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Experimental Investigation of Coconut Shell Charcoal Ash in Bituminous Concrete

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Abstract: For upgradation of roads and to reduce the cost of bituminous road numerous materials are used one among them is coconut shell charcoal ash which is used in flexible pavements as a filler. The primary impartial of this study is to match the results produced by using filler such as fly ash with coconut shell charcoal ash in bituminous concrete. Coconut shell charcoal ash contain the properties like absorption, light weight, low cost, resistance to freezing, resistance to crushing which is the most significant factor for the road pavements. From Marshall stability test stability of Marshall, flow value and void ratio are obtained. The different percentage of coconut shell charcoal ash are 1%, 1.5%, 2%, 2.5% and 3% in test with 5.5% bitumen.

Key words: coconut charcoal shell ash, bitumen, freezing, marshal stability, void ratio.

Introduction

Roads are essential for the development of any country. The structural integrity of a good pavements should provide a durable, seamless and safe means of transportation for the road users. Most countries have seen an increase in tire pressure, traffic volume and an axle load in recent years, if this continuous, the upper layer of the pavement will have subjected to increased pressure. To address these issues mix of bituminous concrete is the best option for handling a high axle load and a large volume of traffic as well as being easy to repair.

Waste materials can be used to replace aggregate, bitumen, filler, lowering costs while also enhancing strength. A considerable amount of waste is produced as a result of increased industry, population, urbanization, development activities, and lifestyle changes. Fly ash, steel slag, plastic garbage and Coconut shell charcoal ash are among the waste materials. (Suchithra et al (2021); Jeffry et al (2018); Jaya et al (2018); Limantara et al (2018); Sarki et al (2010) found that adding different percentage of charcoal 4.5%, 5% ,5.5%,6% with different percentage of bitumen increased its strength, quality, and durability, and showed it might be used in place of coconut shell charcoal ash to enhance the durability, quality, and longevity of bituminous roads. [1]. Noticed that with the addition of 6% of Nano charcoal ash the Marshall stability, ITS, dynamic creep and bituminous concrete's resilient modulus were significantly improved. According to the AFM results, 6 percent of Nano charcoal ash has the relatively surface roughness is reduced, which increases the adherence of the asphalt mixture. FESEM revealed a dense and flat asphalt mix, that increased the engineering properties of the asphalt mix [2]. Nano shell charcoal was shown to reduce penetration and enhance the softening point of bitumen, while increasing the percentage of

Nano shell charcoal it increases the viscosity of the bitumen. [3] It was found that bio asphalt created from algae may be used to replace asphalt or to reduce its use, however distillation of coconut shells and plastic trash can only be used to reduce the use of asphalt obtained from petroleum. [4] When compared to pure epoxy resin, increase in the value of the value of tensile modulus and tensile strength with the addition of coconut shell particles, it slightly decreases the impact strength , and to improve the properties of epoxy polymer coconut shell can be used in eco –building.

The qualities in Coconut Shell Charcoal ash such as crushing resistance, absorption, surface moisture, and heating. Minimal rates, low density, low pollution, and high tensile strength qualities are all advantages of these waste. It is also known as MMC (Metal matrix composites), coconut shell possesses qualities such as strong weather resistance, exact modulus, strength, and damping capacity Ting et al (2015); Girish et al (2020); Abdullah et al (2017); Patilet al (2020); Gopi & Saleem (2017); Norhafizah et al (2016)

