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EXPERIMENTAL PERFORMANCE, MATHEMATICAL MODELING AND DEVELOPMENT OF STRESS BLOCK PARAMETERS OF R.C.C BEAM WITH "V" SHAPED REINFORCEMENT

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ABSTRACT

In civil engineering design and construction the main steel in beams and slabs are used to take the tension and to increase the ductile behavior. In slabs the main and distribution steel is provided in horizontal form. Also the main steel in singly reinforced and doubly reinforced beams is in horizontal form only. But if we replace this horizontal form of the reinforcement in beams and slabs by "V" shaped, reinforcement there will be increase in the moment carrying, shear carrying capacity with reduced deflection by enhancing its ductile behavior because of additional folded plate action and it takes in to account the reversal of loading & thereby the sections becomes more strong in fatigue action.

KEYWORDS: Beams, Slabs, Main Reinforcement, "V" shaped reinforcement and ductility

INTRODUCTION

In civil engineering design and construction steel reinforcements are used to take mainly tension and increase ductility of the members such as beams, slabs, footing, etc. In case of doubly reinforced beams and columns the steel is also used to take compressive force along with increase in its ductility. In present theory the main steel used in the beam at top & bottom is in horizontal form. So instead of providing separately steel at top and bottom side of the beam if the steel is provided in the form of alternate "V" shaped main and distribution steel the beam will also act as a folded plate up certain limit. Because of the action of folded plate in addition to bending and shear the load carrying capacity of the beam will also increase with reduced deflection.

Sidramappa Dharane & Archita Malge [1]: The paper of effect of shape of main reinforcement in slabs. The aim of the work is to study the effect of "V " shaped reinforcement in beams, in this case, instead of horizontal bar at top & bottom in doubly beam, if we replace this horizontal form of the reinforcement in beams and slabs by "V" shaped reinforcement, there will be increase in the moment carrying, shear carrying capacity with reduced deflection because of folded plate action and thereby the sections becomes more economical.

Sidramappa Dharane & Archita Malge [2]: The paper of civil engineering analysis and design software -limitations of end- users and feedback almost all structural engineers are assigning the live loads on all the floors /slabs/beams and analyzing the framed structures. But assigning the live loads on all the floors/beams is not being the critical case. Critical analysis is required for safe design. And to get the critical section it is necessary to improve the software which takes into account the number of trials i.e. various positions of live loads. The software should be improved in such a way that it should take automatically all positions of live load on floors/beams for critical analysis.

Mahmood et. al. [3]: Studied the effect of different numbers of wire mesh layers on the flexural strength of folded and flat ferrocement panels and to compare the effect of varying the number of wire mesh layers on the ductility and the ultimate strength of these types of ferrocement structure. Seven ferrocement elements were constructed and tested each having (600x380mm) horizontal projection and 20mm thick, consisting of four flat panels and three folded panels. The experimental and numerical results show the superiority of the folded to the flat panel in terms of ultimate strength and initiation of cracking.

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Rao et. al. [4]: Studied the shear strength of 6 ferrocement panels having size 600x150mm with 25mm thick. Each panel was tested under various spans to depth ratios from 1 to 6. Based on the experimental result, a formula for predicting the shear strength of the ferrocement panel was proposed. The aim of the work was to study the effect of varying the number of steel wire layers on the flexural behavior of folded ferrocement panels and to compare cracking, ultimate flexural strength and load deflection behavior with that of the flatpanels.

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MATERIALS AND METHODS

A. .Methodology-

The experimental programme consists of casting, testing of reinforced concrete beams, cubes with different shapes of reinforcement provided in the beams at various percentage of steel at top & bottom. The reinforcement provided in the beam is alternatively "V" shaped. Total 38 reinforced high strength concrete beams were cast.

B Details of beam specimen

The specimens used were cubes, beam specimens .Dimensions of each test specimen are as under:
Cube: 150 mmx150 mm x150 mm,
Cube: 75 mmx75 mm x75 mm, Beam:
150 mm x 150 mm x 700 mm Beam
specimens were used to determine .
,flexural of frc beams .
Cubes of 150 mm x 150 mm size
Cubes of 75 mm x 75 mm
were used to find the compressive strength.
Compressive strength of cubes are determined at 28days using compression testing machine (CTM) of capacity 2000 KN. FTM testing machine of capacity 250 KN was used to determine the flexural strength of beams.

C. Test Materials-

1. Cement – Ordinary Portland cement whose 28 day compressive strength was 53Mpa was used.

2. Fine Aggregate - Natural River sand confirming with specific gravity is 2.65 and fineness modulus 2.33 was used.

3. Coarse Aggregate - Crushed Coarse aggregate of 20mm and 10 mm procured from local crusher grading with specific gravity is 2.63 was used.

4. Water- Portable water free from any harmful amounts of oils, alkalis, sugars, salts and organic materials was used for proportioning and curing of concrete.

5.Steel – Diameter of steel is used 6mm.

6. Proportion- cement: sand: aggregate: water (1:1.5:3:0.38)

7. Ferrocement-

7.1 Welded Square Mesh-

- Wire diameter 1 millimetres
- Size of mesh opening 12.5 X 12.5 mm
- Maximum use of 12 layers of mesh per 6 mm of thickness.
- Maximum 10 square in transverse directions.
- Maximum 55 square in longitudinal directions.
- Poisson ratio is 0.3.

