USE OF RECLAIMED ASPHALT PAVEMENT AS A PAVEMENT MATERIAL: A REVIEW

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ABSTRACT:
With enormous construction activities taking place, lack of high quality quarry aggregates has resulted into significant concern for researchers and engineers in the world of different countries including India. Also facing problems such as rising costs, lack of availability and scarcity of natural materials such as aggregates for pavement construction resulted into urgency for finding out sustainable, viable alternative materials which could be considered as partial replacement to natural aggregates. The waste generated from construction and demolition of infrastructure activities (commonly known as C & D Waste) produced large quantity of waste which not only constituent major portion of landfills but also leads to environmental degradation. This generated waste materials could be utilised in different infrastructure activities if properly recycled and with aim of achieving reduction in demand of virgin aggregates or natural aggregates, efforts have been made to incorporate these waste materials generated and occurred from C & D waste and use them as alternatives to naturally available aggregates; as use of these materials resulted into significant environmental benefits such as conservation of natural resources required in different pavement layers construction. This present study reveals more information about the waste materials such as Reclaimed Asphalt Pavement (RAP) generated from C & D waste and their potential reuse as in highway sub base or base material.

Index Terms **- C & D Waste, Reclaimed Asphalt Pavement (RAP), Virgin Aggregates**

I. INTRODUCTION

In recent years, with the rapid growth in the population resulted into generation of more waste from which many of the materials will last long in the environment. These non decaying materials produces waste disposal crisis which again owing to disposal crisis over the world. With the rapid growth in the population, need of good infrastructure based constructed roads network became prime importance to fulfil the requirement for rapid economical growth. With aim of achieving the good connected road network helping provide connectivity to remote areas, accessibility to markets, schools, and hospitals etc; the traditional way of practicing construction of pavements, both for conventional flexible pavements and rigid pavements requires more quantity of naturally available materials such as aggregates required for construction of base, sub base and wearing course of pavements. With respect to meeting the demand of construction activity of roads for base, sub-base and the wearing course, the natural stone aggregates available are heavily consumed occurred from quarries and hence the depletion of these materials would likely to occur. This depletion of natural resources not only leads to reduction of resources, but also consuming lot of energy depleting the energy sources also. Considering the current situation, using recycled materials obtained from the construction and demolition waste (C & D WASTE) could be found as good viable alternatives for natural available aggregates following the suitable recycling techniques available. Reclaimed asphalt pavement (RAP) obtained from the partial or full depth reclamation process is found to be one of the viable alternative for the natural resources to be used in the construction of base, sub base and wearing course of the pavement and has become increasingly adopted in the recent years for the different countries over the world.

II. LITERATURE REVIEW

Reclaimed Asphalt Pavement (RAP):
With the increase in demand for natural resources consumption in construction of flexible pavement and rigid pavement typically constructed over the years, recycling of the pavement materials has become a viable alternative to be used in the pavement maintenance and rehabilitation or construction. Considering the benefits obtained by using the alternative materials to the natural resources, such as conservation and preservation of environment, large quantities of reclaimed asphalt pavement (RAP) obtained through the flexible pavement rehabilitation and reconstruction could be found as one of prime and viable alternative. Considering the above statement, investigations were done by different researchers as follows:

A study was conducted on the use of reclaimed asphalt pavement as base materials **(Sayed et al.1993),** and the results revealed that reclaimed asphalt pavement (RAP) was found to be well graded materials, and the values required by the local governing authority, such as maximum dry density and optimum moisture content, were within range and could be economically used as a base materials .

Mohammad H Maher et al (1997) conducted laboratory and field investigations to evaluate the use of reclaimed asphalt pavement as base and sub-base applications. Following the different test conduction the results obtained showed that the resilient modulus value has a slightly higher than that of dense graded aggregates used in state of New Jersey.

