

ECO-EFFICIENT CONCRETE: TOTAL REPLACEMENT OF CEMENT

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Abstract- This study is based on "Total replacement of cement with natural available raw material such as Lime and silica", it also can be used as a Cement replacement in concrete. Concrete paving blocks are ideal materials on the footpaths and roads for easy laying better look and finish. In this paper, a parametric review for producing paving blocks using Lime and Silica is presented. Lime and Silica are added with the replacement of cement as a binder material in paver blocks. There are, as there have always been, two critical issues with this type of cement replacement. The change in physical properties with respect to compressive strength and the cost analysis of the alternatives. The first stage of this research looks at the change in physical properties of a standard concrete mix when lime is substituted for cement with respect to compressive strength. The results from this research show a linear decline in strength with a linear increase in the relative percentage of lime to cement. A traditional cost analysis looks only at the first or construction cost, without considering the long term cost to mitigate for the increased global warming emissions resulting from the manufacturing process of Portland cement. The Lime Pavers does not cause pollution and they are Ecofriendly. To achieve high strength levels, block producers generally define Lime mixtures by a trial and error process.

Keywords- Lime concrete, cement concrete, normal paver blocks, water, lime and silica replacement, lime silica paver blocks, strength properties.

I. INTRODUCTION

Generally Paver block is produced from the concrete mixture of cement, aggregate, sand and water. Sometimes use the additives such as super plasticizer. First time road is constructed by using paver block in 5000 B.C. by the Minoans. About 2000 years ago, with the help of labor and military group[11]. The purpose of this paper is to investigate the replacement of cement with lime in the production of normal weight concrete with the express objective of reducing the production of greenhouse gas emission by manufacturers of pozzolans. In environmental terms, lime does not generate as much CO₂ in its production as does the production of Portland cement [1-3]. Lime has been used as the basis for the pozzalonic material in concrete for thousands of years. Portland cement's development in the late eighteenth century and its adoption as the primary pozzalonic material in concrete resulted in the displacement of lime as the primary cementations material. Lime has a number of properties that are of interest in the development of long term durability of materials, particularly the slow carbonation rate and resulting self-healing properties [4-7].

First concrete paver blocks was introduced in Holland in the fifties as replacement of paver bricks which had become scarce due to the post-war building construction boom. Several researchers also studied about use of recycled aggregates in concrete pavers such as tiles, clay bricks, glass, and wood [9, 17,18]. This paper deals with the physical strength properties of concrete when the Portland cement is replaced with hydrated lime of varying proportions. Future research will look at the economic impact of the replacement in terms of full life successfully with conventional Portland cement concrete and asphaltic concrete in Europe for many uses. In the United States the concrete paving block industry is relatively new but is growing. Use of block paving in the world may increase in the future, but there is little information available to the CE on the design, construction, and performance of block pavements.

Potentially the application of cement concrete paving blocks are in pavement, footpath in gardens, passengers waiting sheds, bus stops, industry and other public places. With the constructional development in India, demand of paving blocks is increasing day by day [10,12].

Consequently, the present study focuses on modification of cement pastes with binary and ternary cement paste systems in order to determine changes of hydration heat. The concrete paving blocks requires more maintenance cost and the life span of concrete blocks are less that's why we use Lime paving blocks which having self healing property and should have high strength and durability .The lime paving blocks are eco-friendly and maintenance cost is very low.

A. Materials

Lime: It is also the name of the natural mineral (native lime) CaO which is the byproduct of coal seam fires and in altered limestone xenoliths in volcanic eject.

Silica Fume: It is made of the most common elements on earth silicon (Si) and oxygen (O₂). It has been found that silica fume has a superior influence on the strength development of concrete in later stage.

Portlandite (C-H) consumption in the silica fume blended cement pastes is higher than in the illite clay blended cement pastes.

SF accelerates the commencement of the cement minerals hydration process for approximately 1-2 hours. When increasing the amount of SF in the composition, beginning of hydration process starts earlier and the hydration process is longer. Reduction of hydration temperature has a positive influence on the concrete hardening process and decreases the risk of having micro cracks in the concrete at its early age. SF leads to increment of mechanical properties and make concrete Economical and Eco friendly.

