ISBN 978-93-84468-11-8
Proceedings of 2014 International conference on Advanced Engineering Technologies (AET-2014)
Dubai, December 25-26, 2014, pp. 237-242

Comparative Study of the Characteristics of Dunes Sand Only Aggregate Concrete and Ordinary Concrete Modified by Rubber Crumb

A. Mezidi[1], and R. Kettab[2]

[1] University of Khemis Miliana. Ain Defla, Algeria
Email: Aomez2002@yahoo.fr

[2] Professeur, Ecole Nationale polythenique (E.N.P), Algeria
Email: mitiche_rdz@yahoo.fr

Abstract**:** *this article consists of a contribution to the value enhancement of local building materials and industrial waste recovering. It aims to compare the characteristics and behavior of a dunes sand only aggregate concrete with those of an ordinary concrete modified with rubber crumb at various weight contents ranging gradually from 1 to 5%. The optimal rubber crumb content was found to be 3%. Furthermore, the obtained results show that the dunes sand only aggregate concrete has a weaker elasticity modulus (54%) compared to the modified ordinary concrete, hence, it can't be used in the structural elements. Nevertheless, other elements such as, pavements borders, foundations sub-base… etc can be made using this type of concrete. The ordinary concrete mix with rubber crumb and admixture incorporation has proven acceptable performances for an eventual use in structures.*

Keywords: *sand aggregate only concrete; rubber crumb, elasticity modulus, recovering, rheological characteristics*

1. Introduction

Building materials demand is considerably increasing with respect to the country's development and is still unsatisfied because of an insufficient supply. This imbalance, that seems to be long-lasting for the coming years, can't be overcome only by taking profit from local materials available in our country. Besides, recovering the huge amounts of worn tires in construction has threefold benefit: environmental, technical and economical ones. The aim of this article is to study the effects of adding small percentages of rubber crumb on the behavior of either dunes sand only aggregate and ordinary concretes. Whilst their cement content is the same (between 300 and 400 kg/ m^3), the main difference between these two types of concrete lies in their aggregate content and their usage. If the dunes sand only aggregate concrete is set to be used in structural elements construction, it should prove sufficient strength which is linked to mixed constituents relative compaction. [1. 5]

2. Sand Only Aggregate Concrete

Algeria is consuming large quantities of aggregate, of which, it is experiencing scarcity in some regions. Thus, the elaboration of new concretes, made of unconventional type of aggregate, such as sand only aggregate is becoming a necessity. Yet, this type of concrete has well been used before the current ordinary concrete. There are two types of compositions, the first is theoretical and the second is experimental. The study is based on the two main criteria of structural concretes that are the mechanical strength and the workability. [3] Acknowledgements (Use "Header1" style)

Please acknowledge collaborators or anyone who has helped with the paper at the end of the text.

3. Rubber Crumb

Crumb ranges from 25.4 mm aggregate to 0.2 mm fine powder. Rubber wastes constitute a huge recoverable pool either in volume or in weight. The origins of this pool are:

- Worn tires,
- Industrial rubber wastes
- Tires manufacturing wastes
- Retreading wastes

Currently, 25% of the rubber and tires are recovered while there are a variety of treatment modes [4, 6]

4. Research description

4.1 4.1 Objectives [8, 13]

To make use of local materials

To recover wastes (worn tires) in the construction

TABLE I: Fresh Concrete Density

Rubber content (%)	0	1	2	3	4	5
Density (Kg/m3)	2453	2443	2438	2432	2425	2419

To evaluate the effects of adding rubber crumb on ordinary concrete

To evaluate the effects of adding rubber crumb on sand only aggregate concrete

To compare the characteristics of the two concretes modified by this crumb

To compare the behavior of the two concretes modified

5. Rubber Crumb

The polymer studied in this article is a blackish industrial waste resulting from rubber crushing in a fine textured form (1.25 mm maximum and 31 % < 0.08 mm) and 45% purity. It is an elastic material at ambient temperature which is compatible with cement and aggregate. It presents a low viscosity at higher temperature, its melting temperature ranges from 200 à 220 °C.

6. Test on fresh concrete

6.1 Slump Test

For each concrete mix, slump test has been performed and the results and the results are shown on the table below.

