CHAPTER 5

PERFORMANCE STUDY ON RECYCLED CONCRETE MODEL PAVEMENT

5.1 GENERAL

The properties of lean concrete made with recycled aggregates and fly ash reveal that it can be used as a base course in pavement (rural roads). Accordingly a model pavement is constructed and the performance study was carried out.

5.2 OBJECTIVES

The objectives of this study are as follows:

- to ascertain the in-situ compressive and split tensile strength of concrete cores
- to ascertain the durability properties of concrete cores
- to evaluate the pavement performance by conducting condition survey

5.3 TESTS ON MODEL PAVEMENT

5.3.1 Layout

The model pavement consists of three sections, each 3.75 x 5.00 m to accommodate the large quantity of specimens to be extracted. The three sections can be identified as the recycled aggregate concrete, ceramic aggregate concrete and natural aggregate concrete.
5.3.2 Pavement Construction

The thickness of the lean concrete base course was designed as per IRC: SP:20-2002. The detailed design procedure of pavement thickness is presented in Appendix 1. The pavement also requires a surface course, since the lean concrete base course is likely to be eroded under traffic. Design mix tests for M30 grade surface course concrete with natural aggregate were carried out and the mix proportion 1:1.32:2.79 (Cement: Fine aggregate: Coarse aggregate) with water cement ratio of 0.49 was selected. For base course lean concrete, mix of proportion 1:6:12 with 50% replacement of fine aggregate with fly ash was selected.

Initially the existing subgrade was compacted with roller of capacity 10 tonne at optimum moisture content. Over the compacted subgrade the lean concrete mixtures of 1:6:12 with 50% replacement of fine aggregate with fly ash was laid for a thickness of 215 mm in two layers and compacted. Then the surface of the base course concrete was covered with surface course concrete of grade M30 for a thickness of 50 mm. Photographic view of pavement laid is shown in Figure 5.1.

![Figure 5.1 View of Model Pavement](image-url)
5.3.3 Extraction and Testing of Core Samples

Cores were extracted from the outer sections of the pavement and the layout of coring is as shown in Figure 5.2. Cores were staggered as shown to provide the necessary randomness. A minimum separation of 300 mm between cores and 150 mm between cores and pavement edges was specified. Figure 5.3 shows the extraction of core samples using core-cutting machine. The diameter of the cores extracted from the pavement was 100 mm to satisfy the standard length to diameter (L/D) ratio requirement of 2:1.

![Figure 5.2 Layout of Core Extraction](image1)

![Figure 5.3 Extraction of Core Samples](image2)
Core specimens extracted from the pavement were immersed in water for 30 min prior to testing to eliminate variation in moisture conditions at the time of testing. Figure 5.4 shows some of the core samples extracted. Compressive strength (at an age of 7, 28, 56 and 90d) and split tensile strength (at an age of 28d) were determined by testing the core samples extracted from each of the three pavement sections (Figure 5.5).

Durability properties such as voids, density, water absorption, porosity, water sorptivity, sulphate resistance and abrasion resistance at an age of 28, 56, 90, 180 and 360d were also performed on the concrete samples obtained from the field. The core samples of 150 mm diameter were sliced to required size and the tests were performed on concrete specimens as already conducted on laboratory cast specimens.

Figure 5.4 Core Samples

Figure 5.5 Compressive Strength Test on Core Sample
5.4 TEST RESULTS AND ANALYSIS

5.4.1 Compressive Strength

The compressive strength of the core samples at an age of 7, 28, 56 and 90d are shown in Figure 5.6. The equivalent cube of compressive strength of the core samples are tabulated in Table 5.1.

![Figure 5.6 Compressive Strength of Core Samples](image)

**Table 5.1 Equivalent Cube Compressive Strength of Core Samples**

<table>
<thead>
<tr>
<th>Identification</th>
<th>Equivalent cube compressive strength (MPa) at</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7d</td>
</tr>
<tr>
<td>R50</td>
<td>8.060</td>
</tr>
<tr>
<td>N50</td>
<td>9.290</td>
</tr>
</tbody>
</table>
Figure 5.7 shows the mean values of compressive strength of laboratory cured cube samples versus equivalent cube compressive strength of core samples. It was observed that the ratio of equivalent cube compressive strength of core samples and laboratory tested cube samples is 0.95. Hence there is no variation in compressive strength of concrete in the field compared to compressive strength of laboratory samples.

