International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

Available at http://inpressco.com/category/ijcet

Research Article

Influence of mixed Cement Waste and carbon black on the Mechanical properties of SBR/BRcis blends

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Accepted 01 March 2014, Available online 01 April 2014, **Vol.4, No.2 (April 2014)**

Abstract

This article explores the possibility of using cement waste particles as reinforcement in styrene–butadiene rubber/butadiene rubber (SBR/BRcis) vulcanizes, Cement waste and Carbon Black mix is used in this research to enhance some of the mechanical properties of SBR/BRcis blends. In this research, we prepared 16 batches containing SBR (100,80,60.50)pph ,BRcis(0,20,40,50)and 4 loading level from C.B(10,20,30,40)pphr ,Cement waste powder (10,20,30,40)pphr in series . while the hardness ,tensile strength, tear résistance, abrasion wear ,elongation, elastic modulus, fatigue ,and specific gravity have been studied in this research. We found that some of these properties are increasing with the increment mix of C.B, cement waste (pphr) such as hardness ,elastic modulus ,specific gravity ,tensile strength ,tear resistance from other hand fatigue, abrasion wear,elongation,elastic modulus were decreased with increment mix of C.B and Cement waste .

Keywords: *mixed Cement Waste, carbon black, mechanical properties etc.*

Introduction

Blending of two or more types of polymer is a useful technique for the preparation and developing materials with properties superior to those of individual constituents. It is important especially from an industrial point of view to control the state of mixing of polymer blends (McDonel et al,1978).

One of the most important phenomena in material science is the reinforcement of rubber by rigid entities, such as carbon black which has been found to offer substantial improvement in the mechanical properties of rubber because it has very good compatibility with rubbers(JL.Leblance ,1994 ; KN Pandey et al,2003) . Thus, C.B is added to rubber formulations to optimize properties that meet a given service application or sets of performance parameters(UK. Mandal et al,2001 ; J.Fröhlich et al ,2005).

Rubber compounds exhibit several phenomena like the ability to retain elastic properties during prolonged action of compressive stresses compression set behavior, and loss of resiliency The lower the percentage of compression set , the better the material resists permanent deformation under a given deflection and temperature also, the selection of rubber compounds for use in engineering industry(Al-Mosawi et al,2012). Many researchers have extensively studied fluid resistance and compression set behavior of rubber and rubber blend compounds loaded with different filler(KT. Gillen et al,2003). The effect of carbon black loading and cement waste on the percentage of the tensile set and fatigue of SBR and BRcis rubber compounds needs to be understood deeply. Therefore, the aim of this paper is to determine the effect of mix of carbon black and waste on the percentage of the tensile set, fatigue and specific gravity.

Specific gravity tests were carried out by Densitron according to Archimedes principle, it was weighed in air and in water. The specific gravity is calculated by the following equation:

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air} - \text{weight in water}} \times \text{specific gravity of water}$$

So, we can calculate the tensile strength by the equation ;
T.S = F/A
Where F = observed force required to break the specimen.

Young's modulus was reported as the slope of the initial linear region of the stress–strain. Actual experimental values were reported as stress–strain curves. The stress and strain are described by the following expressions (A.H.AL-Noumannee,2010 ; L. E. Nielsen et al,1994)

$$\text{Stress } \sigma = \frac{\text{Force or load F}}{\text{Cross sectional area A}}$$

$$\text{Strain } \varepsilon = \frac{(L - L_o)}{L_o}$$

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Thus, Young's modulus in a tensile test is given by;

$$E = \frac{\Delta\sigma}{\Delta\varepsilon}$$

Therefore the ultimate elongation is mathematically calculated by the relation;

E= [(L-Lo)/Lo]*100%

where Lo=initial thickness ,L=final thickness.

With respect to the tear strength or the tear resistance in rubber ,it may be described as the resistance to growing neck a cut when the tension is applied on the specimen and it is depends upon the width and thickness of the test piece and the test result s as the load necessary to tear specimen of standard width and thickness .

Tear .S = F*t1/t2

Where F=maximum force ,t1=thickness of standard piece,t2= measured thickness of the specimen tested.

