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The Effect of Particle Sizes on the Mechanical Properties for the Sport surfaces Prepared from Crumb Rubber

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Abstract : This research aims to study the effect of particle sizes on mechanical properties for sports surfaces prepared by using the crumb rubber which is considered as pollutant materials for the environments that is available at the state company for rubbers industries and tires industry in Al-Najaf city and in different particle sizes (P.S)which are considered as a base material in this work and added for various ratios from acrylic polymer material as binder material. The binder material added in various ratios (100, 150, 200, 250) g in to crumb rubber (CR) which has different particle sizes (2.3, 2, 1.7, 1.4) mm. and by mechanical tests results we selected the sample (400 CR + 250 BM) with the size of 2mm for crumb rubber for being more convenient and an investigation of the mechanical properties required, the results showed that mechanical properties match with international standards .The results indicated that tensile strength 0.467 MPa, hardness 59.6 Shore A and resilience 52.9 %, compression set 0.69%, density of 11.091 g / cm3, friction coefficient 0.75 and wear resistance 0.647%.
Keywords: Particle Sizes, Mechanical Properties, Sport Surfaces, Crumb Rubber.

1. Introduction

Waste tire related environmental problems and its recycling techniques have been a major challenge to society and also the disposal of these tires becomes a serious problem. The accumulation of scrap waste tires leads to environmental pollution problems. A large fraction of the waste tires is simply dumped in towns where they represent risks such as diseases and accidental fires[1, 2].

Increasingly, waste tires that reach to the end of their serviceable life reused in useful novel applications. Some of these include playground and garden mulch, soil and surface amendments at athletic fields, and bound surfaces at playgrounds and athletic facilities. These modern artificial surfaces reduce the probability of personal injury, supply uniform recreational playing surfaces, promote energy conservation, removes pesticide and fertilizer usage, and backing waste recycling[3-11].

Crumb rubber is produced by shredding and grinding processes for damaged tires into very small particles. In these processes, most of the steel wires and fluff of the recycled tires are removed.

The uses of crumb rubber include running and jogging tracks, athletic fields and golf courses because of the crumb rubber provides resiliency and durability. Crumb rubber is used either in the supporting structure for the playing field (soil sub-base) or mixed with the material that form the running track surface. This makes the stadium or track more resilient, enhances drainage capability and provides softer playing surface for children and athletes to create fewer injuries.

The advantage of using tire crumb powder, as compared to sand or asphalt, in playgrounds is that its Shock-absorbing properties which decreases injuries to players using stadium facilities. Incorporation of rubber into sport surfaces increases safety and/or performance. In the case of Playgrounds, where loose rubber, rubber mats or a coagulated rubber emulsion is laid, rubber surfacing has the highest impact attenuation of any material tested and/or commonly used. The same feature is also displayed when rubber is used in running tracks: the impact on the surface is absorbed largely by the rubber-modified surface, not by the body[3, 10, 12-16].

2. Experimental Part

2.1 Materials

* Crumb rubber: It was brought from the state company for rubbers products and tires industry in Al-Najaf city – Iraq which it a product of scrap tires.

* Acrylic elastomer polymer: It was brought from Iraq factories, which are considered as a binder material.

2.2 Preparation of Samples

The samples prepare by mixing of acrylic elastomer polymer which considers a binder material with crumb rubber. In this process the crumb rubber and binder material mixing by electric mixture device with speed 10 rpm, this speed helps in homogenous of crumb rubber with acrylic polymer. In this process acrylic polymer adds in to various ratio 100, 150, 200,250 g in to 400 g from crumb rubber and mixed together in mixing device at the above speed and at room temperature for period reach to 5 min. after complete mixing process, the mixture put in to mold ha dimension 30 X 30 cm and the surface of mixture modified by manual trowel– after this pressure with load about 10 kg which consider weight of the machine that used in manufacture of sport surface applying on the mixture and leave this load for 5 min after that the load remove and mold leave at room temperature for 24 hr. after this time the sample exits from the mold and which will be ready for inspection.

