A Review: Experimental and Analytical Study of Partially Replaced Waste Materials in Rigid Pavement

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***Abstract*- The road network transport 64.5% of goods in the country. Rural road connectivity improves the transportation. And also rural road connectivity is important key element for rural development, it's developing rural economic and social activities. Village road get low volume traffic density. It's necessary to provide the cost effective solution of connectivity to the village. This present study aims to identify the most suitable material to utilize in concrete pavement. Several studies have been conducted across the worldwide to identify properties of waste materials on concrete and environmental also. From the basis of different studies the waste materials to be selected and replaced partial manner instead of concrete components. From the several studies the suitable replacement percentage to be selected. In this study an attempt has been made to utilize waste material in rigid pavement for low cost concreting purpose. The selected appropriate ranging is to be used for rigid pavement construction in the grade of M30 as per IRC 44.**

Index terms- waste material, rural road, concrete pavement, rigid pavement, partial replacement, low cost concreting

I. INTRODUCTION

Rural road connectivity is important key element for rural development, it's developing rural economic and social activities, thereby increased employment in industries and service sectors as well as agriculture productivity. Those activities improve rural growth opportunities and poverty can be reduced. The road network transport 64.5% of all goods in the country. Generally village road get low volume traffic density because of rural transport traffic vehicle type. It's necessary to provide the cost effective solution of connectivity to the village.As per IRC: SP: 62-2004 rigid pavements are one of the best alternative solutions for flexible pavement. The government of India launched a major program known as Pradhan Mantri Gram Sadak Yojana (PMGSY) in December 2000 and main objectives of this program is to improve rural connectivity, designed new roads and maintained existing roads. The aim of the PMGSY is construct road of length 1,46,185kms of rural road to get benefit of 66,802 rural areas and also made up gradation of 1.94 lakh kilometers. Total investment of this connectivity program of PMGSY is 48,000 crores and up gradation of existing road plan is 79,000 crores. So, identifying cost effective solution is important.

A. RIGID PAVEMENT

The rigid pavement defined as the type of pavement which use plain or reinforced concrete section in surface course instead of asphalt binder. Rigid pavements are suitable for areas with shallow water table.

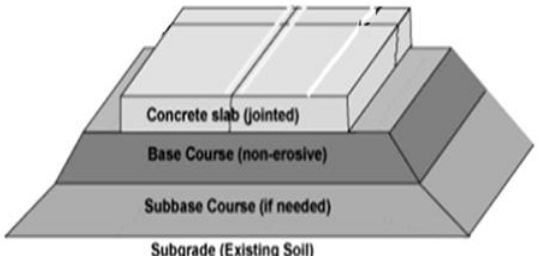


Fig. Road section of a rigid pavement

There are mainly three categories of rigid pavement are as follows:

a. Jointed plain concrete pavement (JPCP)
b. Jointed reinforced concrete pavement (JRCP)

c. Continuously reinforced concrete pavement (CRCP)

II. OBJECTIVES AND SCOPE OF THE PROJECT WORK

Followings are general objectives and scope of the project work

1. To study the properties of selected waste materials.
2. Studying the behavior of rigid pavements.
3. Analysis of rigid pavement
4. To choose an alternative material without compromising with its properties.
5. To optimize the Cost effectiveness of concrete by using different waste materials.
6. To find stress, strain and deflection characters using analysis

III. LITERATURE REVIEW

Main objective of this literature review collection is choosing waste material that can be used instead of concrete materials in partially manner. And also the selected waste materials must satisfy cost effective manner. The literature review is divided following ways based on materials,

A. PAPER WASTE

R.Ilakkiya and Dr. G. Dhanalakshmi (2018) conducted a experimental study on waste add as a additional material without any replacement. The testing purpose the conventional concrete mix 1:1.5:3 was used. The paper waste adds in the form of slurry. For the slurry formation obtained purpose paper kept immersed in water for 3 days. The slurry formation added with the additive range of 5, 10, 15% by the weight of cement, sand and coarse aggregate respectively. Strength of the concrete increased at 10%, after 28th day result the compressive strength is 28.99 N/mm2. Other than compressive strength the flexural strength is 6.5 N/mm2. After increasing paper slurry in the rate about above 10% the compressive and flexural strength reduced but the cost of the concrete get reduced.

