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EFFECT OF LAPPING OF BARS IN FLEXURAL STRENGTH OF REINFORCED CONCRETE BEAM

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Abstract: in the recent years the constructions of large span reinforced concrete structures are common. The reinforced structures consist of reinforcement. Usually the lengths of the bars are of 12 m. In the construction of large span structure the length of the bars will be insufficient; to overcome this problem lapping of bars is essential. Efforts are being made to investigate the importance of lapping in the structures. Many researchers have conducted many experiments and studied the behaviour of lapped structural members.

In the present study a new type of reinforcement arrangements are made to study the flexural strength of reinforced beams. The tests conducted on the specimens are in accordance with Indian standard code. The tests are conducted on the three specimens and this study intends to test the beams made with no lapping, 100% lapping and hook reinforcement respectively. The beams are of size 1800 mm in length and the cross sectional dimension of the beams are 150mm × 200mm. The load and deflection of above mentioned beams are studied and the flexural strength of the above mentioned beams are discussed.

Keywords: LVDT, Flexural Strength, Lapping, Hook Reinforcement, Deflection.

I. INTRODUCTION

Lapping means the two bars of same diameter or different diameter are overlapped side by side to achieve desired design length. In reinforced cement concrete , if the length of reinforcement are need to be extended, then splicing is done to join two reinforcement bars for transferring the forces.

The flexural test is performed to measure the flexural capacity and flexural modulus the flexural strength is also called as modulus of rupture, or as bend strength, and it may be defied as the maximum stress at outermost fibre of the specimen i.e. on compression or tension side of the test specimen.

Now-a-days the increase in construction activates leads to the increase in the demand of raw materials needed for the construction. Always minimization resources in productions of raw materials needed for the construction like river sand is replaced by M.sand and the additives like mineral admixtures are used in place of the cementations material and also in place of fine aggregates likewise here a small effort is made in reducing the reinforcement.

Different types of reinforcement are used in the tension zones of flexural member that is the beam the different types used are like hook, lapped, and normal type of to check which type of reinforcement is suitable to for flexural members. It is not suitable to provide lapping as this leads to the decrease in strength of flexural member and leads to cracking.

II. LITERATURE REVIEW

M. M. El-Hawary, A.T. Kaseem and A.M. El-Nady [1] studied the flexural behaviour in the rectangular beam along lap splice between smooth and deformed reinforcement bars and they concluded that

The stirrups provided along the splice length with the close spacing between the stirrups increased the failure load, cracking load and ductility than the stirrups at splice ends U shaped splice ends increase the failure load, cracking load and ductility then the V & L shaped splice ends. Failure loads increase by the strain hardening of high performance concrete then the normal concrete. The flexural cracks appear denser in case of beams with deformed bars then the smooth bars.

Ahemed El-Azab [2] et.al studied on effect of tension lap on the behaviour of HSC beams the following conclusions were drawn based on the results.

For achieving required bond stress between high strength concrete and tension deformed steel the development must be more than 30 time bar diameter for concrete with compressive strength between 65 N/mm^2 and 93 N/mm^2. The top casted beam showed more average crack width than bottom casted beams the bar diameter, splice length and reinforcement ratio had no effect on failure mode and crack pattern. Top casting position has lower cracking and ultimate load compared to bottom casting position. As the splice length increases the ductility is also increased. Different diameters of bars have no effect on the ductility.

Magada I, Mousa [3] et al conducted experiments on the beams which are having tension lap splice and they have concluded that
For the 12 mm diameter bars with 300mm (25Ø) splice the splitting failure was sudden and violent, it was suggested that in use min transverse reinforcement within the splice zone and beams other than 300 mm lapping shown flexural failure. The presence of 15% of silica fumes minor reduce in the stiffness of the beam and a small reduction in cracking, ultimate loads, ultimate deflection and ductility ratio. The maximum reduction of displacement – ductility was 8 % that led to splitting failure, Thereby reducing the beam bond strength.

