Recycling of waste materials such as waste cooking oil and crumb rubber tyre for asphalt pavement construction

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***Abstract*- The use of waste materials in pavement construction is one of the steps to reduce environmental concern globally. In this study, asphalt mix was modified with crumb rubber tire (CRT), waste cooking oil (WCO), in 0%,2%, 4%, 6%, 8% and 10%. Other materials used for this study include bitumen, coarse aggregates, and stone dust. The optimum bitumen content is found to be 6% for the asphalt mix without addictive this serves as the control mixture for the subsequent mixes. The stability of bitumen modified with CRT and WCO increases with increase in the modifier content. This may be due to the lack of proper decomposition of the waste materials in the mixture. WCO has the highest stability value of 27.4N at 6% this indicates that has more stability than CRT which implies that WCO can withstand any sudden shock or impact abrasion Test result shows that bitumen with CRT, WCO in higher quantities does not increase to abrasion and the subsequently mix durability. Though CRT, WCO can improve the physical properties of bitumen which in turn could affect the mechanical and volumetric properties of asphalt mixture the use of specific amounts (such as 10%, 6%) of CRT, WCO as bitumen modifier in mixtures based on traffic volume can easily satisfy standard requirements which could help in reducing cost of asphaltic concrete and generate economic.**

***Index Terms*- Bitumen, Waste cooking oil, Crumb rubber tyre.**

I. INTRODUCTION

Over the years, the deterioration in roadway pavement in India is kept on increasing. Various maintenance works are required to reduce pavement failure. Increase in road user, will lead to expansion pavement loading thus resulting in pavement failure. The low yield of bitumen under boost transport growth heavier axle load has led to the advanced work and buildup on modified binders. Development of alternative material especially to apply discarded in pavement construction in the steps to reduce environmental concern in many countries. The research with enlargement towards tar began in Europe and has spread around the world. It had done for recognized that material with automatic quality and rheological behaviour of conventional asphalt compositions can be added as it is an effective way to enhance pavement performance. The modifiers influence of bitumen constitution, manufacture of the polymer-modified bitumens, properties of polymer-modified bitumens, and products and applications [1,2]

The cities are stinking from heavy unmanageable solid waste causing pollution in the environment. Hence, the need to study the performance and characteristics towards fragment tire. (CRT), Waste cooking oil (WCO), dust like modifiers in asphalt mix bitumen so as to determine their suitability in asphalt roads and other construction works. Past studies indicates that physical as well as chemical of modified bitumen is improved. Hence, this study investigated the suitability and effects of CRT, WCO as modifier in asphalt mix.When bitumen is applied in the field, it must be heated to a higher temperature, which produces bitumen fume, which contains heavy metals, saturates, and aromatics. The goal of this work is to incorporate waste materials, which includes, oil, tyre rubber powder into bitumen industry in an effort to minimize natural resourced material usage i.e. bitumen resulting in minimizing environmental degradation and positively affecting country's economy by substitution of substantial percentage of costly material i.e. bitumen with waste material. An optimum percentage of conventional bitumen will be replaced with the percentage of waste cooking oil tyre rubber powder thus the use of bitumen will be minimized which is both economically viable and environmental friendly.

OBJECTIVES:

1. To determine the physical properties of bitumen.
2. To determine the physical properties of modified bitumen with partial replacement of bitumen by crumb rubber tyre.
3. To determine the physical properties of modified bitumen with partial replacement of bitumen by waste cooking oil.
4. To compare the physical properties of modified bitumen with bitumen.
5. To determine the marshall stability and flow test of bitumen with partial repplacement of bitumen by crumb rubber tyre and waste cooking oil.

II. LITERATURE REVIEW

1. Gabriel Macedo Duarte, Adalberto Leandro Faxina (2021) in their entitled " Asphalt concrete mixtures modified with Polymeric waste by the wet and dry processes". Polymer modification of asphalt binders is undoubtedly the best technique to improve the asphalt binder properties and consequently, the AC pavement.

