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Study on Engineering Properties of Bituminous Mixes using Coal Ash and Jute Fiber in Flexible Pavements: A Review

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Abstract: ***The paper summarizes the various researches regarding the use of natural fiber such as jute fiber in dense grade bitumen. Many studies regarding use of natural fiber in dense grade bitumen were studied and their effects were also analysed. Thermal power plants that work on coal are important source of power generation in India. These power plants produce coal ash (fly ash and bottom ash) as wastes. Dumping these wastes is threat to environment and causes pollution to natural resources such as air, water, land, and also has harmful effects on human health. This research work is done so that coal ash, namely bottom ash as fine aggregate and fly ash as mineral filler with natural fiber (such as jute fiber)in optimum quantities could be used to improvise the engineering properties of bituminous paving These waste products are available in large quantities and can be used to produce bituminous paving mixes that are economical which t in turn saves the natural aggregates of the country. It was concluded that the bituminous mixes that are designed with coal ash has given satisfactory result in term of performance characteristics, while in Marshall Properties analysis it has shown some draw backs in the ground of high air void and reduced density of mixture***

Keywords: Coal ash, Bottom ash, Fly ash, jute fiber, Emulsion, Indirect tensile strength, asphalt concrete, Georgia Loaded Wheel Tester.

I. INTRODUCTION

Pavements or highways or roads are regarded as country's backbone, upon which it's up swings and progress depend on. All countries normally have a series of programs for building a new road infrastructure or emerging the existing one. Construction of both flexible and rigid pavement include a gross amount of investment to reach better performance oriented and smooth quality of pavement that will endure for long time. In India, where highways are considered as the primary function of transportation, Government of India has been investing a huge amount of money for developing the pavement construction and maintenance. A detailed engineering study may retain significant amount of investment and pavement materials, which in turn achieves a reliable performance of the in-service highway. In case of flexible pavement, two important factors are taken into considerations i.e. Mix design and pavement design. This study is centered on engineering property of bituminous mixes prepared from non-conventional or alternate materials.

II. STATUS OF PAST RESEARCHES

Shuler, T. S. [1976] [1] performed a laboratory study in which he took six samples of bottom ash obtained throughout the state of Indiana and tried to physically characterize the materials. Bituminous mixtures with ash had surprisingly improved in retained stability in the water Sensitivity Test as compared to those without ash, Skid resistance of the mixtures also had improved.

R. E. Long and R.W. Floyd [1982] [2]studied that aggregate shortages and increased transportation costs have greatly increased prices of related construction items in areas of Texas which is not blessed with natural aggregates. They concluded bottom ash blend mixes require more asphalt, produce lower density mixes, cools fast, requires adequate rolling works , mixes exhibit high internal friction with no lateral displacement during compaction, this mix has maintained acceptable skid values, the cost of bottom ash blend mixes is somewhat higher based on additional asphalt used and aggregate transportation costs.

David Q. Hunsucker [1992] [3] conducted an experimental analysis, the experimental section utilized bottom ash aggregate, limestone and natural sand aggregate. He concluded that because of the absorptive characteristics of bottom ash aggregate, nearly fifty percent more bitumen is required in the mixture. The increased asphalt content results in a higher price of bituminous concrete material. Overall performance of a bituminous surface mixture, especially with respect to its skid resistant properties was improved.

Musselman et al. [1994] [4] performed a two year demonstration project they concluded that the use of bottom ash as a fractional substitute for conventional aggregate in pavement seems to be a feasible ash utilization skill. Bottom ash fraction of somewhat less than 50% is suggested for future testing. Gyratory test methods were successful in predicting better pavement performance at lower asphalt content as compared to Marshall Test methods. Public acceptance of the concept of ash utilization in this fashion was obtainable for this demonstration project.

Khaled Ksaibati and Jason Stephen [1999] [5] studied the possible utilization of incorporating bottom ash in bitumen mixes. Laboratory testing was done by using the Georgia Loaded Wheel Tester (GLWT) and Thermal Stress Restrained Specimen Tester (TSRST). Different percentage of bottom ash in bitumen mixes had a significant difference in high-temperature rutting and low-temperature cracking.

