A Review Paper on Partial Replacement of Fine Aggregate and Cement by Industrial Waste

S. Rajesh[1] Dr. J. Venkateswar Rao[2]
[1]P.G Student [2]Professor
[1,2]Department of Civil engineering
[1,2]GMRIT, India

Abstract— This paper presents review of research conducted on paver blocks by previous researchers. The paper mainly focuses on the summary of those investigations which are related to partial replacement of fine aggregate as well as cement with industrial and non-biodegradable wastes. The industrial wastes consists of fly ash, pond ash, hypo sludge, copper slag, crusher dust, construction demolition waste, ceramic waste, textile sludge, slag and baggasse ash etc. the non-biodegradable waste discussed herein are ceramic, rubber and PVC plastic waste. The previous researchers concentrated the superior mechanical properties of the paver blocks after incorporating the waste products as partial replacement of fine aggregate and cement.

Keywords: Fine Aggregate, Cement, Industrial Waste, Non-Biodegradable Wastes, Paver Blocks

I. INTRODUCTION

Due to the increase in constructional activities there are lot of problems arising with concern to humans as well as environment. One of the major problems caused due to these activities is depletion of natural resources due to which hazardous calamities are also being occurred in long term. Fine aggregate is the natural river sand which is depleting rapidly causing lowering of the ground water table and erosion which effects human life. Cement is the hardening material being used in the construction activities produced in tonnes every year. Due to the large amount of production of cement there is a severe effect to the environment because it leads to emission of CO2 which is a harmful gas and accounts in the greenhouse gas. Due to the increase in the greenhouse gases there is depletion in the ozone layer causing a serious problem i.e. global warming which is the major issue for whole world.

Many industrial wastes such as copper slag, crusher dust, ceramic waste, textiles waste, rubber, plastic, fly ash, pond ash, bottom ash etc. are being produced in huge amount every day. The main problem arising due to these industrial wastes is their disposal. Some of these wastes are being disposed on huge lands whereas some are disposed in water. For 1MW of power generation about 1 acre of land is required to dispose the waste obtained from it. Due to which there is degradation of land and water table beneath these landfills also gets affected.

So, to reduce the depleting of natural resources and degradation of land the researchers have found a way for the sustainable use of these industrial waste by incorporating them partially in place of fine aggregate and cement to attain good strength and durability without losing their properties.

II. LITERATURE REVIEW

S. Kalaislevi et al. (2017) have conducted the experimental investigation on the compressive strength development of paver block by replacing the fine aggregate in the mix with the copper slag in the range of 10% to 60% by the weight of fine aggregate. The results proved that the minimum percentage of replacement of copper slag was found to be 30% beyond which a decrease in strength was observed. It was concluded that replacement of sand with copper slag results in an increase in density and compressive strength of paver blocks by 10%.

Radhikesh P. Nanda et al. (2010) produced paver blocks by replacing fine aggregate with crusher dust in percentages of 0, 25, 50, 75 and 100 by weight. From the test results it was observed that there was no significant reductions in the physical and mechanical properties like compressive strength, split tensile strength, flexural strength and abrasion value of paver blocks when fine aggregate was replaced by crusher dust up to 50%. This also results in the reduction in production cost of paver blocks by 56%.

R.Mahadevi et al. (2018) investigated the use of PVC plastic material in the paver blocks of M30 grade as a partial replacement of fine aggregate in percentages of 0, 10, 30. It was found that 20% of PVC by weight of fine aggregate results in similar mechanical properties like that of conventional concrete paver blocks. It was also observed that paver blocks produced from the PVC plastic are having less unit weight as compared to conventional concrete paver blocks.

Akash Gupta et al. (2016) experimented on the mechanical properties of M40 grade paver blocks by replacing 100% fine aggregate with crusher stone dust. It was found that slight decrement in the mechanical properties of paver blocks. For further enhancement of strength properties, use of steel fibers in the proportion of 0.5, 1.0, 1.5, 2.0 and 2.5% by the weight of cement is also examined. It was concluded that the sand can be effectively replaced by crusher dust along with the inclusion of steel fibers.

