EXPERIMENTAL INVESTIGATION ON PARTIALLY REPLACEMENT OF COPPER SLAG POWDER WITH FINE AGGREGATE AND MUSSEL SHELL POWDER WITH CEMENT ON PAVEMENT BLOCKS

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ABSTRACT:***Now a days building demand is constantly increasing & the capital cost of the construction of the building is escalating, The demand for construction material is also increasing, To overcome these type of problem we want to found the new composition with low cost, our ultimate aim of the project is : To introduce copper slag powder &mussel shell powder as fine aggregate &cement respectively as one of the new material in to the pavement block.Interlocking Concrete Block Pavement (ICBP) has been extensively used in a number of countries for quite sometime as a specialized problem-solving technique for providing pavement in areas where conventional types of construction are less durable due to many operational and environmental constraints. ICBP technology has been introduced in India in construction, a decade ago, for specific requirement viz. footpaths, parking areas etc. but now being adopted extensively in different uses where the conventional construction of pavement using hot bituminous mix or cement concrete technology is not feasible or desirable. The paper dwells upon material, construction and laying of concrete block pavement as a new approach in construction of pavement using Interlocking Concrete Paver Blocks.***

Keywords:Cement , Quarry Dust , 6mm coarse aggregate , plasticizer , admixture,Copper slag; Waste material; Replacement of fineaggregate; mussel shell powder; Waste material; Replacement of cement; pavement blocks;Properties of material ; Workability ,Compressive strength.

INTRODUCTION

A **paver** is a paving stone, tile, brickor brick-like piece of concrete commonly used as exterior flooring. In a factory, concrete pavers are made by pouring a mixture of concrete and some type of coloring agent into a mold of some shape and allowing to set. They are applied by pouring a standard concrete foundation, spreading sand on top, and then laying the pavers in the desired pattern. No actual adhesive or retaining method is used other than the weight of the paver itself except edging. Pavers can be used to make roads, driveways, patios, walkways and other outdoor platforms.

An **interlocking concrete paver** is a type of paver. This special type of paver, also known as a **segmental paver**, has emerged over the last couple of decades as a very popular alternative to brick, clay or concrete.Segmental pavers have been used for thousands of years.

The Romans built roads with them that are still there. But it was not until the mid-1940s that pavers began to be produced out of concrete. It started in the Netherlands where all the roads are made to be flexible because the country is below sea level and the ground shifts, moves and sinks. Poured concrete is not an option because it will crack. Individual units not set in concrete, and placed in sand perform far better than concrete. Before the paver was made from concrete, either real stone or a clay product was used.

The first concrete pavers were shaped just like a brick, 4″ by 8″ (10 cm x 20 cm) and they were called Holland Stones and still are today. These units turned out to be economical to produce and were exceedingly strong.In addition to being economical, interlocking concrete pavers are also widely available in water-permeable designs, which have added ecological benefits. By allowing water to drain through the pavers in a way that mimics natural absorption, builders and landscapers are able to limit surface runoff and prevent soil erosion or buildup of standing water in the surrounding land area. Some permeable paver installations are designed to harvest rainwater, which can then be repurposed for uses such as irrigation or washing a car.

The amount of pavement blocks used worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminium combined. Pavement block's use in the modern world is exceeded only by that of naturally occurring water. Pavement blocks is also the basis of a large commercial industry. Globally,the pavement tile industry, one of the largest segment of the concrete market, is projected to exceed $100 billion in revenue by 2015. In theUnited tates alone, concrete production is a $30-billion-per-year industry, considering only the value of the pavement tiles sold each year. Given the size of the industries, and the fundamental way the pavement blocks is used to make an attractive modern world, it is difficult to overstate the role this material plays today.

pavement blocks/ tiles as one of the alternative materials. It is the waste product of copper which is obtained after surface blast cleaning of steel structures to get rid of rusting. It is collected from Cochin Refinery project PDBP (Petroleum Derivative By Products) sector COCHIN, KERALA. The safe disposal of this waste is a lack, costly andcauses environmental pollution. The construction industry is the onlyarea where the safe use of waste material (copper slag) is possible. When it is introduced in pavement blocks as areplacement material, it reduces theenvironmental pollution, space problem and also reduces the cost of the blocks.

However, further additions of copper slag caused reduction in the strength due to an increase of the free water content in the mix. Mixes with 80% and 100% copper slag replacement gave the lowest compressive strength value of approximately 80 MPa, which is almost 16% lower than the strength of the control mix. The results also demonstratedthat the surface water absorption decreased as copper slag quantity increases up to 35% replacement; beyond that level of replacement, the absorption rate increases rapidly. Therefore, it is recommended that 35 wt% of copper slag can used as replacement of quarry dust in order to obtain pavement blocks with good strength, good finishing, durability properties and cost is also reduced.

