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Debonding issues of FRP composites with concrete surface

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Abstract*: In Modern days fiber-reinforced polymer (FRP) composites are rigorously applied to strengthen reinforced concrete structures. FRP composites t proved to be very efficient in gaining higher strengths at structural member level. However, the main issue regarding its use is that it detached from concrete surface. Most practiced methods for FRP-to-concrete applications had shown very positive results, those methods such as FRP U-jackets, Anchoring with FRP anchors, bolting metal plates on FRP composites sheets and mechanical anchoring fastener. The efficiency of those anchoring methods had been tested and equations regarding strains have been developed. Based on those models, strength can be predicated for concrete members, however, strength of the structural system cannot be exactly predicated as the actions in structural system become different during cyclic loading. New anchorage methods, need to be explored to prevent debonding in structural system rather than for single structural members.

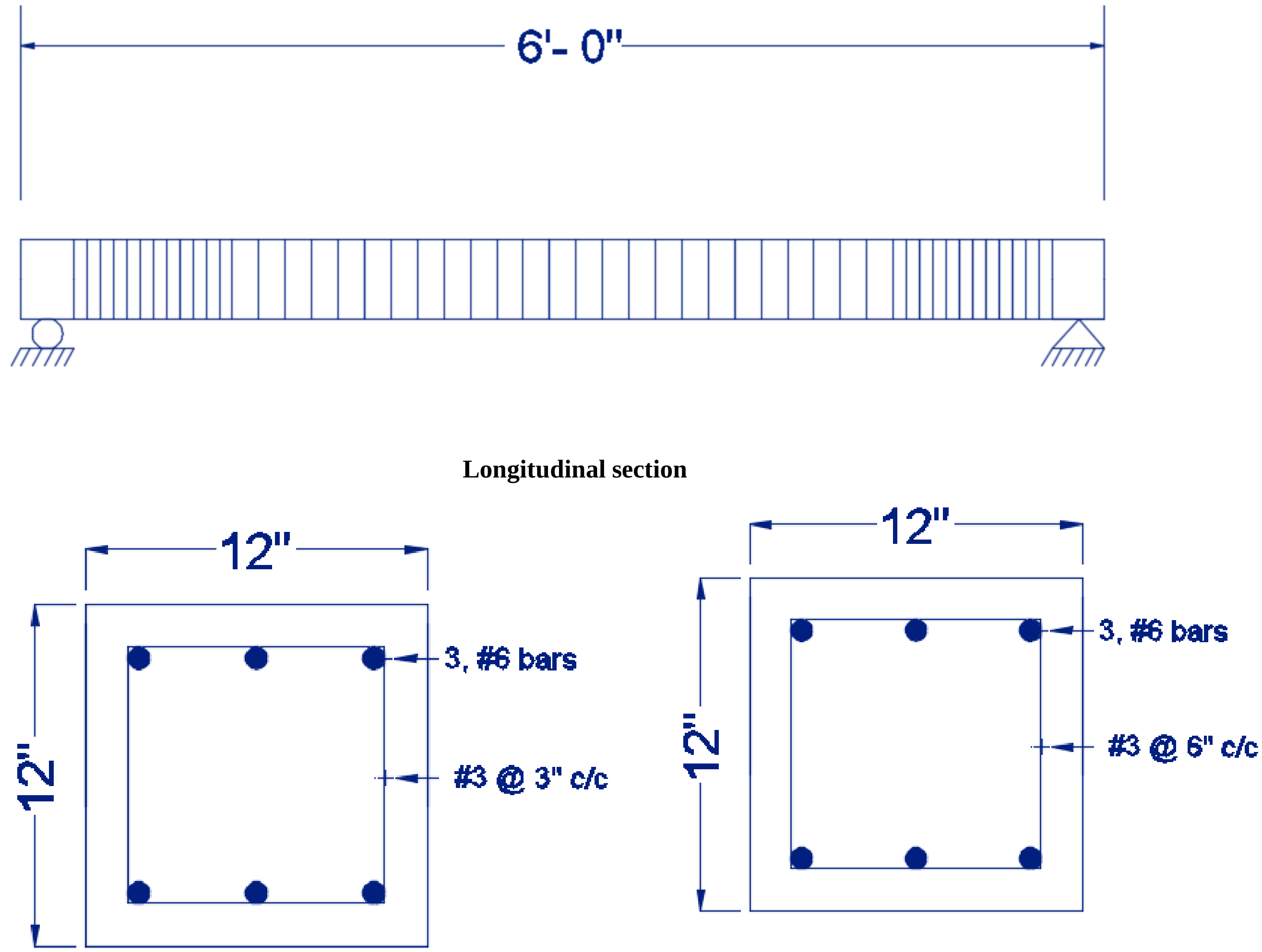
***Keywords*: FRP composites; debonding; RC Frame; brittle failure.**

