An-Najah National University
Faculty of Graduate Studies

Utilization of Waste Tires in the Production of Non-Structural Portland Cement Concrete

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This thesis was defended successfully on 28/5/2007, and approved by.

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DEDICATION

To the owners of the glowing hearts and burning vigor……………….

To those who sacrificed their money, souls and blood for their faith.....

To those who faced the devil of evil and the devil of craving………….

To my tender mother, honored father, dear my wife, my daughter, brothers and sisters.

To all of them,

I dedicate this work

ACKNOWLEDGMENT

Thank God for the blessing granted to us…………………….....................

I feel obliged to extend my sincere thanks to my instructors at An-Najah National University, who were helpful and brace. They were really that burning candles to illuminate our path.

And special thanks to Dr. Osama Abaza who saved no effort in supporting me to complete this work in spite of the difficult circumstances.

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Utilization of Waste Tires in the Production of Non-Structural Portland Cement Concrete

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Abstract

This thesis, generally, aims to explore the potential utilization of waste crumb tires in various Portland Cement Concrete categories for the production of non-structural Portland cement concrete to study the structural behavior of concrete, and to help partially solving environmental problem produced from disposing waste tires.

Raw materials of coarse and fine aggregate used in this thesis were tested, fine aggregate (sand) was replaced using volumetric method by waste crumb tires with 0, 25, 50, 75, and 100% replacements for the various PCC categories of B-150, 200, 250, 300, and B-450 kg/cm^2. Several tests were made on fresh and hardened concrete, like compressive strength, slump, water absorption, density, modulus of elasticity, noise and thermal insulation tests, and abrasion resistance,

Compressive strength, density, and modulus of elasticity decreased as the percent replacement by waste crumb tires increased; water absorption initially decreased and started to increase after an increasing in the percent of replacement, slump showed no significant change. Abrasion resistance, noise and thermal insulation increased as the percent replacement increased.

Finally it is recommended to use waste crumb tires for non-structural Portland cement concrete, such as floor rips, partitions, back stone concrete, concrete blocks, and other non-structural uses.

Key words: Portland cement concrete, waste crumb tire, physical properties, utilization, non-structural concrete.

CHAPTER ONE

INTRODUCTION

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1.1 Background

Modifications of construction materials have an important bearing on the building sector. Several attempts have been therefore made in the building material industry to put to use waste material products, e.g., worn-out tires, into useful and cost effective items. Success in this regard will contribute to the reduction of waste material dumping problems by utilizing the waste materials as raw material for other products.

The waste problem considered as one of the most crucial problems facing the world as a source of the environmental pollution. It is contributing as a direct form in pollution that includes the negative effects on the health by increasing the diseases, diseases vector, percentage of mortality and lowering the standard of living.

The waste usually defined as the all remains things resulted from production, transfer and uses processes, and in general all transmitted things and resources that the owner or the producer wants to dispose or must dispose to prevent the risk on the health of the human and save the environment in general.

During last recent years, many improvements in West Bank have occurred in all parts of life such as social, industrial, economical etc. Like all countries in the world, this will lead to generate new ways of living and increase the human requirements, and will also increase types and quantities of the waste in the West Bank, without any active processes to provide solution to this problem.

One of the important types of remains is waste tires which have been classified as a part of municipal solid waste (MSW), resulted from the increase of vehicle ownership and traffic volume within the Palestinian territories. This eventually will increase consumption of tires over time. Current practices show that residents throw it randomly in different places such as valleys, road sides, open areas, and waste dumpsites in improper ways taking the means of open fire, and without consideration of risk on human health and environment. Figures 1.1 and 1.2 show some of the forms of dumping and wrong practices for waste tires.

Figure 1.1: Used tires waste in an open area

Figure 1.2: Waste tire dump on fire

1.2 Problem Statement

In presenting the properties of tires, it can be seen that tire is a rubber article with a complex structure, in which rubber represents approximately (85%) of the weight of car or truck tires (DiChristina 1994).

The average tire life is 50,000 km, after which it must be replaced (DiChristina 1994). In the assessment of the size of this environmental problem, the weights of scrap tires generating in the West Bank is given in Table 1.1 and Figs.1.3, and 1.4 (Israeli Central Bureau of Statistics, 2005).

Table (1.1): Weights of scrap tires for different classes of vehicles in the West Bank

Type of Vehicles	Weight of tires (Ton/Year)
Private car	2500
Light truck up to 10 ton	2000
Heavy trucks and buses	2300
Agriculture and heavy equipment	700
Other vehicles	500
Total	**8000**

Source: Israeli Central Bureau of statistics, 2005

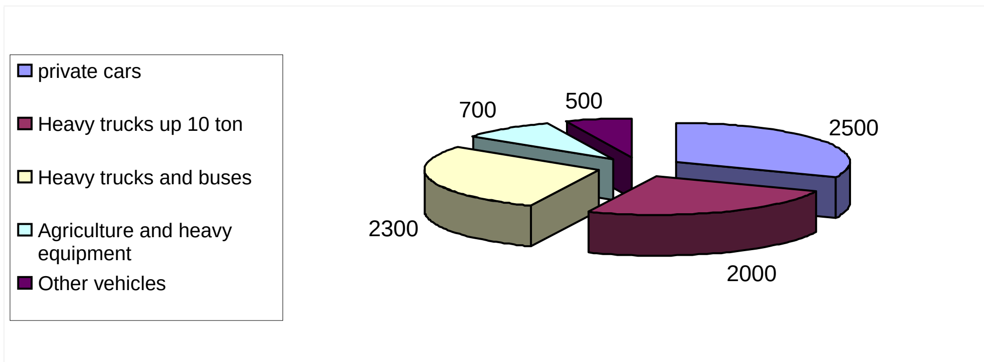

Figure 1.3: Weights chart of scrap tires

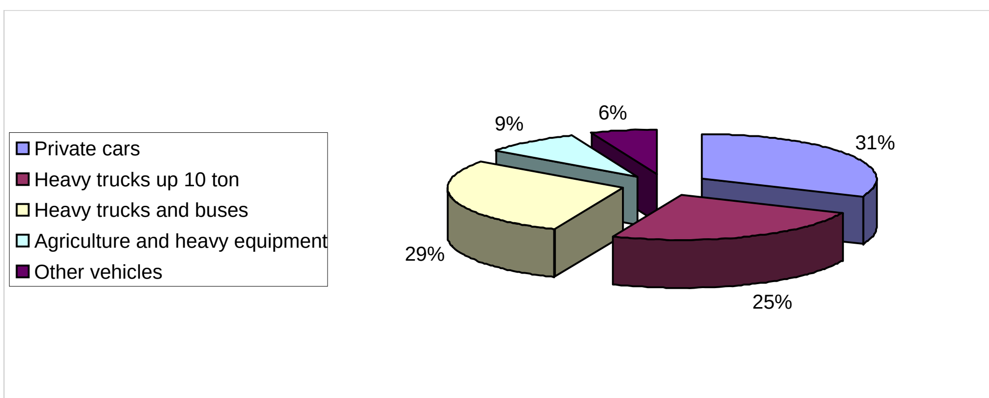

Figure 1.4: Weight fraction chart of total weight of scrap tires

Waste rubber tires cause serious environmental problems all over the world. One of the potential means of utilizing the waste tires is to process this waste material for the protection of the environment and society. It is suggested to use this waste tires as an additive in Portland cement concrete (PCC) mixes for non-structural applications, which would partially help in solving this problem.

