Analysis and Design Study of Concrete Paver Blocks with Feedback Loop

Raman, Rahul Sikka, Bhawna Arora

Abstract—Concrete block pavement (CBP) can be an alternative pavement to asphalt and concrete pavements. CBP is formed from individual concrete paving blocks (CPBs) that fit next to one another on a suitable subbase leaving a specific joint space among them to be filled with jointing sand. CBP differ from other pavements according to their mechanical behaviour, manufacturing technique, structural design, installation technique and structural behaviour. For a serviceable pavement all of these subjects have to be studied. This study aims to design the paver blocks of specified strength and to eliminate the defects arose during the life of the paver blocks. For this purpose, several designs mixes with different cement contents and W/C ratios were designed and the one meeting all the required criterion is selected. However, even after getting desired strength and other required properties some defects arises in the lifespan of the blocks. These defects are then further studied by collecting data of all the defects. Defects arising in the paver blocks include mainly edge breaking and lesser strength of the blocks. Recorded data is used for further modification in the design of the blocks and better quality control of material and manufacturing process is obtained. The compressive strength, tensile splitting strength, abrasion resistance, density and % water absorption tests were performed on each mix at 7, 14, 28 days. This study concludes that with better control at the quality of the materials and in the manufacturing process better products can be made. All the defects arising in the blocks are eliminated with the re-design of the blocks by data collection studies for the defects of blocks.

Index Terms—Concrete paving block, concrete block pavement, re-design, quality control

I. INTRODUCTION

CBP/ICBP consists of a surface layer of small-element, solid un-reinforced pre-cast concrete Paver blocks lay on a thin, compacted bedding material which is constructed over a properly profiled base course and is bounded by edge restraints/kerb stones. The block joints are filled using suitable fine material. A properly designed and constructed CBP/ICBP gives excellent performance when applied at locations where conventional systems have lower service life due to a number of geological, traffic, environmental and operational constraints. Many number of such applications for light, medium, heavy and very heavy traffic conditions are currently in practice around the world. In India, research and development work in this field started at Central Road Research Institute in the nineties. Currently the Indian Institute of Technology (IIT), Kharagpur, has joined in the research and development efforts. Application of CBP/ICBP technique is finding increasing popularity around the country, especially in metropolitan cities as well as in large and medium towns.

LITERATURE

The surface of ICBP comprises concrete blocks bedded and joined in sand. It transfer the traffic loads to the substructure of the pavement. The load spreading capacity of concrete blocks layer depends on the interaction of individual blocks with joining sand to build up resistance against applied load. The shape, size, thickness, laying patterns are important block parameters which influences the block parameters.

Some early plate load studies (Knapton 1976, Clark 1978) suggested that load spreading ability was not significantly affected by block shape. Latter accelerated trafficking studies (Shackle 1993) established that shaped blocks exhibited smaller deflection than rectangular blocks of similar thickness installed in same laying pattern under same applied load. (Shackel 1980, Jacobs and Houben 1988) found that, in their early life, block pavements stiffen progressively with an increase in load repetitions. However Shackel clarified that the progressive stiffening did not influence the magnitude of resilient deflection of ICBP. Elastic deflection is decreased with an increase in number of load repetition, rather than an increase, as observed in flexible and rigid pavements.
DESIGN OF CONCRETE PAVER BLOCKS

- IS Method of Design of Concrete Paver Blocks
  We have designed the blocks using the Indian Standard method of design. This helped us achieving the goal of strength of tiles in minimum specified strength. Use of admixture aided in the higher strength of the blocks in lesser time.

**Design of Paver Blocks**

The following materials are used for mix proportioning of grade of Paver Blocks:

**Materials in use for Design:** Type of cement used Shree Cement OPC-43 Grade, Maximum nominal size of aggregate-20mm, Minimum cement content-330kg/m$^3$, Maximum water-cement ratio-0.40, Workability-100mm, Exposure conditions-Severe, Method of transporting and placing- Manual, Type aggregate-Crushed Angular Aggregate, Maximum cement content-450kg/m$^3$, Admixture used-Super plasticizer.