As compared to pure epoxy resin, As the proportion of coconut shell particles increased, the elastic modulus and tensile strength increased, whereas the impact strength decreased slightly. [5] The major aim is to compare the outcomes produced by employing fillers such as Fly ash with coconut shell charcoal, stone dust, Portland cement. Coconut Shell Charcoal has features such as crushing resistance, absorption, surface moisture, grading, freezing resistance, light weight, heating, and synthetic resin glues, all of which are good for road pavement. [6] concluded that the resin specimen with coconut shell filler improved tensile strength by up to 7.5 percent while decreasing flexural strength. [7] In road construction coconut outer cover and coconut fibers are use in road construction, coconut fiber improves the stability and skid resistance and on the other hand coconut shell charcoal ash can improve static creep and tensile strength of the pavements. [8] Coconut shell charcoal replaced in the pavements including other fillers such as stone dust [9] Coconut shell charcoal is the byproduct of coconut shell use as a binder in asphalt mix replaced with the percentage of bitumen to improve the properties of binders. [10]. Coconut shell Charcoal ash has properties such as crushing resistance, absorption, surface moisture, heating, and so on. Because powder of coconut shells is used to bind the aggregates, concrete pavement releases a significant amount of Co2 into the environment. [11]. Instead of stabilized agents, rice husk ash, fly ash, coconut shell charcoal, and sugar cane straw can be utilized. [12,13,14,15,16]. When we add coconut shell charcoal ash powder to a porous asphalt mixture greatly decreases the traffic noise coefficient. [17]. The optimum content of the bitumen for the marshal test of the asphalt mixture is 5.1% [18]. Recently, materials like nanoscale have been measured as a strong competitor to extend the life of pavements. The nominal particle sizes vary from 1nm to 100nm. [19,20].

Material

- **Bitumen:** Bitumen is a binding agent, because of its outstanding binding properties, bitumen is used in road building and is derived from petroleum refineries. When we decrease the temperature, bitumen acts like an elastic material and it behave like a viscous fluid when we increase the temp.

- VG30 grade of bitumen was used in this research.
- The test on the bitumen sample are in the below table.

TEST SAMPLE	VALUES
Specific gravity	1.1
Penetration test	67
Ductility test	43
Flash point test	168.6℃
Fire point test	189℃

B. Aggregates

- **Coarse aggregates:** Coarse aggregates are irregular broken stones or naturally found round gravel used for the process of making concrete. The coarse aggregate should be broken rocks that pass through a 19mm sieve but are retained in a 4.75mm sieve. Specific gravity, crushing test, abrasion test and impact test were the test conducted on the coarse aggregates.
- **Fine aggregates**: Fine aggregates are filler materials with a smaller particle size that are used in road construction. Fine aggregates are particles that pass through a 4.75mm sieve but are retained on 0.75mm sieve. In road building, the fine aggregates fill the voids between the coarse aggregates.

TEST SAMPLE	VALUES
Specific gravity	2.8
Crushing test	33
Abrasion test	26
Impact test	24

- **Fillers:** Filler is defined as aggregates that pass through a 0.75-micron sieve. Fillers are of different types such as fly ash, stone dust, coconut shell charcoal, cement etc. It increases stiffness and of mortar matrix and asphalt.

COCONUT SHELL CHARCOAL: Coconut shell is considered as a waste and of no use but it is hard in nature and can be used for many purposes like burning, decorative purpose etc. but after burning it can be use as different construction work as coconut shell is available in abundance so to avoid its wastage and to take its good benefits it can be used in numerous ways. In this work of research coconut shell charcoal ash is used as a filler obtained by burning coconut shell. Coconut shell was bought from local market and burned in furnace at temperature of 700C for 15 minutes. After burning completely, at room temperature the coconut shell was kept to cool and then ground in a grinder and fine powder charcoal ash was obtained which was further sieved from 0.75mm sieve.

MATERIAL AND METHODS:

- **MATERIAL:**

In this research work the coconut shell was bought from a coconut vendor in KHARAR, PUNJAB. The coconut shell picture is presented below.

Fig 1: Coconut shell

Fig 2: Crushed coconut shell

- **Equipment used**
  - Electric furnace
  - Scanning electronic microscopy (SEM)
  - Energy Dispersive X-ray spectroscopy (EDS)

GRADTION OF AGGREGATES: According to IS 2386 Part 1 (wet grading process), the mutual grading of coarse aggregates, fine aggregates, and filler falls within the limits stated in table.

