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Study of Various Types of Mechanical Splice Used for Rebar in Reinforced Concrete Structure

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ABSTRACT: Construction practices within the building of concrete structures have centered on the use of steel reinforcement to transfer tension and shear forces. Lap splicing has become the conventional method of interfacing the steel reinforcing bars. Splicing the Reinforcement bars by laps or welding has different defects, such as low-quality welds, insufficient length of lap, disappointment in joints, increment in work taking a toll, etc. The present is focused on the utilization and applicability of reinforcement couplers, especially threaded couplers. The cost of steel is determined by providing lap splices within the columns. It shows an increase in the generally unwavering quality of reinforcement splices. The considerations included calculations and financial possibilities for mechanical couplers and how couplers have successfully saved significant amounts of money in a single building. The fortification couplers not only provide strength to the joints, but they are also an economic means of connecting two bars.

KEYWORDS: Mechanical Splice, Reinforcement R/F, Mechanical Couplers, Lap Splices, Column.

I.INTRODUCTION

Lap splicing, which requires the overlapping of two parallel bars, has long been accepted as an effective and economical splicing method.[1] Lap splicing has become the traditional method of connecting the steel reinforcing bars.[5] Splicing the Support bars by laps or welding has different defects such as low-quality welds, lacking length of laps, failure in joints, increment in work fetched, etc. This rather simple statement causes significant challenges for designers.[2] Not only must analysis be performed to determine the amount of steel required, but the required development lengths for adequate bonding of the reinforcing steel also must be computed.[6] Lastly, all this information is used in the detailing of the section (refer to Fig.No.1).[3, 4] In many cases, there may be problems locating all the steel required within the space provided. In addition, there may be additional cover or confinement required to control the lap length to reach the capacity needed in the length provided. [6] The splicing of large-diameter bars can lead to required lengths easily over a meter in length, requirement that is not easily met in many situations.

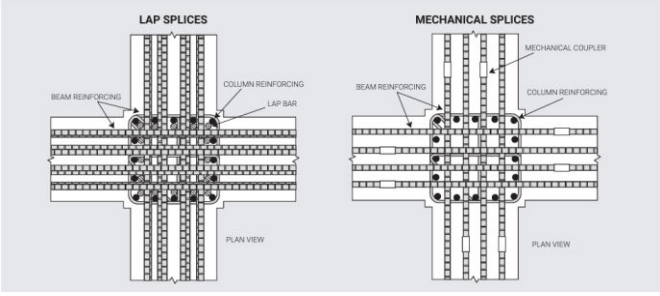

Fig.No.1: Lap Splices & Mechanical Splices. (from Dextra)

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Types Of Couplers

The coupler system is available in several styles to meet virtually any application.[9] The applications include standard bar-to-bar connections, presaging applications, hooked bar applications, closure pours, precast connections, rebar terminations and anchorages, transition splices, segmental construction, and connections to structural steel.[6,9] Most popular splicing systems are Interlock, Quick wedge, Speed sleeve, Terminator, Lock, Form saver, Taper thread splices.

II.LITERATURE REVIEW

Lap splicing has been the conventional method for connecting steel reinforcing bars for many years. Splicing the steel reinforcing bars by lapping or welding has various imperfections such as inadequate length of laps, low-quality welds, increase in labour cost, failure in joints, etc. Overcome the problems stated above new techniques for splicing steel reinforcing bars have come into practice. The present study is focused on the investigation of new techniques for splicing steel reinforcing bars. The use and applicability of reinforcement couplers as an alternative to lap splices would overcome the reinforcement congestion problem and increase the strength of the structure. It was found that the use of reinforcement couplers significantly reduces the consumption of both reinforcing steel and construction time. It also increases the overall reliability of reinforcement splices.

The previous papers are on “The improvement of the threaded-based mechanical splice by modifying the threaded system: Study of techniques cold rolling and rotating friction welding” (Md. Reza Shirzad, F. Nateghi-Alahi, 2023) [1], “Behavior of lap splices in reinforced concrete beams after bar yielding.” (Haavisto J., Heikki A. 2023) [2], “Predicting tensile strength of spliced and non-spliced steel bars using machine learning- and regression-based methods” (Hamed Dabiri 2022) [3], “Review of mechanical bar couplers for splicing precast concrete members.” (Khitmatgars D. 2021) [4].
The studies on mechanical splices are commonly based on strength, durability, performance, and alternatives of the lapping with the literature survey**,** in this report the cost of the product and quantity for different types of buildings where we can use it.