Jungwoo lee [4] et al conducted experiments and tests, for the evaluation of flexural bond characteristics of UHPC, they have concluded that
From pull out test for minimum lap splice length, the lap length increased to 2.2, 3.0, 4.0, and 5.5 times the rebar diameter in the flexural specimen. When the cover was not completely secured when the lap splice length was increased there was no such expected improvement in performance was not achieved For secured cover depth, for least lap-splice length corresponding to 2.2 times the rebar diameter for this lap length load bearing and ductile capacity could be secured as per UHPC structure design guideline lap- splice length corresponding to 5.5 times rebar diameter was seen to provide 250% margin compared to 2.2Øtimes the rebar diameter.

T. Subbalakshmi [5] and team conducted experiments on flexural behaviour of RHPC beams subjected to bending The industrial by-products used were silica fumes (SF), steel slag aggregate (SSA), and the bottom ash (BA)
The industrial by-product combination like silica fumes + steel slag aggregate additive increased in the load and deflection due to the flexure and ductile behaviour as compared with the reference beam
The load carrying capacity of the beams which were casted using the industrial by-products like SF and SSA increased by 25% compared with other beams
After conducting the tests on the beams made using different proportion of industrial by-products the researchers concluded that in the moment-curvature relationship, the maximum curvature is obtained or seen in the beam casted using SF & SSA additive. The beams with admixtures increases the ductility in the beams compared with the reference beam. The additives silica fumes is replaced with cement , bottom ash with fine aggregate and steel slag aggregate with coarse aggregate improved the structural performance.

Shivakumar C [6] and team conducted experiment and studied the flexural strength of concrete of grade forty with the lapping of bars the efforts re made to study the importance of lapping in the flexural members where usually the lapping of forty times the diameter are provided here the boat sand is replaced with M.sand after all the test are conducted they concluded that
The both sands have same properties. The beams made using with M.sand increases the ultimate strength and increase in cracking. The increase in lapping percentage increases load carrying capacity. Failure occurs readily in beams with 25% lapping of bars when compared with other lap length.

S. Hadimani [7] and team conducted the experiments and made study on flexural of mix twenty grade concrete with lapping of bars. Here to reduces the use of water course sand with M.sand as the availability of this sand was easy and cheap as compared with the other which may be contains different organic and inorganic materials and the presence of silt leads to early cracks in the structures constructed the load versus deflection are studied. And they observed that deflection was liner till the crack 1 after this the sudden variations is seen and from the results the zero lapping are have more strength to the bars of 25, 50, & 100 % lapping's. After all the results are studied and the researchers came to the conclusion that
The alternative for river sand is M.sand. The maximum load carrying capacity is for the beams with zero lapping that is the no lapping is done in the tension zone. The maximum the lapping less is the deflection. As the lapping length increases the load carrying capacity increases.

III. EXPERIMENTAL WORKS

3.1 Specimens Details

A total of three beams were fabricated and tested in this project. This consist of beams with different reinforcement details and they are beam without lapping, beam with 100% lapping and beam with hook reinforcement. The beams are denoted by 30N, 30L and 30H respectively. The beam sizes are 1800 mm in length, 150 mm width and 200 mm depth. The effective length of the beams was 1500mm and the details of the beams are given in table 1 and table 2
The beams were tested by placing the beam simply supported and load was applied with two equal point loads at middle third of the span

TABLE I
BEAM DETAILS

Particulars	Width (mm)	Depth (mm)	L_{eff} (mm)	A_{st}	Stirrups
Beam without lapping	150	200	1500	3#10	#6 @ 125 mm c/c
Beam with 100% lapping	150	200	1500	3#10	#6 @ 125 mm c/c
Beam with Hook reinforcement	150	200	1500	3#10	#6 @ 125 mm c/c

