

Study on Shear Behaviour of High Strength Polymer Modified Reinforced Concrete Beams

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ABSTRACT: Polymer concrete is a type of concrete which has polymer in it and similar ingredients of concrete. During mixing process polymers are added to the concrete, in turn they increase the binding properties and adhesion with the aggregates. Here we used the natural rubber latex as a polymer and metakaolin as additive which increases the compressive and flexural strength and reduces the permeability. Total 12 numbers of high strength concrete beams of M70 grade were casted in the laboratory out of which 6 are controlled beams and 6 are strengthened by adding rubber latex. The strengthened beams of M70 grade showed 2 to 20% of increase in shear capacity with respect to the controlled beams of same grade.

KEYWORDS: Polymer concrete, High strength concrete, Metakaolin and Rubber latex, M70.

I. INTRODUCTION

Generally reinforced concrete beams are designed for safety in order to resist higher compressive and shear force, but the sudden failure of reinforced concrete beams are due to shear. Hence beams were primarily designed for shear. Since shear failure is frequent and sudden with little or no advanced warning, the design for shear must ensure that the shear strength for every member in the structure exceeds the flexural strength. The shear failure mechanism varies depending upon the cross-sectional dimensions, the geometry, the types of loading, and the properties of the member. The shear failure is difficult to predict accurately despite extensive experimental research. Diagonal cracks are the main mode of shear failure in reinforced concrete beams located near the supports and caused by excess applied shear forces. Beams fail immediately upon formation of critical cracks in the high-shear region near the supports. Whenever the value of actual shear stress exceeds the permissible shear stress of the concrete used, the shear reinforcement must be provided to prevent the shear failure. Here we provided the shear reinforcement in form of stirrups.

Rubber latex is added in concrete additional with cement and aggregates at the time of mixing. When the latex is added with other ingredients, the fresh concrete is produced with consistency and workability characteristics slightly different from normal concrete. After curing, the latex-modified concrete (LMC) consists of hydrated cement paste and aggregate which are interconnected by a continuous film of latex. This continuous film imparts the superior physical and chemical properties to latex-modified concrete. Hardened latex-modified concretes possess good strength, adhesion, pore structure, impermeability and durability. Because of the polymer mix, the 28-day compressive strength increases with some percentage of rubber latex as per past findings by researchers. The maximum shear strength is achieved due to optimum dosage of rubber latex.

Shear failure of a reinforced concrete beam is sudden, brittle and has the potential for catastrophic consequences. Because of this unpredictable nature of shear failures, general guidelines required to design for shear strength and which is greater than the flexural strength of a beam in all regions. The shear failure occurs in form of diagonal tension shear failure, bond splitting, crushing of compression strut. To avoid these shear failures we provided the shear reinforcement in the form of stirrups. Reinforced concrete structures should have stirrup reinforcement equal to the minimum requirement specified by the code. The theoretical analysis shows that the amount of stirrup of 0.2% should

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Issue 8, August 2015

be provided. Here we observed that as the spacing of the shear reinforcement decreased the shear strength of the beam increased.

II. RELATED WORK

The theoretical study is made on 12 number high strength concrete beams of M70 grade by varying a stirrup spacing 0mm, 50mm, 100mm, 150mm, 200mm, 250mm for 6 controlled beams and 6 beams were strengthened by adding rubber latex. Beams have same geometrical properties. For shear reinforcement 8mm dia bars were used, 12mm and 8mm dia bars are used for longitudinal reinforcement as shown in Figure 1.

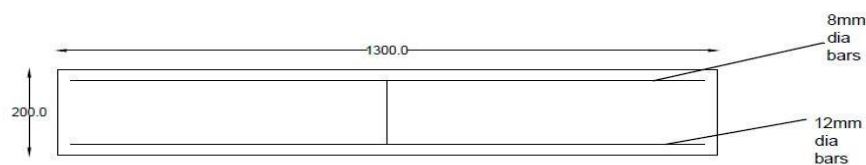


Figure 1: Longitudinal section of a beam

SHEAR STRENGTH OF CONTROL BEAMS OF M70

Beam HCB1: Figure 2 shows the cross section of beam the HCB1

HCB1–High strength Control beam (M70) of no stirrups

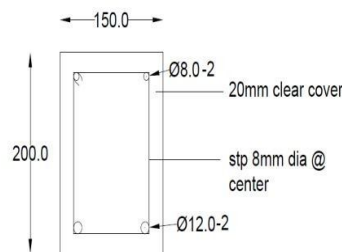


Figure 2: Reinforcement detailing of beam the HCB1

8 mm dia Top bars of 2No's,
12 mm dia Bottom bars of 2No's,
Clear cover is 20mm

f_{ck} is 70N/mm^2 and

f_y is 500N/mm^2

$d = 200 - 20 - 12/2$

$d = 174\text{mm}$.