2. Wan Nur Aifa Wan Azahar, Ramadhansyah putra Jaya, Mohd Rosli Hainin Mastura Buianag, Norzit (2016) in their paper Entitled " Chemical modification of waste cooking oil to improve the physical and rheological properties of Asphalt binder". The improvement of good bonding in modified asphalt binder by using treated WCO.
3. Zhaoxing Xie and Junan shen (2015) in their paper entitled " Performance of porous European mix (PEM) pavements Added with crumb rubbers in dry process". This paper presented a preliminary evaluation of the long-term performance of rubberised PEM pavements.
4. Aslam A Al-Omari, Taisir S Khedaywi, Mohammad A Khasawneh (2018) in their entitled "Laboratory Characterization of asphalt binders modified with waste vegetable oil using SuperPaveSpecifications". The disposal o the waste oils and fats is the main reason behind considering their management an important challenge.

III. MATERIALS

Bitumen, granite (coarse) aggregates, stone-dust (fine aggregate),CRT, WCO, were considered in the study. The bitumen used which served as binder was sourced from IBC India. The granular and cumulative collection were obtained from local suppliers within India. The WCO was obtained from Restaurants, Hotel within India. While the CRT were collected from vulcanizers workshops in India. Table 1 and 2 present the physical properties of aggregates and the of 80/100 bitumen used in the study for heat combine pitch mixtures based on ASTM D3515.

Table 3.1: Physical Properties of Aggregates

Test	*Method*	*Obtained values*	*Standard Requirements*
Conventional Aggregates			
Specific gravity	*ASTM C127*	*2.66*	*-(coarse)*
Specific gravity	*ASTM C128*	*2.63*	*-(fine)*
Water absorption	*ASTM C127*	*0.32%*	*-(Coarse)*
Water absorption	*ASTM C128*	*1.01%*	*-(fine)*
Aggregate impact	*BS 812: part 3*	*15.37%*	*Below 15%Value*
Aggregate crushing	*BS 812: part 3*	*30%Value*	

Table 3.2: Physical Properties of 80/100 Binder

Test	*Method*	*Obtained values*	*Standard Requirements*
SofteningPoint	*ASTM D36*	*50℃*	*47-49℃*
Penetration	*ASTM D5*	*36.3mm*	*84-95mm*
Ductility	*ASTM D113*	*115.3cm*	-
Specific Gravity	*ASTM D70*	*1.1*	-

Table 3.3 Binder Content

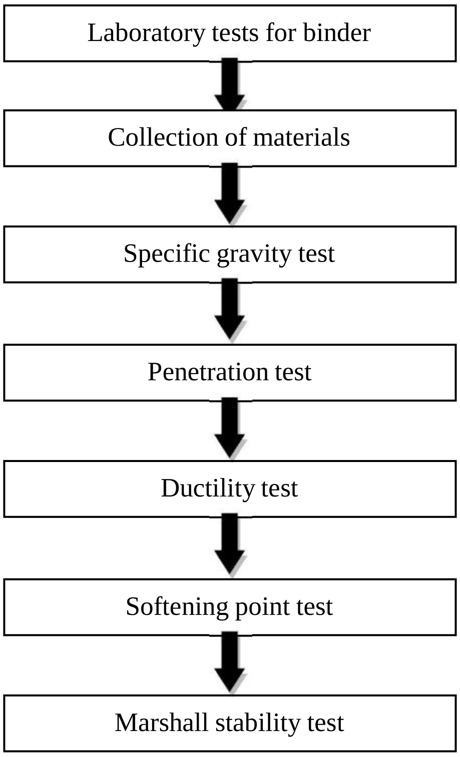
CB(%)	*Modified(%) CRT*	*WCO*
100	-	-
98	*2*	*2*
96	*4*	*4*
94	*6*	*6*
92	*8*	*8*
90	*10*	*10*

IV. METHODOLOGY

TEST ON BITUMINOUS MATERIALS

1. Collection of materials.
2. The properties of the different samples were characterized using various tests viz, Ductility test, Penetration test Softening Point test, Viscosity test, Specific gravity test and Marshall stability test.
3. Samples were prepared from the mixture of Bitumen, Coarse Aggregates, Filler, waste ground tire rubber and waste Cooking oil.

