GREEN KERB – GREEN TECHNOLOGY TECHNIQUE IN THE DEVELOPMENT OF ALTERNATIVES KERB USING OLD TIRE

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By

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I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

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Date :

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ABSTRAK

Satu teknologi akan dikenalkan pada kerb jalan pada masa yang akan datang. Rekabentuk ini adalah berlainan dari segi campuran konkrit, selain dari itu dimensi dan spesifikasi JKR tetap sama. Teknologi baru ini akan dapat memberi impak kepada dunia inovasi dan eko-sistem. Campuran yang akan berubah adalah campuran aggregat kasar, iaitu aggregat kasar akan digantikan dengan cebisan tayar yang di potong mengikut saiz aggregate kasar dalam lingkungan 15-20 mm, dan ianya dicampurkan dengan konkrit mengikut peratus gantian dengan aggregat kasar. Antara ujian yang dijalankan ialah kejatuhan 'slump', mampatan dan 'rebound hammer'. Keputusan nilai 'slump' menunjukkan kebolehkerjaan tinggi apabila peratus campuran meningkat, nilai mampatan dan 'rebound hammer' menurun apabila peratus campuran meningkat. Keputusan nilai 'rebound hammer' menunjukkan campuran konkrit tersebut boleh menyerap impak. Kajian ini akan berjaya jika menggunakan peratus campuran yang betul, campuran yang digunakan ialah 0%, 10%, 20% and 30%. Dengan menggunakan peratus campuran 20%, jumlah berat satu kerb jalan dapat dikurangkan sebanyak 8% dan jumlah kos anggaran untuk jalanraya dimana panjangnya 1 kilometer menelan perbelanjaan sebanyak RM 23,171 untuk kerb jalan biasa dan RM 21,387 untuk kerb jalan campuran tayar. Nilai peratus campuran 20% menunjukkan keputusan yang baik keseluruhanya, dan ia memenuhi standard JKR (JKR/SPJ/1988) yang ditetapkan.

ABSTRACT

A technology is introduced on road kerbs in near future. This design is having different prospective mainly in concrete mixture, other than that the dimension and it existing JKR requirements still the same. This technology will give a positive impact on the innovation industry and eco-system. The difference from other kerbs is that the changes on coarse aggregate proportion in the concrete, that is the coarse aggregate will be replaced with crumb rubber from vehicle tyres after been cut to the specified dimension as coarse aggregate from 15-20 mm. Then it will be mix together with concrete regarding to the percentage replaced by coarse aggregate. Few testing are done such as slump, compression and rebound hammer test. The result for slump test shows high in workability at the percentage of crumb rubber increase, the compression value decrease and the rebound hammer test shows the concrete able to absorb the energy and reduce the surface hardness. This study will bring a new hope if the mixing percentage is done correctly. The total weight of road kerb is reduced by almost 8% in this new technology, and the total estimated cost for road kerb for 1 kilometre of road is about RM 23,171 for normal road kerb and RM 21,387 for this green kerb. This 20% CR mixtures shows good result among other mixtures. The percentage of CR used are 20%, this particular percentage has good workability, satisfy the concrete grade 25 strength required and standard JKR (JKR/SPJ/1988).

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LIST OF ABBREVIATIONS

JKR	**J**abatan **K**erja **R**aya
CR	**C**rumb **R**ubber
ASTM	**A**merican **S**ociety for **T**esting and **M**aterials
CCSR20	**C**oncrete With **C**ombined-**S**ize **R**ubber, 20% Fine Aggregate By Volume
CRA20	**C**oncrete With **R**ubber Sample **A**, 20% Fine Aggregate By Volume
CRB20	**C**oncrete With **R**ubber Sample **B**, 20% Fine Aggregate By Volume
CRC20	**C**oncrete With **R**ubber Sample **C**, 20% Fine Aggregate By Volume
CSR	**C**ombined-**S**ize Distribution **R**ubber

CHAPTER 1

INTRODUCTION

1.1 Introduction

Concrete is made of cement, aggregates and water. Concrete is one of the widely used as construction materials around the world. Aggregates the biggest contributor in concrete according to its weight, that is about 70% by weight of the concrete. Day by day the demand for natural resource like aggregates increases rapidly as the construction industry activity also peaks. The problem starts here, when the source which is natural aggregates tend to decrease every day to meet the high demand. Therefore an alternative is to provide materials that will have similar properties to aggregates in the production of concrete.