Sagar S et al. (2018) this paper studied the character of waste paper in concrete with the help of compressive and water absorption test. The conventional test results are compared with replaced result to obtain solutions. The M25, M30 & M35 grade concrete mix used for testing. The water absorption test was carried out every 5% increase of waste material. The paper pulp replaced instead of fine aggregate. From results the compressive strength gets increased at 5%, after 5% the compressive strength get reduced compared with conventional and 5% replaced product. Water absorption ratios of the replaced concrete get increased compared with conventional one. And also the paper replacements produce light weight concrete. This light weight concrete is suitable for decorative purpose. Apart from strength analysis the CO2 emission rate is reduced in papercrete.

B. PLASTIC WASTE

Ahmad K. Jassim (2017) Carried a research on high density polyethylene (HDPE) is mixed with Portland cement to identify the possibility to produce plastic cement. The high density poly ethylene purpose bottle and food crates are used. The cement replaced by the polyethylene waste from the ratio of the 0, 15, 25, 30, 35,40,60, 80%. For obtaining waste HDPE in equal size purpose the grinding process carried out. Plastic cement with 60% of polyethylene makes a good workability. The best moisture absorption made by 25-30% of replacement. The stress strain behavior of this mix is plastic behavior in nature. The suitable percentage of waste HDPE is 25 to 35% which give good properties of mixture. Workability is reduced. Best compressive strength is obtained at 25% in the range of 2352N (pointload)

M.Chandu et al. (2016) In this study the low density poly ethylene (LDPE), poly propylene (PP), high density poly ethylene (HDPE) is used for project. The performance of the concrete was obtained by crushing, impact, compressive strength, abrasion of aggregates. As per this study the 1km of single lane road consume 10,00,000 plastic bags(LDPE) the plastic waste separation purpose the shredding machine used From this study the compressive strength and tensile strength of the concrete is increased at 5% of plastic coating. Testing purpose M35 concrete mix is used. From the result the performance of the concrete is increased by increasing plastic coat on the aggregate especially increasing waste in the range of 5%. The low density polythene type of plastic give better results than polypropylene. The bonding between the aggregates is reduced to make a road failures i.e., pot holes.

K. Sharma et al. (2015), The aim of this project is to use waste plastic is a binding material. Initially the plastic waste is collected from municipality and separation of plastic from organic waste is made. The plastic not directly used. The plastic used as a coating on top of the aggregates to reduce the amount of water absorption to increase the binding capacity of the pavement. The poly ethylene type of plastic is used for the project. The agglometeator shredding machine is used for cutting various waste plastic into equal size. The crushing value is increased using the plastic coat. The use of this innovative technology increased the strength. The strength confirmation made by conducting crushing test and los angeles tests. The author says this technique increased strength as well as increase total life time of the project. Uses of plastic coat on the aggregate reduce the usage of bitumen and increase the strength in 10%. This concept is innovative but cost wise this project cost is little higher compare to conventional one. But comparing lifetime circle this method is more effective one.

Senthilkumar Ariyamuthu and Rajagopalan Varadarajan (2015), an attempt made to use 40 micron size of plastic added with additive material in rigid pavement concrete to find compressive strength for those additive percentages. The additive percentage is 0, 0.25, 0.5, 1% by the weight of the cement. The waste plastic material is shredded and added with concrete mix as per code provisions i.e., IRC44-2008. The experimental result says the concrete strength is increased in the percentage range of 0.25%. 3.02% of compressive strength gets increased. The split tensile strength increased upto 3.35% while adding plastic. But, the workability of the concrete mixing is reduced while adding plastic. After increasing percentage of plastic in the range above 0.25% the compressive strength reduced upto 3.91% for 1% of plastic adding. The split tensile reduced in the range of 4.07% for 1% of plastic.

C. WASTE TYRE AND RUBBER

T. Senthil Vadivel and R. Thenmozhi (2018) states that1.2 billions of waste tyre rubber produced worldwide in a year. Out of 100%, 11% of postconsumer tyres are reused, recycled and 27% are sent to landfill (inner material) and only 4% is used for civil engineering projects. Waste tyre is replaced instead on fine aggregate. The ratios of 2,4,6,8 and 10% tyre used in replacing manner. The M20 and M25 mix used for testing purpose in the ratio of (1:1.43:3.03) & 1:1.21:2.71. The two different mix proportions of M20 and M25 Grade by weight with water cement ratios of 0.50 and 0.45 respectively. cube, cylinder & beam were prepared with M20, & M25 mix for this study with 2, 4, 6, 8 & 10 percentage of replacement of waste tyre rubber with fine aggregate. Shredded rubber crumbs are used for fine aggregate replacements in the sieve size of 2.36mm and 1.18mm. from results the Compressive strength decreases when the percentage of replacement of rubber increases. Split tensile strength decreases at the maximum of 25% at 10% replaced in fine aggregate. There is no change in workability while adding.