Taha R. et al. (1999) participated in a laboratory research to determine if recovered asphalt pavement might be utilised as a replacement for available virgin aggregates in pavement applications. Because a considerable amount of recovered asphalt pavement remains unutilized in the Sultanate of Oman, this study investigated the usage of RAP in pavement applications. Various mixes were created based on the RAP/virgin aggregates ratio. According to the findings of a laboratory research, a minimum of 10% recycled

asphalt pavement (RAP) may be used as the greater California bearing ratio and dry density obtained when using Reclaimed Asphalt Pavement alone.

Ramzi Taha, Ali al Harthy et al (2002) evaluated cement stabilized- RAP and RAP-virgin aggregates blends as an option for base course layers in the laboratory. Different mixes of virgin aggregates/RAP were produced and cured using 3-7% type I Portland cement, respectively. After completion of required curing period for respected samples prepared, with the addition of cement and virgin aggregates, the optimum moisture content, maximum dry density, and RAP strength all increased significantly. Also longer period of curing helps for yielding higher strength of materials. A total amount 100% use of reclaimed asphalt pavement was not referred unless stabilised with the cement.

Ramzi Taha (2003) studied the possible application of cement kiln dust–stabilized RAP and RAP with virgin aggregates mixes in an experimental study effort on assessing cement kiln dust stabilised reclaimed asphalt pavement aggregates as a pavement bases. The various mixes were prepared by changing the amounts of Reclaimed Asphalt Pavement (RAP) and virgin aggregates from 0 % to 100% adding the cement kiln dust from o% to 20% in it. The various findings obtained show that the inclusion of cement kiln dust and virgin aggregates to the blends may have aided in improving the MDD and UCS of the RAP. A cement kiln dust content of 15% appears to be optimal for achieving higher strength, and RAP aggregates may be used as a viable alternative to naturally available aggregates.

W. Spencer Guthrie et al. (2005) studied the environmental impacts of reclaimed asphalt pavement (i.e. RAP) on mechanical characteristics of foundation materials that might be used in the pavement. The purpose of this study was to look at the impact of reclaimed asphalt pavement on mechanical characteristics, using two different types of aggregates that are generally sub-rounded and angular aggregates considered during work. After collecting result data, it was discovered that the California bearing ratio (CBR) values fall by 13 to 29 percent on average, with a 25 percent increase in reclaimed asphalt pavement (RAP). From 0% to 25% RAP, an increase in stiffness was seen; however above 25% RAP level, the trend was reversed (i.e. decreasing in nature).

Ashley V Brown et al (2006) additionally investigated and evaluated the work for utilising cement stabilisation of aggregate base materials combined with RAP. The study's initial goal was to see how RAP and cement content affected the strength and durability of recycled aggregate base materials. The laboratory study included an experimental design that took into account five different types of RAP and cement contents with various percentages. The unconfined compressive strength and tube section tests were used to determine the strength and durability of the materials. Based on the overall results, it was determined that blends containing 75% Reclaimed Asphalt Pavement (RAP) tend to be extremely sensitive to cement concentration, whereas blends containing 1% cement were shown to be less sensitive to reclaimed asphalt pavement.

In an experimental research on appraising recycled or alternative materials as pavement bases, **Sireesh Saride, A D Puppala et al (2009)** investigated two types of recycled materials: (RAP) and quarry fines. Based on laboratory and field performance, certain findings were reached that showed both materials to have very minimal swelling and compressibility. When compared to untreated samples, the unconfined compressive strength of the blends tested improved considerably with the addition of cement content. Installed inclinometer for assessing deflection values determined to be within acceptable limits. Finally, it was discovered that the recycled materials used in this research study were capable of withstanding high traffic loads.

Derya Daniz et al. (2010) were involved in work that investigated the expansive properties of reclaimed asphalt pavement (RAP) and virgin aggregates used as base materials, with the main goal being to understand the properties of reclaimed asphalt pavement, which included steel slag aggregates (SSA). Different samples were collected from the location named as state of Illinois with application in as pavement bases and sub bases in appropriate proportions following ASTM codes of practice. Following the experimental work, it was determined and stated that, according to the ASTM code of procedures, RAP with steel slag 60%, surface RAP 90% rap was effectively placed as a base and sub base in pavement. Without appropriate curing, porous and nonporous steel slag aggregates should never be utilised in base and sub bases.