3. Results and Discussion

3.1 Tensile Strength

Form Figure (1) we noted increasing the tensile strength with increasing of the particle size and proportion of binder material and the reason for this is to get a large interlocking and attraction between crumb rubber powder and binder material.

And by the figure below we noted that the highest value for the tensile strength is at 2 mm particle size and the reason for this is to get complete homogenous between crumb rubber and binder material.

But if less particle size, the surface area will increase and consequently the particles need to a binder material more due to the presence of high free volume and therefore, the resistance to tensile stress will be reduced compared with the higher particle size, the free volume will be reduced for bulk and thus the material will more interlocking and attraction and thus give a higher tensile strength.

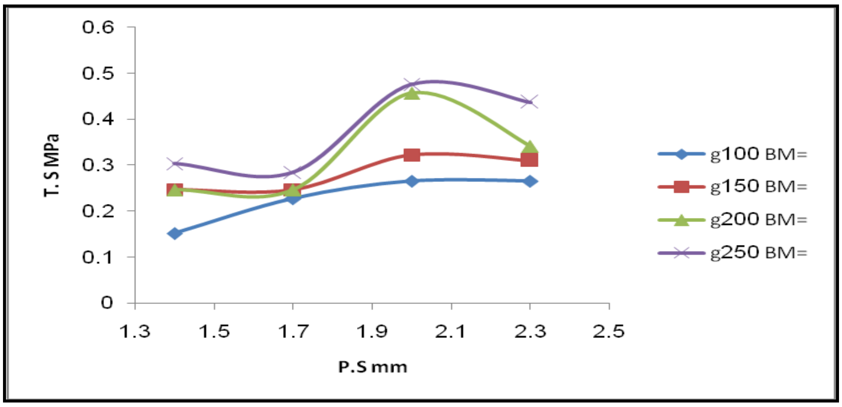

Fig.1: Relationship between tensile strength and particle sizes with various ratios of binder material

3.2 Hardness and Resilience

The relationship between hardness and resilience is a direct where if hardness increases, the resilience will increase and vice versa, and through the forms (2) and (3) we noted an increase in both hardness and resilience values with increasing of the proportion of a binder material (acrylic polymer), where is the relationship between the two properties and binder material is a direct relationship, where if ratio of binder material increase these properties will increases and the reason for this is formation large interlocking between crumb rubber particles and binder material and thus will resistance forces that applied them and as a result, the hardness and resilience increases as well as we note to increasing in both hardness and resilience with increasing particle size but less when particle size reaches to 2.3 mm because of the large pores (free volume) existing between the grains which do not resist any forces so the value of the hardness and resilience reduce at this size.

As for the size of 2 mm gives the highest values of hardness and resilience due to get a balance between the binder material, particle size and pores.

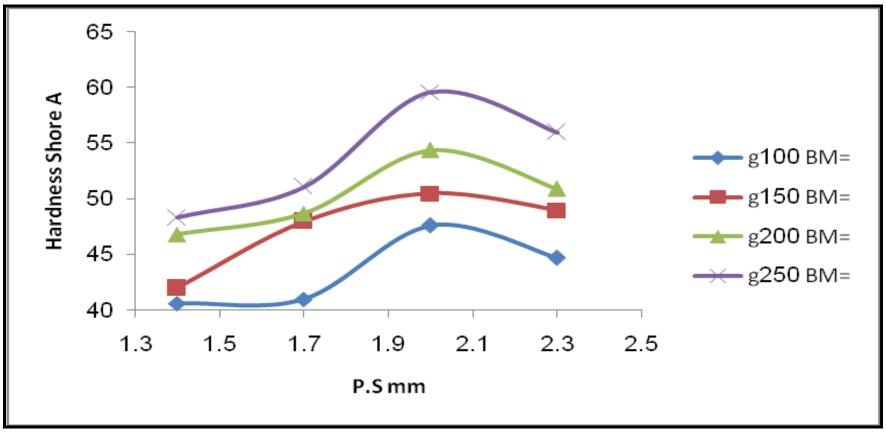

Fig.2: Relationship between hardness and particle sizes with various ratios of binder material