Another alternative material which is used in the pavement block is the mussel shell powder which is also a waste material obtained from the coastal areas where it has a large amount of lime content which is used as replacement of cement. The sea shells are high potential materials to become partial cement replacement and filler in pavement blocks. The calcium carbonate ($CaCO_3$) in the sea shells is more than 90% and is similar to the contain of calcium carbonate in the limestone dust that been used in the Portland cement production. Impressively, the crystal structures of seashells are largely composed of calcite and aragonite, which have higher strengths and density than limestone powder. The material is collected from Fort Kochi, Cochin, Kerala.

However, further additions of mussel shell powder caused reduction in the strength due to an increase of the free water content in the mix. Mixes with 15% and 20% mussel shell powder replacement gave the lowest compressive strength value of approximately 50 MPa, which is almost 10% lower than the strength of the control mix. The results also demonstratedthat the surface water absorption decreased as mussel shell powder quantity increases up to 5% replacement; beyond that level of replacement, theabsorption rate increases rapidly. Therefore, it is recommended that 5 wt% of mussel shell powder can used as replacement of cement in order to obtain pavement blocks with good strength, good finishing, durability properties and cost is also reduced.

Figure 1: PAVEMENT BLOCK

2.MATERIALS USED

There are many types of paver blocks available, created by varying theproportions of the main ingredients below. In this way or by substitutionfor the cementations and aggregate phases, the finished product can betailored to its application with varying strength, density, or chemicaland thermal resistance properties.

Cement: Cement, commonly Portland cement, and other cementitious materials such as fly ash and slag cement, serve as a binder for the aggregate. The cement used in this study is of OPC 53 grade conforming to IS 12269.

TABLE 1:CHEMICAL COMPOSITION OF CEMENT

Compound	% by weight1
Tricalcium aluminate	10
Tetracalciumaluminoferrite	8
Belite or dicalcium silicate	20
Alite or tricalcium silicate	55
Sodium oxide	Up to 2
Potassium oxide	
Gypsum	5

Aggregate: Aggregate consists of small chips of material in
apaver block mix, generally a coarse gravel or crushed rocks suchas limestone, or granite, along with finer materials such as quarry dust. Thefine aggregate used in this study is quarry dust conforming to grading zone IV

aggregate used in this study isof angular in shape and the maximum nominal size of

coarse aggregateis 6 mm and it is Conforming to Table 2 of IS 383.

FIGURE 2.6mm aggregate & 53 Grade Portland Cement

Quarry Dust

Copper slag: Copper slag is an irregular, black, glassy and granularin nature and its properties are similar to the quarry dust. In this project,Copper slag used is brought fromCochin Refinery project PDBP (Petroleum Derivative By Products) sector COCHIN, KERALA..**Each ton of steel need to be blasted with will generate approximately 2.2-3 tons of copperslag**. Sterlite Industries India Ltd produces 400,000t/year ofcopperand during the process, around 800,000t of copper slag is generated in ayear. The chemical traces such ascopper, sulphate and alumina presentin the slag are not harmful. Also this PDBP sector also produces

TABLE 2. Properties of Copper Slag

Physical Properties of Copper Slag: **Physical Composition**	
Specific gravity	3.30
Hardness	7Moh scale
Conductivity mS/M	4.8
Chloride Content	<0.0002
Carbonates	Not detected
Sulphates	0.65%
Water Absorption	Not detected
Arsenic	Not detected
Cadmium	Not detected

TABLE 3 : Chemical properties Copper Slag

Chemical Composition

Al_2O_3	3.01%
Tio_2	0.60%
$Fe2o_3$	55.00%
SiO_2	35.00%
CaO	0.20%
MgO	0.90%
K_2O	1.02%
Na_2O	0.95%
CU	0.42%

FIGURE 3. Copper Slag

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Mussel Shell: The mussel shell were obtained from Fort Kochi coastal area, they were free of dirt and organic matters.The shells were calcined in an electric muffle furnace at 10000 C and thereafter grinded to fine particles with the aid of a grinding machine. The resulting ash was then sieved through BS sieve (75microns) to obtain a fine ash.