"I. INTRODUCTION"

In Reinforced concrete structures, beam-column joints are important components when structures are located in high earthquakes area. Recent earthquakes have causes damages to beam-column joints especially in shear, show importance of beam-column joints. (Sezen et al. 2000, Dogangun 2004, Zhao et al. 2008). Design of a joint is done such that to prevent shear damages under cyclic loading. During construction, the amount of reinforcement in joints is often not provided as it required lead to brittle shear failure of joints. In order to improve the seismic performance of joints, non-conventional materials such as Fiber reinforced polymers composites have been practiced (Jiuru et al. 2992 Similarly, this study investigates Concrete cylinders were kept in water tank for 28-days while proper curing was done for 14-days by wrapping moist bags/clothes around all members of both models for desired strength achievement. Gergely et al (2000) experimentally work on 1/3- scaled exterior beam-column joints retrofitted with carbon sheets. Important conclusions in this research were that concrete surface preparation and the fiber location and orientation are main controlling factors. The main conclusion was that FRP composites provide a viable solution in improving the shear capacity of exterior RC joints, however, debonding was main source to prevent FRP composites from achieving full strength.

"II. METHODOLOGY"

In this research, reinforced concrete members were studied. Three specimens of beams were casted and tested. The details about beam is given in figure 1.
Mix design analysis were performed for 28- days compressive strength of 3000 psi concrete. The ratio after mix design analysis was done for concrete found out to be 1:2:2.5 and water to cement ratio was 0.55. Concrete was then prepared with given ratio for verification. Standard sized concrete cylinders were filled with concrete and cured for 28-days. After 28-days, the concrete cylinders were tested with Universal Testing Machine as shown in figure 3. The stress strain curve of the concrete cylinders is shown in figure 3. The average 28-days compressive strength was found out to be 3209 psi. Once concrete strength verified, form work was erected for construction of specimens were done. Specimens were constructed with normal weight concrete. Steel reinforcement of Grade-60 as per ASTM-615 was used in construction. Reinforcement details were such that in beams, 3 #8 bars were used on both side, top and bottom while #3 bar is used as shear reinforcement having 3-inch center to center spacing. Reinforcement details are shown in figure 1. After concreting, specimens were then left for 28 days to fully cured. After fully cured, the formwork was removed and frame were then while wash. At the age of 35-days from concreting in all specimens will be available for testing to get required data. Force controlled loading will be applied to beam. Third point loading will be applied. The experimental setup is shown in figure 4. Once the specimens will be tested then strengthening of beams will be done in as per the standard procedure recommended by ACI 440.2R-08 followed by retesting of retrofitted specimens.



Longitudinal section

X- Section near support

X- Section at mid length

Figure 1. Full scaled reinforce concrete beam and reinforcement details

"III. Experimental Setup"

The main response quantity to be assessed was flexure strength of specimens. Location of the loading and its rate of application would be such that to give fully flexure response and to avoid any dynamic effect. Third-point loading was applied on the specimens. The experimental setup has been shown in figure 2.

