A STUDY OF USING TYRE POWDER RUBBER AS PARTIALLY REPLACEMENT OF FINE AGGREGATE IN CONCRETE

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ABSTRAK

Penggunaan tayar sampah sebagai komponen dalam konkrit telah mendapat perhatian besar dalam masyarakat kejuruteraan. Kelestarian adalah kebimbangan pertama serta sifat produk. Banyak penyelidikan telah dilakukan terhadap penggunaan sisa Tayar Getah sebagai pengganti agregat agregat dan kursus agregat untuk menghasilkan konkrit yang mapan. Kajian ini adalah penyiasatan terhadap prestasi konkrit menggunakan getah tayar sebagai sebahagian daripada penggantian agregat halus. Tiga campuran konkrit dijalankan dengan tahap 0%, 5% dan 10% penggantian untuk mengkaji kesan menggunakan getah tayar dalam kekuatan mampatan, kekuatan lenturan, dan ujian kelajuan ultra nadi. Dalam pengeluaran konkrit, simen Portland Komposit, agregat kasar, agregat halus, sisa getah dan air serbuk tayar digunakan sebagai bahan dalam proses pencampuran. Saiz maksimum agregat kasar adalah 20 mm dan saiz agregat halus untuk penyelidikan ini adalah antara 4.75 mm dan 2.36 mm. Eksperimen dijalankan untuk kekuatan mampatan, lenturan, kelajuan ultra nadi. Dalam kajian ini, keputusan ujian kemerosotan setiap batch berada pada jarak 64-75 kebolehgunaan. Selain itu, konkrit dengan 0%, 5% dan 10% daripada penggantian getah tayar mencapai kekuatan mampatan sebanyak 40.27, 29.13 dan 26.15 N / mm2. Sementara kekuatan lenturan masing-masing adalah 5.648, 5.056, dan 4.21. Keputusan menunjukkan bahawa kekuatan konkrit dikurangkan secara beransur-ansur dengan peningkatan peratusan penggantian serbuk tayar. Keputusan kelajuan ultra nadi dengan kisaran 3.58-4.17Km / s menunjukkan bahawa kualiti dan integriti konkrit adalah baik. Walaupun campuran konkrit getah secara amnya mempunyai kekuatan mampatan dan lenturan berkurang yang mungkin mengehadkan penggunaannya dalam aplikasi struktur tertentu, ia mempunyai beberapa sifat yang diinginkan, seperti ketumpatan yang lebih rendah dan ketangguhan yang lebih tinggi berbanding konkrit konvensional.

ABSTRACT

The use of waste tire as a component in concrete has taken a great attention in engineering society. Sustainability was the first concern as well as properties of the product. Many researches have been done on the use of tires waste Rubber as a replacement of fine aggregate and course aggregate to produce environmentally sustainable concrete. This study is investigation on the performance of concrete using tyre rubber as partially replacement of fine aggregate. Three mixes of concrete are carried out with 0%, 5% and 10% level of replacement to investigate the effect of using tyre rubber in compressive strength, flexural strength, and ultra-pulse velocity test. In concrete production, Portland Composite cement, coarse aggregate, fine aggregate, water and tyre powder rubber waste are used as the materials in mixing process. The maximum size of coarse aggregate is 20 mm and the size of fine aggregate for this research is between 4.75 mm and 2.36 mm. The experiments conducted to compressive strength, flexural, ultra-pulse velocity respectively. In this research, slump test result of each batch is at range of 64-75 workability. Besides that, concrete with 0%, 5%, and 10% of tyre rubber replacement achieved compressive strength of 40.27, 29.13, and 26.15 N/mm2, respectively. While flexural strength is 5.648, 5.056, and 4.21, respectively. Results showed that strength of concrete reduced gradually with increasing percentage of tyre powder replacement. Results of ultra pules velocity with range of 3.58-4.17Km/s indicated that quality and integrity of concrete is good. Even though rubberized concrete mixture generally has a reduced compressive and flexural strength that may limit its use in certain structural applications, it possesses several desirable properties, such as lower density and higher toughness compared to conventional concrete.

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LIST OF SYMBOLS

˚C	Degree Celsius
%	Percentage
Δ	Tolerance to Accommodate fixing precision
G	Grade

LIST OF ABBREVIATIONS

OPC	Ordinary Portland cement
ASTM	American Society for Testing and Materials
FKASA	Fakulti Kejuruteraan Awam dan Sumber Alam
UTM	Universal Testing Machine
UMP	Universiti Malaysia Pahang
US	United State
w/c	Water-Cement ratio
s/c	Sand-Cement ratio
MgO	Magnesium Oxide
SO_3	Sulphur Trioxide
CO_2	Carbon Dioxide
CH	Calcium Hydroxide
CSH	Calcium Silicate Hydrate
C_3S	Tricalcium Silicate
CaO	Calcium Oxide
SiO_2	Silicon Dioxide

$A_{l2}OH_3$	Aluminium Trioxide
Fe_2O_3	Ferric Oxide
Kg/ m^3	Kilogram per meter cube
MPa	Mega Pascal
lbs	Pound
pints	Unit of Volume
L	Litre
mm	Milimeter
h	Hour
cm^2/g	Centimeter square per gram
kN	kilo Newton
kN/s	kilo Newton per second
kPa	kilo Pascal
ºC	Degree Celcius
Mw	Saturated Weight
N	Newton
TR	Tyre Powder Rub

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Material researchers have tried for many years to make concrete a ductile material. However, due to the fragile nature of concrete, the most direct and effective approach to damage-tolerant concrete structures would appear to be incorporated intrinsic tensile ductility into concrete. Concrete structures are highly susceptible to tensile cracking due to different types of effects and subjected loading itself. However, Tensile strength of plain concrete is very low compared to compressive strength.

Many studies have focused on testing the effects of using rubber on the mechanical properties of concrete with different rubber sizes and different proportions. Jusli et al. (2014) investigated the mechanical properties of concrete consisting two kinds of tire rubber particles. The rubber particles have replaced the aggregate in the mixture with a proportion of (25, 50, 75, and 100). The result showed that ductile behavior of the concrete was more than in plain concrete specimens when observing stress-strain curve under compression. Sofi, A. (2014) have used a crumb rubber as a replacement of fine aggregate in the mixture with a proportion (20,34,60,80, and 100). They showed that the more crumb rubber is used, the flexural, compressive, and splitting strength of rubber is reduced.

This research is an attempt to provide a solution by Using powdered rubber as a replacement for cement to enhance and improve ductility of the concrete, and at the same time observing the changing of other mechanical properties such as compressive, and flexural strength.

In addition, discarded tyres waste is a globally environmental problem as materials of tires especially rubber is hard to degrade and take long time which cause a great pollution dilemma. Using scrap tires rubber as a replacement of aggregate from natural resources is considered as sustainable approach toward environment and produce a green concrete. The global problem with landfill disposal of automobile tires and plastics can only be solved by the feasible option left, and that is recycling and utilization of the recycled products. The application of recycling discarded tires will solve the environmental issue of industrial solid wastes and it is acted as a promising modifier to improve mechanical properties of concrete.

1.2 PROBLEM STATEMENT

The use of waste tire as a component in concrete has taken a great attention in engineering society. Sustainability was the first concern as well as properties of the product. Many researches have been done on the use of tires waste Rubber as a replacement of fine aggregate and course aggregate. Investigations are conducted to testify the effect of waste tire in the mechanical properties of concrete. 303 million scrap tires each year are consumed in US at a rate of one tire per person per year (NBMCW April 2013). IN 2015, US has generated about 280 million scrap tires. 87.9% are moved to recycling markets and the rest percentage are dumped to landfilled (RMA October 2016). Furthermore, about 3 billion scrap tires used in US are stockpiled. Scrap tires accumulation is a wide world problem as these scrap tyres contain complex materials that is difficult and take long time to degrade. The available studies regarding utilization of waste rubber tires in concrete provide a strong recommendation for the use of tyre waste as a partial replacement of fine aggregate in concrete production (Onuaguluchi and Panesar, 2014). The using of the solid waste will minimize the environmental impact and in the same time will reduce natural resources consumption (Wang et al., 2013). Recycling of scrap tires to be used in building industry is effectively prevent environmental pollution and aid to economically design of buildings and infrastructure.

Powdered rubber is a term that describe rubber recycled from scrap tires. The process of production of rubber has two steps. Frist of all, removing fluff and steel, then using cracker mill or granulator, assisted with mechanical or cryogenic means, to reduce the tire particles size. There are two major types of tires, automobile and truck tires, and there are significance differences between those two types. Therefore, it is important to specify the source of rubber as it has a remarkable influence on the characteristics, shape, and texture of the concrete. Studies have categorized concrete mix design of discarded tire rubber into three main categories:

1) Chipped rubber: Rubber with dimension (25-30mm) used as a replacement of course aggregates.

2) Crumb rubber: Rubber with irregular particles with dimension (3-10mm) used as a replacement of fine aggregates.

3) Powdered rubber: Rubbers with dimension smaller than 1mm used as a filler in concrete.

1.3 AIMS AND OBJECTIVES OF STUDY

The purpose of this study is to evaluate the properties of concrete using waste materials from the power plants in Malaysia. Replacements of fine aggregate and cement for the mixing of new concrete is one of the ways to achieve a more environmentally friendly concrete. This absolutely can reduce the consumption of energy and natural resources and the area of landfills required for the waste concrete. The objectives of this study are as follows:

i. To investigate the effect of using different percentage of powdered rubber as a replacement for fine aggregate in compressive strength of concrete.

ii. To investigate the effect of using of powdered rubber as partially replacement for fine aggregate in flexural strength of concrete.

iii. To investigate the effect of using different percentage of powdered rubber as a replacement for fine aggregate in integrity and quality of concrete.

