EXPERIMENTAL STUDY ON USE OF HYPO SLUDGE IN PAVER BLOCKS

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Abstract—Concrete paver blocks in road pavement is better option in roads construction if conventional road construction is not desirable, uneconomical and has some environmental constraints. Interlocking Concrete Block Pavement (ICBP) is widely now used in India as a part of construction for footpaths, parking areas etc. In present study, paver blocks were prepared of M40 design mix proportions as per IS standards and an attempt is made for experimental investigation on strength of paver block by partial replacement of cement via 0%, 5%, 10%, 15% and 20% of Hypo Sludge. Water absorption, Compressive test and flexural test are performed to check the water content and strength of paver blocks. To get better compressive results, 0.3% of nylon fibre is added of total volume of concrete for 15% hypo sludge and results are compared with standard and finally cost comparison is done.

Keywords—Hypo sludge, Nylon fibre, Water absorption, Compressive Strength and Flexural Strength.

I. INTRODUCTION

In today’s era, when hot bituminous mix or cement concrete technology is not feasible or desirable due to some constraints, Interlocking Concrete Block Pavement (ICBP) has extensively used in a number of countries. As per IS 15658:2006, for different road traffics, such as light, medium, heavy and very heavy traffic, different paving applications is used. The advantages of Paver blocks are that it eliminates laborious construction work, reduce storage place, reduces extra cost and give smooth finishes. Lastly it also saves time and energy as they are ready to use thus it is overall cost effective. Paver blocks of size 195 x 195 x 65 mm is prepared and various tests on it are performed.

II. MATERIALS AND TEST PERFORMED

Cement: Confirming to IS: 8112 (1989), Ordinary Portland cement (OPC) of 53 grade is used for experimental casting of paver blocks. Physical properties of OPC are given in Table 1.

| Sr No | Properties               | Test Results |
|-------|--------------------------|--------------|
| 1     | Specific gravity         | 3.15         |
| 2     | Consistency limit        | 33%          |
| 3     | Setting time in minutes  |              |
|       | (a) Initial setting time | 30 minutes   |
|       | (b) Final setting time   | 600 minutes  |

Coarse aggregate: Confirming to IS: 383, locally available coarse aggregate of nominal size 20 mm is used for preparing paver blocks. Physical properties of coarse aggregate are given in Table 2

| Sr No | Properties         | Test Results |
|-------|--------------------|--------------|
| 1     | Specific gravity   | 2.67         |
| 2     | Water absorption   | 0.21%        |
| 3     | Aggregate Impact value | 13.70%     |
**Fine aggregate**: Confirming to IS: 383, the river sand is used in design mix. Physical tests conducted on fine aggregate are given in Table 3.

| Sr No | Properties            | Test Results |
|-------|------------------------|--------------|
| 1     | Specific gravity       | 2.61         |
| 2     | Water absorption       | 0.33%        |
| 3     | Fineness Modulus       | 2.75         |

**Hypo sludge**: Hypo sludge is produced in a large amount as by product of paper industry. It contains low calcium and minimum amount of silica and it can be used as a partial replacement of cement. Hypo sludge is shown in Fig 1. Physical tests conducted on Hypo sludge are given in Table 4.

![Hypo sludge](image)

**Table 4: Physical Properties of Hyposludge**

| Sr No | Properties                  | Test Results |
|-------|------------------------------|--------------|
| 1     | Setting time in minutes     |              |
|       | (a) Initial setting time    | 35           |
|       | (b) Final setting time      | 595          |

**Nylon fibre**: It is a generic designation for a family of synthetic polymers. It is used in construction because of its qualities like it has high abrasive resistance, increases strength, arrests cracks and also improves quality. Fig 2 shows nylon fibre.

![Nylon fibre](image)
III. MIX DESIGN

For preparation of paver blocks, M40 grade concrete was designed as per Indian Standard method and the same was used to prepare various test samples. The design mix proportion considered is 0% replacement considering conventional concrete is 1:1.64:2.93 having a water cement ratio of 0.45

IV. EXPERIMENTAL METHODOLOGY

4.1 Water Absorption: One of the most important properties of a good quality paver block is to have low permeability. Paver blocks are not impervious to water, and in order to bond well with mortar, they must be able to absorb some water. The increase in weight as a percentage of the original weight is expressed as its absorption (in percent). As per Indian standards the average absorption of the test samples shall not be greater than 5% with no individual unit greater than 7%. Average dry weight of three samples of same proportions is taken and after 28 days the blocks are removed from water and kept for 4 hours and again average wet weight of three samples was taken. The values comes within IS code range. Thus it will not cause any dampness. Table 7 shows the values of dry weights and wet weights of paver blocks.

| Description               | Dry weight | Wet weight |
|---------------------------|------------|------------|
| 0% Replacement            | 6.125      | 6.210      |
| 5% Replacement            | 6.083      | 6.163      |
| 10% Replacement           | 6.124      | 6.213      |
| 15% Replacement           | 5.884      | 5.983      |
| 20% Replacement           | 6.013      | 5.923      |
| 15% Rep with 0.3% Nylon fibre | 5.645   | 5.772      |

