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Study the effect of adding dust of cement in some of the mechanical properties of SBR composites

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ABSTRACT

Composite materials consists of merging two materials or more are different in mechanical and physical properties. The aim of research is to study the effect of changing in the reinforcement percentage by dust of cement in mechanical Properties for composite material consist of SBR rubber and reclaim reinforced by dust (0, 10, 20, 30, 40, 50 pphr), which included tensile strength, modulus, hardness, tear, resilience, after reinforced SBR rubber composite with different weight percentage from dust and study the effect on mechanical properties as illustrated in the diagrams.

***Keywords*:** Composite Materials; Mechanical Properties; Dust of Cement

1. INTRODUCTION

Since the early 1960s, there has been an ever-increasing demand for newer, stronger, stiffer, and yet lighter-weight materials in fields such as aerospace, transportation, and construction. High demands on materials for better overall performance has led to extensive research and development efforts in the composites fields. These materials have low specific gravity that make their properties particularly better in strength and modulus Composite materials are constructed from two or more elements to provide a material that has different properties to the individual elements. Composite materials that exist today can be categorized into five major classes, which include ceramic matrix composites (CMCs), metal matrix composites (MMCs), intermetallic matrix composites (IMCs), carbon-carbon composites (CCCs) and polymer matrix composites (PMCs) In this discussion, considerable attention is paid to the latter class of materials (PMCs), which included rubber matrix campsites (RMC) specially Acrylonitrile Butadiene-Styrene Rubber (SBR). There are three important kinds of reinforcement system of polymer matrix, Particular, short-fiber and continuous-fiber composites [1-5]. The study of the mechanical properties of materials Engineering one of the very important things that must be Taken into consideration because they define the behavior of these materials under influence of stress applying on it [6] and Under the influence of various external conditions as Pressure, temperature, time of stress Damocles, The speed of the stress, the nature of chemical solvents And other factors that affect a lot on the mechanical properties of the polymer matrix composite materials, the study of Mechanical properties a very complex because of many Variables that affecting on each property [7-9], in this research samples were prepared from a SBR reinforced by a different weight percentage of dust of cement particles and then the mechanical properties was studied.

2. MATRIX MATERIALS

SBR

A polymer widely used because of its good properties and his compositional formula shown in Figure (1). A general-purpose synthetic rubber, produced from a copolymer of styrene and butadiene. Exceeding all other synthetic rubbers in consumption, SBR is used in great quantities in automobile and truck tires, generally as an abrasion-resistant replacement for natural rubber (produced from polyisoprene).

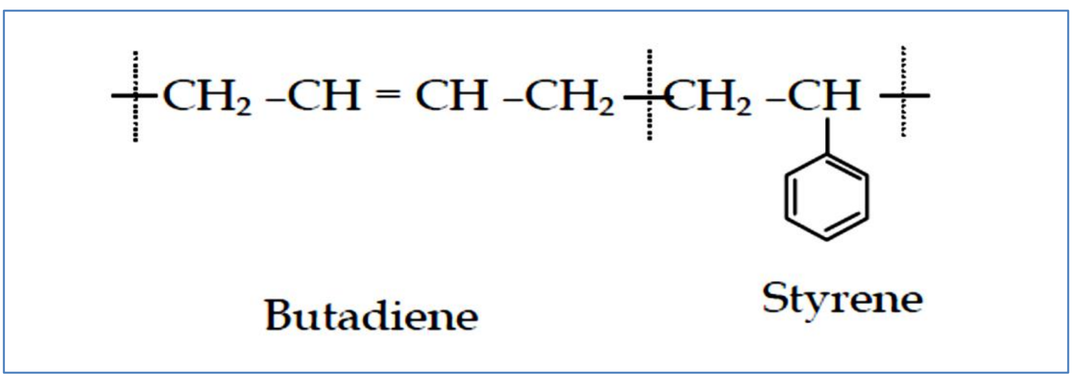

Figure 1. Compositional Formula of Styrene-Butadiene Rubber (SBR) [10].

SBR is a mixture of approximately 75 percent butadiene (CH_2=CH-CH=CH_2) and 25 percent styrene (CH_2=CHC_6H_5). In most cases these two compounds are copolymerized (their single – unit molecules linked to form long multiple-unit molecules) in emulsion process, in which a soap like surface-acting agent disperses, or emulsifies, the materials in a water solution. Other materials in the solution include free-radical initiators, which begin the polymerization process, and stabilizers, which prevent deterioration of the final product.

Upon polymerization, the styrene and butadiene repeating units are arranged in a random manner along the polymer chain. The polymer chains are cross-linked in the vulcanization process. For many purposes SBR directly replaces natural rubber, the choice depending simply on economics. Its particular advantages include excellent abrasion resistance, crack resistance, and generally better aging characteristics. Like natural rubber, SBR is swollen and weakened by hydrocarbon oils and is degraded over time by atmospheric oxygen and ozone.