Wear is defined as the damage of a solid surface, generally involving progressive loss of material, due to relative motion between that surface and contacting substance or substances There are many equations to described abrasive wear, the simplest equation to calculate the specific wear rate is by measuring wear volume from the measurement of loss in weight ,i.e.

$$K_\circ = \frac{\Delta V}{Pd}$$

Where K_O specific wear rate, ΔV is the volume loss in cubic millimeters or cubic meter, P is the load in Newton's, and d, is the sliding distance in meters (A.H.AL-Noumannee,2010).

Fatigue may be defined as the change in properties that occur in a material after prolonged period action of stress or strain. The fatigue failure process involves a period during which cracks nucleate in regions that were initially free of observed cracks. Many factors influence fatigue nucleation (K. S. Loganathan,1998).

1- Type of rubber , type and degree of crosslinking , additives such as protective agents , reinforcement phase such as filler (type , volume fraction) and fibers (type , aspect ratio , orientation) which control the basic crack growth characteristics and the size of the flaws that are present initially .

2- Mechanical considerations such as, the shape and size of the article, the nature and magnitude of the deformations and the frequency and the form of the cycling.

The two widely used fatigue life parameters which are reported in point (2) for crack nucleation prediction in rubber are maximum principle strain (or stretch); minimum strain; and strain energy density, Our study is focused on maximum strain. Strain is a natural choice because it can be directly determined from displacements X which can be readily measured in rubber. Another factor is the R – ratio which is defined in following equation:

$$R = \frac{\sigma_{\min}}{\sigma_{\max}} \quad \text{Or} \quad R = \frac{\varepsilon_{\min}}{\varepsilon_{\max}}$$

Where σ_{Min} , is minimum stress ; σ_{Max} the maximum load stress ε_{Min} is minimum strain ; and ε_{Max} is the maximum strain . The R – ratio of strain cycle has a significant effect on fatigue life (N. Andre et al,1999).

Materials

SBR and BRcis were reinforced by different volume fractions of mixed carbon black N375 and cement waste.

In this study, BRcis used have properties are listed in Table (1).

The SBR used is SBR–1502 with 23.5% styrene content (made by an emulsion process), supplied by the Petkim, Turkey. The Properties of SBR are listed in Table (2)while the properties of N375 are listed in Table (3). The properties of cement waste powder (particle size 75 µm) are listed in table (4), Zinc oxide (97%) and stearic acid (99.4%) were supplied by Durham, U.K. The 6PPD[N-(1,3 – Dimethyl butyl) – N – Phenyl – Para – Phenylenediamine] (98%).MBS[N- oxydiethylene-benzothiazole 2- sulfonamide] (98.2%) is supplied by ITT , India . Paraphenic oil was supplied by the South Patrol Company. Sulfur was supplied by the Durham, U.K.

Table (1) Properties of BR_{cis}.

Properties	**%**
Density (g/cm^3)	0.90
ETA extract	1.00 % max.
Volatile matter	0.75% max.
Ash	0.20% max.

Table (2) Properties SBR 1502.

Properties	
Density (g/cm^3)	0.95
Bound styrene	23.5 ± % max.
Volatile matter	0.75% max.
Ash	1.5% max.
Soap	0.5% max.
Organic acid	4.7 – 7.2%

Table (3) Properties of Carbon black N375.

properties	**N375**
Density (g/cm^3)	1.8
Specific surface areas(Iodine number) m^2/g	92±5
DBP absorption number ml/100g	114±5
Particle size (µm)	75
Loss at 105 °C	1%
Ash content	0.75%

Table (4) Analysis of cement waste powder.

Composition	**%**
SiO2	11.11
Al2O3	2.38
Fe202	2.55
Ca0	46,29
Mg0	1.12
SO3	0.59
LOI	35.33

Laboratory mill

Baby mill was used in this research to prepare the batches,

Table (5) Compounding ingredients.

Compounding ingredients%	recipe 1	Recipe 2	recipe 3	Recipe 4
SBR 1502	100	80	60	50
BRcis	0	20	40	50
Zinc Oxid	5	5	5	5
Stearic Acid	2	2	2	2
Paraphinic Oil	2	2	2	2
Carbon Black	Variable (10,20,30,40)	Variable (10,20,30,40)	Variable (10,20,30,40)	variable(10,20,30,40)
Cement Waste	Variable (10,20,30,40)	Variable (10,20,30,40)	Variable (10,20,30,40)	variable(10,20,30,40)
6PPD	0.5	0.5	0.5	0.5
MBS	1	1	1	1
Sulfur	1.5	1.5	1.5	1.5

it have two roll mills, having provisions for passing cold water. These rolls are cylindrical in shape and of 150mm diameter and 300mm in length in the other hand the roll speed is 20 r.p.m.