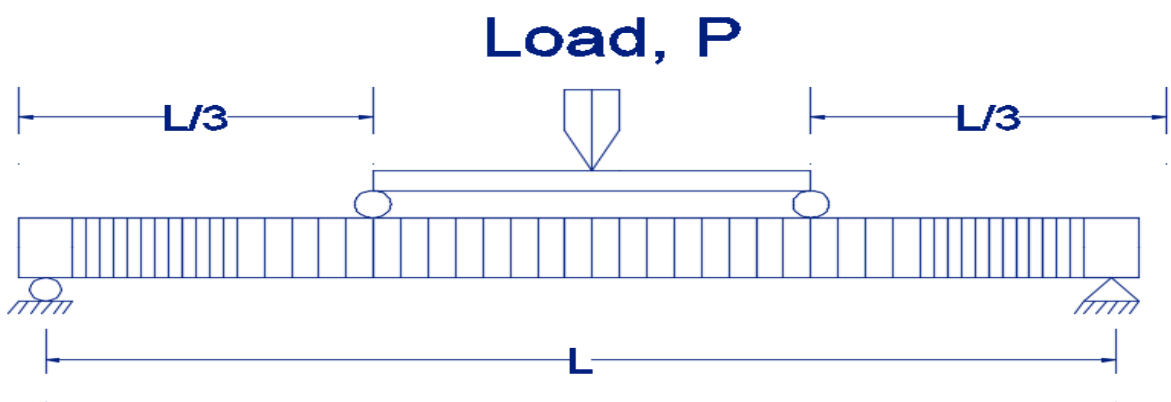


Figure 2. Experimental Setup

(a)

(b)

(c)

(d)

(e)

(f)

Figure 3. (a) Concrete cylinders casted; (b) Concrete cylinders casted; (c) Concrete cylinder tested by UTM; (d) reinforcement of beam; (d) reinforcement placed in formwork; (f) concreting of beam

Figure 4. Test Setup for testing controlled specimen

"IV. Results"

The already constructed specimens were tested. The beams were tested using third point loading as mentioned earlier. All the beams were loaded to full loading and when the drop-in loading occur the test was stopped. The force displacement curve of three tested specimens are plotted as shown in figure 5. The following observations have been observed during test.

(1) Initially the specimens show elastic behavior as shown in load displacement curve.
(2) When load was increased gradually the cracks become appeared in the specimen at mid span of beam, as flexural stress concentration region.
(3) As the load increased, the already cracks become wider.
(4) Finally, the test was stopped when concrete on compression side crushed.

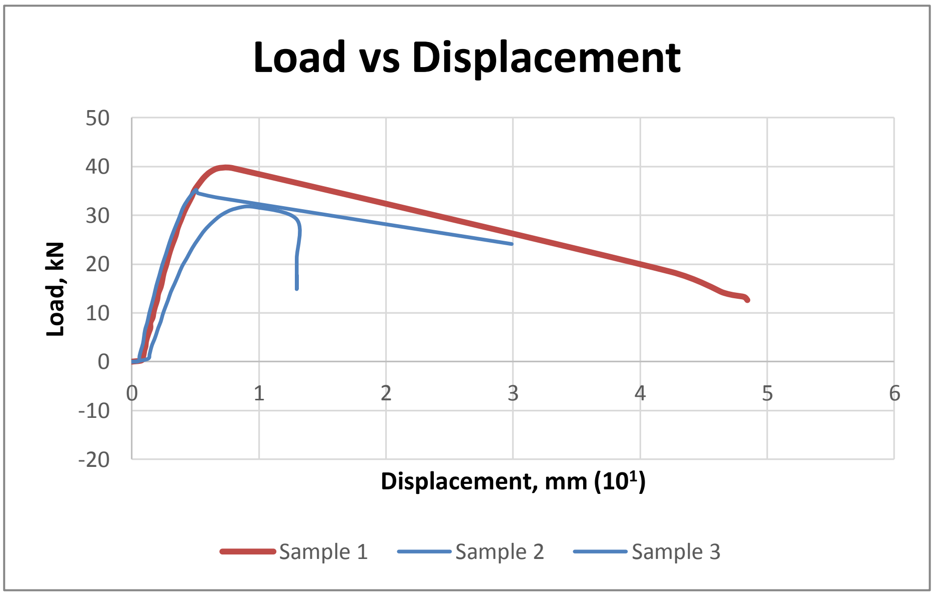


Figure 5. Load - Displacement curve for concrete beams

"IV. Future Work"

The tested control specimens will be retrofitted with FRP composites and will be retested to look for debonding of FRP composites and the strength increase. The results will be then compared with control specimens.

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