REINFORCEMENT PROFILE:-
1. *"V" SHAPED ONE WAY DIRECTION REINFORCEMENT*:-

In reinforced cement concrete beam the main reinforcement is provided along the longitudinal direction is straight bar and in transverse direction trough shaped reinforcement is provided at 60 mm spacing each interval. Because of "V" arrangement the load carrying capacity, moment resisting capacity, shear resisting capacity & ductility will increase with reduce deflection and self weight. Also it takes into account the reversal of loading. Due to inter locking of trough shaped reinforcement the bond between concrete and steel is very strong.
The fig shows the detailed "V" shaped arrangement.

"V" Shaped Reinforcement Profile

2. *"V" SHAPED TWO WAY DIRECTIONA REINFORCEMENT:-*

In reinforced cement concrete beam the main reinforcement is provided along the longitudinal direction is trough shaped and in transverse direction trough shaped reinforcement is provided at 60 mm spacing each interval. Because of "V" arrangement the load carrying capacity, moment resisting capacity, shear resisting capacity & ductility will increase with reduce deflection and self weight. Also it takes into account the reversal of loading. Due to inter locking of trough shaped reinforcement the bond between concrete and steel is very strong. Due to folded plate action the beam takes reversal loading which is beneficial earthquake.

The fig shows the detailed "V" shaped arrangement.

"V" Shaped Reinforcement Profile

7.2Proportion-cement:sand:water (1:2:0.38)

III RESULT AND DISCUSSSION

A. *.Figures and tables-*

Results after casting, testing of concrete beams are shown in table 1.

Result of average collapse load for Rcc, Ferrocement & "V" shaped reinforcement beam specimens shown in table.

Table 1

Sr.no	Mix designation	Specification	28 th days Collapse Load (KN)	
			Collapse load KN	Average Collapse load KN
1	BC -1	RCC NO OF BAR AT TOP &BOTTOM -2	84	83.33
2	BC -2	RCC NO OF BAR AT TOP & BOTTOM – 2	85	
3	BC -3	RCC NO OF BAR AT TOP & BOTTOM – 2	72	
4	BC-4	RCC NO OF BAR AT TOP & BOTTOM – 3	86	94
5	BC-5	RCC NO OF BAR AT TOP & BOTTOM – 3	98	
6	BC-6	RCC NO OF BAR AT TOP & BOTTOM – 3	98	
7	BC -7	RCC NO OF BAR AT TOP & BOTTOM – 4	104	114.66
8	BC- 8	RCC NO OF BAR AT TOP & BOTTOM – 4	110	
9	BC -9	RCC NO OF BAR AT TOP & BOTTOM – 4	130	
10	DHC- 1	ONE DRECTIONAL "V" SHAPED REINFORCEMENT	93	95.50
11	DHC- 2	ONE DRECTIONAL "V" SHAPED REINFORCEMENT	98	
12	DHC- 3	TWO DRECTIONAL "V" SHAPED REINFORCEMENT	95	96
13	DHC- 4	TWO DRECTIONAL "V" SHAPED REINFORCEMENT	97	
14	BC- 10	FERROCEMENT NO.OF MESH – 3	20	20.5
15	BC -11	FERROCEMENT NO.OF MESH – 3	21	

LSM CALCULATINON-:

LSM CALCULATION-1. RCC NO OF BAR AT TOP & BOTTOM-2

By using LSM we can calculate the collapse load (W) of section

Given data:

Width of section (b)=150 mm, Depth of section (D)= 150 mm ,effective cover (d')=15 mm, effective depth (d)=135 mm ,Diameter of Bar (d)= 6mm ,Grade of concrete (fck)=20 N/mm^2, Grade of steel (fy)= 250 N/mm^2,

→

Asc= 2 X π/4 X d^2= 2 X π/4 X 6^2= 56.54 mm^2 In compression zone)

Assume Xu =0.4 d = 0.4 X 135 = 54 mm

1. Tensile force in concrete (Tu) = 0.87fy. Ast =$12.29 x 10^3$ N

2. Compressive force in concrete (Cu) = 0.36fck X Xub + fsc X Asc - 0.446 fck X Asc =76.017 X10^3 N

3. Moment of Resistance (MR) = C_{cu} (d – 0.416 $X_{u)}$ + C_{su} (d-d') = 8.038 x10^6 KNM.

MR=BM

8.038 x10^6 = WL/6

∴ W = 80.38 KN.