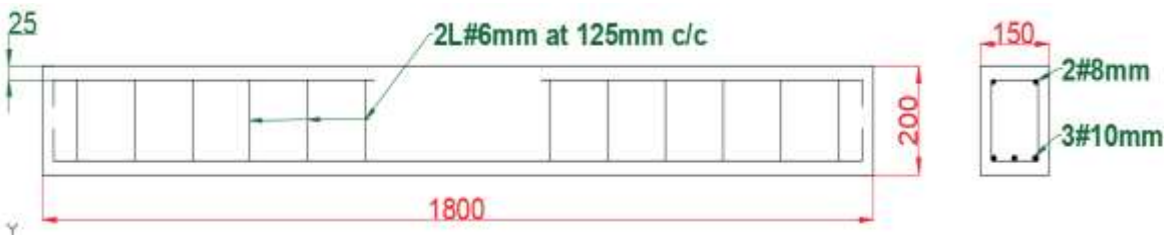


Fig.1 Beam without lapping

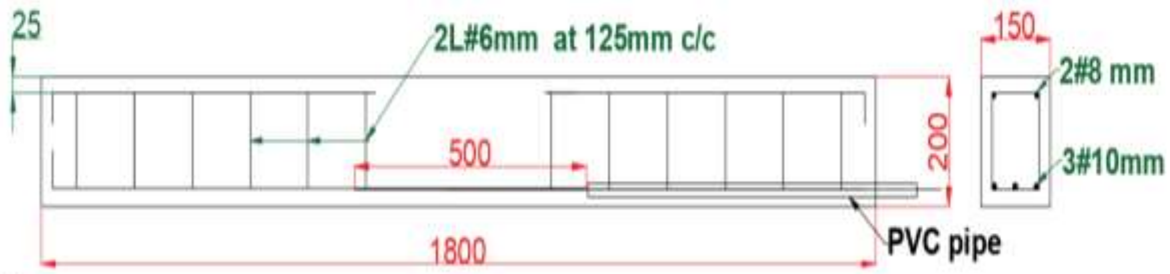


Fig.2 Beam with 100% lapping

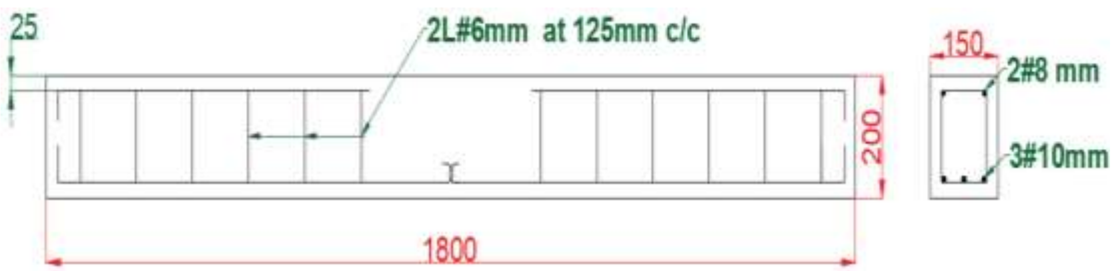


Fig.3 Beam with Hook Reinforcement

TABLE II
BEAM REINFORCEMENT DETAILS

Beam	Top bars	Bottom bars	Stirrups
100% lapped	2#8mm dia	3#10mm dia	2L-6mm dia at125mm c/c
Hooked	2#8mm dia	3#10mm dia	2L-6mm dia at125mm c/c
No lapping	2#8mm dia	3#10mm dia	2L-6mm dia at125mm c/c

3.2 Materials and Design Mix

The different materials used in the production of concrete were cement, coarse aggregate, fine aggregate and water. The cement used was Ordinary Portland Cement. The bars were Fe-415, the coarse aggregates are of zone II and the boat sand is used as fine aggregates all materials were confirming to Indian Standards. The grade of concrete was M30.

3.3 Test Setup and Test Procedure

The beams were placed simply supported in the loading frame of 200T capacity. The load is being applied by a hydraulic jack. The beams were connected with the channels get the reading of deflection, load carrying capacity. The test set up is shown in the figure 1.