III.METHODOLOGY OF PROPOSED SURVEY

Objectives

In this study different types of structural drawings are collected from CC precast, E-struct & Colonnade consultants.

- Identification of the lapping location.
- To study mechanical splices alternatives to lap splices on different types of buildings be it a double or multi-story building, in this study, the rebar coupler is primed for multi-family residential buildings G+4 to G+6.
- In this study the effect of ‘Reinforcement bar coupler’ as an alternative to ‘lap splice’ in compression members.

Location of Couplers
Identification of the lapping connection was in this study; we have considered on every floor there is a lap that has been taken for the calculation of the quantity and cost of rebar and coupler. In this study, structural drawing is referred to as identifying the location, shown in Fig No.2.

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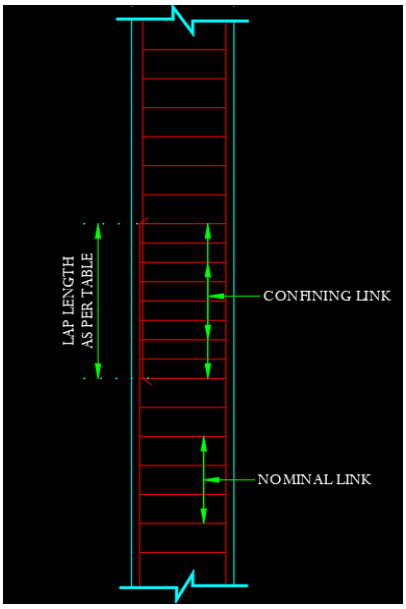

Fig.No.2: Lapping in Column shown in Structural Drawing

Calculation of R/F and Couplers

The calculation of the R/F required for lapping is calculated and the cost for a single location is shown below:

- Weight calculation considers for 16mm bar the development length of L_d is 50d from IS CODE 456:2000 where d is the diameter of the bar.
- The cost of steel is taken as 60 Rs. /Kg.
- The cost of a 16mm coupler is 55 Rs. /Unit with labour cost from Dextra.
- $\frac{D^2}{162}$ where, D is diameter of steel bar & 162 is a constant value this equation is used for calculation of unit wt. of steel bar.
  - Development length $\mathbf{L_d}$ = 50*16

    = 800 mm = 0.8 m .....(1)
  - **Wt. of 16mm steel bar per meter =** $\frac{D^2}{162}$

    $= \frac{16^2}{162}$ **= 1.58 kg/m.** .....(2)
  - By multiplying the above equation (1&2) is

    =0.8*1.58

    =1.265 kg.
  - The unit wt. of one bar is **1.265 kg.**

    Now,
    - Unit Cost of steel bar for 16mm = 1.265 *60

      = 75.84 /-
    - Unit Cost of the coupler for 16mm = 1*55

      = **55/-**

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- The above calculation for a 16mm steel bar and coupler shows the cost of a coupler is less than that of a steel bar.

IV. ECONOMIC FEASIBILITY OF THE MECHANICAL SPLICES

The cost has been computed based on steel in lapping which indicates couplers are an effective and economic replacement for lap splices. Table No.1 shows how couples have effectively saved a significant amount of money in a single joint. The total cost saved per joint for 16 mm rebar is Rs. 21/- and for 20 mm rebar is Rs.160/- which is much less than what would have been spent if lapping had been done by using the site method or simply I.S. 456: 2000 specification. On the same line for 12 mm rebar, the saving is comparatively less.

