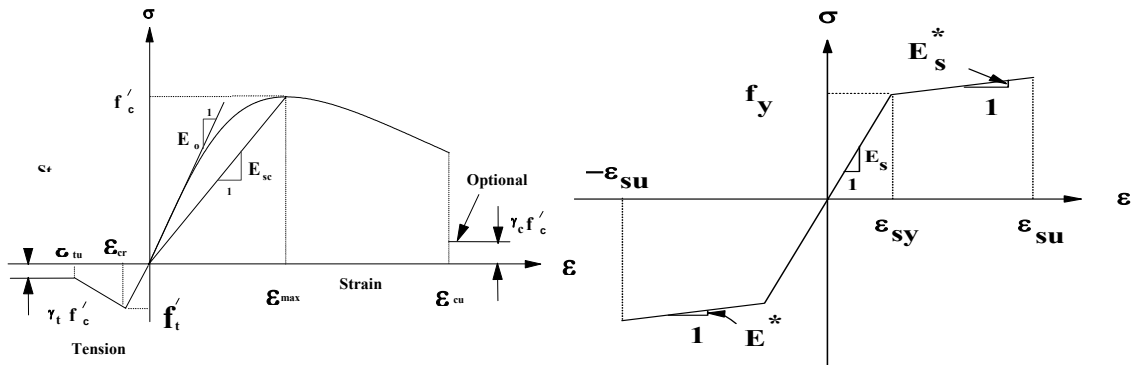
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NONLACS

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Facet shell element

h  $\epsilon_{tu}$  mm -

4B14 1B1

6p7 [ ]

[ ] Ramakrishnan & Ananthanarayana

[ ] (1997)

6P7 4B14

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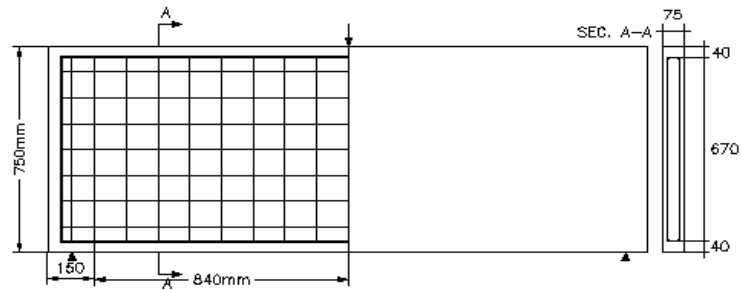
$\epsilon_{tu}$

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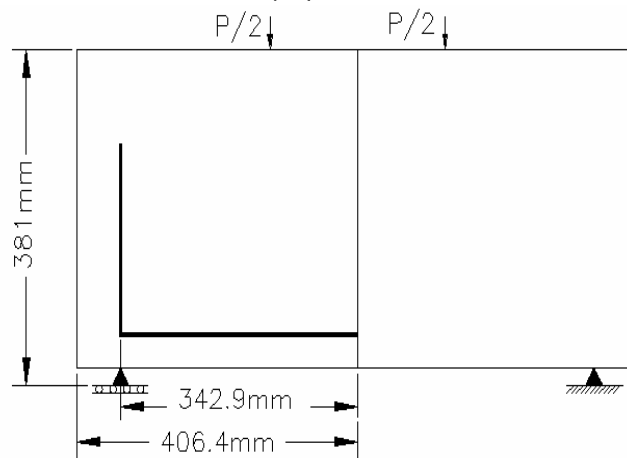
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$$\epsilon_{tu} = 0.004 e^{(-0.008 h)}$$

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6p7 ( 4B14 (

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6p7 4B14 1B1

نام تیر	د هانه L (mm)	عمق h (mm)	عرض b (mm)	$f'_c$ MPa	$f_t$ MPa	$E_c$ $\frac{KN}{mm^2}$	$E_s$ $\frac{KN}{mm^2}$	$f_y$ MPa	$A_s$ فولاد ( $mm^2$ )	$A_s$ فولاد اصلي پائين ( $mm^2$ )	$A_s$ فولاد قائم جان (درصد)	مقاومت نهایی آزمایشگ اهی $P_u$ (kN)
1B1				/	/	/			/			/
4B14				/	/	/			/	/		/
6p7	/		/	/	/	/						

