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Research Article

Modification of Iraqi Asphalt 40/50 Properties Using Saw Dust (SD) and Natural Rubber Latex

Rusul M. Darwesh[1], Balqees M. Al-Dabbagh[1], Firas A. Mohammed[2]
[1] Department of Applied sciences, Materials science, University of Technology, IRAQ.
[2] Petroleum research and development center, Ministry of oil, IRAQ.
*Correspondent Author Email: rusulrusul83@yahoo.com

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Abstract
The aim of this research is to enhance the fundamental properties for asphalt binder as those specifications relate to performance of asphalt mixtures. In this paper studied the effect of add (2, 4 %) SD in different sizes and (3, 5 and 7%) Natural rubber latex to the straight asphalt 40/50 produced from Al-Dura refinery at 160°C, it was added each additive separately and then added together to asphalt in same temperature, then tested physically and mechanically according to the American Society for Testing and Materials (ASTM), the result showed largely improvement.

Keyword: Asphalt binder, asphalt mixture, physical and chemical properties, sawdust, Natural rubber latex

الخلاصة
الهدف من هذا البحث هو تحسين خصائص الرابط الاسفلتي واداؤه خلال الخرسانة الاسفلتية, حيث تم دراسة تأثير اضافة (2,4 %) من نشارة الخشب وبعدة احجام و(3,5 و7%) من المطاط الطبيعي اللاتكس الى الاسفلت نوع 50/40 المنتج من مصفى الدورة عند درجة حرارة 160°C, وتم إضافة كل مضاف الى الاسفلت على حدى ثم تم اضافة المضافين معا الى الاسفلت وبنفس الدرجة الحرارية, بعد ذلك تم اختبار النتائج فيزيائيا وميكانيكيا وفقا للمواصفات التابعة للجمعية الامريكية للاختبارات والمواد(ASTM) واظهرت النتائج تحسن كبيرا.

Introduction
Asphalt used in many applications especially in pavements [1] related to rheological properties where have a thermoplastic nature (making it solid in low temperature and soft in high temperature), adhesion, cohesion and water proofing properties [2].
Asphalts black or dark brown in color, amorphous and composed principally of high molecular weight hydrocarbons, soluble in carbon disulfide and in trichloroethylene with density 1g/cm3 and flows at high temperature.
Paving asphalt subjected to repeated loads and thermal loading, which make it lose the ability to maintain optimal performance and this leads to appearance defects on the asphalt pavement and structural degradation, therefore improving the quality of asphalt by additives is the target for researchers and engineers. [3].
In this research the additives was selected to enhance the quality of asphalt, blend and compatibility with it, to Produce a new better binder type by increase viscosity, elasticity, softening point, stability and the strength of mixtures and improve the pavements, rutting resistance, thermal cracking, and fatigue resistance of blends after investigated by the physical and mechanical tests shown below.

Materials and Methodologies
Sawdust (SD) is a waste products obtained by cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool. Wood consists of carbon about 50%, hydrogen, oxygen and ash. These elements share in to the formation cellulose which represents the chief constituent of plant cell wall and perhaps, characterized of fiber by durability and resistance to compression and hardness, which increases when the density is increase and increase the adhesion. In addition, it can reduce costs, and also environmental cost due to the recycling of waste sawdust [4].
The natural rubber latex(NRL) has a colloidal suspension collected from trees containing ~60%

rubber after stabilized with NH3with chemical formula $(C5H8)_n$, it has advantages such as elasticity, lower mixing temperature and faster mixing and has some disadvantages such as foaming, ammonia vapor and heat loss [5].

