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Studies on Shear Behavior of Normal Strength Polymer Modified Reinforced Concrete Beams

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Abstract: - **Use of Natural Rubber Latex is most widely accepted in case of strengthening concrete members. Inclusion of Rubber latex to the concrete beam, the shear capacity can be increased marginally. This paper shows investigation both by Theoretical and Experimental to enhance the shear capacity of Reinforced concrete beams using rubber latex as naturally occurred polymers. Totally 12 beams were casted of normal strength M30 grade, in this 12 beams, 6 are polymer free beams and rest 6 are polymer modified beams(PMB), each beam of standard dimension width 150mm, depth 200mm and length 1300mm. All the 12 beams are having same dimensions, stirrup spacing is altered and half of them made with natural polymer i.e. rubber latex. The shear capacity shown by the beams were compared both theoretically and experimentally, the PMB shows 2% to 10% increase in shear capacity as compared to polymer free beams.**

Keywords—Normal strength Concrete, Polymer modified beams (PMB), Rubber Latex, Shear capacity.

I. INTRODUCTION

The reinforced concrete beams are designed with an objective of safety, strength and flexure. The RC beams sometimes undergo failure mainly due to shear in majority of all cases, flexure is always considered first in the design of RC beams, and limits are then placed on amounts of flexural reinforcement. Shear failure always occur suddenly without giving any advance warning, hence shear is considered as main thing in design of beams. The failure due to shear is always unpredictable, diagonal cracks are first occurred due to shear failure and it will be almost located near the supports of beam, these diagonal cracks occurs due to application of excess shear force. The shear reinforcement is provided when actual shear stress is greater than permissible shear stress. The inclined shear cracks extended 45^o from the middle depth of beam near support and the cracks extended towards compressive zone. Stirrups are always used as shear reinforcement in the construction of reinforced structures, bent up bars are used with stirrups to avoid shear failure.

A. Polymers in Concrete

The Concrete which has polymer as additive is called as polymer concrete and these concrete has same ingredients. By adding polymers into the concrete mix binding property and adhesive property with the aggregates will be increased the long range bonding network structure is formed by addition of polymers and usually cement will form short range bonding network structure. Some of the advantages of polymers are good adhesion with other materials and it shows good resistance against chemical attacks and any external damages. The polymer modified concrete has fair mechanical and physical properties.

B. Latex Modified Concrete

Latex modified concrete usually called as LMC. Polymer is a material that composed of number of simplex molecules; these molecules are called as monomers. The monomers present in the polymer will combined due to reaction, and this process is called polymerization. When Latex is added to the fresh concrete, it will increase the fresh properties of concrete by increasing workability. After concrete curing LMC mainly contains hydrated cement paste and which are connected with aggregates and form thin films.

C. Rubber Latex Influence in Concrete

The latex modified shows good strength properties, good adhesion properties, reduces permeability of concrete, increases durability of concrete, and increases pore structure, and also the compressive strength for 7,14,21,28 days considerably increases.

II. THEORETICAL STUDIES

Theoretical studies conducted for 12 normal strength M30 beams, all the beams having the same dimensions i.e. width 150mm, depth 200mm, length 1300mm. In these 12 beams 6 beams were made without latex and 6 beams were casted using latex as natural polymer. All the beams compared with their results in both theoretical and experimental way. Also these 12 beams have same dimension with varying spacing of stirrups.

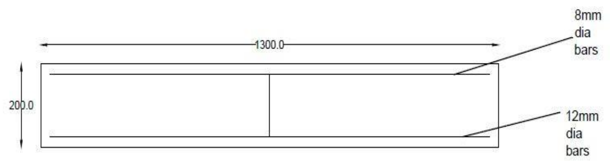

Figure1. Longitudinal section of beam

Table 1: Beams Casted

Grade Of Concrete	Number Of Beams	Inclusion of Latex
M30	6	Without Rubber Latex
M30	6	With Rubber Latex

A. Shear Capacity of Normal Strength Control Beams (M30)

Beam NCB1: The Figure 2 shows the cross section of beam NCB1.