In Malaysia, with the increase of vehicles which corresponds to the number of tires. After replacing the tires after wear and tear, the number of used tires then eventually ends up at landfills as waste. For some reason, the workshop owner did not know the correct way to dispose the used tires, which results in disposing them in open land, landfills or burning them. This method of tire disposal gave a lot of negative impact to environment and dangerous to human health as the toxic gases are dangerous to the nature. In the world, billions of tires are being buried and dumped away, causing severe environmental impacts. Burning of tires in the open, bring serious damage to environment and human as well.

One of the main option for concrete is to reduce the proportions of coarse aggregate. The coarse aggregates is the main proportions in the mix design. In this study, we are trying to reduce the coarse aggregates with crumb rubber. However, it is proposed that the alternative concrete to be used for non critical concrete elements such as road kerbs.

Concrete kerbs are concrete element commonly used for safety barriers, dividers and at road shoulders. It provides the necessary protection to the pavement and road users. Thus, it does not require a critical concrete properties such as those needed for beams, slabs or columns. The kerbs are more to aesthetic and safety purpose for road and road users and JKR codes require that they are made using Grade 20 and Grade 25 concrete.

The kerbs have to provide safety features as well as protecting the road users and itself. The kerbs tend to be damaged after impact of vehicles. So the kerbs should have properties that will absorb the energy during impact and thus reduces the damage. It must also have the characteristics to resist from cracking and deterioration due to environmental effects. The ease of doing construction work, for example for the workers to move the kerbs with ease, they should be easy to handle, not too heavy and easy to construct.

1.2 Problem Statement

In Malaysia, there are about 57,391 tons of tires generated every year and only 40% of it will be dispose correctly stated by Boon et al. (2017). Besides that, waste materials in Malaysia are too much to handle and it is continuously increasing day by day. The tires will be a great hazard to the environment and ecosystem if it is not disposed correctly such as open burning or disposing them at landfills.

Nowadays the road kerbs are too heavy to handle by the workers as it is being build using concrete and it has coarse aggregates. The coarse aggregates made up of biggest weight percentage to the ration. In order to reduce we need to replace with other material. Thus, natural resources such as aggregates is decreasing at an alarming rate stated by Kumar et al. (2016). The aggregates need to be replaced with other materials or reduce the usage of natural aggregates. The tires can be shredded such as tire shreds, crumb rubber according to specific sizes. The road kerb at junction or corner usually damaged or cracks, due to that there is a need to make a durable and impact absorbing road kerb.

Therefore, a proposal is being drawn up to use vehicle tyres to replace natural coarse aggregates to make road kerbs.

1.3 Objectives

The objectives of the study are;

1. To determine the optimum mix ratio for Crumb Rubber in kerb

2. To evaluate the mechanical performance of green kerb

3. To produce a green kerb prototype

1.4 Scope

The project is limited to the use of crumb rubber as aggregates for concrete Grade 25 mix according to JKR specification (JKR/SPJ/1988) for road kerbs.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

The growth of automobile industry and the increase use of cars, lorries and motorcycle as the main mode of transport have boosted tire production. Recycle or reuse materials can be considered as a green product as it reduces the consumption of fresh raw materials and reduce disposal, as well it reduces pollution from the process. In the early 1990s, extensive research were carried out on how to use used tires for different applications. Nowadays there is an issue that the tyres are not permissible to be thrown directly to landfill, it is more acceptable to send the used tyres to recycle facility where it will be disposed by shredding process to reduce its bulkiness and to extract the steel ring inside the tyre.

Materials used in the concrete is the most important aspect to be considered. Thus that decision will determine the strength and quality of concrete product and also each concrete product must meet the standard requirements. There are some flaws in materials that will make the quality of the concrete low and eventually the price of the product also will drop. The tyres also take time to degrade by themselves but it consume a lot of space at landfill. Unfortunately, landfills in Malaysia are almost at highest usage rate compared to natural degradation process.