Rahul Mahla and Er. R.P. Mahla (2015) carried experimental study an attempt made to identify the various properties and strength with the coarse tyre rubber chips as aggregate. Scrap tyre waste rubber chips, has been used as coarse aggregate with the replacement of conventional coarse aggregate. In this experimental investigation, the M20 grade concrete used. Shredded rubber is used to replace the coarse aggregate. The replacement was carried out in the range of 10,25,50% instead of coarse aggregeate. The introduction of waste rubber tyre chips into concrete significantly increased the slump and workability. The loss of strength was obtained in both compressive and tensile in nature. Introduction of waste tyre as alternative source to aggregates in concrete, increase the weak properties of concrete.

D.RECYCLED CONCRETE AGGREGATE

Nivetha.R et al. (2018), experimentally investigate the demolished waste replaced instead of coarse aggregate in the range of 10,15,20%. This study the M25 mix design used for testing. DCA produced by the crushing of concrete rubble, then screening and removal of contaminants such as plaster. The strength of the concrete is increased while increasing demolition percentage. Upto 20% the strength of the concrete is increased. Water absorption details are not explained by this paper. At the end of 28 days the concrete crushing strength is increased. i.e.,34.26N/mm2. The cost of the construction is reduced while using recycled aggregate and also the environmental pollution reduced. The DCA is suitable for low cost concrete.

S. Jagadeesh et al. (2018). carried out the study, pozzolanic materials is added as a partial replacement of cement to improve properties of recycled coarse aggregates(RCA) by triple mixing approach. Triple mixing method will increase the properties of RCA by surface coating of pozzolana materials like Fly & Silica fume. The natural coarse aggregates replaced by recycled coarse aggregate by 25%, 50%, 75% and 100%. Recycled coarse aggregates (RCA) get greater water absorption and lower density while compared with conventional coarse aggregatesWith increase in replacement levels of Recycled coarse aggregates (RCA) there is a reduction in both tensile properties i.e., split tensile strength and flexural strength.

Nikita Patel and Dr. Piyush Patel (2016) use Recycled concrete aggregates (RCA) are used in concrete in replacement of conventional aggregates 20mm and grit aggregates, replacement of 50%. The compressive strength test carried out at 3,28,56th day from molding. After analyzing every result the replacement range of 50% get high strength. From split tensile strength result the tensile strength of the cylinder get reduced when compared with conventional concrete mix. At the end of 28 days the split tensile reduced in the range of 0.92%. after 56 days the split tensile strength reduced in the range of 0.99%. the rebound hammer result also proves the 50% replacement of RCA increase the compressive strength.

Er. Nirmaljeet and Er. Vikram (2017), this study based on analysis of plastic and hardens stage of concrete mix with different replacement levels of coarse aggregate with recycled aggregate and also the cement replaced by fly ash. The testing purpose the aggregate grades of M25, M30, M35 mix grades are used. The RCA replaced in the range of 50, 100% of natural aggregate weight. The cement replaced by 15% and 25% of its weight with flyash. 72 cube specimen and 36 beam specimens were made for testing purpose. The recycled aggregate obtained from M30 grade of concrete mix. The testing carried in two stages. At first stage the M25,M30 grade used for testing. Second stage time M35 grade used. Recycled aggregate obtained from lower grade mix cannot use for higher grade of concrete mixing. At fully replaced recycled aggregate with natural aggregate in M25 achieved its maximum strength. The fly ash addition increases the workability improvement. And also if we are adding amount of RCA in concrete is increase workability of the work. RCA from higher strength is suitable for lower strength mix. In M35 grade 100% replacement of NA(natural aggregate) by RCA with fly ash 25% time the maximum strength is attained.

S. Sakthivel et al. (2017) investigate demolished coarse aggregate (DCA) and steel fibers(SF) from lathe waste are replacing in coarse aggregate in different percentages. 40,50&60% of DCA with 1% of steel fiber from lathe waste replaced by the weight of coarse aggregate. The compressive strength computed at 7,14,28 days and strength compared with conventional concrete. The steel fiber size is retained at 2.5mm sieve. The mix ratio of 1:1.2:2.8 is used for testing. The replacement of DCA and steel fiber gives better result in compression and tension. The compression of those percentage with conventional one the replacement concrete get high strength compare to conventional one. The specimen made with 40% DCA and 1%SF replacement by coarse aggregate gives better compressive strength upto 1.27% increased, Split tensile strength increased upto 1.11% and Flexural strength of 1.29% increased.

