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Study of Soil Stabilization with Cement and Demolition Waste in Highway Subgrade: A Review

Fayaz Ahmad Bhat[1], Dr. Rakesh Gupta[2]
[1]*M. Tech Scholar, Civil Department, SRMIET, Bhurewala, Ambala*
[2]*Assistant/Associate Professor, Civil Department, SRMIET, Bhurewala, Ambala*

***Abstract:** This paper summarises the various researches regarding the use of construction and demolition waste in pavement sub-grade. Many studies regarding use of construction and demolition waste in pavement sub-grade were studied and their effects were also analysed. After the analysis and study it was concluded that the construction and demolition waste can be used as a soil stabilizer. It not only enhances the various properties of sub-grade but also helps in the solving of problems regarding waste disposal. Using construction and demolition waste in pavement sub-grade not only helps in the removal of environmental hazards of the waste material but also helps in the reduction of cost of landfilling and also reduces the cost of construction of embankment. Further it is also concluded that Construction and demolition waste contains aggregates of variable sizes including coarser and finer. Coarser fractions have been used as recycled aggregates in pavement construction but finer fractions are being left out still as waste material. Its finer fractions being fine enough to alter the soil gradation; on admixing of the same could improve the packing density of the soil mass. Hence, efforts should be made to exploit these fines as a soil stabilizer for improving the properties of clayey soil as subgrade.*

***Keywords:** Soil, waste, sub-grade, CBR, fly-ash, stabilisation, construction and demolition waste.*

I. INTRODUCTION

The word soil is derived from the 'Latin' word 'Solium'. The word 'Solium' in 'Latin' means the top layer of the earth on which plants grow according to Webster's dictionary. Generally soil consists of water, air and solid particles. Soil is formed either by physical weathering or by chemical weathering. Beside the complexity of understanding soil, geotechnical engineers made their best efforts to group the soil based on its specific response to different environmental conditions. Soil can be classified as highly compressible and soil of low compressibility, expansive and non-expansive, sensitive & insensitive, highly plastic, very soft to stiff clay, loose and dense sand, etc. Soil stabilisation is the process of alteration of soil in order to enhance its properties. Soil stabilisation not only increases the shear strength of soil but also helps to control the swell shrink properties of soil, thus improving the load bearing capacity of soil subgrade to support pavements.

II. STATUS OF PAST RESEARCHES

In 2004 the utilization of cement kiln dust in soil stabilization was evaluated. Atterberg limits and strength tests were conducted before and after selected durability test. Relative values of soil stiffness were also tracked over a 28 days curing period. The test results showed a significant improvement in performance with the addition of cement kiln dust. [1]

In 2008 the effectiveness of various construction and demolition wastes for the sustaible development goal was reviewed, studied and presented the various categories of such wastes and reported the use of fines from these wastes to be very effective, especially its significance in improving the CBR of the subgrade soils. [2]

In 2010 it was observed that the stabilized sub-grade provides a strong base to withstand load from the heavy vehicle. Studies on sub-grade stabilizations with various materials is a developing research field since strength of sub-grade makes a significant impact on the performance of pavement structures. Investigations on recycled materials as alternatives for stabilization binders and materials are becoming popular to reduce the demand on natural sources and then to reduce the cost. Strengthening the sub-grades with fly ash under various conditions has been seen in recent past studies. [3]

In 2012 a study on the application of construction demolition waste for improving performance of subgrade and sub-base layers the same to be quite effective in the stabilization process was done. The CBR value improved significantly by mixing soil with C & D wastes. [4]

In 2012 a study on five different types of C&D waste was conducted. The different types of C&D materials tested are RAP (Reclaimed Asphalt Pavement), CB (Crushed Brick), FRG (Fine Recycled Glass), WR (Waste Rock) and RCA (Recycled Concrete

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Aggregate). Various geo-environmental and geotechnical properties was investigated in this research to use these C&D waste in pavement application. The durability in abrasion was more for FRG, RCA and WR as compare to CB and RAP. RCA, WR and CB fulfil the CBR (California bearing ratio) and RLT (Repeated load triaxial test) requirements thus can be used as sub-base material whereas RAP and FRG need to improve its CBR value by mixing with additives or other high quality materials. [5]

In 2012 a laboratory study on C&D waste for use in sub-base & base course of flexible pavement was conducted. C&D waste which contains C&D powder, C&D Jeera Size Aggregates (size less than 6mm), C&D aggregates (size between 20mm to 6mm). The C&D waste mix in the ratio 50:31:19 (C&D powder 50%: C&D jeera size aggregate 31%: C&D aggregates 19%) with 3%, 5% & 7% cement content was mechanically stabilized and unconfined test were performed on the stabilized mix. It was concluded that C&D waste mix stabilized with 5% cement can be used in sub-base and base courses. [6]