Fine aggregates: Natural river sand is used in this study which conforming to Zone III as per IS 383 (1987) or crushed stone with most particles passing through a 9.5mm sieve.

Water: The water shall be clean and free from deleterious matter. It shall meet the requirements stipulated in IS 456:2000.

B. Mechanism About strength Development

- Contribution of LIME :-

When slaked lime (calcium hydroxide) is mixed with sand and water to form mortar for building purposes and when the masonry has been laid, the slaked lime in the mortar slowly begins to react with carbon dioxide to form calcium carbonate (limestone) according to the reaction:



The carbon dioxide that takes part in this reaction is principally available in the air or dissolved in rainwater.

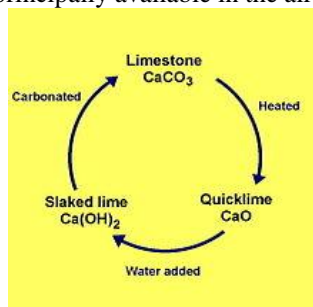


Figure 1:- The lime cycle

- **Contribution of SILICA FUME :-**

Silica fume (SF) is composed of very small particles which may form agglomerations, when mixed with water, and are soon covered with a gel-like layer. Water may become enclosed in this layer, which has been suggested as the cause of the rapid water consumption of SF mixtures. If the w/c ratio is low, cement and water do not come into full contact initially, as the voids may not be full of water. It is concluded that SF accelerates the commencement of the cement minerals hydration process for approximately 1-2 hours. When increasing the amount of SF in the composition, beginning of hydration process starts earlier and the hydration process is longer. Reduction of hydration temperature has a positive influence on the concrete hardening process and decreases the risk of having micro cracks in the concrete at its early age. SF leads to increment of mechanical properties and make concrete Economical and Eco friendly (A).

C. Properties of Lime Paving Blocks

The most important properties of lime paver blocks are its compressive strength and durability in the hardened state and its workability and cohesiveness in the plastic state. The fundamental problem of mix design is the relationship between these properties and the characteristics of the mix, and this, naturally governs the procedure for selecting the mix proportions.

A. Compressive strength

The rate of gain of compressive strength of lime paver blocks of given proportions varies with the type of cement and with the curing temperature; these conditions are normally determined for a particular mix design. In all cases of mix design, we assume the Lime paver blocks to be fully compacted. The compressive strength can be directly related to the water cement ratio. The loading rate has been kept constant in MPa/sec [32]

B. Durability

The resistance of Lime paver blocks to attack by weathering or chemical action depends on there being adequate resistance to the penetration of water, or any other solution, into the material because the attack is not confined on the surface. Durability is, therefore, improved by reducing the pores in the Lime paver blocks; this is achieved by having a low water cement ratio and the Lime paver blocks fully compacted.

C. Workability

The workability is affected by the water cement ratio and cement content, the shape, texture, maximum size and the particle distribution of the aggregate. The slump value has been determined as per [B]

D. Cohesiveness

Cohesiveness is required to prevent the mix falling apart and to reduce the possibility of segregation of the coarse and fine particles during handling.