1.3 Goals and Objectives

This research aims to help in assisting partially the environmental issue resulted from disposing waste vehicle tires. The objective of this research is to investigate the utilization of rubber tires in the form of shredded tires (crumbs) in PCC for non-structural concrete through investigating its impact on the physical characteristics of PCC as compressive strength, workability, water absorption (porosity), noise insulation, thermal insulation, and abrasion.

Detailed review of different studies and researches about utilizing waste tires in several applications is presented in Chapter Two. This chapter includes background about waste tire as an environmental problem, civil engineering application of recycled rubber from scrap tires, properties of concrete containing scrap tires, tires manufacturing, typical chemical composition and crumb manufacturing.

Chapter Three presents the methodology of utilizing rubber waste tires by using this waste as a constituent of the PCC mixes by partial or full replacement of fine aggregate (sand), and the experimental tests used in this thesis to identify the materials and the tests on the concrete mixes.

Experimental tests results are presented in Chapter Four. Chapter Five illustrated the analysis of the results. Chapter Six concludes the work done in this thesis, it emphasizes on the importance of studying the utilization of waste tires in the production of these kinds of concrete mixes, and the recommendations of the future working is also presented in this chapter.

CHAPTER TWO

LIBRARY SEARCH

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2.1 Background

Solid waste management is one of the major environmental concerns in the world. Each year thousands of tires are added to stockpiles, landfills, and illegal dumps across the West Bank and Gaza Strip, which causes extensive environmental and hazardous problems.

Waste tires stockpiles are dangerous not only due to potential environmental threat, but also from fire hazards and creating a breeding grounds for rats, mice, vermin's and mosquitoes (Naik and Singh 1991, Singh 1993). Over the years, disposal of tires has become one of the serious problems for the environment. Land-filling is becoming unacceptable for waste tires because of the rapid depletion of available sites for waste disposal.

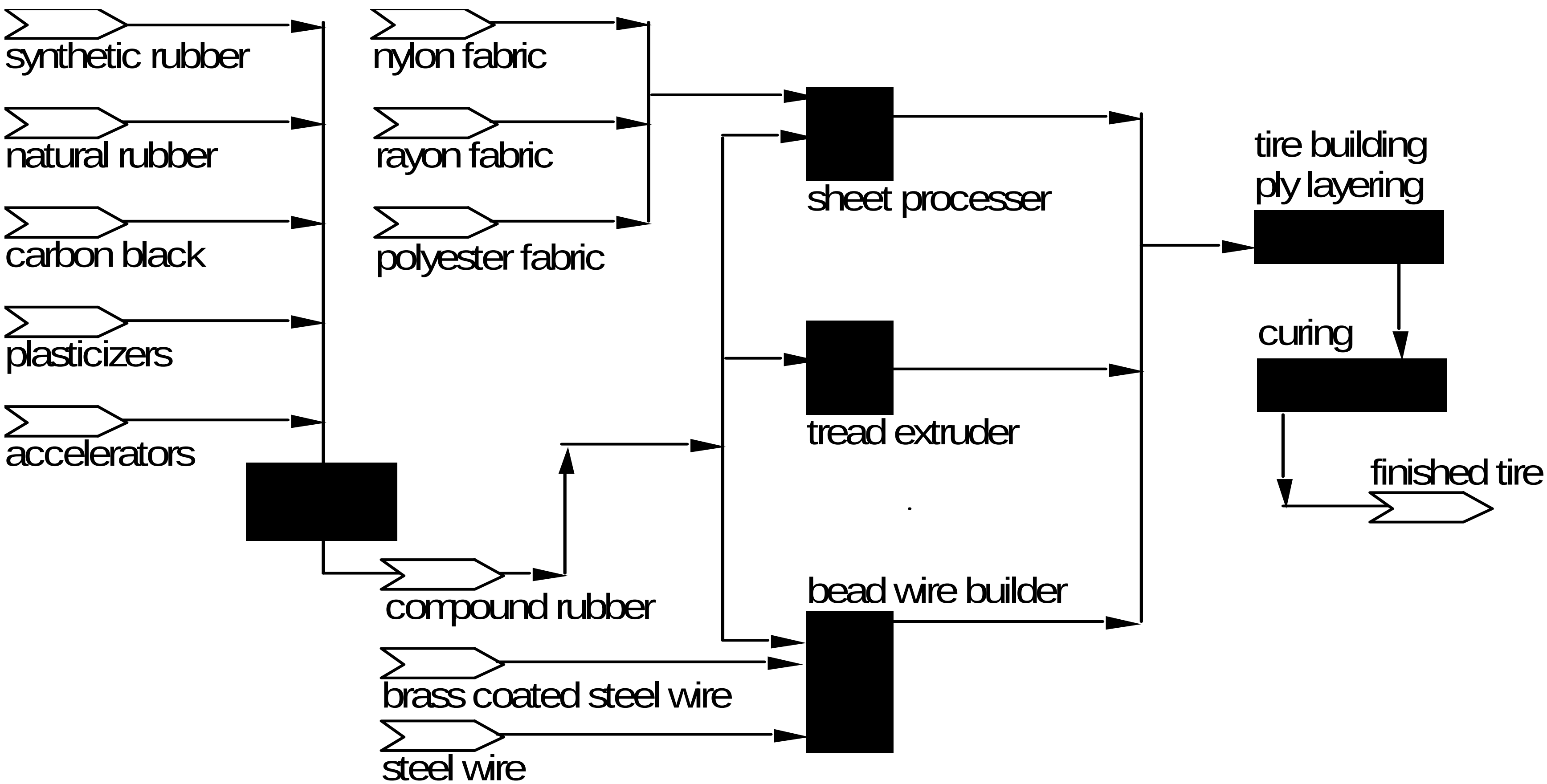
In France, which produces over 10 million scrap-tires per year will have a dwindling supply of landfills starting from July 2002; due to a new law that forbids any new landfill in the country. Used tires are required to be shredded before land-filling. Innovative solutions to meet the challenge of tire disposal problem have long been in development.

