IMPROVEMENT OF SUBBASE OF FLEXIBLE PAVEMENT USING WASTE ASPHALT PAVEMENT MATERIALS

Nirmal Chandra Roy[1,2] , Tuhin Dewan[3*], Md. Roknuzzaman[4] , Md. Shamim Hossain[5] , Mariam Mahtadin Meem[6]

[1] Assistant Professor, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, e-mail: ncr.civil@hstu.ac.bd
[2] Graduate Students, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh,
[3] Graduate Students, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, e-mail: dewantuhin2@gmail.com
[4] Assistant Professor, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, e-mail: mrz.civil@hstu.ac.bd
[5] Graduate Students, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, e-mail: shamimhossain1807320@gmail.com
[6] Graduate Students, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, e-mail: mmahtadin@gmail.com

***Corresponding Author**

ABSTRACT

The Being a developing nation, Bangladesh is constructed numerous national highways, metropolitan roads, and village roads. Around 7 crore tons of natural aggregates are thought to be used annually in Bangladesh's road construction. Globally the amount of waste asphalt is increasing day by day. The Government of Bangladesh has set a target of using 25% waste asphalt in road construction by 2025. Our study is to examine the suitability of using these waste asphalt pavement materials as potential subbase materials for flexible pavement. Use of Waste Asphalt Pavement (WAP) materials reduces the amount of use of virgin materials thus helps to conserve the natural resources. In this study laboratory CBR and ACV test have been conducted on WAP mixed with various percentages of , Crushed Stone Aggregates (CSA) , Cement and Saw Dust Ash (SDA). The CBR values of the following proportions of 75% CSA+ 25% WAP + 3% cement, 75% WAP + 25% CSA + 6% cement, 50% WAP + 50% CSA + 3% cement, 50% WAP + 50% CSA + 6% cement, 75% CSA + 25% WAP + 3% SDA, 75% CSA + 25% WAP + 6% SDA, 50% CSA + 50% WAP + 3% SDA and 50% CSA + 50% WAP + 6% SDA are 50.5%, 73.6%, 31%, 47.4%, 45.2%, 51%, 26.5% and 31.3% respectively. Generally, for flexible pavement, required CBR values for subbase layer is 30%. So, the above proportions are preferable for subbase layer.

Keywords: *Waste Asphalt Pavement, Crushed Stone Aggregate, Saw Dust Ash, California Bearing Ratio.*

1. INTRODUCTION

As more and more old pavements are being reconstructed, there is a rising amount of waste asphalt pavement materials on a global scale. Our ecology is negatively impacted by these discarded asphalt products. Some disadvantages of WAP materials are, it can be challenging to develop and generate a consistent asphalt mixture due to the higher quality variability of WAP materials compared to virgin materials. Risky synthetic compounds such weighty metals and polycyclic fragrant hydrocarbons can be found in WAP materials. These compounds have the potential to harm soil and water if they are not handled properly (Edil and Tuncer, 2011; Song et al., 2018). It has some advantages such as since WAP does not require the same level of processing as fresh asphalt, it is often far less expensive. This can result in substantial financial savings for both taxpayers and project owners. By reusing discarded asphalt, the amount of garbage disposed in landfills can be reduced. The National Asphalt Paving Association (NAPA) assumes that reusing asphalt prevents around 60 million cubic yards of garbage space annually. There are several places where WAP can be employed, including driveways, parking lots, and motorways (George et al., 2019; Milad et al., 2020). WAP materials are additionally employed for flexible pavement granular subbase. CBR for granular sub-base is typically 30% for flexible pavement (Saha et al., 2017). The Reclaimed Asphalt Pavement Stabilized with Saw Dust Ash to improve the sub-base layer of pavement. The 90% RAP and 10% SDA mix, soaked for 24 hours and recording a CBR value of 26%, can be employed as sub-base material in flexible pavements since it may improve strength over time (Osinubi K. J. et al., 2012). The RAP blends with 15% Recycled Concrete Aggregate material satisfies the tri-axial repeated load requirements for usage in pavement sub-base layers (Arulrajah et al., 2014). The blended samples with 75% RAP material and 25% fresh granular showed a significant increase in resilient modulus (MR) values, especially at higher bulk stress levels (Arshad M. et. al., 2017). CBR values of 100% WAP have been found to range from 9.4% and 25.4%. According to the current investigation, CBR values of 75% WAP + 25% CSA with 6% cement and 50% WAP + 50% CSA with 6% Saw Dust Ash are greater than 30%. As a result of the strength considerations in respect to CBR, WAP mixed with CSA and a little amount of cement and Saw Dust Ash can be used as a flexible pavement sub-base course (Kolawole et al., 2017). A series of CBR tests were performed on WAP, WAP-CSA mix, and the same mixture stabilized with varied ratios of cement and Saw Dust Ash in the current study.