It takes a long time to degrade rubber, and this process will effect the environment and ecosystem. It will also consume most of the landfill area. So to solve this problem, tires need to be reuse in other industry such as construction or manufacturing. For example car tires can be used as vase for plants. In some industry like construction, they already implementing this idea but the acceptance is still low. One of the method in industry is they use crumb rubber as replacement for natural aggregates. Many findings stated that the research about rubber has been done and some if it shows that the crumb rubber is used as aggregates replacement for pavement and concrete structure.

2.2 Past Studies

2.2.1 Strength

The rubber lightweight aggregate concrete shows that the strength starts to decrease with increasing mixing ratio of the rubber particles. This study is done by Lv et al. (2015) and observed that the compressive strength decrease gradually from 41.5 MPa to 7.8 MPa when the rubber particles content increase from 0% to 100%, that is about a 83% reduction of strength on day 28. The reduction of compressive strength on day 7 and day 1 were 81% and 78% where the result shows in Figure 2.1. The possible cause for such a huge strength loss could be to the reduction of the amount of the solid load-carrying material with increasing rubber particles content. The other cause of strength reduction are the adhesion properties between the surface of rubber particles and cement paste might degrade, the adhesive effect is not same like as aggregate. Thus it stimulate increase of the volume of weak phase and interface transition zone.

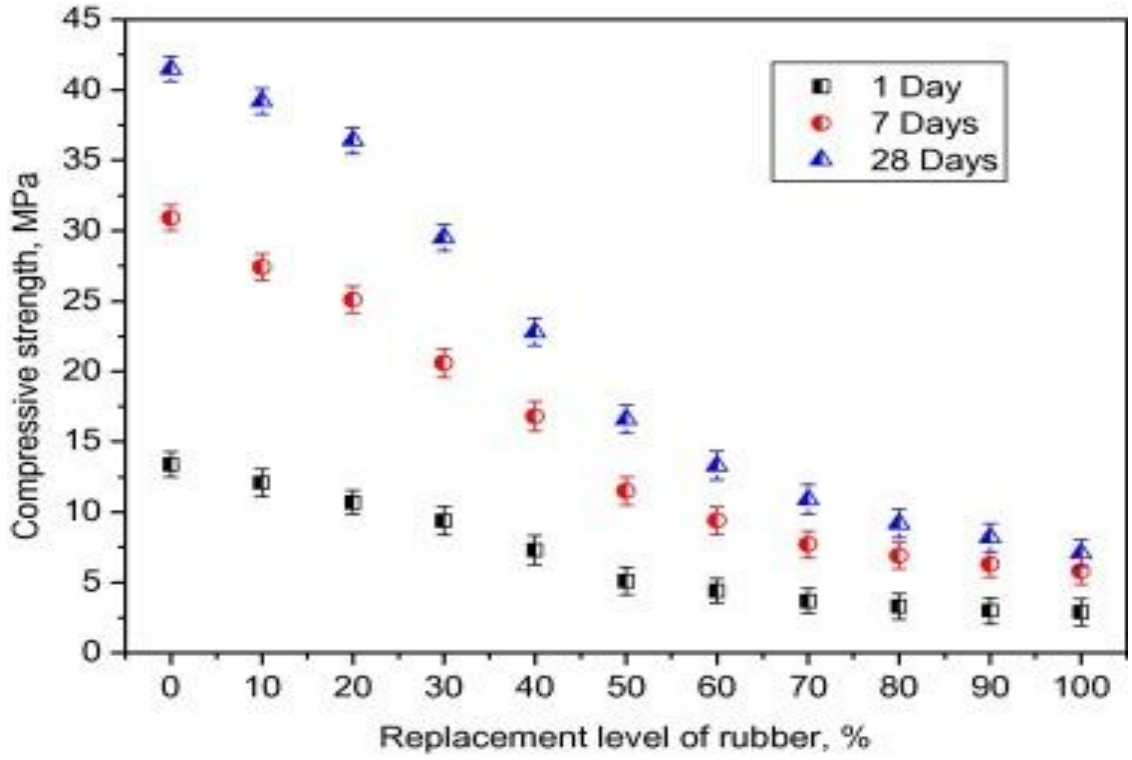

Figure 2.1 : Compressive strength vs. replacement level of rubber % from (Lv et al., 2015)