FIGURE 4.Mussel shell

TABLE 4: CHEMICAL COMPOSITION OF MUSSELSHELL

COMPOSITION	PERCENTAGE
SiO_2	0.73
Al_2O_3	0.13
Fe_2O_3	0.05
CaO	53.38
MgO	0.03
Na_2O	0.44
K2O	0.02
Cl	0.02
SO_4	0.11
$CaCO_3$	95.6

Water: Water is then mixed with this dry composite, which produces a semi-liquid that workers can shape (typically by pouring itinto a form). The concrete solidifies and hardens to rock-hard strengththrough a chemical process called hydration. The water reacts with thecement, which bonds the other components together, creating a robuststone-like material. The good quality water is used in this study.

3. INITIALTEST TO BE DONE BEFORE CASTING :

Before the preparation of mix design various test should be conducted for knowing the strength of materials that are :

- Initial and final setting time of cement and sea shell powder.
- Fineness test of cement and mussel shell powder.
- Fineness test of copper slag and Msand.
- Specific gravity of mussel shell powder ,Msand,copper slag, cement and coarse aggregate.

TABLE 5: INITIAL AND FINAL SETTING TIME OF MUSSEL SHELL POWDER.

Sample % added to cement	Initial setting time in minutes	Final setting time in minutes
5%	100	160
10%	105	180
		200

4. MIX D SIGN

NOTE :

As the pavement blocks are the mini texture of concrete the mix design is done as per concrete proportions and set for the purpose of casting.

The mould we used for our pavement blocks are of 0.48sq.feet and we converted in to volume and mix design were prepared as per. The pavement block that we made consist of 2 layers that are of M10 and M25 in which we preferred nominal mix as well design mix .the M10 is for colour pigment layer used for 8 mm thickness and M25 is for second layer of 52mm which gives main strength for the pavement blocks.

Indian Standard Recommended Method of Concrete Mix Design (IS 10262 – 1982)[21]

The Bureau of Indian Standards recommended a set of procedure for design of concrete mix mainly based on the work done in national laboratories. The mix design procedures are covered in IS 10262–82[21]. The methods given can be applied for both medium strength and high strength concrete. Before we proceed with describing this method step by step, the following short comings in this method are pointed out. Some of them have arisen in view of the revision of IS 456–2000[20]. The procedures of concrete mix design needs revision and at this point of time (2000 AD) a committee has been formed to look into the matter of Mix Design.

i)Target mean strength for Mix Design:

Concrete mix should be designed for certain higher strength than characteristic strength so that the field strength or site strength of concrete will not be falling below the characteristic strength by certain percent of the result. Assuming 5 percent of the site results are allowed to fall below the characteristic strength, the target mean strength is given by the following relation:

f'ck =fck + t×S f' =fck + 1.65 S

S = Standard deviation t = Tolerance factor

Enough number of trails were not conducted prior to the mix design, standard deviation can be assumed from table 11.21 which is taken from IS 456 : 2000[20]

ii)Water cement ratio:

The water content of concrete is influenced by a number of factors such as aggregate size, shape, texture, workability, cement and other supplementary cementitious material type and content and chemical admixture. The quantity of maximum mixing water per unit volume of concrete is given in table 11.23 in IS 10262 - 1982[21]. The quantity of water given in table is for

angular coarse aggregate and for 25 to 50 mm slump

range.

iii)Cementitious material content:

Cement plus supplementary cementitious material content per unit volume of concrete may be calculated from the free water-cement ratio and the quantity of water per unit volume of concrete. The cementitious material content so calculated shall be checked against the minimum cementitious content for the durability requirement and greater of the two values adopted. The minimum cement content is given in table 9.23 and table 9.12 in IS10262-1982[21].

iv) coarse aggregate proportions:

Aggregates of the same nominal maximum, size type and grading will produce concrete of satisfactory workability, when a given volume of coarse aggregate is used. Approximate aggregate volume in given table 11.24 (IS 456:2000)[20] for a w/c ratio of 0.5. This aggregate volume may be adjusted for other w/c ratio in the following way. For every decrease of w/c ratio by 0.05, the coarse aggregate volume may be increased by 1.0 per cent to reduce the sand content for every increase of w/c ratio by 0.05 the coarse aggregate volume may be decreased by 1.0 percent to increase the sand content.