4. The asphalt binder is replaced with 10 and 50% of waste cooking oil by weight collection of materials.
5. Test on specimens.
6. Comparison of data.
7. Conclusion.



Moulds Samples

V. RESULTS AND DISCUSSION

RESULTS OF PHYSICAL PROPERTY TESTS ON MODIFIED BITUMEN

 BITUMEN SAMPLE	 BITUMEN + OIL SAMPLE
\  BITUMEN + CRT SAMPLE	 BITUMEN + CRT + OIL SAMPLE

Figure 1 Bitumen Sample

i. SPECIFIC GRAVITY

Table-1 Specific gravity-Crumb Rubber Tyre & Waste Cooking Oil

Bitumen	CRT	Value	WCO	Value
100	0%	1.05	0%	1.17
98	2%	1.07	2%	1.14
96	4%	1	4%	1.14
94	6%	0.96	6%	1.14
92	8%	0.93	8%	1.17
90	10%	0.90	10%	1.23

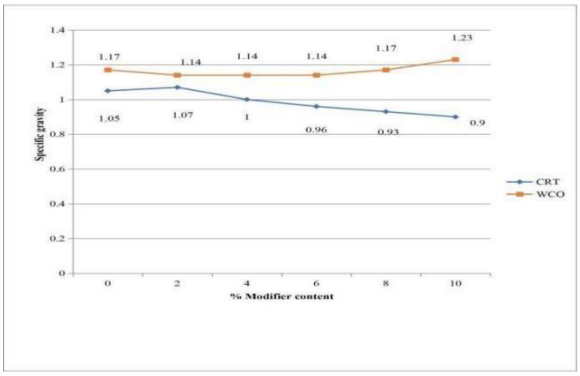


Figure 2 Specific gravity of modified Bitumen

The above figure shows the specific gravity of the modified bitumen. Values obtained for CRT, WCO are within the Standard specified. With the highest value been 1.120 at 10% CRT. And thus, allow for volumetric conversions during the mix design.

ii. PENETRATION TEST

Table-2 Penetration- Crumb Rubber Tyre & Penetration- Waste Cooking oil

Bitumen	CRT	Value	WCO	Value
100	0%	36.3mm	0%	36.3mm
98	2%	32mm	2%	35mm
96	4%	27.4mm	4%	40mm
94	6%	22.4mm	6%	45mm
92	8%	28mm	8%	60mm
90	10%	32mm	10%	12mm

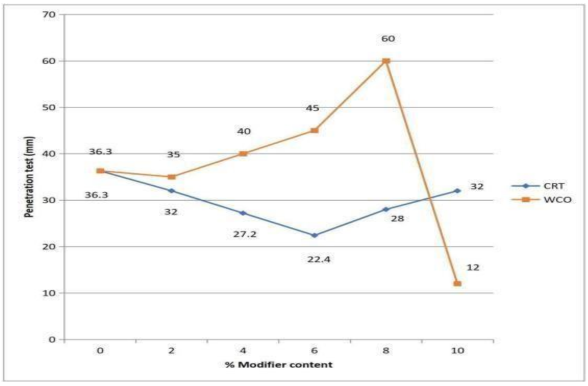


Figure 3 Penetration of modified Bitumen

The above figure shows the penetration the modified bitumen outcomes at 0% the measure of penetration was 36.3mm. This decreased to 32mm at 2% CRT, 27.2mm at 4%, 22.4mm at 6%, 28mm at 8% and 32mm at 10%. The penetration value is Compared of 0% modified bitumen with WCO modifier shows an expanding in value for 4%,6%,8% and 10%. For WCO, the penetration at 2% is 35mm this decreased to 12mm at 10%. The low penetration values of modified bitumen could have been caused by pouring temperature, six o needles, weight placed on the needle, and the test temperature.

iii. SOFTENING POINT TESTiv.