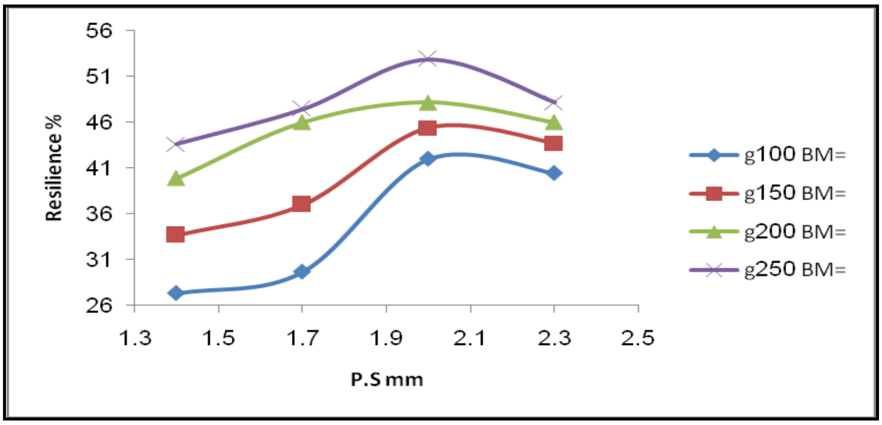

Fig.3: Relationship between resilience and particle sizes with various ratios of binder material

3.3 Friction Coefficient

Through figure (4) we noted that the coefficient of friction increases with decrease particle size of the crumb rubber and this attributed that when the least particle size of the rubber crumb, binder material which have high viscosity is difficult to penetration between the pores and thus readily be remove granules during friction and it is known already that it should avoid the few particle volumes because of its high cost compared to large particle sizes.

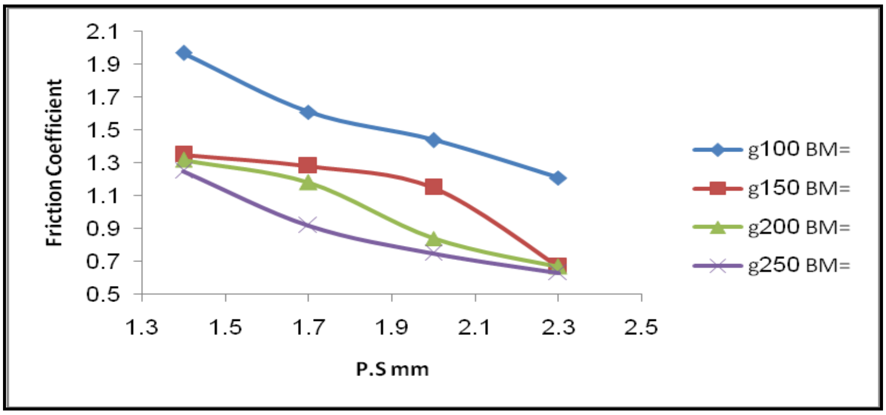

Fig.4: Relationship between friction coefficient and particle sizes with various ratios of binder material

3.4 Wear Resistance

From figure (5) we noted that the rate of granules loss decrease with increasing of binder material ratio and the reason for this is due to increase of attraction number between crumb rubber and binder material with increasing of binder material ratio and so increase the linkage strength between granule and other and be the difficulty of separation between them so the amount of the loss of granules reduce with increases the proportion of binder material and this loss the decrease with increases the particle size...