V) fine aggregate proportion:

From all the above steps, we have estimated the proportions of all the ingredients except coarse and fine aggregates. As a next step, find out the absolute volume of **all the so far known ingredients. Deduct the sum of all the known absolute volume from unit volume (1 m3), the result will be the absolute volume of coarse and fine aggregates put together. We know the volume of coarse aggregate and hence volume of fine aggregate can be calculated.**

vi)Trail Mix:

With the last step the weight of all the ingredients in kg/m3 can be found out. Observe the workability bleeding and segregation characteristics and cohesiveness of concrete etc. The measured workability in terms of slump or flow value is different from stipulated value, the water and /or admixture content may be adjusted suitably. With this adjustment, the mix proportions will be recalculated, keeping the w/c ratio at the preselected value, which will comprise trail mix no 2. In addition, two more trail mixes no 3 & 4 shall be made with water content same as trail mix no 2 and varying the w/c ratio by +/- 10 percent of the preselected value.

FIGURE 5: THE BLOCKS MANUFACTURED AFTER REPLACEMENT OF COPPER SLAG AND MUSSEL SHELL WITH MSAND AND CEMENT.

5. RESULTS AND DISCUSSIONS

The main test conducted to know the strength of concrete pavement blocks are compressive strength after demouldng of blocks. It consist mixing of concrete for the purpose of making pavement blocks in thelaboratory by replacing Copper Slag as fine aggregate and mussel shell with cement with proportions (by weight) of Copper Slag and sea shell added to concrete mixtures were as follows:

0% (for the control mix), 20%, ,30%, and 40% for copper slag and shell by 0%, 5%,10%,15%. Block samples were prepared and are tested, to slump, Density and compressive Strength. Strength Test One of the most important properties of concrete pavement blocks is the measurement of its ability to withstand compressive loads. This is referred to as a compressive strength and is expressed as load per unit area. One method for determining the compressive strength of concrete is toapply a load at a constant rate on a pavement blocks, until the sample fails. The compression tests performed in this project were completed in accordance with IS standard 516"Methods of Tests for Strength of Concrete". Theapparatus used to determine the compressive strength of concrete in this project was a testing machine.

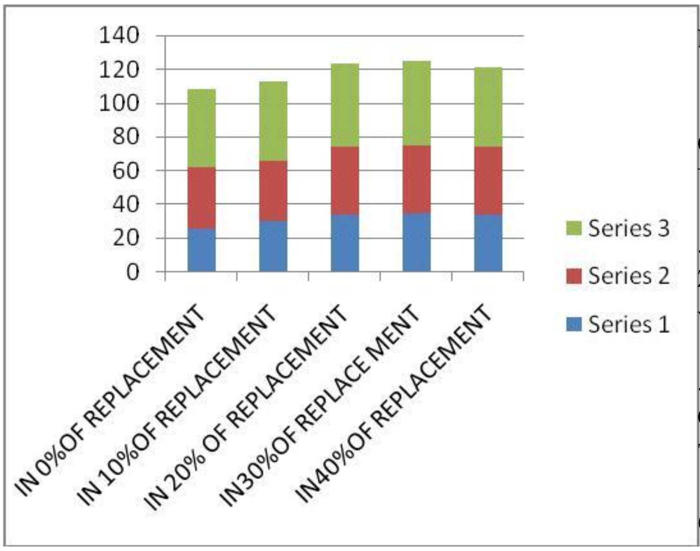
TABLE 6:Comparison of Convention pavement block with Copper Slag and seashell Replaced pavement block in N/mm2

NOTE:
There was no curing done for the pavement blocks .the test was conducted after naturally drying it for minimum of 5 days.

C-copper slag
MS-mussel shell powder

0%	10% (C) and 5% (MS)	20%(C) and 10% (MS)	30% (C) and 15% (MS)	40% (C) and 15% (M)
26.8	30	35.22	35	33.80
36.10	36.88	41.20	40.09	39.8
45.72	47	48.04	49	47

FIGURE 6: SHOWING THE COMPRESSIVE STRENGTH VERIATION IN PAVEMENT BLOCKS



5. CONCLUSIONS

Based on the test results, the following conclusions are drawn:

1. By adding different dosages of copper slag and sea shell powder in pavement block we observed that compressive strength at 5 days gain early strength for lower percentage dosages of copper slag and seashell. This is attributed high percent of silica, high toughness of copper slag and better heat of hydration

2. But at 10 days gain later compressive strength for higher percentage of dosages of copper slag i.e 30%It is almost equal to conventional pavement block. This is attributed that copper slag has high density than sand, so self weight of pavement block is increases.

3. In this study, the effect of replacing cement by ground seashell on the mechanistic properties of concrete was examined. Replacement of the cement with the mussel seashell led to a decrease of compressive strength of seashell
concrete blocks but adding of copper slag maintained the strength compared with the control OPC concrete.

4. Keeping in view of savings in natural resources, sustainability, environment, production cost, maintenance cost and all other CS properties, it can be recommended as an innovative construction material for the use of constructions.

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