2. METHODOLOGY

3. Materials

4. Waste Asphalt Pavement (WAP)

WAP material is a material containing asphalt and aggregate that have been discarded from the pavement. These materials are produced when flexible pavement is reconstructed or resurfaced. WAP is made up of high-quality, well-graded aggregates coated in asphalt when appropriately crushed and screened (Federal Highway Administration, 2008). WAP was gathered from a road construction site in the Eidgah residential sector of Dinajpur town, Dinajpur, where milling was taking place prior to repair and strengthening. WAP grain size is observed to be 100% passing 37.5mm sieve. WAP CBR values range from 9.4% to 25.4%. When mixed with CSA and a particular quantity of cement and saw dust ash, the CBR value of WAP is raised by more than 30%. The aggregate crushing value was discovered to be 25%. According to modified proctor tests, the MDD and OMC were 2.09 gm/cc and 3.08%, respectively.

5. Crushed Stone Aggregate (CSA)

Crushed stone is a significant raw material used in building, agriculture, and other sectors. It is normally generated from the excavation of an appropriate rock quarry and crushing the extracted rock to the intended shape (USGS Minerals Information, 2007). According to previous study, the strength of WAP materials with respect to of CBR rises when mixed with virgin aggregates. As a result, it was decided to combine WAP with virgin aggregate in various concentrations. However, due to financial reasons, CSA has been classified as virgin aggregates. The CSA for this experiment was gathered on the HSTU campus and is from the Panchagarh district. The CSA have a grain size of 100% passing a 37.5mm sieve. According to modified proctor tests, the MDD and OMC were 2.22 gm/cc and 4.61%, respectively. CBR ranges from 53% to 95%. The aggregate crushing value was discovered to be 19%.

6. Cement

Cement is a chemical ingredient typically employed as a binding element in construction projects. Cements used in construction are typically inorganic, frequently based on lime or calcium silicate, and can be classified as either Ordinary Portland Cement (OPC) of grade 43, which is commercially available, has been utilized as a stabilizer for WAP and WAP-CSA mixes (Rodgers and Lucy, 2018).

7. Saw Dust Ash

Sawdust is an organic waste that is produced as a byproduct or waste product at the time of woodworking operations. The dust is typically utilized as a household fuel (Marthong, 2012). The saw dust was gathered from a nearby sawmill at Jamtoli in Dinajpur. The saw dust ash was obtained by incinerating the saw dust. Calcium, potassium, magnesium, copper, zinc, iron, silicon, and boron are the most significant components in saw dust ash (Misra, 1993). Before being used in the study, the ash had to pass through a sieve No.200 with a 0.075 mm aperture.

8. ILLUSTRATIONS

9. California Bearing Ratio (CBR) Tests

The CBR tests were carried out in conformity with WAP, CSA, and WAP-CSA mixes in various proportions and on above proportion Stabilized with cements and saw dust ash (ASTM D 1883). Photographs of CBR tests are indicated in Figure 1.

Figure 1 California Bearing Ratio (CBR)

10. Results and Discussions

3.2.1 100% WAP

Results of CBR Test for 100% WAP with varying percentages of Cement and Saw Dust Ash (SDA) are indicated in Figure 2.