In SBR, however, the main effect of oxidation is increased interlinking of the polymer chains, so, unlike natural rubber, it tends to harden with age instead of softening. The most important limitations of SBR are poor strength without reinforcement by fillers such as carbon black (although with carbon black it is quite strong and abrasion-resistant), low resilience, low tear strength (particularly at high temperatures), and poor tack (i.e., it is not tacky or sticky to the touch).

These characteristics determine the use of the rubber in tire treads; essentially, its proportions decrease as the need for heat resistance increases until 100 percent natural rubber is reached in the heaviest and most severe uses, such as tires for buses and aircraft. A large amount of SBR is produced in latex form as a rubbery adhesive for use in applications such as carpet backing. Other applications are in belting, flooring, wire and cable insulation, and footwear.

SBR is a product of synthetic rubber research that took place in Europe and the United States under the impetus of natural rubber shortages during World Wars I and II. By 1929 German chemists at IG Farben had developed a series of synthetic elastomers by copolymerizing two compounds in the presence of a catalyst. This series was called Buna, after butadiene, one of the copolymers, and sodium (natrium), the polymerization catalyst. During World War II the United States, cut off from its East Asian supplies of natural rubber, developed a number of synthetics, including a copolymer of butadiene and styrene. This general-purpose rubber, which had been called Buna S by German chemists Eduard Tschunkur and Walter Bock, who had patented it in 1933, was given the wartime designation GR-S (Government Rubber-Styrene) by the Americans, who improved upon its production. Subsequently known as SBR, this copolymer soon became the most important synthetic rubber, representing about one-half of the total world production.

Dustof Cement

Dust of cement is a coal combustion byproduct, which accumulates due to electrostatic precipitation of the flue gases in thermal power plant. When coal is burnt in thermal power plant the dust is carried forward in flue gases as fused particles, which solidifies as a spherical particle. Most of these spherical particles have a gas bubble at the center. The dust depending upon the source of coal, contain different proportions of silica, alumina, oxides of iron, calcium, magnesium etc. along with elements like carbon, Ti, Mg, etc. So the fly ash has properties combined of spherical particles and that of metals and metal oxides. Table (1) shows the results of chemical analysis of the dust using a technique (XRD).

Accelerators

Accelerators of vulcanization are classified into organic and inorganic types. Organic accelerators are known to the rubber industry for over a century. Their use in rubber compounding has become universal. Some examples of organic accelerators are hexamine, mercapto-N-cyclohexylbenzothiazolesulfenamide, sodium diethyl dithiocarbamate, tetramethylthiuram disulfide, tetramethylthiurammonosulfide, etc.

These compounds represent almost the entire range of organic accelerators from moderate to ultra-accelerators. Inorganic accelerators such as lime and litharge are used in slow curing products like rubber lining. Accelerators reduce the time required for vulcanization. The benefits of using accelerators are economy of heat, greater uniformity of finished goods, improved physical properties, improved appearance, and better resistance to deterioration [11].

Vulcanizing Agents

Sulfur is the most well-known vulcanizing agent. It is easily available in powder and pilled form packed in polyethylene bags. Sulfur vastly improves the properties of raw rubber which is sticky and soluble in solvents. With the addition of sulfur, rubber is converted into a non-tacky, tough, and elastic product. [12]

Activators

Activators help accelerators in the vulcanization process. Zinc oxide and zinc stearates are the most popular activators. Zinc oxide is also a reinforcing filler. Stearic Acid (Rubber Grade) is a mixture of fatty acids composed primarily of octadecanoic (stearic), and hexadecanoic (palmitic 50 %) acids to a controlled titer (molecular composition) and acid value (presence of unsaturation). It is a light-colored, waxy solid with a characteristic fatty odor. [13]

Process Oils

These materials are added to rubbers primarily to aid in the processing operations such as mixing, calendaring , and extruding. They are used along with fillers to reduce the cost of the compound. Peptizing agents are also softeners which increase the mastication efficiency and reduce the Mooney viscosity level to the desired process ability. [14]

3. EXPERIMENTAL WORK

Very briefly, the open mill mixing process is to masticate the polymers until an even and smooth band is formed around the front roller.Zinc oxide are added followed by stearic acid and CBS. The fillers and oil are added alternately and finally the vulcanizing materials. During the whole operation, cutting and blending by hand rolling is carried out. So mixing is the first stage in the conversion of rubber and its compound ingredients into finished products. The mixing was carried out on available laboratory mill, rolls dimensions are: outside (150 mm), working distance (300 mm), speed of the slow roll (24 rpm) and gear ratio (1.4). The roll mill has the facility of controlling the gab distance between the rolls and the rolls temperatures. The mixing operation was executed on two stages., the ingredients of rubber blend are showing in Table (1)

The steps of mixing process are:

1. Passing rubbers through rolls several times with decreasing a mill roll opening to 0.2 cm, at 70 °C.

2. Passing reclaim with rubbers through rolls several times.
3. Adding of zinc oxide.
4. Adding of stearic acid.
5. Adding of oil process.
6. Adding the accelerator CBS.
7. Cooling the batch to the room temperature.
8. Adding the dust with different weight percentage for each recipe.
9. Adding the sulfur to the master batch.

Finally the vulcanization processes are doing in the thermal piston, and we are making sheets in order to conducting the necessary tests and according to the universal system "ASTM".

