INTERNATIONAL JOURNAL OF: BUILT ENVIRONMENT AND EARTH SCIENCE

TIMBOU-AFRICA ACADEMIC PUBLICATIONS
INTERNATIONAL JOURNAL, NOVEMBER, 2022 EDITIONS
VOL. 11 NO. 4 ISSN: 1881-2167

ASPHALT PAVEMENT RECYCLING WITH SUGERCANE BAGASSE ASH (SBA) AS FILLER

ABAH JOHNSON CANDY; OJO ITODO DANIEL; & DR SANI MAGAJI

Department of civil Engineering Technology, School of Engineering Technology, Federal Polytechnic, Kaura Namoda, Zamfara State

(Tetfund Sponsored Institutional Based Research)

ABSTRACT

Large quantities of agro-based wastes are generated daily and their safe disposal is raising much concern in most part of the world and Nigeria is not an exception being known for its agricultural activities. The recent trends in the stabilization/modification of construction materials have evolved innovative techniques of utilizing these materials. Recycling of Reclaimed Asphalt Pavement (RAP) and its modification to meet design specifications is among these techniques. It is in the light of this that a laboratory based investigations on the suitability of Sugarcane Bagasse Ash as filler in Hot-mix

Introduction

In the construction industry today, frantic efforts are being made by stakeholders in the area of recycling what is being considered as a waste material for beneficial use especially in road maintenance and rehabilitation. Removed deteriorated asphalt pavement is one of such materials being reclaimed and recycled in road construction especially in the developed countries whereby it is incorporated into asphalt paving mix by means of hot or cold recycling. It is also used as an aggregate in base, sub-base and sub-grade.

Some additives such as cement, Fly-ash and foamed bitumen among others are applied to the Reclaimed Asphalt Pavement (RAP) during the recycling process. Sugarcane bagasse ash an agro-based waste material has become useful in engineering application and other field of studies as readily available. In hollow concrete masonry units, RAP is used as an alternative to aggregate in the stabilization and modification of problematic soils especially in road construction. This research tends to explore the possible application of sugarcane bagasse ash (SBA) as filler in RAP recycling as it will examine the properties of sugarcane bagasse ash and its possible use as filler in RAP, in hot-mix asphalt design (HMA).

Sugarcane bagasse ash is obtained in large quantities as agro-based waste materials in almost every part of the West African region with impeding management and disposal problems. Cost of pavement production is increasing while construction materials are becoming highly scarce, and the fact that innovative techniques are being evolved in utilizing locally available, environmentally friendly, cost effective industrial and/or agro-

asphalt recycling of RAP is being conducted. The oxide composition test of the SCBA was performed using X-Ray Fluorescence (XRF) and from the result, SCBA is adjudged pozzolanic (combined weight of S_iO_2, Al_2O_3, Fe_2O_3) is 76.7 % by weight which is higher than minimum requirement 70% for a material to be pozzolanic (Raheem, et al, 2010). The result of the sieve analysis showed 82.4% of the SCBA passed sieve No. 200 which is greater than 65% - 70% specification which also describes its fineness and pozzolanic characteristics. Marshall Stability Hot-mix asphalt design method was employed to test the performance indices of the blended materials in terms of their known engineering properties. At 70% RAP, 30% fresh aggregate and the addition of SCBA at 3% of the total combined weight of aggregate (RAP + fresh aggregate), a good design mix was obtained. SCBA is adjudged to be pozzolanic; it can therefore be used as filler to provide the stiffening strength requirement like cement. The combination above is considered as the most cost effective.

Keywords: RAP, Sugarcane bagasse ash, recycling, filler, hot-mix asphalt

based waste materials, it is appropriate that modification and improvement of construction materials be stepped up with the SCBA in focus.