Menglan Zeng and Khaled Ksaibati [2003] [6] moisture induced damage of bitumen mixtures comprising bottom ash were examined. Asphalt mixtures featured with stone chips had higher indirect tensile strength (ITS) values compared to limestone aggregate in dry condition. The addition of lime or bottom ash did not change ITS values to much effect.

Putman, Bradley J., and Serji N. Amirkhanian [2004] [7] studied the use of waste fiber in stone mastic asphalt mixture (SMA). He used waste tire and carpet fibers as an additive to stabilizing the excessive drain-down due to relatively high air void in SMA. The mix comprising tire fibers did not lose any toughness when conditioned in water. Samples containing contained tire and carpet fibers 100.9 and 101.8% respectively were resistant towards moisture induced damage.

Khaled Ksaibati and Shiva Rama Krishna Sayiri [2006] [8] evaluated the performance of bitumen mix using bottom ash from three power plants in Wyoming. The field study was carried out with the Falling Weight Deflectometer (FWD). Pavement Condition Index (PCI) values also evaluated the field and laboratory evaluations shows that 15% substitution of bottom ash had no effect on performance of bituminous pavement. The GLWT results show that limestone mixes with or without bottom ash have analogous rut depth resistance. Nitrogen analysis results showed bottom ash mixes were more resistant to moisture induced damage.

Kumar, Pawan, Satish Chandra, and Sunil Bose [2007] [9] studied the performances of the SMA mixture modified with crumb rubber modified binder (CRMB) and low viscosity binder coated jute fibers.. From the test observation he conclude that fiber content of 0.3% by weight of the mix improve the Drain-down property of the mix. Also in moisture susceptibility test the mixture shows satisfactory result. The observation from Hamburg wheel tracking tests, aging tests and flexural fatigue tests carried out on three mixes of SMA indicate better result than conventional mix.

Partl, Manfred, K. Sokolov, and H. Kim. [10] [2008] conducted Laboratory study on special type of carbon fiber grid which was placed at different depth in asphalt pavements. The purpose of the study was to obtain the design information about the position of the grid which will give optimum result. Two different types of asphalt pavements were examined (a) asphalt concrete and (b) mastic asphalt. This study reveals that with addition of carbon grid stiffness, failure strain and stress, and resistance against low temperature cracking increased. However, during rutting tests with Model Mobile traffic Load Simulator (MMLS) it was found that the grid was not able to improve resistance against flow value in the mastic asphalt layer.

Sinha, A. K., et al. [2009] [11] conducted test on sub-soil for a proposed road construction of a 4 km with pond ash which is running from Kalindi Colony to Kalindi Kunj in New Delhi, India. Some field tests were conducted such as Standard Penetration Test (SPT) and Cone Penetration Test (CPT). . It is observed that under the highest flood level with seismic effect, the fly ash embankment is exposed to both sudden draw down and steady seepage conditions.

Boyes, Anthony John. [2011] [12] fly ash used as mineral filler in asphalt mixes that can aid in reducing bituminous moisture induce damage and reinforcement. Effect of two waste products such as cement kiln dust (CKD) and fly ash on anti stripping properties was investigated by compared them with hydrated lime and an amine-based chemical additive. The observation shown that class C fly ash can be used as an anti-stripping additive in asphalt mix; however it is expensive than amine chemicals or lime. Combinations of 5% and 7% class C fly ash and 1.5% and 2% lime where determined to have significantly higher conditioned compressive strengths than control.

Gunalaan Vasudevan [2013] [13] Performance characteristics of Bottom ash in HMA (Hot Mix Asphalt) were tested. When incorporated with bitumen and evaluated the positive modifications of engineering properties of the Marshall cube with respect to texture and appearance. Based on the experimental results, the sample with bottom ash is superior to conventional samples in terms of stiffness, strength and the sample flow. Subsequently, the pavement will become stronger and can withstand if loaded high traffic load. However, setbacks with the usages of coal bottom ash as filler where the air void content showed an increase resulting in reduced density.

