Utilization of Brine Sludge in Non-Traffic Paver Blocks

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Abstract— In the present work, brine sludge is mixed in M30 Concrete mix of paver blocks. A paver is a paving-stone, tile, brick or brick-like piece of concrete which is commonly used as exterior flooring, footpaths and as non-traffic constructions. In the factories, concrete paver blocks are made by pouring a mixture of concrete and some different type of colouring agents into moulds of some shape and allowing to set. Different proportions of brine sludge is mixed in in concrete mix and then tested for engineering properties. The Brine sludge was collected from Grasim Industry Nagda (M.P). By using inductively coupled plasma atomic emission spectroscopy in IIT Powai, elements present in sludge was determined. The thesis presents these results that the sludge can be utilized up to 35% in paver blocks which have been used in non-traffic areas. If more than 35% of sludge is added to the paver block mix, then it fails to satisfy obligatory requirement of the IS-15658 code.

Key words: Brine Sludge, Concrete Mix, Non-Traffic, Paver blocks

I. Introduction

The rapid growth of industrialization in India in the recent years is the vital feature of nation's economic development. But the other side of industrialization has been the serious damage to the surrounding environment due to the wastes and pollutants generated from the industries. A huge amount of wastes has been generated through various chemical, mining, steel, fertilizer, paper, and pulp industries, out of their production processes. The improper and uncontrolled dumping of these wastes causes hazardous and irreparable damage to the surface and ground water, air, and soil and has become a matter of serious concern for the protection of environment. Thus, the utilization/recycling of these wastes are quite desirable for the sustainable development of the economy and for ensuring a clean and safe environment.

As more waste creates environmental concerns of toxic threat. An economical viable solution to this problem should include utilization/recycling of waste materials for new products which in turn minimize the heavy burden on the nation's landfills. Recycling of waste construction materials saves natural resources, saves energy, reduces solid waste, reduces water and pollutants and reduces greenhouse gases. The construction industry can start being aware of and take advantage of the benefits of using waste and recycled materials. Studies have investigated the use of acceptable waste, recycled and reusable materials and methods. The use of swine manure, animal fat, silica fume, roofing shingles, empty palm fruit bunch, citrus peels, cement kiln dust, fly ash, foundry sand, slag, glass, plastic, carpet, tire scraps, asphalt pavement and concrete aggregate in construction is becoming popular due to the shortage and increasing cost of raw materials.

II. Historical Review

Balasubramanian et al. (2005) examined that the textile effluent treatment plant sludge can be used in building materials. He conducted the tests according to BIS and found that in certain non-structural materials sludge can be used up to 30%. He discovered that use of ETP sludge in building material could serve as an alternative solution for its disposal. He proposed usage of ETP sludge in flooring tiles, paver blocks, bricks etc. The textile sludge used was collected from the Veerapandi CETP, tripur town Coimbatore district.

Bolden et al. (2012) in his study he conducted a survey which targeted the experts from construction sectors and investigated the current practices which involves use of waste material or recycled material in construction. He concluded that the use of recycled materials has positive impacts, like it enhances the sustainability of construction industry by reducing the cost and pollution and it also reduces the need for the use of natural resources for the construction purposes. In his survey he found out that several industries are not aware of use of recycled or waste material hence documents and data should be maintained for waste material which can be used in construction industries.

Nguyen et al. (2013) performed experiment on pervious concrete pavers based on seashells by-products confirmed the feasibility of utilization of this waste as a replacement in the composition of concrete. Most of the aggregates which are used as natural aggregates in concrete are usually excavated from river beds, quarries, dredged from sand or shingle banks under the sea. In order to reduce the environmental impact of building materials and especially natural resource consumption, the reuse of waste and by-products is one of the solution. Studies have been carried out to investigate the replacement of natural Aggregates in concrete by recycled aggregates, slag aggregates, and recently seashells.

