Performance of reinforcement connections in concrete structures as an Alternative to Lap Splices

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Abstract: Reinforced concrete is widely used in civil engineering. In construction practices, the buildings of concrete structure have focused on the use of steel reinforcement used for transfer of tension and shear forces. Lap splicing is the conventional method of connecting steel reinforcement bars since many years. However splicing of bars by lapping or welding has its imperfections such as inadequate length of laps, time consumption, failure in joints, low quality welds, increase in labor cost, etc. To overcome the problems stated above a new technique for splicing reinforcing bars has come into practice. Present paper is focus on Performance of reinforcement connections in concrete structures. The use and applicability of reinforcement couplers as an alternative to lap splices would overcome reinforcement congestion problems and increase strength of structure. It was found that use of reinforcement coupler significantly reduces the consumption of both reinforcing steel and construction time. It also increases overall reliability of reinforcement splices. Couplers not only provide strength to joints but also prove as an economic mean for connections of two bars. The objective of this research study is to compare the strength and behavior of normal and coupled bars under tensile loading and to study the economic cost comparison of the same.

Keywords: Mechanical Rebar Coupler, Lap Splice, Reinforced Concrete Connection

1. Introduction

The reinforced concrete is widely used in civil engineering industry globally. The increasing use of cast in –situ reinforced concrete leads to development of new technologies. It helps to increase the quality of structure and reduces time consumption of construction works. In the reinforced concrete structures, some reinforcing bars must be spliced. The length of a bar required may be longer than the stock length of steel, or the bar maybe too long to be shipped conveniently. In either case, rebar installers end up with two or more pieces of steel that must be spliced together. Lap splicing, which requires the overlapping of two bars, has long been accepted as an effective, economical splicing method. We cannot avoid lapping as the bars come in standard lengths of 18m-12m. However lap splices cannot be used for bars having diameter greater than 36mm, so the bars having diameter greater than 36mm may be welded or coupled by using reinforcement couplers. Whereas welding requires skilled workmanship and continuous power supply. Therefore to overcome the above disadvantages and complexity of welded and spliced connection the rebar couplers are preferred for connection.

Steel rebar of large diameter used in concrete members requires about 15% more steel than that used in a single bar. The practice of lapping large diameter bars has been discontinued, considering congestion of rebar and economy, by providing **"Mechanical Couplers".** The Indian construction industry has felt immediate need, and is encouraging builders to use mechanical couplers for use in many major infrastructure and multistoried construction projects. The use of mechanical couplers for

connecting rebar is a promising technology; it is continuing to develop in terms of types of couplers available and their performance. The supply of couplers is becoming a global business and because of diversity in design codes, construction practices and specifications, standardization of specification and testing of coupler performance has been slow. The type of couplers available can be conveniently categorized on basis of joint made between the coupler and reinforcing steel. With all coupler systems, the joint is made either in fabricators work or on construction site. Therefore there is a requirement for control of both the coupler manufacturing operation, and also the production of splice itself, which will normally require some end preparation of the bar.

2. Study and methodology

The study was divided into different parts as structural analysis, specifications and manufacturing, estimation and comparison made between mechanical and lap splices. Their performance was analyzed on the basis of ultimate tensile capacity and percentage elongation.

A. Structural analysis

i. The development length and bond stress can be determined from IS 456: 2000.

ii. IS 4694:1968 States the information about basic dimensions for square threads.

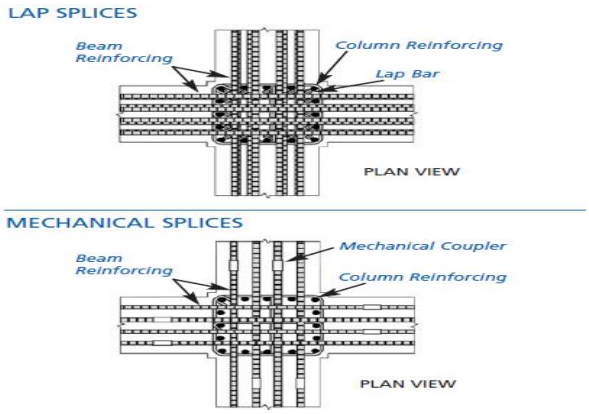
iii. IS 7008:1988 States the information about isometric trapezoidal screw threads.

iv. Tensile Strength- The tensile strength of the mechanical splice should not be less than 690 N/mm^2.

v. Percentage Elongation - The minimum percentage elongation at maximum force should be minimum 3% before the failure of test piece.

B. Specifications and manufacturing

According to the specifications required various materials and their alloys can be used for preparing the couplers. Generally the couplers are manufactured from mild steel. The manufacturing of couplers includes various steps such as cutting, boring, threading, tapping and finishing. Couplers are manufactured on Metal Lathe machine.



C. Economic Survey

The conventional lap splicing methods require more time and steel. Hence there is wastage of money and also more wastage of reinforcement bars as scrap. We can avoid this by giving alternative to conventional lap splicing by mechanical splicing. For that purpose economic survey is much more needed.