It can be noticed that the measured slump increases with the rubber content. This can be explained by the fact that the rubber is coarser than sand thus will absorb less water.

TABLE II: Slump Test for Each Rubber Content

Rubber content (%)	0	1	2	3	4	5
Measured slump (cm)	5.2	5.4	6.4	7.6	7.8	8.6

6.2 Density

Test pieces volume is V = 10×10×10 = 1000 cm3. Fresh concrete density for various rubber contents is shown on table 2

Concrete density is inversely proportional to the rubber content. This can be explained by the fact that the rubber density (0.54 t/m3) is too low compared with to sand's one (2,56 t/m3)

7. Tests on hard concrete

7.1 Compressive strength

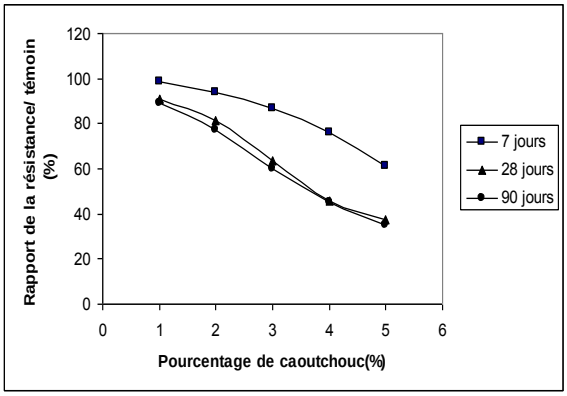

Fig. 1: Variation of the OCRC compressive strength against pilot's one according to rubber content.

The compressive strength is inversely proportional to the rubber content. For a 4% rubber content, the concrete compressive strength represents 45% of the pilot's strength. This is due to the inter-granular weak cohesion favored by rubber particles.

It can be admitted that 3% rubber content is an interesting percentage since the obtained compressive strength represents 63% at 28 days and 60% at 90 days of the pilot concrete strength.

7.2 Tension by bending strength

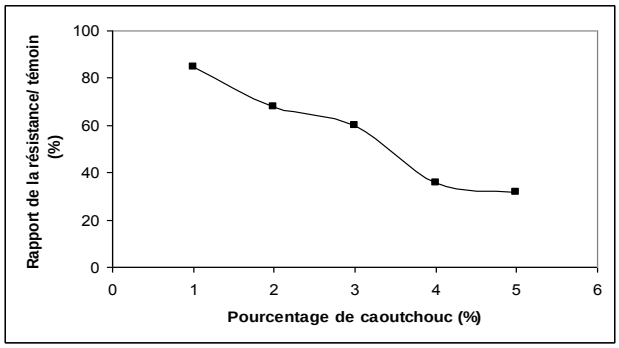

Fig. 2: Variation of the OCRC tension by bending strength against pilot's one according to rubber content.

The tension by bending strength is inversely proportional to rubber content.

For a 4% rubber content, the strength represents 35% of the pilot's one. This is due to the inter-granular weak cohesion favored by rubber particles.

According to obtained results, it can be admitted that 3% rubber content is an interesting percentage since the obtained tension by bending strength represents 60% at 28 days of the pilot concrete strength.

7.3 Modified ordinary concrete relative compaction

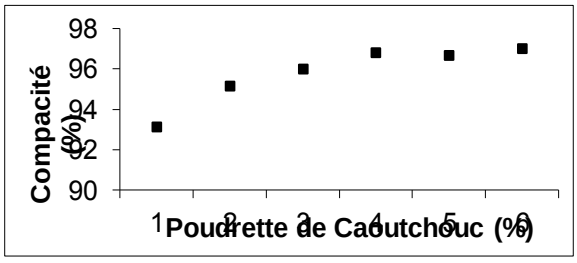

Fig. 3: OCRC relative compaction against rubber content.

When gradually increasing the rubber content from 0 to 5% by a 1% step, it can be noticed that the concrete relative compactness increases from 0 to 1%. The inter-granular aggregates gaps were occupied by rubber fillers

decreasing so the gaps volume which increases the compaction in a lightly noticeable way between 1% and 5% since most of the gaps was already filled. Thus, it can be said that the relative compactness stabilizes above 1 %.