Dinesh W. Gawtre et al. (2016) studied the sustainable use of concrete waste in the manufacturing of interlocking paver blocks. The demolition waste was crushed into small particles and replaced in the paver blocks partially by fine aggregate and coarse aggregates about 50% in the top and bottom layer of the paver blocks. Different tests were being performed on the demolition waste such as impact value test and crushing value test which resulted in 14.6% and 13.25% respectively higher than the requirements as per IS recommendations. M35 grade of concrete was being used with a number of samples and compressive and tensile tests were conducted which resulted in 35.63 MPa that is more than the design standards for compressive strength but the average split tensile strength was not satisfactory which was about 1.5 Mpa. It is concluded that M35 grade of concrete paver blocks about 50% of construction and demolition waste can be used for pedestrian, car parking, office complexes and rural roads with less traffic, etc.

Jaoquim nery Santana filho et al.(2017) studied the feasibility of using iron ore tailings as fine aggregate replacement in the proportions of 10% to 80%. Specimen were subjected to physical analysis, such as expansion, porosity, and water absorption as well as mechanical tests like compressive strength and surface abrasion and the results were compared to conventional blocks. From the results it was concluded that with paver blocks 10% and 20% of iron ore tailings surpassed the minimum normalative limit of 50 Mpa and can be used in special pavements. The 20% replacement showed lower water absorption and porosity as compared to conventional blocks.

Koli Nishikant et al. (2016) studied the possibility of using waste glass as partial replacement of fine aggregate in the production of paver blocks. The fine aggregate was replaced by waste glass material in percentages of 15, 30, 45. It was observed that up to 30% of replacement, the compressive strength of paver blocks was found to be increasing. On the other hand, flexural strength was decreasing with the increase in waste glass material. It was reported that the increase in waste glass enhanced the workability and reduced the water absorption

Bharati Murgan Rethinavelsamy (2015) investigated the feasibility of utilizing the waste tyre crumb rubber as partial replacement of fine aggregate in precast concrete paver blocks. M40 grade concrete was taken for this study. The percentages of replacement were 5, 10, 15, 20, and 25 by volume of sand. Various physical and mechanical properties examined were density, compressive strength, split tensile strength, flexural strength, rebound hammer, and ultrasonic pulse velocity at curing period of 7, 28 and 56 days. The results revealed that the partial replacement upto 15% crumb rubber with fine aggregate attains the required strength 46.50 Mpa which is greater as compared to conventional concrete.

Dinesh W. Gawatre (2016) have conducted the experiment for the sustainable use of concrete waste in producing the interlocking concrete paver blocks by partial replacement of coarse and fine aggregates respectively from 0% to 100% and the compressive and flexural tests were conducted on the samples after 14 days and 28 days. From the results it was concluded that the impact value and crushing values were 14.6% and 13.25% respectively which were far better than required specifications. The compressive test for 40% replacement of debris gave 30.33 Mpa after 28 days and the flexural strength was 4.75 Mpa after 28 days with 50% debris replacement.

Eshmaiel ganjan et.al. (2014) examined the feasibility of reducing cement by partially replacing the cement with mineral wastes in the concrete paver blocks. Tests like tensile strength skid/skip and freeze/thaw resistance of paving blocks were conducted on the paver blocks. The different mineral wastes used in the investigation were run-of-station ash (ROSA), basic oxygen slag (BOS), ground granulated blast furnace (GGBS), plaster board gypsum (PG), and cement bypass dust (BPD). The outcomes of the investigation concluded that blocks which were being prepared by using OPC50/GGBS45/BPD05 reduced the cement content by 30% as compared to the percentage of cement used in the conventional blocks at the same time meeting the requirement of 3.6 MPa tensile strength.

Abhishek N Kasid et al. (2016) focused on the minimization of the use of cement by partial replacement of fly ash and glass powder in varying proportions thereby helps in the reduction of the solid waste produced. Total 104 specimens were cast by keeping constant replacement of cement with 25% fly ash and by varying the glass powder in the combination of 0%, 25%, 50%, 75%, and 100%. The compressive strength of paver blocks at 7 days and 28 days curing period were determined. From the results, it was proved that with the increase in the percentage of fly ash and glass powder the strength goes on increasing.