Penetration test: it is a measure of hardness of asphalt. Softening point is the temperature at which the asphalt becomes soft under the influence of steel ball and it is affects the asphalt surface in bleeding. Ductility Test: It is the measure of cohesion strength and adhesion of bitumen. Viscosity Test: It is defined as the fluid characteristic of bitumen material at application temperature therefore it affects on the strength properties Toughness and Tenacity: Toughness is defined as the work required separating the tension head from a sample of asphalt under a specified test conditions. Tenacity is defined as the work required stretching the material after the initial resistance is overcome. Penetration Index (PI): It is a consistency is an empirical measure of the resistance exhibited by a fluid to continuous deformation when it is subjected to shearing stress. PVN: is a function of Asphalt cement behavior at low temp performance.

Mechanical Tests (Marshall Test): has been carried out according to standard test method for resistance to plastic flow of bituminous paving mixture loaded on the lateral surface, it include tests (stability, flow, air voids%, bulk density and stiffness).

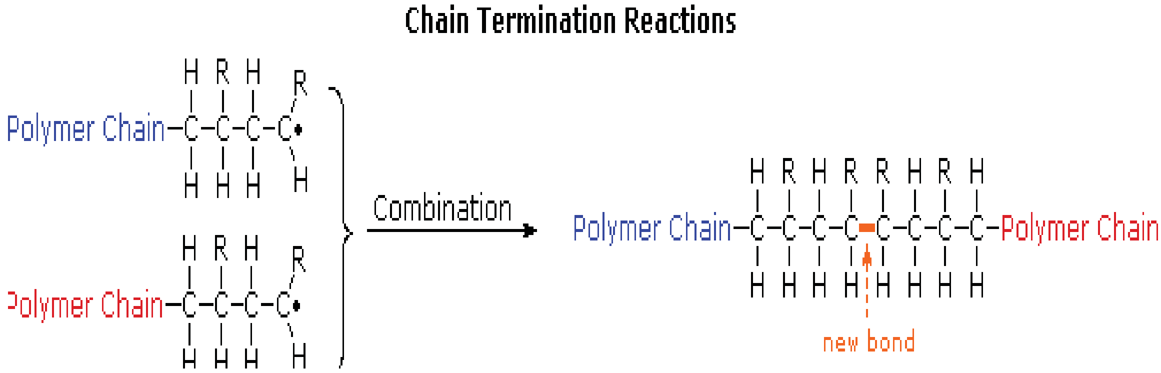

Figure 1: Additives compatible with asphalt.

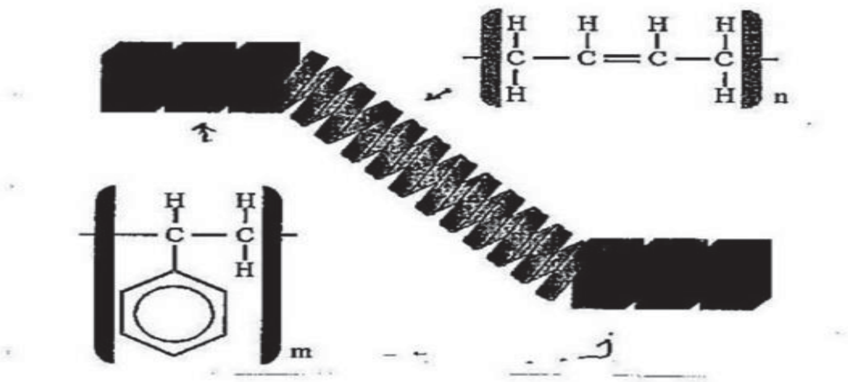

Figure 2: Structure of NRL [5].

The saw dusts with linear chain add to hot asphalt with homogeneous distribution of the components. There will be bonding across the interface and have inter-diffused into one another (Close in concept to the mechanical interlock theory). Consequently improvement of all asphalt properties except ductility test, there for natural rubber latex (NRL) was chosen for the purpose of increasing ductility value as elastomer polymer to enhance the elastic recovery of modified asphalt and reduces the thermal degradation problem. This is because the (NRL) polymer occupies a space of total mix and cause reduction in asphalt volume.