The focus of this research work is to examine the suitability of Asphalt Pavement Recycling with Sugarcane Bagasse Ash (SBA) as Filler. This was achieved through the following objectives which form the practical basis. To determine chemical (oxide) composition of the sugarcane bagasse ash, To conduct the Particle size distribution tests for the RAP/fresh aggregate and sugarcane bagasse ash in accordance with BS 1377, 1990; and AASHTO T 27, To determine the suitability of RAP for Reuse in Pavement by comparing the test results with general Specifications for Roads and Bridges, Federal Ministry of Works and Housing (F.M.O.W & H.) Nigeria.

Reshmi Banerjee (2015), defined Recycling is a process to change waste materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution by reducing the need for “conventional” waste disposal, and lower greenhouse gas emissions as compared to plastic production. Recycling is a key component of modern waste reduction and is the third component of the “Reduce, Reuse and Recycle” waste hierarchy.

Björn Appelqvist (2014) has defined recycling as “Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes which includes the reprocessing of organic materials. Recovered materials brought back into the value chain utilized as secondary raw materials”

Recycling is a dynamic process that restores the life cycle of a material, as waste materials can be transformed into new and useful materials. Recycling prevents waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce water pollution (from landfill) by reducing the need for conventional waste disposal, and lower greenhouse gas emissions as compared to virgin production.

Both bitumen and aggregates in RAP are non-renewable resources and while asphalt pavement deteriorates with age, any asphalt pavement can be restored to its original or near original consistency by the process of recycling, which is usually achieved by blending RAP with fresh aggregate, bitumen and rejuvenating agent.

The recycling of existing asphalt pavement materials produces new pavements with appreciable savings in material, cost, and energy, and at the same time, mixtures containing reclaimed asphalt pavement (RAP) have been found to perform equally as virgin mixtures hence, the reclaimed asphalt pavement (RAP) is one of the most recycled materials in the world. (Ahmed & Abdulla, 2015)

Removal and reuse of asphalt layer of existing pavement is termed as reclaimed asphalt pavement (RAP); while full depth reclamation (FDR) is defined as removal and reuse of hot mix asphalt layer and entire base course. RAP can be reused immediately at sites. (Brajesh 2015)

A filler is a very finely ground material of about the same fineness as Portland cement, which, due to its physical properties, has a beneficial effect on some properties of concrete, such as density, workability, permeability, etc. (Neville 2011).

Mineral filler consists of very fine, inert mineral matter that is added to the hot mix asphalt to improve the density and strength of the mixture. Filler is generally selected based on its ability to increase the stiffness of the binder mastic or improve adhesion between the binders and aggregate (Road Note 19). The amount of filler as a standard is 7% - 14% of the total weight of material for wearing course of road pavement. Typical mineral filler completely passes a 0.060 mm (No.30) sieve with at least 65 percent of the particles passing the 0.075 mm (No. 200) sieve.

Mineral fillers serve the following purposes in bituminous mix:

It forms mortar or mastic with the binder that contributes to improved stiffening of the mix.

It behaves as mineral aggregates and hence contributes to the contact points between individual aggregate particles.

In the recycling process, additive/filler material is applied. Some of the commonly used mineral fillers in bituminous pavement mix are stone dust, slag dust, hydrated lime, cement, fly ash and loess. These filler materials are not readily available at affordable cost. However, lot of research efforts has gone into waste materials in the construction industry exploring for alternatives at affordable cost. Such materials include industrial, domestic and agro-based waste (Raheem *et al*, 2010). Among the agro-based wastes is Sugarcane Bagasse Ash (SBA) is an agro-based waste product, which is available in abundance in sub-Saharan Africa.

Penki et`al (2016), in a study stated that coarse aggregates contribution to the stability of a bituminous paving mixture is mostly due to interlocking and frictional resistance of adjacent particles, while the contribution of fines or sand to stability failure function is filling of voids between coarse aggregates, and mineral filler is often seen as a void filling agent.