D. RISE HUSK ASH (RHA)

Ayesha Siddika1et al. (2018) RHA gets high pozzolanic activities and its suitable one for replacement of cement in concrete. This paper studies various physical and strength characters of concrete with various replacement levels. The RHA formation required controlled incineration temperature range from 500-700 °C and the specific surface area up to 150 m2 /g. the cement replaced by the RHA is 10% and 15%. Adding RHA is increase stiffness by increasing cohesion of the concrete mix. Lower slump cone value is obtained at adding rise husk time. The compressive strength and tensile strength of concrete specimen is give better result with 10% cement replacement with RHA compare to conventional one. Use of RHA in concrete lowers the reduction in strength due to some chemical attack.

Rohit Siwach et al. (2015) in this study waste rise husk used in the form of ash and comparative study made with fly ash and combination of both. The study carried out in rajpura, Punjab. The rice husk ash gets no useful application and usually dumped into water streams and caused pollution and contamination so avoiding those problem purpose rise husk ash used as mineral admixture for concrete.

.IS 456- 2000 recommends use of RHA usage in concrete but does not specify quantities. The rise husk ash replaced by cement In the ratio of 0,10,20,30% by the weight of cement. The result shows Partial replacement of cement along with rice husk ash does not contribute to gain in flexural strength. Combination of fly ash and RHA is unable to achieve flexural strength in required level. But, RHA is suitable for environmental friendly concrete.

E.GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Krishnaveni.S et al. (2018) examine the Ground granulated Blast furnace slag (GGBS) as partial replacement material for cement and garbage ash as a partial replaced material for conventional fine aggregate. The GGBS replaced by the cement in the percentage of 40% and the garbage ash replaced in various percentage range 0,10,20,30% for M30 concrete. The comparative study carried out for conventional mix strength with replaced concrete strength. The compressive strength of the concrete increased when increasing amount of GGBS with cement. But replaced result shows the GGBS replaced deduce the use of cement content and also reduce the amount of CO2 emission. Most suitable mix is 40% GGBS+ garbage ash 10,20% mix. The maximum strength attained in the mix of 40% GGBS+ garbage ash 20%, the strength is 34.5N/mm2. The cost of GGBS in the market is 3 times less than the cost of the cement including packing, transporting.

K. K.Siddhartha et al. (2018) carried the experimental investigation made for partial replacement of GGBS instead of cement and partial replacement of steel slag instead of fine aggregate. The replacements of cement by GGBS in the percentage of 40%, 50% and 60% and replacement of fine aggregate with steel slag by 10%, 20% and 30% The strength studies carried out and compare both strength to choose best one. The compressive strength decreased in composite binder and split tensile strength gets increased. The percentage of increase in strength decrease with further adding amount of GGBS. Increasing amount of steel slag may cause corrosion.

Dumpati Mamatha et al. (2018), In this project the partial replacement of cement by GGBS and Fly Ash. GGBS and Fly Ash replaces the cement at 20%, 40% and 20%,30%.The grade of concrete is M40.The concrete tests are carried out for 7,14, and 28 days. The water cement ratio was maintained at 0.45 for all mixes. This experimental program is study the strength and durability characteristics of pavement quality concrete containing GGBS and fly ash. The rate of strength gain in compressive strength, and flexural strength of concrete is very fast at 14 days curing period and the rate gets increases with age of curing. From the results 65% of strength is achieved at 7th day. Therefore, speedy construction is possible.

Baskaran.P et al. (2017) According to this paper experimental investigation was made that the possibility of utilizing granulated blast furnace slag (GGBS) in cement concrete as a sand replacement. The percentage of GGBS replacement is 0,5,10 and 15 % to natural sand for the standard w/c ratio of 0.4 is considered. The testing purpose mix design M25 (0.40:1:1.26:2.74) is used. The specimens tested for 7days, 14 days and 28 days. Its achieved maximum compressive strength when sand is partial replacement of fine aggregate with GGBS (15%). The maximum flexural strength for partial replacement of sand with GGBS be achieved by 15% is found to be greater than the conventional concrete. From the results, The optimum percentage for replacement of GGBS is 15%.