Table 1. Results of Chemical Analysis of the Dust.

Ingredients	Ratio
SiO_2	13.40
R_2O_3	5.44
Al_2O_3	2.80
Fe_2O_3	2.64
SO_3	9.83
CaO	37.97
L.O.I	18.50
Total	85.14
MgO	1.68
Res	86.82

Mechanical Properties

Tensile Strength: This is defined as the force per unit of original cross-sectional area which is applied at the time of rupture of the dumbbell test specimen. It is calculated by dividing breaking force in Newton's by the cross-section of unstressed specimen in square meters the samples were prepared by cutting uncured compound sheet to give a test piece of constant volume. This test had been done according to ASTM-D 2705 & D2084-89 [14].

Modulus: The term modulus, or stress, is used to express the amount of pull in Newton per square meter required to stretch the test piece to a given elongation. It expresses resistance to extension, or stiffness in the vulcanized rubber.

Once again, in the common parlance of rubber technology the stress required for a given elongation is used to represent the material stiffness. This quantity is called the modulus.

A 300% modulus, for example, means the stress required to produce a 300% elongation. In mechanical engineering usage, however, the term modulus is defined as the ratio of stress to strain. If this ratio is constant the material is said to be obey Hook's law and the constant is called Young's modulus or modulus of elasticity. In practice, the term Young's modulus is often used to represent the ratio of stress to strain even in situations where it may vary with change in elongation [15].

Tensile strength and elongation properties serve as an index to the general quality of a rubber compound. Rubber compound less than 6.9 MPa in tensile strength are usually poor in most mechanical properties and those with tensile strength over 15.7 MPa are usually good in most mechanical properties [16]. The above three tests were carried out by using Monsanto T10 Tensometer equipment and according to ASTM-D412 [17].

Hardness: Typically defined as resistance to indentation under specific conditions This test is conducted on rubbers in accordance with ASTM D2240-75, D1415-68, and D531-78 [18]. Tear resistance (or tear strength): is resistance to the growth of a cut or nick in a vulcanized (cured) rubber specimen when tension is applied, this test was were carried out by using Monsanto T10.

Elongation: The term elongation is used to describe the ability of rubber to stretch without breaking. To describe this property as measurement, it is more accurate to refer to it as "ultimate elongation", since its value, expressed as percent of the original length, is taken at the moment of the rupture [12].

4. RESULT AND DISCUSSION

As showing in Figures 2-4, as additives increase the tensile strength ,modulus ,tear resistance, increase also because of increasing cross-link between rubber and filler and this result from the small particle size of the fillers" waste of cement" that mean large surface area can interact with rubber chain and this agree mental with [19].

As showing in Figure 5, as additives increase, hardness increase because of the interacting between additives" waste of cement" and rubber chains that lead to increasing the ability of Penetration resistance and this agree mental with [20].

As showing in Figure 6, as additives increase, resilience decrease because of the increase of cross-link and after applying outside energy on the sample will make it absorbed it and change it to a heat distribute between the rubber chains.

As showing in Figure 7, as additives increase, the compression set increase also because of increasing cross-link between rubber and filler and this result from the small particle size of the fillers" waste of cement" that mean large surface area can interact with rubber chain.

As showing in Figure 8, as additives increase, the elongation increase also because of increasing cross-link between rubber and filler.

As showing in Figures 9 and 10, as additives increase, the density and specific gravity increase, in this cases the dust of cement contributes to the closure of the spaces available in the rubbery recipe.

As a result the density and specific gravity will increase.

Table 2. Ingredients of Rubber Blend.

CONTENTS pphr	RECIPE 1	RECIPE 2	RECIPE 3	RECIPE 4
SBR rubber	100	95	90	85
Reclaim	0	5	10	15
ZnO	5	5	5	5
stearic acid	2	2	2	2
CBS	1.2	1.2	1.2	1.2
Sulfur	1.8	1.8	1.8	1.8
Oil	5	5	5	5
Dust	0, 10, 20, 30, 40, 50	0, 10, 20, 30, 40, 50	0, 10, 20, 30, 40, 50	0, 10, 20, 30, 40, 50