2.2 Tire Manufacturing

The tire manufacturing process includes the manufacture of rubber and placing additives in the rubber. It also includes the coating of fabrics for the radial belts and bias plies and integrating them into the rubber. Rayon, nylon, and now more commonly polyester in addition to building wire bead stock, make up the structural components of tires. The fabric with rubber, the bead stock with rubber, and the rubber tread is combined on a drum by layering (the tread is put on last). There can be as many as 40 layers of fabric and steel bead wire on a truck tire. Once the layers are put on, the tire stock is put into a mold over an inflatable steam heated tube. The tube is inflated and the mold is closed. The tire is heated and cured and the excess rubber extrudes out of weep holes in the mold. Curing times and temperatures vary widely between manufacturers and tire compositions. Typical curing times are around 20 minutes with temperatures around 160°F. The curing is the vulcanization takes place (CIWMB 1994). Figure 2.1 shows a flow chart of the process of manufacturing and Table 2.1 gives the typical materials used in manufacturing tires.

2.2.1 Manufacture of Crumb Rubber

Crumb rubber is made by a combination or application of several size reduction technologies. These technologies may be divided into two major processing categories, mechanical grinding and cryogenic reduction.



Source: (CIWMB 1994)
Figure 2.1: Flow Chart Summarizing Tire Manufacturing Process

Table 2.1 Typical materials used in manufacturing tire

1. Synthetic rubber
2. Natural rubber
3. Sulfur and sulfur compounds
4. Phenolic resin
5. Oil
(i) Aromatic
(ii) Naphthenic
(iii) Paraffinic
6. Fabric
(i) Polyester
(ii) Nylon
7. Petroleum waxes
8. Pigments
(i) Zinc oxide
(ii) Titanium dioxide
9. Carbon black
10. Fatty acids
11. Inert materials
12. Steel wires

Source: (Siddique et al 2004)

2.2.1.1 Mechanical Grinding

Mechanical grinding is the most commonly used process. The method consists of mechanically breaking down the rubber into small particles using a variety of grinding techniques, such as cracker mills, granulators, etc. The steel components are removed by a magnetic separator (sieve shakers and conventional separators, such as centrifugal, air classification, density etc. are also used). The fiber components are separated by air classifiers or other separation equipment. These systems are well established and can produce crumb rubber (varying particle size, grades, quality etc.) at relatively low cost. The system is easy to maintain and requires few people to operate and service. Replacement parts are generally easy to obtain and install. The other important advantage of mechanical grinding relates to the shape and physical properties of the crumb rubber particles. The shape and surface texture of the crumb rubber particles are relatively rounded and smooth, and are able to form molecular cross-links with virgin rubber material. The rubber particles are broken down under high shear stress. Since the tire compound consists of a carbon-sulfur cross-linked matrix, the grinding process causes 'de-linking' of the material. The resulting 'de-linked' material is more viscous compared to virgin rubber and is a unique characteristic of mechanically ground crumb rubber. For applications involving compounding with virgin rubber or plastic, crumb rubber provides some advantageous attributes to the viscoelastic compound. The crumb rubber particles do not cause a deterioration of tensile strength at low to moderate loading (Blumenthal 1998).

The main disadvantage is related to cost. Figure 2.2 shows a typical waste tire machine.

Figure 2.2: Typical Shredding Waste Tire Machine

2.2.1.2 Cryogenics

The cryogenic process consists of freezing the shredded rubber at an extremely low temperature (far below the glass transition temperature of the compound). The frozen rubber compound is then easily shattered into small particles. The fiber and steel are removed in the same fashion as in mechanical grinding. The advantages of the system are cleaner and faster operation resulting in the production of fine mesh size. The most significant disadvantage is the slightly higher cost due to the added cost of cooling (liquid nitrogen, etc.) (Blumenthal 1998).

2.3 Civil Engineering Applications of Recycled Rubber from Scrap Tires

Scrap tire chips and their granular counterpart, crumb rubber, have been successfully used in a number of civil engineering applications. Tire chips consist of tire pieces that are roughly shredded into 2.5 to 30 cm lengths. They often contain fabric and steel belts that are exposed at the cut edge of the tire chip. Tire chips have been researched extensively as lightweight fill for embankments and retaining walls (Tweedie et al. 1998, Bosscher et al. 1997, Masad et al. 1996, Upton and Machan 1993, Humphrey and Manion 1992), but have also been used as drainage layers for roads and in septic tank leach fields (Humphrey 1999). According to Humphrey (1999), some of the advantageous properties of tire chips in civil engineering applications include low material density, high bulk permeability, high thermal insulation, high durability, and high bulk compressibility. In many cases, scrap tire chips may also represent the least expensive alternative to other fill materials.

Crumb rubber is a finely ground tire rubber from which the fabric and steel belts have been removed. It has a granular texture and ranges in size from very fine powder to sand-sized particles. Crumb rubber has been successfully used as an alternative aggregate source in both asphalt concrete and PCC.

This waste material has been used in several engineering structures like highway Base-courses, embankments, etc. No local experience have been recorded any utilization or management of this waste material, on the contrary, several cases of fatal and hazardous conditions occur on daily bases as a result of ignorance and bad handling of this waste material. It is important to note that the generation of this material on daily basis locally and world wide is beyond tolerated level, which makes it an urgent and a standing issue to deal with.

2.3.1 Subgrade Insulation for Roads

Excess water is released when subgrade soils thaw in the spring. Placing a 15 to 30 cm thick tire shred layer under the road cab prevents the subgrade soils from freezing in the first place. In addition, the high permeability of tire shreds allows water to drain from beneath the roads, preventing damage to road surfaces (ASTM D6270-98). Figure 2.3 shows a typical layout of shredded tires for highway construction. (Tires manufacture's Association, 2003).

2.3.2 Subgrade Fill and Embankments

Tire shreds can be used to construct embankments on weak, compressible foundation soils. Tire shreds are viable in this application due to their light weight. For most projects, using tire shreds as a lightweight fill material is significantly a cheaper alternative. (Tires manufacture's Association, 2003).

Figure 2.3: Shredded scrap tires used as road base

2.3.3 Backfill for Walls and Bridge Abutments

Tire shreds can be useful as backfill for walls and bridge abutments. The weight of the tire shreds reduces horizontal pressures and allows for construction of thinner, less expensive walls. Tire shreds can also reduce problems with water and frost build-up behind walls because tire shreds are free draining and provide good thermal insulation. Recent research has demonstrated the benefits of using tire shreds in backfill for walls and bridge abutments. (Tires manufacture's Association, 2003).

2.3.4 Landfills

Landfill construction and operation is a growing market application for tire shreds. Scrap tire shreds can replace other construction materials that would have to be purchased. Scrap tires may be used as a lightweight backfill in gas venting systems, in leachate collection systems, and in operational liners. They may also be used in landfill capping and closures, and as a material for daily cover. (Tires manufacture's Association, 2003).