$V_u = V_{uc} + V_{us}$

$V_{uc} = \tau_{cmax} \times b \times d$

$\tau_{cmax} = 4\text{N/mm}^2$ for M70 grade as in IS456-2000

$V_{uc} = 4 \times 150 \times 174 = 105.50\text{kN}$

$V_{us} = 0$ (No stirrups)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

$V_u = 105.50 \text{ kN}$

Table1: Ultimate shear capacity of Controlled beams (M70)

Sl. No	Beam description	V_u (kN)
1	HCB1	105.50
2	HCB2	257.69
3	HCB3	181.59
4	HCB4	156.23
5	HCB5	143.55
6	HCB6	135.94

The above table shows the ultimate shear carrying capacity of control beams, as the shear spacing decreases the shear strength capacity of the beam increases.

SHEAR STRENGTH OF STRENGTHENED BEAMS OF M70

Beam HSB1: Figure 3 shows the cross section of beam the HSB1

HSB1– High strength Strengthened beam (M70) of no stirrups

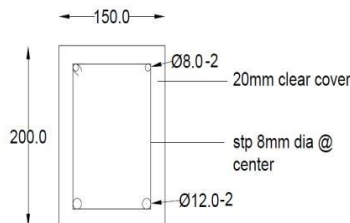


Figure3: Reinforcement detailing of beam the HSB1

8 mm dia Top bars of 2 No's,
12 mm dia Bottom bars of 2 No's,

Clear cover is 20mm

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f_y is 500 N/mm^2

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International Journal of Innovative Research in Science, Engineering and Technology

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III. . EXPERIMENTAL WORK

Cement

Chettinad cement (OPC) of grade 43 conforming to IS 8112 was used in this investigation. Its physical properties were tested in accordance with B.I.S specification.

Fine aggregate

The locally obtainable river sand conforming to zone-II of IS 383-1970 was used as fine aggregate in this research.

Coarse aggregate

The locally obtainable crushed granite has been utilized as coarse aggregate in this project. Coarse aggregate of 12.5 mm and down size are used in this project work.

Water

Clean water, which is free from organic substance, is used for concrete mixing. Water has the following functions during mixing of concrete; water reacts with cement to form paste in which aggregates are in suspension until paste gets hardened, and it acts as a lubricant while mixing sand and cement.

Natural rubber latex

Natural Rubber latex is procured from Shashikant & Company, Mumbai, Maharashtra. It is having a specific gravity of 0.94 and particle size of 0.2 μ m.

Metakaolin

Metakaolin is formed when pure or refined Kaolinite clay is processed by calcinations at a temperature in between 650°C to 850°C and grinding is done to get a fineness of 700 to 900 m²/g. It reacts rapidly with calcium hydroxide in the cement paste, converting unstable compounds of cement paste into stable cementitious compounds. Metakaolin used for this investigation is procured from ASTRA chemicals Ltd, Chennai, Tamilnadu.

Super plasticizer

Conplast SP430 (G) is an admixture collected from Fosroc solutions. Conplast SP430 (G) is added where there is a need of high workability, delays in transportation and placing, and retention are required, or when high temperatures causes rapid slump loss. It enables production of high quality concrete.

Reinforcing steel

Longitudinal reinforcement used in this project is HYSD bars of 8mm dia at top and 12mm at the soffit of the

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

beam, the stirrups are of 8mm dia all conforming to IS1786:1979.



Figure 4: Reinforcement details

Proportioning of concrete mix

To achieve M70 grade of concrete with a proportion of 1:0.98:1.22, maximum size of coarse aggregate used was 12.5mm and the water cement ratio is 0.30 along with super plasticizer and the slump obtained is of 70mm. 0.3% by weight of cement of Natural Rubber Latex is added to achieve strengthened mix.

Formwork

Fig shows the form work which is used in this project. Form work is placed on the concrete floor and mobile oil is applied to the inner surface of the form work. Reinforcements are placed inside the form work by placing 20mm cover blocks at bottom and at sides. Joints in the form work are sealed and concrete mix is poured in to it.



Figure 5: Formwork

Concrete mixing

Concrete mixing is made by using a mechanical mixer conforming to IS 12119 and IS 1791. Aggregates and cement are added in to the mixer one by one and adequate quantity of water is added in to it to get the uniform mix. Mixing is continued for 2 minutes after all the ingredients are added in to the mixer as per IS code

Curing of beams

After 48 hours, beams are removed from the mould and placed on the concrete slab and covered with gunny bags and water is applied six times a day to keep them in wet condition. Same routine is continued for 28 days.

IV.. RESULTS AND DISCUSSIONS

The experimental studies were conducted in civil engineering department, AIT, chikkamagaluru. Here, an attempt has been carried out to bring the comparison between the theoretical value and experimental value regarding, Shear

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

capacity and deflection. Related tables and graphs have been illustrated in order to make the concepts clear.