Tahsina Binte Alam; Magdy Abdelrahman and Scott A. Schram (2010) studied Laboratory characterisation of RAP as a base layer. Previous literature indicated that, RAP has a structural value as a pavement layer. The mechanistic–empirical pavement design guide requires properties such as the resilient modulus (MR) of unbound layers. The resilient modulus from laboratory tests was used to evaluate the behaviour of a base layer mixture containing varying amounts of RAP. RAP from millings was mixed in varying amounts with local aggregates. Resilient modulus testing revealed that when RAP concentration grew, so did the MR. The results also revealed a link between M_R and density. According to the findings, RAP possible to be employed in pavement base layer applications.

Deren yaun; Soheil Nazarien et al (2011) conducted research on the mix design of cement treated base materials with high content for RAP in order to better understand and assess the best blend material mix for achieving a practical base course. Various mixes including 100%, 75 % and 50% RAP, as well as 0-6 % cement content was evaluated with both virgin and salvage aggregates. The experimental findings showed that, in addition to the cement content, the quantity of reclaimed asphalt pavement content and finer aggregates content had a substantial impact on the RAP mix characteristics. The cement concentration discovered to be around 4%, 3%, and 2% for reclaimed asphalt pavement content in the order of 100%, 75%, and 50% material does not have a serious effect on strength and modulus properties of cement treated mixes.

Montepara A, Tebaldi G., et al (2012) tested RAP and natural aggregates mixtures for use as pavement sub base layers. The performance of a sub base produced by mixing 50% natural aggregates and 50% RAP was investigated in this study. LWD tests done shortly after construction revealed a similar performance of a combination mixed with 50% RAP and a mixture made entirely of natural aggregates. Mixing with natural aggregates to construct the sub base layer is an additional alternative. According to the results, sub base produced by combining a high proportion of RAP with natural aggregates obtained the same short and long term

performances, albeit somewhat higher. Additional triaxial experiments are being conducted to evaluate the internal friction angle and to provide a detailed mechanical characterisation of unbound mixes containing a high proportion of RAP.

Albert M Bleakley and Paul J Cosentino (2013) conducted research to improve the characteristics of recycled asphalt pavement as a foundation material by mixing and chemical stabilisation. The recovered asphalt pavement (RAP) and aggregate mixes were compacted by modified proctor test in the experimental-laboratory technique, with or without the application of chemical stabilisation. The findings for various proportions were obtained, and it was found that a mixed mix with RAP of 75% or less worked adequately with and without the inclusion of cement as a stabiliser. The lime rock bearing ratio test (LBR), which was used in place of the California bearing ratio (CBR) to assess the strength of the mix, likewise yielded substantial results as required by the local authorities. The amount of stabilisers used made a significant effect.

Deepti A, Sireesh Saride, et al (2014) examined fly ash-treated RAP for the construction of feasible pavement bases from an Indian viewpoint. Because of rising prices and unavailability of natural resources such as aggregates, transportation authorities are looking for alternative pavement designs for new construction, maintenance, and rehabilitation. While researching the background of research work, it was discovered that very little work had been done on the usage of RAP in various layers of the pavement. The primary goal of the study was to examine the use of recovered aggregates from older pavements with the addition of stabilisers to enhance pavement performance for long-term durability and to reduce asphalt coursing, which in turn helping reduction in the carbon footprint. Samples were obtained from ongoing project site, and the specimens were produced using RAP as the primary component. In addition, fly ash is added as a stabiliser, and the mixtures are tested in the laboratory for strength and stiffness. The results showed that a RAP base layer stabilised with fly ash substantially enhanced the resilient behaviour at 30% fly ash substitution by weight. The performance degraded more as the fly ash concentration increased. Overall, it was determined that reclaimed asphalt pavement stabilised with fly ash may be utilised as a base or sub base.