Check for stress-

$(6max)_T$ = M/I x Y

$(6max)_T$ = 16.67 N/mm^2

16.67 N/mm2=17.833N/mm2 -Hence ok.

In this case the therotical $(6max)_T$ is matches with the experimental & ansys results, it means that the valu of 6max is equal to the actual value of stress in experimental & ansys results$(6max)_A$

LSM CALCULATION-2. RCC NO OF BAR AT TOP & BOTTOM-3

By using LSM we can calculate the collapse load (W) of section

Given data:

Width of section (b)=150 mm, Depth of section (D)= 150 mm ,effective cover (d')=15 mm, effective depth (d)=135 mm , Diameter of Bar (d)= 6mm ,Grade of concrete (fck)=20 N/mm^2, Grade of steel (fy)= 250 N/mm^2,

→

Asc= 3 X π/4 X d^2= 2 X π/4 X 6^2= 84.82 mm In compression zone

Assume Xu =0.4 d = 0.4 X 135 = 54 mm

1.Tensile force in concrete (Tu) = 0.87fy. Ast =$18.44x10^3$ N

2. Compressive force in concrete (Cu) = 0.36fck X Xub + fsc X Asc - 0.446 fck X Asc =76.011 X10^3 N

3. Moment of Resistance (MR) = C_{cu} (d – 0.416 $X_{u)}$ + C_{su} (d-d') =8.77 x10^6KNM.

MR=BM

8.77 x10^6= WL/6

∴ W = 87.76 KN

Check for stress-

$(6max)_T$ = $\frac{\sigma}{Y}$M/I x Y

(6max)T = 18.21 N/mm2

18.21 N/mm^2=19.995N/mm^2 - Hence ok.

In this case the therotical $(6max)_T$ is matches with the experimental & ansys results, it means that the valu of 6max is equal to the actual value of stress in experimental & ansys results$(6max)_A$

LSM CALCULATION-3. ONE DIRECTIONAL "V" SHAPED STRAIGTH BAR AT TOP-2 &BOTTOM -3

By using LSM we can calculate the collapse load (W) of section

Given data:

Width of section (b)=150 mm, Depth of section (D)= 150 mm ,effective cover (d')=15 mm, effective depth (d)=135 mm , Diameter of Bar (d)= 6mm ,Grade of concrete (fck)=20 N/mm^2, Grade of steel (fy)= 250 N/mm^2,

→

Asc= 3 X π/4 X d^2= 2 X π/4 X 6^2= 84.82 mm In compression zone

Assume Xu =0.4 d = 0.4 X 135 = 54 mm

1.Tensile force in concrete (Tu) = 0.87fy. Ast =$18.44x10^3$ N

2. Compressive force in concrete (Cu) = 0.36fck X Xub + fsc X Asc - 0.446 fck X Asc =76.011 X10^3 N

3. Moment of Resistance (MR) = C_{cu} (d – 0.416 $X_{u)}$ + C_{su} (d-d') =8.77 x10^6KNM.

MR=BM

8.77 x10^6= WL/6

∴ W = 87.76 KN

Check for stress-

$(6max)_T$ = $\frac{\sigma}{Y}$- M/I x Y

$(6max)_T$ = 18.20 N/mm^2

18.20 N/mm^2=20.217N/mm^2 - Hence ok.

In this case the therotical $(6max)_T$ is matches with the experimental & ansys results, it means that the valu of 6max is equal to the actual value of stress in experimental & ansys results$(6max)_A$

LSM CALCULATION-4. TWO DIRECTIONAL "V" SHAPED REINFORCEMENT.

By using LSM we can calculate the collapse load (W) of section

Given data:

Width of section (b)=150 mm, Depth of section (D)= 150 mm

,effective cover (d')=15 mm, effective depth (d)=135 mm ,

Diameter of Bar (d)= 6mm ,

Grade of concrete (fck)=20 N/mm,^{2}

Grade of steel (fy)= 250 N/ mm^2,

→

Asc= 4 X π/4 X d^2= 2 X π/4 X 6^2= 113.097 mm^2

In compression zone

Assume Xu =0.4 d = 0.4 X 135 = 54 mm

1.Tensile force in concrete (Tu) = 0.87fy. Ast =24.59x10^3 N

2. Compressive force in concrete (Cu) = 0.36fck X Xub + fsc X Asc - 0.446 fck X Asc =81.90X10^3 N

3. Moment of Resistance (MR) = C_{cu} (d – 0.416 $X_{u)}$ + C_{su} (d-d') =9.51 x10^{6}KNM.

MR=BM

9.51 x10^6= WL/6

∴ W = 95.14KN

Check for stress-

$(6max)_T$ = M/I x Y

$(6max)_T$ = 19.73 N/mm^2

19.73 N/mm^2=20.505N/mm^2 - Hence ok.

In this case the therotical $(6max)_T$ is matches with the experimental & ansys results, it means that the valu of 6max is equal to the actual value of stress in experimental & ansys results$(6max)_A$

WSM CALCULATIONS 1- RCC NO OF BAR AT TOP -2 & BOTTOM-2:

Given data:

Width of section (b)=150 mm, Depth of section (D)= 150 mm

,effective cover (d')=15 mm, effective depth (d)=135 mm

,Diameter of Bar (d)= 6mm ,Grade of concrete (fck)=20

N/mm,^{2} Grade of steel (fy)= 250 N/ mm^2,

→

Asc= 2 X π/4 X d^2= 2 X π/4 X 6^2= 56.54 mm^2 (In compression zone)

$6_{cbc = c = 7}$, and m =13.33------------------- for M20 grade concrete ,Table no 2.1, Page No-42

1.Depth of N.A (n) :-

Using equation to find the value of n=?

b x n^2 /2 + (mc -1) Asc (n – d') = m x Ast (d – n)- --------------------------- [1]

But, mc =1.5 m= 1.5 x 13.33 =19.995

Putting above values in equation (1) we get,

150x n^2 /2 + (19.995 – 1) x 56.54 (n -15) = 13.33 x56.54 (135 –n)

75 n^2 +1.827 x10^3 n -117.84 x 10^3 = 0

Solving we get,

n= 29.28 mm.