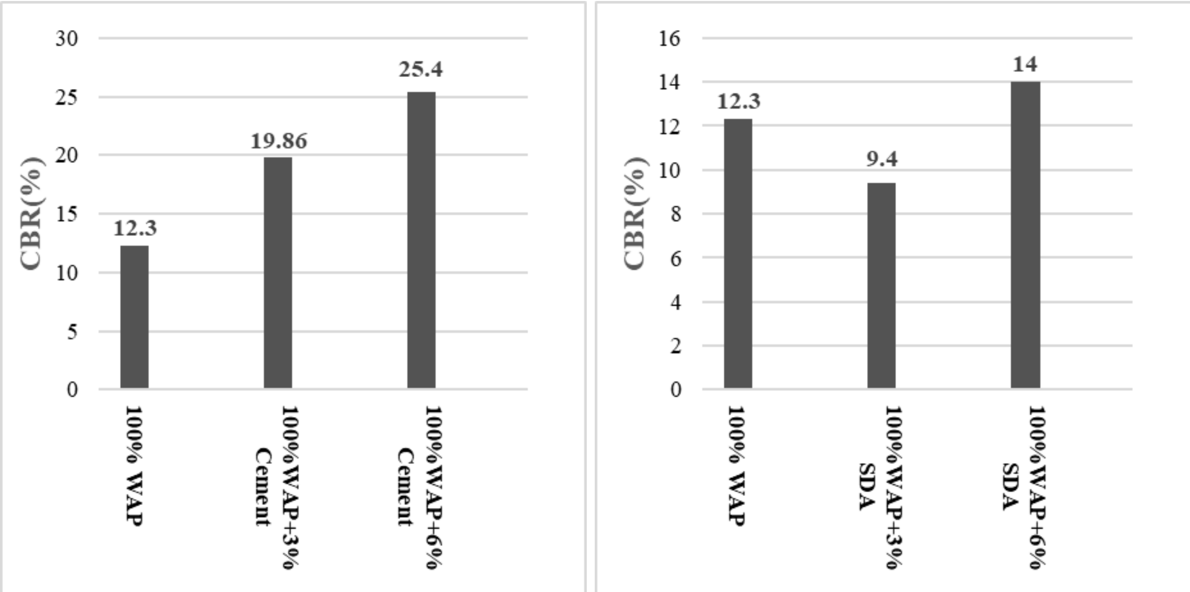

Figure 2 CBR Values for 100% WAP with varying percentages of cement and SDA

When aggregates are stabilized with cement and SDA, it has been shown that CBR values rise. The above proportions of 100% WAP should not be taken into consideration because for subbase materials the minimal acceptable CBR value is 30%.

3.2.2 75% WAP+25% CSA

Results of CBR Test for 75% WAP+25% CSA with different percentages of cement and Saw Dust Ash (SDA) are indicated in Figure 3. When aggregates are stabilized with cement and SDA, it has been shown that CBR values rise. Since sub-base materials must have a minimum CBR value of 30%, consideration should be given to 75% WAP + 25% CSA + 6% Cement, as it exceeds 30% CBR.