1.4 SIGNIFICANCE OF STUDY

The significant of this study is to investigate the impact of using recycled tyre waste rubber as a replacement of fine aggregate on the mechanical properties of concrete compared to plain concrete. Using tyres waste as a replacement of natural resources is helped to produce a green and friendly concrete. Tyres waste are a worldwide environmental issue, so that recycling tyres to be used as a replacement to natural resources is consider as a good solution. This study is conducted to:

- provide more knowledge on the performance of concrete containing waste materials as a partial sand replacement
- Reduce dependency on natural resources
- Solve landfill problem for construction industry.
- Develop the uses of industrial waste materials as a new approach to promote the green environment and sustainability in construction industry.

1.5 SCOPE AND LIMITATION

As this research in recommending add on the tyre rubber as a fine aggregate into concrete in the composition of concrete G40. The focus is on the performance of the concrete as tyre rubber is added as partially replacement of fine aggregate. Some tests and experiments are proposed to be carried out to determine the performance of concrete produced.

The tests carried out carried out in the investigations are slump, compressive strength, flexural strength and ultra-pulse velocity test tested according to BS1881: Part 102, 118, 116, and 203 respectively. Slump test was chosen as the workability test. Two type of test to investigate compressive strength and flexural strength to test the maximum load that the cube and beam able to sustain. In addition, Ultra pulse velocity test will be conducted to test the quality of concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 CONCRETE

Concrete is made up by consolidating cement, aggregates, water and chemical material in suitable extent and setting the outcome is harden over time. Concrete production is comprising of a few systems to deliver a high-quality concrete that is batching, mixing, consolidation, finishing and curing. Every progressions of the procedure make an exceptional commitment to the nature of the final concrete product (Kejin & Jiong, 2005). Inadequate regard for any strides may bring about poor cement. Solid needs more consideration underway procedure.

In construction industry, concrete is one of the imperative materials to develop the building or framework. Concrete likewise is the development material which is exceptionally added to the business. In year 1955, the first longest vehicular bridge on the world traversing about 24 miles and name it Lake Pontchartrain Causeway (Robert,nd). It is the first large scale of precast concrete. These days, individuals continue building high rise like World Trade Centre Tower and Burj Khalifa while this two building are primarily utilized for the structures. It’s evident from go up to this point; concrete is assuming the essential part in construction industry.

Because of the waste management issues and green building issue, concrete need to be developed in the admiration of nature inside of an economic advancement point of view. Other than that, the creation of cement is delivering extensive measure of carbon dioxide which is harmful to nature. Hence, waste components like oil palm and sludge are blended into solid keeping in mind the end goal to decrease the waste material and moderate nature contamination.

2.2 DURABILITY OF CONCRETE

Cracking of concrete is not only caused by structure load, as well as with durability and long-term life (Mihashi et al., 2004). Strength of concrete is the fundamental issue advancement for concrete. As indicated by ACI 318, guaranteed the structure of the mixture is additionally upgraded to oppose the important introduction condition that effect on durability of concrete.

This implies protection is expected to keep erosion either from carbonation, drying shrinkage and cracking. Engineer should not depend exclusively on determining on rate of compressive quality, volume of water-concrete proportion, least of cementation substance and air entrainment. By and large, toughness of concrete not deliberately influenced by material and the structure of the mixture additionally needs to take consideration.

2.3 PERMEABILITY OF CONCRETE

Permeability or porousness of concrete is really the measure of water, air and different substances, for example, chloride particle to go into concrete. Concrete contain pores that permit less demanding passage, while littler pores diminish the rate at which these substances enter the concrete (Slag Cement Association., 2002). Permeability of concrete has an association with the consumption of reinforcing steel. Low porousness concrete can decrease the potential for reinforcing steel to erode when presented to chloride or water by constraining the pervasion of those chlorides or water into concrete. Case in point, when reinforcing steel in concrete erode, the result of that erosion takes up more volume than the first steel and reasons the concrete to crack. Cracking additionally bring both the concrete and reinforcing steel to the trustworthiness of the structure or building.

2.4 CEMENT

There are various properties and utilizations of cements for utilization in concrete including Portland, mixed and hydraulic cement. Portland cement is a principle component of concrete. Cement is hardened in light of the chemical reaction and water so it goes about as a bonding agent to concrete. Cement bond the aggregates and sand together with water to structures high compressive quality after it hardened.

As per Portland Cement Association (2009), the fundamental elements of cement, is a nearly controlled chemical combination of calcium, silicon, aluminium, iron and little measure of different fixings to which gypsum is included the last granulating procedure to manage the setting time of the concrete Lime and silica make up around 85% of the mass. Regular among the material utilized as a part of its fabricate are limestone, shells and chalk or marl joined with shale, clay, slate or blast furnace slag, silica sand and iron mineral. Thusly, the properties of concrete are impacted by the properties of cement. The sort and extent of concrete influence both the new and solidified properties of cement. A comprehension of bond qualities can give knowledge to a large number of the issues emerging in solid development. The synthetic properties of concrete are indicated in Table 2.1 (Kurtis, nd).

Table 2. 1: The Cement Properties

Oxide Analysis	**Percentage (%)**
SiO_2	20.60
Al_2O_3	5.07
Fe_2O_3	2.90
CaO	63.90
MgO	1.53
K_2O	0.73
Na_2O	0.15
SO_3	2.53
I.L	1.28

2.5 AGGREGATES

Concrete will be cement and water paste in which aggregates particles are installed. Aggregates are granular material, for example, sand, gravel, crushed stones and blast-furnace slag. Aggregates make up 60-75% of concrete so they have a large impact of the properties of the concrete (ACI E1-07). Natural sand and gravel is the created by the activity wind and water, while crushed stones coarse and fine aggregates are delivered by pounding natural stone. The shape and surface of aggregates influences the properties of fresh concrete more than hardened concrete. As per Hudson (2003), shape and composition of the aggregates are more vital than evaluating and declares that the attention on reviewing is fundamentally because of the noteworthy utilization of natural sands. Accordingly, for the aggregates with certain shape and surface will fundamentally impact the execution of concrete.

As per Mehta (1993), the aggregate particles for concrete ought to be with smooth surface to enhance workability, yet a rougher surface creates a more grounded bond between the paste and the aggregates making a higher strength. Consequently, the choice of aggregates is imperative to structure of concrete which will influence the sturdiness and workability of concrete.

2.6 COARSE AGGREGATES

Coarse aggregate ordinarily contain of little molecule of that are limited contrasts to the aggregates surface (Steven et al., 2005). Past research relates the vicinity that surface of these aggregate with malicious properties of concrete. Other than that, distinctive kind of coarse aggregate will impact the quality of concrete while sizes of the coarse aggregate likewise assuming a critical part to enhance quality of concrete (Chen et al., 2005). As per (Erol et al., 2005), examination about impact of coarse aggregate state of the quality of black-top concrete blend, realized that state of coarse aggregate is altogether to concrete blends. In this manner, the impacts of aggregate shape and surface on the quality of solidified concrete ought not be over-summed up. Other than that, aggregate properties essentially influence workability of concrete furthermore the toughness, quality, warm properties, and thickness of solidified concrete. More precise and less circular coarse aggregates obliged higher blending water and fine aggregate substance to give a given workability (ACI E1-07).

2.7 FINE AGGREGATES

Fine aggregate is a fundamental part of concrete. Fine aggregates comprise of characteristic assets and produced from stone rock. The most normally utilized fine aggregate is characteristic waterway sand. The finer aggregate have better beneficial outcomes on the properties of concrete and solidified superior concrete. Fine aggregate are assuming essential part in the concrete mixture. As indicated by Steven et al, (2005), fine aggregate molecule shape and composition influence concrete essentially through their impact on the workability of new concrete. The impact of fine aggregate shape and composition on the quality hardened concrete is totally identified with the subsequent of the concrete, gave that the fine aggregate has an evaluating inside regularly acknowledged points of confinement and that reviewing is considered in selecting concrete extents (ACI E1-07).

2.8 WATER

Water is vital contemplations on the nature of mixing water are those identified with the impact on workability, quality and sturdiness (Cement Concrete & Aggregate Australia). Water for mixing concrete ought to be free from alkali, acid, oil and natural purities. As indicated by Wood (1992), less water in mixing certainly cause concrete more strength and toughness yet guarantee it is workable. Moreover, excess of water bringing about feeble and permeable concrete. Any regular water that is drinkable and has no affirmed taste or smell can be utilized as part for making concrete. Wash water is usually utilized as blending water as a part of prepared blended concrete. Intemperate debasements in blending water not just may influence setting time and concrete quality, additionally may bring about blossoming, recoloring, erosion of reinforcement, volume unsteadiness and lessened strength. Nonetheless, oversea nations like United States are utilizing waste water, for example, commercial ventures waste water and sewage water in blending concrete (CCAA, 2004). Waste water likewise needs to satisfy the necessity by ASTM C94 to mix with concrete without influencing strength and toughness of concrete.

2.9 TYRE RUBBER

2.9.1 TYRE

Tyre is defined as a flexible rubber that is attached to the wheel rime to provide a gripping surface to give a smooth moving for vehicles. The pneumatic tire has been invented by Robert Thomson in 1845. One of ehe main raw material used in manufacturing tire is natural rubber. However, synthetic rubber is used. Rubber is used due to its good characteristics that can develop a proper characteristic of wear-resistance, resiliency and strength. Tires are used in automobiles, buses, trucks, tractors, industrial vehicles, motorcycles and others.

2.9.2 LIFE-SPAN OF TYRES

Tires are an advanced form of the wheel, before they get discarded and end up as waste, tires are used in various modes transport. Once the tire casing gets worn out, they are either rethreaded or if the tires are beyond rethreading, they are disposed of as waste. What extremely happens to discarded tires is of constitutes to this research.