David et`al (2016) in a research stated that Bagasse-ash is suitable as a filler based on testing with a variety of Bagasse-ash and cement content. Also, the use of Bagasse-ash as a filler can both reduced the needs of cement filler and provide a fairly high economic value in addition to overcoming the existing waste.

Murana& Sani (2015), study the effect of partial replacement of cement with bagasse ash in hot mix asphalt and revealed that the cement/bagasse ash mixes exhibits satisfactory trend results with average bitumen content, while stability increases with decrease in bagasse content. In conclusion, it was stated that bagasse ash as a partial replacement for cement will help in solving environmental problems of bagasse waste disposal experienced in urban areas; thus help in achieving the phrase "waste to wealth`

According to (Raheem, *et al,* 2010), The chemical composition of some agro-based wastes contained lot of silica (SiO_2) and ASTM C618 – 7 specifies that materials with a combined weight of silica, alumina and ferrous oxides of 70% and above be characterized as pozzolanic

MATERIALS AND METHODS

Materials: Materials used for this research include the following.

The Sugarcane Bagasse was sourced locally from sugarcane farm plantation in Zaria local government area of Kaduna state.

Hot-Mix Asphalt (HMA) main components made of, asphalt cement and aggregate from fresh and RAP materials as well as sugarcane bagasse ash (SBA) as filler material.

The reclaimed asphalt pavement material used was obtained from a scarified discarded pavement surface of a road around GIWA along Funtua – Zaria road. The reclaimed asphalt pavement which was pulverized manually was supplied by a vendor after the site was identified.

Fresh aggregate used in this research work was obtained from a quarry of Mother Cat Limited Quarry, a civil engineering construction company located along Gusau -Talata Mafara road. The aggregate was supplied in various sizes (all-in aggregate) after identification of the site.

The bitumen was supplied from the asphalt plant of Mother Cat Limited located as mentioned above. It is 60/70 grade cutback bitumen which is the commonly used bitumen in road construction for medium traffic.

Methods

The Sugarcane Bagasse was burnt in the open atmosphere and ash after complete burning, was collected, sealed up and transported to the laboratory. It was then ground and sieved through the British Standard No. 200 sieve. The material passing the sieve is then mixed with RAP and fresh aggregate using trial and error method of blending. Partial replacement was adopted. The required ratios of the specimen for the necessary tests was 100% RAP & 0% fresh aggregate, 80% RAP & 20% fresh aggregate, 70% RAP & 30% fresh aggregate, 60% RAP & 40% fresh aggregate, 50% RAP & 50% fresh aggregate.

Investigation was conducted on Briquettes prepared by reconstituting RAP with the addition of fresh aggregate, Sugarcane Bagasse Ash (filler) and bitumen

The chemical analysis of the oxide composition of sugarcane bagasse was performed in the laboratory by subjecting the material to X- Ray Fluorescence test. X-ray Fluorescence (XRF) which is a non-destructive analytical technique used to determine the elemental composition of materials was used in this research to obtain the oxide composition of the mineral fillers.

TIJBEES
ISSN: 1881-2167

Marshal Stability test method was used to determine the optimum bitumen content and for evaluating SCBA specimen in order to achieve the optimum bagasse ash replacement for mineral filler

The Physical and mechanical properties of aggregate was also conducted, Particle size distribution of materials which includes, SCBA, fresh aggregates, and reclaimed asphalt pavement (RAP) was conducted using sieve analysis test method in the laboratory. The SCBA was sieved through sieve size of (0.63 – 0.075) mm arranged in descending order of size, while the fresh aggregates and RAP were sieved through sieve size of (22.0 – 0.075) mm also arranged in descending order of size.