Grading	**1.0**	**2.0**
Aggregate size (nominal)	**1.9 cm**	**1.32cm**
Thickness of layers	**5.0 cm**	**3.0-4.0 cm**
IS Sieve (cm)	**Cumulative % of total agg passing by weight**	
4.5		
3.75		
2.65	100%	
1.9	90-100%	100%
1.32	59-79%	90-100%
0.95	52-72%	70-88%
0.475	35-55%	53-71%
0.236	28-44%	42-58%
0.118	20-34%	34-48%
0.06	15-27%	26-38%
0.03	10-20%	18-28%
0.015	5-13%	12-20%
0.0075	2-8%	4-10%
Percentage Bitumen content by mass of total mix	Minimum 5.2%	minimum 5.4%

MARSHALL MIX DESIGN: in 1939 Marshall mix design was invented in the highway department of Mississippi by Bruce Marshall. The process of Marshall mix design is based on the choice of asphalt binders components with an acceptable density which fulfills the less stability and range of flow parameters. It is measured dynamically at a deformation rate of 50mm per min by compacting cylindrical specimen of bituminous mixes. Marshall mix design's two main qualities. (i) density-void analysis (ii) flow stability test. The mix's Marshall stability is determined by the specimen carried maximum load at a standard test temperature of 60°C. The flow value represents the amount of deformation experienced by the test specimen during loading to the maximum load.

METHODOLOGY:

Three compacted Marshall test method of mix design three compacted specimens are made for each binder content. At least four specimen of the binder contents should be tested in order to determine the optimum binder content preparation of Test Specimens.

Preparation of Test Specimen

- The coarse and fine aggregate, filler material should be balanced in accordance with the appropriate specifications as per job mix formula.
- To achieve the specified thickness, aggregates of 1200 gm and filler are required.
- Aggregates were heated at a temperature of 165℃ to 190℃ in a pan.

- Add Coconut shell charcoal ash in aggregate and mix it thoroughly.
- Bitumen is heated at a temperature 120℃ to 165℃ and thoroughly mix at a specific temperature.
- Assemble the mould and rammer kept pre heated at 95℃ to 150℃.
- Place the filter paper at the bottom of mould.
- When the material is transfer into the mould, the material will be compacted 75 times both side.
- After 24 hours with the help of extractor the specimen is extracted from the mould.
- After that the test will be conducted on the specimen.

RESULTS AND DISCUSSION:

Optimum Bitumen Mix Result:

Where there is the maximum stability the optimum of bitumen content is bring out. The maximum stability is obtained at 5.5% in this study of bitumen which is 19 KN for fly ash 2% of total weight of mix as a filler.

Bitumen %	4.5%	5%	5.5%	6%	6.5%
Density (KN)	14.6	17	16	15	13.3
Flow (mm)	2.97	3	3.3	2.7	2.6

MARSALL SATBILITY TEST

1. **STABILITY:** The stability of the Marshall cake is calculated by the load taken on the specimen and multiplying it by the correlation ratio, which is calculated from the sample's height/volume or thickness. With the increase of the % of filler such as fly ash in the stability increases up to a certain point and then gradually decreases but in case of coconut shell charcoal ash the stability increases up to maximum point.