2.9.3 TYRE RUBBER WASTE

Tyre rubber is a solid waste that result from discarded tyres. Using rubber in many application results in increasing the volume of tyre rubber wastes. Increasing demand of automobiles and the manufacturing of tyres has grown tremendously around the world. It was statistically estimated that throughout the world with an average of one tyre per person per year is discarded. It is undegradable material that causes serious environmental hazardous.

At the point when tyres are unused are disposed into landfills, concrete reusing tyre rubber is an undeniably regular strategy. reusing has various advantages that have made it a more the craving to hold development expenses down.

Reusing tyre rubber waste gives maintainability a few distinct ways. The basic demonstration of reusing this solide waste diminishes the measure of material that must be land-filled. As space for landfills gets to be premium, it is not only helping decrease the requirement for landfills, as well as lessens the financial effect of the task. In addition, utilizing tyre rubber as aggregates decreases the requirement for virgin aggregates.

2.10 SOLIDE WASTE REUSABLE IN CONSTRUCTION INDUSTRY

The construction industry assumes a critical part in Malaysia's improvement both in term of infrastructure and economic advancement. The transfers of general waste turn into a noteworthy ecological issue in Malaysia. In this manner, the likelihood of reusing the waste items in constructions material is progressively vital.

2.10.1 Tyre Rubber as Partial Replacement in Concrete

Since using tires causing a huge environmental concern, many researches have been focused on the possibilities of reusing of this waste material. Those studies have involved using tire rubber in concrete as a filler and partial replacing of fine and coarse aggregate in the mix. The effects on mechanical properties were investigated. Those studies have consistently concluded that by increasing the amount of rubber in the concrete mix, there were reduction in the compressive strength. Some researchers founded that the elastic modulus of the concrete decreases by increasing the amount of rubber (Gerges et al., 2018). Few researches have investigated the effect of rubber on the dynamic properties of concrete (Ataman et al., 2012). Those researches have concluded that rubberized concrete has greater energy-absorbing capabilities and plasticity than regular concrete. Those conclusions have also been confirmed in a study related to the brittleness index of rubberized concrete. This study has showed that as the amount of tyre rubber increases the brittleness index decreases, which discloses the greater plasticity and ductility of rubberized concrete (Guo et al., 2017).

Atahan and Sevim has carried a full dynamic impact test on rubberized concrete. Full-scale of six shaped barriers were made with different mix proportion of tyre rubber. An accelerometer instrumented to a 500 kg bogie vehicle impacted the barriers at 20 km/h. Research has showed that significantly increases in the amount of energy dissipated by the barriers by the increasing the amount of tyre rubber in concrete mix when compared to plain concrete Atahan & sevim (2017).

A research by Nehdi and Khan has investigated the engineering properties, such as, compressive strength, flexural strength, split-tensile strength, workability, toughness, elastic modulus, impact resistance, Poisson's ratio, heat and sound insulation, and thawing and freezing resistance of concrete containing tyre rubber. They also have showed the advantageous of using magnesium oxychloride cement as a binder for rubberized concrete Nehdi & Khan (2001).

Thomas and Gupta studied the effect of partially replacing coarse aggregate. Different amounts of rubber tire chips were used in the mixes. It was explained that rubberized concrete has reduction in compressive and flexural strengths compared to plain concrete. It was concluded that the specimens contained tyre rubber before fracture exhibited significant displacement and subjected to ductile failure. The results of experiments showed that specimens with tyre rubber had high toughness compared to plain specimens.

The use of crumb rubber as a replacement for mineral aggregates in concrete resulted in a vast beneficial use of tires. However, none of the studies have elucidated in any detail the beneficial aspects of crumb rubber and the mechanism by which the properties of crumb rubber reinforced concrete differ from the traditional concrete. Crumb rubber can be a lightweight substitute for mineral aggregates as its density is less than half of that of mineral aggregate. Mineral aggregates have a unit weight or density ranging between 1600 and 2080 kg/m3 while crumb rubber unit weight or density ranges between 640 and 720 kg/m3. The effect of adding two kinds of crumb rubber and chipped rubber were studied by Khatib and Bayomy (1999). They prepared three groups of concrete mixtures: in group A, crumb rubber was used to replace fine aggregate, while in group B, chipped rubber was used to replace coarse aggregate, and in group C, both types of rubber were used in equal volumes. All the three groups had eight different rubber contents varying between 5 and 100%. It was noticed that there was a decrease in slump with an increase in the rubber content; admixtures made with fine crumb rubber was more workable than those with coarse tire chips or those with a combination of tire chips and crumb rubber.

Herrnandez et al. (2002) has investigated the dynamic characteristics of rubberized concrete material. The rubberized concrete showed possible advantages in reducing or minimizing the vibration and impact effect due to the unique elasticity properties of the rubber material. They have examined the physical and mechanical properties of rubberized concretes with initial compressive strength of 20 MPa. The amounts of the rubber used in the rubberized concrete were15%, 30%, and 45% by volume of the total aggregates. This study has concluded that a general reduction in the compressive strength of rubberized concrete has occurred. As mentioned above, most of the literature review has shown a significant decrease in the mechanical properties of concrete after the addition of tire rubber particles as aggregates. The use of only coarse rubber particles affects the properties of concrete more negatively than do only fine particles. Moreover, the plastic energy capacity of the normal concrete has increased by adding rubber. Due to their high plastic energy capacities, concrete has shown high strains, particularly under the impact effects. Fattuhi & Clark (1996) have proposed that rubberize concrete could possibly be utilized in the following applications:

1) In foundation pad for machinery, and in railway stations, where vibrations damping is needed.

2) In trench filling and pipe bedding, pile heads, and paving slabs.

3) In railway buffers, barriers, and bunkers, where the resistance to impact or blast is required.

Most recently, Gupta et al. (2014) have extensively explored the effect of the use of a combination of waste rubber and silica fume on the durability and the mechanical properties of the concrete mix. The effect of replacement of fine aggregates by waste rubber fibers with a combination silica fume as of replacement of cement, on the impact resistance of concrete has also been assessed by Gupta et al. (2015). The main purpose of this study consists of exploring the feasibility of incorporating scrap tires in form of rubber powder as fine aggregates in concrete mixes and to determine its effect on the mechanical properties of the concrete mix. The parameters that were monitored comprised the influence of the rubber content on the mechanical properties of rubberized concrete starting with the 0% rubber content (no rubber) and up to 20% rubber content. The hardened concrete properties like the compressive strength, split tensile strength, and impact load were scrutinized. Generally, several impact tests procedures have been employed to demonstrate the relative brittleness and impact resistance of concrete and similar construction materials by Kishi et al. (2002). However, none of these tests procedures has been declared a standard test, at least in part due to the lack of statistical data on the variation of the results.

In this regard, ACI Committee 544 (2010) proposed a drop-weight impact test to evaluate the impact resistance of fibre concrete. The test is widely used since it is simple and economical. Thus, this test was adopted for this study to investigate rubber concrete. Accordingly, a special impact mechanism was designed and fabricated according to ACI recommendations relating to the adoption of the drop weight impact test technique. A summary of the impact test is that, the concrete samples are plated on the bottom of the mechanism with a thin layer of petroleum jelly or a heavy grease and placed on the base plate within the positioning lugs with the finished face up. The positioning bracket is then bolted in place, and the hardened steel ball is placed on top of the specimen within the bracket. The drop hammer is placed with its base upon the steel ball and held there with just enough down pressure to keep it from bouncing off the ball during the test. The base plate is withdrawn to a rigid base, such as a concrete floor or cast concrete block. The hammer is dropped repeatedly, and the number of blows required to cause the first visible crack on the top and to cause ultimate failure are both recorded. Ultimate failure is defined to be the opening of the cracks in the specimen just enough for the pieces of concrete to touch three of the four positioning lugs on the base plate. The results of these tests display a high variability and may vary greatly with the different types of mixtures.

In conclusion, Information of rubberized concrete is still having many gaps that should be defined especially with respect to dynamic properties. However, there are several gaps in the available information on rubberized concrete with respect to dynamic testing. Very few studies have addressed the effects of replacing both coarse and fine aggregates on the dynamic response behavior of this composite material. Most studies investigated up to 50% aggregate replacement with rubber. Hence, more research is warranted to investigate the effects of replacing up to 100% of aggregates with rubber on dynamic properties of rubberized concrete.

Gerges et al. (2018) has studied the effect of using tyre rubber in Mechanical and dynamical properties as Partial fine aggregates replacement in concrete mix. He has found that powdered rubber leads to a reduction in the density of the final product, because the specific gravity of rubber used was less than that of fine aggregates. Furthermore, decreasing in the rubberized concrete strength (compressive and tensile strength) with the increasing powdered rubber content in the mixture is always detected. The strength reduction may be attributed to two reasons. First, because the rubber particles are much softer (elastically deformable) than the surrounding mineral materials, and on loading, cracks are initiated quickly around the rubber particles in the mix, which accelerates the failure of the rubber–cement matrix. Second, soft rubber particles may behave as voids in the concrete matrix, due to the lack of adhesion between the rubber particles and the cement paste. In addition, for a design mix strength ranging between 30 MPa and 50 MPa, the reduction in the compressive strength is consistent and almost at a constant ratio with the increase in the percent of powdered rubber. The reduction in strength is an average of 30, 35, 50, and 63% against a powdered rubber replacement of fine aggregates at 5, 10, 15, and 20%, respectively. The addition of powdered rubber yields a slight improvement in the concrete tensile strength at all rubber percentages but still results in less improvement compared to the compressive strength reduction rate.