Garg et al. (2013) demonstrated that automobile sludge up to 35% can be utilized for making building components like paver blocks, flooring tiles, and clay bricks. In order to reduce the environmental impact of construction materials, the incorporation of alternative materials is becoming an important option in the construction industry. In India, several industries generate effluent treatment plant (ETP) sludge as a waste of effluent and sewage treatment plant during the treatment process comprising of chemical coagulation, flocculation and liquid/solid separation. This sludge degrades the environment and poses hazards to both human and animal life, thus causing concerns for their disposal. Due to the indiscriminate land disposal trends, large areas of fertile land have become barren and unproductive for agricultural purposes. Efforts are, therefore, being made throughout the world to effectively recycle these industrial wastes in eco-friendly construction materials.

Soutsos et al. (2010) investigated the use of construction and demolition waste as an aggregate in casting of paving blocks. The experimental work done involves two series of tests i.e paving blocks made with concrete and masonry derived aggregate and variables that were investigated by replacing a) coarse aggregate b) fine aggregate c) fine aggregate and coarse aggregate both. Different mechanical properties were compared between paving blocks made with recycled material and paver blocks made with newly quarried aggregates. The research showed that selection of appropriate levels of newly quarried with recycled demolition aggregate can lead to paving blocks with similar mechanical properties without the need to increase the cement content.

Xue et al. (2005) experimentally investigated that basic oxygen furnace can be used as aggregate in asphalt mixture. It is known that steel slag is a by-product during steel making process, and the majority of them engrosses a mass of ground and gradually become an environmental problem. Hence disposing and its handling are very important. On the other hand, in the most industrial countries, there is a great demand for aggregate mainly in civil engineering industry, especially in the field of road construction. The demand of so many natural aggregate resources causes environmental problems, or increase cost of project. By testing and analyzing, BOF steel slag he concluded that it can be used as asphalt mixture aggregate in expressway construction, the road constructed with steel slag is successfully paved and normally used. Hence he concluded that utilization of BOF steel slag in construction of road is a new approach to utilize BOF steel slag which decrease threat to the environment.

III. Objective of Study

The research aims at the utilization of brine sludge in casting of non-traffic paver blocks. The following objectives are emphasized for this research work and are summarized below:

- Collection of industrial sludge from Nagda.
- Casting of paver blocks by mixing sludge into concrete mix in different proportions.
- Testing of paver blocks for different engineering properties

IV. Material

A. Cement

Binding material that sets and hardens and used as a binder for other materials is known as cement. Cement which is used for construction purposes can be classified as hydraulic and non-hydraulic. The most commonly used cement for construction purposes is ordinary Portland cement.53 grade ordinary Portland cement is used for the casting of paver blocks.

The ordinary Portland cement is manufactured by thoroughly mixing together calcareous and argillaceous and/or other silica alumina or iron oxide bearing materials, burning them at a clinkering temperature and grinding the clinker to produce a cement.(IS 12269).

B. Fine Aggregates

90-100 % of total aggregates passes through 4.75 mm sieve is known as fine aggregate.

- Natural sand: Aggregate formed due to natural disintegration of rock and deposited by streams or glacier.
- Crushed stone sand: Aggregate formed due to crushing of hard stones.
- Crushed gravel sand: Aggregate formed due to crushing of natural gravels
- Natural sand is used for casting of paver blocks. Grading zone for sand is Narmada zone
- Specific gravity of sand passing through 4.75 mm sieve is 2.68

C. Coarse Aggregate

90-100% of total aggregate retained on 4.75 mm sieve is known as coarse aggregate.

According to IS 383 coarse aggregate are:

- Uncrushed gravel or stone resulting from natural disintegration of rock.
- Crushed gravel or stone which is result of crushing of gravel or hard stone.
- Partially crushed gravel or stone when it is product of the mixing of (A) and (B)

Coarse aggregate which is used for paver blocks is 10mm aggregate.