2. Moment of Resistance (MR) = b x n x c/2 (d – n/3) + (mc -1) Asc x C' (d – d')-----------[2]

But, C' = C (b – d'/ n) = 7 (150 -15 /29.28) =32.27

Putting above values in equation (2) we get,

(MR) = 150 x 29.28x (7/2) (135- 29.28/3) + (19.995 – 1) x 56.54 x 32.27 x (135 – 15)

=6.084 x 10^6 KNM.

∴ Moment of Resistance (MR) =6.084 x10^6 KNM.

Equating MR to BM

MR=BM

BM = 6.084 x 10^6

But, BM formula for two point loading is = WL/6

∴ WL/6 = 6.084 x 10^6

WL = 6.084 x 10^6 x 6

WL =36.504 x 10^6/600

∴ W =60.84 KN.

Check for stress-

By using flexural strength formula we can calculate the maximum stress (6_{max}), which is matches the results of Ansys stress & experimental stress.

M/I = 6/Y

Where,

M = Bending moment

I = Moment of inertia

Y= Depth of N.A to top of beam, (i.e d/2)

1. Bending moment (M) = WL/6
= 60.84 x10^{3}x 700/6
= 7.098 x10^6 knm.

2. Moment of inertia (I) = bd^3/12
= 150 x 150^3/12
=42.18 x 10^6 mm^4

3. Depth of N.A to top of beam (Y)= d/2
= 150/2
= 75 mm

4. Maximum stress (6_{max}) = M/I x Y
= 7.098 x10^6/42.18 x 10^6 x75

(6max) = 12.62 N/mm^2

In this case the therotical 6max is not approximately matches with the experimental & ansys results, it means that the value of 6max is less than actual value of stress in experimental & ansys results.So that the variation of stress block is not goes parabolic.

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$(6max)_T < (6max)_A$----Hence not ok.
12.62 N/mm^2 < 17.833N/mm^2---Hence not ok.
Hence we can not use this stress varitation diagram for new stress block diagram approch.

WSM CALCULATIONS 2- RCC NO OF BAR AT TOP -3 & BOTTOM-3:

Given data:
Width of section (b)=150 mm, Depth of section (D)= 150 mm ,effective cover (d')=15 mm, effective depth (d)=135 mm ,Diameter of Bar (d)= 6mm ,Grade of concrete (fck)=20 N/mm,^{2} Grade of steel (fy)= 250 N/ mm^2,

→

Asc= 3 X π/4 X d^2= 3 X π/4 X 6^2= 84.82 mm^2 (In compression zone)
$6_{cbc = c = 7}$, and m =13.33------------------- for M20 grade concrete ,Table no 2.1, Page No-42

1. Depth of N.A (n) :-
Using equation to find the value of n=?
b x n^2 /2 + (mc -1) Asc (n – d') = m x Ast (d – n)----------------------------- [1]
But, mc =1.5 m= 1.5 x 13.33 =19.995
Putting above values in equation (1) we get,
150x n^2 /2 + (19.995 – 1) x 84.82 (n -15) = 13.33 x84.82 (135 –n)
75 n^2 +2.741 x10^3 n -176.79 x 10^3 = 0
Solving we get,
n= 33.60 mm.
2. Moment of Resistance (MR) = b x n x c/2 (d – n/3) + (mc -1) Asc x C' (d – d')-----------[2]
But, C' = C (b – d'/ n) = 7 (150 -15 /33.60) =28.12
Putting above values in equation (2) we get,
(MR) = 150 x 33.60x (7/2) (135- 33.60/3) + (19.995 – 1) x 84.82 x 28.12 x (135 – 15)
=7.62 x 10^6 KNM.
∴ Moment of Resistance (MR) =7.62 x10^6 KNM.

Equating MR to BM
MR=BM
BM = 7.62 x 10^6
But, BM formula for two point loading is = WL/6

∴ WL/6 = 7.62 x 10^6
WL = 7.62 x 10^6 x 6
WL =45.72 x 10^6/600
∴ W =76.20 KN.
Check for stress-
By using flexural strength formula we can calculate the maximum stress (6_{max}), which is matches the results of Ansys stress & experimental stress.

M/I = 6/Y

Where,
M = Bending moment
I = Moment of inertia
Y= Depth of N.A to top of beam, (i.e d/2)

1. Bending momen (M) = WL/6
= 76.20 x10^{3}x 700/6
= 8.89 x10^6 knm.
2. Moment of inertia (I) = bd^3/12
= 150 x 150^3/12
=42.18 x 10^6 mm^4
3. Depth of N.A to top of beam (Y)= d/2
= 150/2
= 75 mm
4. Maximum stress (6_{max}) = M/I x Y
= 8.89 x10^6/42.18 x 10^6 x75
(6max) = 15.80 N/mm^2

In this case the therotical 6max is not approximately matches with the experimental & ansys results, it means that the value of 6max is less than actual value of stress in experimental & ansys results.So that the variation of stress block is not goes parabolic.
$(6max)_T < (6max)_A$ ------Hence not ok.
15.80 N/mm^2 < 19.995N/mm^2---Hence not ok.