The addition of powdered rubber to the concrete mix results in a negative effect on the modulus of elasticity. The decrease of elasticity reflects the capability of rubberized concrete to behave in an elastic manner when loaded in tension, thus improving the failure manners of typical concrete. Rubberized concrete exhibits enhanced energy absorption since the concrete did not undergo a typical brittle failure yet it encountered a ductile, plastic failure mode. Concrete of compressive strength of 50 MPa, definitely displays a much better resiliency for rubberized concrete than plain concrete. This is not true for concrete of compressive strengths below 50 MPa, which displays a consistent reduction in resiliency. Even though the rubberized concrete mixture has generally a reduced compressive strength that may limit its use in certain structural applications, it possesses a number of desirable properties, such as lower density, higher toughness, and higher impact resistance, compared to conventional concrete.

Henry et al. (2012) has investigated Properties and mechanical environmental efficiency of concrete combining recycled rubber with waste materials. He found that Increasing the amount of rubber crumbs from 0% to 50% linearly reduced the compressive strength, regardless of the aggregate or binder type, and also reduced the rate of strength development from 28 to 91 days. Combination of rubber crumbs with recycled aggregates, with fly ash and with both recycled aggregates and fly ash reduced strength in that order. As the amount of rubber crumbs increased, the effect of recycled aggregates on strength was reduced until only the effect of fly ash could be seen at 50% rubber crumb replacement ratio.

The usage of fly ash did not appear to improve bonding between the rubber crumbs and the cement matrix nor between the recycled aggregates and the cement matrix. Increasing the amount of rubber crumbs also linearly reduced Young's modulus, and the effect was the same regardless of aggregate or binder type. The effect of fly ash and recycled aggregate could be seen even when increasing the amount of rubber crumbs to 50%. The JSCE standard curve was found to overestimate Young's modulus of nearly all the experimental series. The usage of 25% rubber crumbs could drastically reduce brittle failure under compression loading and prevent explosive destruction of the high-strength specimens. This was observed to occur both when the water–binder ratio was held constant, as well as between mixes with comparable compressive strength, and also for both normal and recycled aggregates. The effect of rubber crumbs on the air permeability coefficient depended primarily on the binder type. In the case of non-fly ash concretes, air permeability increased steadily as the amount of rubber crumbs increased, and the effect of recycled aggregates was marked and constant. For fly ash concretes, increasing the rubber crumbs to 25% produced only a small change, but increasing to 50% drastically increased the air permeability. The effect of recycled aggregates was small regardless of the rubber crumb replacement ratio, and the effectiveness of fly ash for improving the air permeability of both rubber crumb and recycled aggregate concretes could be seen. The mechanical–environmental efficiency of the mixes was calculated using an index which weighted the compressive strength by the volume of raw materials in each experimental mix.

Overall, the usage of only 100% recycled aggregates had the highest efficiency, followed by the mixes with no waste materials, combining recycled aggregate with 25% rubber crumbs, and combining recycled aggregates with fly ash. Rubber crumbs were found to be an inefficient means for reducing environmental impact when using the weighted strength as an evaluation index. When comparing the weighted strengths of concretes at a target strength level, the combination of recycled aggregates and fly ash was most efficient at the 40 MPa level and the combination of recycled aggregates, fly ash and 25% rubber crumbs was most efficient at the 30 MPa level.

Liu & Zhang (2015) have conducted a study to investigate utilization of powder rubber in concrete Tyre rubber powder with 5.3% of sieve residue on mesh 40 is utilized in concrete. The have conclude that In line with the various modifications in the rubber powder surface, improvement in in the properties and the interface bonding of concrete mixtures was observed. The bridge between rubber and matrix. The compressive strength and flexural strength of rubber concrete were always lower than those of the control concrete (plain concrete), owing to the weak load-bearing capacity of rubber powder.

However, when rubber powder was treated with silane coupling agent, the negative effects on the strength of the concrete mixtures became less significant. When rubber powder was treated with silane coupling agent, the impact toughness of the concrete mixtures was higher than in untreated or Na-treated rubber concrete mixtures. Compared with the control concrete, the plastic deformation capacity was better in rubber concrete mixtures whether the rubber powder was treated or not. For ductility, the strain of Si-treated rubber concrete mixtures was the highest of all rubber concrete mixtures. After rubber powder was soaked in silane coupling agent for 24 h, the interface combinations of the rubber powder and the concrete matrix became firmer, due to the stronger crosslinking of hydrogen bonds and covalent bonds.

Other researchers have been more interested in improving the properties of concrete blocks by adding waste rubber to the original mixtures. For example, Ling et al. (2009) categorized the blocks into three types (high strength and low toughness (Type I), high strength and moderate toughness (Type II), and low strength and high toughness (Type III)) according to the process. The effects of waste rubber particles or fibres as fine aggregate on the mechanical properties of concrete or concrete pedestrian blocks were investigated.

Sukontasukkul & Chaikaew (2006) soaked rubber particles in sodium hydroxide solution and then added the treated particles to cement paste to improve its properties. They found that this pretreatment enhances the rubber–matrix adhesion, improves the flexural strength and fracture energy of the cement paste, and lowers the decrease in compressive strength. Examination of the available literature has not turned up any other methods of modifying the rubber surface in rubber concrete, but there are interesting points of reference in other fields.

Prk & Cho (2003) have investigated the influence of silane coupling agent on the properties of silica/rubber composites and they reported that the agent leads to increased adhesion at the interfaces between the silica and the rubber matrix. Also, the effects of silane coupling agent on improving the interfaces between short natural fibers and rubber have been analyzed by Abdelmouleh et al. (2007), who found that the use of silane coupling agent enhances the mechanical performances of the composites and bonds the fibers and rubber more tightly.

Therefore, the potential of silane coupling agent as a link between rubber and inorganic materials has been fully recognized in the previous studies. Based on the information gathered, it seems that a method which uses silane coupling agent to modify rubber powder might play a vital role in improving the properties and interfaces of rubber powder and inorganic material. In this study, silane coupling agent was used as a modifier to improve the interface bonding between rubber powder and the concrete matrix. Besides this agent, another agent (sodium hydroxide) was applied as well for comparison.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter discussed the steps of materials preparation, mixing process and methods to perform the test. Most of all the work had been done in Concrete Laboratory of Civil Engineering and Earth Resources at University Malaysia Pahang (UMP).

3.2 Materials

This research for the most part is on the use of waste material as replacement substance in concrete. The materials utilized for this test are Portland cement, tyre powder rubber as coarse aggregate, fine aggregates, coarse aggregate, water and superplasticizer.

3.2.1 Cement

Cement used in this research was Ordinary Portland Cement (OPC) brand Orang Kuat with 32.5 MPa following the standard BS EN 197 – 1:2011. Figure 3.1below showed the type of cement used in this study.

Figure 3. 1: YTL Portland Cement

3.2.2 Tyre Powder Rubber

Tyre Powder rubber with size 0.425mm will be used as a partial replacement of fine aggregate with 5 and10 percent of fine aggregate content.

Figure 3. 2: Tyre Powder Rubber

3.2.3 Fine Aggregate

Figure 3.3 show River sand which were mined in Sungai Panching, Kuantan, Pahang to be used as fine aggregates in UMP Laboratory. River sand used as a fine aggregate. River sand is a rounded grain and generally in white-grey colour with 4.25mm as maximum size

Figure 3. 3 : Fine Aggregate

3.2.4 Coarse Aggregate

Coarse aggregates are particles more prominent than 4.75mm, however by and large range between 9.5mm to 37.5mm in distance across. In this study, granite aggregate used as coarse with 20mm size as a maximum and 5mm as a minimum. Granite stone is hard, tough, and nearly massive, and therefore it is popular in construction industry through the history.

Figure 3. 4 : Coarse Aggregate

3.2.5 Superplasticizer

In this study, Sika Viscocrete 2199 superplasticizer with 1500 mL/100 Kg of cement added during concrete mixing to ensure high water reduction, short time replacement, high early strength, superior cohesion with no segregation, and low creep and shrinking. It is a liquid admixture used to produce high slump concrete.

Figure 3. 5: Superplasticizer

3.3 PRE –MIXING EXPERIMENTS

In this studied-mixing experiment are important to determine the performance of concrete. Before casting the concrete, there are certain things to be considered which are moisture content, mixing procedures and clear and size of mould.

3.3.1 Concrete Mixing

The procedure of mixing concrete are carried out under temperature 28 to 31 Celsius at laboratory. Concrete mixing are using concrete mixer to improve workmanship and performance of concrete. The procedures of mixing concrete are pouring the aggregates, sand, water, concrete waste as coarse aggregate, and cement. Each of the components needs rotating mixing of 30 seconds. Before pouring the components of concrete, the bucket of concrete mixer are in wetter condition to prevent the absorption of the surface of bucket.Table 3.1 show the materials for 1m3 concrete G40 were used for this concrete mixture.

Table 3. 1: Materials For 1 m3 Concrete Grade 40

Materials	Weight
Cement	320 kg/m^3
Sand	640 kg/m^3
Aggregate	1280 kg/m^3
Water	128 kg/m^3

3.3.2 Mould

Figure 3.7 shown the concrete cube mould size 100mm x 100mm x 100mm used to produce concrete cubes. All moulds were cleaned and coated with one layer of oil before concrete placement in order to easily remove it after it become hardened. During casting the concrete cube, the concrete must be poured in 3 layers and each layer was compacted by compacting bar with 25 times. Lastly, the mould is place on the vibrator machine to smooth the top level of concrete on the mould.

Figure 3. 6 : Concrete Cube Mould

For the flexural test, it used the concrete beam 100mm x 100mm x 500mm casted according to (BS 1881: Part 109). The concrete beam is specific for flexural test. The mould should be cleaned and to be coated with a layer of oil for easily removed. The concrete specimens in the steel mould were in one layer and compact it with 25 strokes. After that, plasterer float was used to smooth the top level of the concrete mould. Then, it will be left in the laboratory under ambient temperature. After a few hours, mould would be covered by the plastic sheet to prevent moisture lost. After 1 day, it is demoulding and placed the concrete into curing.