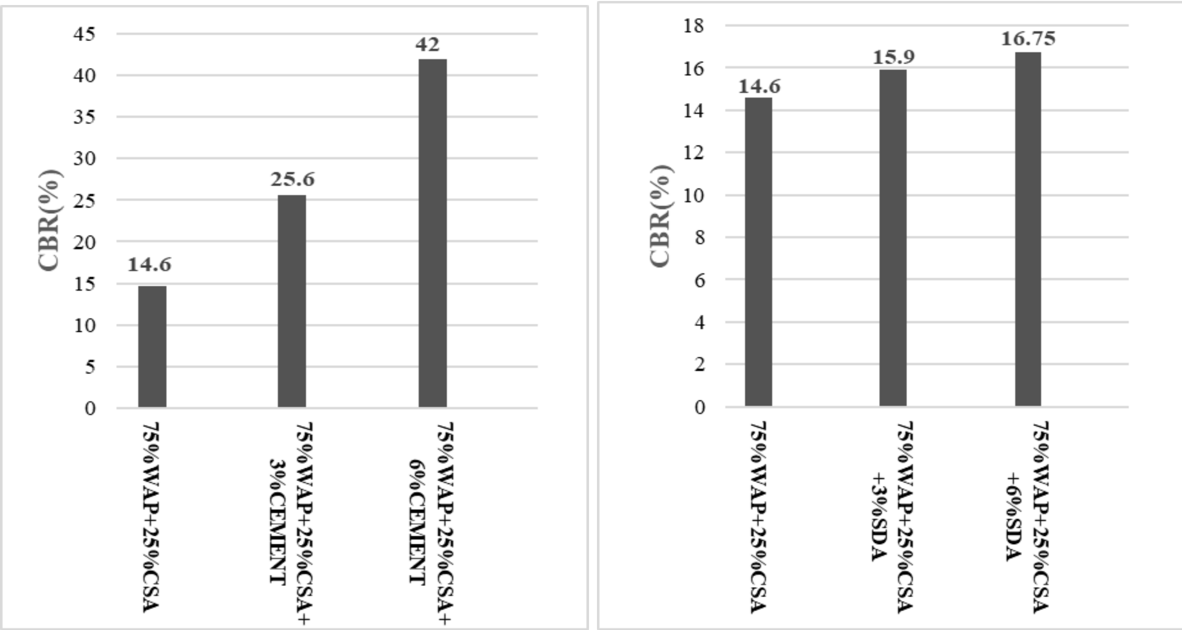

Figure 3 CBR Values for 75% WAP+25% CSA with different percentages of cement and SDA

3.2.3 50% WAP+50% CSA

Results of CBR Test for 50% WAP+50% CSA with various percentages of cement and Saw Dust Ash (SDA) are indicated in Figure 4.

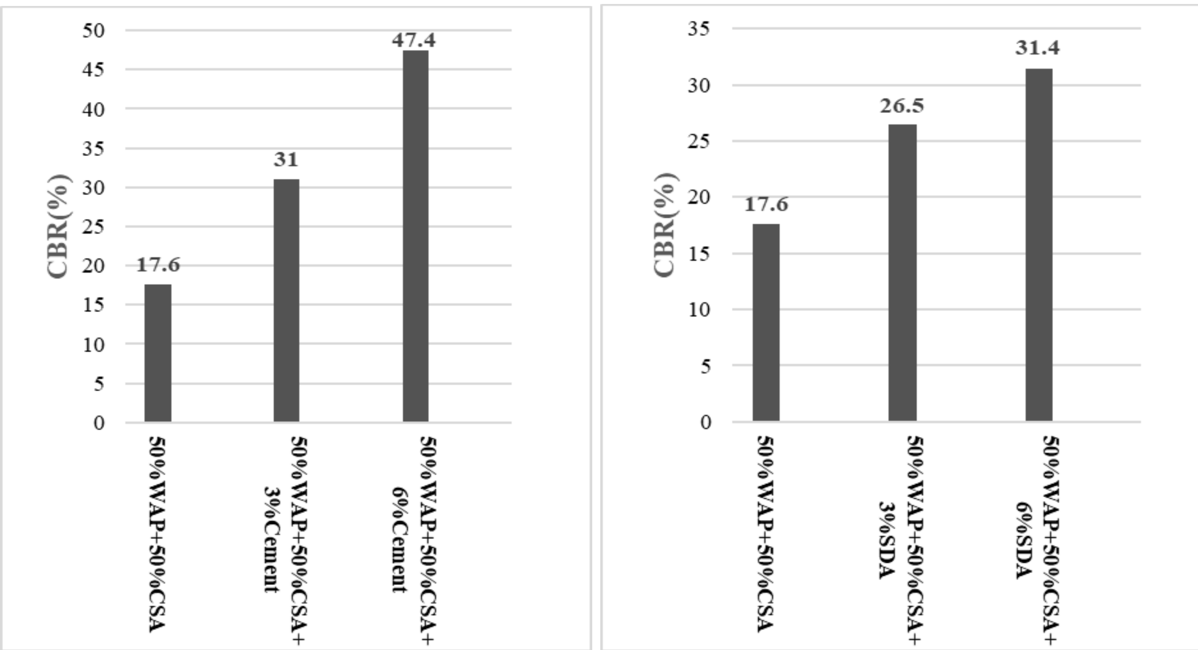

Figure 4 CBR Values for 50% WAP+50% CSA with various percentages of cement and SDA

When % CSA aggregates, % cement and % SDA are increased in the specimen, it has been shown that CBR values rise. Since sub-base materials must have a minimum CBR value of 30%, consideration should be given to 50% WAP + 50% CSA + 3% Cement, 50% WAP + 50% CSA + 6% Cement and 50% WAP + 50% CSA + 6% SDA, as these exceed 30% CBR.