Hence we can not use this stress varitation diagram for new stress block diagram approch.

WSM CALCULATIONS 3- ONE DIRECTIONAL "V" SHAPED AND OTHER DIRECTIONAL STRAIGTH BAR AT TOP-2 &BOTTOM -3

Given data:
Width of section (b)=150 mm, Depth of section (D)= 150 mm ,effective cover (d')=15 mm, effective depth (d)=135 mm ,Diameter of Bar (d)= 6mm ,Grade of concrete (fck)=20 N/mm,^{2} Grade of steel (fy)= 250 N/ mm^2,
→

Asc= 3 X π/4 X d^2= 3 X π/4 X 6^2= 84.82 mm^2 (In compression zone)
$6_{cbc = c = 7}$, and m =13.33------------------- for M20 grade concrete ,Table no 2.1, Page No-42

1.Depth of N.A (n) :-
Using equation to find the value of n=?
b x n^2 /2 + (mc -1) Asc (n – d') = m x Ast (d – n)----------------------------- [1]
But, mc =1.5 m= 1.5 x 13.33 =19.995
Putting above values in equation (1) we get,
150x n^2 /2 + (19.995 – 1) x 84.82 (n -15) = 13.33 x84.82 (135 –n)
75 n^2 +2.741 x10^3 n -176.79 x 10^3 = 0
Solving we get,
n= 33.60 mm.
2. Moment of Resistance (MR) = b x n x c/2 (d – n/3) + (mc -1) Asc x C' (d – d')-----------[2]
But, C' = C (b – d'/ n) = 7 (150 -15 /33.60) =28.12
Putting above values in equation (2) we get,
(MR) = 150 x 33.60x (7/2) (135- 33.60/3) + (19.995 – 1) x 84.82 x 28.12 x (135 – 15)
=7.62 x 10^6 KNM.

∴ Moment of Resistance (MR) =7.62 x10^6 KNM.

Equating MR to BM
MR=BM
BM = 7.62 x 10^6

But, BM formula for two point loading is = WL/6

∴ WL/6 = 7.62 x 10^6
WL = 7.62 x 10^6 x 6
WL =45.72 x 10^6/600
∴ W =76.20 KN.

Check for stress-
By using flexural strength formula we can calculate the maximum stress (6_{max}), which is matches the results of Ansys stress & experimental stress.

M/I = 6/Y

Where,
M = Bending moment
I = Moment of inertia
Y= Depth of N.A to top of beam, (i.e d/2)

1. Bending moment (M) = WL/6
= 76.20 x10 ^{3}x 700/6
= 8.89 x10^6 KNm.
2. Moment of inertia (I) = $bd^3/12$
= 150 x 150 ^{3}/12
=42.18 x 10^6 mm^4
3. Depth of N.A to top of beam (Y)= d/2
= 150/2
= 75 mm
4. Maximum stress (6_{max}) = M/I x Y
= 8.89 x10^6/42.18 x 10^6 x75

$(6max)$ = 15.81 N/mm^2

In this case the therotical 6max is not approximately matches with the experimental & ansys results, it means that the value of 6max is less than actual value of stress in experimental & ansys results.So that the variation of stress block is not goes parabolic.

$(6max)_T < (6max)_A$ --Hence not ok.
15.81 N/mm^2 < 20.217N/mm^2--Hence not ok.

Hence we can not use this stress varitation diagram for new stress block diagram approch.

WSM CALCULATIONS 4- TWO DIRECTIONAL "V" SHAPED REINFORCEMENT

Given data:
Width of section (b)=150 mm, Depth of section (D)= 150 mm ,effective cover (d')=15 mm, effective depth (d)=135 mm ,Diameter of Bar (d)= 6mm ,Grade of concrete (fck)=20 N/mm,^{2} Grade of steel (fy)= 250 N/ mm^2,

→

Asc= 4 X π/4 X d^2= 3 X π/4 X 6^2= 113.097 mm^2 (In compression zone)

$6_{cbc = c = 7}$, and m =13.33------------------ for M20 grade concrete ,Table no 2.1, Page No-42

1.Depth of N.A (n) :-
Using equation to find the value of n=?
b x n^2/2 + (mc -1) Asc (n – d') = m x Ast (d – n)------------------------------ [1]

Specimens	Average Collapse load by(EXP) (KN)	Collapse load by (ANSYS) (KN)	Collapse load by LSM (KN)	Collapse load by WSM (KN)	Stress Results			
					Experimental result Mpa	Ansys result Mpa	New approch LSM Results Mpa	New approch WSM Results Mpa
RCC NO OF BAR AT TOP -2& BOTTOM-2	83.66	82.8	80.38	60.84	17.35	17.83	16.67	12.62
RCC NO OF BAR AT TOP -3& BOTTOM-3	94	93.4	87.76	76.20	19.49	19.99	18.21	15.80
RCC NO OF BAR AT TOP -4& BOTTOM-4	114.66	112.2	95.14	89.93	23.64	23.23	19.73	18.65
ONE DIRCTIONAL "V" SHAPED	95.5	94.7	87.76	76.20	19.80	20.21	18.20	15.81
TWO DIRCTIONAL "V" SHAPED	96	95.4	95.14	89.94	19.91	20.50	19.73	18.65

But, mc =1.5 m= 1.5 x 13.33 =19.995
Putting above values in equation (1) we get,
150x n^2/2 + (19.995 – 1) x 113.097 (n -15) = 13.33 x113.097 (135 –n)
75 n^2 +3.655 x10 ^{3} n -235.73 x 10^3 = 0
Solving we get,
n= 36.76 mm.