**Test results Obtained for Design Mix:** Cement used-Shree cement OPC-43 grade, Specific gravity of cement-3.10, Chemical Admixture- Super plasticizer, Specific gravity of coarse aggregate-2.74 and Fine aggregate-2.8, Water absorption of coarse aggregate-0.5% and Fine aggregate-1.0%

**Sieve analysis:**

1) Coarse aggregate (Test result)

<table>
<thead>
<tr>
<th>IS Sieve Sizes mm</th>
<th>Analysis of Coarse Aggregate Fraction</th>
<th>Percentage of Different Fractions</th>
<th>Remarks (Results)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>I 100 II 100</td>
<td>I 60 II 40 III 100</td>
<td>Conforms to IS 383</td>
</tr>
<tr>
<td>10</td>
<td>I 10 II 71.20</td>
<td>0 28.5 28.5</td>
<td></td>
</tr>
<tr>
<td>4.75</td>
<td>- 9.60</td>
<td>- 4 3.7</td>
<td></td>
</tr>
<tr>
<td>2.36</td>
<td>- 0</td>
<td>- - -</td>
<td></td>
</tr>
</tbody>
</table>

2) Fine aggregate (Test Results)

Text in Bolds shows our test results.

<table>
<thead>
<tr>
<th>IS SIEVE DESIGNATION</th>
<th>PERCENT PASSING FOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grading zone I</td>
</tr>
<tr>
<td>10 mm</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>90-100</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>60-95</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>30-70</td>
</tr>
<tr>
<td>600 micron</td>
<td>15-34</td>
</tr>
<tr>
<td>300 micron</td>
<td>5-20</td>
</tr>
<tr>
<td>150 micron</td>
<td>0-10</td>
</tr>
</tbody>
</table>

Results shows that the fine aggregates belongs to the Grading Zone-I.

**Target Strength for Mix Proportioning of Paver Blocks**

Assumed Standard Deviation (N/mm$^2$), $s = 5N/mm^2$ for Grade of Concrete M-35
Therefore, target strength = $35 + 1.65 \times 5 = 43.25$ N/mm$^2$

**SELECTION OF WATER-CEMENT RATIO**

Selected Minimum cement-content, Maximum water-cement ratio and Minimum Grade of concrete for Severe Exposure with Normal Weight Aggregate of 20mm Nominal maximum size. Maximum water-cement ratio = 0.45. Based on practical data, adopt water-cement ratio as 0.40. 0.40<0.45 Hence, OK.

**SELECTION OF WATER CONTENT**
Maximum water content 186 litre (for 25 to 50 mm slump range) for 20 mm aggregate. Estimated water content for 100 mm slump = 186 + 186 x 6/100 = 197 litre. As super-plasticizer is used, the water content can be reduced up to 25 per cent and above. Hence, the arrived water content = 197 x 0.75 = 147.75 litre.

**CALCULATION OF CEMENT CONTENT**

Water-cement ratio = 0.40, Calculated Cement content = 147.75/0.40 = 369.375 (370Kg Approx.). Minimum cement content for 'severe' exposure condition = 320 kg/m^3.

**PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT**

Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 = 0.60. In the present case water-cement ratio is 0.40. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10. The proportion of volume of coarse aggregate is increased by 0.02 (at the rate of +/- 0.05 change in water-cement ratio). Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.40 = 0.62. Volume of fine aggregate content = 1 - 0.62 = 0.38.