3.2.4 25% WAP+75% CSA

Results of CBR Test for 25% WAP+75% CSA with different percentages of cement and Saw Dust Ash (SDA) are indicated in Figure 5.

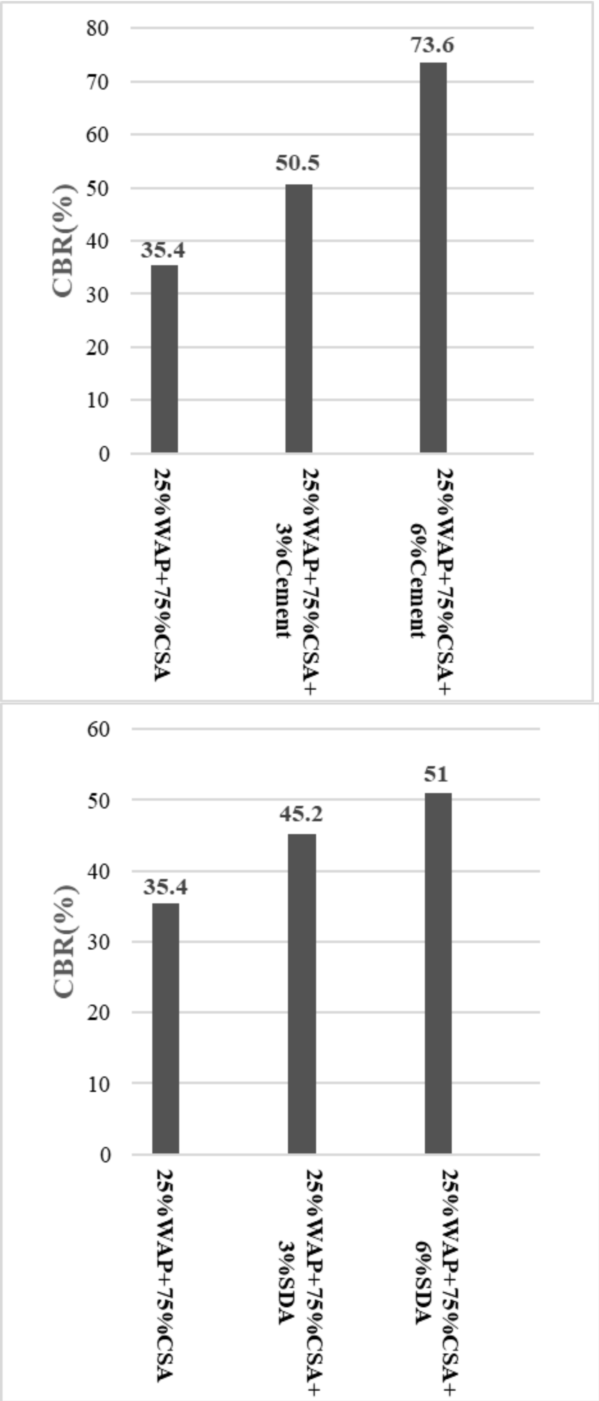

Figure 5 CBR Values for 25% WAP+75% CSA with different percentages of cement and SDA

When % CSA aggregates, % cement and % SDA are increased in the specimen, it has been shown that CBR values rise. Since subbase materials must have a minimum CBR value of 30%, consideration should be given to all the proportions of 25%WAP+75%CSA, as these exceed 30% CBR.

From the above results, it becomes clear that as the % CSA increases, the % CBR also increases. But the aim of this study is to find out the optimum percentage of % CSA and % WAP stabilised with cement and SDA.