RESULTS AND DISCUSSION

Chemical (Oxide) Composition of (SCBA)

Table 3.1: Chemical Composition of Sugarcane Bagasse Ash (SCBA)

Components	Sio_2	Al_2o_3	Fe_2o_3	Cao	Mgo	So_3	K_2o	Carbon
Weight %	62.22	5.83	8.64	7.81	2.76	1.56	7.66	11.03

Composition by weight in SCBA of $Sio_2 + Al_2o_3 + Fe_2o_3 = 76.7\ \% > 70\%$

The desirable properties of mineral filler in terms of fineness and pozzolanic characteristics were met with the sugarcane bagasse Ash (SCBA) since the percentage passing sieve No. 200 of 82.4% is greater than 65% - 70% specification. In addition to its fineness, SCBA is adjudged pozzolanic with (combined weight of S_iO_2, Al_2O_3, Fe_2O_3) of 76.7 % by weight which is higher than minimum requirement 70% for a material to be considered pozzolanic (Raheem, *et al,* 2010), thus capable in providing strength requirement (stiffness) as that of ordinary Portland cement (OPC). With the above qualities, SCBA can be used as filler in hot mix design of asphalt pavement

Particle Size Distribution of SCBA

The result of the Particle size distribution tests for the sugarcane bagasse ash (SBA) and RAP/fresh aggregate in accordance with BS 1377, 1990; and AASHTO T 27 are presented in Table 3.2 and Table3.3 respectively.

Table 3.2: Particle size distribution for sugarcane bagasse Ash (SBA)

Sieve Size (mm)	Percentage passing (%)
0.63	100
0.60	100
0.43	99.03
0.315	98.22
0.30	98.1
0.15	93.2
0.075	82.4

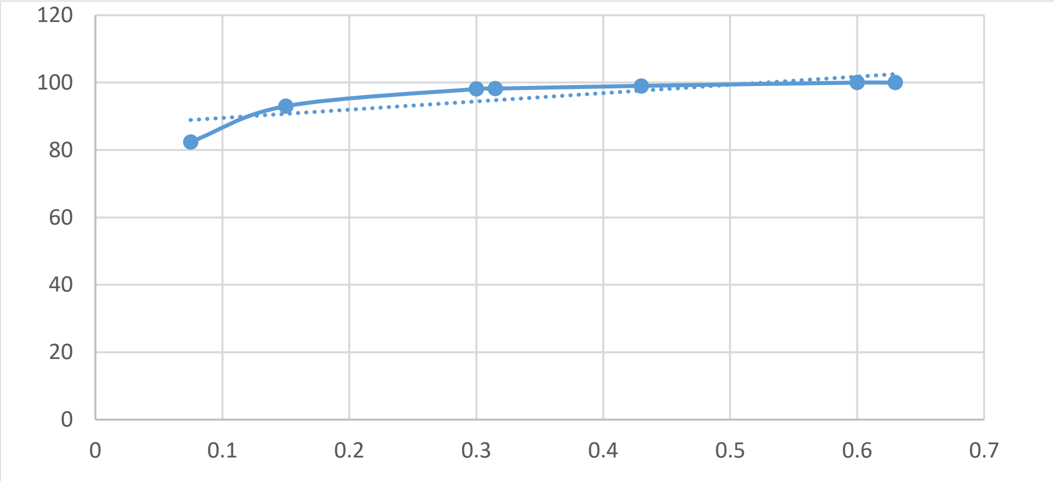

Figure 3.1: particle size distribution of SCBA

Table 3.3: Particle Size Distribution for RAP and Fresh Aggregates

Sieve size (mm)	Percentage Passing (%)	
	RAP	Fresh Aggregate
22.0	-	100
19.0	100	98.9
12.5	85.6	83.1
9.5	71.2	73.0
6.3	53.7	58.9
2.36	32.8	42.4
1.18	23.1	34.3
0.60	9.4	28.1
0.30	5.8	19.6
0.15	1.9	9.8
0.075	0.7	6.2