1B1

140 kN

NONLACS2

QLC3 shell

Plane- stress and bending

75 kN

( )

Smearred Layer

$\epsilon_{tu} = 0.002$

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4B14 1B1

NONLACS2

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( % )

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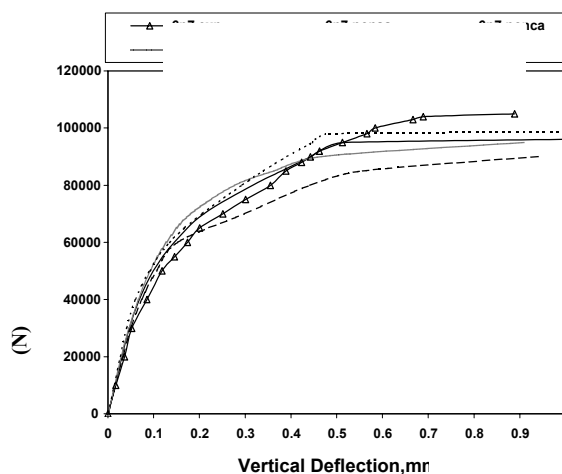
6p7

(P<sub>u</sub>)

-

		P <sub>u</sub> (kN)	( ) P <sub>u</sub> (NON) / P <sub>u</sub> (exp)
6p7 , exp			
6p7 , nonda			/
6p7 , nonaa			
6p7 , nonba			/
6p7 , nonca			/
6p7 , exp			
6p7 , nondam			
6p7 , nonaam			/
6p7 , nonbam			
6p7 , noncam			/

Deep Beam6p7



(mm)

( $\epsilon_{tu} = 0.002$ )

6p7

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( )

( )

(f)

( )

6p7

( )

$f_{t=3.1}$

( )

$f_t$

(f)

( )

$(\epsilon_{cr} = f_t / E_c)$

( )

6p7

(f)

**(Parametric Study)**

(6p7 )

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$(P_{cr})$

( )