The reduction of compressive strength is caused by replacing the natural river sand with the soft rubber aggregate. As shown by Su et al. (2015), the percentage of reduction by 10.6%, 9.6%, 9.5% and 9.8%, this is reduce as the mix proportion different from others, for example concrete with combined-size rubber, 20% fine aggregate by volume (CCSR20), concrete with rubber sample A, 20% fine aggregate by volume (CRA20), concrete with rubber sample B, 20% fine aggregate by volume (CRB20), and concrete with rubber sample C, 20% fine aggregate by volume (CRC20). The value decrease from 10.6% for CRA20 , 9.6% for CRB20, 9,5% for CRC20 and 9.8% for CCSR20.

Su et al. (2015) mentioned that the inconstancy in the concrete mix is caused by low stiffness and poor surface texture, thus resulting in strength reduction, Figure 2.2 shows the data from this study. The surface of rubber particles and the cement does not bond well. This same decrease in strength with the use of rubber particles in concrete also shown by Guo et al. (2014) and Li et al. (2004).

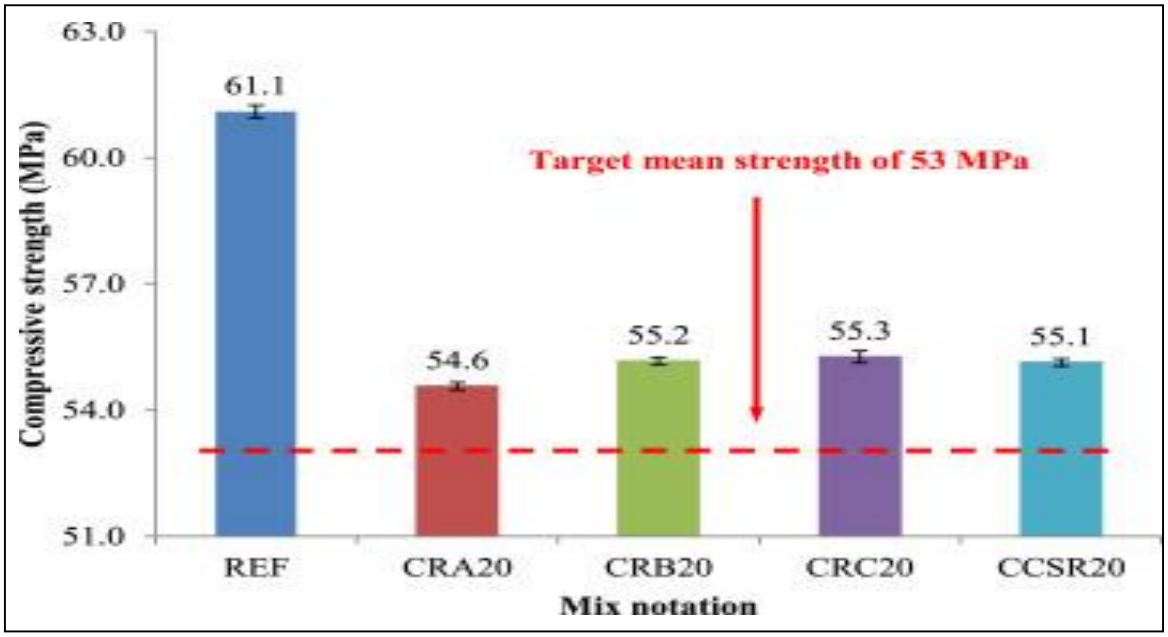

Figure 2.2 : The compression strength versus mix notation (Su et al., 2015)

The studies by Issa and Salem (2013) stated that the strength reduce as the rubber content increase in the concrete mix. Issa and Salem (2013) have studied the mix percentage from 0% until 100%, and the result shows a steady drop in compressive strength. Figure (2.3) shows compression strength versus % rubber content.