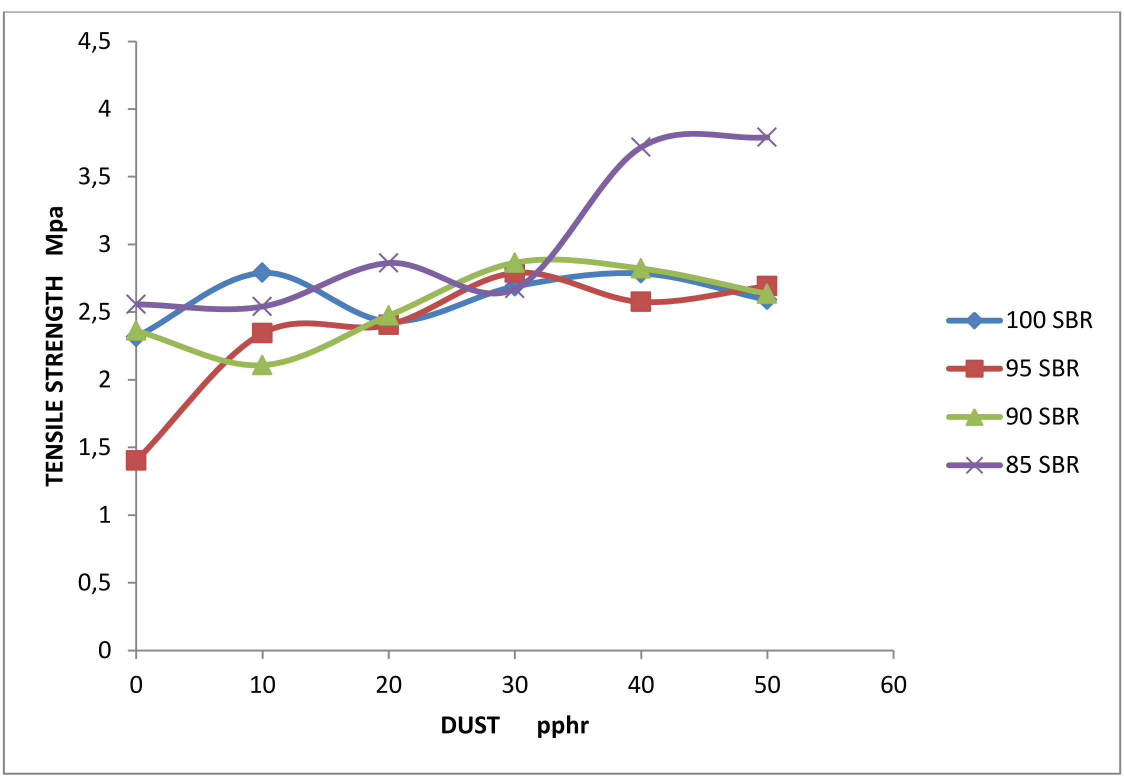

Figure 2. Effect of Adding Dust on Tensile Strength.

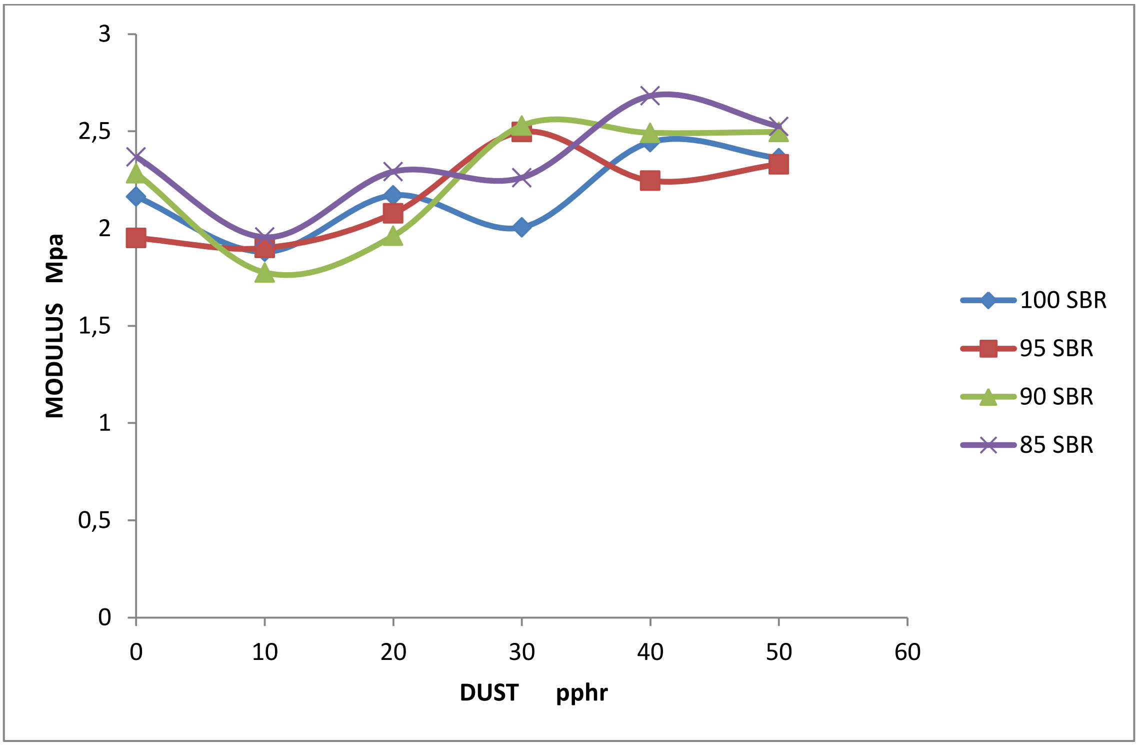

Figure 3. Effect of Adding Dust on Modulus.