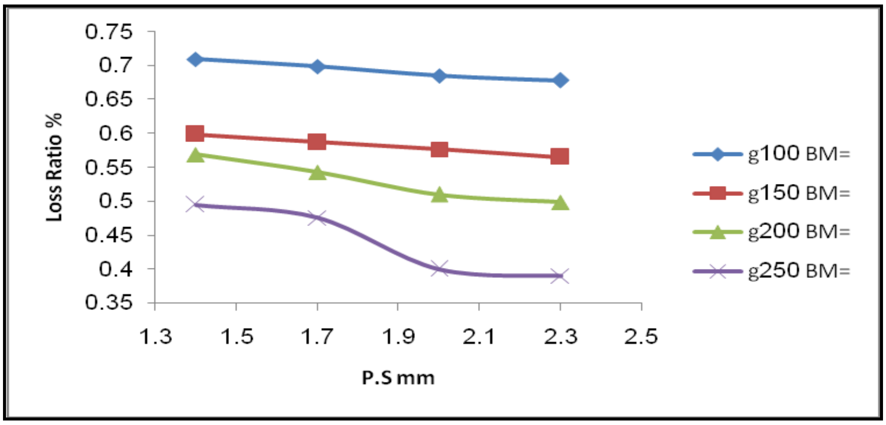

Fig.5: Relationship between wear resistance and particle sizes with various ratios of binder material

3.5 Density

Figure (6) shows gradually increasing in density with the increasing in the proportion of the addition of binder material the reason attributed to the fact that binder material works to fill in the gaps (the pores of all kinds) formed within the prepared sample, leading to reduce the divergences between the molecules of the material and is therefore working on increasing weight for volume unit.

Through the figure below we note that the density increases with increasing particle size, due to the gaps formed in the large-particle-size sample is greater than the formed gaps in the small particle size samples and this facilitates the entry of binder material to gaps while binder material do not fall entirely upon the small particle size which lead to not completely filling up.

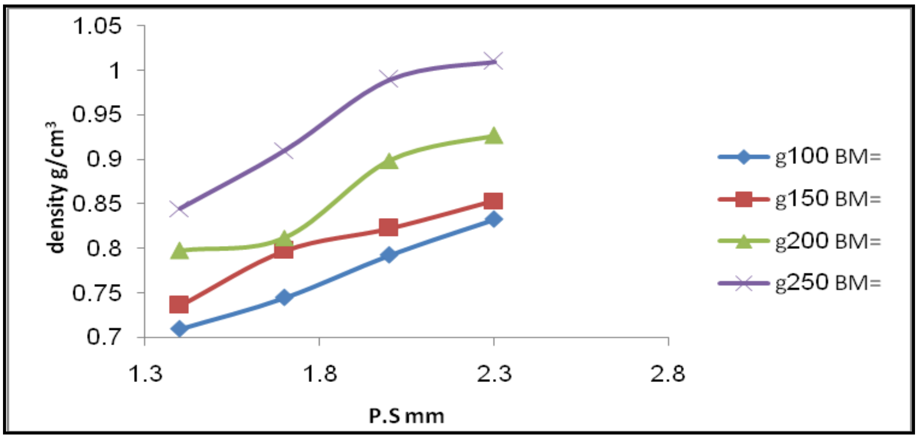

Fig.6: Relationship between density and particle sizes with various ratios of binder material

3.6 Absorbent

Form figure (7) we noted that the absorbance values ratios decrease with the increase in the proportion of binder material and the reason for this is if binder material ratio increasing, the gaps and pores will be filled by the binder material which is from water-resistant type (water proof) and thus do not allow for water to co-exist within these gaps, therefor the absorbance will reduce. Noting that the absorbance values for the few granular sizes higher than the high granular sizes because of the increased surface area of the granular and therefore has the ability to absorb more amount of the water compared to high granule sizes[3, 17-19].