2. Moment of Resistance (MR) = b x n x c/2 (d – n/3) + (mc -1) Asc x C' (d – d')-----------[2]
But, C' = C (b – d'/ n) = 7 (150 -15 /36.76) =25.70
Putting above values in equation (2) we get,
(MR) = 150 x 36.76x (7/2) (135- 36.76/3) + (19.995 – 1) x 113.097 x 25.70 x (135 – 15)
=8.99 x 10^6 Knm.
∴ Moment of Resistance (MR) = 8.99 x10^6 Knm.

Equating MR to BM
MR=BM
BM = 8.99 x 10^6

But, BM formula for two point loading is = WL/6

∴ WL/6 = 8.99 x 10^6
WL = 8.99 x 10^6 x 6
WL =53.96 x 10^6/600
∴ W =89.94 KN.

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6.2.4 Check for stress-

By using flexural strength formula we can calculate the maximum stress (6_{max}), which is matches the results of Ansys stress & experimental stress.

$$M/I = 6/Y$$

Where,

M = Bending moment

I = Moment of inertia

Y= Depth of N.A to top of beam, (i.e d/2)

1. Bending momen (M) = WL/6
$= 89.94 \times 10^{3} \times 700/6$
$= 10.49 \times 10^{6}$ knm.
2. Moment of inertia (I) = $bd^3/12$
$= 150 \times 150^{3}/12$
$= 42.18 \times 10^{6}\ mm^4$
3. Depth of N.A to top of beam (Y)= d/2
= 150/2
= 75 mm
4. Maximum stress (6_{max}) = M/I x Y
$= 10.49 \times 10^{6}/42.18 \times 10^{6} \times 75$
$(6max) = 18.65\ N/mm^2$

In this case the therotical 6max is not approximately matches with the experimental & ansys results, it means that the value of 6max is less than actual value of stress in experimental & ansys results.So that the variation of stress block is not goes parabolic.

$(6max)_T < (6max)_A$ -----Hence not ok.

$18.65\ N/mm^2 < 20.505 N/mm^2$--Hence not ok.

Hence we can not use this stress varitation diagram for new stress block diagram approch.

Collapse load results & Stress distribution Results:-

By calculating the above theoretical values of load & stress, the experimental collapse load values is nearly matches with the values of limit states of collapse load so we can draw the new stress block diagram for limit state of collapse, but the stress distribution by the ansys is matches with the limit state of stress diagram i.e. the variation of stress distribution using the ansys stress diagram is going straight at top fiber & then decreasing with parabolic to the neutral axis at 'zero' point.

Stress distribution Results:-

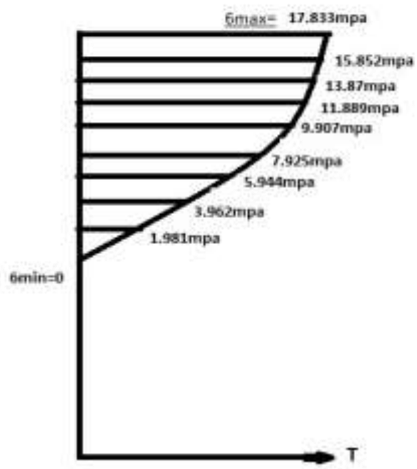
The interpretation of results of all the stress block parameters is goes parabolic & decrease from top fibre compression zone to the neutral axis is at 'zero' point, so that the limit state theory is applicable for such stress distribution of stress block parameters. The stress block distribution of all the beams is as shown in the Table no.6.3

Sr no	Mix proport ion	Specificat ion	Stress Results				Remark
			Experimental result Mpa	Ansys result Mpa	New approach LSM Results Mpa	New approch WSM Results Mpa	
1	M20	RCC NO OF BARS– 2	17.351	17.833	16.67	12.62	LSM IS APPLICABLE
2	M20	RCC NO OF BARS– 3	19.496	19.995	18.21	15.80	
3	M20	RCC NO OF BARS– 4	23.644	23.237	19.73	18.65	
4	M20	ONE DIRECTIONAL "V" SHAPED REINFORCEMENT	19.80	20.217	18.20	15.81	
5	M20	TWO DIRECTIONAL "V" SHAPED REINFORCEMENT	19.91	20.505	19.73	18.65	

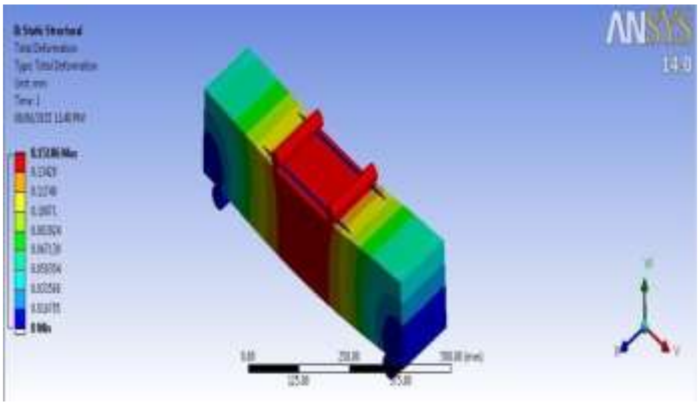
New Stress Distribution Diagram : Rcc- no of bar At top-2 & bottom-2