2.3.5 Other Uses

Fattuhi and Clark (1996) have suggested that rubcrete could possibly be used in the following areas:

1. Where vibration damping is needed, such as in foundation pad for rotating machinery and in railway stations,

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

3. For resistance to impact or blast is required such as in railway buffers, jersey barriers (a protective concrete barrier used as a highway divider and a means of preventing access to a prohibited area) and bunkers. Rubcrete, because of its light unit weight (density ranges from 900 to 1600 kg/m3) may also be suitable for architectural applications such as: (1) Nailing concrete, (2) False facades, (3) Stone backing and (4) Interior construction.

Topcu and Avcular (1997) have suggested that rubber-concrete may be used in highway construction as: (1) Shock absorber in sound barriers, (2) Sound boaster (which controls the sound effectively), and (3) in buildings as an earthquake shock-wave absorber. However, research is needed before definite recommendations can be made.

Al-Akhras and Smadi (2002) studied the properties of tire-rubber ash (TRA) mortar. Tire rubber chips were obtained and burned at a controlled temperature of 850 Cº for 72 hours. The residue of tire-rubber chips (ash) was collected. TRA was utilized as partial replacement of sand in five percentages ranging from 0% to 10% with an increment of 2.5% by weight of sand. Based on the test results, they concluded that: as the TRA content increased, the workability of the fresh mortar decreased. This behavior is due to the increase in the cementitiouse materials in the mortar mix, due particularly to the large surface area of the added TRA. In addition both initial and final setting time increased with the increase in TRA content. The initial setting time increased from 145 min for the control paste mix to 220 min for 10% TRA paste mix. The final setting time increased from 270 min for control paste mix to 390 min for 10% TRA paste mix. Further more the TRA specimens showed higher compressive strengths at various curing periods up to 90 days compared with those of the control specimens. Also, the tensile and flexural strengths of the TRA mortar specimens were higher than those of the control specimens.

Pierce and Blackwell (2003) in their paper highlighted the use of crumb rubber in flowable fill. In their investigation, they replaced sand with crumb rubber to produce flowable fill. Experimental results indicated that crumb rubber can be successfully used to produce a lightweight (1.2–1.6 g/cm^3) flowable fill with excavatable 28-day compressive strengths ranging from 0.02 to 0.09 MPa. Based on their investigation, they concluded that a crumb rubber-based flowable fill can be used in a substantial number of construction applications, such as bridge abutment fills, trench fills and foundation fills.

The following are also some examples on using scrap tires:

- Playground surface material.
- Gravel substitute.
- Drainage around building foundations and building foundation insulation.
- Erosion control/rainwater runoff barriers (whole tires).
- Wetlands/marsh establishment (whole tires).
- Crash barriers around race tracks (whole tires).
- Boat bumpers at marinas (whole tires).
- Artificial reefs (whole tires).

2.4 Studies and Research

The use of rubber waste shredded tires was studied in the past by many researchers.

Chunk rubber from recycled tires was used as a road construction material; the feasibility of using large rubber chunks from shredded tires as aggregates in cold-mixes for road construction was investigated (Hossain 1995). The research was directed toward development of a chunk rubber asphalt concrete mix design for low volume road construction using local aggregate, shredded tire rubber chunks and a cationic emulsion. A set of mixes using different combinations of chunk rubber content, emulsion content and fly ash content were tested. Based on the Marshall Stability results, some of these mixes appeared to be suitable as binder courses or stabilized drainable bases for low volume roads.

In asphalt rubber pavement for the purpose of producing asphalt rubber pavements, old tires are shredded to make crumbs of rubber about the size of coarse sand. This rubber is then mixed with asphalt and cement. The resulting mix is then blended with aggregates such as sand or crushed gravel using conventional methods to produce the mixture of paving material.

A research in construction of a test embankment using a sand–tire shred mixture as fill material was made (Sungmin et al. 2005). Use of tire shreds in construction projects, such as highway embankments, is becoming an accepted way of beneficially recycling scrap tires. Sungmin indicated that mixtures of tire shreds and sand are viable materials for embankment construction.

Another research work was made for the determination of the optimum conditions for tire rubber in asphalt concrete (Ahmet et al. 2004). Tire rubber waste recycling in self-compacting concrete, the rubber waste tire was used in this kind of concrete and the mechanical and micro structural behavior were investigated in the study.

A systematic experimental study was performed recently for improving strength and toughness of Rubber Modified Concrete (RMC) (Xi et al. 2003). Two types of rubber particles of different sizes (large and small) were used to study the size effect on mechanical properties of RMC. Result of tension test, fatigue test, and ultrasound velocity test showed that the RMC has higher energy dissipation capacities than regular concrete, that is, the RMC has high toughness and high ductility. As a result, there is an increase in the toughness and ductility. The failure modes of the RMC indicate that the RMC samples can withhold very large deformation and still keep their integrity.

Waste tire steel beads were also used in PCC. The experimental results indicate that although the compressive strength is reduced when steel beads are used, the toughness of the material greatly increases. Moreover, the workability of the mixtures fabricated was not significantly affected (Christos and Matthew 2006)

In the study of the development of waste tire modified concrete, two types of waste tire configurations were evaluated (Guoqiang et al. 2004). One was in the form of chips, or particles and the other was in the form of fibers. Conclusions showed that fibers performed better than chips do. Although thinner fibers perform better than thicker fibers do, the effect was not very significant. Steel belt wires in waste tires had a positive effect on increasing the strength of rubberized concrete. Truck tires performed better than car tires did.

Another research was done using Chopped Worn-Out Tires in production of light weight concrete masonry units (Al-Hadithi et al. 1999). This research, generally aimed at defining the possibility of using chopped worn-out tires to produce lightweight concrete building units.

Many experimental mixtures were made with different percentages of chopped worn-out tires after identifying the importance of produced characteristics of the mixtures.

For producing lightweight Chopped worn-out tires concrete mixes, many trials were adopted in selecting the required mixes.

The methodology of aggregate replacement was to substitute a certain volume of aggregate by the same volume of Chopped worn-out tires, but with different partial replacement ratios (PRR'S) for the sand and the gravel. For production and testing Chopped worn-out tires in Hollow-Concrete blocks units with a new suggested geometry, in addition to the conventional units, to enhance the structural properties of walls and the other properties which are provided by using Chopped worn-out tires, five short walls were built from fine-block using both Chopped worn-out tires (concrete and mortar) mixes with their corresponding plain mixes (without Chopped worn-out tires). Also two short walls were built from traditional Hollow-Concrete block with two holes using plain mixes (without chopped worn-out tires).

These walls were tested to study the structural behavior of such walls. All the mixes used Ordinary Portland Cement. The sand was a washed and dried natural river sand with a size range of (0.15-4.75mm), with bulk specific gravity 2.6. The gravel was washed and dried natural gravel with a size range of 1.18 to 9.5 mm, with specific gravity of 2.7.