E. Different Types and Shapes of paving blocks

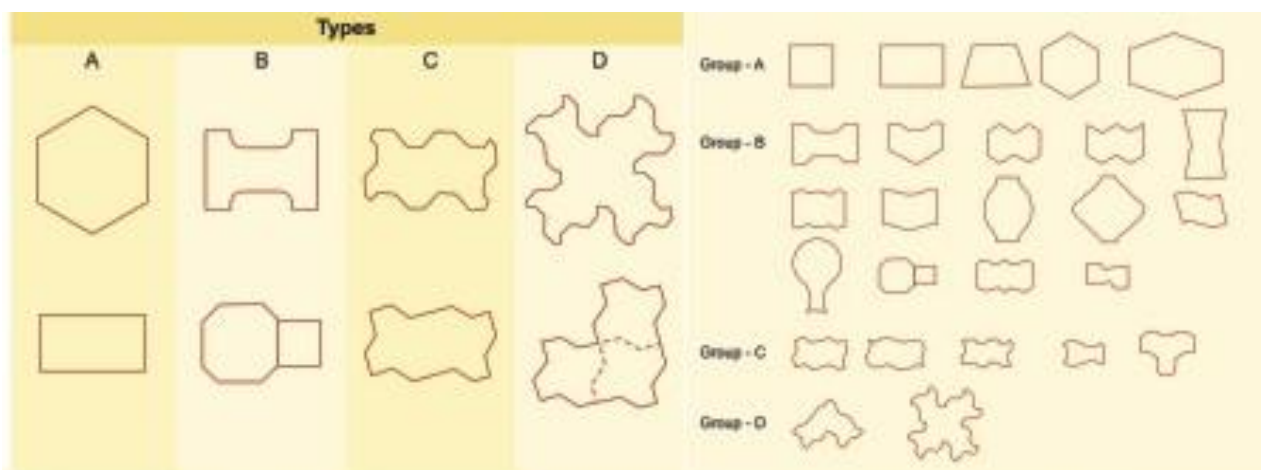


Figure 1: Four generic types of Paver Blocks Figure 2: Typical shapes of Paver blocks

Figure 2: Typical Types and Shapes of Paver blocks

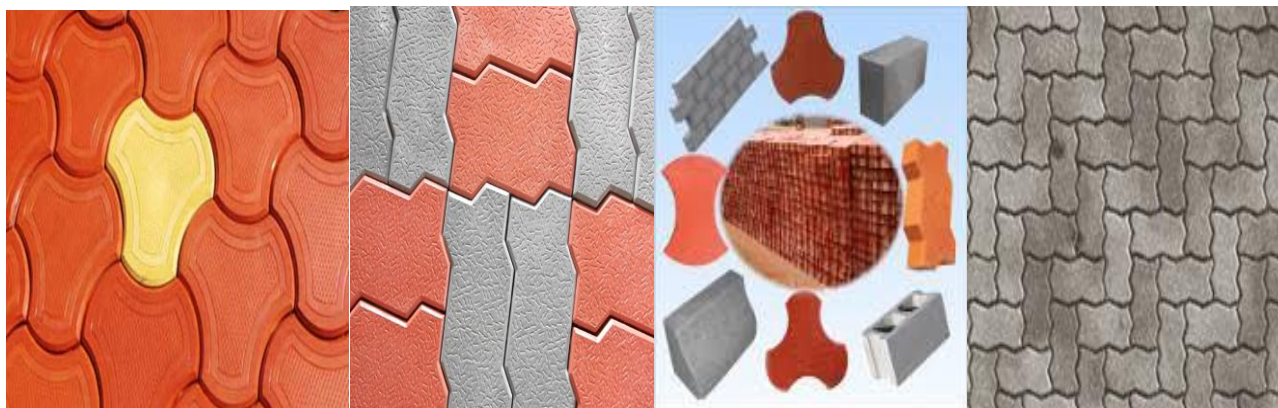


Photo 1: Different types of paver block



Figure 3: Rubber mould for paver block

F. OBJECTIVE AND SCOPE

The objective of this Study-

- To study the effect on the properties of paver block by fully replacement of cement with lime and silica fume. Here Paver Block is manufactured by using Lime, Silica, Fine aggregate and makes the paver block more durable and effective and economical.
- Total replacement of Cement for making cheaper Paver Block.
- It is generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve this type of Aggregate is used by which it becomes cheaper and giving the same strength as given by using 10mm, 20mm or more Coarse Aggregate.
- Study the Compressive Strength of Paver Block in 7 days, 14 days and 28 days respectively also to study the effect on flexural strength, Impact strength, Abrasion Resistance and water absorption by ordinary paver block and full replacement of cement paver blocks.
- Apart from these the concrete paving blocks can be tested for acid attacks and water attacks.

G. Mix Design:-

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

The mix design of lime paving blocks are based on Trial and Error methods.

H. Testing:

After molding paver blocks are tested as per IS 15658: 2006

- Compressive strength:** Compressive strength of paving blocks is determined in accordance to IS . Minimum compressive strength of a single block should be above 30 Mpa.