The variation of stress distribution of rcc no of bar At top-2 & bottom-2 as shown in table and fig. below

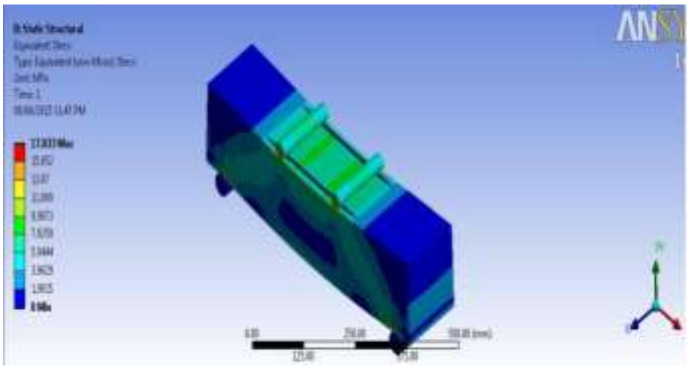
Stress Results		
Experimental result Mpa	Ansys result Mpa	New approach LSM Results Mpa
17.351	17.833	16.67



New Rcc Stress Block Diagram
No of bar At top-2 & bottom-2



Deflection of beam having 2 bar at top and bottom

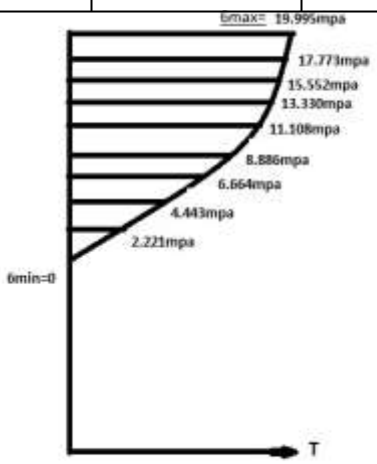


Von-Mises stress of beam having two bar at top and bottom.

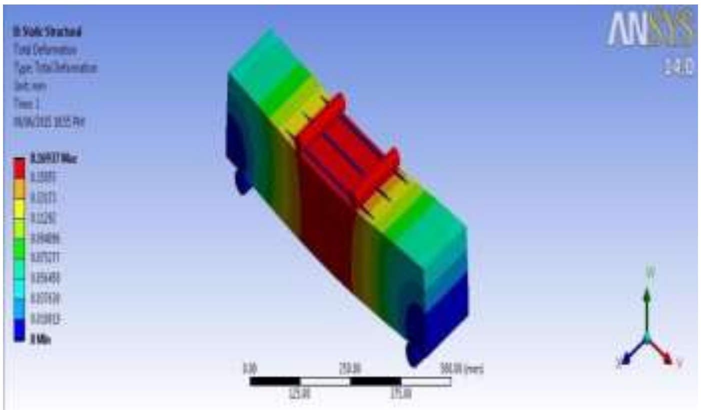
New Stress Distribution Diagram : Rcc- no of bar At top-3 & bottom-3

The variation of stress distribution of rcc no of bar At top-3 & bottom-3 as shown in table and fig

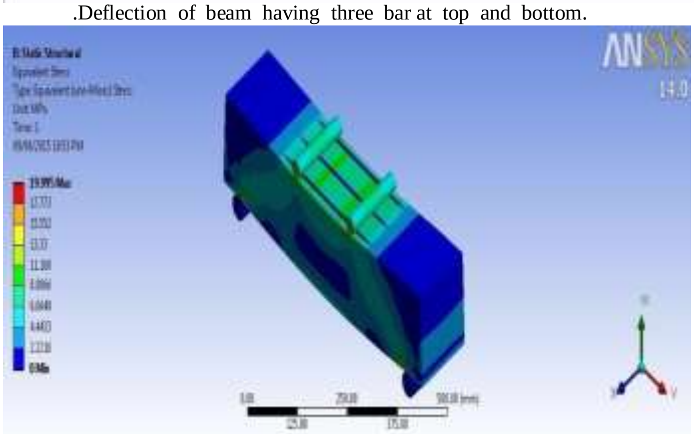
Stress Results		
Experimental result Mpa	Ansys result Mpa	New approach LSM Results Mpa
19.496	19.995	18.21



New Rcc Stress Block Diagram
No of bar At top-2 & bottom-2



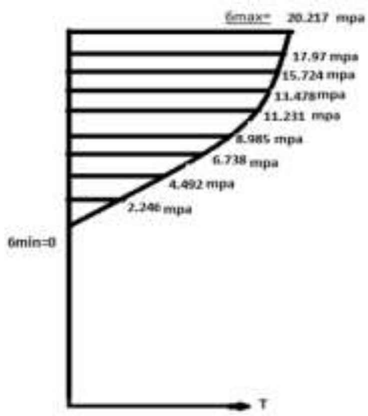
.Deflection of beam having three bar at top and bottom.