Table No.1: Cost Analysis

Bar Diameter (mm)	Weight of Steel per meter (kg/m)	Development Length (m) Ld	Quantity of Steel in (kg.)	Cost of Steel Rs.	Cost of the Coupler Rs.	Total Saving Rs.
16	1.58	0.800	1.26	76/-	55/-	21/-
20	2.47	1.000	2.47	185/-	70/-	160/-
25	3.85	1.250	4.81	289/-	110/-	180/-
28	4.84	1.4	6.77	407/-	130/-	277/-

V.RESULTS

By streamlining the construction process, mechanical splice couplers contribute to increased efficiency and productivity on-site, ultimately reducing project overheads. Moreover, mechanical couplers provide superior structural integrity and reliability compared to traditional rebar lapping. Their design ensures a strong and durable bond between adjacent bars, minimizing the risk of material wastage and costly repairs due to inadequate connections.

Mechanical couplers for rebar offer a more sustainable and cost-effective solution over time, reducing labor and material expenses associated with traditional methods. The cost comparison between the coupler and R/F is shown in Fig No. 5 where X is the quantity of R/F and coupler.

The weight of R/F for 12&16mm diameter bar with respect to total slab area is shown in Fig No. 3.

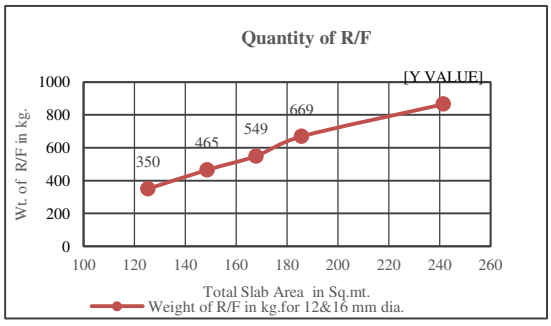

Fig. No.3: Weight of the R/F Required for Lapping.

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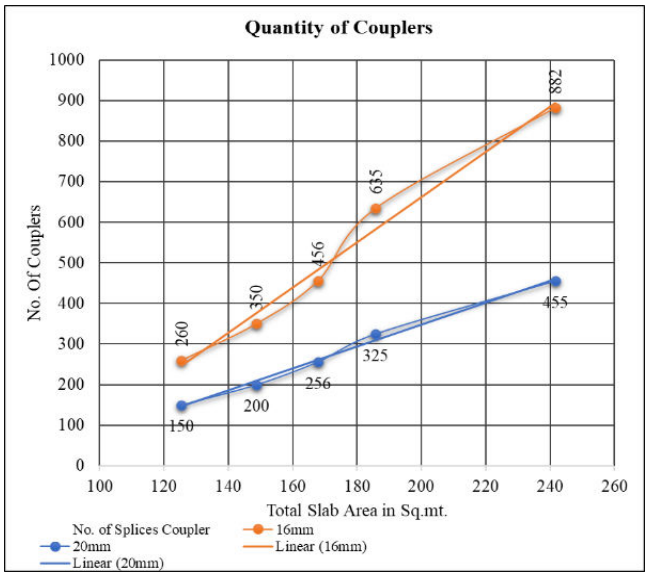

Fig. No.4: Quantity of the Couplers with Total Slab Area.

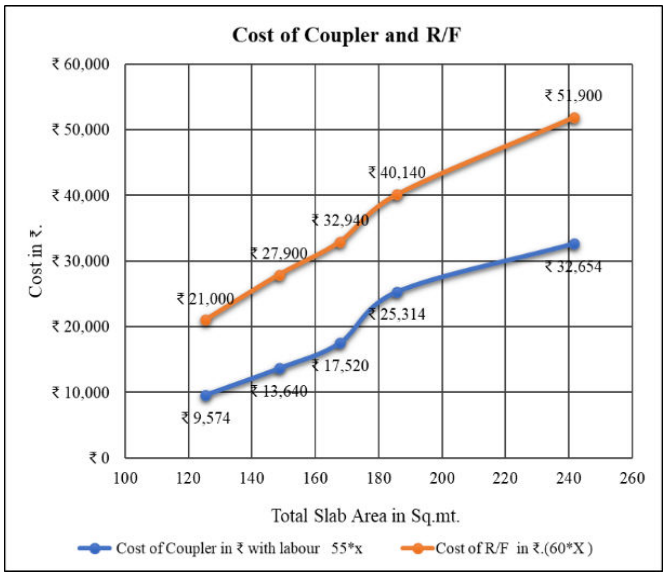

Fig. No.5: Cost Comparison of Couplers and R/F.