Table 3 Softening point- Crumb Rubber Tyre & Waste Cooking Oil

Bitumen	CRT	Softeningpoint	WCO	Softeningpoint
100	0%	50°C	0%	50°C
98	2%	67°C	2%	73°C
96	4%	54.5°C	4%	44°C
94	6%	56.5°C	6%	40.5°C
92	8%	66°C	8%	49°C
90	10%	76°C	10%	47°C

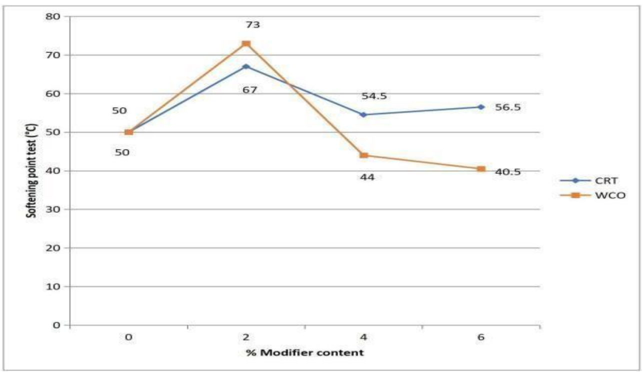


Figure 4 Softening point of modified Bitumen

The above graph shows at 0% CRT content, the softening point of bitumen was 50℃ this increased to 67℃ at 2% CRT and later decrease at 4% to 54.5℃ it then increase to 56.5℃, 66℃, and 76℃ for 6%, 8% and 10% CRT respectively. As shown, the softening point increases with increase in percentage addition of CRT. On addition of 2% WCO to the bitumen the softening point value was 73℃, 44℃ for 4%,40.5℃ for 6% this then increased to 49℃ for 8% addition and later decreased to 47℃ for 10%. This might be because of viscosity of WCO. All the percentage additions of CRT to bitumen are beyond the specified softness of 47-490℃ (ASTM D36). This implies that modified bitumen with CRT and WCO makes the mixture to be soften beyond the required standard for HMA mix. This due to may be to rate of heating and the bitumen grade (the harder the grade, the more will be the softening point). Additions of WCO to bitumen between 4-10% are within the specifications required for HMA. At temperature beyond the soften point, the bitumen will begin to melt and thus, result in sticky pavement.

iv. DUCTILITY

Table 4 Ductility- Waste Cooking Oil

Bitumen	Crumb Rubber Tyre (**CRT**)	**Ductility Value**	**WCO**	**Value**
100	0%	115.5cm	0%	115.3cm
98	2%	21cm	2%	70cm
96	4%	24.5cm	4%	55cm
94	6%	26.6cm	6%	53cm
92	8%	28.2cm	8%	37cm
90	10%	25.6cm	10%	42.5cm

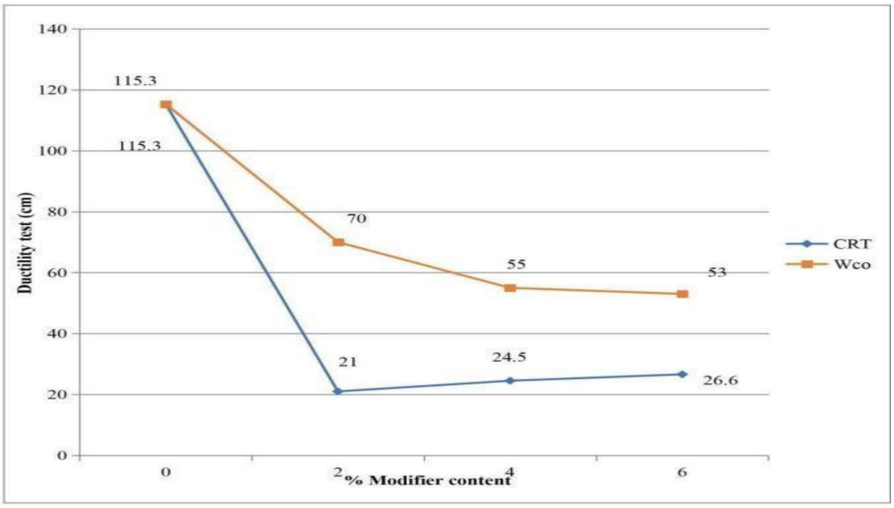


Figure 5 Ductility of modified Bitumen

The above graph shows the ductility test 0% modifier is 115.5cm at 2% addition of CRT is decreases to 21cm, 24.5cm at 4%, 26.6cm at 6%, 28.2cm at 8% and 25.6cm at 10%. Modification of bitumen with WCO showed a reduction in the ductility value from 70cm to 2% to 42.5cm at 10%. Among the three modifiers, WCO has the highest ductility when added to bitumen. This Tends to order to minimum requirements as compared to CRT.