**MIX CALCULATIONS**

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m^3

b) Volume of cement = \( \frac{\text{Mass of Cement}}{\text{Specific Gravity of Cement}} \times \frac{1}{1000} \)

\[
= \frac{370}{3.1} \times \frac{1}{1000} \\
= 0.119 m^3
\]

c) Volume of Water = \( \frac{\text{Mass of Water}}{\text{Specific Gravity of Water}} \times \frac{1}{1000} \)

\[
= \frac{147.75}{1.0} \times \frac{1}{1000} \\
= 0.147 m^3
\]

d) Volume of chemical Admixture (Super-Plasticizer) @3% by mass of cement content = \( \frac{\text{Mass of Chemical Admixture}}{\text{Specific Gravity of Admixture}} \times \frac{1}{1000} \)

\[
= \frac{11.1}{1.21} \times \frac{1}{1000} \\
= 0.009 m^3
\]

e) Volume of all in aggregate = 1 - (0.119 + 0.147 + 0.009) = 0.725 m^3

f) Mass of coarse Aggregate = 0.725 x 0.62 x 2.74 x 1000 = 1231.63 kg

g) Mass of Fine Aggregate = 0.725 x 0.38 x 2.8 x 1000 = 771.4 kg

**MIX PROPORTIONS FOR TRIAL NUMBER 1**

Cement-370kg, Water-147.75litre, Fine aggregate-771.4kg, Coarse aggregate-1231.63kg, Chemical admixture-11.1kg, Water-cement ratio-0.40.

**MIX PROPORTIONS FOR TRIAL NUMBER 2**

Cement-375kg, Water-150litre, Fine aggregate-780.4kg, Coarse aggregate-1220.63kg, Chemical admixture-10.1kg, Water-cement ratio-0.40.

**QUALITY CONTROL/ASSURANCE IN MANUFACTURING OF BLOCKS**

Quality control is the use of techniques and activities to achieve sustain and improve the quality of the paver blocks produced. It involves integrating techniques and activities specification of all the materials and final paver block required.

Quality Control Measures adopted in the Materials:

- Tests on aggregate Sieve Analysis Results (Coarse Aggregate)

<table>
<thead>
<tr>
<th>IS Sieve</th>
<th>Percentage Passing Through Sieve (Results)</th>
<th>Percentage of Passing Through Sieve (Indian Standard Requirements)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40mm</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>20mm</td>
<td>96</td>
<td>95 to 100</td>
</tr>
<tr>
<td>16mm</td>
<td>77</td>
<td>-</td>
</tr>
<tr>
<td>12.5mm</td>
<td>48</td>
<td>-</td>
</tr>
<tr>
<td>10mm</td>
<td>27</td>
<td>25-55</td>
</tr>
<tr>
<td>4.75mm</td>
<td>8</td>
<td>0-10</td>
</tr>
<tr>
<td>2.36mm</td>
<td>2</td>
<td>-</td>
</tr>
</tbody>
</table>

Results shows the aggregate is well graded and conforms to the IS Specifications.
• **Specific Gravity of Aggregates:** Coarse aggregate-2.75 and Fine aggregate-2.79
• **Tests on Cement:** Specific gravity of the cement is tested. And results of the random sampling and testing are conforming to the values used in the mix design of the paver blocks. Specific Gravity of cement: 3.10

**Quality control measures in the manufacturing process:**

• **Decrease in reject rate and increase in product quality.**
  The nos of the rejected paver blocks after the final product is manufactured decreased upto 60%. Visual inspection of the product showed promising increase in the quality of the blocks.

• **Reduction in price of products hence better value for money.**
  The price of the expensive materials used is the major factor which increases the overall price of the product. Since we designed the product and blocks are manufactured in totally controlled environment and methods the overall price of the commodity is reduced upto15%.

• **Increase in product yield which should make economic mass production possible.**
  This is the one of the factor by which we can benefit a lot. However at this point we don’t required mass production. But still this method can be used to benefit when mass production is required.

**TESTING OF PAVER BLOCKS**

• **Compressive Strength Test**
  Compressive strength of paver blocks shall be determined as per the Indian Standard methods. Paver blocks strength need to be specified in terms of 28 days compressive strength. In case the compressive strength of paver blocks is determined for ages other than 28 days, the actual age at testing is to be reported. The compressive strength of the blocks is the major factor which governs the usage and durability of the blocks. Sampling of the blocks is done as per the IS requirements and the blocks are tested. 8 blocks are randomly selected and sample is then taken to the laboratory.