Ramalhilagam B.H et al. (2018) investigated the use of eggshell powder as the partial replacement of the cement in various percentages from 0 to 25 by weight of cement at an interval of 5 %. Compressive and flexural strength tests were performed on the specimens at 7 days and 28 days of curing. The results proved that there was an increase in the compressive strength about 13.4% and flexural strength by 19.5% at 10% the eggshell powder replacement.

Vijaya Kishore. K (2016) studied the use of textile sludge obtained from the textile industry with the combination of the addition of fly ash and silica fume in different combinations. M50 grade of concrete paver blocks were prepared by the partial replacement of cement with textile sludge in percentages of 0, 10, 20, 30 and 40. Additionally for the above mixes fly ash and silica fume were also used individually as mineral admixtures by replacing the cement about 10 – 40 % and 2.5 - 5% respectively. From the results of compressive strength shown that paver blocks with combination of 10% sludge + 10% fly ash and 10% sludge + 20 % fly as cement replacement have attained more than 40 Mpa compressive strength .

G.Pragna et al. (2017) investigated the partial replacement of cement with the fly ash, GGBS and glass fiber in different proportions and combinations. The glass fibers added was in the range of 0.2% to 0.8% in which the 0.4% addition found to be to be the optimum one. The fly ash and GGBS were used as mineral admixture individually and partially replaced the cement about 15% to 60% by weight. Compressive, flexural and water absorption properties of the paver blocks were evaluated. The results revealed that 30% of fly ash + 0.4% of glass fibers and 30% of GGBS + 0.4% of glass fibers was the optimum mix from the economic point of view without losing he mechanical properties compared to the conventional paver blocks.

P.R.Kannan Rajkumar et al. (2016) studied the use of bagasse ash as partial replacement of the 50% cement by weight. Total of four trial mixes were cast in which two of them as per IRC and rest were according to IS 10262. The compressive strength tests were conducted at 7 and 28 days curing period. The results showed that use of bagasse ash in paver blocks results in an additional thickness of the pavement by 70 mm when compared with the flexible pavement and the design life of the concrete paver blocks was enhanced to 20 years when 50% of bagasse ash was used as partial replacement of cement and also cheaper by 24.15% compared to plain concrete.

Mithun et al. (2016) investigated the use of hypo sludge as the partial replacement of cement in M30 grade concrete paver blocks. Cement was replaced in the range of 0%, 10 %, 20%, 30%, 40 %, 50% and 60% and then hypo

sludge is also used as 100% fine aggregate replacement. The compressive tests were performed for the casted molds. The test results proved that 10% replacement of cement with the hypo sludge gives optimum results equal to conventional concrete and 100% replacement of fine aggregate can also be done to attain the targeted compressive strength.

Thakur Anil Kumar et al. (2014) conducted an experimental work to know the effect on the properties of concrete paver blocks with the addition of nylon fiber in M20 grade paver blocks. At first, the nylon fiber was added at 0.1%, 0.2%, 0.3%, 0.4% and 0.5% in the mix and found that the compressive strength was increased by the addition of 0.3% of nylon fibers. By making this 0.3% as optimum value. With this optimum value of fibers in the mix cement was further replaced with fly ash in 10%, 20% and 30% and the compressive strength of the resulting mix were evaluated. The tests results showed that paver blocks with 20% cement replacement by fly ash achieved same compressive strength as that of the conventional concrete paver blocks.

Utsav Talavia et al. (2017) have conducted an experimental study on the concrete paver blocks by partially replacing the cement with the hypo sludge in M40 grade paver blocks in proportions of 0%, 5%, 10%, 15% and 20% by weight of cement and studied for the compressive, flexural tests, water absorption and cost analysis of concrete paver blocks. It was found that for 15% replacement of cement with fly ash the compressive strength of paver blocks is marginally less when compared to that of conventional paver blocks. By the addition of 0.3% of nylon fiber to the mix of 15% of partial replacement of cement by hypo sludge resulted in compressive strength which was higher than that of the conventional blocks. From the results it was observed that 5% of replacement gives the minimum value for the water absorption test. The compressive strength was maximum when 10% of the hypo sludge was replaced by the cement and flexural strength was maximum when 5% of hypo sludge was used. The cost analysis has proven that it was reduced when the hypo sludge was replaced by cement.