Deepti Avirneni, Pranav R.T. Peddinti, and Sireesh Saride (2016) investigated geopolymer stabilised base courses with the use of RAP material in the base. The adoption of RAP in the construction of base courses has been discovered and shown to be a feasible option not only to conserve natural resources, but also to cut costs, reduce pollution, and reduce land filling. Several recent studies have shown that untreated RAP is ineffective unless used with VA and/or stabilised with additives due to its poor gradation and bonding properties. Because most design requirements limit the quantity of RAP in the base course to up to 30% by weight, it was recommended in this study to promote a high proportion of Reclaimed asphalt pavement in the base course by stabilising the RAP: Virgin Aggregates are mixed with flyash. The current investigation confirmed the appropriateness of these blends in terms of initial compressive strength and equivalent strength during alternating wet/dry cycles. Leachate tests were also performed to validate the permeability of the stabilizer/activator employed. The complete test findings revealed that of RAP: VA mixtures strength deficiency was minimal, making them acceptable to use in as for base course.

Anand J. Puppala, Aravind Pedarla, Bhaskar Chittoori et al (2017) investigated the prolonged durability of chemically treated RAP as a base course in the pavement section. Recent research has shown that when combined with aggregate and stabilised with cement or fly ash additives, RAP may be utilised successfully in foundation layers. This use in the pavement foundation layer maximises the application of RAP material and reduces its discarding in landfills, help in becoming environmental beneficial technique. The prolonged durability of untreated and stabilised specimens was evaluated in this study by completing conventional durability tests to simulate moisture changes in the field caused by seasonal dissimilarity. Additionally, leachate experiments carried out to investigate the influence of precipitation penetration on the stabiliser from stabilised RAP mixes. According on the durability experiments attended on the RAP mixes studied, the mix with 60% RAP and 40% base with 2% cement produced compatible results when correlated to the other sample combinations tested. For all samples tested, the quantity of calcium-ion consternation leached out of the treated mixtures was below 50 ppm. After 7 and 14 cycles of leaching, the resulting strength was near to the necessary 300-psi strength, indicating that the samples were functioning satisfactorily. These chemically treated mixes were recommended for road foundation layers due to their modest volumetric changes and little leaching strength loss.

Surender Singh, G.D.R.N. Ransinchung, and Praveen Kumar (2017) researched and analysed the usefulness of RAP aggregates in rigid pavements. The inclusion of dust, asphalt film, and aggregated particles is thought to be the principle reason of the features of RAP-comprehensive concrete being reduced. These contaminants were removed using the technique Abrasion and Attrition (AB&AT). Six mixes were created by substituting Natural Aggregates (NA) in various amounts with RAP aggregates. It was discovered that DRAP aggregates using the AB&AT technique significantly assisted in eliminating impurities, resulting in better bonding. The addition of beneficiated RAP aggregates to concrete increased the workability of the mix while decreasing the hardened concrete characteristics. Although acquired findings were determined to be inside the allowable values for generating a concrete mix with of 40 MPa.

III. CONCLUSIONS:

This above research article gives an overview and information about use of RAP as a pavement base or sub-base material. With following the suitable guidelines and the design procedure one can adopt this material as a partial replacement to the natural aggregates. Following different conclusions were drawn out from literature review:

- The addition of waste material RAP as partial replacement to natural aggregates found to be a good and viable alternative as a pavement sub-base material which can help into reducing scarcity of naturally available aggregates required in the construction of different pavement layers.
- The quantity of rap to be added with the virgin aggregates or old aggregates depends upon the different strength parameter and was limited up to 80% replacement to natural aggregates.
- The use of 100% RAP was not advisable without being stabilised with stabilisation agents such as cement.
- With the use of varying percentage of RAP with or without stabilisation agents could helped in reducing the total project cost upto 30%.

- The use of RAP aggregates obtained through the rehabilitation of flexible pavement could be found as suitable and viable alternative to the natural aggregates.

However it is observed that one cannot use the 100% RAP material without being stabilised using stabilised agents. So it could be the challenging work for upcoming researchers.

IV. ACKNOWLEDGMENT

The author would like to acknowledge Department of Civil Engineering, Sandip University, Nashik for their support and Dr. P.L. Naktode, Professor and Head of Civil Engineering Department, Sandip University, Nashik for his continuous guidance and providing important inputs regarding research work.

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