The hydraulic press is equipped with thermocouple and maximum temperature is equal to 300°C and vulcanization process was performed at 165º and 20 min.

Moulds preparation

The necessary moulds were manufactured for test samples to study their mechanical properties according to British standards (BS).

Mould for Testing hardness, and specific gravity

For preparing samples for hardness and density tests , the mould in the laboratories of Tire Company was used The mould consists of three parts ,the middle part in a dimension of 200mm*180mm*6.5mm which contains (9) circular equivolume open with 65mm diameter and 5 mm thickness while one of the other two parts is bottom base and the other is a cover for the purpose of samples thickness regulation .They have a dimension of 150*150*10mm.

Mould for preparing samples for tensile, tear, elongation, and modulus tests

For preparing samples for the above tests, the sheet sample from each recipe with a dimension of 150*150*2.5mm was prepared by using mould which consists of three parts, the middle one in a dimension of 395mm*158mm*2.5mm contains six sections with 150*150*2.5mm dimension fixed on base of 395*160*10mm and covered with a cover of the same dimension as that of the base for regulation of thickness .

Mould for Fatigue Test Samples

For preparing fatigue test samples the mould dimensions contain half circular middle notch with a radius of 2.5mm. The mould consists of three parts ,the middle part with a dimension of 282*222*6mm contains on 6 empty spaces with (153*62mm)dimension a circular middle notch with a radius of 2.5mm divided the part and the 6 vacant.

Mould for abrasion resistance test

Preparing samples for abrasion resistance test, the mold of the laboratories of Tires company was used , The mould consists of two parts , each part has a dimension of 240 x 240 x 15 mm . The bottom base have four circular cavities, its diameter 73.5 mm and pin in center of cavity , its dimension 12.7 x 12.7 mm , the four cylindrical cavities were put in their cavities with dimensions of 73.4 x 13 mm.

Preparations of batches

The batches were prepared by mill laboratory, the compounding ingredients are shown in table (5).

Equipment for the measurement of Tensile Strength,Tear resistance, Elongation and Modulus of elasticity .

Tests were carried out on samples prepared by laboratory mill according to ASTM D412. Monsanto T10 tensometer was used . The test sample which is movable at speed of 500 mm/min for all except for tear resistance the speed at 50 mm/min.

Equipment for Abrasion resistance

The croydon Akron Abrasion Tester was used.

Equipment for Fatigue measurement

Tests were carried out on prepared samples and according to ASTM D430 by using the Wallace tester.

Equipment for Hardness (IRHD) measurement

The International Hardness test is used for measuring the penetration of rigid ball (according to Brinall method) into the rubber specimen tests were carried out according to ASTM D1415 specifications.

Result and Discussion

We can show from figure (1) that the hardness increasing linearly with increasing of mixed C.B and cement waste, This can be attributed to the physical cross-linking that presents between the rubber chains and this lead to increase hardness. This behaviors is agrees with the results of (A.H.AL-Noumannee,2010). So, the hardness is higher when SBR ratio is higher because SBR hardness is higher than BRcis hardness.

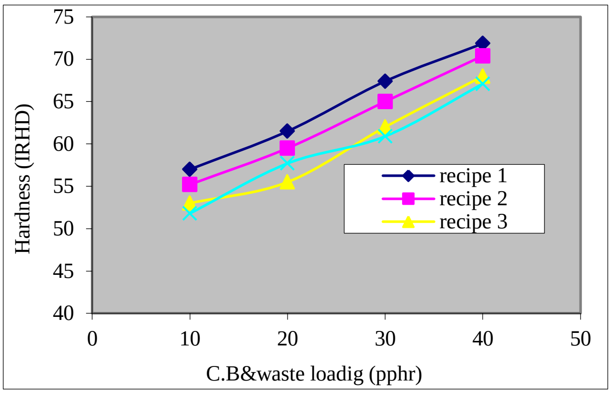

Figure (1) Relation between C.B,waste loading and hardness for different batches

Figure (2) shows a graphical relationship between mixed of C.B and waste loading with abrasion wear ,while the abrasion wear is decreasing with increasing C.B,waste loading .This can be attributed to the increasing waste which leads to or assists to tear the rubber chains through the fraction .These observation and results agree with those poblished (J .H .Kim et al,2005;A.H.AL-Noumannee,2010) .So the abrasion wear is higher when the hardness is higher.