P.Kirubaghram et al. (2017) studied the behavior of the paver blocks when cement was replaced by the crushed rubber powder by the weight in the proportion of 0%, 5%, 10%, 15%, and 20%. Compressive as well as impact test of the paver blocks were evaluated. The results showed that the compressive strength was 51Mpa at 20% replacement and the impact strength was 15 blows which was about 50% increase in both compressive and impact tests compared to the conventional concrete paver blocks.

Sanjith. S et al. (2017) performed a comparative study on the compressive strength and cost analysis of the recyclable materials by partially replacing fine aggregate and cement in different proportions in two different combinations. In the first one, the cement was being replaced in the proportions of 30%, 40% and 50% with fly ash along with the addition of coconut fibers in proportions of 0.5% and 1% in volume of concrete. In the second combination, the sand was being replaced by 15%, 20% and 25% by quarry dust and cement by foundry sand in the proportions of 15%, 20% and 25%. It was being found that in case of fly ash and coconut fibers combination use of 40% of fly ash with 1% coconut fiber yields maximum compressive strength. Whereas 20% of quarry dust and 20% of foundry sand replacement resulted in optimum maximum compressive strength.

Sharada Sharma et al. (2014) studied the construction of paver blocks by partially replacing the cement with waste brick kiln dust. Also a superplasticizer was used to reduce the water. M35 grade was used with 0%, 5%, 10%, 15%, 20%, 25% and 30% .A maximum of 2% adding the superplasticizer by the weight of the cement used for the mix. Molds of 200 × 160 × 80 mm were used for casting and tested for water absorption and compressive strength for 7, 14, 28 days after curing. The results indicated that the water absorption percentage was increased as a number of days was increased and also varied with the replacement of cement with the brick kiln dust. The compressive strength was increased till 15% of replacement of cement with brick kiln dust and then decreases gradually.

E. Anji Reddy et al. (2015) studied the effect of partial replacement of rice husk ash using nylon fiber with the cement. The study includes M35 grade of concrete with the addition of nylon fiber in the percentage of 0.1 to 0.5 by the weight of cement and it was found that 0.3% was optimum addition from the maximum compressive strength point of view. The results showed that with the 0.3% of addition of nylon fiber the compressive strength was found to be 18.86% compared to the conventional mix. For the obtained optimum mix, partial replacement of cement with rice husk ash in percentage of 10 to 30 and tested for compressive strength. Paver blocks with the maximum dose of 20% of rice husk ash gave maximum strength.

J.Jegan et al. (2018) conducted an experimental investigation on the strength and performance of the paver blocks using granite powder as a partial replacement of cement in percentages of 25, 50 and 75. M40 grade of concrete was considered for this study. Blocks were prepared by using 250*123*80 mm of zigzag shape and were tested for the compressive and flexural strength. The test results showed that with the 25% replacement of cement the compressive strength achieved was 44 N/mm2, which is 7% more than the compressive strength of conventional concrete paver and flexural strength at 25% replacement was 5.51% N/mm2 which is 12% more than the flexural strength of the conventional strength.

Omoniyi T.E. et al. (2013) have conducted the experimental investigation by partially replacing the cement with rice husk ash in proportion of 0%,10%, 20%, 30% by weight. Also added bamboo fibers in 0%, 1%, 2%, 3% by the weight of cement. Mechanical tests such as compressive strength, flexural strength and abrasive strength were performed. From the results it was concluded that 20% of cement replacement with rice husk ash and inclusion of 3% of bamboo fibers results in comparable strength.