Figure 3. 7 : Concrete Beam Mould

3.4 EXPERIMENTS

3.4.1 Slump Test

The purpose of slump test is to determine the workability of concrete. Workability is important for fresh concrete. If the workability of concrete is low, the concrete mixtures are difficult to be compacted and increase the risk of structure. The method to determine the slump test is according to British Standard 1881: Part 102. Slump cone ensured that the internal surface is clean. The fresh concrete was placed and filled by 3 layers in the slump cones, each of filled layers will be compacted with compacting bar with 25 strokes. After filled the slump cone, remove carefully, slowly and ensured the fresh concrete are not touched. Next, measure the difference of the height of slump cone and the fresh concrete. The difference in height is the slump of the fresh concrete which categories as very low, low, medium and high and show in Table 3.2.

Table 3. 2: Description of Concrete Workability and Magnitude of Slump

Workability	**Slump (mm)**
Very Low	0-25
Low	25-50
Medium	50-100
High	100-175

Figure 3. 8: Slump Test Equipment

3.4.2 Sieve Analysis

Sieve analysis experiment is important to ensure the nominal size of the aggregate used in the concrete mixtures. The coarse aggregate was weighted for 2000g to conduct the sieve analysis test. The coarse aggregate must be in dry condition before carried out the sieve analysis test. The sieve arranged in a descending order which the 25 mm is at the top which following by 20 mm, 14 mm, 10 mm, and 5 mm. The coarse aggregate was placed at the top of the sieve and ensure the cover plate was tightened as to prevent the aggregate drop out.Time for sieve analysis test is 10 minutes and repeated 3 times as to obtain more accurate data.

Figure 3. 9 : Sieve Analysis Machine

3.4.3 Ultra-Pulse velocity Test

Ultrasonic pulse velocity test consists of measuring travel time, T of ultrasonic pulse of 50 to 54 kHz, produced by an electro-acoustical transducer, held in contact with one surface of the concrete member under test and receiving the same by a similar transducer in contact with the surface at the other end. The test has been conducted according to DOE (the Department of Environmental, HMSO, 1988.

With the path length L, (i.e. the distance between the two probes) and time of travel T, the pulse velocity (V=L/T) is calculated. Higher the elastic modulus, density and integrity of the concrete, higher is the pulse velocity. The ultrasonic pulse velocity depends on the density and elastic properties of the material being tested.

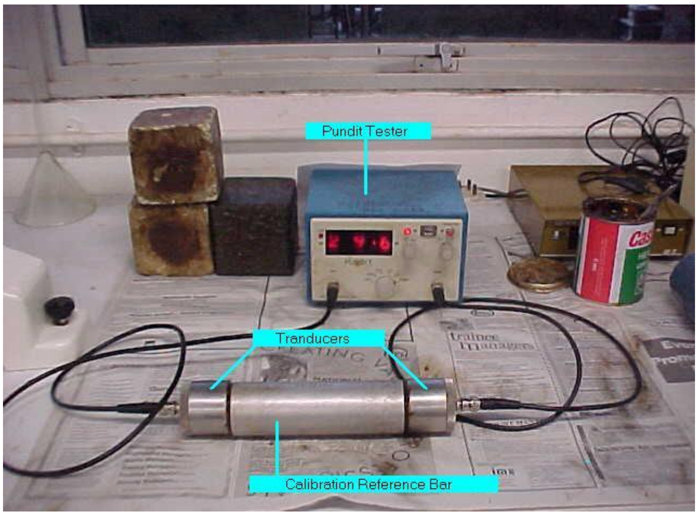

Figure 3. 10 : Ultra-Pulse Velocity Machine

Table 3. 3:Classification of Concrete Quality

Longitudinal pulse velocity (Km/s)	**Concrete Quality**
> 4.5	Excellent
3.5-4.5	Good
3.0-3.5	Doubtful
2.0-3.0	Poor

3.4.4 Compressive Strength Test

The compressive strength of concrete cubes (100 mm x 100 mm x 100 mm) was according to British Standard (BS 1881: Part 116). The concrete was tested by compressive strength testing machine as shown in Figure 3.11. Before carried out the test, the concrete cubes were weight by the scale kg. These reading are used for input in the compressive strength machine for analyzing the data and result. The test was carried out by testing 2 cubes for every concrete mixture at the same age. Besides that, the test was carried out on the concrete age is 7 and 28 days. Concrete age in 7 days can know the early strength of concrete, 7 days can estimate the ultimate strength and 28 days can confirm the ultimate strength of concrete.

Figure 3. 11 : Compressive Strength Test

3.4.5 Flexural Strength Test

The flexural test of the concrete beam (100 mm x 100 mm x 500 mm) was tested by British Standard (1881: Part 118). This test is to focus the Ultimate flexural strength that to focus the maximum load of the beam ready to maintain. The test was done at a fixed load and the test was end after the concrete pillar is broken. At the point when the concrete beam is broken, the information on flexural strength results were recorded in the computer and indicated in chart.

Figure 3. 12 : Flexural Strength Test

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this study, tyre powder rubber is used as partial replacement cement and fine aggregates in the concrete mixture to determine the strength of concrete. From the results, tests were carried out in research methodology and followed by discussion of results. Comparison of new mixture of concrete using tyre powder rubber as partially replacement of cement and fine aggregate with the normal concrete Grade 30 will be reported in this chapter. Besides that, the suitability of concrete in construction application will be determined from the results and the recommendations are made.

4.2 Sieve Analysis

In this research, sieve analysis test was carried out for the aggregates which are fine aggregates which is sand and the coarse aggregate which consists of normal coarse aggregate used in concrete mixture. In this test, the sieve analysis for coarse aggregate and fine aggregate were carried out three times to obtain the accurate data. The different data are needed specially to ensure the consistency of the result and determine the fineness modulus of these materials for concrete mixing.

It is shown that the result obtained from the sieve analysis test which is no aggregate retained at the sieve 25 mm and 8 to 9 percent of aggregates was retained at 20 mm. For the sieve 14 mm, it retained the highest percentage among the percent retained shown in the table. However, there were 3 to 5 percent of coarse aggregate were retained at the sieve 5 mm based on Table 4.1, 4.2, and 4.3

From the grading curve of the coarse aggregate. Based on the data obtained from the test, it can be concluded that the overall size of the coarse aggregate was considered good and suitable for concrete mixing for the research. Workability of concrete also depends on size of the coarse aggregate based on Figure 4.1.

Table 4. 1:Coarse Aggregate Sieve Analysis No. 1

Sieve Opening (mm)	**Weight of Coarse Aggregate Retained (g)**	**Weight of Coarse Aggregate Passing (g)**	**Percent of Coarse Aggregate Retained (%)**	**Cumulative Weight Retained (%)**	**Cumulative Weight Passing (%)**
25	0	2000	0.00	0.00	100.00
20	165	1835	8.20	8.20	91.80
14	1257	578	62.80	71.00	29.00
10	511	67	25.60	96.60	3.40
5	67	0	3.40	100.00	0.00
Total Percentage of Cumulative Weight Retained					175.80
Fineness Modulus					1.758

Table 4. 2 :Coarse Aggregate Sieve Analysis No. 2

Sieve Opening (mm)	**Weight of Coarse Aggregate Retained (g)**	**Weight of Coarse Aggregate Passing (g)**	**Percent of Coarse Aggregate Retained (%)**	**Cumulative Weight Retained (%)**	**Cumulative Weight Passing (%)**
25	0	2000	0.00	0.00	100.0
20	167	1833	8.35	8.35	91.65
14	1187	646	59.35	67.70	32.30
10	559	87	27.95	95.65	4.35
5	87	0	4.35	100.00	0.00
Total Percentage of Cumulative Weight Retained					171.7
Fineness Modulus					1.717

Table 4. 3:Coarse Aggregate Sieve Analysis No. 3

Sieve Opening (mm)	**Weight of Coarse Aggregate Retained (g)**	**Weight of Coarse Aggregate Passing (g)**	**Percent of Coarse Aggregate Retained (%)**	**Cumulative Weight Retained (%)**	**Cumulative Weight Passing (%)**
25	0	2000	0.00	0.00	100.00
20	188	1812	9.40	9.40	90.60
14	1214	598	60.70	70.10	29.90
10	504	94	25.20	95.30	4.70
5	94	0	4.70	100.00	0.00
Total Percentage of Cumulative Weight Retained					174.80
Fineness Modulus					1.748

