Interlocking Pavement Tiles using RCA with Industrial Waste as Admixtures

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ABSTRACT

The unprecedented increase in construction and developmental activities in the current era brings with it many irreversible impacts on the environment. The major impacts being the depletion of natural resources and generation of an enormous quantity of Construction and Demolition (C&D) wastes. Hence it has become important to reuse and recycle C & D wastes generated. These wastes can be processed to obtain Recycled Concrete Aggregates (RCA), which can be used for producing recycled concrete. It was found that the strength of Recycled concrete matches with that of paver quality concrete. Therefore, the study aims at producing interlocking paver blocks by replacing the normal coarse aggregates in pavers by RCA along with fly ash as admixture, an industrial waste. Fly ash being a pozzolanic admixture is used in order to overcome the loss of strength due to the addition of RCA. In the present study, a 30% replacement of normal aggregates with RCA and 15% replacement of cement with fly ash in the mix was used as it was found to provide the optimum strength. A comparison of the important properties of paver blocks were conducted between normal concrete pavers, pavers with RCA replacement and pavers with RCA replacement and fly ash. It was found out from the study that Interlocking pavers with partial replacement of normal aggregates with RCA and fly ash obtained strength comparable to that of normal paver blocks. Hence these paver blocks can be used for laying of roads and can contribute towards a sustainable development.

Keywords: Construction, Recycled Concrete Aggregate, Demolition waste.

1 INTRODUCTION

Urbanization and development have been occurring at an unprecedented rate in the past few decades. The inevitable impacts of rapid urbanization are the depletion of natural resources and the generation of waste. Construction industry is found to have a dominant role in environmental deterioration, mainly due to the large-scale construction activities taking place in the urban areas. Concrete remains the major construction material used in India albeit many new construction materials have been developed. Consequently, 75 percent of natural resources are used by the construction industry since concrete is mainly composed of aggregates. Abundant quantities of wastes are generated due to the demolition of buildings and structures that have exceeded their age and limit of use. The solid waste accumulated is most commonly and ineffectively disposed off in landfills at high costs which ultimately results in the depletion of landfill space and also usable land. However, with urbanisation comes the moral responsibility of sustaining the environment. The enormous quantities of demolished concrete wastes available at various construction sites, which are posing a serious problem of disposal in urban areas can be recycled and used.Therefore,C & D waste can be effectively used up to produce recycled aggregate concrete (RAC) which is a highly attractive and promising technology for ensuring sustainability in the construction industry.

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One of the major challenges associated with RAC is to obtain recycled aggregates that are having properties comparable with that of normal aggregates. The mortar that is attached to the surface of recycled concrete aggregates (RCA) cannot be completely removed making the quality of recycled aggregates inferior to that of normal aggregates. Various treatments has been carried in this project to remove the extra interfacial transition zone (ITZ) present between the aggregate and the adhered concrete in the recycled aggregates. Mineral admixtures are also added in recycled aggregate concrete mix to obtain a strength comparable to that of normal mix.

Recycled aggregate concrete is not much suited for large scale building construction since various treatment methods are required to be conducted on aggregates to improve the properties of RAC which may not result in proper quality control of concrete at site. Therefore, RAC is more suitable for prefabricated projects like paver blocks. Interlocking pavement tiles are gaining popularity in this era as bituminous roads are being replaced with concrete tiles due to their greater durability and ease of construction. Hence the significance of incorporating recycled aggregate in these pavement blocks is evident, ensuring a sustainable development. Mineral admixtures were added to the recycled aggregate concrete mix in order to improve the properties of RAC and to compensate for the inferior properties of recycled aggregate. Use of fly ash as an admixture improves the properties and also helps in utilisation and reduction of industrial waste.

The aim of the project was to make interlocking pavement tiles with RAC and fly ash as mineral admixture. In India, bituminous and concrete roads are now being replaced by interlocking tiles. At the same time a lot of concrete debris is produced due to developmental projects that are taking place. Interlocking tiles also provide protection against flooding as water can seep through the interlocking edges. Hence these tiles are well suited for the prevailing conditions

2 METHODOLOGY

2.1 COLLECTION OF DEMOLISHED WASTE

The C & D waste required for the extraction of RCA was collected from the demolished site of Holy Faith H2O at Maradu, Kochi. About 150 kg of concrete debris were collected and was used for the preparation of the recycled aggregate.