In 2013 the importance of reduce, reuse and recycle (3R) concept for managing construction waste in India was studied. The study shows that the total quantity of C&D waste generated in India is estimated to 11.4 to 14.69 million tonnes per annum. [7]

In 2013 various tests were conducted on CDW (construction and demolition waste) aggregates to check its suitability as sub-base layer in flexible pavement. In this study it was observed that good quality of materials can be produce from CDW for sub-base and base-course which satisfy the flexible road requirement. The compatibility and strength of CDW aggregates was same as of crushed stone aggregates used in sub-base and base-course. Abrasion value and aggregate crushing value are slightly on the higher side for CDW aggregates as required by MORTH specification. The water absorption of CDW aggregates was high compared to crushed stone. [8]

In 2014 behaviour of Alccofine in expansive soil when used as stabilizer material for sub-grade was studied. Soaked (4 day curing) CBR test was performed on stabilized & un-stabilized soil. When alccofine alone was used with soil small improvement was shown in CBR value of soil, hence cement was used as binder material to improve the CBR. Different proportions of Soil: Alccofine: Cement on which soaked CBR test was carried were (100:0:0, 100:2:1, 100:3:1.5, 100:4.5:2.5 & 100:6:3.5). The CBR results of different mix proportion give the optimum percentage of cement and alccofine (i.e. 4.5% cement & 2.5% alccofine). When 4.5% cement and 2.5% alccofine by weight of soil was used, the maximum layer thickness reduction of 28.85%, 28.16% and 28.12% for traffic intensity 50, 100 & 150 msa was determined. Hence the study concluded that for a road stretch of length=1km & width=7m cost up to INR 3.58 lacs, 5.6 lacs and 7.61 lacs can be saved for traffic intensity 50, 100 & 150 msa, if optimum percentage of cement and alccofine is used. [9]

In 2014 study on the improvement of the strength of inorganic clayey soil using cement additive was done. Their researches show about the transformation of soil index properties of untreated local soil and also study the impact of addition of 2% PPC to untreated soil by dry weight of the soil to be stabilized for road construction plus the benefit of economy to pavement designers and contractors. Engineering properties of clayey soil got improved at 2% PPC. Maximum dry density increases at decreased LL and PL values. Comparing CBR value of untreated CL soil and same treated with 2% PPC indicates good rise from 6.64% to 21.82%, improving sub grade load carrying capacity. [10]

In 2014 an experimental study using two waste materials i.e. crushed RAC (recycled asphalt concrete) &RCC (recycled cement concrete) in unbound base layer of flexible pavement was carried. The natural aggregates of unbound base layer were replaced by RAC and RCC in different proportion (0 %, 20 %, 50 % & 75 % by weight). Toughness of RAC and RCC was lower as compared to natural aggregates. Bulk density of unbound base layer decreases with addition of RAC & RCC, which will decrease the transportation cost. The soundness requirement for unbound base layer was fulfilled, when RAC & RCC was added. MDD (Maximum dry density) decrease with increase in RAC & RCC content. The OMC (Optimum moisture content) increases & decreases respectively with increases in RAC & RCC. The unbound base layer containing RAC & RCC shows lower strength than the primary aggregate. The inclusion of RCC (20%, 50% & 75%) in unbound base layer fulfils the minimum requirement of CBR (California bearing ratio) in all proportion; whereas RAC between 20 to 50% cannot meet up the CBR requirement. RAC make the unbound layer sensitive to compaction level which requires more control during compaction of such materials. [11]

In 2014 the behaviour of three different types of industrial waste materials in application of pavements was experimentally studied. The three types of industrial waste used in experimentation were fly ash, stone dust, WRP (waste recycle product) which were reinforced with HDPE (high density polyethylene) waste strips. The strip content (0.25%-4% by weight) and aspect ratio 1, 2 & 3 was used to investigate its effect on CBR (California bearing ratio), PPLR12.5mm (Peak piston load ratio at 12.5mm penetration) & sub-grade modulus of plastic strip-reinforced specimens. In this study it was observed that addition of waste plastic strips to industrial wastes results in increase in CBR & Ks (sub-grade modulus). The maximum improvement in CBR value was obtained when 4% strip content & aspect ratio 3 was used. CBR value of unreinforced WRP was very high therefore the base course material can be replaced directly by this waste material. Sub-grade modulus for fly ash, stone dust & WRP increases with 4% strip content &

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aspect ratio of 3. The total thickness of pavement can be reduced if HDPE strip reinforced waste materials are used as sub-grade. [12]

In 2016 study on the use of Construction and Demolition Waste in roads and footpaths was conducted. The various types of Construction and Demolition Waste studied include Recycled Concrete Aggregate (RCA) crushed bricks (cb) reclaimed asphalt pavement (RAP) fine recycled glass (FRG) and waste rock (WR). It was found that Construction and Demolition Waste material were suitable for roads and footpaths. [13]