Shiny Brintha G and Sakthieswaran N (2016) made a research work carried out to evaluate harden property of concrete for M30 grade mix with GGBS, Metakaolin and Copper Slag for replacement of cement and fine aggregates. The Metakaolin and GGBS were used equal percentage of 5, 10, 15, 20 and 25 % by the weight of cement. The copper slag used instead of fine aggregate in the percentage of 25,50,75%. The adopted water cement ratio is 0.38. the better workability obtained in the mix of 15- 20% of GGBS and metakaolin with 50% of copper slag. The maximum compressive strength obtained in the mix of 50% copper slag and 20% of GGBS and metakaolin. The maximum split tensile obtained in the percentage of concrete containing 50% copper slag and 15% of GGBS and metakaolin. The maximum felxtural strength obtained at the replacement level of 50% copper slag and 15% of GGBS and metakaolin.

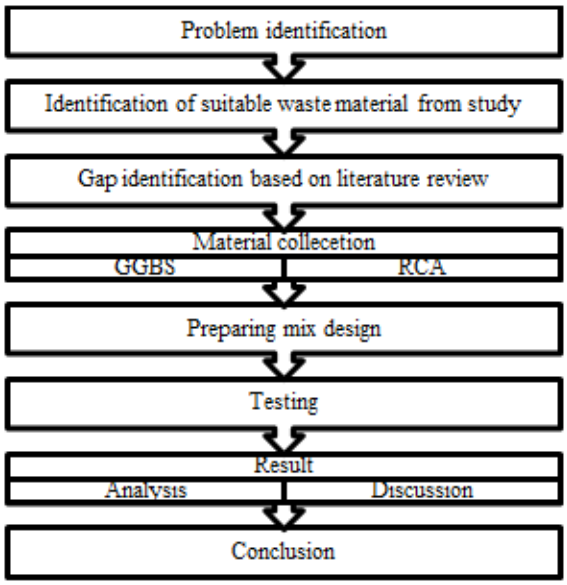
N Sellakkannu and Roshini P (2017) made a Experimental Investigation on Partial Replacement of Cement by GGBS. Ground Granulated Blast Furnace

Slag (GGBS) was partially replaced by the weight of cement in the percentages of 0%, 10%, 20%, 30%, and 40% . the concrete mix was made in M30. The super plasticizer used for concrete making (Fosroc Conplast SP430 DIS, Sulphonated Napthalene Formaldehyde). From the study results usage of GGBS instead of cement by the partial manner reduce the amount of heat produced in hydration process. The safe replacement of cement by the GGBS is 30%. GGBS increase the surface finish and reduce the bleeding.

F. SUMMARY

From above studies, the Recycled Concrete Aggregate (RCA) and Ground Granulated Blast Furnace Slag (GGBS) is suitable for low cost concreting without affecting strength of the concrete. From studies suitable range of replacement of RCA and GGBS is 30% by the weight of coarse aggregate and cement respectively. As per IRC 44: 2017, minimum M40 grade of concrete i.e.,flexural strength 4.5 MPa for construction of concrete pavements. For otherthan district road minimum M30 grade of concrete (flexural strength 3.8 MPa) is recommended to be used.

IV. METHODOLOGY



V. CONCLUSION

A.Paper: the paper waste is suitable for low cost concrete making. But, apart from cost the paper waste is not suitable for rigid pavement. Because of poor satisfy the strength condition. It's suitable only for decorative and light weight condition.

B.Plastic: studies the plastic wastes improve pavement performance when adding in coating technique. plastic waste is suitable for rigid pavement for some performance improvement. But, plastic waste not suitable for low cost concreting its reduce workability.

C.Tyre and rubber: . The introductions of waste tyre increase the weak properties of the concrete. And also some time the workability of the concrete gets reduced. Upto 20% waste tyre is suitable for slightly reducing compressive strength in nature. So the waste tyre is not suitable for rigid pavement in high percentage.

D.RHA: the RHA suitable in mineral admixer form. RHA improve cohesive property to increase stiffness. But, due to some chemical reactions concrete lowers its strength when using RHA in the huge range.

E.RCA&GGBS: Based on literature survey It was concluded that waste materials the RCA& GGBS is suitable for low cost concreting without affecting strength of the concrete. using RCA increase water absorption and reducing workability is compensated by GGBS. Because GGBS increase stiffness, reduce porosity in concrete mix.

F.Future work (works do be done):

1. To find workability of M30 mix for various replacement percentage.
2. To find toughness and hardness characters of RCA.
3. Durability check for various replacement percentages.
4. To find various stresses in rigid pavement.
5. Identify optimum percentage for replacement of GGBS and RCA and low cost concreting.

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