![Graph showing comparison of compressive strength](image)

**Figure 5.7 Comparison of Compressive Strength of Laboratory and Field Samples**

### 5.4.2 Split Tensile Strength

The split tensile strength of the core samples at an age of 28d are determined. Figure 5.8 shows the comparison between split tensile strength of field and laboratory samples. From the test results it was observed that, there is no significant variation between split tensile strength of field and laboratory samples.
5.4.3 Durability Properties

The bulk density, voids and water absorption of concrete specimens at various ages obtained from pavement are shown graphically in Figure 5.9, Figure 5.10 and Figure 5.11 respectively. The results show that there is no significant variation in density, voids and water absorption of concrete specimens tested between 28d and 360d.
Figure 5.10  Volume of Voids of Field Samples

Figure 5.11  Water Absorption of Field Samples

Figure 5.12 shows the values of sorptivity coefficient of the natural aggregate concrete and recycled concrete samples obtained from the field at
the age of 28, 56, 90, 180 and 360d. There is no significant difference in sorptivity coefficient for the concrete samples made with recycled aggregates and natural aggregate.

![Sorptivity Coefficient of Field Samples](image)

**Figure 5.12  Sorptivity Coefficient of Field Samples**

Sulphate resistance test was conducted at the age of 28, 56 and 90d and the loss in compressive strength compared to compressive strength at respective ages is presented in Table 5.2. The test results show that there is no significant difference in loss in compressive strength between natural aggregate concrete and recycled concrete.

**Table 5.2 Sulphate Resistance - Field Samples**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Age (d)</th>
<th>Loss in compressive strength (%)</th>
<th>R50</th>
<th>C50</th>
<th>N50</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>4.70</td>
<td>3.47</td>
<td>3.23</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>56</td>
<td>4.34</td>
<td>3.28</td>
<td>3.04</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>4.20</td>
<td>3.15</td>
<td>2.96</td>
<td></td>
</tr>
</tbody>
</table>
5.5 PAVEMENT EVALUATION

5.5.1 Condition Survey

Visual observations were also made and recorded to determine the performance of the pavement with respect to pavement distress during a service period of one year. The average daily traffic in the pavement was observed as 15 vehicles per day. The condition survey conducted was explained in detail and these inspection procedures offer a method of determining pavement condition that involves observing and recording the presence of specific types and severities of defects or distresses in the pavement surface.

5.5.1.1 Cracking

The cracking defects are irregular breaks that may form transversely, longitudinally, or diagonally within a panel. Construction joints, which are straight and obviously formed or cut, are not considered cracks.

5.5.1.2 Pumping and blowing

Pumping and blowing refer to the ejection of water from underneath the pavement. Cyclic wheel loadings eject water through or along the transverse or longitudinal joints and cracks, or at panel edges. The ejected water also carries fine soil particles, thus eroding the pavement foundation. Pumping is recognized by the visible fine soil left on the dried surface of the roadway and/or shoulder areas.

5.5.1.3 Spalling

Spalling occurs when fragments break off or chip off along the edges of the pavement joints or cracks. These spalls may be large wedges or flakes, or they may be only lost pieces of aggregate.
5.5.1.4 **Scaling**

Pavement scaling is the progressive disintegration of the pavement from the surface downward, or from the edges inward, by the dislodgment of aggregate particles. In severe cases, the surface is very rough and irregular.

5.5.1.5 **Blowups**

Blowups are the shattering or upward buckling of pavement panels at transverse cracks or joints. The occurrence is caused by the expansion of a plain cement concrete pavement when all available room for expansion has been previously taken and the plain cement concrete pavement is tightly confined.

5.5.2 **Severity**

Visual observation has revealed no major cracks or other pavement distresses such as spalling; pumping and blowing; scaling; and blowups in the model pavement during the one year of service.

5.6 **SUMMARY**

The study conducted on the constructed model pavement reveals that the performance of the pavement constructed using recycled concrete and natural aggregate concrete with 50% replacement of fine aggregate with fly ash was good during a service period of one year.