Cracking pattern for M70 beam



Figure 6: Loading arrangement

Figure 6 shows the beam placement in the Universal Testing Machine (UTM). The arrangement of the two point loading system is done with the help of I section and solid pipe.

Control beams



Figure 7: Failure of beam HCB-2

Cracking pattern of Control beam can be seen in the above figure 7. The beam is loaded up to failure and hair cracks are observed at bottom of mid span and progressed upwards and the beam fails in flexure. As per Limit state method the theoretical ultimate load is 257.69kN and ultimate load obtained in experimental results is 281.93kN shown in the table 3.

Rubber latex strengthened beams



Fig.8: Failure of beam HSB-2

Cracking pattern of Modified beam is clearly seen in figure 8. The beam is loaded up to failure and hair cracks are observed at bottom of mid span and progressed upwards and the beam fails in flexure. As per Limit state method the theoretical ultimate load is 257.69kN and ultimate load obtained in experimental results is 285.62kN shown in the table 4.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Table 3: Theoretical and experimental results comparison of ultimate Loads of Controlled beams

Sl.No	Beam description	Mode of Failure	Ultimate load (kN)	
			Theoretical	Experimental
1	HCB1	Shear	105.50	136.53
2	HCB2	Flexure	257.69	281.93
3	HCB3	Shear	181.59	203.52
4	HCB4	Shear	156.23	179.31
5	HCB5	Shear	143.55	166.43
6	HCB6	Shear	135.94	159.81

Table 4: Theoretical and experimental results comparison of Ultimate Loads of Rubber Latex strengthened beams

Sl.No	Beam description	Mode of Failure	Ultimate load (kN)	
			Theoretical	Experimental
1	HSB1	Shear	105.50	169.40
2	HSB2	Flexure	257.69	285.62
3	HSB3	Flexure	181.59	201.05
4	HSB4	Shear	156.23	193.35
5	HSB5	Shear	143.55	165.35
6	HSB6	Flexure	135.94	167.50

Load v/s Deflection curve

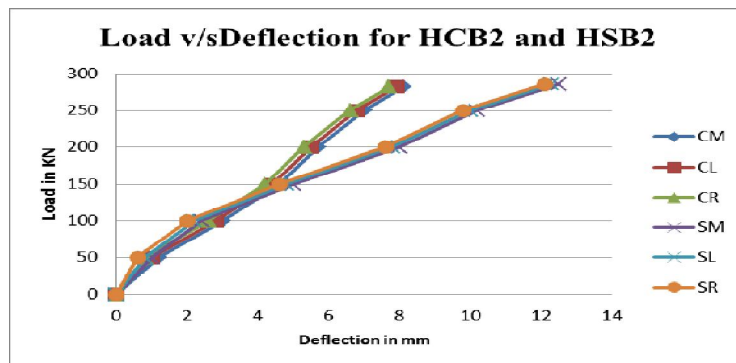


Figure 9: Load v/s Deflection curve for HCB2 and HSB2

Figure 9 shows the graph plotted of load v/s deflection for these two beams. Beam HCB2 has less deflection compared to beam HSB2.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 8, August 2015

Load v/s Deflection for all M70 beams

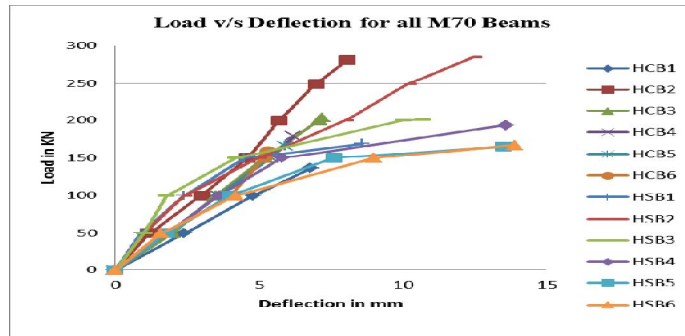


Figure 10: Load v/s Deflection curve for all M70 beams

Figure 10 shows the graph plotted of load v/s deflection for all M70 beams. The graph shows that beam HSB2 has more ultimate load carrying capacity compared to all beams and beam HSB6 has more deflection compared to all beams.

V. CONCLUSIONS

1. Strengthened beams have initial cracks at higher ultimate load compared to control beams.
2. Beams are strengthened using Natural Rubber Latex and the shear capacity increased by 2% to 24% for HSC beams.
3. When control beams are strengthened, the failure occurs due to flexure and initial cracks appears in flexural zone and propagates towards the neutral axis of the beam as load increases
4. By strengthening the beams in shear, the failure takes place due to flexural failure which gives sufficient warning when compared to shear failure which is brittle and catastrophic.
5. Cracks in the controlled beams were wider and more in number compared to strengthened beams.
6. Ultimate load obtained from experiment for control and strengthened beams of M70 are more than ultimate load from theoretical calculations.

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