Fig. 2 Experimental Set Up

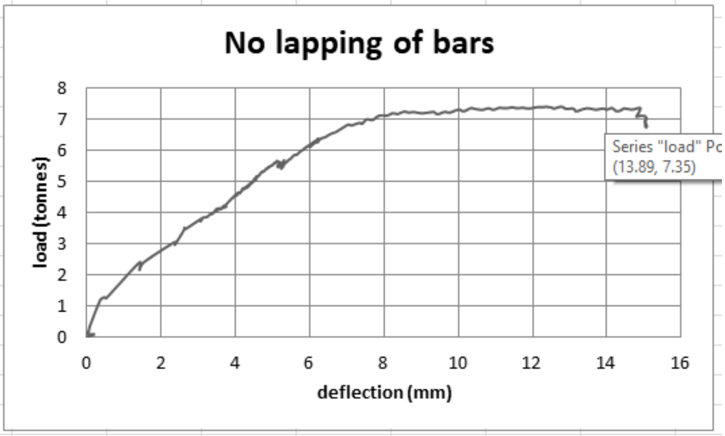
Step in testing of beam:

- The beam size of 1800 x 200 x 150 mm in the strength of 30Mpa is casted with different types of reinforcement.
- Beams are tested by 1000 KN loading frame with hydraulic jack of capacity 2000KN. Load is applied on the beam by using two pint loading system to provide constant moment
- The beam was supported on two simple supports resting on steel plates of size 200 mm x 100 mm.
- The front face of the specimen was white washed and marked with grids of size 50 mm x 50 mm to study the crack propagation.
- The LVDT's and PI gauges are attached at the centre of the specimen along the depth of the beam to locate the neutral axis.
- The deflections of the beam at the centre, at the 1/3rd of the span and end settlements were measured by means of LVDT's and dial gauges.
- Four LVDT's were used at different points viz., one at centre bottom position of beam to measure the deflection second and third at the front face if the beam to measure the compression and tension and forth LVDT is attached to the projected reinforcing bar to measure its nature of compression or tension
- Based on the observation, the graphs are being plotted for load vs displacement and value vs time.
- The load is applied gradually and the readings are measured for every 2 sec.
- The crack pattern is captured and the failure of beam is determined at particular load.
- The crack patterns and cracking loads and the graphs are studied and the results are discussed in below.

IV. RESULTS AND DISCUSSIONS

4.1 *Tests on Beam without Lapping*

The beam without lapping is tested. After applying the loads the flexural characteristics are recorded that is load deflection with the help of LVDT's. Using those values the load versus deflection curve for the beam with no lapping is plotted below.



Graph 1 load v/s deflection graphs for beam without lapping

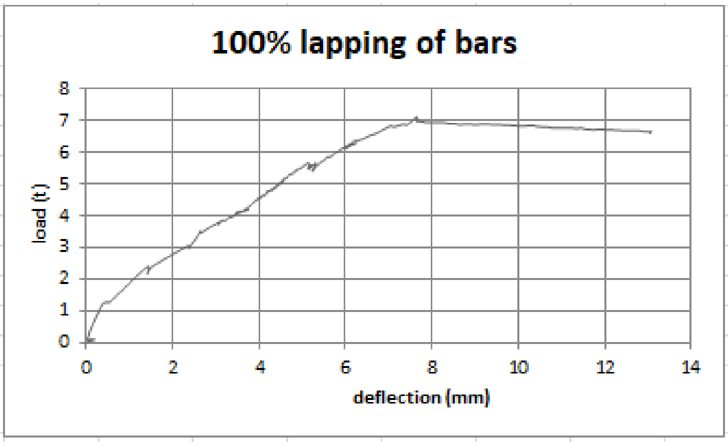
While the load is applied gradually initially the small cracks were seen in the flexure zone that is middle L/3 of effective length and then after the u1timate load the cracks were prominent. U1timate load = 7.33 tonnes, Crack width = 2.5 mm and Central deflection = 15.06 mm

4.2 Tests on Beam with 100 % Lapping

The beam with 100% lapping is tested in the loading frame and the crack pattern for the beam shown in figure below

Fig 2 Crack Pattern for the Beam With 100% Lapping

Here, from the graph relationship between the load deflection of beam with 100% lapping of bars is studied, the deflection on horizontal coordinate and the load is on vertical coordinate



Graph 2 Load V/S Deflection Graph for 100% Lapping Of Bars

Observations made:

While the load is applied gradually initially the small cracks were seen in the flexure zone that is middle L/3 of effective length and then after the u1timate load the cracks were prominent and large. At u1timate load the crack sound was more.