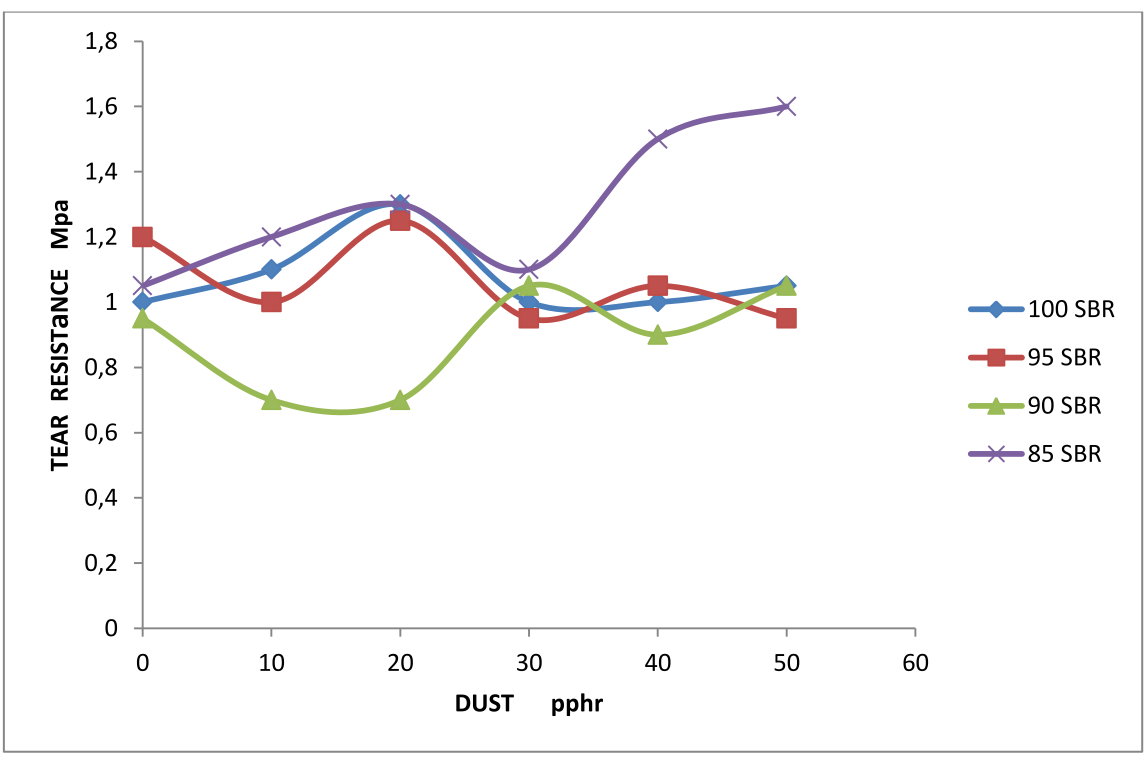

Figure 4. Effect of Adding Dust on Tear Resistance.

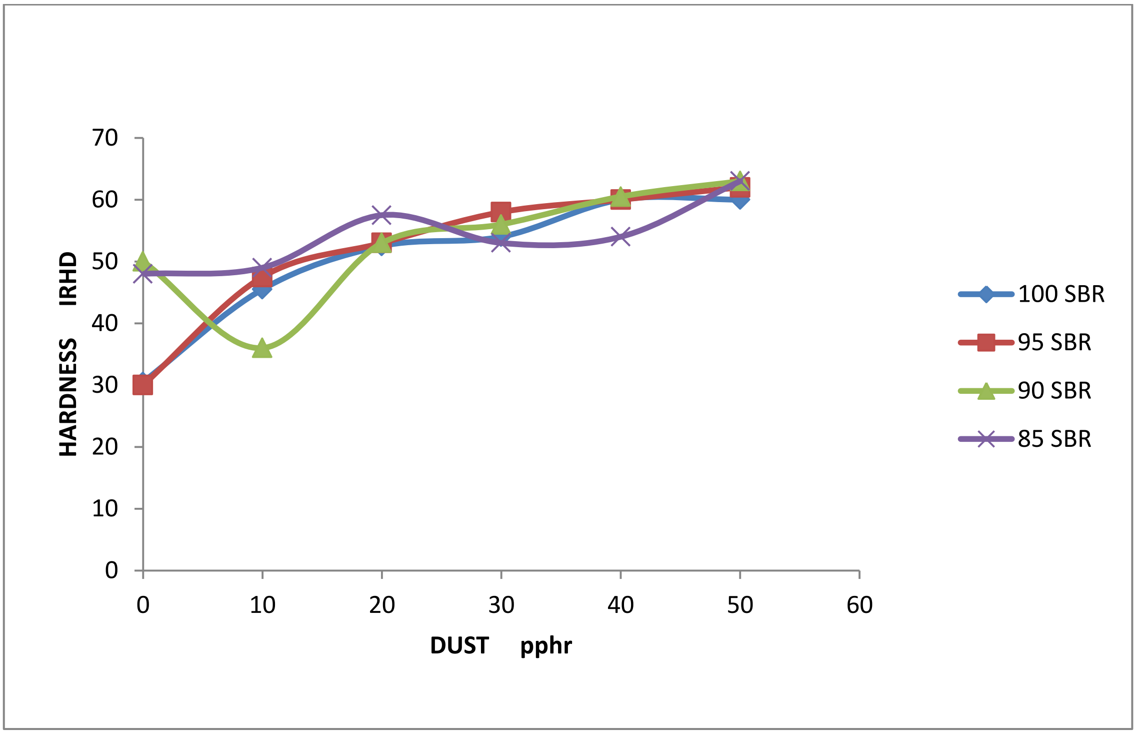

Figure 5. Effect of Adding Dust on Hardness.