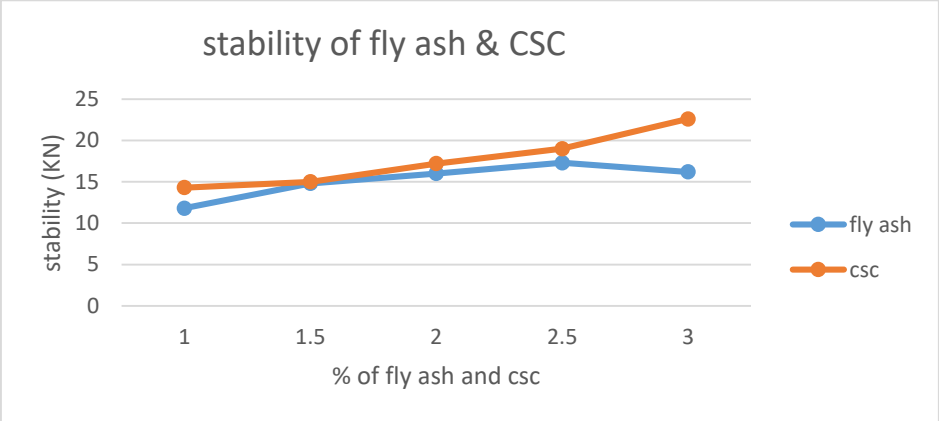

Fig 3: stability of Marshall sample

2 **FLOW VALUE:** When the maximum load is applied on the specimen which is often where failure happen. The flow value rises as the filler level rises. The flow grows slowly at first, but as the filler content increases, the flow value potentially increases.

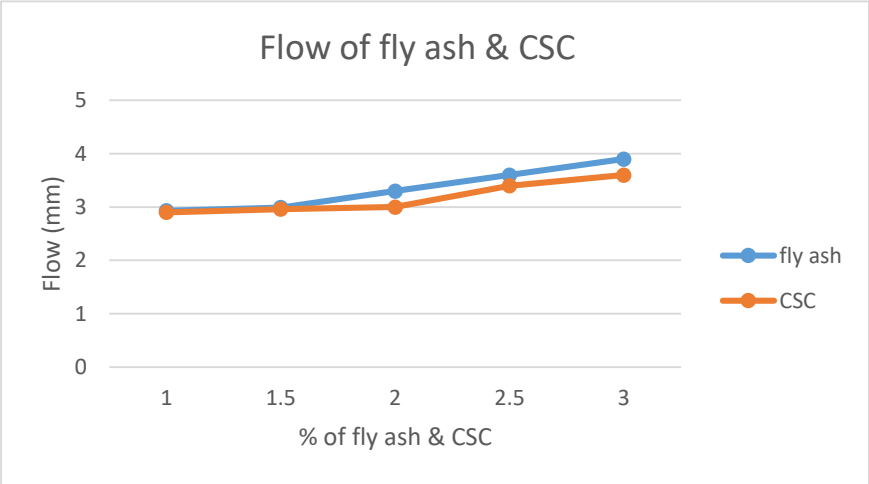

fig 4: flow value of Marshall test

3 **AIR VOIDS:** The gap between the aggregates is known as the air void. The vacuum shrinks as bitumen and fillers are added. Bitumen bridges the existing gap and improves compatibility. The air spaces initially reduce slowly, but when the amount of fillers such as fly ash and coconut shell charcoal increases, the air voids reduce rapidly. The inclusion of stabilizer in addition to bitumen, helps to fill the vacuum.