The workability is improved when the rubber content is increased. This fact is explained by the weak water adsorption by rubber particles which saves a certain amount of mixing water for other concrete constituents without varying W/C ratio that remains fixed (W/C= 0,51)

8. Conclusion

Analyzing the compressive and tension by bending strengths test results allows us to conclude that 3% rubber content is an interesting percentage that can be considered as an **optimal value.**

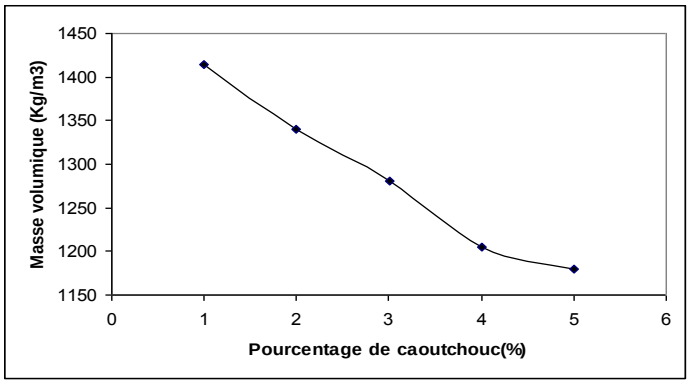

Fig. 4: DSCRC density.

The density is inversely proportional to rubber content. It is reduced because of the light weight of the rubber crumb

Due to its fine texture, sand dunes only aggregate concrete is lighter than conventional concretes.

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Due to its fine texture, sand dunes only aggregate concrete is lighter than conventional concretes.

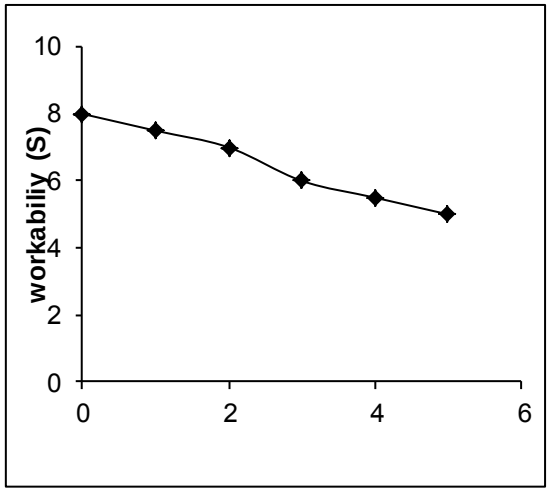

Fig. 5: Variation of DSCRC workability against Rubber Content

Adding rubber crumb will even lighten dunes sand only aggregate concrete. The higher the rubber crumb content, the lower the concrete density. This is normal since porous rubber grains have been introduced in a dense and heavy cement matrix. In addition, it can be noted that the density decreases in an almost linear way.

The compressive strength is inversely proportional to the rubber content. For a 4% rubber content, the concrete compressive strength represents 36% of the pilot's strength. Like ordinary concrete, this is due to the inter-granular weak cohesion favored by rubber particles.

TABLE III: DSCRC compressive strength at 7, 28 and 90 days

	Compositions	DSC 0 %	DSCRC 1%	DSCRC 2%	DSCRC 3%	DSCRC 4%	DSCRC 5%
CS (MPa)	7 Days	10	8.6	6.9	5.29	4.15	4.06
	28 Days	22.6	16	13.2	10.29	8.15	7.65
	90 Days	23.2	16.5	13.71	11.3	9.12	8.7

It can be admitted that 3% rubber content is an interesting percentage since the obtained compressive strength represents 45% at 28 days and 48% at 90 days of the pilot concrete strength.

TABLE IV: DSCRC tension by bending strength against pilot's one according to rubber content

Concrete mixs	DSCRC 1%	DSCRC 2%	DSCRC 3%	DSCRC 4%	DSCRC 5%
TS 28 days (MPa)	1.83	1.7	1.57	1.25	1.13

Tension by bending strength is inversely proportional to rubber crumb content.

For a 4% rubber content, the tensile strength represents 43% of the pilot's one. Like the ordinary concrete, this is due to the inter-granular weak cohesion favored by rubber particles.