The Chopped worn-out tires used in this work had a maximum size of 6.35mm and a specific gravity of 0.95. The dry constituents were initially mixed for 1.0 minute with Chopped worn-out tires mixes, the Chopped worn-out tires were then incorporated into the dry mix through a dispenser, and the mixing continued for another 1.0 minute to allow uniform distribution of the Chopped worn-out tires in the mixture. After adding the water, the constituents were then mixed for a further 2.0 minutes to produce a homogeneous mixture. Different specimens were prepared and a number of tests were made, the tests included compressive strength, axially load capacity of walls and prisms, measurement of longitudinal and traverse strains were made on both faces of walls using mechanical extensometers with high sensitivity.

The main conclusions from this investigations were incorporating Chopped worn-out tires into the mortar and concrete mixes as a partial replacement of aggregate reduced its unit weight, compressive strength and flexural strength and increased its thermal insulation significantly, the Chopped worn-out tires concrete masonry wall had numerous benefits especially in the reduction of the dead loads, improving the thermal insulation and provided a satisfactory structural function, the absorption of the Chopped worn-out tires concrete units was within the range of ACI 531-83 requirements for the corresponding lightweight masonry unit, the performance of fin-blocks was superior as compared with that of conventional blocks, and cracks occurred simultaneously in masonry units and mortar, these cracks which developed in a masonry wall before failure were visible to the naked eye.

2.5 Fresh Concrete Properties Containing Scrap-rubber Tires

2.5.1 Slump

Raghvan et al. (1998) reported that mortars incorporating rubber shreds achieved workability (defined as the ease with which mortar/concrete can be mixed, transported and placed) comparable to or better than a control mortar without rubber particles.

Khatib and Bayomy (1999) investigated the workability of rubber concrete and reported that there was a decrease in slump with increase in rubber content as a percentage of total aggregate volume. They further noted that at rubber contents of 40%, slump was almost zero and concrete was not workable manually. It was also observed that mixtures made with fine crumb rubber were more workable than those with coarse tire chips or a combination of tire chips and crumb rubber.

2.5.2 Air Content

Fedro et al. (1996) have reported higher air content in rubber concrete mixtures than control mixtures even without the use of air-entraining admixture (AEA). Similar observations were also made by Khatib and Bayomy (1999). This may be due to the non-polar nature of rubber particles and their tendency to entrap air in their out surfaces. Also when rubber was added to a concrete mixture, it might attract air as it had the tendency to repel water, and then air might adhere to the rubber particles. Therefore, increasing the rubber content results in higher air contents in rubber concrete mixtures, there by, decreasing the unit weight of the mixtures.

2.5.3 Unit Weight

Because of low specific gravity of rubber particles, unit weight of mixtures containing rubber decreases with the increase in the percentage of rubber content. Moreover, increase in rubber content increased the air content, which in turn reduced the unit weight of the mixtures. The decrease in unit weight of rubber concrete was negligible when rubber content is lower than 10–20% of the total aggregate volume (Khatib and Bayomy 1999).

2.5.4 Hardened Properties

Several authors (Ali et al. 1993, Rostami et al. 1993, Eldin and Senouci 1993, Topcu 1995) reported the compressive strength results of rubberized concrete. Results of various studies indicated that the size, proportions and surface texture of rubber particles noticeably affected compressive strength of rubber concrete mixtures. Eldin and Senouci (1993) reported that concrete mixtures with tire chips and crumb rubber aggregates exhibited lower compressive and splitting tensile strengths than regular PCC. There was approximately 85% reduction in compressive strength and 50% reduction in splitting tensile strength when coarse aggregate was fully replaced by coarse crumb rubber chips. However, a reduction of about 65% in compressive strength and up to 50% in splitting tensile strength was observed when fine aggregate was fully replaced by fine crumb rubber. Both of these mixtures demonstrated a ductile failure and had the ability to absorb a large amount of energy under compressive and tensile loads Khatib and Bayomy (1999).

Topcu (1995) also showed that the addition of coarse rubber-chips in concrete lowered the compressive strength more than the addition of fine crumb rubber. However, results reported by Ali et al (1993) and Fattuhi and Clark (1996) indicated the opposite trend. Studies have indicated that if the rubber particles have rougher surface or given a pretreatment, then better and improved bonding may develop with the surrounding matrix, and, therefore, that may result in higher compressive strength. Pretreatments may vary from washing rubber particles with water to acid etching, plasma pretreatment and various coupling agents (Naik and Singh 1991).

In acid pretreatment, rubber particles are soaked in an alkaline solution (NaOH) for 5 minutes and then rinsed with water. This treatment enhances the strength of concrete containing rubber particles through a microscopic (a very small) increase in the surface texture of the rubber particles.

Eldin and Senouci (1993) soaked and thoroughly washed rubber aggregates with water to remove contaminants, while Rostami et al. (1993) used water, water and carbon tetrachloride solvent, and water and a latex admixture cleaner. Results showed that concrete containing water washed rubber particles achieved about 16% higher compressive strength than concrete containing untreated rubber aggregates, whereas this improvement in compressive strength was 57% when rubber aggregates treated with carbon tetrachloride were used.

Segre and Joekes (2000) worked on the use of tire rubber particles as addition to cement paste. In their work, the surface of powdered tire rubber (particles of maximum size 35 mesh, 500 μm) was modified to increase its adhesion to cement paste. Low-cost procedures and reagents were used in the surface treatment to minimize the final cost of the modified material. Among the surface treatments tested to enhance the hydrophilicity of the rubber surface, a sodium hydroxide (NaOH) solution gave the best result. The particles were surface-treated with NaOH saturated aqueous solutions for 20 minutes before using them in concrete. Then, scanning electron microscopy (SEM) and measurements of water absorption, density, flexural strength, compressive strength, abrasion resistance, modulus of elasticity and fracture energy were performed using test specimens (W/C, water-to cementitiouse materials ratio as 0.36) containing 10% of powdered rubber or rubber treated with 10% NaOH. The test results showed that the NaOH treatment enhances the adhesion of tire rubber particles to cement paste, and mechanical properties such as flexural strength and fracture energy were improved with the use of tire rubber particles as addition instead of substitution for aggregate. The reduction in the compressive strength (33%) was observed, which is lower than that reported in the literature.

Lee et al. (1998) developed ‘‘tire-added latex concrete’’ to incorporate recycled tire rubber as a part of concrete. Crumb rubber from used tires was used in TALC (tire-added latex concrete) as a substitute for fine aggregates or styrene–butadiene rubber (SBR) latex while maintaining the same water cementitiouse materials ratio. TALC showed higher flexural and impact strengths than those of Portland cement, latex modified concrete and rubber added concrete. Pictures taken using the SEM seem to support that there was better bonding between crumb rubber and Portland cement paste due to latex. TALC showed potential as a viable construction material that is less brittle than other types of concrete.