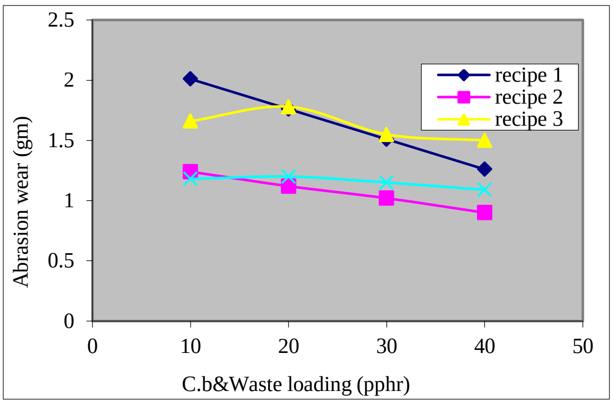

Figure (2) Relation between C.b&waste loadningand abrasion wear for different batches

As the specific gravity is concerned is directly proportion to the increase of C.B,waste loading because the increment of C.B,waste molecules in the volume unit leads to increase the specific gravity, So, if the SBR ratio is more than BRcis ratio therefore ;the specific gravity is higher because the density of pure SBR is higher than BRcis density.

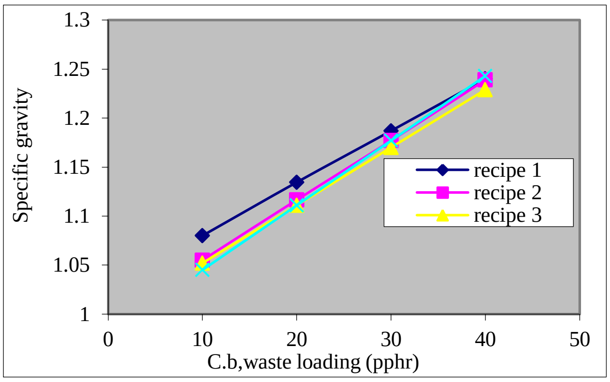

Figure (3) Relation between C.b,waste wt and specific gravity for different batches

Figures (4) shows decreasing in the flexibility or fatigue as mixed of C.B&waste % increases. This is due to increasing of the contact area with the rubber .This will result in increasing stress surface which causes (fault). Such result agrees with that of other workers (A.H.AL-Noumannee,2010).

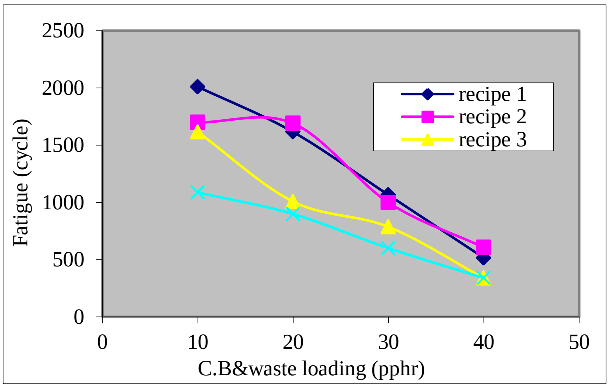

Figure (4) Relation between C.B,waste loading and fatigue for different batches

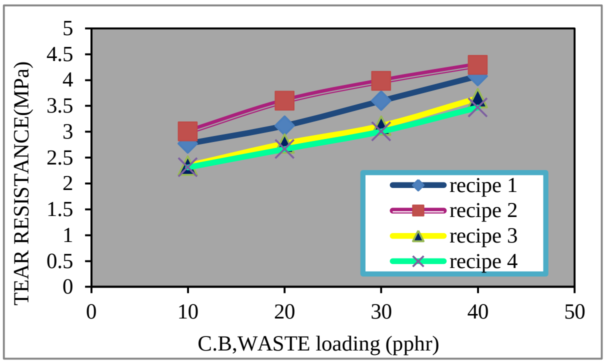

Figure (5) Relation between C,B .waste loading andtear resistance for different batches