Shyam Prakash Konganti (2017) compared the strength performance and production cost of paver blocks by partial replacing the fine aggregate with different industrial waste products such as coal dust, quarry dust, ceramic dust and glass powder. The percentages of replacement are varying between 0 to 40. M20 grade of concrete was considered for this purpose. From the results it was concluded that the replacement of 20% quarry dust enhances the compressive strength by 51%, whereas for glass powder the strength is gradually decreased with the increment in glass powder. It

was noticed that in case of ceramic dust, beyond 20% causes a decrease in the strength of concrete, but it has a higher profit percentage up to 40% replacement. Replacement with coal dust decreases the strength properties with the increase in the percentages and therefore not recommended by the authors.

III. CONCLUSION

The following concluded were drawn from a broad overview of the literature review.

1) Fine aggregate can be replaced partially by different materials such as copper slag, stone crusher dust, PVC plastic material, construction and demolition waste, waste glass material, coal dust, ceramic dust, waste tyre crumb rubber in concrete paver blocks without affecting its properties
2) Cement can be replaced partially by different materials such as fly ash, glass powder, textile sludge, hypo sludge, silica fume, GGBS, baggasse ash, rice husk ash, brick kiln dust, foundry sand, granite powder and other waste materials in concrete paver blocks without affecting its properties.
3) As the above materials used are mostly the waste products being obtained from different industries and materials can be sustainably used in paver blocks and helps in reducing the degradation of natural materials and disposal problems.

REFERENCES

[1] S.Kalaiselvi, S.Prabhakaran, Jagadeesan.K (2015), "An Experimental Investigation on Partial Replacement ofCopper Slag as Fine Aggregate in Paver Block", International Journal of ChemTech Research, Vol.10 No.9, pp 306-310,
[2] Radhikesh P. Nanda, Amiya K. Das, Moharana. N.C (2010), "Stone crusher dust as a fine aggregate in Concrete for paving blocks", International Journal of Civil and Structural Engineering, Vol. 1, Issue 3, PP: 613-620.
[3] R.Mahadevi,S.Abirami, P.Jananipriya, J.Karunya and M.Sakthipriya (2018) "An Experimental Investigation On Concrete Paver Block By Using Pvc Plastic Material" international journal of modern trends in engineering and research" IJMTER.2018.5073.XONCE.
[4] Akash Gupta, Prof. Archana Tiwari (2016) "Effect on Mechanical Properties of Paver Block Consist Crusher Stone Dust as Fine Aggregate with Inclusion of Steel Fiber", International Journal for Research in Applied Science & Engineering Technology, vol.4 issue x PP: 529-534.JMTER
[5] Dinesh W. Gawatre, Rohit S. Chhajed, Prashik B. Panpatil (2016), "Manufacture of Paver Block Using Partial Replacement of Construction And Demolition Concrete Waste", International Journal of Pure And Applied Research In Engineering AndTechnology, Vol. 4, Issue 9, PP: 11-18.
[6] Joaquim Nery Sant'ana Filho; Sidney Nicodemos Da Silva, D.Sc.; Gabriela Cordeiro Silva, D.Sc.; Julia Castro Mendes; and Ricardo André Fiorotti Peixoto, D.Sc.(2017) "Technical and Environmental Feasibility of Interlocking Concrete Pavers with Iron Ore Tailings from Tailings Dams" American Society of Civil Engineers.(ASCE)MT.1943-5533.0001937.
[7] Koli Nishikant, Aiwale Nachiket, Inamdar Avadhut, Abhishek Sangar (2016), "Manufacturing of Concrete paving Block byUsing Waste Glass Material", International Journal of Scientific and Research Publications, Vol. 6, Issue 6, PP: 61-77, 2016
[8] Bharathi Murugan Rethinavelsamy & NatarajanChidambarathanu (2015) "Investigation on precast concrete paver block with waste tyre crumb rubber" Road Materials and Pavement Design,dx.doi.org/10.1080/14680629.2015.1119056
[9] Dinesh W.Gawatre , Akshay S. Ghaytadkar, Nikhil N. Gage, Sumit D. Bhor, Shubhum S. Deore (2017) "To Improve Mechanical Properties of Concrete Paver Blocks" IOSR Journal of Mechanical and Civil Engineering, Volume 14, Issue 3, PP 147-151.
[10] Eshmaiel Ganjian, Ph.D.; Ghassan Jalull; and Homayoon Sadeghi-Pouya, Ph.D. (2014) "Reducing Cement Contents of Paving Blocks by Using Mineral Waste and by-Product Materials" American Society of Civil Engineers.(ASCE)MT.1943-5533.0001037
[11] Abhishek N Kashid , Seema S Rathod, Shrikant T Varpe (2016), "Sustainability Approach For Concrete Paver Block Using Glass Industrial Wastes" International Journal Of Engineering Sciences & Research Technology, zenodo.159197.
[12] Ramathilagam.B., Aravinth.K, Ananth.C, Arisivamani.L (2018) " An Experimental Investigation of EGGSHELL POWDER as a Partial Replacement of Cement in Paverblock" International Journal of Engineering Science and Computing, Volume 8 Issue No.4.
[13] Vijaya kishore. K (2012), "Utilization Of Sludge Concrete In Paver Blocks " International Journal Of Emerging Trends In Engineering And Development" Vol. 4 Issue 2, PP: 509-516.
[14] G.Pragna, P.M.S.S.Kumar (2017), "An Experimental Study on StrengthImprovement of Concrete Paver Blocks byUsing Flyash, Glass Fiber and GGBS" International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 2, PP: 2972-2987.
[15] P. R. Kannan Rajkumar, K. Divya Krishnan, P. T. Ravichandran, T. Aarthi Harini (2016), "Study on the use of Bagasse Ash Paver Blocks in Low Volume Traffic Road Pavement" Indian Journal of Science and Technology, Vol 9(5),
[16] Mithun, Chethan Kumar N T (2016), " Hypo Sludge Paver Blocks" International Journal Of Advanced Technology In Engineering And Sciences, Vol. 4 Issue 7, PP: 224-228.
[17] Thakur Anil Kumar, Saxena Anil Kumar, Arora T. R. () "Effect of Partial Replacement of Cement by Fly Ash with Using Nylon Fiber in Concrete Paver Block" International Journal of Engineering Research & Technology, Vol. 3 Issue 1 PP:21083-2187.
[18] Utsav Talavia, Parth Talavia, Shubham Garg, Jeet Maradia, Tausif Kauswala (2017) "Experimental Study On Use Of Hypo Sludge In Paver Blocks" International Journal Of Modern Trends In Engineering And Research, Volume 04, Issue 5,PP:69-75