Results and Discussion

The addition of Sawdust (SD) and Natural rubber latex (NRL) to the asphalt with good mixing is the key to improving performance, all physical properties improved. The Figure (3) shows the penetration value generally will improve and decrease from 40 to 26 that is mean the additives improve the penetration value and makes the asphalt harder, softening point is increasing from 48.8 to 62 °C this indication to increase plasticity and decrease the temperature susceptibility, and for ductility values, it decrease from 100 to 31.5 with (4% SD), but when add NRL to SD keep value 100cm or more than it. Improving in viscosity values from 450 to with 1870 mean aggregates could absorb less asphalt and was able to be coated with thick film, thereby increasing adhesion among aggregates. Such results could be increasing the stability and reduce rate of stripping as shown in Figure (5). Toughness will enhance from 0.9 to 8.5 and tenacity increase from 0.3 to 6.7 with (2% SD + NRL5%), this enhance mean increase cohesive strength of asphalt and make it stiffen under loads as shown in Figure (6). Reducing the temperature susceptibility as shown in Figure(7), where have been improved the penetration index (PI) from -1.96 to -0.03 and the PVN from – 0.95 to 0.35, the mixture becomes more durable, all tests above shown mentioned with results in table (1).

Table 1: Physical and mechanical results.

Modifier content / test	**penetration**	**Softening point**	**viscosity**	**ductility**	**toughne**	**tenacity**	**Penetration index**	**Penetration viscosity number**
AS	40	48.8	450	100	0.9	0.3	-1.96	**- 0.95**
As+ SD 2% (2-1mm)	37.4	51	558	100	1	0.3	-1.56	**- 0.73**
AS + SD4% (2-1mm)	24.8	52	590	40	1.1	0.5	-2.09	**- 1.02**
AS +SD4% (1-0.6mm)	23.5	54.8	900	90	1.4	0.4	-1.59	**- 0.55**
AS + SD4% (0.6-0.25mm)	31.5	52.3	577	31.5	1.4	0.5	-1.6	**- 0.84**
AS+3% NRL	38.5	53	876	100	3.8	2.4	-1.06	**- 0.15**
AS+5% NRL	37.5	55.8	1100	100	4.8	3.9	-0.49	**0.1**
AS+7% NRL	37	56.9	1200	100	5	4.1	-0.49	**0.15**
AS + NRL5% +SD 2%	31.4	56.5	1370	100	8.3	6.7	-0.71	**0.18**
AS + NRL5% +SD 4%	29	60.4	1542	100	8.4	5.4	-0.11	**0.24**
AS + NRL5% +SD 6%	28.3	62	1680	100	8.1	5.8	-0.13	**0.31**
AS + NRL5% +SD 8%	26	62	1870	68	8.5	5.6	-0.03	**0.35**

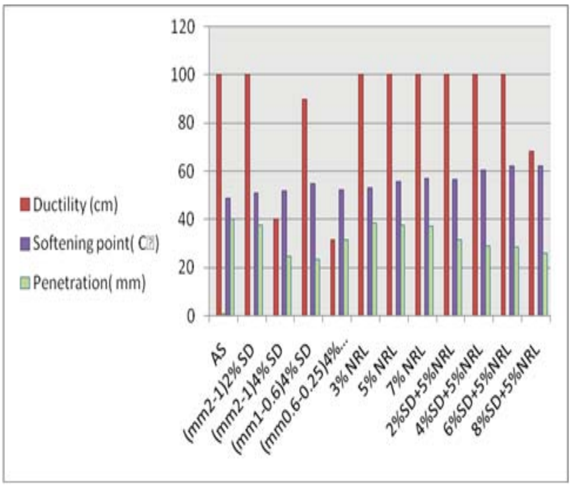

Figure 3: Influence of weight percentage and diameter of SD and NRL on Softening point, penetration and ductility tests.

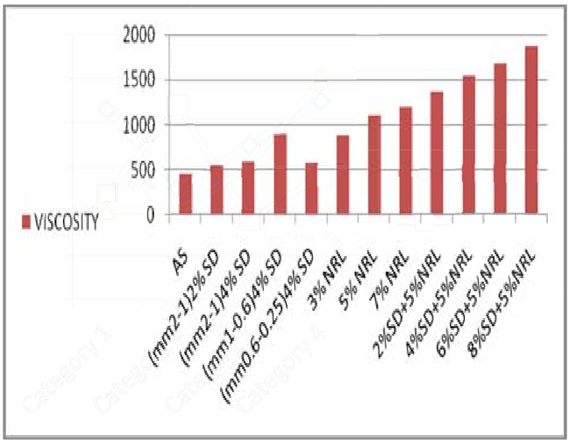

Figure 4: Influence of weight percentage and diameter of SD and NRL on Viscosity Test.

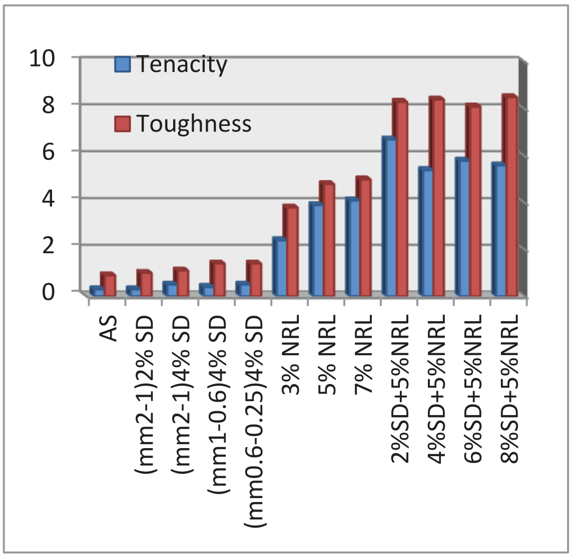

Figure 5: Influence of weight percentage and diameter of SD and NRL on Toughness and Tenacity.

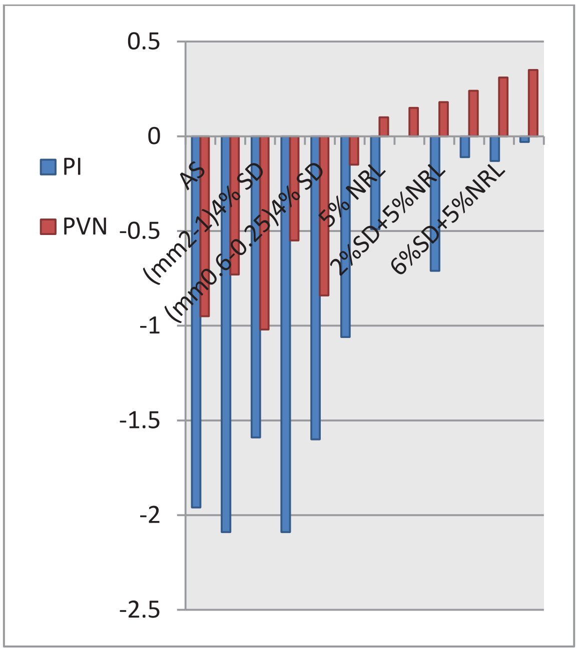

Figure 6: Influence of weight percentage and diameter of SD and NRL on Penetration index and PVN.

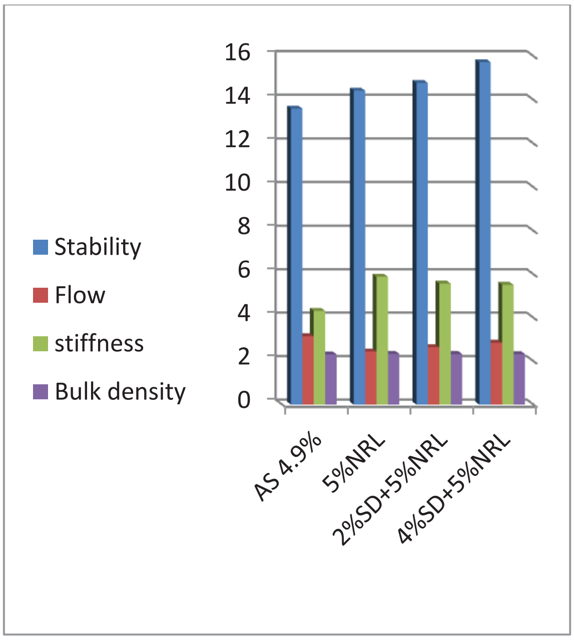

Figure 7: Influence of weight percentage and diameter of SD and NRL on stability, flow, stiffness and bulk density.

After determining the optimum asphalt binder by Marshall method (4.9), asphalt concrete mixture was done for three samples mentioned in Table 2 and investigated their properties.
The Figure (8) shown the stability value increase from 13.6 to 15.724 with (4% SD+5%NRL) this will be benefiting for the flexible pavement and so more resistance to both reflective and fatigue

cracking.
Further, the asphalt becomes more resistant to aging, the bulk density increase from 2.3181 to 2.3379 with (5%NRL), Stiffness from 4.317 to 5.886 this indicate to less strain through high stress and flow decrease from 3.15 to 2.4 mean no flow under load. The air voids content decrease from 4.2 to 3.533 with (5%NRL) (mixing with enough air voids improves stability and lessens bleeding when compacted), as shown in Figure (8), this improvement reflected in the performance of asphalt concrete.

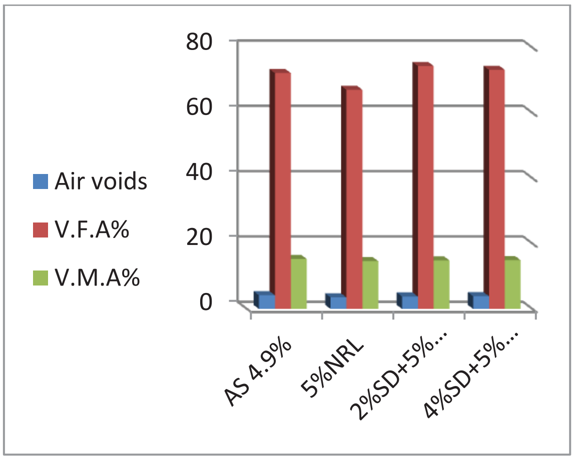

Figure 8: Influence of weight percentage and diameter of SD and NRL on air voids, V. F. A%, V. M. A% content.

Table 2: results of mechanical tests

	AS 4.9%	AS+5%NRL	As 4.9+NRL5%+SD2%	As 4.9+NRL5%+SD4%
Stability	13.6	14.4215	14.774	15.724
Flow	3.15	2.45	2.65	2.85
stiffness	4.3174	5.886	5.5750	5.5175
Bulk density	2.3181	2.3379	2.3313	2.3288
Air voids	4.2	3.533	3.807	3.907
V. F. A%	72.211	67.0849	74.3749	73.1950
V. M. A%	15.311	14.613	14.855	14.944

Conclusions

The well distribution of SD and cross-linking reactions of unsaturated carbon- carbon bonds of NRL with the hot asphalt enhance all physical properties, such as the increasing of softening point is indicates that will not bleed in pavement at high temperature, the increasing in viscosity mean more resist to flow, in addition to enhance the cohesion and adhesion properties. that's mean a greater force or tensile stress is required to break the molecular bonds of modified binders and cause failure and this reflected on the role of asphalt binder in asphalt concrete mixture and therefore improves the flexibility and the service life of the road and stability toward loads and environmental conditions and improvement the resistance to rutting at high temperatures and to cracking at low temperatures.

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