2.2 PROCESSING OF DEMOLISHED WASTE

Processing of demolished waste includes numerous steps to obtain recycled aggregates that are fit for use. They remove the mortar adhered to the surface of aggregates. The processed aggregates are treated using certain methods to improve the properties of the aggregate in order to make it suitable for being used in the manufacture of concrete. The collected concrete debris was first crushed to reduce the size and then subjected to various treatment processes.

2.2.1 Manual Crushing

The concrete debris were broken down manually into suitable size ranging from 40-60 mm using a hammer so as to make it into the same size as of natural crushed rock aggregates.

2.3 Methods to improve the properties of Recycled Concrete Aggregates

2.3.1 Abrasion of RCA

The manually crushed concrete aggregates contain a large amount of adhered mortar on it. This attached mortar if not removed from the aggregates will increase the water absorption when introduced into concrete mortar.

Due to this action concrete mixes tend to become dry and thereby reduces its strength and workability. Abrasion was performed on the concrete waste to strip off the attached mortar from the aggregates in Los Angeles abrasion machine.

2.3.2 Beneficiation of RCA

In order to remove the loosely adhered mortar that remained attached to the RCA after abrasion, the aggregates were pre-soaked in 0.2 molar sulphuric acid solution for 24 hours and then washed with water. This process is said to improve the surface properties of the aggregates.

2.3.3 Cement slurry treatment

Cement slurry treatment is carried out to neutralize any excess acid remaining on the surface of aggregates after beneficiation. If not removed, it can cause salt formation in the pavement tiles once they are cast and can have an adverse effect on its strength. For this treatment aggregates were immersed in cement paste prepared with cement and water.

2.4 MATERIALS USED

All the materials were tested as per the standard procedures laid down in the IS codes.

a) Cement: The cement used was Portland Pozzolana Cement. This was conforming to IS 1489 (Part 1) 1991. The specific gravity of the cement was found to be 3.15.

b) Fine aggregate: The fine aggregate used for the production of concrete mortar was manufactured sand or M-sand. The material conforming to IS 383-1970 was chosen. The manufactured sand was tested under conditions specified by IS 2386 (Part 3)–1963. The specific gravity was found to be 2.65.Sieve analysis was conducted to determine the particle size distribution of aggregates. According to the grading limits as per IS – 383 the zone of the fine aggregate was identified as zone II

c) Recycled coarse aggregate: The construction and demolished waste from Holyfaith H_20 at Maradu was used as a source for the preparation of the RAC. These concrete debris were crushed manually and subsequently abraded using Los Angeles abrasion testing machine and then sieved. The aggregate passing through 12mm sieve and retained on 4.75 mm sieve was used as RCA. The specific gravity was found to be 2.78.

d) Normal Coarse Aggregate: The aggregate conforming to IS standards were taken. The aggregate passing through 12mm sieve and retained on 4.75mm sieve were selected as the normal aggregate which is to be replaced in proportion by the recycled concrete aggregates. The specific gravity was found out to be 2.74.

2.5 MIX PROPORTIONS

The mix proportion selected was that of M40 mix. Three different mix proportions were produced

Type 1 (Normal mix) : Normal M40 mix without any replacement

Type 2 (Mix with RCA) : M40 mix with 30% replacement of normal coarse aggregates (NCA) with recycled coarse aggregates (RCA)

Type 3(Mix with RCA and fly ash) : M40 mix with 30% replacement of NCA with RCA and 15% replacement of cement with fly ash

The mixes were prepared manually in a trolley. The arrived mix proportion was 1:0.913:1.15

3 TESTS CONDUCTED

As per IS 15658, the tests to be conducted on interlocking concrete paver blocks are

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- Compressive strength test
- Water absorption test
- Abrasion test
- Flexural strength test

Slump test was also conducted to assess the workability of the mix. A minimum slump of 60mm is required. After the test, the slump obtained was 90mm which is satisfactory.

4 RESULTS AND DISCUSSIONS

The table below shows the results of Compressive strength test, Water absorption test, Abrasion test and Flexural strength test of Type 1, 2 and 3 paver blocks.

Table 1 : Comparison of results of Physical properties for Type 1,2 and 3 paver blocks

Mix	Compressive strength (N/mm^2)	Water Absorption (%)	Abrasion Resistance (mm)	Flexural (N/mm^2)
Type 1	39.57	2.15	1.58	6.27
Type 2	34.2	3.01	1.94	5.54
Type 3	38.625	2.2	1.62	6.09

4.1 Compressive strength

From Table 1 it can be seen that the highest compressive strength is obtained for Type 1 paver tiles which is the control mix. Lowest compressive strength is obtained for type 2 paver tiles as 30% normal aggregates are replaced with RCA and no fly ash is added to improve its strength. As fly ash is added along with RCA replacement, strength similar to that of type 1 was obtained for type 3.