11.CONCLUSIONS

As sub-base materials for flexible pavement, WAP materials were assessed in this study based on their CBR performance. WAP materials were combined with CSA, stabilized with cement and SDA, and then tested to determine the CBR of various mixture proportions. The CBR values of the following proportions of 75% CSA + 25% WAP + 3% cement, 75% WAP + 25% CSA + 6% cement, 50% WAP + 50% CSA + 3% cement, 50% WAP + 50% CSA + 6% cement, 75% CSA + 25% WAP + 3% SDA, 75% CSA + 25% WAP + 6% SDA, 50% CSA + 50% WAP + 3% SDA and 50% CSA + 50% WAP + 6% SDA are 50.5%, 73.6%, 31%, 47.4%, 45.2%, 51%, 26.5% and 31.3% respectively. For a flexible pavement subbase, a 30% CBR is necessary. For economical purposes the following proportions are to be recommended for sub-base course of flexible pavements based on CBR value rise when WAP is combined with CSA.

- 50% CSA +50% WAP stabilized with 6% SDA.
- 50% CSA +50% WAP stabilized with 3% cement

ACKNOWLEDGEMENTS

Author wishes to thank the department of Civil Engineering, Hajee Mohammad Danesh Science and Technology University, Bangladesh for providing excellent support and resources which have been essential in facilitating in this research. Also, the faculty and their stuffs and dedication to academic excellence had created an environment that fosters intellectual growth and knowledge dissemination.

REFERENCES

Arshad M, Ahmed M. (2017). “Potential use of reclaimed asphalt pavement and recycled concrete aggregate in base/subbase layers of flexible pavements.” Construction and Building Materials 151, 83–97.

Arulrajah A., Piratheepan J., and Disfani M. M. (2014). “Reclaimed Asphalt Pavement and Recycled Concrete Aggregate Blends in Pavement Subbases: Laboratory and Field Evaluation” Journal of Materials in Civil Engineering, Vol. 26, No. 2.

American Society for Testing and Materials (ASTM D 1883 – 07E1). Standard test method for CBR (California Bearing Ratio) of laboratory compacted soils.

British Standard (BS:812-110:1990). Determination of Aggregate Crushing Value Test.

C. Marthong, (2012). “Sawdust Ash (SDA) as Partial Replacement of Cement.” International Journal of Engineering Research and Applications (IJERA) Vol. 2, Issue-4.

Edil, Tuncer B., (2011). “Specifications and Recommendations for Recycled Materials Used as Unbound Base Course.” *University of Wisconsin-Madison*.

Federal Highway Administration (FHWA), (2208) “User Guidelines for Byproducts and Secondary Use Materials in Pavement Construction,”.

George, A. M., Banerjee, A., Puppala, A. J., & Saladhi, M., (2019). “Performance Evaluation of Geocell-reinforced Reclaimed Asphalt Pavement (RAP) Bases in Flexible Pavements.” *International Journal of Pavement Engineering.* 1-11.

Kolawole J. Osinubi, Joseph E. Edeh, and Williams O. Onoja, (2011). “Sawdust Ash Stabilization of Reclaimed Asphalt Pavement.” *Journal of ASTM International*, Vol. 9, No. 2.

Milad A., Aizat Mohd Taib, Abobaker G. F Ahmeda, Mohmed Solla, Nur Izzi Md Yusoff, (2020). “A Review of The Use of Reclaimed Asphalt Pavement for Road Paving Applications.” *Jurnal Teknologi (Sciences & Engineering)* 82:3, 35–44.

Misra, M. K., Ragland, K. W., and Baker, A. J., (1993). "Wood Ash Composition as a Function of Furnace Temperature." *Biomass Bioenergy*, Vol. 4, pp. 103–116.

Osinubi K. J., Joseph E., and Williams O., (2012). "Sawdust Ash Stabilization of Reclaimed Asphalt Pavement." *Journal of ASTM International*, Vol. 9, No. 2.

Rodgers, Lucy, (2018) "The massive CO2 emitter you may not know about". BBC News

Saha D. C, J. N. Mandal, (2017). "Laboratory investigations on Reclaimed Asphalt Pavement (RAP) for using it as base course of flexible pavement." *Procedia Engineering* 189, 434 – 439.

Song, W., Huang, B., & Shu, X., (2018). "Influence of Warm mix Asphalt Technology and Rejuvenator on Performance of Asphalt Mixtures Containing 50% Reclaimed Asphalt Pavement." *Journal of Cleaner Production*. 192: 191-198.