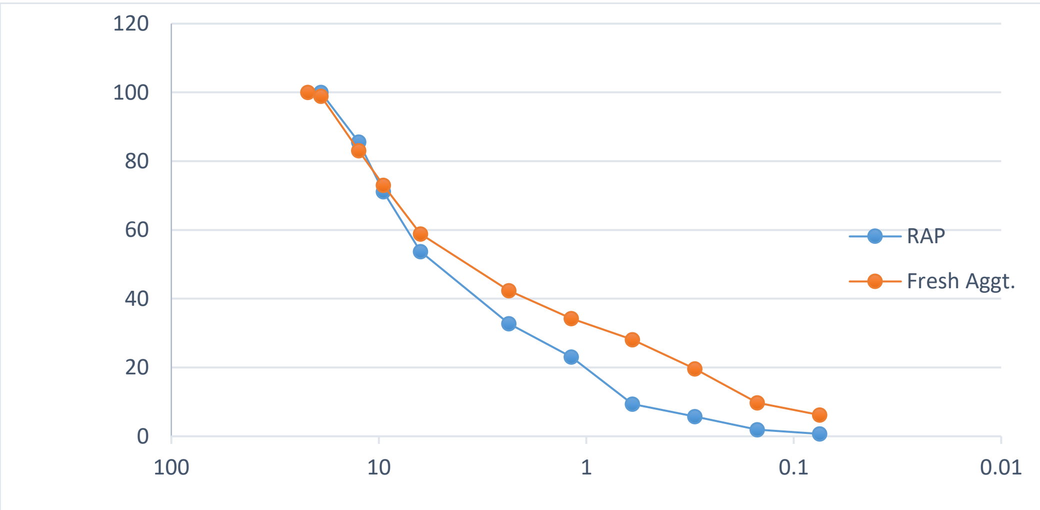

Figure 3.2: particle size distribution of (RAP) and fresh aggregate

Figures 3.1 and 3.2 demonstrates the graphical representation of the particle size distribution of sugarcane bagasse, reclaimed asphalt pavement (RAP) and fresh aggregate respectively as presented in tables 3. 2 and 3. 3

SUITABILITY OF RAP FOR REUSE IN PAVEMENT

The test results of RAP and fresh aggregate particle size distribution as compared with the Nigeria general specification for roads and bridges 1997 "Federal ministry of works and housing (F.M.O.W & H)" is presented in table 3.4, while the RAP particle size distribution trying to fit within the envelope of the upper and lower limits of the specification is represented graphically in figure 3.3.

Table 3.4: Particle Size Distribution for RAP and fresh aggregate Compared with Specification

Sieve Size	Percentage Passing		Specification
(mm)	RAP	Fresh Aggregate	(F.M.O.W.)
25	-	100	-
19.00	100	98.9	100
12.50	85.6	83.1	85 – 100
9.50	71.2	73.0	75 – 92
6.30	53.7	58.9	65 – 82
2.36	32.8	42.4	50 – 65
1.18	23.1	34.3	36 – 51
0.60	9.4	28.1	26 – 40
0.30	5.8	19.6	18 – 30
0.15	1.9	9.8	13 – 24
0.075	0.7	6.2	7 – 14