Biel and Lee (1996) reported that the type of cement noticeably affects the compressive strength of rubcrete. They used two types of cement, magnesium oxychloride cement and Portland cement, in making rubcrete. The percentage of fine aggregate substitution varied from 0 to 90% by weight. It was observed that 90% loss in compressive strength occurred for both Portland cement rubber concrete (PCRC) and magnesium oxychloride cement rubber concrete (MOCRC) when aggregates (90% of fine aggregate and 25% of total aggregate) were replaced by untreated rubber. Magnesium oxychloride cement concrete exhibited approximately 2.5 times the compressive strength of PCC for both inclusions of rubber and without inclusion of rubber in the concrete. In terms of splitting tensile strength, PCC specimens made with 25% of rubber by total aggregate volume retained 20% of their splitting tensile strength after initial failure, whereas the magnesium oxychloride cement concrete specimens with the same rubber content retained 34% of their splitting tensile strength. They further noted that use of magnesium oxychloride cement may provide high strength and better bonding characteristics to rubber concrete, and rubber concrete made with magnesium oxychloride cement could possibly be used in structural applications if rubber content is limited to 17% of the total volume of the aggregate.

2.5.5 Shrinkage

A limited amount of literature is available concerning the plastic shrinkage of concrete containing rubber particles. Preliminary results reported by Raghvan et al. (1998) suggested that incorporation of rubber shreds (two different shapes of rubber particles as constituents of mortar: (1) granules, about 2 mm in diameter and (2) shreds having two sizes which were, nominally, 5.5 mm to 1.2 mm and 10.8 mm to 1.8 mm (length diameter) to mortar help in reducing plastic shrinkage cracking in comparison to control mortar. Raghvan et al. (1998) further reported that control specimens developed cracks having an average width of about 0.9 mm, while the average crack width for specimens with a mass fraction of 5% rubber shreds was about 0.4 to 0.6 mm. It was also reported that onset time of cracking was delayed by the addition of 5% rubber shreds. Mortar without rubber 566 R. Siddique, T.R. Naik/Waste Management 24 (2004) 563–569 shreds cracked within 30 minutes, while mortar with 15% fraction by mass cracked after 1 hour. It was further indicated that the higher the content of rubber shreds, the smaller the crack length and width, and the onset time of cracking was more delayed.

2.5.6 Toughness and Impact Resistance

Tantala et al. (1996) investigated the toughness (toughness is also known as energy absorption capacity and is generally defined as the area under load deflection curve of a flexural specimen) of a control concrete mixture and rubcrete mixtures with 5% and 10% buff rubber by volume of coarse aggregate. They reported that toughness of both rubcrete mixtures was higher than the control concrete mixture. However, the toughness of rubcrete mixture with 10% buff rubber (2 to 6 mm) was lower than that of rubcrete with 5% buff rubber because of the decrease in compressive strength. Tantala et al. (1996) Based on their investigations on use of rubber shreds (having two sizes which were, nominally, 5.5 mm to 1.2 mm and 10.8 mm to 1.8 mm) and granular (about 2 mm in diameter) rubber in mortar, Raghvan et al. (1998) reported that mortar specimens with rubber shreds were able to withstand additional load after peak load. The specimens were not separated into two pieces under the failure flexural load because of bridging of cracks by rubber shreds, but specimens made with granular rubber particles broke into two pieces at the failure load. This indicates that post-crack strength seemed to be enhanced when rubber shreds are used instead of granular rubber.

Khatib and Bayomy (1999) reported that as the rubber content is increased, rubcrete specimens tend to fail gradually and failure mode shape of the test specimen is either a conical or columnar (conical failure is gradual, whereas columnar is more of shreds having two sizes which were, nominally, 5.5 mm to 1.2 mm and 10.8 mm to 1.8 mm (length diameter) sudden failure). At a rubber content of 60%, by total aggregate volume, the specimens exhibited elastic deformations, which the specimens retained after unloading.

Eldin and Senouci (1993) demonstrated that the failure mode of specimens containing rubber particles was gradual as opposed to brittle. Biel and Lee (1996) reported that failure of concrete specimens with 30, 45, and 60% replacement of fine aggregate with rubber particles occurred as a gradual shear that resulted in a diagonal failure, whereas failure of plain (control) concrete specimens was explosive, leaving specimens in several pieces.

Goulias and Ali (1997) found that the dynamic modulus of elasticity and rigidity decreased with an increase in the rubber content, indicating a less stiff and less brittle material. They further reported that dampening capacity of concrete (a measure of the ability of the material to decrease the amplitude of free vibrations in its body) seemed to decrease with an increase in rubber content. However, Topcu and Avcular (1997) recommended the use of rubberized concrete in circumstances where vibration damping is required.

Similar observations were also made by Fattuhi and Clark (1996), and Topcu and Avcular (1997) reported that the impact resistance of concrete increased when rubber aggregates were incorporated into the concrete mixtures. The increase in resistance was derived from the enhanced ability of the material to absorb energy. Eldin and Senouci (1993), and Topcu (1995) also reported similar results.

Olivares et al. (2002) have reported that addition of crumb tire rubber volume fractions up to 5% in a cement matrix did not yield a significant variation of the concrete mechanical features, either maximum stress or elastic modulus.

2.5.7 Freezing and Thawing Resistance

Savas et al. (1996) carried out investigations to study the rapid freezing and thawing (ASTM C 666, Procedure A) durability of rubber concrete. Various mixtures were made by incorporating 10, 15, 20, and 30% ground rubber by weight of cement used for the control mixture. Based on their studies, they concluded that: (1) Rubcrete mixtures with 10% and 15% ground rubber (2 to 6 mm in size) exhibited durability factors higher than

60% after 300 freezing and thawing cycles, but mixtures with 20% and 30% ground rubber by weight of cement could not meet the ASTM standards (durability factor), (2) Air-entrainment did not provide improvements in freezing and thawing durability for concrete mixtures with 10, 20 and 30% ground tire rubber, and (3) Increase in scaling (scaling gives an evaluation of the surface exposed to freezing and thawing cycles as measured by the loss of weight) increased with the increase in freezing and thawing cycles.

Benazzouk and Queneudec (2002) studied the freeze–thaw durability of cement–rubber composites through the use of two types of rubber aggregates. The types of the aggregates were: compact rubber aggregate (CRA) and expanded rubber aggregates (ERA). Volume-ratio of the aggregates ranged from 9% to 40%. The results showed improvements in the durability of the composite containing 30% and 40% rubber by volume. Improvement in the durability of the composite containing ERA type aggregates is better than composite made with CRA aggregates. The finding is more distinct for ERA type.