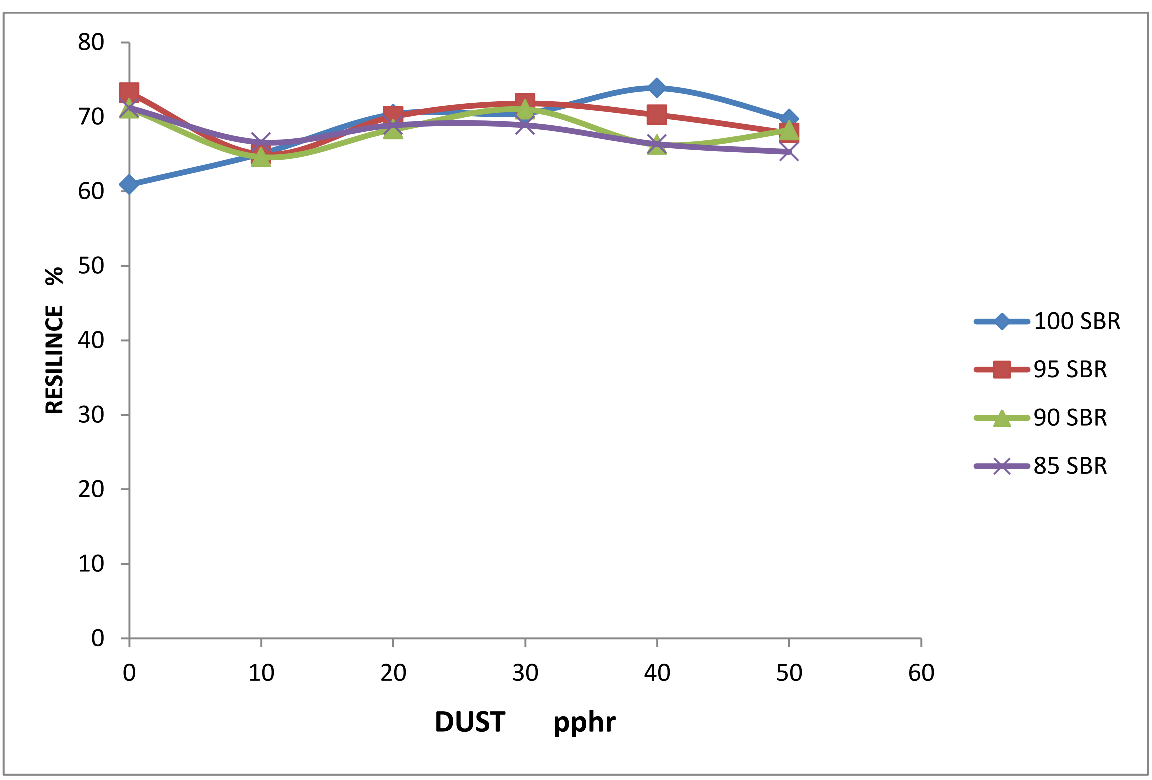

Figure 6. Effect of Adding Dust on Resilience.