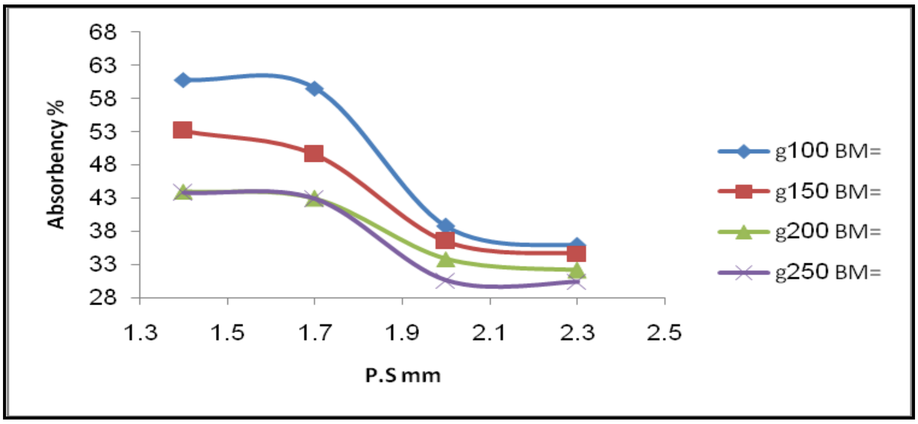

Fig.7: Relationship between absorbency and particle sizes with various ratios of binder material

3.7 Fatigue Resistance

Fatigue is a property of material to resist crack growth and by the figure (8) we note that the crack growth resistance increases with binder material ratio and this is attributable to the formation crosslinking between crumb rubber particles and the additive, which resist crack growth.

Through the below figure we noted that fatigue resistance increases with decrease in particle size of the crumb rubber because it is at the higher granular size the surface roughness will increase and thus be more exposed for the growth of cracks and thus do not resistance to crack growth compared with the granular size little, the surface roughness will be reduced and therefore smoothness increases so fatigue resistance is high.

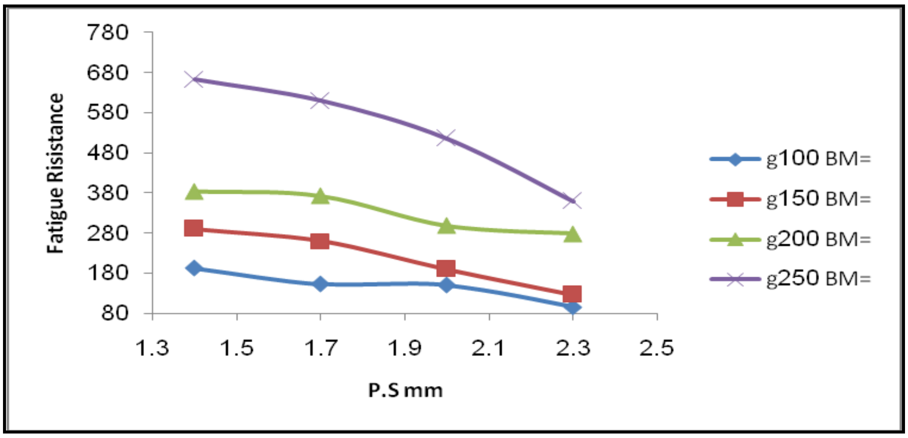

Fig.8: Relationship between fatigue resistance and particle sizes with various ratios of binder material

Standard specification depended in the research

Properties	Standard Specification		Units
	ASTM	**BS 7188: 1998**	
Hardness	60+/-5 (D-2240)		Shore A
Tensile Strength		0.4	MPa
Friction coefficient	0.88 (C-1028)		
Wear Resistance	0.5 (D- 3389)		g
Resilience		Less of 90	%
Compression Set	12 or less(D-395)		%
Density	1.0412 (D-792)		g/cm^3

Conclusion:

Studying the effect of particle sizes on mechanical properties for sports surfaces prepared by using the crumb rubber which is considered as pollutant materials for the environments that is available at the state company for rubbers industries and tires industry in Al-Najaf city and in different particle sizes (P.S)which are considered as a base material in this work and added for various ratios from acrylic polymer material as binder material. The binder material added in various ratios (100, 150, 200, 250) g in to crumb rubber (CR) which has different particle sizes (2.3, 2, 1.7, 1.4) mm. and by mechanical tests results we selected the sample (400 CR + 250 BM) with the size of 2mm for crumb rubber for being more convenient and an investigation of the mechanical properties required, the results showed that mechanical properties match with international standards . The results indicated that tensile strength 0.467 MPa, hardness 59.6 Shore A and resilience 52.9 %, compression set 0.69%, density of 11.091 g / cm3, friction coefficient 0.75 and wear resistance 0.647%.

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