Paine et al. (2002) investigated the use of crumb rubber as an alternative to air-entrainment for providing freeze–thaw resisting concrete. Three sizes of crumb rubber, 0.5 to 1.5, 2–8 and 5 to 25 mm were used. Test results showed that there is potential for using crumb rubber as a freeze–thaw resisting agent in concrete. The R. Siddique, T.R. Naik / Waste Management 24 (2004) 563–569 567 crumb rubber concrete performed significantly better under freeze–thaw conditions than plain concrete, and the performance of crumb rubber concrete in terms of scaling was similar to that of air-entrained concrete.

Studies presented in this chapter deals with the behavior of concrete and asphalt mixes after adding additives through replacement in different procedures, this leads to study more about the physical characteristics of concrete mixes in a different proportions and help in setting the methodology for this thesis as well as make a comparable analysis with the outcome of this thesis.

CHAPTER THREE

METHODOLOGY

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This thesis aims at utilizing rubber waste tires as a constituent in Portland cement concrete mixes and its products as a partial replacement of natural and artificial aggregate components.

3.2 Work Procedure

The following represents the methodology by which to study the effect of utilizing waste crumb tires in Portland cement concrete mixes were done.

3.2.1 Materials

The materials used in this thesis were obtained from Mawasi concrete plant in Nablus city (Nablus industrial area near Beit-Eiba village). The original source of crushed coarse aggregate are Abu Shusheh Crusher Corporation and Daymoona (Naqap desert area) for fine aggregate (sand), and grinded tires (crumb) was obtained from ALLOCK and SONS LTD (UK). Though, large amounts of waste tires exist in the West Bank area, no industries exist yet for the availability waste tires crumbs.

The basic ingredients of PCC and its products, which were used in this research work, are:

1- Normal Portland cement (Cement type 1).

2- Natural Coarse aggregate (sedimentary rock source).

3- Natural Fine aggregate (sand).

4- Water (fresh drinkable water).

5- Grinded tires (fine crumb tires).

3.2.2 Raw Material Tests

The raw materials used in this research work were tested for the purpose of identification of basic physical characteristics using the following tests:

- Sieve analysis. (ASTM C-136)
- Specific gravity and water absorption. (ASTM C-127)
- Abrasion (Lose Angles abrasion test). (ASTM C-88)
- Amount of fines and injurious particles (Sand equivalent) (ASTM D-2419).

Tests results of the raw materials used will be presented in the following chapter of this thesis.

3.2.3 Plain Portland Cement Concrete Mixes

Standard Portland cement concrete mixes without crumb rubber were made with different grades and different water cement ratios. These mixes were used as a reference standard comparison mixes. Such mixes reflect the local design mixes used by the ready mix plants.

Table 3.1 shows the proportions of the raw materials used for each grade for one cubic meter of Portland cement concrete. Table 3.2 shows the mix ingredients for a batch of 0.01 cubic meters.

Table (3.1): Concrete mix design by weight of mix ingredients (kg/m^3 of PCC)

Concrete Grade	B-150	B-200	B-250	B-300	B-450
Coarse aggregate (size1)	650	650	590	590	590
Coarse aggregate (size2)	220	220	220	220	220
Coarse aggregate size3)	425	425	440	440	440
Sand	500	520	580	580	590
Cement	200	220	260	290	470
Water	180-200	180-200	180-200	180-200	180-200

Source: Mawasi Palestine Company for Concrete (2006)

Table (3.2): Mix ingredients (kg/0.01m^3 of PCC)

Concrete Grade	B-150	B-200	B-250	B-300	B-450
Coarse aggregate	12.95	12.95	12.50	12.50	12.50
Fine aggregate (sand)	5.0	5.2	5.8	5.8	5.5
Cement	2.0	2.2	2.6	2.9	4.7
Water	1.9	1.95	1.9	1.8	2.0
W/C	0.95	0.89	0.73	0.62	0.43

3.2.4 Crumb Portland Cement Concrete Mixes

Portland cement concrete mixes utilizing crumb waste tires by volumetric replacement of sand with different proportions of replacements, basically 25, 50, 75, and 100% replacements were made. Tables 3.3 through 3.7 show the replacement of fine aggregate (sand) in different proportions by the crumb waste tires volumetric.

By dividing the weight of sand to be replaced by crumb waste tires by its specific gravity, the volume of sand was obtained; this volume is to be replaced by volume of crumb tire waste converted to weight using the following physical characteristics which was tested as a part of this thesis:

- Dry Rodded Weight of Sand = 1.431 g/cm3
- Dry Rodded Weight of crumbed tires waste = 0.640 g/cm3
- Specific Gravity of Sand = 2.644 g/cm3
- Specific Gravity of crumbed waste tires = 1.140 g/cm3

Table (3.3): Grade B-150 of PCC for batch mix

B-150		
0.0% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5000	1893.9	0.0
25% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
1250	473.5	0.540
50% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
2500	947.0	1.080
75% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
3750	1420.5	1.619
100% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5000	1893.9	2.159

Table (3.4): Grade B-200 of PCC for batch mix

B-200		
0.0% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5200	1969.7	0.0
25% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm3)	Equivalent Weight of shredded tires (Kg)
1300	492.4	0.561
50% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
2600	984.8	1.123
75% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
3900	1477.3	1.684
100% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5200	1969.7	2.245

Table (3.5): Grade B-250 of PCC for batch mix

B-250		
0.0% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5800	2197.0	0.0
25% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
1450	549.2	0.626
50% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
2900	1098.5	1.252
75% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
4350	1647.7	1.878
100% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5800	2197.0	2.505

Table (3.6): Grade B-300 of PCC for batch mix

B-300		
0.0% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5800	2197.0	0.0
25% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
1450	549.2	0.626
50% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
2900	1098.5	1.252
75% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
4350	1647.7	1.878
100% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5800	2197.0	2.505

Table (3.7): Grade B-450 of PCC for batch mix

B-450		
0.0% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5900	2234.8	0.0
25% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
1475	558.7	0.637
50% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
2950	1117.4	1.274
75% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
4425	1676.1	1.911
100% of sand by weight is to be replaced by shredded tires		
Weight of sand (gm)	Volume of sand (cm^3)	Equivalent Weight of shredded tires (Kg)
5900	2234.8	2.548

3.3 Tests on PCC

Slump test was made on fresh concrete to measure the effect of change in ingredients on workability according to the addition of crumb waste tires.

The following tests on hardened concrete were made using four specimens (cubes) from each proportion made:

- Compressive Strength (PS-55): It is worth to note that the Palestinian standard requires a 7 days curing while the ASTM standards require a curing conditions 28 days curing after casting the molds.

- Water Absorption (ASTM C-642).

- Abrasion (ASTM C-944).

- Modulus of Elasticity (ASTM C-469).

- Weight before replacement and weight after replacement.