[19] Kirubagharan, R. Gowtham, Albert Duraisingh, Akshai B Nair (2017) "Experimental Study On Behaviour Of Paver Block Using Crushed Rubber Powder" International Journal of Civil Engineering and Technology, Vol. 8, Issue 3, PP: 582–589
[20] Sanjith.S, Senthurvasen.K.E, Thrni.R , Vishnuprasad.K, Dhivya.B (2017) "Partial replacement of cement and fine aggregate by recyclable materials in paver blocks' International Journal of Intellectual Advancements and Research in Engineering Computations, Volume-5 Issue-1
[21] Sharda Sharma, Ritesh Mall, Khalid Raza (2014) "Effect of waste brick kiln dust with partial replacement of cement with adding superplasticizer in construction of Paver Blocks" International Journal of Science, Engineering and Technology Research, Volume 3, Issue
[22] E. Anji Reddy Vishal Gupta Deepak Garg (2015) "Effect of Partial Replacement of Cement by Rice Husk Ash Using Nylon Fiber in Concrete Paver Block" International Journal for Scientific Research & Development| Vol. 3, Issue 03 PP: 45-48.
[23] J.Jegan, B.Sriram (2018) "Replacement Of Cement By Granite Powder In Paver Blocks" International Research Journal of Engineering and Technology, Volume: 05 Issue: 06.
[24] Basil M. Mali (2016) "Study On Geopolymer Concrete Used ForPaving Blocks", International Journal of Innovative Research in Advanced Engineering, Vol. 3, Issue 9, pp. 62-66.
[25] Joel Santhosh, Ravikant Talluri (2015) "Manufacture of interlocking concrete Paving blocks with fly ash and glass powder", International Journal of Civil Engineering and Technology, Vol. 6, Issue 4, pp. 55-64.