III. CONCLUSION

Concluding From the literature study it is clear that the bituminous mixes that are prepared with bottom ash has given satisfactory result in term of performance characteristics, it has shown some draw backs in the ground of high air void and reduced density of mixture in Marshall Properties analysis. Besides this, the study of using of bottom ash and fly ash (coal ash) together in the bituminous mix, which is the main motivation of this research work. Again the use of fiber is limited to SMA and BC due to its comparatively high air voids content. Hence in many research work fibers are used as an additive or as a stabilizing agent in SMA or BC.

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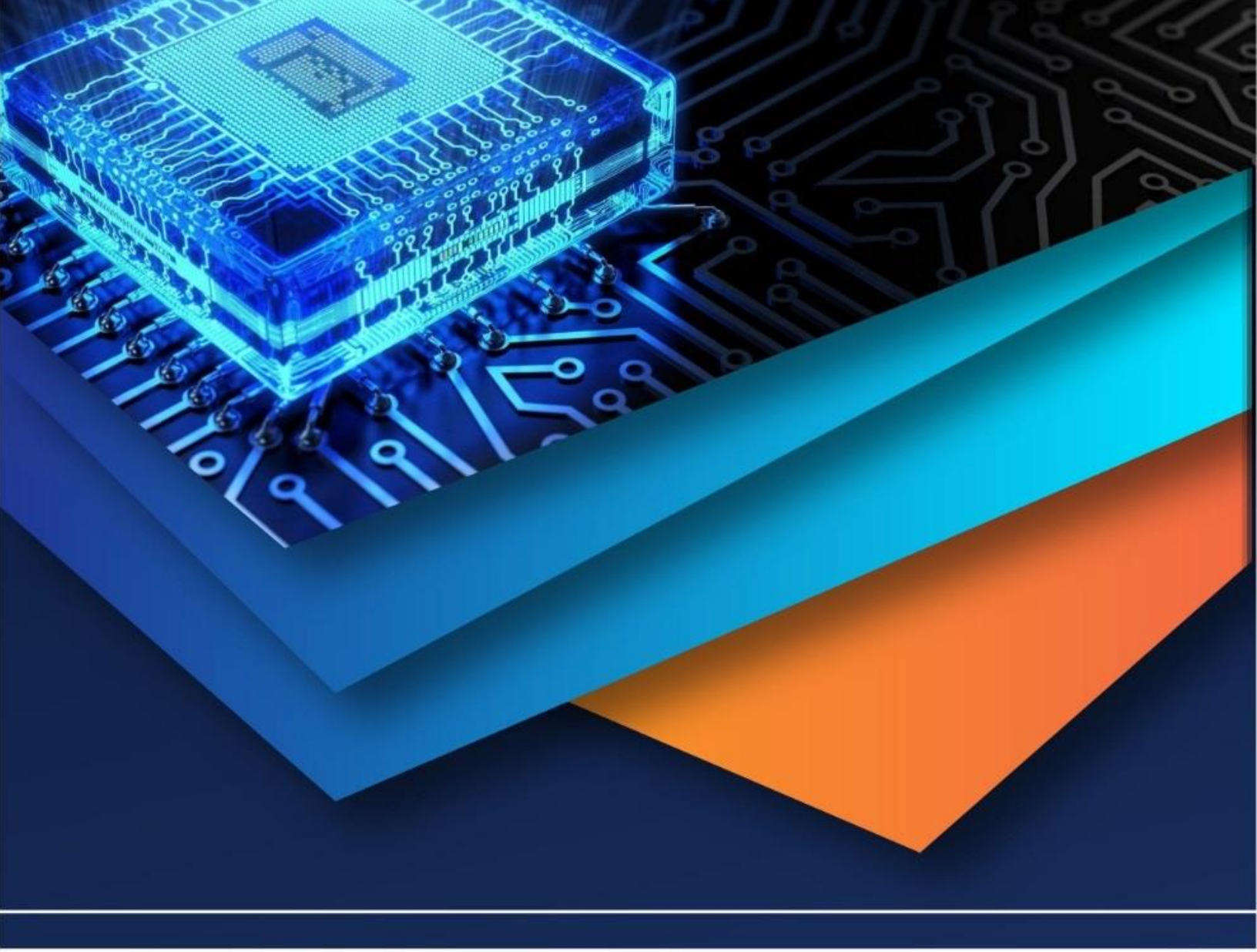

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