4.2 Flexural strength

From table 1 it can be found that highest flexural strength was obtained for type 1 paver tiles. From this study, only 10% reduction of flexural strength is observed for type 2 when compared to type 1 paver blocks. However, much strength reduction was not observed for type 3 due to the addition of fly ash.

4.3 Water absorption

Water absorption is the least for Type 1 paver tiles. The water absorption of Type 2 paver tiles was obtained about 40% greater than Type 1 due to the presence of extra Interfacial Transition Zone (ITZ) between the aggregate surface and the thin layer of adhered mortar. Absorption in Type 3 paver tiles has increased by only 1.5% than that of Type 1 since the fly ash added to the mix reduces the water absorption.

4.4 Abrasion Resistance

Lowest value of Abrasion loss was obtained for Type 1 pavers. The abrasion loss in Type 2 paver tiles is found to be about 23% higher than Type 1 pavers due to weak aggregate mortar binding between the aggregate surface and the fresh mortar which is due to the presence of an extra ITZ in RCA. Only negligible or slight abrasion loss was observed in Type 3 when compared to Type 1 due to the addition of 15% fly ash which compensates for the abrasion loss due to the addition of RCA.

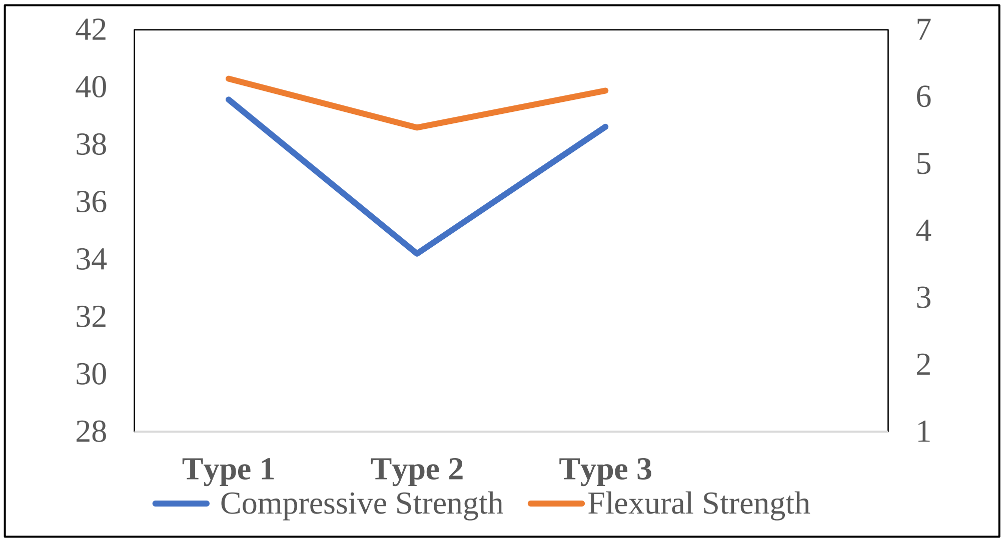

Figure 1. Variation in Compressive Strength and Flexural Strength

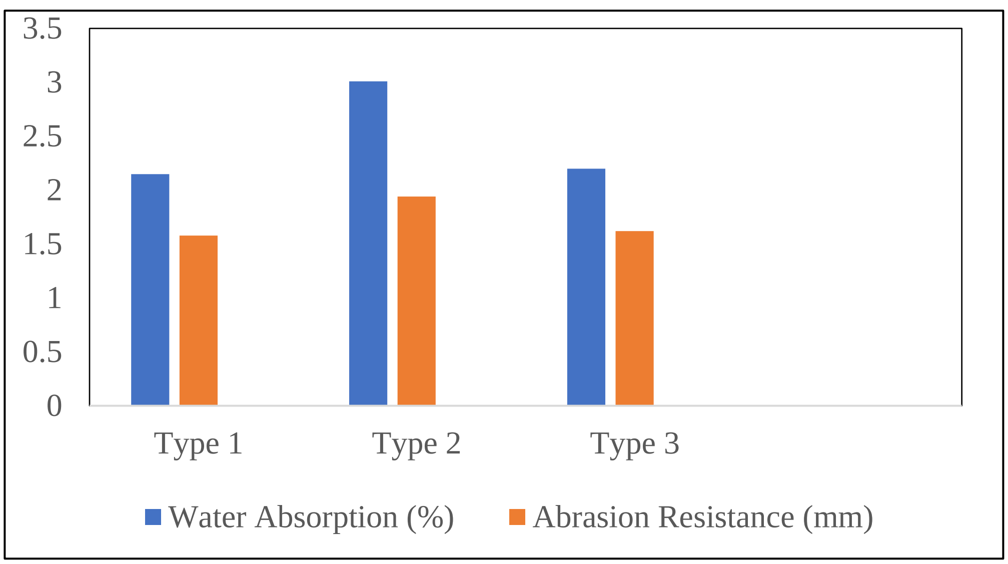

Figure 2. Variation in Water Absorption and Abrasion Resistance

5 CONCLUSION

As per the study, the value of compressive strength obtained for paver blocks replaced with RCA and fly ash satisfies the strength requirement for paver blocks. The value of water absorption obtained is also within the

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specified limits. As a result, a part of Normal Concrete Aggregate (NCA) can be replaced by Recycled Concrete Aggregate (RCA) for manufacturing paver blocks without much effect on its strength and durability if suitable mineral admixtures are added as it efficiently overcomes the shortfalls of RAC. Use of construction and demolition waste in the manufacture of paver blocks, decreases the amount of waste generated every year. It also aids in recycling and reducing the demand for natural aggregates and encourages sustainable practices in the construction industry. It also reduces the cost of materials used for making pavement tiles as it reduces the demand for new aggregates. Also, in the present era, tarred roads are being replaced by concrete paver tiles. The interlocks in tiles provide a greater durability. Hence it can be concluded that RAC is most suitable for making paver blocks than any other structures due to its low strength requirements.