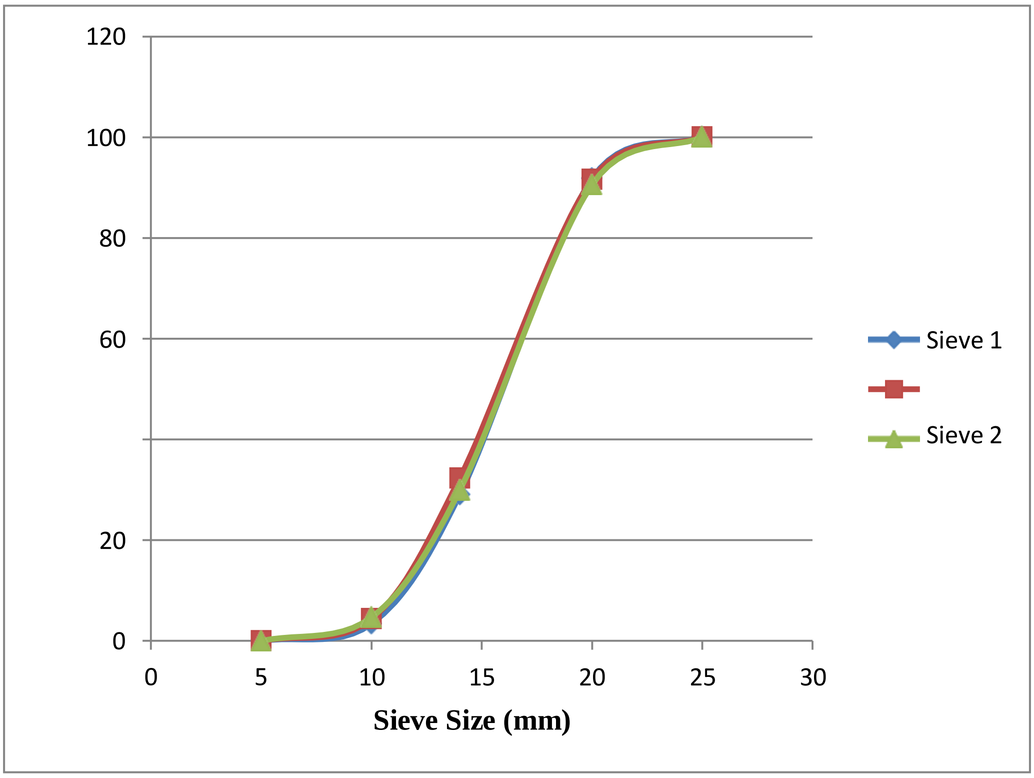

Figure 4. 1: The Sieve Analysis Test Result of Coarse Aggregate

It is shown the data that were obtained from sieve analysis test for the fine aggregate. From the result, it can be concluded that there were no fine aggregate retained at sieve 14mm and 6 to 10 percent of fine aggregate were retained at sieve 10mm based on Table 4.4, 4.5 and Table 4.6.

Furthermore, the highest percentage of fine aggregate retained was at sieve 4.75 mm which is about 32 % and followed by sieve 2.36 mm which is 31 % from the total fine aggregate for this sieve analysis test. Thus, it also can be concluded that the particular sizes of fine aggregate are between 2.36 mm and 4.75 mm and the total fine aggregate retained at sieve 1.18 mm are higher compared to the sieve 0.60 mm, 0.03 mm and 0.15 mm which only about 0 to 3% are retained.

It is shown the curve of percentage of fine aggregate retained at each sieve. The highest percentage of fine aggregate retained is at sieve size 4.75 mm and 2.36 mm. The sizes of fine aggregate between these two areas are used for concrete mixing to determine the strength of the concrete produced according to Figure 4.2.

Table 4. 4: Fine Aggregate Sieve Analysis No. 1

Sieve Opening (mm)	**Weight of Fine Aggregate Retained (g)**	**Weight of Fine Aggregate Passing (g)**	**Percent of Fine Aggregate Retained (%)**	**Cumulative Weight Retained (%)**	**Cumulative Weight Passing (%)**
14	0	2000	0.00	0.00	100.00
10	124	1876	6.20	6.20	93.80
4.75	655	1221	32.75	38.95	61.05
2.36	644	577	32.20	71.15	28.85
1.18	518	59	25.90	97.05	2.95
0.60	51	8	2.55	99.60	0.40
0.30	5	3	0.25	99.85	0.15
0.15	2	1	0.10	99.95	0.05
Pan	1	0	0.05	100.00	0.00
	Total Percentage of Cumulative Weight Retained				512.75
	Fineness Modulus				5.12

Table 4. 5: Fine Aggregate Sieve Analysis No. 2

Sieve Opening (mm)	**Weight of Fine Aggregate Retained (g)**	**Weight of Fine Aggregate Passing (g)**	**Percent of Fine Aggregate Retained (%)**	**Cumulative Weight Retained (%)**	**Cumulative Weight Passing (%)**
14	0	2000	0.00	0.00	100.00
10	189	1811	9.45	9.45	90.55
4.75	645	1166	32.25	41.70	58.30
2.36	623	543	31.15	72.85	27.15
1.18	497	46	24.85	97.70	2.30
0.60	42	4	2.10	99.80	0.20
0.30	2	2	0.10	99.90	0.10
0.15	1	1	0.05	99.95	0.05
Pan	1	0	0.05	100.00	0.00
	Total Percentage of Cumulative Weight Retained				521.35
	Fineness Modulus				5.21

Table 4. 6:Fine Aggregate Sieve Analysis No. 3

Sieve Opening (mm)	**Weight of Fine Aggregate Retained (g)**	**Weight of Fine Aggregate Passing (g)**	**Percent of Fine Aggregate Retained (%)**	**Cumulative Weight Retained (%)**	**Cumulative Weight Passing (%)**
14	0	2000	0.00	0.00	100.00
10	121	1879	6.05	6.05	93.95
4.75	655	1224	32.75	38.80	61.20
2.36	632	592	31.60	70.40	29.60
1.18	524	68	26.20	96.60	3.40
0.60	59	9	2.95	99.55	0.45
0.30	5	4	0.25	99.80	0.20
0.15	2	2	0.10	99.90	0.10
Pan	2	0	0.10	100.00	0.00
	Total Percentage of Cumulative Weight Retained				511.10
	Fineness Modulus				5.11

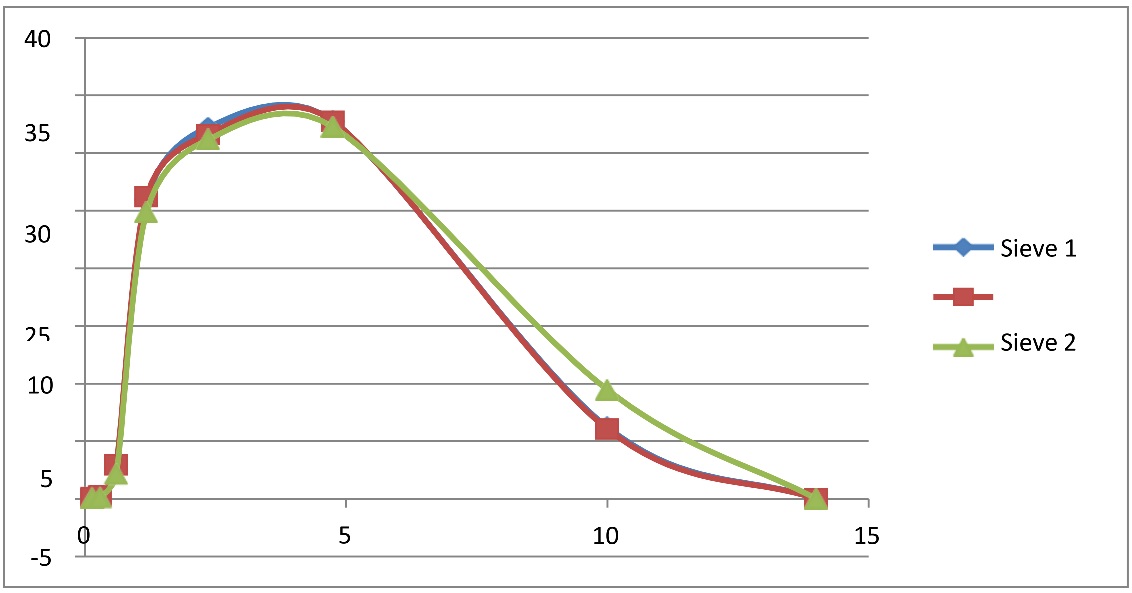

Figure 4. 2 : Percentage of Fine Aggregate Retained

4.3 Trial Mix

In order to get the correct concrete proportion in the concrete mixing, the trial mixes played an important role during the concrete mixing procedure. For this research, concrete Grade 30 was used for the performance of concrete. Thus, the concrete proportion is developed in order to get the desired concrete grade. So, the concrete proportion should be measured correctly to ensure that the performance of concrete can be achieved. In this research, concrete Grade 30 are used with 2 proportions with partial replacement of crushed concrete waste which are 10% and 20% to determine the strength of the concrete. To determine the workability of concrete specimens, the water cement ratio is remained unchanged. Hence, the quantities of raw materials needed for the concrete proportion of Grade 30 in 1 m3 of concrete are shown in Table 4.7.

Table 4. 7 : Raw Materials for 1m3 Concrete Grade 40

Materials	Weight
Cement	320 kg/m^3
Sand	640 kg/m^3
Aggregate	1280 kg/m^3
Water	128 kg/m^3

4.4 Experimental Tests

4.4.1 Slump Test

Slump tests are important part of concrete casting especially in construction industry. Slump test is done to determine the workability of concrete before proceeding to the casting process. For example, each of concrete tracks is carried out the slump test to measure the workability of the concrete before concrete pouring. For this study, slump test is chosen to be the workability test for the concrete specimens produced. Slump test was carried out for every batch of concrete produced in this research. Slump test was carried out according to (BS EN 12350: Part 2 (2009)). All the mixes have achieved the target slump height within the range of 75±25mm.