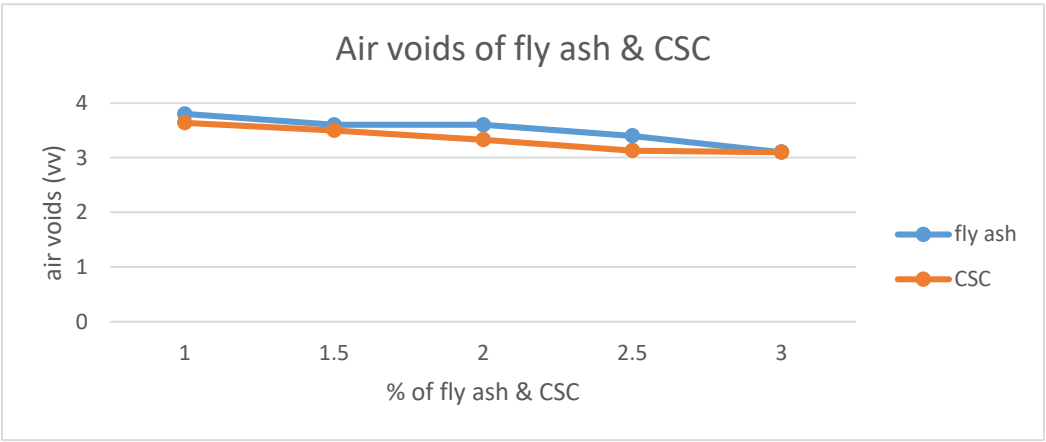

Fig 5: Air voids of marshal sample

4 **VMA:** The percentage void in mineral is the total percentage of void space between the granular particles in the compacted paving mixture, including air voids, and the total volume occupied by effective asphalt content. With the increase of the percentage of fillers such as coconut charcoal ash and fly ash the VMA of the specimen decreases.

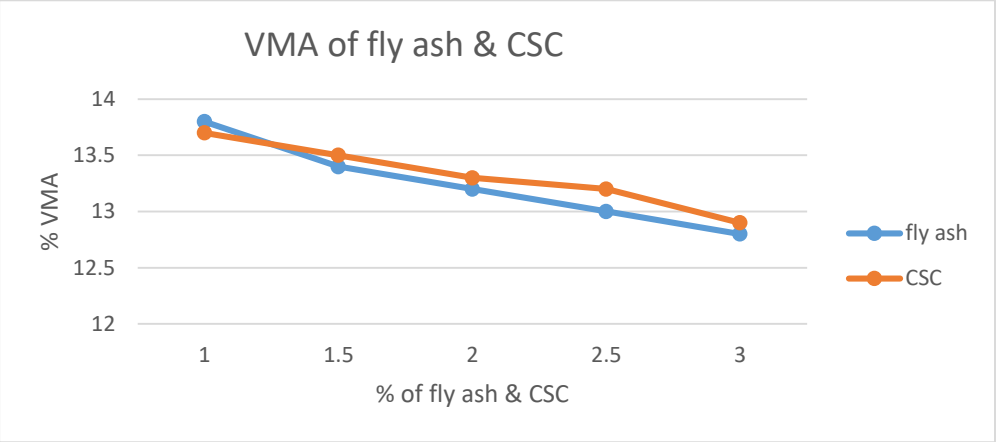

Fig 6: VMA of marshal sample

CONCLUSION

- The extreme stability found in case of coconut shell charcoal ash is 22.6 with the percentage of 3% and in case of fly ash maximum stability is 17.3 with the percentage of 2.5%.
- The stability is more than 8KN in case of coconut shell charcoal ash as a filler, so we can use it as a filler in the road pavements.
- Flow value is also increasing with the use of both fillers, so we can use coconut shell charcoal as a filler.
- Air voids also decreases with the increase of fillers use in sample.
- With the increase of fillers in Marshall sample the voids in minerals (VMA) decreases.
- Based on the results of the test conducted on the specimen, it can be stated that coconut shell charcoal ash as a filler may be utilized because of its filler properties since it meets all of the requirements.

References

1. Suchithra, S., Madhankumar, S., GowshicPrasanna, M., Nandhakumar, V., & Jayashree, S. (2021). Basic Experimental Studies on Coconut Shell Charcoal Ash in Modified Bitumen. *Recent Advancements in Geotechnical Engineering: NCRAG'21*, *19*, 123.Jeffry, S. N. A., Jaya, R. P., Hassan, N. A., Yaacob, H., & Satar, M. K. I. M. (2018). Mechanical performance of asphalt mixture containing nano-charcoal coconut shell ash. *Construction and Building Materials*, *173*, 40-48.

2. Jeffry, S. N. A., Jaya, R. P., Hassan, N. A., Yaacob, H., Mirza, J., & Drahman, S. H. (2018). Effects of nanocharcoal coconut-shell ash on the physical and rheological properties of bitumen. *Construction and Building Materials*, *158*, 1-10.