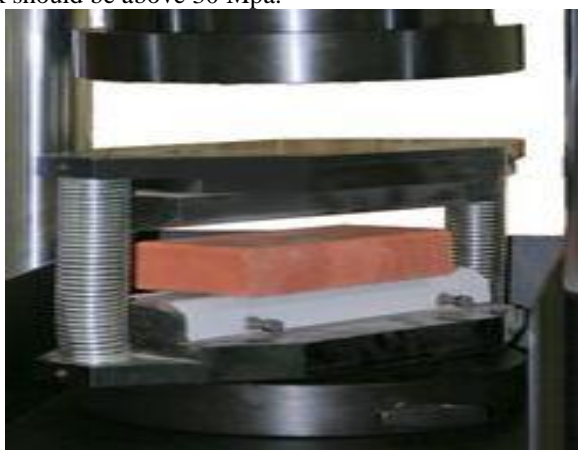


Figure 4: Compressive Test on Paver Blocks

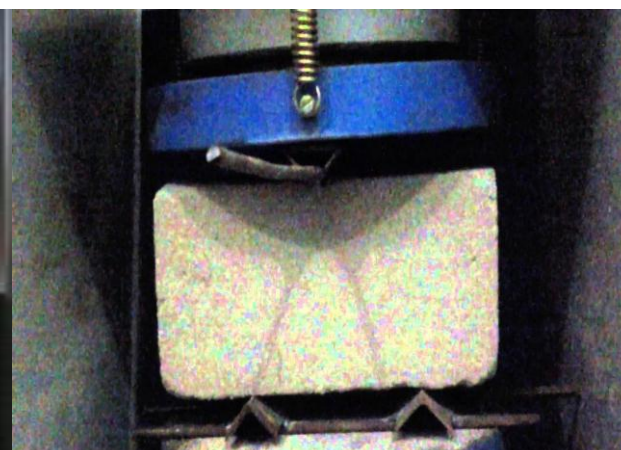


Figure 5: Flexural Test on Paver Blocks

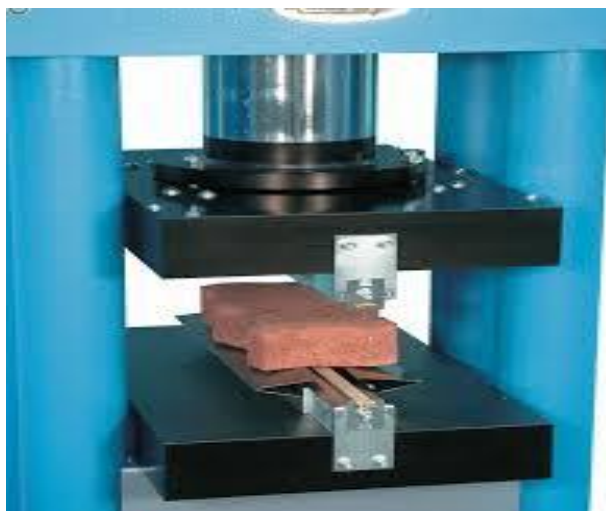


Figure 6: Flexural Test on Paver Blocks



Figure 7: Impact Test on Paver Blocks



Figure 8. Abrasion Resistance (Bohme test)



Figure 9. Water absorption test for paver block

2. **Flexural strength:** Flexural strength of paving blocks are determined and can be expressed in terms of flexural stress or in the form of a breaking load. It is suggested that minimum flexural strength of single block should be above 4.5 Mpa and Tested according to IS.
3. **Water Absorption:** Water Absorption of Paving Block Is determined as per IS IS 15658: 2006, According to IS water absorption of individual Lime paver blocks paving block should not less than 7% or maximum 6% by mass.
4. **Abrasion Resistance:** It is a property which allows a material to resist wear. Abrasion resistance characteristics are determined according to guidelines of IS Precast Concrete paver blocks.
5. **Impact test:** the test is conducted according to IS. It consists of aggregate impact testing machine. The weight of hammer in aggregate impact testing machine is 14 kg. During testing, a steel ball of 2.1 cm was used at center of paver blocks from top surface. Blows are applied on each paver blocks till failure occurs.

I. Optional Requirements:

1. Tensile Splitting Strength:

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature.

2. **Freeze-Thaw Durability:** When water freezes, it expands about 9 percent. As the water in moist concrete freezes it produces pressure in the pores of the concrete. If the pressure developed exceeds the tensile strength of the concrete, the cavity will dilate and rupture.