U1timate load = 6.98 tonnes, Crack width = 6 mm and Central deflection = 13.05 mm

4.3 Tests on Beam with Hook Lapping

The beam with hook reinforcement is tested in the loading frame and the crack pattern for the beam shown in figure below.

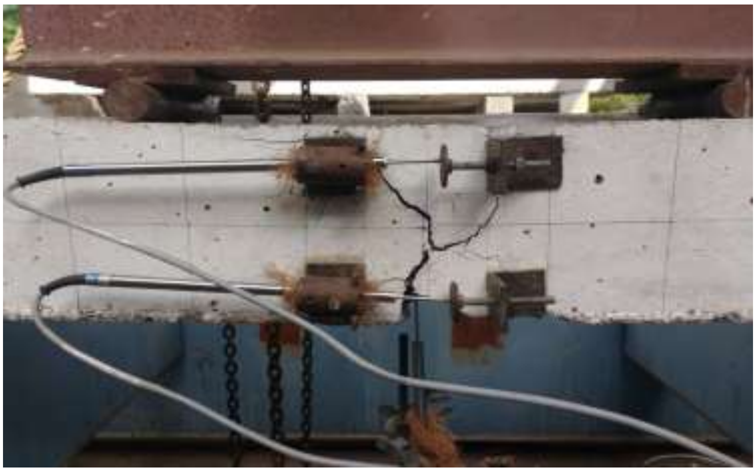


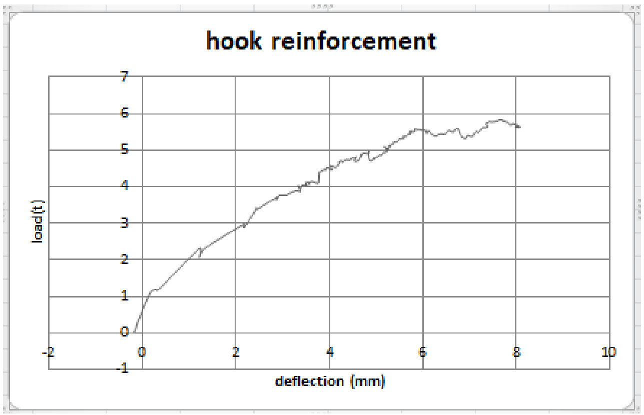
Fig 3 Cracks on the beam with hook reinforcement

Fig 4 Cracks in beam with hook reinforcement

Observations made:

While the load is applied gradually initially the small cracks were seen in the flexure zone that is middle L/3 of effective length and then after the u1timate load the cracks were prominent and large. The crack was near to the centre of the beam and the crack was propagated at the centre. And the failure of cover is seen. The cover of the beam fell down but the beam was taking up loads.

The graph is plotted deflection on horizontal co-ordinate and load on vertical axis. The hook reinforcement failed very early and the cracks are prominent and the cover failure occurred. The ultimate load, crack width and central deflection are



Graph 3 load v/s deflection graph for hook reinforcement

U1timate load = 5.56 tonnes, Crack Width = 4 mm and Central Deflection = 11.23 mm

CONCLUSIONS

The following conclusions can be drawn after studying the test results:

1. The beam without lapping has more load carrying capacity i.e. 13.17% more than that of the beam with full lapping and 25.28% more than that of beam with hook reinforcement.
2. The beam with hook reinforcement fails early at ultimate load as compared with beam without lapping and the beam with 100% lapping.
3. The cover spoiling is seen that is the failure of cover in the hook reinforced beam.
4. The crack widths are less in beam without lapping and more in beam with hook reinforced beam and maximum in beam with 100% lapping.
5. The beams shall not be provided with lapping but for the large span structure it is very essential to provide lapping in such case beams 100% lapping is suitable.
6. The loading capacity increases with increase in the lapping percentage.

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