**Area of the Paver Block:** Plan Area of paver blocks 28300mm

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Tiles Area mm²</th>
<th>Max Load (N)</th>
<th>Compressive Strength N/mm²</th>
<th>Corrected Com. Stg. After applying Correction factor N/mm²</th>
<th>Corrected Average Comp. Strength N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>28300</td>
<td>919500</td>
<td>32.49</td>
<td>38.34</td>
<td>40.82</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td>963000</td>
<td>34.03</td>
<td>40.16</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td>999000</td>
<td>35.3</td>
<td>41.65</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>101050</td>
<td>35.71</td>
<td>42.14</td>
<td>40.82</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td>981000</td>
<td>34.66</td>
<td>40.9</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td>962500</td>
<td>34.01</td>
<td>40.13</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td>100650</td>
<td>0</td>
<td>41.97</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>990000</td>
<td>34.98</td>
<td>41.28</td>
<td></td>
</tr>
</tbody>
</table>

Criteria for passing of the concrete blocks as per IS 15658:
Average Strength of the blocks as observed in the tests results: 40.82 N/mm². According to the IS specifications average strength should be: = 35 + 0.825x5 = 39.125N/mm². And our resulting strength of the blocks is 40.82 which is greater than the requirements of IS Specifications.

Correction Factor to be used for testing the Compressive Strength.

• **Tensile Splitting Test**
  The tensile splitting strength of paver blocks should be determined as per the method given in the Indian Standard Code IS 15658 (Annex-F).

The Flexural strength of the blocks is determined and found to be:

**Result of Splitting test:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Maximum Load at Splitting (N)</th>
<th>Flexural Strength (N/mm²)</th>
<th>Average Flexural Strength(N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8490</td>
<td>3.97</td>
<td>4.07</td>
</tr>
<tr>
<td>2</td>
<td>8540</td>
<td>4.00</td>
<td></td>
</tr>
</tbody>
</table>
The average flexural strength of the blocks is less than that of the requirement as per the Indian Standard. 

**4.14 N/mm² (Required Flexural Strength ≥ 4.07 N/mm² (Observed Flexural Strength of the specimens))**

This sample doesn’t conform to the specifications of the Indian Standard code; hence the design needs to be modified.

**LIFE OF BLOCKS AND FEEDBACK FROM PAVER BLOCK USAGE**

In the life of the paver blocks many defects may arise and they have an adverse effect on the remaining life of the paver blocks. These effects need to be detected and the control measures can be adopted for these in the mix design and in the manufacturing process of the blocks. Some of these defects are identified in this study and the measures to control these defects are adopted. The design is modified and remedial controls are also applied in process.

**Defects identified:-**

- **Corner Breakage**: Tiles with broken corner with more than 5mm in any length of the tile is considered broken. All such blocks are identified and data is recorded for further studies.

- **Tiles breaking**: Any block which is broken in shear is considered broken in this study. Such blocks are not fitted for the traffic and must be removed. Lesser the numbers of the failed blocks higher the reliability of the paver blocks. All such paver blocks are identified and the data is recorded for further modification in the design or in the process of the making of the blocks.

**Data collection studies**

<table>
<thead>
<tr>
<th>S. No</th>
<th>No. of tiles Observed</th>
<th>Defective Pieces (Broken Corners)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10000</td>
<td>340</td>
</tr>
<tr>
<td>2</td>
<td>10000</td>
<td>230</td>
</tr>
<tr>
<td>3</td>
<td>10000</td>
<td>310</td>
</tr>
<tr>
<td>4</td>
<td>10000</td>
<td>290</td>
</tr>
</tbody>
</table>

These defects can be removed once the design of the paver blocks is modified.