VI. MARSHALL STABILITY AND FLOW TEST

Marshall stability result for CRT is shown in Figure. It is apparent that the presence of CRT in the bitumen combine effectively improves the stability values which will result in an improvement of mixture toughness. This result specifies that the mixture using CRT would have higher performance than using the standard mixture. Variation of marshall stability and flow value with modified CRT content are given in Figure this indicate that the stability of bitumen modified with CRT content. The flow value of asphalt mixincreases initially reaches maximum value and then decreases with increase in CRT Content. The flow value of bitumen mix with conventional bitumen is 3.5.s

M1 - Only Bitumen
M2 - Bitumen + WCO (6%)
M3 - Bitumen + CRT (10%)
M4 - Mix (Bitumen + CRT +WCO

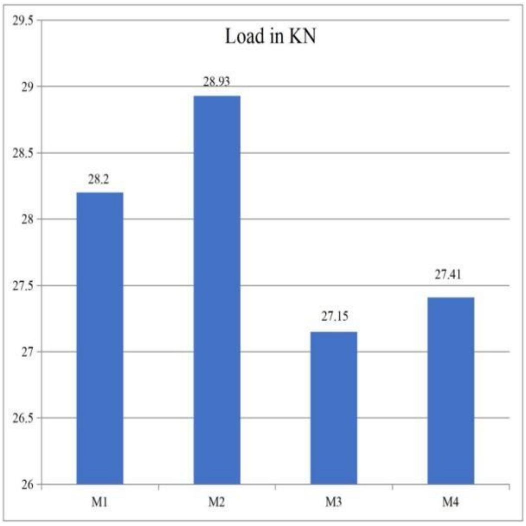


Figure 6 Marshal Stability Value in KN

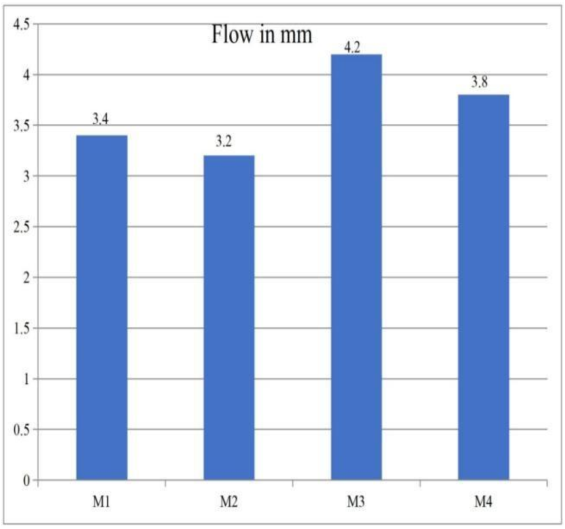


Figure 7 Marshall Stability: Flow Test

CONCLUSION

This study presented the lab results obtained from the modification of bitumen with CRT, WCO, on the performance of HMA, the following conclusion are obtained:

- The OBC for convectional bitumen as recommended by standard is between 4% - 6% based on the test conducted, the OBC of CRT, WCO modified bitumen were within the range specified by the standard.
- The maximum stability value obtained is 27.6N by using CRT as modifier at OBC of 10%, 27N for WCO at 6% modifier and 27.3N was obtained at 6% when was used as modifier. This indicates that WCO has more stability than CRT and WCO which implies that can withstand any sudden shock or impact.
- Generally, it can be inferred that this study as promoted suitable technology sustainable development through waste recycling to produce a new material in an environment friendly manner.

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