Figure (5-7) show the increasing tensile strength ,tear resistance and elastic modulus as mixed of C.B& waste loading increases because of this increasing the interaction of C.B &waste with the rubber blends to chain resulting in more physical bonds and an increase in surface activity which gives high tensile strength ,high rear resistance and high elastic modulus . This result agrees with that of other workers (Al-Maamory,2005;A.H.AL-Noumannee,2010) . and the relation between loading and tensile strength is non-linear since the value of tensile is starting decrease with high loading . So we can shows that the tensile strength , tear resistance, and elastic modulus are decreasing with enhancing BRcis ratio increase.

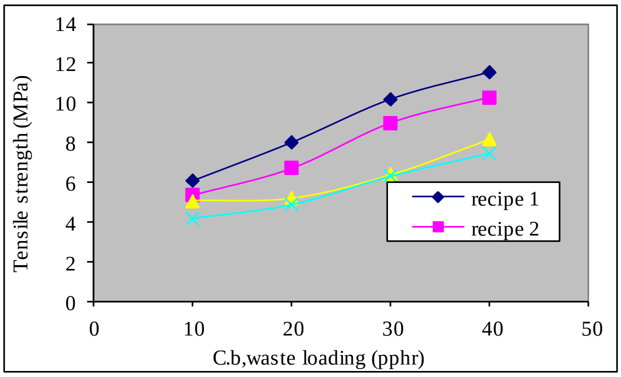

Figure (6) Relation between C.b,waste loading and tensile strength for different batches

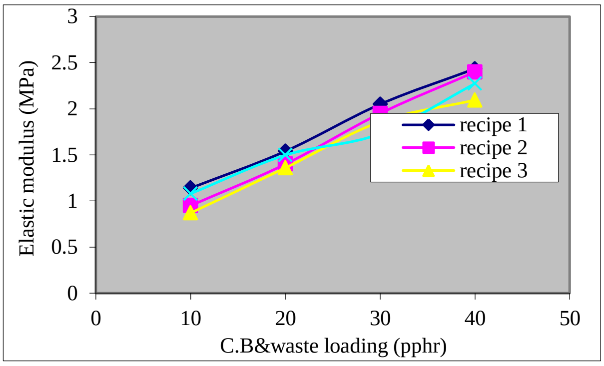

Figure (7) Relation between C.B&waste loading and elastic modulus for different batches

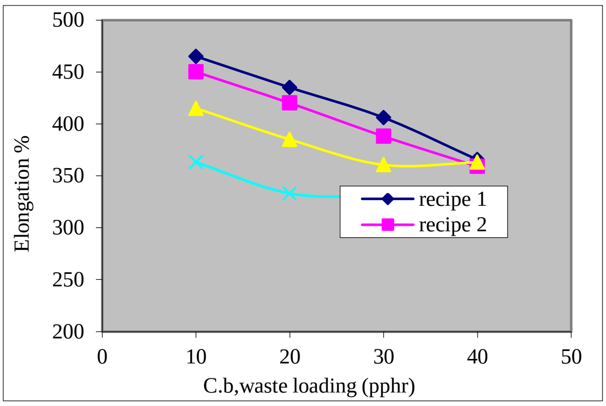

Figure (8) Relation between C.b,waste loadingt and elongation for different batches

With respect to figure (8), we indicated that the elongation% decreases with increasing mix of C.B, cement waste loading level which attributed to the elongation property was due to cohesive of polymer chains .So, we can show that the elongation decreases with increasing BRcis content .

Conclusions

1) Mechanical properties are improved as C.B and cement waste mixing percentage increases in such as hardness ,tensile strength ,tear resistance, modulus and specific gravity except abrasion wear, fatigue and elongation which gradually decrease.

2)Improvement in mechanical properties has advantages and disadvantages according to the engineering uses such as fenders in the port.

3)The tensile strength started with decrement after loading 50(pphr) or at high loading level.

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