The slump test result for concrete with partially replacement of Tyre powder rubber as fine aggregate. The result obtained shows that different proportion of slump test is in true slump categories. Based on the results, it can be concluded that the slump produced are in the range of 75 mm to 64 mm. From the graph, it shows that (0%) replacement is the highest slump which is 75 mm and the lowest slump is (10%) with 64 mm. However, the result obtained is still in true slump and medium categories of slump test. According to British Standard 1881, from range 60 mm to 80 mm are considered in medium workability of concrete class. Control mix achieved the highest slump as shown in Table 4.8 and Figure 4.3

Table 4. 8: Slump Test Result of Each Batch of Concrete Specimen

Concrete Batch	**Water Ratio**	**Slump (mm)**
B1 (0%)	0.52	75
B2 (TR-5%)	0.52	68
B3 (TR-10%B)	0.52	64

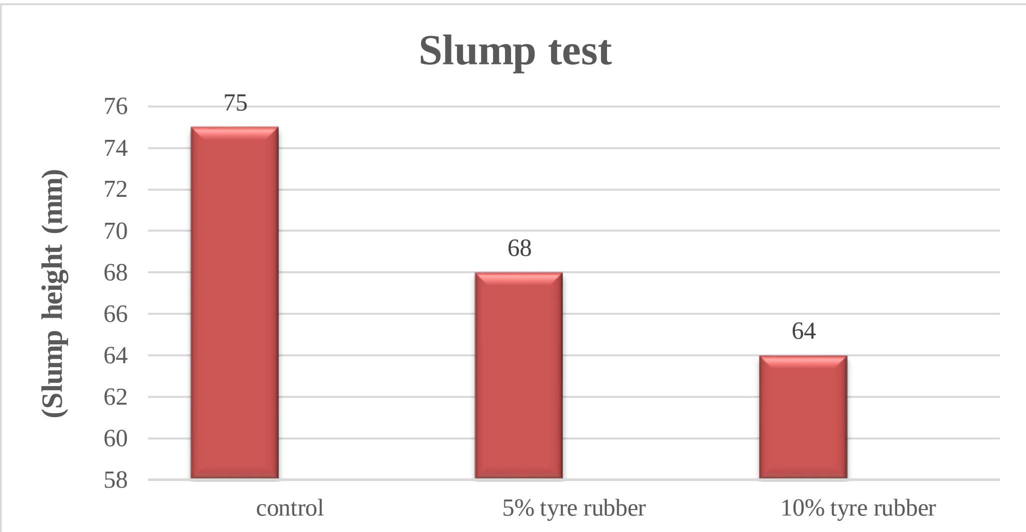

Figure 4. 3 : Slump Test Result of Each Batch of Concrete Specimens

4.4.2 Ultra-Pulse Velocity Test

The UPV test was conducted on all the cubes before its compressive test was done. Quality of concrete in terms of strength, homogeneity, trapped air, internal flaws, cracks, segregation, honeycombing, compaction, workmanship, and durability can be concluded from this test. The transit time for all the cubes that was tested showed an average reading, resulting in conclusion of the cubes being good conditioned cubes. The L measured for every cube is 150mm, which is 0.00015km.

The results of transit time and its respective calculations for cubes tested on the 7 and 28th days. Results has an average of transit time at 3.5-4.5 km/s which is according to concrete quality classification considered as a good concrete the overall quality of rubberized concrete considered as good according to classification of concrete quality. Control specimens achieved the highest ultra-pulse velocity (4.17 Km/s) after 28 days of curing. Rubberized concrete with 5% of tyre powder replacement has achieved (3.52Km/s). Tre powder rubber increase acted like voids resulting a concrete with less integrity which decreased the ultra-pulse velocity of concrete. Soft rubber particles may behave as voids in the concrete matrix, due to the lack of adhesion between the rubber particles and the cement paste wchich leads to produce concrete with less quality. Table 4.9, Table 4.10 and Figure 4.4 below show results of ultra-pulse velocity after 7days and 28days of curing

Table 4. 9: Ultra-Pulse Velocity Results for 7 days Specimens

G40	mass (g)			Pulse Velocity (km/s)			Average (km/s)
Specimen	1	2	3	1	2	3	
Control	7740	7820	7783	3.915	3.980	3.865	3.92
TR-5%	7353	7429	7394	3.64	3.79	3.7	3.71
TR-10%	6966	7038	7004	3.56	3.61	3.57	3.58

Table 4. 10: Ultra-Pulse Velocity Results for 28 days Specimens

G40	mass (g)			Pulse Velocity (km/s)			Average (km/s)
Specimen	1	2	3	1	2	3	
Control	7869	7969	7919	4.143	4.363	4.01	4.17
TR-5%	7476	7571	7524	3.77	3.93	3.82	3.84
TR-10%	7082	7172	7129	3.648	3.698	3.66	3.67

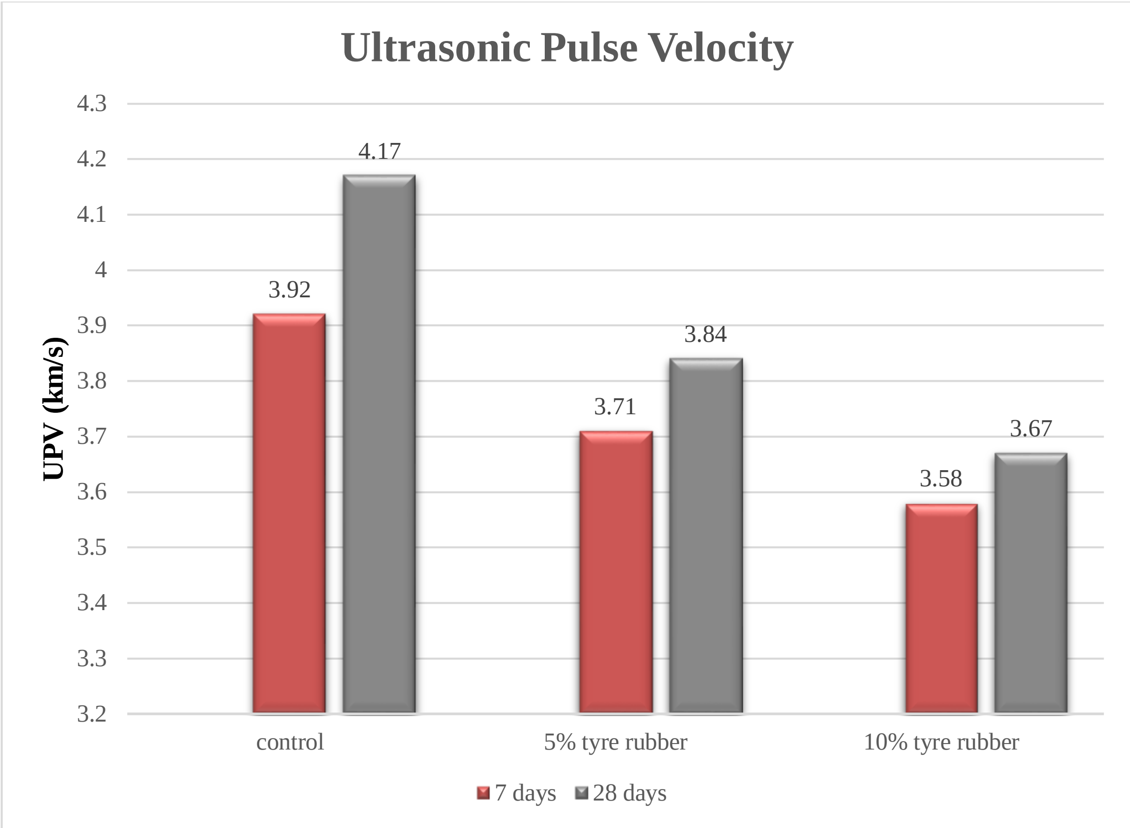

Figure 4. 4 : Ultra-Pulse velocity results of 7 and 28 days

4.4.3 Compressive Strength Test

Compressive strength test is one of the important properties of concrete. In this study, the test age of the concrete was 7- and 28-days concrete cubes were tested for the same concrete proportion to obtain the average data. Table 4.9 and 4.10 show the result of compressive strength test of concrete cubes with the respective strength days which are 7 and 28 days. For 7 days strength of concrete, the mix 1 (control) show the highest compressive strength achieved which is 35.825 N/ mm^2 followed by mix 2 (TR-5%) 23.76 N/ mm^2 and the lowest compressive strength by Mix 3 (TR-10%) 21.94 N/ mm^2. For the next Days, which is at 28 days, the compressive strength of the concrete cubes are increasing as it supposed to be. The highest strength achieved by mix 1 (TR-0%) which is (40.27 N/ mm^2) and also followed by 5% tyre powder rubber mix which is

(29.13 N/ mm^2). As well the both 7 and 28 days the lowest strength was Mix 3 (TR-5%) which is 21.94 N/ mm^2 and 26.15 N/ mm^2, respectively. Reduction in strength increase with increasing level of replacement of tyre powder rubber as shown in Table 4.11, Table 4.12 and Figure 4.5

Table 4. 11 : Compressive Strength Results for 7 Days Specimens

G40	mass (g)			Compressive Strength (N/mm^2)			Average (N/mm^2)
Specimen	1	2	3	1	2	3	
Control	7740	7820	7577.2	32.95	38.7	33.731	35.825
TR-5%	7353	7429	7198	23.78	25	22.5	23.76
TR-10%	6966	7038	6819	21.20	22.31	21.57	21.94

Table 4. 12: Compressive Strength Results for 28 Days Specimens

G40	mass (g)			Compressive Strength (N/mm^2)			Average (N/mm^2)
Specimen	1	2	3	1	2	3	
Control	7869	7969	7919	42.83	37.71	33.83	40.27
TR-5%	7476	7571	7523	28.41	29.78	29.2	29.13
TR-10%	7082	7172	7127	25.50	26.22	26.73	26.15