- **Table 8.3: Broken Paver Blocks**

<table>
<thead>
<tr>
<th>S. No</th>
<th>No. of laid tiles Observed</th>
<th>Broken Paver Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50000</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>50000</td>
<td>21</td>
</tr>
<tr>
<td>3</td>
<td>50000</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>50000</td>
<td>23</td>
</tr>
</tbody>
</table>

**RE-DESIGNING: USE OF FEEDBACK DATA IN DESIGN MODIFICATION**

**Design of Paver Blocks**

First of all, the cement slurry topping in the paver blocks is increased by the 1mm since it is mainly responsible for the wear and tear of the blocks mostly. Hence, Area of blocks 283cm². The topping requirement 3mm thick. Hence the volume of the cement slurry required for the one block is 283x0.3= 84.9cm³. Now the modification in the design and quality control in manufacturing is required to eliminate the numbers of the failed paver blocks.

The design of the blocks is modified as below:

- The following materials are used for mix proportioning of grade of paver blocks:
  - **Materials in use for Design**: Type of cement used Shree Cement OPC -43 Grade, Maximum nominal size of aggregate-20mm, Minimum cement content-330kg/m³, Maximum water-cement ratio-0.38, Workability-100mm, Exposure conditions-Severe, Method of transporting and placing-Manual, Type aggregate-Crushed Angular Aggregate, Maximum cement content-450kg/m³, Admixture used-Super plasticizer.
  - **Test results Obtained for Design Mix**: Cement used-Shree cement OPC-43 grade, Specific gravity of cement-3.10, Chemical Admixture- Super plasticizer, Specific gravity of Coarse aggregate-2.74 and Fine aggregate-2.8, Water absorption of Coarse aggregate-0.5% and Fine aggregate-1.0%.

  
  Sieve analysis:

  - **Table 9.1: Coarse Aggregate**
Analysis and Design Study of Concrete Paver Blocks with Feedback Loop

<table>
<thead>
<tr>
<th>IS Sieve Sizes Mn</th>
<th>Analysis of Coarse Aggregate Fraction</th>
<th>Percentage of Different Fractions</th>
<th>Remarks (Results)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>I</td>
</tr>
<tr>
<td>20</td>
<td>100</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>71.2</td>
<td>0</td>
</tr>
<tr>
<td>4.75</td>
<td>9.60</td>
<td>4</td>
<td>3.7</td>
</tr>
<tr>
<td>2.36</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conforms to IS 383

2) Fine aggregate (Test Results)

Text in Bolds shows our test results.

Table 9.2: Fine Aggregate Zoning

<table>
<thead>
<tr>
<th>IS SIEVE DESIGNATION</th>
<th>Grading zone I</th>
<th>Grading zone II</th>
<th>Grading zone III</th>
<th>Grading zone IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mm</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>90-100</td>
<td>90-100</td>
<td>90-100</td>
<td>95-100</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>60-95</td>
<td>75-100</td>
<td>85-100</td>
<td>95-100</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>30-70</td>
<td>55-90</td>
<td>75-100</td>
<td>90-100</td>
</tr>
<tr>
<td>600 micron</td>
<td>15-34</td>
<td>35-59</td>
<td>60-79</td>
<td>80-100</td>
</tr>
<tr>
<td>300 micron</td>
<td>5-20</td>
<td>8-30</td>
<td>12-40</td>
<td>15-50</td>
</tr>
<tr>
<td>150 micron</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>0-15</td>
</tr>
</tbody>
</table>

Results shows that the fine aggregates belongs to the Grading Zone-I.

Target Strength for Mix Proportioning of Paver Blocks

Assumed Standard Deviation (N/mm²), \( s = 5 N/mm^2 \) for Grade of Concrete M-35

Therefore, target strength = \( 35 + 1.65 \times 5 = 43.25 \) N/mm²

SELECTION OF WATER-CEMENT RATIO

Selected Minimum cement-content, Maximum water-cement ratio and Minimum Grade of concrete for Severe Exposure with Normal Weight Aggregate of 20mm Nominal maximum size.

Maximum water-cement ratio = 0.45. Based on practical data, adopt water-cement ratio as 0.38.

SELECTION OF WATER CONTENT

Maximum water content 186 litre (for 25 to 50 mm slump range) for 20 mm aggregate. Estimated water content for 100mm slump \( = 186 + 186 \times 6/100 = 197 \) litre. As super-plasticizer is used, the water content can be reduced up 25 per cent and above.