- The Quantity of Couplers for 12&16mm diameter bars with respect to the total slab area is shown in Fig No. 4.
- Fig No. 5 represents that the cost of splice couplers is lower than the traditional lapping method, their installation process is significantly quicker and simpler, from the fig. approx. cost can be determined.

Cost Comparison

This study proves the use of mechanical couplers in reinforcement to reduce the significant amount of steel and increases the structural performance like continuity of load path and high load carrying capacity when compared to the traditional lapping method. The economic survey report for both lapping and mechanical couplers is shown in Table No.2.

Table No.2 Cost Comparison of R/F And Couplers for Residential Multi-Family Buildings

Sr. No.	Type of Buildings	R/F Cost (Inc. Installation and labour cost) Rs.	Coupler Cost (Inc. Installation and labour cost) Rs.	Cost Saved (Inc. Installation and labour cost) Rs.
1	RB G+3	21,000/-	9,574/-	11,425/-
2	RB G+4	27,900/-	13,640/-	14,260/-
3	RB G+3	32,940/-	17,520/-	15,420/-
4	RB G+4	40,140/-	25,314/-	14,826/-
5	RB G+5	51,900/-	32,654/-	19,246/-

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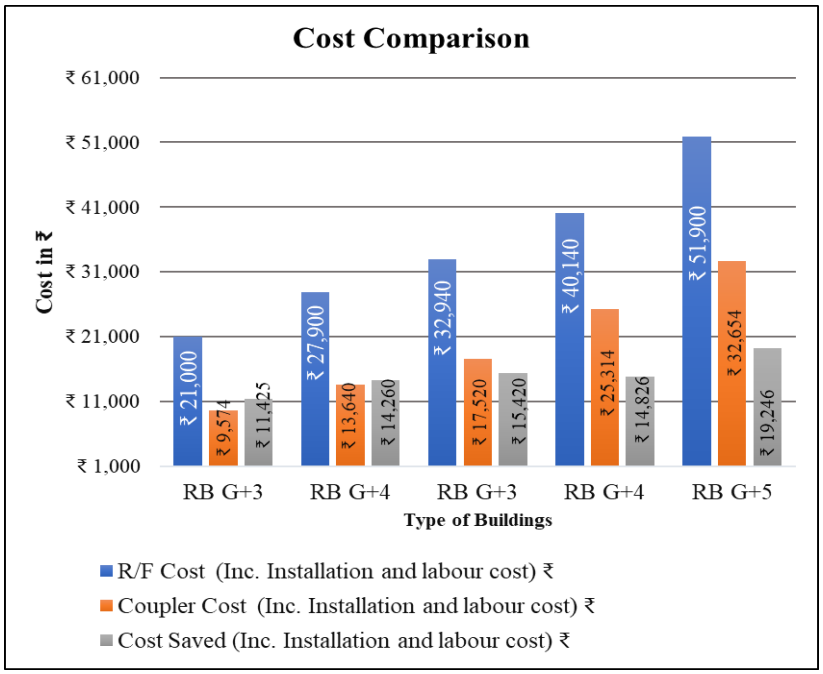

Fig. No.6: Cost Comparison

Firstly, while the upfront cost of splice couplers is lower than the traditional lapping method, their installation process is significantly quicker and simpler. This results in reduced labour costs and shorter construction times, translating to overall savings in project expenses.

VI. CONCLUSION AND FUTURE WORK

This study shows that couplers are an effective and economical replacement for lap splices and can save a huge amount of money on a single joint. The couplers were considerably more cost-effective and time-saving than welding the bars together. No special high strength, enlarged thread section, or increased rebar size is necessary, thus allowing the supply of reinforced bars from multiple sources for maximum cost savings. The threaded splice is a widely used mechanical splicing system worldwide.

Future Scope

Continued research and innovation can lead to cost-effective solutions that reduce material and labour costs associated with traditional rebar splicing methods. Mechanical couplers that offer faster installation times and reduced project timelines can contribute to overall project efficiency and competitiveness.

- The development of new and improved materials for mechanical rebar couplers can enhance their performance and durability.
- This can involve the use of high-strength alloys or composite materials that offer superior mechanical properties and corrosion resistance, further extending the lifespan of reinforced concrete structures.

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