Abstract:
Lap splicing has become the traditional method of connecting two steel reinforcing bars when you have to provide reinforcement in large members such as beams slabs and column to obtain load path continuity. The overlap load transfer mechanism takes advantage of the bond between the steel and concrete to transfer the load. The load in one bar is transferred to the concrete and then from the concrete to the ongoing bar. The bond is largely influenced by the surface characteristics of the reinforcing bars such as ribs, types of ribs etc. Lap splices are not considered reliable under cyclic loading and they are not effective for larger spans and have many ‘hidden’ costs. As a result, engineers started use of mechanical splices which lead to huge cost savings. Also mechanical splices have various other benefits such as reduces congestion and are more reliable since they do not depend on concrete for load transfer. Superior cyclic performance and greater structural integrity during manmade, seismic or other natural events are other advantages of mechanical splices. Mechanical splicing does away with the tedious calculations needed to determine proper lap lengths, and their potential errors. Because mechanical splices do not overlap, less rebar is used, reducing materials costs. This paper verifies the strength of different coupled and normal bars and also an economic viability study. Different types of samples were tested under UTM and the reports are studied to calculate the economic cost comparison of the same.


1. INTRODUCTION
Lap splicing has become the traditional method of connecting two steel reinforcing bars. Lap splice and welded splices have various imperfections such as poor quality of welds, increased labour cost, requires skilled labour inadequate length of laps, failure at joints, etc. There are basic ways to splice the bars

1. Lap splices.
2. Mechanical splices.
3. Welded splices.

Lapped joints are not that effective mean of splicing since it has various disadvantages such as greater congestion, time consuming and also lap splices are not considered reliable under cyclic loading and they are not effective for larger spans and have many ‘hidden’ costs and it does not provide load path continuity, independent of the condition of concrete. Mechanical splices i.e. the coupler system is used to connect two bars in field quickly and easily. Hence mechanical splices such as threaded couplers can be very effective since they ease the design parameters, easy in installation and also reduce the amount of reinforcement required. Hence more and more engineers are specifying mechanical reinforcement connections over lap splices since they have found that mechanical connections afford a reliability and consistency that can’t be found with lap splicing. Mechanical splices deliver higher performance than a typical lap splice. Generally, this is 125% - 150% of the reinforcement bar and this is also economic means of connecting two bars. The purpose of this study is to compare the strength and behaviour of normal and coupled bars under tensile loading and also to study the economic cost comparison of the same.

2. OBJECTIVES
The objective of the study is to compare the strength and behaviour of normal and coupled bars under tensile loading and also to study the economic cost comparison of the same. For this reason, tensile load tests were carried out on a total of three specimens in UTM and the reports are studied to calculate the economic cost comparison of the same.

3. MATERIALS AND SPECIFICATIONS:
The materials used in this experimental work were

1. Mechanical threaded coupler
2. HYSO BARS (Fe-500).

3.1 Mechanical threaded coupler:
Generally couplers are manufactured from mild steel, but in some cases alloys of different metals can also be used. The material should be such that couplers meet the minimum strength requirement (125% of yield strength of rebar). The manufacturing of couplers includes different basic steps as cutting, boring, threading, finishing. Every manufacturer gives his own specifications regarding coupler selection. A very important aspect of coupler selection is selection of material and specification given for them as shown in Table 1.

3.2 HYSO Bars:
Fe-500 steel bars of different diameters 16, 25, 32 mm were used in the experiment. All the steel bars used in the experimentation are of same manufacturing company.
4. EXPERIMENTAL PROCEDURE

The various steps involved in testing are
1. Preparation of mechanical joint.
2. Testing of specimen.

4.1 Preparation of mechanical joint:
The steps involved in preparation of mechanical joint are:
1. Preparation of rebar
2. Installation of coupler

4.1.1 Preparation of rebar:
Preparation of rebar consists of two steps:

a. Peeling: The end of reinforcing bar is peeled as per required size.

Figure 1. Peeling of bars.

b. Roll Threading: The peeled area of the reinforcing bar is threaded by rolling.

Figure 2. Roll threading of bars.

4.1.2. Installation of coupler:

a. The coupler is normally supplied to a reinforcing bar, ready to be installed and cast in concrete.
b. After casting of the concrete and when ready to extend, remove the plastic end cap from the coupler, position the continuation bar in the sleeve and rotate the bar into the coupler.
c. Continue to screw the bar into the coupler until tight and
d. To ensure correct installation, tighten the joint to the specified torque using a calibrated torque wrench on the continuation bar

4.2 Testing of specimen:
The structural study of couplers included in the study is the initial design equations given by NCMA [national concrete masonry association] and IBC [Indian buildings congress].

4.2.1 Procedure:
1. Put gauge marks on the specimen.
2. Measure the initial gauge length and diameter.

3. Select a load scale to deform and fracture the specimen. Note the tensile strength of the material and the type used has to be known approximately.
4. Record the maximum load.
5. Conduct the test until fracture.
6. Measure the final gauge length and diameter. The diameter should be measured from the neck.