Hence, the arrived water content \( = 197 \times 0.75 = 147.75 \) litre.

CALCULATION OF CEMENT CONTENT

Water-cement ratio= 0.38, Calculated Cement content = 147.75/0.38 = 388.375 (389 Kg Approx.). Minimum cement content for 'severe' exposure condition = 320 kg/m³. Hence, OK.

PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 = 0.60. In the present case water-cement ratio is 0.40. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10. The proportion of volume of coarse aggregate is increased by 0.02 (at the rate of ±0.01 for every ± 0.05 change in water-cement ratio). Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.38 = 0.624. Volume of fine aggregate content = 1 - 0.624 = 0.376

MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows:

h) Volume of concrete = \( 1 \) m³

i) Volume of cement = \( \frac{\text{Mass of Cement}}{\text{Specific Gravity of Cement}} \times \frac{1}{1000} \)

\[ = \frac{389}{3.10} \times \frac{1}{1000} \]

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Volume of Water: 
\[ \text{Volume of Water} = \frac{\text{Mass of Water}}{\text{Specific Gravity of Water}} \times \frac{1}{1000} \]
\[ = \frac{147.75}{0.125} \times 1 \times \frac{1}{1000} \]
\[ = 1.197 \times 1 \times \frac{1}{1000} \]
\[ = 0.147 \text{ m}^3 \]

Volume of chemical Admixture (Super-Plasticizer) @3% by mass of cement content: 
\[ \text{Volume of Admixture} = \frac{\text{Mass of Admixture}}{\text{Specific Gravity of Admixture}} \times \frac{1}{1000} \]
\[ = \frac{11.1}{1.21} \times \frac{1}{1000} \]
\[ = 0.009 \text{ m}^3 \]

Volume of All in aggregate: 
\[ \text{Volume of All in Aggregate} = 1 - (0.125 + 0.147 + 0.009) = 0.719 \text{ m}^3 \]

Mass of Coarse Aggregate: 
\[ \text{Mass of Coarse Aggregate} = 0.719 \times 0.624 \times 2.74 \times 1000 = 1229.63 \text{ kg} \]

Mass of Fine Aggregate: 
\[ \text{Mass of Fine Aggregate} = 0.719 \times 0.376 \times 2.8 \times 1000 = 756.4 \text{ kg} \]

MIX PROPORTIONS FOR FINAL DESIGN
Cement - 389 kg, Water - 147.75 litre, Fine aggregate - 756.4 kg, Coarse aggregate - 1229.63 kg, Chemical admixture - 11.1 kg, Water-cement ratio - 0.38.

ELIMINATION OF DEFECTS
Our re-designed product eliminates most of the commonly occurring defects in the paver blocks. Defects which showed up early in the life of the blocks now no longer exist. The tests results and site performance both supports our study. This makes it a successful case of the studying defects and elimination of them with experimental studies.

RESULT/CONCLUSION
The aim of the study was to determine the better design mix for paver block's longevity. In this study, we determined the design mix for our requirements and defects occurring in the lifespan of the blocks are then identified. These identified defects needed to be removed from the blocks. A study is then carried out to determine the possible causes of those defects in the paver blocks. A second mix-design is then carried out keeping in mind those identified defects. After the design of the blocks studies are again carried out to determine the elimination of the defects. If that mix-design doesn’t solve our problems, then, a third iteration could be carried to possibly eliminate all still occurring defects.

Our study shows that with better knowledge of the practical usage of the blocks and better knowledge of the defects occurring in the blocks a very suitable mix-design can be carried out to eliminate all the problems occurring in the interlocking paver blocks.

Data of corner breaking and compressive failure of the blocks is accumulated from different sites of same mix-design. This helped us to proceed and determine the failures occurring in the blocks. Hence, with enough knowledge of the usage and defects occurring in the blocks a very well worked out design mix for making concrete paver blocks is possible for maximum lifespan of the blocks.

REFERENCES
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