NCB1 – Normal strength control beam (M30) Without Stirrups.

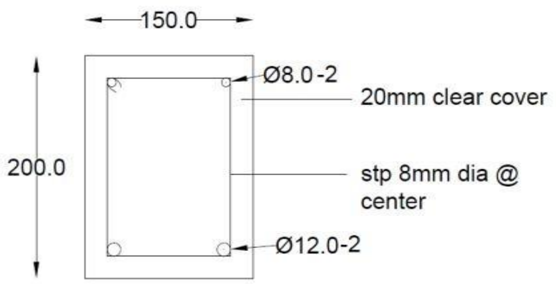

Figure 2. Reinforcement details of Beam NCB1.

8mm dia of Top bars 2No's,
12mm dia of Bottom bars 2No's,
Clear cover is 20mm,
fck is 30 N/mm^2, fy is 500 N/mm^2
d = 200 – 20 – 12/2 = 174mm
$V_u = V_{uc} + V_{us}$,
$V_{uc} = \tau cmax \times bd$,
$\tau cmax = 3.5\ N/mm^2$ for M30 grade as in IS 456-2000
Vuc = 3.5x150x174= 92.36kN
V_{us} = 0 (No Stirrups)
V_u = 92.36kN.

B. Shear Capacity of Normal Strength Strengthened Beams (M30)

Beam NSB1: The Figure 3 shows the cross section of beam NSB1.

NSB1 – Normal strength strengthened beam (M30) With Stirrups.

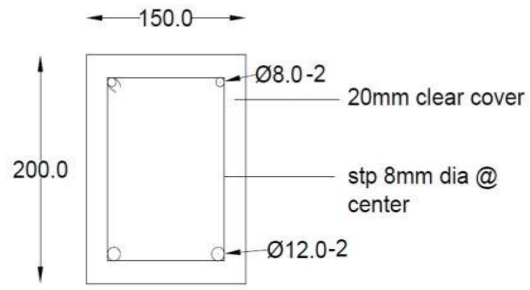

Figure 3. Reinforcement details of Beam NSB1.

8mm dia of Top bars 2No's,
12mm dia of Bottom bars 2No's,
Clear cover is 20mm,
fck is 30 N/mm^2, fy is 500 N/mm^2
d = 200 – 20 – 12/2 = 174mm
$V_u = V_{uc} + V_{us}$,
$V_{uc} = \tau cmax \times bd$,
$\tau cmax = 4\ N/mm^2$ for M30 grade as in IS 456-2000
Vuc = 4x150x174= 105.5kN
V_{us} = 0 (No Stirrups)
V_u = 105.5kN.

Table 2: Ultimate shear Capacity of control beams (M30)

Sl. No	Spacing in mm	Beam Description	V_u in kN
1	0	NCB1	92.36
2	50	NCB2	244.54
3	100	NCB3	168.45
4	150	NCB4	143.08
5	200	NCB5	130.40
6	250	NCB6	122.80

Table 3: Ultimate shear Capacity of strengthened beams (M30)

Sl. No	Spacing in mm	Beam Description	V_u in kN
1	0	NSB1	105.50
2	50	NSB2	257.69
3	100	NSB3	181.59
4	150	NSB4	156.23
5	200	NSB5	143.55
6	250	NSB6	135.94

III. EXPERIMENTAL WORK

The Experiments were conducted on the materials which are used to develop a mix.

A. Materials

a) Cement: We used Chettinad cement (OPC) of grade 43 and it is confirming to IS 8112, experiments were conducted to know few properties in which few are quoted out. The Specific gravity is 3.13, its Fineness modulus is 3%, Initial and final Setting Time is 53 minutes and 362 minutes respectively.

b) Fine Aggregates: We Used locally available river sand and it is confirming to Zone-II of IS 383-1970, its specific gravity is 2.44 and water absorption will be of 0.9% .

c) Coarse Aggregates: We used locally available crushed granite, crushed rocks as the coarse aggregates. The Coarse aggregates should be of 20mm down size, the physical properties were concluded by experiments, specific gravity 2.62 and water absorption will be 0.3%.

d) Water: The water which is free from organic, inorganic and other impurities was used for concrete mixing. The cement react with water to form a paste until the paste gets hardened the aggregates will be in suspension. While mixing of sand and cement the water acts as lubricant.

e) Natural Rubber Latex: We used the rubber latex which was procured from Shashikant & Company, Mumbai, Maharashtra, the color white, dry rubber content 60, total solids 61.5, PH 8, particle size 0.2micro meter, specific gravity 0.94.

Figure4. Naturally Occurring Rubber Latex

f) Rebar: HYSD bars were used. The reinforcement details consists of 8mm dia and 12mm dia at Top and Bottom respectively, the stirrups of 8mm dia was used and it is confirming to IS 1786-1979.

Figure5. Reinforcement Details

B. Proportioning Of Concrete Mix

As per the Codal provisions IS10262-2009 and IS456-2000, the design mix was developed, which satisfies all the fresh properties. For achieving M30 concrete the mix ratio used was 1: 1.42: 2.58 with the water cement ratio of 0.45, slump obtained 50mm, Natural rubber latex added 0.9% of weight of the cement.

C. Form Work

Mobil oil applied to the form work which is placed on the floor by giving 20mm cover at bottom and sides to the reinforcement placed. Both sides of joints were made tight and concrete is poured to continue with further action.

D. Concrete Mixing

Concrete mixed with the use of mechanical mixer with the guidelines of IS 12119 and IS 1791. Fine aggregate, coarse aggregate and cement was added to the mixer one after the other and estimated quantity of water is then added to it for getting the uniform mix. Mixing is continued for some 2 minutes after all the ingredients are added in to the mixer as per IS code.

E. Curing Of Concrete After 24 hours, beams were removed from the moulds and placed on the concrete slab floor .Which are then covered with the gunny bags and water is applied frequently i.e. more than six times a day to keep them always in a wet condition. Same procedure will be continued for the rest of 28 days.

IV. RESULTS AND DISCUSSIONS

The experimental studies were conducted in department of civil engineering, AIT, Chikkamagalur. An attempt has made to bring the comparison between the theoretical value and experimental value regarding, Shear capacity and deflection. Related tables and graphs have been illustrated in order to make the concepts clear. In the loading frame 12 beams are tested and dial gauges were placed at the soffit of the beam near mid span, quarter span and three fourthspan to know the deflection. The load is increased gradually up to failure. Loading arrangement is shown in Figure6.

Figure6. Loading arrangement

A. Sample of Failure Mode and Cracking Patterns of M30 Control Beams

Beam NCB1

Figure7: Failure of beam NCB1

Figure7 shows the cracking pattern of beam. The beam is loaded up to failure and hair cracks are observed at bottom of right span and progressed upwards and the beam fails in shear. As per Limit state method the theoretical ultimate load is 92.36kN and ultimate load obtained in experimental results is 127.06kN shown in the table 4.

B. Sample of Failure Mode and Cracking Patterns of M30 Strengthened Beams

Beam NSB1

Figure8: Failure of beam NSB1

Figure8 shows the cracking pattern of beam. The beam is loaded up to failure and hair cracks are observed at bottom of right span and progressed upwards and the beam fails in shear. As per Limit state method the theoretical ultimate load is 105.50kN and ultimate load obtained in experimental results is 140.81kN shown in the table 5.