3. Limantara, A. D., Gardjito, E., Ridwan, A., Subiyanto, B., Raharjo, D., Santoso, A., ... & Sudarmanto, H. L. (2019, December). Comparative Study of Bio-Asphalt, Coconut Shell Distillation Tar, and Plastic Road in terms of Construction, Economical, and Regulatory Aspects. In *Journal of Physics: Conference Series* (Vol. 1364, No. 1, p. 012058). IOP Publishing.

4. Sarki, J., Hassan, S. B., Aigbodion, V. S., & Oghenevweta, J. E. (2011). Potential of using coconut shell particle fillers in eco-composite materials. *Journal of alloys and compounds*, *509*(5), 2381-2385.

5. Patil, J. K., Biradar, A., Upare, R., Kudale, G., & Shelar, S. Assessment of Coconut Shell Charcoal as Filler in Stone Matrix Asphalt.

6. GOPI, E., & SALEEM, M. EXPERIMENTAL RESULTS OF COCONUT SHELL POLYMER MATRIX COMPOSITES.

7. Ting, T. L., Jaya, R. P., Hassan, N. A., Yaacob, H., & Jayanti, D. S. (2015). A review of utilization of coconut shell and coconut fiber in road construction. *Jurnal Teknologi*, *76*(14).

8. Girish, D., Reddy, S., & Hanumantharao, C. (2020). Partial Replacement of Stone Dust with Coconut Shell Charcoal Powder in Flexible Pavement. *Test Engineering and Management*, *83*, 890-896.

9. Abdullah, M. E., Rosni, M., Najihah, N., Jaya, R. P., Yaacob, H., & Hassan, N. A. (2017). Effect of charcoal ash coconut shell from waste material at different size on the physical properties of bitumen. In *Key Engineering Materials* (Vol. 744, pp. 121-125). Trans Tech Publications Ltd.

10. Girish, D., Reddy, S., & Hanumantharao, C. (2020). Partial Replacement of Stone Dust with Coconut Shell Charcoal Powder in Flexible Pavement. *Test Engineering and Management*, *83*, 890-896.

11. Sheeba, B. S., & Sasikumar, A. (2017). Utilization of Rice husk ash as a soil stabilizer. *International Research Journal of Engineering and Technology (IRJET)*, *4*(11), 1799-1801.

12. Amu, O. O., Owokade, O. S., & Shitan, O. I. (2011). Potentials of coconut shell and husk ash on the geotechnical properties of lateritic soil for road works. *International Journal of Engineering and Technology*, *3*(2), 87-94.

13. Yuliet, R., & Permana, D. (2021, July). Utilization of Coconut Shell Charcoal to Improve Bearing Capacity of Clay as Subgrade for Road Pavement. In *IOP Conference Series: Earth and Environmental Science* (Vol. 832, No. 1, p. 012041). IOP Publishing.] Ogunribido THT 2011 International Journal of Science and Emerging Technology 3 102 - 106.

14. Segun, N. E., & Oluyemisi, E. H. (2017). Effects of coconut shell ash on lime-stabilized lateritic soil. *MOJ Civil Engineering*, *2*(4), 140-143.

15. Norhafizah, M., & Hainin, M. R. (2016). The effect of coconut shell on engineering properties of porous asphalt mixture. *Jurnal Teknologi*, *78*(7-2).

16. Amiera Jeffry, S. N., Jaya, R. P., Manap, N., Miron, N. A., & Hassan, N. A. (2016). The influence of coconut shell as coarse aggregates in asphalt mixture. In *Key Engineering Materials* (Vol. 700, pp. 227-237). Trans Tech Publications Ltd.

17. Li, R., Xiao, F., Amirkhanian, S., You, Z., & Huang, J. (2017). Developments of nano materials and technologies on asphalt materials–A review. *Construction and Building Materials*, *143*, 633-648.

18. Fang, C., Yu, R., Liu, S., & Li, Y. (2013). Nanomaterials applied in asphalt modification: a review. *Journal of Materials Science & Technology*, *29*(7), 589-594.