4.2 Compressive Strength: Compressive strength is an important parameter in evaluation of paving block quality. The compressive strength of the specimens was determined at 28 days of age. Three sample of paving block were tested using Standard compression testing machine, average strength value is calculated in Table 7 for 28 days. Individual paver block strength shall not be less than 85% of the specified strength. The specified average 28 days compressive strength of different grades of paver blocks are grade of the concrete \( \geq F_{ck} + 0.825 \times \text{standard deviation (round of nearest 0.5 N/mm}^2 \). Table 8 shows the results of ultimate compressive strength for 28 days.
Table 8: Compressive Test results

| Description                  | Ultimate Load in kN | Ultimate compressive strength in N/mm² |
|------------------------------|---------------------|---------------------------------------|
| 0% Replacement               | 2294                | 60.31                                 |
| 5% Replacement               | 2452                | 64.48                                 |
| 10% Replacement              | 2535                | 66.63                                 |
| 15% Replacement              | 2240                | 58.91                                 |
| 20% Replacement              | 2300                | 60.48                                 |
| 15% Replacement with 0.3% Nylon fibre | 2513                | 66.08                                 |

**Fig 4: Graph for ultimate compressive strength for different proportions**

4.3 Flexural Compressive Strength: The flexural strength of paving blocks can be expressed in terms of flexural stress or in terms of breaking load. Larger paving slabs and under heavy traffic conditions paver blocks react differently under wheel loads to normal concrete pavers. Having a larger surface area, aspect ratio and thinner, the slabs bend easily under wheel loads—much like a beam. The flexural length of the panel units is taken as the end to end plan dimension of the units. Loading shall be applied at a uniform rate such that the total load is applied in not less than one min and not more than 3 min. Table 9 shows the results of flexural compressive strength of paver blocks. Three samples were tested of each proportion and average flexural strength is carried out. The set up of flexural strength on paver block is shown in Fig 3.

**Fig 3: Flexural strength setup on paver block**
Table 9: Flexural Compressive Strength results

| Description                      | Flexural strength in N/mm² |
|----------------------------------|---------------------------|
| 0% Replacement                   | 3.94                      |
| 5% Replacement                   | 4.23                      |
| 10% Replacement                  | 4.00                      |
| 15% Replacement                  | 3.47                      |
| 20% Replacement                  | 3.41                      |
| 15% Replacement with 0.3% Nylon fibre | 3.34                  |

V. COST EVALUATION

Cost analysis is carried out for the optimum proportion of percentage of hypo sludge in concrete. The work is carried in GC Dave Company at Anand, Gujarat. The cost is compared to the conventional concrete.

a) Cost of Materials

- Cost of cement per bag = Rs 320/
- Cost of sand per m³ = Rs 1100/
- Cost of hypo sludge per kg = Rs 1.5
- Cost of coarse aggregate per m³ = Rs 800/

(All the rates are included with lead charges).

Table 6: Cost evaluation for different design mix proportions

| Description          | Replacement | Cement (per kg) | Coarse Aggregate (per m³) | Fine Aggregate (per m³) | Hypo sludge (per kg) | Total Cost  |
|----------------------|-------------|-----------------|----------------------------|-------------------------|----------------------|-------------|
| Quantity (kg)        | 0% with cement (A) | 426.84          | 1239.37                    | 704.55                  | -                    | 5089.51     |
|                      | Rate        | 6.4             | 1.54                       | 0.64                    | -                    |             |
|                      | Cost        | 2730            | 1908.6                     | 450.91                  | -                    |             |
| Quantity (kg)        | 05% with cement (B) | 405.76          | 1239.37                    | 704.55                  | 21.35                | 4957.26     |
|                      | Rate        | 6.41            | 1.54                       | 0.64                    | 0.08                 |             |
|                      | Cost        | 2596.05         | 1908.6                     | 450.91                  | 1.70                 |             |
| Quantity (kg)        | 10% with cement (C) | 384.10          | 1239.37                    | 704.55                  | 42.71                | 4697.39     |
|                      | Rate        | 6.07            | 1.54                       | 0.64                    | 0.15                 |             |
|                      | Cost        | 2331.48         | 1908.6                     | 450.91                  | 6.40                 |             |
| Quantity (kg)        | 15% with cement (D) | 363.36          | 1239.37                    | 704.55                  | 63.76                | 4462.31     |
|                      | Rate        | 5.74            | 1.54                       | 0.64                    | 0.27                 |             |
|                      | Cost        | 2085.6          | 1908.6                     | 450.91                  | 17.2                 |             |
| Quantity (kg)        | 20% with cement (E) | 344.12          | 1239.37                    | 704.55                  | 85.02                | 4257.87     |
|                      | Rate        | 5.44            | 1.54                       | 0.64                    | 0.31                 |             |
|                      | Cost        | 1872.01         | 1908.6                     | 450.91                  | 26.35                |             |
| Quantity (kg)        | 15% with cement | 363.05          | 1239.97                    | 704.45                  | 63.76                |             |
VI. CONCLUSION

Study have been carried out on M40 grade concrete, where test like water absorption, compression test and flexural tests were carried out on standard concrete and various proportions.

1. Study shows that water absorption values for 5% replacement gives minimum value and as the percentage of hypo sludge is increasing, more the value of water absorption is coming. When nylon fibre is added, the water absorption comes to be optimum.

2. It has been observed that in case of compression test, for 10% hyposludge, compressive strength comes to be maximum and also addition of 0.3% of nylon fibre, the compressive strength increases to some extent

3. The values for 5% hypo sludge, the flexural strength comes to be maximum and in addition of nylon fibre, it gives less flexural strength.

4. Cost of cement will be reduced by addition of hyposludge as obtained from cost analysis

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