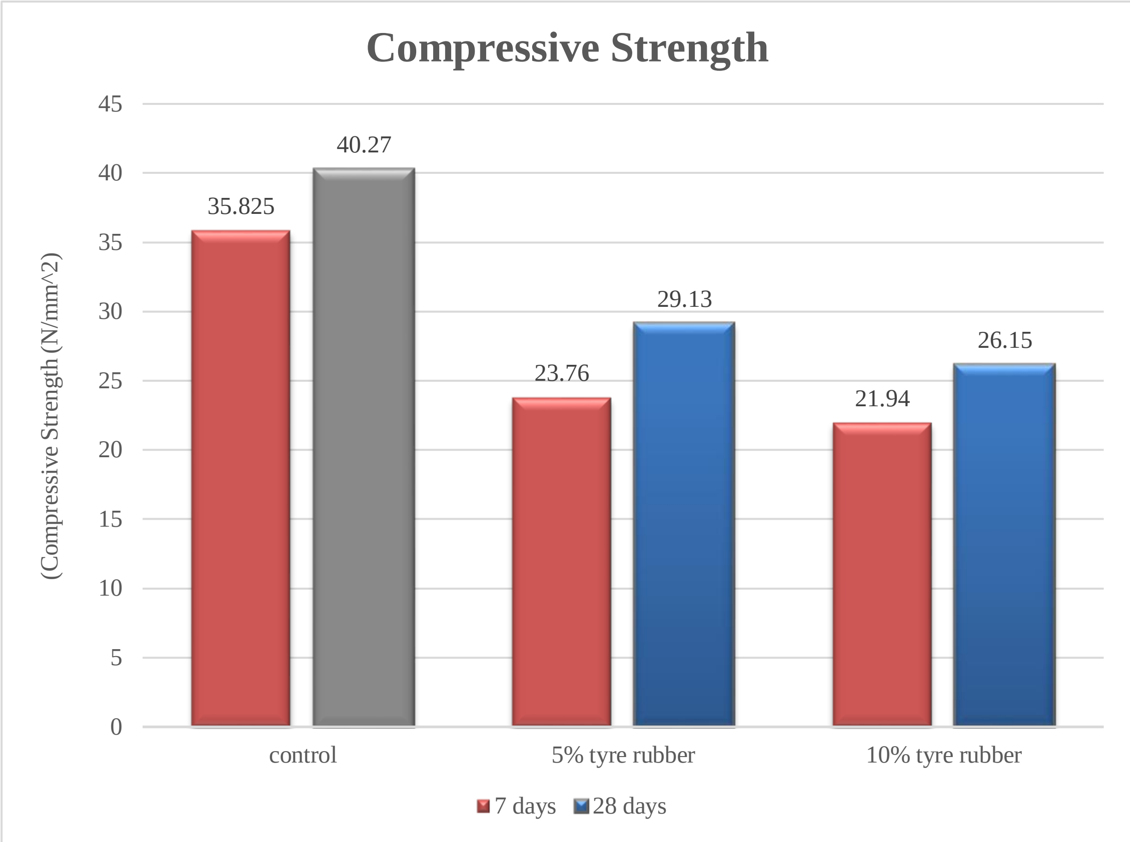

Figure 4. 5 : compressive Strength Test Result for 7- and 28-Days

4.4.4 Flexural Strength Test

The flexural strength analysis was also done by using the average of samples result. Figure 4.2 shows the flexural strength for 7 and 28 days. Based on the result obtained, the highest flexural strength for 7 days is achieved in mix 1 (control) which is 3.66 N/ mm^2 and the lowest strength is achieved by Mix 3 (TR-10%) 3.07 N/ mm^2. Meanwhile, the highest 28-day flexural strength was observed as 5.66 N/ mm^2, also followed by mix 2 (TR-5%) which is 5.056 N/ mm^2. The lowest strength for 28 days is by mix 3 (TR-10%) which is 4.21 N/ mm^2. It can be concluded that flexural strength of rubberized concrete decreases with increasing level of replacement of tyre powder rubber. The reduction of flexural strength may attribute to lack of cohesion between tyre powder rubber and the other material of concrete mix in flexural strength of fly ash-bottom ash concrete compare with control. The flexural strength obtained are between 3.051 and 5.648 N/ mm^2 as shown in Table 4.13. Table 4.14 and Figure 4.6.

Table 4. 13 : Flexural Strength Results for 7 Days Specimens

G40	Mass (g)			Flexural (N/mm^2)	Strength		Average (N/$mm^{2)}$
Batch	1	2	3	1	2	3	
Control	1222	1195	1185	4.189	3.281	3.512	3.66
TR-5%	1161	1135	1126	3.53	3.44	3.26	3.41
TR-10%	1012	1076	1067	2.89	3.17	3.15	3.07

Table 4. 14: Flexural Strength Results for 28 Days Specimens

G40	Mass (g)			Flexural (N/mm^2)	Strength		Average (N/$mm^{2)}$
Batch	1	2	3	1	2	3	
Control	1185	1223	1204	5.650	5.679	5.615	5.648
TR-5%	9533	9402	9468	5.24	4.90	5.03	5.056
TR-10%	8991	8867	8929	4.36	4.15	4.12	4.21

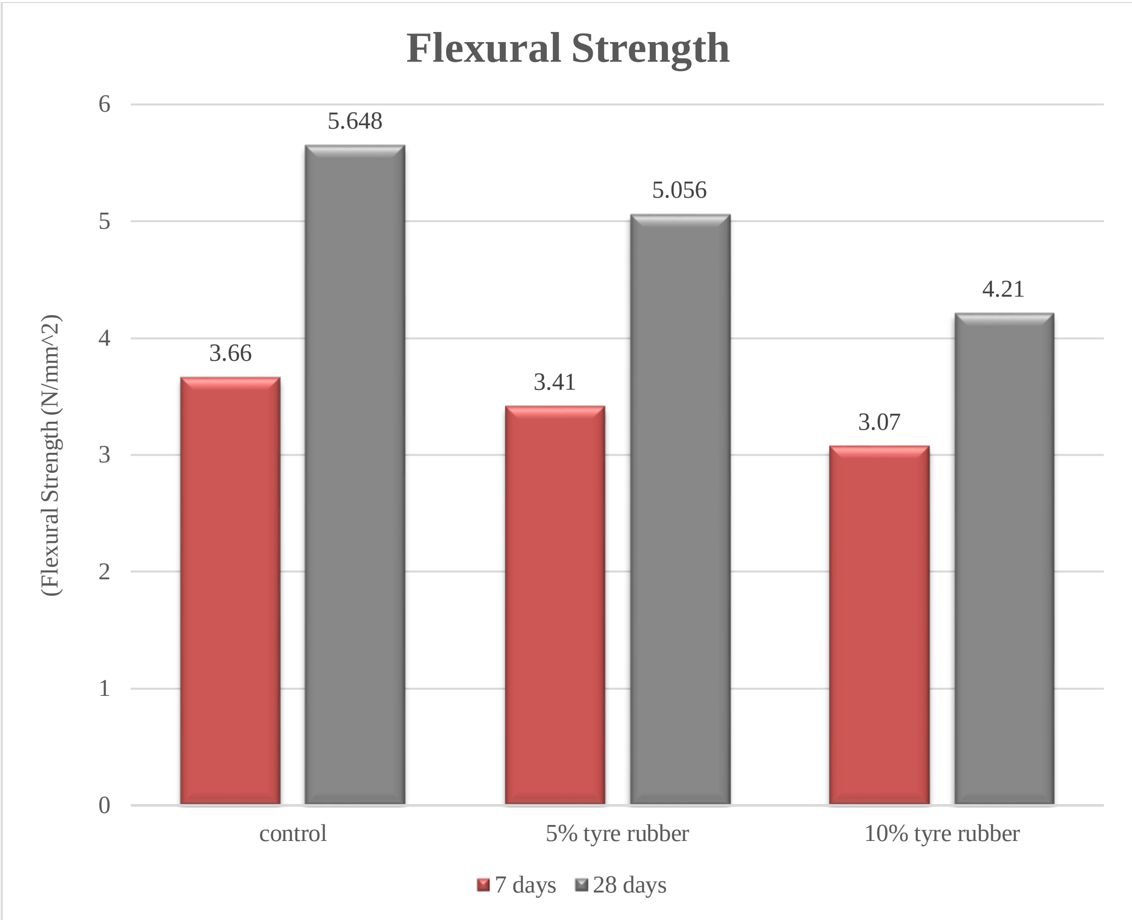

Figure 4. 6 Figure 4. 7 : Flexural Strength of 7- and 28-Days Specimens

CHAPTER 5

CONCLUSION

5.1 Conclusion

The following are the several conclusions obtained from the experimental data:

- Ultra pulse velosity test showed that rubberized concrete classified as good and pulse velocity decreased as incresing perentage of tyre powder rubber.
- Compressive strength of rubberized concrete with 5% of tyre powder has achieved higher strength than concrete rubberized concrete with 10% tyre powder rubber.
- Flexural strength of rubberized concrete with 5% of tyre powder has achieved higher strength than concrete rubberized concrete with 10% tyre powder rubber.
- Reduction in compressive strength was higher than flexural strength.
- Reduction of compressive strength and flexural strength increase with increasing percentage of tyre powder rubber.
- Reduction in compressive strength was higher than flexural strength.
- The strength reduction may be attributed to two reasons:

1) The rubber particles are much softer than the surrounding mineral materials, and on loading, cracks are initiated quickly around the rubber particles in the mix, which accelerates the failure of the rubber-cement matrix.

2) because of low specific gravity of tyre powder rubber and lack of bonding of rubber with other concrete ingredients, there is a tendency for rubber to move upwards during vibration leading to higher rubber concentration at the top layer. Such a non-homogeneous concrete sample leads to reduced strengths.

3) Soft rubber particles may behave as voids in the concrete matrix, due to the lack of adhesion between the rubber particles and the cement paste.

5.2 Recommendations

These are recommendations for improvement and further study in the future as follows:

- Studying the effect of using tyre powder rubber as partially replacement for fine aggregate in durability properties of concrete.
- Investigate the effect of using tyre powder rubber as a filler in the mechanical and durability of conrete.
- Investigating the effect of using higher percentage of tyre powder as fine aggregate replacement in mechanical and drubility properties of concrete but percentage of sand replacement should not exceed 30%.

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