Von-Mises stress of beam having three bar at top and bottom

New Stress Distribution Diagram : "V" shaped- no of bar At top-2 & bottom-3

Stress Results		
Experimental result Mpa	Ansys result Mpa	New approach LSM Results Mpa
19.80	20.217	18.20



New "V" shaped Stress Block Diagram
(One Way Directional)

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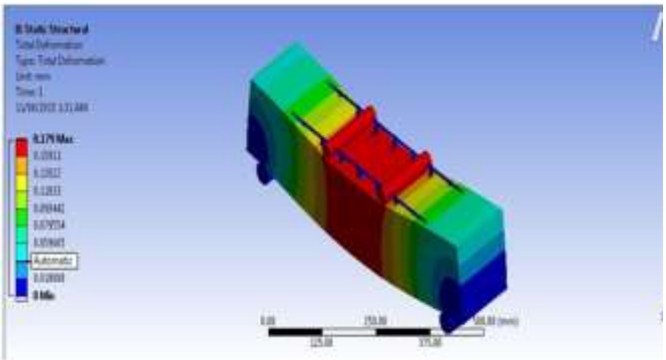
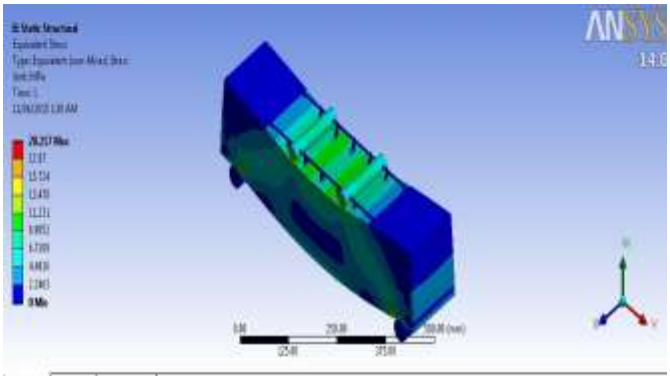


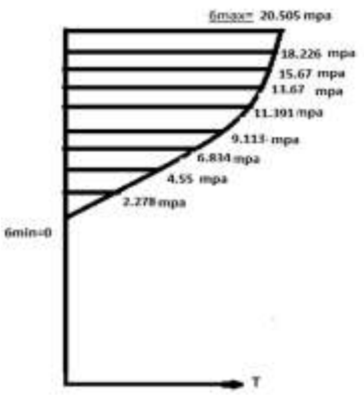
Deflection of beam having one directional "V" shaped reinforcement



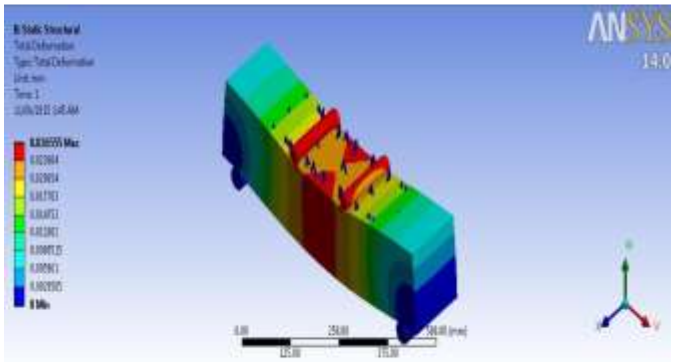
Von-Misses stress of beam having one directional “V” shaped reinforcement.

New Stress Distribution Diagram: “V” shaped- no of bar in longitudinal direction -3

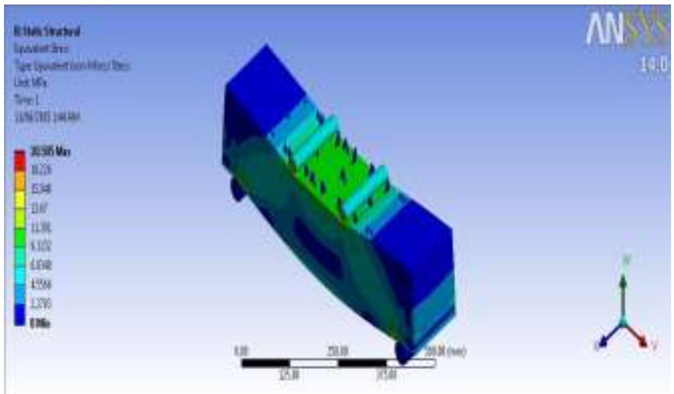
Stress Results		
Experimental result Mpa	Ansys result Mpa	New approach LSM Results Mpa
19.91	20.505	19.73



New “V” shaped Stress Block Diagram
(Two Way Directional)



Deflection of beam having two directional “V” shaped



Von-Mises stress of beam having two directional “V” shaped reinforcemet

PROJECT PHOTO:-

No of beams casting

Flexural Testing Machine

Beam Testing with dial gauge

Initial cracking

Failure pattern of reinforced concrete beams

CONCLUSION

The following conclusions can be drawn from the outcome of this project study:

1. The variation of ANSYS stress results is approximately matches with the stress results of theoretical calculation by limit state method of stress, so that the stress variation of stress block diagram is goes parabolic to the neutral axis zero.
2. Increase in moment resisisting , shear force, ductile behaviour capacity of the beams.
3. Increase in stiffness of the beams and reduces the deflections.
4. Increase in durability of the beams.

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