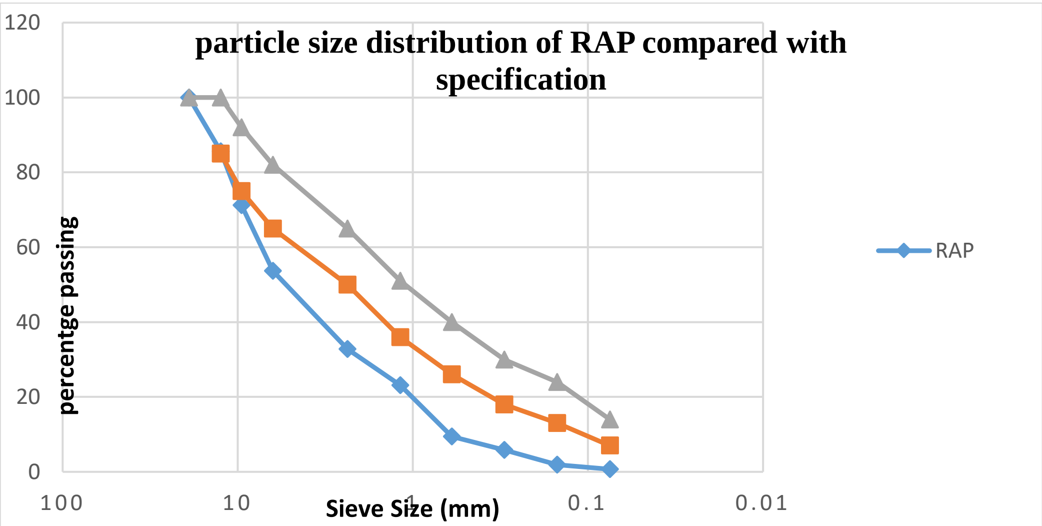

Figure 3.3: Particles size distribution for RAP compared with specification.

It is clear from table 4.5 and Fig 1, that RAP did not fit in to F.M.O.W.&H gradation envelope Thus, RAP gradation requires a boost from both fresh aggregates and Filler materials in order to be appropriate for production of pavement bituminous mixes.

BLENDED OF AGGREGATES.

The reclaimed asphalt pavement (RAP) material was reconstituted by the addition of fresh aggregate and SCBA (filler) employing the trial and error method of proportioning. A typical comparative table between the gradation of the combined materials with specifications (F.M.O.W, Nigeria) is shown in Table 4.6 below.

Table 3.5: Samples of different composition of RAP and Natural aggregate

Sample Ref. No.	Detail of Composition
A1	100% RAP + 0% Natural aggregate
A2	80% RAP + 20% Natural aggregate
A3	70% RAP + 30% Natural aggregate
A4	60% RAP + 40% Natural aggregate
A5	50% RAP + 50% Natural aggregate

Table 3.6: Comparison of Blended Aggregates gradation with specification

S/No.	Sieve Size	Percentage of Filler Content (%)					Specification of FMOW&H
		0.5	1.5	2.0	2.5	3.0	
1	19.000	100.000	100.000	100.000	100.000	100.000	100
2	12.500	99.810	99.810	99. 810	99. 810	99. 810	85 – 100
3	9.500	89.800	89. 800	89. 800	89.800	89. 800	75 – 92
4	6.300	76.770	76.770	76. 770	76. 770	76. 770	65 – 82
5	2.360	64.360	64. 360	64. 360	64. 360	64. 360	50 – 65
6	1.180	41.470	41. 470	41. 470	41. 470	41. 470	36 – 51
7	0.600	32.950	32. 950	32. 950	32. 950	32. 950	26 – 40
8	0.300	24.119	24. 119	24. 119	24. 119	24. 119	18 – 30
9	0.150	16.306	16.251	16.238	16.216	16.204	13 – 24
10	0.075	6.916	6.784	6.718	6.652	7.832	7 – 14

The preliminary test results in this research indicated the aggregate in the RAP has to be built up with fresh aggregate because its gradation falls outside the specification envelope. Bitumen content in the RAP was rather very viscous thereby indicating oxidation. The physical and mechanical properties of RAP have passed the minimum requirements for mix design. Sieve analysis on sugarcane bagasse Ash showed that, the material can be used as filler since over 80% of SCBA passes No. 200 sieve which satisfied the fineness requirement of filler which states that at least 65% must pass No. 200 sieve. Furthermore, SCBA is adjudged to be pozzolanic, it can therefore be used as filler to provide the stiffening strength requirement.