Table 4: Theoretical and experimental results comparison of ultimate Loads of Controlled beams

Sl. No	Beam Description	Mode Of Failure	Ultimate Load Theoretical (kN)	Ultimate Load Experimental (kN)
1	NCB1	Shear	92.36	127.06
2	NCB2	Flexure	244.54	241.71
3	NCB3	Shear	168.45	184.06
4	NCB4	Shear	143.08	162.76
5	NCB5	Shear	130.40	160.66
6	NCB6	Shear	122.79	141.00

Table 5: Theoretical and experimental results comparison of ultimate Loads of strengthened beams

Sl. No	Beam Description	Mode Of Failure	Ultimate Load Theoretical (kN)	Ultimate Load Experimental (kN)
1	NSB1	Shear	105.50	120.00
2	NSB2	Flexure	257.69	265.71
3	NSB3	Flexure	181.59	190.78
4	NSB4	Flexure	156.23	170.65
5	NSB5	Shear	143.55	158.81
6	NSB6	Flexure	135.04	147.05

V. LOAD V/S DEFLECTION CURVES

A. Load v/s Deflection Curves of Beam NCB1 and NSB1

All beams were subjected to two points loading and displacements were noted at center, left and right span of beams and load v/s deflection curves were drawn.

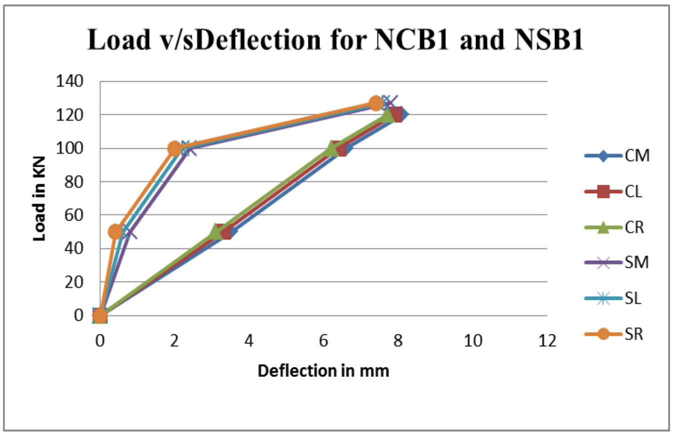

Figure A. shows the graph plotted for load v/s deflection of these two beams. From this graph we can notice that beam NCB1 has more ultimate load carrying capacity than beam NSB1 and beam NCB1 has more deflection compared to beam NSB1.

B. Load v/s Deflection Curves of All Beam

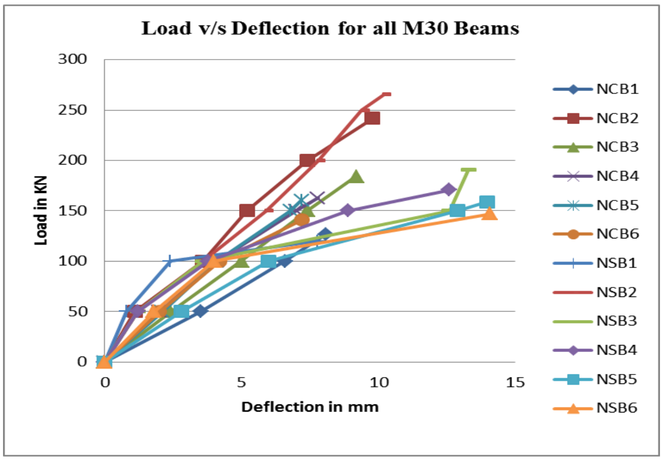

Figure B. shows the graph plotted of load v/s deflection for all beams. From this graph we can notice that beam NSB2 has more ultimate load carrying capacity compared to all beams and beam NSB6 has more deflection compared to all beams.

VI. CONCLUSION

1. In case of strengthened beams, the initial cracks will occur only at higher loads but in case of normal beams cracks starts at low loads.
2. By using the rubber latex as the natural polymers, the beams were strengthened which concluded in the graphs shown. It shows increase in shear capacity from 2% to 10%.
3. By using polymers, the beams were strengthened in shear; failure which is occurred due to flexure gives sufficient warning.
4. The experimental ultimate load will be more than the loads from the theoretical calculations for beams of Normal strength.

5. Cracks occurred in the control beams will be wider than the cracks appeared in the strengthened beams.
6. The strengthened beams will show adequate warning before the failure, hence polymers plays a very important role in these types of conditions.

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