$(P_w)$

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		///	

6p7

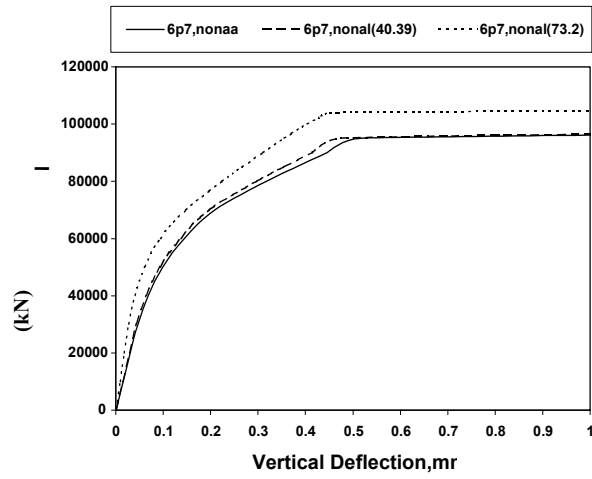
( ) 6p7 -

	( )	$P_u$ (kN)	$P_u(\text{NON})/P_u(\text{exp})$ ( )
6p7 , nonaa(1.00)	$f_t$ (N/mm <sup>2</sup> )	/	/
6p7 , nonaa(1.4)		/	/
6p7 , nonaa(1.75)		/	/
6p7 , nonaa(3.1)		/	/
6p7 , nonal(40.39)	$f'_c$ (N/mm <sup>2</sup> )	/	/
6p7 , nonal (73.2)		/	
6p7 , nonah (250)	$f_y$ (N/mm <sup>2</sup> )		
6p7 , nonah (450)			/
6p7 , nonag (0.00)	$A_s$ (mm <sup>2</sup> )	/	/
6p7 , nonag (113.1)		/	/
6p7 , nonas (0.28)	( )		/
6p7 , nonas (0.5)			/
6p7 , nonaf (0.08)	( )		/
6p7 , nonaf (0.15)			/
6p7 , nonaf (0.22)			
6p7 , nonan (0.07)	( )		/
6p7 , nonan (0.14)			
6p7 , nonad (25.1)	(I) $A_s$ (mm <sup>2</sup> )	/	/
6p7 , nonad (56.5)		/	/
6p7,nonad (100.5)		/	/
6p7 , nonac (25.1)	(II) $A_s$ (mm <sup>2</sup> )	/	/
6p7 , nonac (56.5)		/	/
6p7 , nonac (100.5)		/	/
6p7 , nonab (25.1)	(III) $A_s$ (mm <sup>2</sup> )	/	/
6p7 , nonab (56.5)		/	/
6p7,nonab (100.5)		/	/



	$f_t$ (N/mm <sup>2</sup> )	$P_{cr}$ (kN)	$P_y$ (kN)	$P_u$ (kN)
6p7,nonaa(1.00)	1.00			
6p7,nonaa(1.4)	1.4			
6p7,nonaa(1.75)	1.75			
6p7,nonaa(3.1)	3.1			

### Deep Beam 6p7



(mm)

6p7

MPa

$f_c$

kN

(6p7)

( )

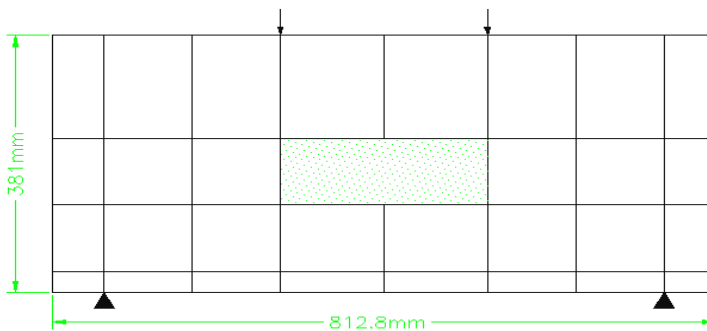
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6P7

) 6p7  
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 6p7  
 ( )  
 (% % % )  
 kN Mpa  
 -  
 ( )  
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 ( )

6p7

	$f_y$ (N/mm <sup>2</sup> )	$P_y$ (kN)	$P_u$ (kN)
6p7,nonah(250)		/	
6p7,nonaa(345)		/	
6p7,nonah(450)			



(% ) 6p7

(III )

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(III )

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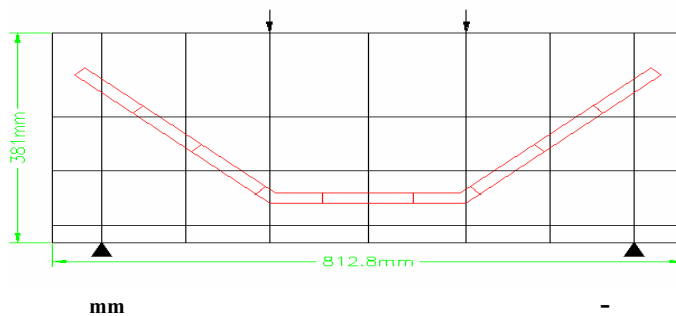
6p7

6p7

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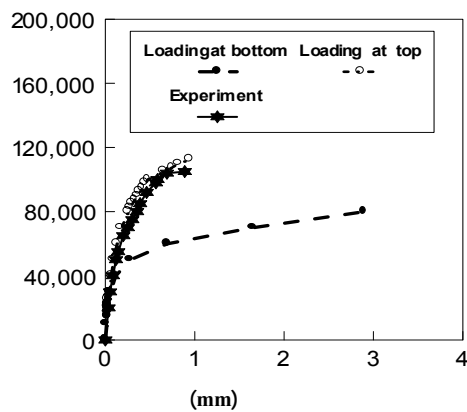
(I )

(II )



mm

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6p7

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