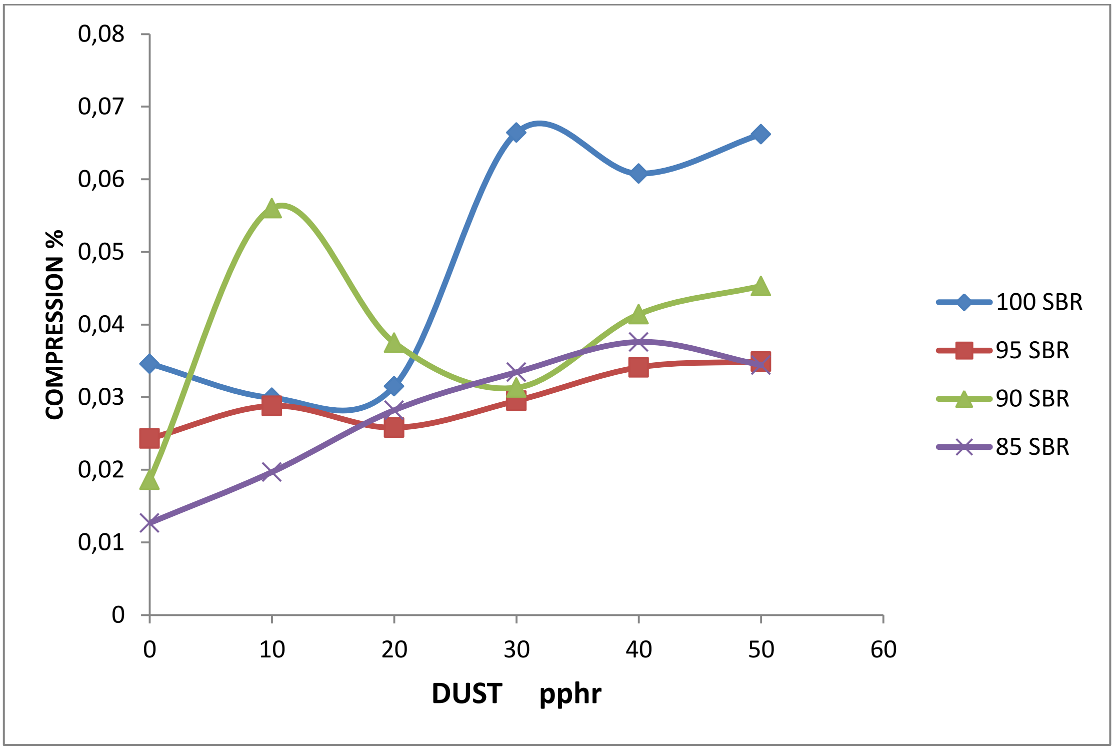

Figure 7. Effect of Adding Dust on Compression.

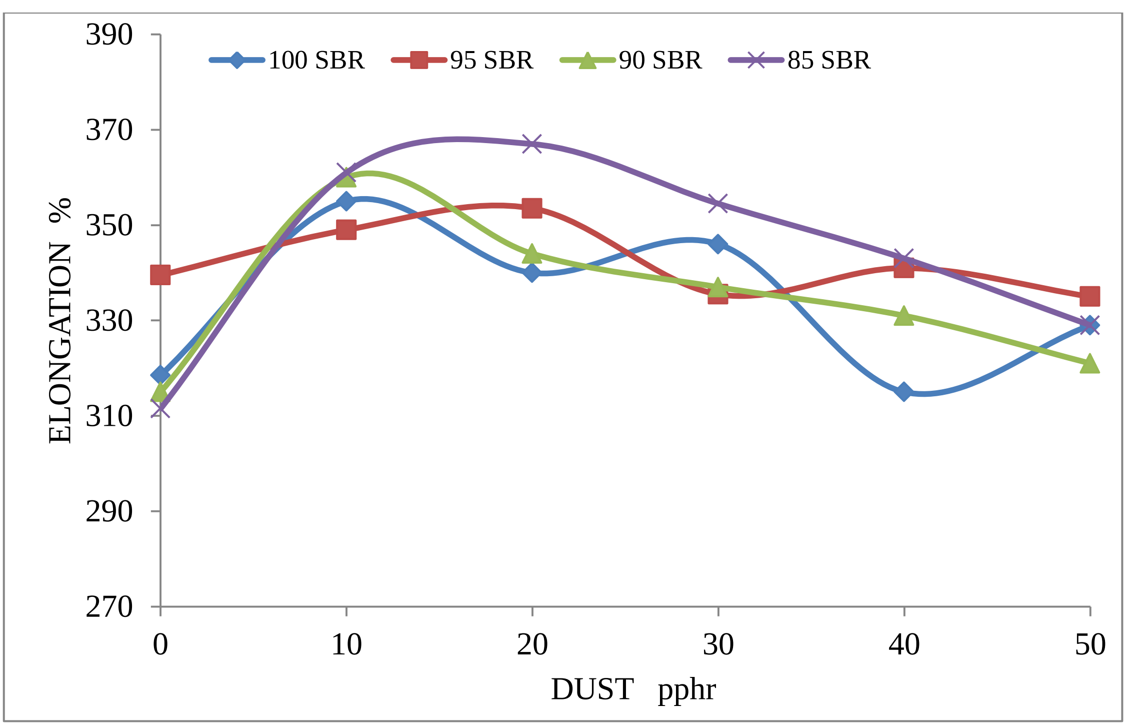

Figure 8. Effect of Adding Dust on Elongation.