According to the obtained results, it can be admitted that 3% rubber content is an interesting percentage since the obtained tension by bending strength represents 54% at 28 days of the pilot concrete strength.

Modified Dunes Sand only aggregate concrete relative compaction

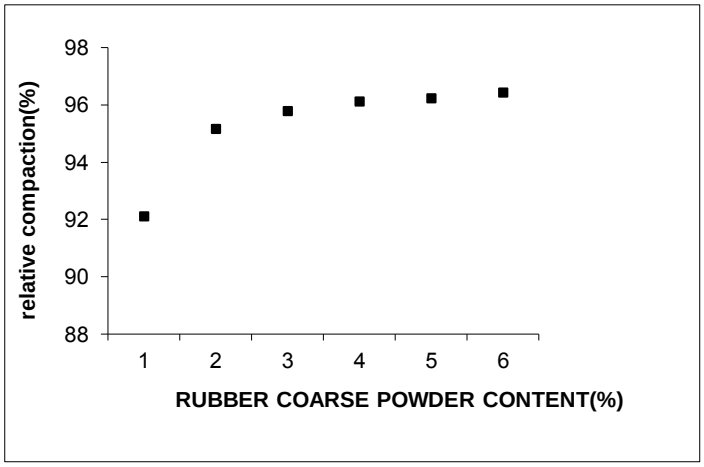

Fig. 6: variation of Relative Compaction against Rubber crumb for DSCRC.

When gradually increasing the rubber content from 0 to 5% by a 1% step, it can be noticed that the concrete relative compactness increases from 0 et 1%. The inter-granular aggregates gaps were occupied by rubber fillers decreasing so the gaps volume which increases the relative compaction in a lightly noticeable way between 1% and 4% since most of the gaps was already filled. Thus, it can be said that the relative compactness stabilizes above 1 %

The workability is enhanced when increasing the rubber content which can be justified by the weak water adsorption by rubber particles which saves a certain amount of mixing water for other concrete components without varying W/C ratio that remains fixed (W/C= 0,69)

9. General conclusion

This study has demonstrated the opportunity for the value enhancement of sand dunes that represents 70% of local materials in the Algerian South and a waste that is resulting from worn tires which is present in high non recovered quantities. Hence, a threefold issue can be resolved: environmental protection by reducing waste storages areas and the resulting contamination, economical and technical issues encountered in the construction fields because of the scarcity of building materials.

The incorporation of an NBR (Acrylonitrile Butadian Rubber) elastomer in coarse rubber form in an ordinary and a dunes sand only aggregate concretes has been considered not to enhance mechanical performance

but in order to compare their behavior and their characteristics. This non biodegradable polymer is an industrial waste, and its recovery will contribute to the environment protection. The experimental study of tested mixs has demonstrated that adding low percentages of rubber to dunes sand only aggregate and ordinary concretes is not recommended if the strength is the main objective.

In fact, while well chosen additives amount often leads to enhancing the blends characteristics and properties and while the enhancement increases with the modification degree, excess can sometimes leads to the opposite.

- The rubber crumb optimal percentage incorporation is 3% for both concretes;
- Owing to its small particle size distribution, dunes sand only aggregate concrete is lighter than ordinary concrete. Adding the rubber crumb will even lighten them because of the introduction of rubber particles with porous structure in a heavier and denser cement matrix. This decrease is almost linear;
- The workability is improved when the rubber content is increased. This fact is explained by the weak water absorption by rubber particles which saves a certain amount of mixing water for other concrete constituents;
- The compressive strength decreases while the incorporated rubber content increases;
- The compressive strength is inversely proportional to the rubber content. For a 4% rubber content, the compressive strength represents 45% of the pilot's strengths for ordinary concrete and 36% for dunes sand only aggregate concrete. This is due to the inter-granular weak cohesion favored by rubber particles.
- Mechanical and rheological properties of dunes sand only aggregate modified concrete compared with those of ordinary one with the same rubber content are not in favor of using it in structural elements. Nevertheless, dunes sand only aggregate can be used as a material for pavement borders, decorative elements, roads separation in motorways, etc.

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