III. CONCLUSION

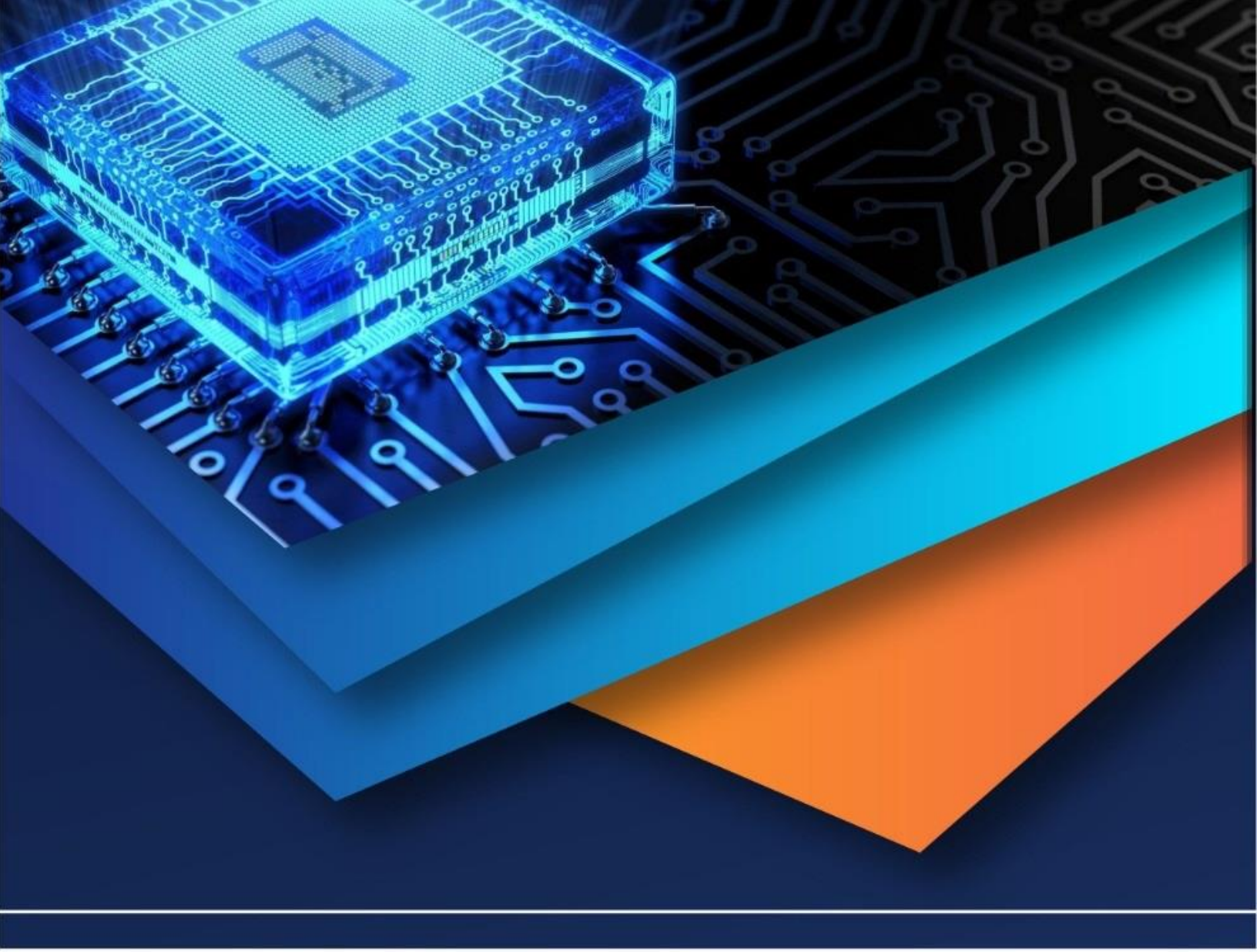
After going through number of papers it is concluded that the construction and demolition waste can be used as a soil stabilizer. The studies show that large quantities of construction and demolition waste is being generated annually in India. Due to the large quantities of C&D waste which is produced in the country, its disposal in landfills poses a serious environmental problem. Therefore, attempts have to be made to separate waste according to the type of material and subsequently find possible applications for its reuse. This will helps to reduce the environmental hazards of the waste material, cost of landfilling and cost of construction of embankment in comparison to other stabilization methods.

Material engineers are steadily looking for suitable and cheaper stabilizers for use in clayey soil stabilization as alternatives to costly additives, like, cement, lime etc. Construction and demolition waste contains aggregates of variable sizes including coarser and finer, coarser fraction have been used as recycled aggregates in pavement construction but finer fractions are being left out still as waste material. Its finer fractions being fine enough to alter the soil gradation; on admixing of the same could improve the packing density of the soil mass. Hence, efforts should be made to exploit these fines as a soil stabilizer for improving the properties of clayey soil as subgrade.

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