D. Water

Water fit for drinking purposes is suitable for making concrete. Water which is used for paver blocks should be free from acids, alkalies or any type of organic impurities.PH value of water should not be less than 6.water which is used for mixing concrete is suitable for curing. However water which is used for curing should not produce any objectionable stain or unsightly deposits on paver blocks.

Water has two function in concrete mix used for paver blocks

- Cement and water reacts chemically and form a paste in which inert aggregate are suspended until cement paste is hardened
- It is a lubricant in the mixture of cement and aggregate

E. Sludge

Viscose staple fibre (VSF), a man-made biodegradable fibre with characteristics similar to cotton. VSF commonly used in apparels, home textiles, dress material, knitted wear and non-woven applications. Rayon grade caustic soda is an important raw material in VSF production to achieve good supply of this chemical Grasim set up a rayon grade caustic soda unit at Nagda in 1972 with an initial capacity of 33,000 TPa. This has since grown to 452 Ktpa, making it the country’s largest caustic soda unit.

The sludge sample is procured from Nagda Grasim industry and used in paver blocks in different percentages. Main constituent of the Brine sludge are AL, B, Ba, Ca, Co, Cr, Cu, Fe ,K ,Li ,Mg ,Mn ,Na ,Ni ,P ,S ,Sc ,Si ,Sr ,Ti ,V,Y, Yb ,Zn ,Zr.

These elements are determined using inductively coupled plasma atomic emission spectroscopy in IIT Powai.

V. METHODOLOGY

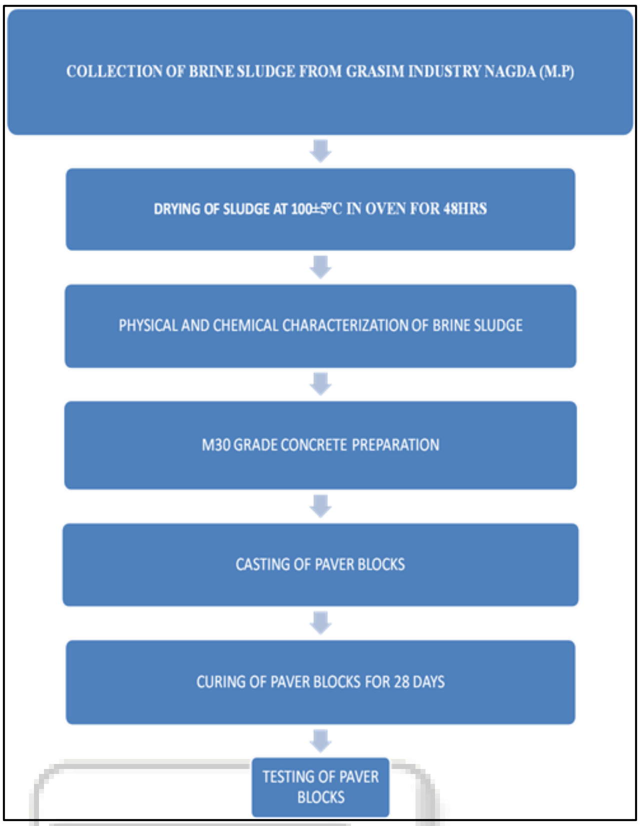

Fig. 1: Flow graph of Methodology

VI. OBSERVATIONS

Sample	Cement	Sludge	Coarse Aggregate	Fine Aggregate
S-1	25	-	40	35
S-2	25	27.5	22.5	25
S-3	25	35	20	20
S-4	25	40	15.5	19.5

Table 1: Composition of Paver Blocks (By weight %)

Sample	Mean Thickness (mm)
Sample-1(S-1)	56
Sample-2(S-2)	57
Sample-3(S-3)	48.25
Sample-4(S-4)	58.75

Table 2: Mean thickness of the samples

Sr. No.	Sample	Average Compressive Strength (N/mm^2)	Percentage decrease in Compressive strength (%)
1	Sample 1(S-1)	39.8	
2	Sample 2(S-2)	35.05	11.93
3	Sample 3(S-3)	34.26	13.9
4	Sample 4(S-4)	28.54	28.29