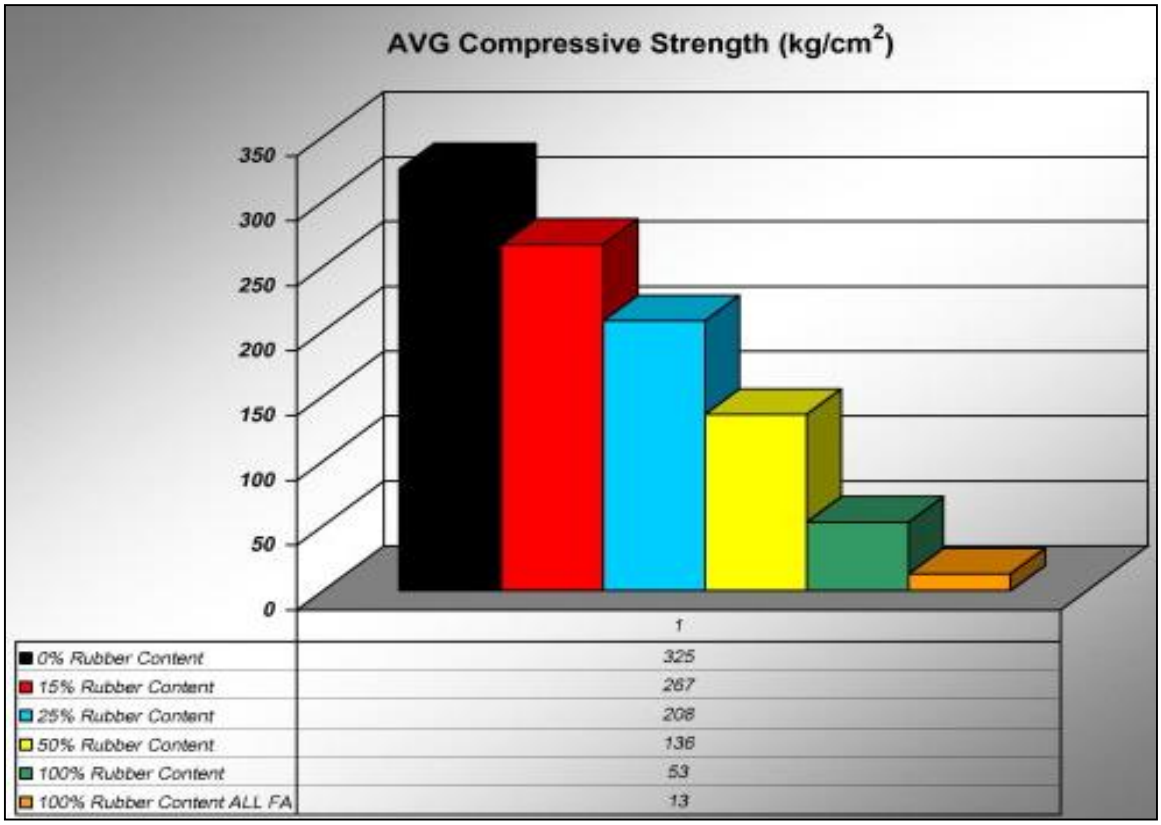

Figure 2.3 : Shows the past studies of compressive strength vs. % rubber content (Issa and Salem, 2013)

In other study, Dumne (2013) have prepared a concrete mix with 1: 2.10 : 3.90 ratio to test the strength on the cube after 7 and 28 days. The result shows the same trend as other studies, there are 0% drop of strength loss at 0% rubber aggregates mix, for 5% rubber aggregates mix the strength loss about 28.95% for 28 days, for 10% rubber aggregates mix the strength loss about 42.89% and for 15% rubber aggregates mix the strength loss about 55.21%.

The higher the strength loss mean the concrete mix is not strong and the bond between cement and rubber particles is not good. Figure 2.4 shows the strength gain takes place up to its 7 days of curing later on its gaining rate becomes slower.