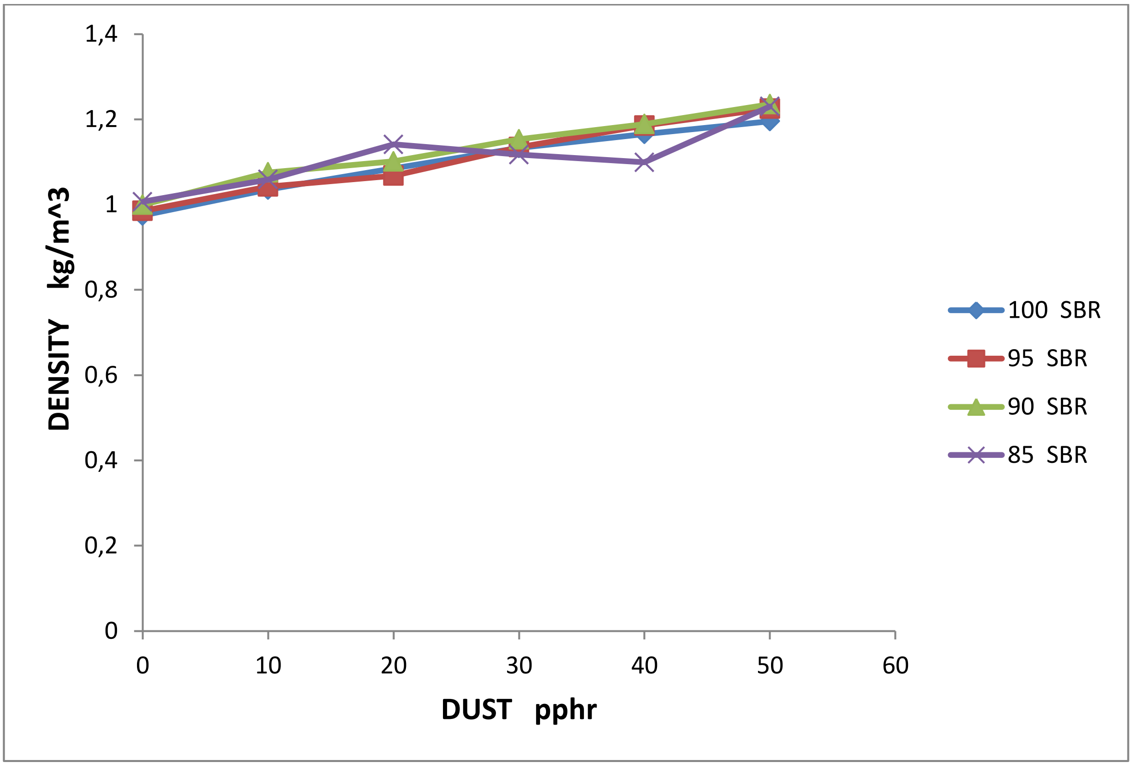

Figure 9. Effect of Adding Dust on Density.

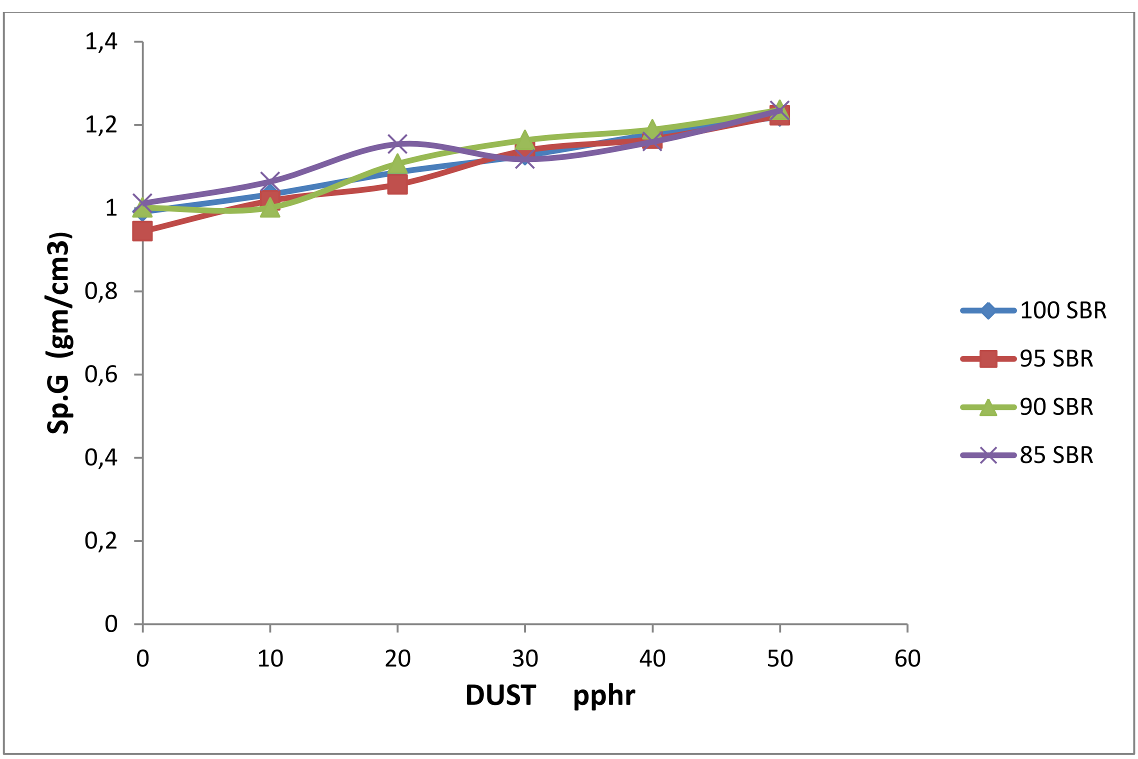

Figure 10. Effect of Adding Dust on specific gravity.

5. CONCLUSIONS

1. The increase of additives ratios dust of cement causes increase the tensile strength and modulus.
2. The increase of additives ratio dust of cement causes decreasing in resilience.
3. The increase of additives ratios of dust of cement causes increase the hardness.
4. The increasing of additives ratios dust of cement increase the tear resistance.
5. The increasing of additives ratios dust of cement increase the compression set.
6. The increasing of additives ratios dust of cement increase the density and specific gravity.

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