Table 3: Comparison between compressive strengths of sample S-1, S-2, S-3 & S-4

VII. DISCUSSION

From above results we can see that compressive strength decreases with increase in the percentage of sludge. The percentage decrease from S-1 to S-2 and S-1 to S-3 is less as compared to percentage decrease in S-1 to S-4.Strength of concrete depends upon several factors like Ratio of cement to mixing water, Ratio of cement to aggregates, the strength of the mortar, the bond between the mortar and the coarse aggregate, Grading, surface texture, shape, strength, and stiffness of aggregate particles and Maximum size of aggregate. After addition of sludge in concrete, mix ratio of cement to aggregate decreases as well as stiffness of aggregate decreases. This leads to decrease in compressive strength.

Water absorption increases with increase in percentage of sludge. The percentage increase from S-1 to S-2 and S-1 to S-3 is less as compared to percentage increase in S-1 to S-4. It is commonly accepted that water demand and cement content in a concrete mixture increases as the maximum coarse aggregate size decreases. The required volume of paste in a concrete mixture must increase, due to the increased surface area of smaller aggregate sizes, to coat all of the aggregate particles.

Similar Trend of decrease in compressive strength and increase in water absorption were studied by MRIDUL GARG and AAKANKSHA PUNDIR "Utilization of Brine Sludge in Non-structural Building Components: A Sustainable Approach".

VIII. CONCLUSION

In this experimental investigation the compressive strength and water absorption of paver blocks are calculated. Four sets of paver blocks are casted with different percentage of sludge. From the experimental results and calculated values of strength, the following conclusions are drawn:

A. Sample-1 (S-1)

In sample S-1 sludge is not mixed and M30 grade concrete is prepared .M-30 grade paver blocks are generally used for non-traffic areas.

- Compressive strength of paver block is 39.8 N/mm^2
- Water absorption of paver block is 4.62%

B. Sample-2 (S-2)

In sample S-2 27.5% of sludge is added. coarse aggregates and fine aggregates are replaced by sludge

- Compressive strength of paver block is 35.05N/mm^2. Though compressive strength of sample S-2 decreases after addition of sludge but it conforms to the minimum limit of M30 grade paver blocks.
- Water absorption of paver block is 5.26% which satisfies the specified limits mentioned in IS-15658.

C. Sample-3 (S-3)

In sample S-3 35% of sludge is added. Natural aggregates and fine aggregates are replaced by sludge

- Compressive strength of paver block is 34.26N/mm^2. Though compressive strength of sample S-3 decreases after addition of sludge but it conforms to the minimum limit of M30 grade paver blocks.
- Water absorption of paver block is 6.09% which satisfies the specified limits mentioned in IS-15658.

D. Sample-4 (S-4)

In sample S-4 40% of sludge is added. Natural aggregates and fine aggregates are replaced by sludge

- Compressive strength of paver block is 28.54N/mm².compressive strength of sample S-4 decreases after addition of sludge and it doesn't conforms to the minimum limits of M30 grade paver blocks.
- Water absorption of paver block is 8.7% which does not satisfies the specified limits mentioned in IS-15658.

The 28 days cured cement concrete paver blocks of M30 grade were tested for basic properties which are required for non-traffic paver blocks. It was observed that compressive strength decreases and water absorption increases from S-2 to S-4 as compared to S-1.However, the properties of S-2 and S-4 satisfies the minimum limits mentioned in IS-15658 . On other hand sample S-4 failed to pass the minimum strength criterion for M30 grade paver blocks.

On the basis of properties of blocks and considering the use of brine sludge sample S-3 is optimized i.e 35% of sludge can be used in mix design of non-traffic (M30) paver blocks. This percentage replacement may provide alternative solution for disposal of brine sludge.

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