5. EXPERIMENTAL RESULTS

The average comparative results of 16mm, 25mm, 32mm bars where tested under tensile loading in UTM for normal and coupled bars were tested and are shown in Table 2.

6. COST ANALYSIS

A cost analysis has been done based on steel saving in lapping which indicates that couplers are cost effective compare to the lap splicing and are shown in Table 3. Hence mechanical splices such as threaded couplers can be very effective since they ease the design parameters, easy in installation and also reduce the amount of reinforcement required and thus saving a huge amount of money in a single joint. The total cost saved per joint for 25mm rebar is Rs 197/- and for 32mm rebar is Rs. 461/- which is way far less than what would have been spent if lapping would have been as per I.S.456-2000 specifications and for 16 mm rebar the saving is comparatively less.

Figure 3. Graph of Cost Analysis

7. CONCLUSION

This study shows that couplers are an effective and an economic replacement of lap splice. The coupler used here is “Threaded couplers”. Thus by this saving a huge amount of money in a single joint and it is also the simplest type of coupler used in the reinforcement to connect two bars in field quickly and easily. Hence mechanical splices such as threaded couplers can be very effective since they ease the design parameters, easy in installation and also reduce the amount of reinforcement required and thus by ensuring maximum cost saving.
### Table 1. Specifications of Coupler

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Material</th>
<th>External Diameter (mm)</th>
<th>Internal Diameter (mm)</th>
<th>Length (mm)</th>
<th>Pitch (mm)</th>
<th>Weight (kgs)</th>
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<tbody>
<tr>
<td>16</td>
<td>EN8D</td>
<td>25</td>
<td>13.5</td>
<td>40</td>
<td>2.5</td>
<td>0.145</td>
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<tr>
<td>20</td>
<td>EN8D</td>
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<td>48</td>
<td>2.5</td>
<td>0.292</td>
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<tr>
<td>25</td>
<td>EN8D</td>
<td>40</td>
<td>22</td>
<td>60</td>
<td>3</td>
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</tr>
<tr>
<td>32</td>
<td>EN8D</td>
<td>50</td>
<td>29</td>
<td>72</td>
<td>3</td>
<td>0.810</td>
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<tr>
<td>40</td>
<td>EM8D</td>
<td>60</td>
<td>37</td>
<td>90</td>
<td>3</td>
<td>1.250</td>
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### Table 2. Average comparative results of 16mm, 25mm, 32mm diameter rebar for splicing

<table>
<thead>
<tr>
<th>Samples</th>
<th>Identification mark</th>
<th>Nominal diameter(mm)</th>
<th>Cross sectional area of the test piece (mm²)</th>
<th>Mass/meter(kg/m)</th>
<th>Gauge length(mm)</th>
<th>a) Yield stress obtained(N/mm²)</th>
<th>b) Yield stress standard as per I.S 1786(N/mm²)</th>
<th>a) Ultimate stress Obtained(N/mm²)</th>
<th>b) Ultimate stress Standard as per I.S. 1786(N/mm²)</th>
<th>Percentage Elongation</th>
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<td></td>
<td></td>
<td>16-TS</td>
<td>201.2</td>
<td>1.58</td>
<td>200</td>
<td>574.1</td>
<td>&gt;500</td>
<td>686.32</td>
<td>&gt;545</td>
<td>16.41%</td>
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<tr>
<td></td>
<td></td>
<td>25-TS</td>
<td>491.1</td>
<td>3.85</td>
<td>200</td>
<td>544.91</td>
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<td>673.48</td>
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<td>32-TS</td>
<td>804.6</td>
<td>6.31</td>
<td>200</td>
<td>596.05</td>
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<td>708.28</td>
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<td>17.26%</td>
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<td></td>
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<td>16-TS</td>
<td>201.2</td>
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<td>3.85</td>
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<td></td>
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<td>32-TS</td>
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<td>6.31</td>
<td>200</td>
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<td>695.27</td>
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<td>16.74%</td>
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### Table 3. Cost Analysis (For M20 grade of concrete)

<table>
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<tr>
<th>Bar diameter (mm)</th>
<th>Weight of steel per meter</th>
<th>Development length (mm) Ld</th>
<th>Grade of concrete</th>
<th>Cost of steel (Rs/kg)</th>
<th>Quantity of steel saved (kg)</th>
<th>Steel saving</th>
<th>Cost of coupler</th>
<th>Total saving</th>
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<td>32</td>
<td>6.31</td>
<td>1925</td>
<td>M20</td>
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<td>M20</td>
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<td>1.58</td>
<td>910</td>
<td>M20</td>
<td>47</td>
<td>1.43</td>
<td>68</td>
<td>40</td>
<td>28</td>
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</table>

8. REFERENCE:


