INFLUENCE OF THE NATURE OF THE AGGREGATES ON THE STABILITY OF BITUMINOUS MIXTURES

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ABSTRACT

Extending the service life of asphalt pavements is a function of the stability of the various constituent material mixtures prepared to make the pavement structure.

The methods of pavement do not take into account the nature of the aggregates, although the characteristics of the aggregates have an influence on the behavior of bituminous materials by their mineralogical nature, their mechanical properties and their geometrical characteristics.

Bituminous mixtures used in this study are made with aggregates from several deposits at different quarries. The different samples of bituminous mixtures with different aggregates are submitted to a series of laboratory dry and wet tests.

This study allowed us to observe and determine the influence of each of the intrinsic properties of aggregates on the strength and stability of asphalt studies.

1. Introduction:

The need to improve or optimize the sustainability of road pavement (or aeronautics) during the design of new pavements or maintenance of roads deteriorated, is a major concern for managers of public works. In this context, the evaluation of the performance of aggregates used in asphalt, in the long term, through relevant laboratory tests is essential.

The aggregates play an important role in the behavior of the concrete. Their influence is very strong in terms of mechanical performance, to get concrete having good characteristics, several parameters come into play in the choice of aggregates: quality, mineralogy, shape and size appropriate associated [6].Aggregates constitute the biggest part of bituminous materials; the percentage by weight ranges from about 92 per cent for a wearing course asphalt to about 96 per cent for a continuously graded macadam. With such a big proportion in bituminous materials, the aggregate has important effects on the strength and stiffness of bituminous mixtures [7].

The physical properties of coarse aggregates are more significant in new generation bituminous mixtures [8], the Aggregate properties have a greater impact on adhesion than some of the binder properties. Size and shape of the aggregate, pore volume and size, surface area, chemical constituents at the surface, acidity and alkalinity, adsorption size surface density, and surface charge or polarity are some of the widely cited aggregate characteristics that can influence moisture damage. The Loss of adhesion between bitumen and aggregate, and the detrimental effect of water is a well-known cause of failure in bituminous composites [9]. Evaluation of adhesion between these materials has largely remained phenomenological and subjective [10].

The objective of this work is to study the influence of the nature of the aggregates on the stability of bituminous concrete and more particularly the mineralogical nature of the aggregates according to the type of aggregate**.**

2. MATERIALS USED

2.1 The aggregates

Mineral aggregates make up between 80% and 90% of the total volume or 94% to 95% of the mass of hot mix asphalt (HMA). For this reason, it is important to maximize the quality of the mineral aggregates to ensure the proper performance of our nation's road ways

2.1.1 The aggregates used in this study

In this work we used the following granular classes: 0/3, 3/8 and 8/15 for the formulation of BB 0/14
The different types of aggregates used are presented in table 1 and figure 1.

Table 1. Quarries of Aggregates

Type	Quarry
1	Oued El Keberit, Souk Ahras
2	Mesloula, Tebessa
3	El fedjoudj, Guelma
4	Ain Touta, Batna
5	Akadh, Tebessa

Type 1 type 2 type 3 type 4 Type 5

Figure 1.The different types of aggregates used.

2.1.2 Aggregates Tests

a) Granulometric analysis by sieving

The granulometric analysis is the process of studying the distribution of the different grains of a sample, according to their characteristics (weight, size ...), look at figure 2.

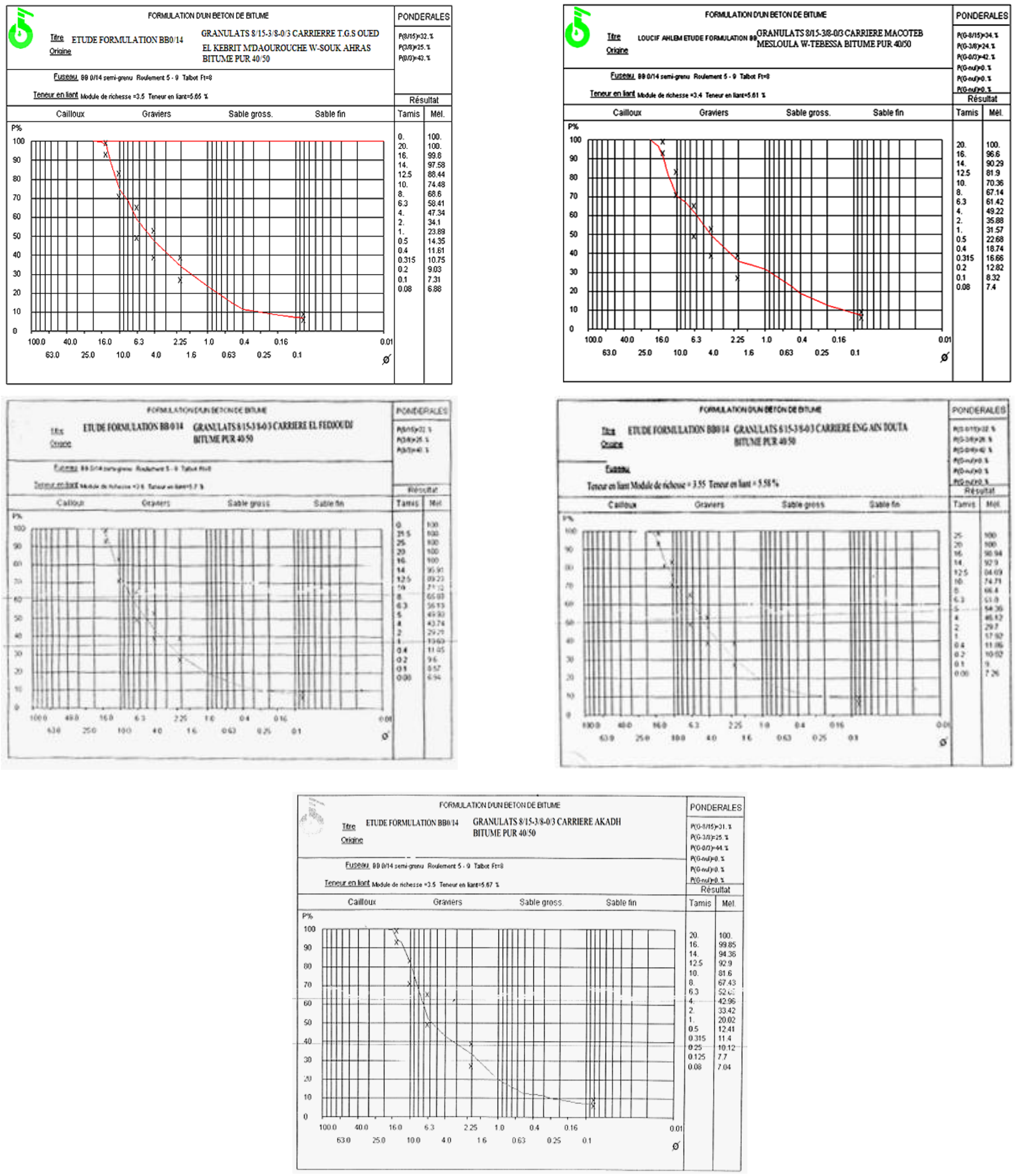

Figure 2. The granulometric curves

b) Densities

The determination of density is therefore simply by measuring the weight and volume of the corresponding materials. The dry bulk density ρd is the mass of dry aggregate (Ms) occupying an apparent volume (= volume of solids Vs + void volume: Vv), Table 2.

Table 2. Densities

Type of aggregates	Fractions	Ms (gr/cm^3)	ρd (gr/cm^3)
Type 1	8/15	1.466	2.672
	3/8	1.426	2.665
	0/3	1.562	2.594
Type 2	8/15	1.441	2.603
	3/8	1.456	2.615
	0/3	1.591	2.555
Type 3	8/15	1.459	2.660
	3/8	1.470	2.660
	0/3	1.470	2.648
Type 4	8/15	1.357	2.685
	3/8	1.401	2.542
	0/3	1.362	2.603
Type 5	8/15	1.402	2.629
	3/8	1.389	2.610
	0/3	1.371	2.610

c) Shape or flakiness index

The shape of aggregate particle has a significant influence on the performance of the bituminous pavement. Particle shape can be described as cubical, flat, elongated and round, the different flakiness indexes are presented in Table 3.

Table 3. Flakiness index.

Essais tests	Reference	Type1	Type2	Type3	Type4	Type5	spécification
A [%]	NF EN 933-3	17.95	23.04	12.43	20.9	4.0	≤ 30

d) Resistance to fragmentation and abrasion

Several studies have evaluated the micro-deval test for inclusion as a durability test for aggregates. In the micro-deval test, the aggregate is loaded in a jar with water and a charge of steel shot and then rotated at 100 RPM for 2 hours. This is not an impact test; however, as the aggregate breaks down, abrasive slurry is created in addition to the steel shot. Table 4 Present Values Intrinsic characteristics of the aggregates fraction 8/15.

Table 4. Intrinsic characteristics of the aggregates.

Essais tests	Reference	Type 1	Type 2	Type 3	Type 4	Type 5	specification
L.A [%]	NF EN 1097-2	20.5	24.7	25.0	23.80	22.1	≤ 25
M.D.E [%]	NF EN 1097-1 NF EN 1097-1/A1	18.84	21.00	22.00	20.00	17.20	≤ 20

e) Chemical tests

Chemical properties of aggregates:

- The chloride content NaCl ;
- The content compounds containing of gypsum $CaCO_4$ $2H_2O$;
- The level of insoluble elements;
- The content of carbonates $CaCO_3$.

The results of the chemicals tests are in the table 5.

Table 5. Results of the Chemical tests.

Samples	Content expressed as % weight / to dry materials				Degree of aggressiveness
	insolubles	$CaCO_3$	$CaCO_4\ 2H_2O$	NaCl	
Type 1	6.38	92.06	Traces	0.00	Null
Type 2	9.54	89.07	Traces	0.00	Null
Type 3	5.15	91.73	Traces	0.11	Null
Type 4	6.83	91.23	Traces	0.00	Null
Type 5	7.53	90.04	Traces	0.00	Null

2.2 Bitumen

The bitumen used for the manufacture of bituminous concrete is pure bitumen. The average penetration tests gave 42, which classifies the bituminous binder in class 40/50. The binder content obtained for each types of aggregates is in the table 6**.**

Table 6. Binder content

Type of aggregates	Type 1	Type 2	Type 3	Type 4	Type 5
Binder content	5.65	5.61	5.70	5.58	5.67

3. FORMULATION OF BITUMINOUS MIXTURE:

The composition of bituminous concrete influence decisively on the durability and performance coatings. The purpose of the formulation is to choose a mixture having the best ability to compaction, which could give greater stability to the hydrocarbon mixture. To date optimization formulas for bituminous mixtures are still a too empirical approach based on traditional tests often provide little correlation with actual performance materials. The second methodology used is to choose the same granular mixture several formulas to have a good performance in the time. We will check after their mechanical performance by Duriez and Marshall Tests.
For the formulation of Bituminous Concrete 0/14 we used the Geopack V8 software.

4. EXPERIMENTAL PROGRAM

4.1 Marshall Test

Test designed to determine, for compaction temperature energy, the Marshall stability and Marshall flow of a hydrocarbon mixture a test piece of predetermined size [11]. Table 7 Present Results of the Marshall Test.

Table 7. Results of the Marshall Test

Samples	N°of test piece	γd (gr/cm^3)	compactness (%)	stability (kg)	Flow (1/10Mm)
Type 1	**1**	2,271	93,03	1000	2.80
	2	2,275	93,19	1000	2.86
	3	2,324	95,20	1300	2.09
Type 2	**1**	2,304	94,31	1300	2.40
	2	2,295	93,94	1200	2.55
	3	2,330	95,37	1300	2.35
Type 3	**1**	2.342	95.98	1205	2.85
	2	2.334	95.56	1150	3.90
	3	2.343	96.02	1200	3.05
Type 4	**1**	2.293	93.94	1100	3.20
	2	2.277	93.28	1200	2.49
	3	2.296	94.05	1200	3.10
Type 5	**1**	2.275	93.20	1100	3.20
	2	2.271	93.03	1100	3.25
	3	2.295	94.00	1200	3.11

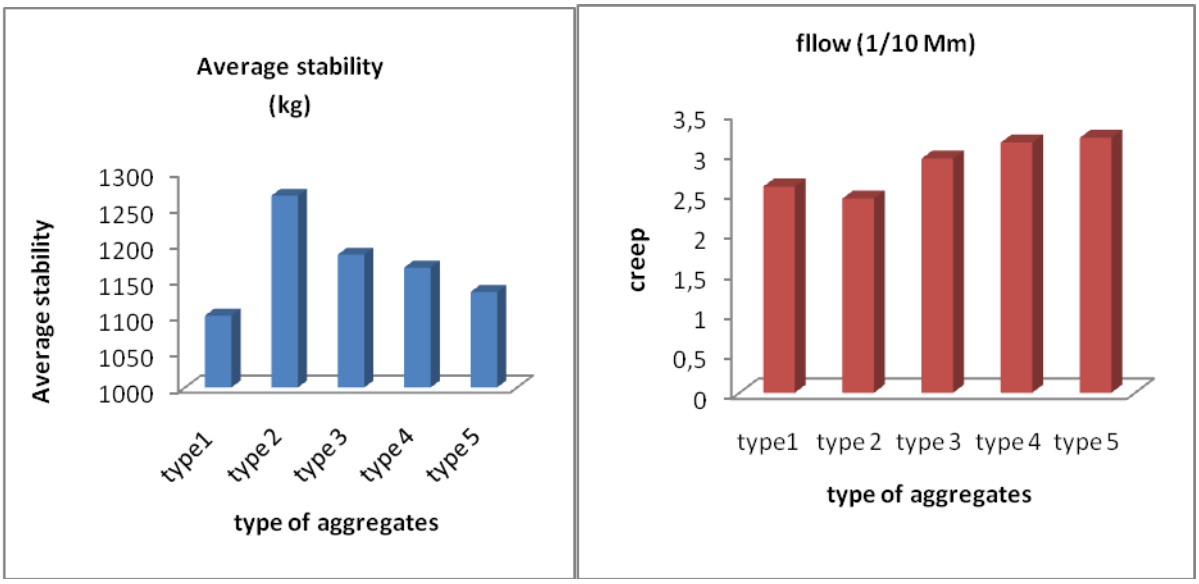

Figure 3. Histograms stability and flow of the test coated Marshall.

4.1 Duriez Test

The hydrocarbon mixture is compacted into a cylindrical mold by a double-acting static pressure. Part of the test is maintained without immersion at temperature (18°C) and humidity controlled.

The other part is kept submerged. Each group of samples was crushed in simple compression. The ratio of the resistance after immersion in dry strength gives the water resistance of the mixture.

The ratio of resistance following immersion to dry resistance yields the water resistance value for the mix. Dry resistance represents one approach to describing mechanical characteristics, [12]. Table 8 Present Results of the Duriez Test.

Table 8. Results of Duriez Test.

Samples	N°	γd (gr/cm^3)	compactness (%)	Stability (kg)	Rc (Bar)	Rc' (Bar)	Ratio $\frac{Rc'}{Rc}$	Imbibition rate
Type 1	**1**	2.278	93.32	4000	/	79.61	0.80	1.15
	2	2.259	92.54	4000	/	79.61		1.21
	3	/	/	5000	99.52	/	0.80	/
	4	/	/	5000	99.52	/		/
Type 2	**1**	2.279	93.28	4500	/	89.57	0.91	0.94
	2	2.279	93.28	4400	/	87.57		0.92
	3	/	/	4900	97.53	/	0.91	/
	4	/	/	4800	95.54	/		/
Type 3	**1**	2.323	95.52	3500	/	69.66	0.77	2.08
	2	2.331	95.53	3800	/	75.63		2.25
	3	/	/	4500	89.57	/	0.79	/
	4	/	/	4800	95.54	/		/
Type 4	**1**	2.280	93.40	4000	/	79.61	0.81	1.95
	2	2.306	94.46	4100	/	81.60		2.15
	3	/	/	4900	97.53	/	0.83	/
	4	/	/	4900	97.53	/		/
Type 5	**1**	2.347	96.14	3500	/	69.66	0.86	1.23
	2	2.367	96.96	3500	/	69.66		1.04
	3	/	/	4050	80.61	/	0.87	/
	4	/	/	4000	79.61	/		/

Rc : air resistance **; Rc' :** resistance after immersion in water.

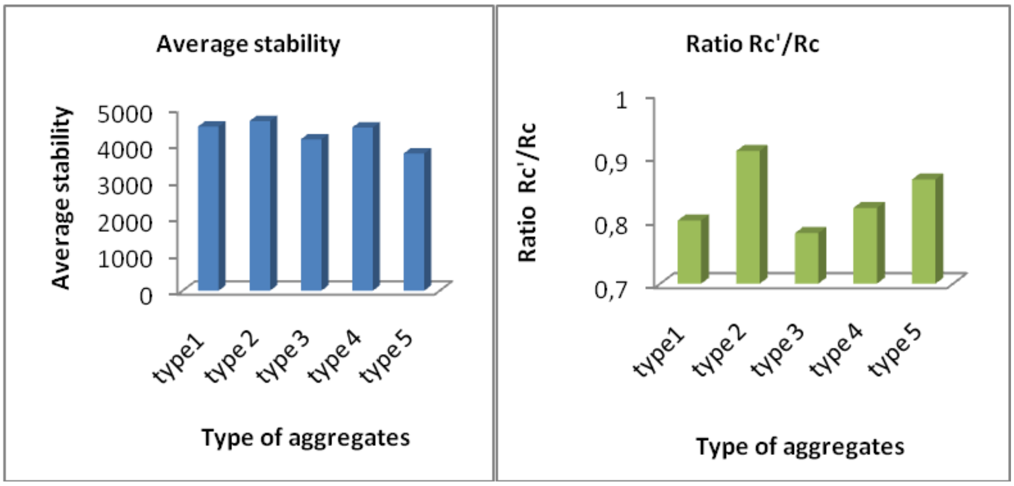

Figure 4. Histograms stability and water resistance of the coated test Duriez.

5. RESULTS AND INTERPRETATIONS

According to the results of this study, we can see that the size is variable, considerable differences passers are seen between the aggregate type 5 and other types for each sieve, it is related to the techniques and manufacturing conditions in aggregates quarries.

This study shows that all the coefficients flattening not exceed the specification of which is 30, then flattening coefficients of all types studied have a relatively small influence in the angularity of aggregates, thus the roughness of the coatings.

Second we find that all types of aggregates have Los Angeles coefficient slightly higher than the specification is 20, which explains the appearance fragmental of these limestone.

These aggregates have a good resistance to wear in the presence of water because all types of aggregates have a micro deval below the specification of which is 25.

According to the results of the Marshall test applied to all types we can see that the mixture made from type 2 has good stability, the same type of aggregate according to Duriez test gives a very good performance in water.

6. CONCLUSION

The aggregates used in the work of building and public works must meet quality requirements and specific characteristics in each use. It is therefore necessary to establish the characteristics by various laboratory tests.

In view of the results of this study can be seen irregularities manufacturing aggregates. This affects in a direct way on the manufacture of coated, an audit in quarries is necessary to overcome the defects mentioned above.

The high content of insoluble parts by weight relative to the dry material of the type of granulate 2 explains the good stability and very good water resistance of asphalt mixture made from this type.

For type 2 we can see a low value of flow which increases the resistance of asphalt mixture rutting phenomenon. In light of this study it is necessary to recommend the use of aggregates is high weight insoluble elements to obtain high quality asphalt to improve the characteristics of pavements.

We can conclude that the aggregate influence the behavior of pavement materials by their mineralogical. Their mechanical properties and their geometrical characteristics and the respective influence of macrotexture and microtexture of the coating are not separable and are complementary.

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