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REFERENCES

Jindal,A.G.D., and Ransinchung,R.N., (2018), "Behavioural study of pavement quality concrete containing construction, industrial and agricultural wastes,"*International Journal of Pavement Research and Technology*, Vol.11, No.5, pp 488-501

Maiera,P.L.S.,and Durhamb,A., (2012), "Beneficial use of recycled materials in concrete mixtures," *Construction and Building Materials,* Vol.29, pp 428-437

Berndt,M.L., (2009), "Properties of Sustainable Concrete Containing Fly Ash, Slag and Recycled Concrete Aggregate," *Construction and Building Materials*, Vol.23, pp 2606-2613

Thomas,c., Brito,J.D., Cimentada,A., and Sainz-Aja,J.A., (2020), "Macro- and micro- properties of multi-recycled aggregate concrete," *Journal of Cleaner Production,* Vol.245, Article 118843

Bai,G., Zhu,C., Liu,C., and Liu,B., (2020), "An evaluation of the recycled aggregate characteristics and the recycled aggregate concrete mechanical properties," *Construction and Building Materials*, Vol.240, Article 117978

Paola,D.M., Laura,M., and Americo,C., (2019), "Concrete block pavements in urban and local roads: analysis of stress-strain condition and proposal for a catalogue," *Journal of Traffic and Transportation Engineering (English Edition),* Vol.6, No.6, pp 557-556

Manoj,B., and Saravanakumar,P., (2015), "Effect of Sulfuric Acid Treated Recycled Aggregates on Properties of Concrete," *International Journal of ChemTech Research*, Vol.8, No.2, pp 476-482

Makul,N., (2020), "Cost-benefit analysis of the production of ready-mixed high performance concrete made with recycled concrete aggregate: A case study in Thailand," *Heliyon,* Vol.6, No.6, Article e04135

IS 10262: 2019, (2019), *Indian Standard Guidelines for Concrete Mix Proportioning,* Bureau of Indian Standards, New Delhi, India

IS 456: 2000, (2000), *Indian Standard Code of Practise for Plain and Reinforced Concrete,* Bureau of Indian Standards, New Delhi, India

Muneera,S., and Rupa,A., (2016), "Use of Recycled Aggregate in Concrete," *International Journal of Science and Research,* Vol.5, No.8, pp 1253-1255

Kim,K., Shin,M., and Cha,S., (2013), "Combined effects of recycled aggregate and fly ash towards concrete sustainability," *Construction and Building Materials* Vol.48, pp 499-507