J. Advantages Of Lime Paving Blocks :-

- a) It is more durable as compare to Concrete paving blocks.
- b) It is Eco-friendly.
- c) It increases the appearance of paving blocks and building.
- d) Maintenance cost is not required.
- e) The lime paving blocks are cheaper than Concrete paver blocks paving blocks.
- f) It having high strength as compare to concrete paver block.
- g) It has self-healing property.
- h) The lime mortar paste is also used for plastering purpose.
- i) Initial setting time is high we can keep mixed material for long time.
- j) Concrete block pavement will absorb stress such as small earthquakes, freezes and thaws, and ground erosion by flexing

K. Dis-advantages Of Lime Paving Blocks :-

- a) Initial setting time is high formwork should keep for long time i.e. Form work cost increases, construction time increases, curing time delayed and finely target time increases.

- b) Time consuming. Less block molds with respect to time as compare to concrete blocks
- c) Sometime admixtures are required for maintaining water content.
- d) No specific IS available for mix design. Mix design is done according to trial and error basis.

II. LITERATURE SURVEY

A. IS 15658:2006 on "Precast Concrete Blocks for Paving" : A segmented concrete paving is a system of an individual shaped blocks arranged to form a continuous hardwearing surface overlay. Over the past two decades, paving composed of segmental blocks has become a feature of our towns and cities. It is to be found in commercial industrial and residential areas, in the paving malls, plazas, parking areas and bus stops. It has been successfully used for embankment walls, slope protection and erosion control. During this period, extensive research has been carried out on the engineering characteristics and structural performance of segmental block paving. Existing pavements subjected to heavy bus traffic and industrial loads have been monitored and their service life shown to be satisfactory. The South African Bureau of Standards has published specifications relating to the quality of concrete paving blocks and required standards of construction. The Committee of Urban Transport Authorities has published a catalogue of designs for segmental block pavements. The engineering and specification aspects have been satisfactorily solved, and this type of paving has a proven performance and service record. But the aesthetic use of segmented paving and the contribution it can make to improve our urban landscape is only now being appreciated.

B. R. C. Yeole1, Dr. M. B.Varma[2]: Concrete paving blocks are ideal materials on the footpaths and roads for easy laying, better look and finish. In this paper, a parametric experimental study for producing paving blocks using waste steel aggregates (the form of rounded bearings of size 6.35 mm) is presented. Waste steel bearings are added in concrete of paver blocks in various percentages. Rubber pads are also used below the paver blocks. Impact strength of paver blocks with various percentages of waste steel aggregates and using rubber pads is investigated. Test results show that combination of using rubber pads and adding various percentages of waste steel aggregates in paver blocks gives upto 50% more impact strength than ordinary paver blocks.

C. Poonam Sharma, Ramesh Kumar Batra[3]:

Solid unreinforced pre-cast cement blocks concrete paver is a versatile, aesthetically attractive, functional, cost effective and requires little or no maintenance if correctly manufactured and placed. Paver blocks can be used for different traffic categories i.e. Non-traffic, Light-traffic, Medium-traffic, Heavy-traffic and Very heavy traffic. Most concrete block paving constructed in South Africa has performed satisfactorily but there are two main areas of concern: occasional failure due to excessive surface wear, and variability in the strength of blocks. Paving block is a very common and popular method of hard landscaping that is suitable for various applications including: driveways, paths, public utility areas, garage, forecourts and roads etc. After the useful life of paver blocks, demolished ones can be used as recycle aggregate conveniently.

D. Hughes, D.C., et al., Calcination of Roman cement[4]: A pilot study using cement-stones from Whit by. Construction and Building Materials, 2008. 22

E.S Marshal and Sons Ltd UK [5]: Mix design can be regarded as the process of selections of the proportion of different constituent of concrete to produce the product of required quality. In the past the mix design has been simple as possible and the concrete quality and mix proportion were regarded as been synonymous. The tendency to change specifications, so that ,instead of stating the mix proportion, only the required properties of concrete are given.

III.CONCLUSION

Through the comparison, we can conclude that the Lime paver blocks have lots of advantages then concrete paving blocks; It is economical as compare to concrete blocks and also have high strength and durability and should not cause any pollution. It also resist acid attacks and water attacks and having self-healing property.

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