Table 3.7:Test results of filler and aggregate in Comparison with standard specifications

S/No.	Properties	Code specifications	Test Results
1	Specific gravity (SCBA)	2.85	2.847
2	Specific gravity (fine aggregate)	2.60 – 2.90	2.68
3	Specific gravity (coarse aggregate)	2.60 – 2.90	2.63
4	Aggregate impact Value (C A)	< 30%	22.37

The properties of the materials studied here meet the requirement of the standard specifications as compared in the table 3.7.

CONCLUSION

Conclusion

This paper presents a laboratory based study that was conducted to evaluate the performance of asphalt concrete mix design using sugarcane bagasse ash (SCBA) as filler in hot mix recycled asphalt pavement (RAP) and to establish the best possible combination of RAP, Fresh Aggregate and SCBA that meet the Nigerian specifications for Hot-mix asphalt design. The basic goal and objectives of the research is achieved from the results of the laboratory experiments hence sugarcane bagasse ash is adjoined to be pozzolanic and suitable to be used as filler.

REFERENCES

A.A Murana & L. Sani (2015), partial replacement of cement with bagasse ash in hot mix asphalt; Nigerian journal of Technology. Vol.34, No. 4

A. M. Neville (2011), Properties of concrete, 5thedt., Pearson Education ltd, Harlow, England.

Abarshi, M.D. (1988): Use of Billet Scales as filler in Asphaltic Concrete: MSc Thesis submitted to the department of Civil Engineering, Ahmadu Bello University, Zaria.

Ahmed Ebrahim Abu El-Maaty& Abdulla Ibrahim Elmohr (2015), Characterization of Recycled Asphalt Pavement (RAP) for Use in Flexible Pavement. American Journal of Engineering and Applied Sciences

American Association of State Highway and Transportation Officials (AASHTO -2000 – 2001) AASHTO Provisional Standards: Washington, DC.

Brajesh Mishra (2015), A Study on Use of Reclaimed Asphalt Pavement (RAP) Materials in Flexible Pavements. International Journal of Innovative Research in Science, Engineering and Technology; Vol. 4, Issue 12.

British Standard 1377 (1990) Methods of Test for Soils for Civil Engineering purposes. Technical Information Services Department, CNL Technical Information Services, BSI Publications, 389 Chiswick High Road London W4 4AL.

David D.M. Huwae, L.R.Parera and J.Tanijaya (2016), Bagasse-Ash as Filler in HRS (Hot Rolled Sheet) Mixture; world congress on advance in civil, environmental and materials research (ACEM 16), Jeju Island, Korea

Eyo, T. B. (2007): Asphalt 100% recyclable: Federal Roads Agency (FERMA) Research and Development Unit Read op, Series 1, pp.3-19. April-June Edition

FHWA (2008). "User guidelines for byproducts and Secondary use materials in pavement Construction." Federal Highway Administration,

Overseas Road Note 19 (2002): A Guide to the Design of Hot Mix Asphalt in Tropical and Sub-Tropical Countries:

Penki Ramu, P.Sarika, V.Premraj Kumar &Dr.P.Sravana (2016), Analytical Method for Asphalt Concrete Job Mix Formula Design; International Research Journal of Engineering and Technology (IRJET). Volume: 03 Issue: 10

Raheem, A. A., Oyebisi, S. O, Akintayo, S. O, Oyeniran, M. I. (2010). Effects of Admixtures on the Properties of Corn Cob Ash Cement Concrete. *Leonardo Electronic Journal of Practices and Technologies.*6: 13-20.

Salman, Ahmed Bhutta, (1998): Mechanistic-Empirical Pavement Design Procedure for Geo-Synthetically Stabilized Flexible Pavements: A Dissertation of Ph.D. Submitted to the Virginia Polytechnic Institute and State University.

Reshmi Banerjee (2015), International Journal of Innovative Research in Electrical, Electronics, Instrumentation, and Control Engineering. Vol. 3, Issue 6, June 2015

Björn Appelqvist (2014), International Solid Waste Association (ISWA) Beacon Conference on Waste Prevention and Recycling Copenhagen, June 16th – 17th 2014