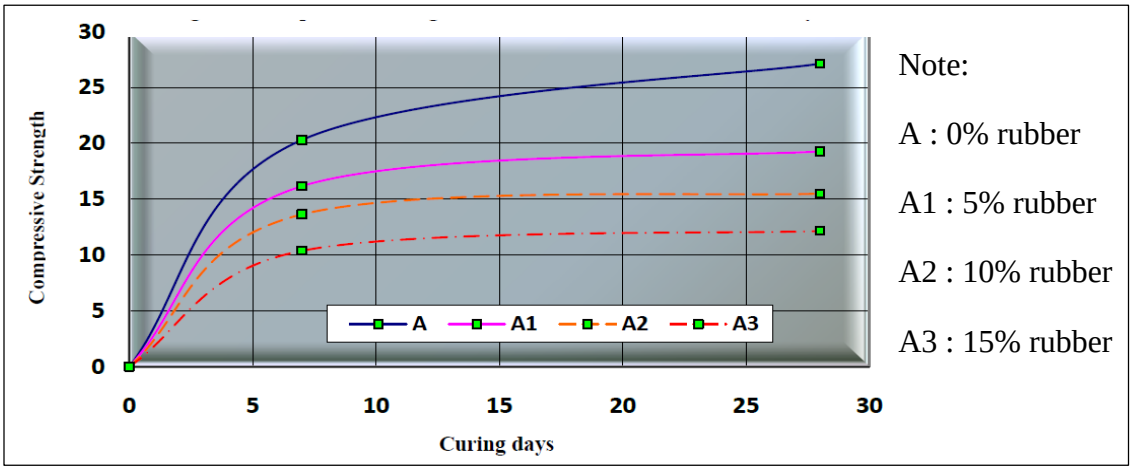

Figure 2.4 : Compressive strength versus curing days (Dumne, 2013)

There studies that are tested rubber aggregates on super structures such as column. Son et al. (2011) result shows almost the same as others, where maximum compressive capacity decreases as the rubber content in the concrete rises. As can be seen from Figure 2.5 there are two type of aggregates one is 0.6mm and 1mm in size, both shows different result. The 1mm size rubber aggregates have higher compressive strength and 0.6mm size has the lowest compressive capacity. The results on average, adding 0.5 – 1 % waste rubber particles to the 24 MPa and 28 MPa concrete mixtures.

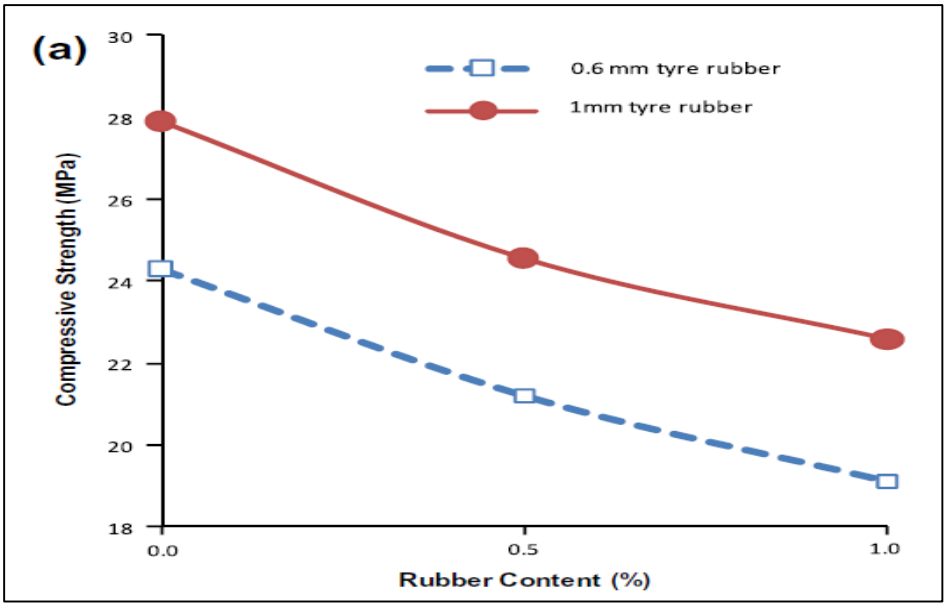

Figure 2.5 : Showing compression strength result for 0.6 and 1mm tyre rubber (Son et al., 2011)

Siddique and Naik (2004) have mention that the compressive strength of mixtures is affected by size, proportion and surface texture of rubber particles. Approximately 85% reduction in compressive strength when coarse aggregate was fully replaced by coarse crumb rubber. Although the strength in not satisfied but the mixture had the ability to absorb a large amount of energy under compressive loads.

Studies have been indicated that if the rubber particles have large, rough surface or even pre-treatment, it will give good bonding that may result in higher compressive strength. Naik and Singh (1991), have suggested that pre-treatment may vary from washing it with waster to acid etching, plasma pre-treatment and various coupling agents.