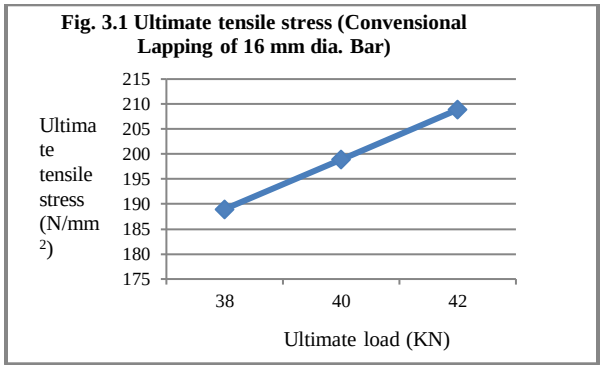
Table 1. Economy Survey For Various bars Diameters.

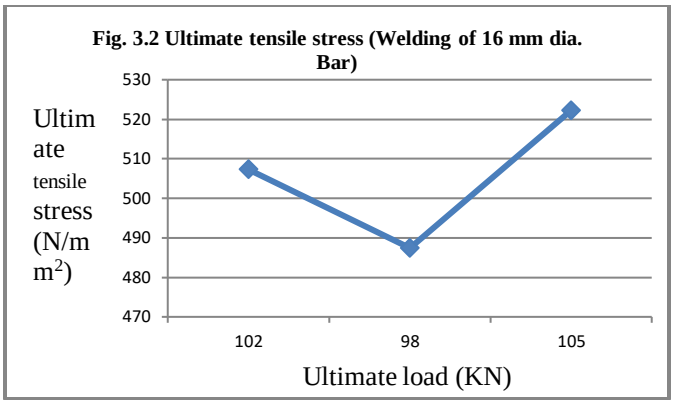
Description	Units	Quantities			
Rebar diameter	MM	16	20	25	32
Length of rebar	M	12	12	12	12
Weight of rebar per meter.	Kg/M	1.571	2.469	3.858	6.321
Cost of steel	Rs	50	50	50	50
Rebar length as per floor	M	4	4	4	4
Lap considered	D	50	50	50	50
Lap length	M	0.8	1	1.25	1.6
Weight of overlapping	Kg	1.26	2.47	4.82	10.11

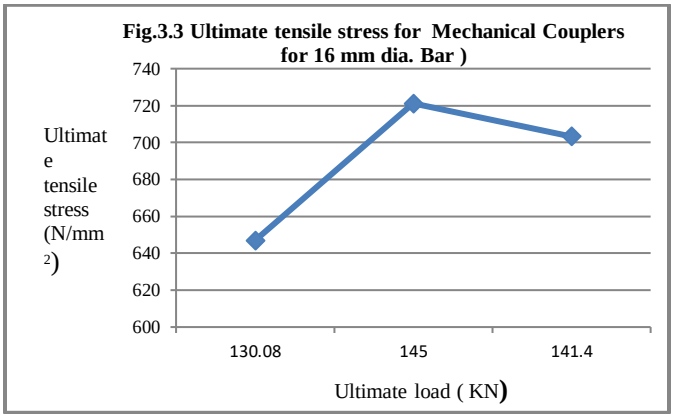
lap					
Total bar consumed per floor	M	4.8	5	5.25	5.6
No. of lap in 12 m rebar	No.	2	2	2	2
Actual consumption of bar	M	9.6	10	10.5	11.2
Wastage scrap in length	M	2.4	2	1.5	0.8
Wastage in Kg	Kg	3.769	4.938	5.787	5.057
Wastage as scrap in 12 meters in Rs.	Rs.	188.47	246.91	289.35	252.84

3) Test Results

The Tensile test carried on 16 mm diameter bar with Conventional Lap Slice, welded Slices and available mechanical Threaded coupler as per recommended in IS code 1786-2008. The average tensile stress obtained was 198.94 N/mm^2 for Conventional Lap splice in 16 mm diameter bar (fig.3.1).Similarly the average tensile stress obtained from Weld splice is 505.65 N/mm^2 (fig.3.2) and the average tensile stress obtained for mechanical coupler is 690.46 N/mm^2 (fig.3.3).



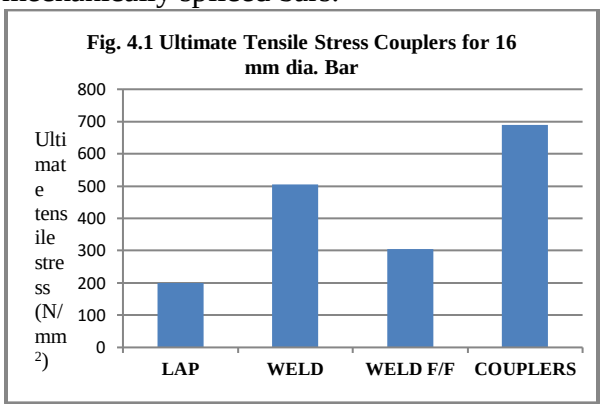




4. Conclusion

The use of mechanical splices as an alternative to lapping of reinforcement is a viable one in many situations. Couplers having high carbon contents have high strength and in addition with greater thickness are more sustainable and effective. A comparison was done to show cost of lapping and use of mechanical couplers which shows that, the use of couplers significantly reduces both the consumption and construction time and reinforcing steel. The mechanical coupler has significant improvement in loading capacity and ductility better than the conventional splicing methods independent of the concrete conditions.
The conclusion from various test and survey are as stated below-
1.TensileTest- Mechanical splice gives high performance than conventional lap splice; this is generally 125-150% than conventional lapping strength.

2. Ultimate load- The ultimate load carrying capacity of lapped bar was less than mechanically spliced bars.



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