3.4 Thermal and Sound Insulation testing

For sound and thermal insulation, a concrete wood mold having a dimension of 15x15x5cm was made, three specimens of each proportion were made as shown in Figure 3.1 with 0.0%, 25%, 50%, 75% and 100% crumbed waste tires with properties same as that of concrete cubes mixes.

Figure 3.1: Concrete mold (15x15x5cm Dimension)

A wooden box was made in a way that the heat will be directly move or transfer from one chamber having constant temperature exposed on one of the faces of the specimen for a period of time through the specimen to another chamber. The temperature was measured until the temperature became constant in the two faces of concrete specimen using a laser thermometer (High Temperature Infrared Thermometer, Type K/J/T/E/R). Figures 3.2, 3.3, and 3.4 show the mechanism of the testing.

Figure 3.2: Wooden box face with two opening one for source and the other for measuring (40x40x100cm Dimension)

Figure 3.3: Wooden box back (the other face) with one opening for measuring.

Figure 3.4: Specimen location (at the middle of the wooden box) with frame dimension 15x15x15 cm

The same procedure was made for testing the sound insulation using a constant noise source and a noise measuring device (Sound Level Meter Auto range, RS – 232).

CHAPTER FOUR

EXPERIMENTAL TESTS RESULTS

CHAPTER FOUR

EXPERIMENTAL TESTS RESULTS

4.1 Introduction

This chapter presents a summary of the results which were obtained from laboratory tests that have been done on the samples. Tests were done on materials (fine and coarse aggregates), fresh and hardened concrete.

4.2 Materials Testing Results

Table 4.1 summarizes the tests results of the properties of materials used in this thesis. Notice that these materials are used locally in West Bank by concrete plants, and Figure 4.1 gives the specification of aggregates used in the mixes.

Table (4.1): Materials tests results

RESULTS OF AGGREGATE TESTING												
1- Gradation (ASTM C-136)												
Sieve No.		**1"**	**3/4"**	**1/2"**	**3/8"**	**# 4**	**# 8**	**# 16**	**# 30**	**# 50**	**# 100**	**# 200**
Coarse aggregate	**Percent Passing**	100	75	59	54	26	11	3.9	3.3	2.8	2.5	2.4
Fine aggregate		-	-	100	100	99.0	97.0	92.2	64.6	26.3	6.1	3.9
Crumb tires		-	-	-	-	-	-	-	100	47.4	26.7	0.0

No.	**Type of test**	**Standard**	**Unit**	**Result**		
				Coarse aggregate	**Fine aggregate**	**Shredded tires**
2.	Bulk specific gravity	ASTM C-127	-	2.560	2.521	1.131
3.	Specific gravity (Saturated surface Dry – SSD)		-	2.621	2.640	1.140
4.	Specific gravity. (Apparent)		-	2.716	2.734	1.152
5.	Water absorption		%	1.02	0.5	-
6.	Los Angeles abrasion	ASTM C-88	%	30.1	-	-
7.	Sand equivalent	ASTM D-2419	-	-	66.0	-
8.	Clay lumps and friable particles	ASTM-C142	%	1.1	-	-

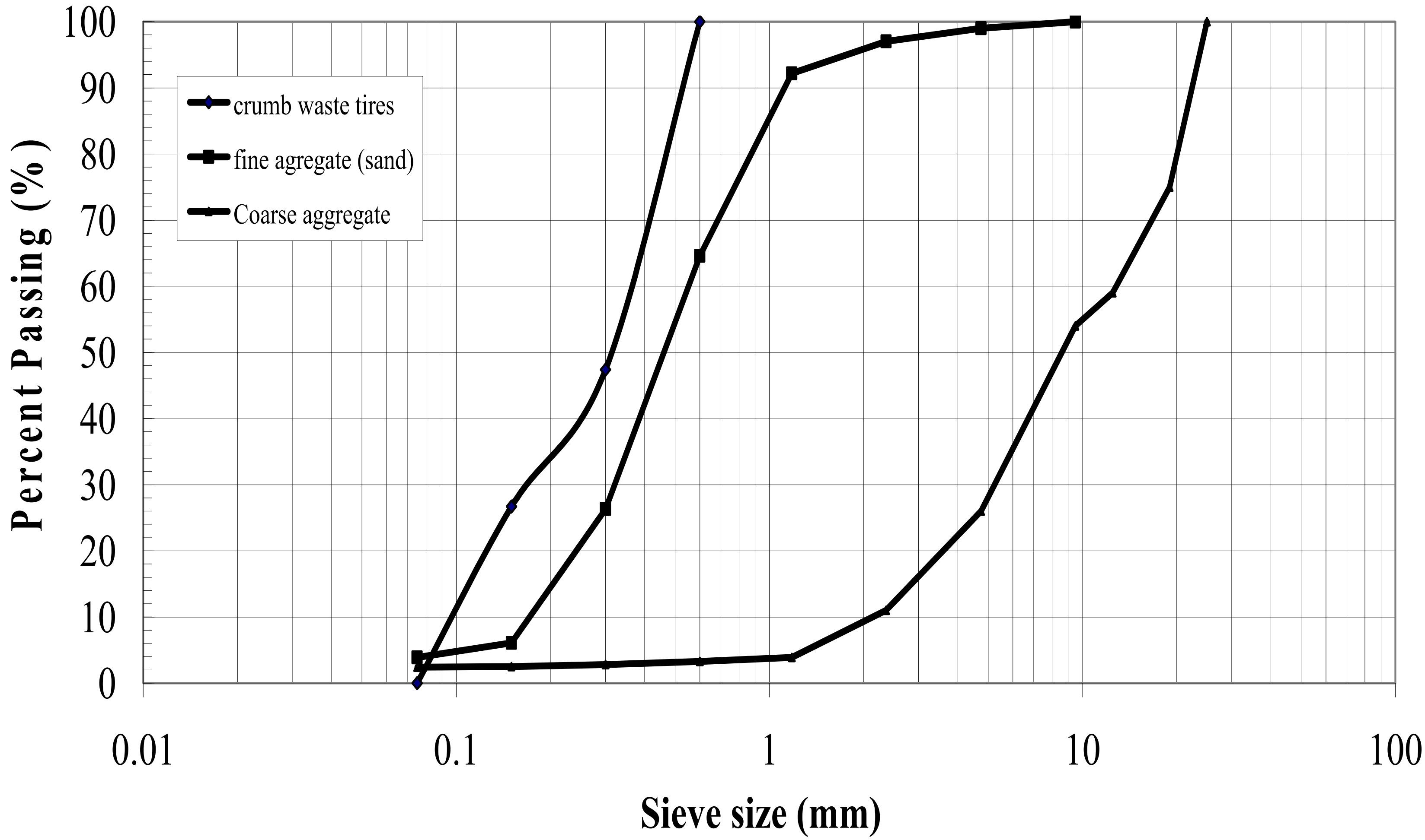


Figure 4.1: Particle size distribution

4.3 Concrete Compressive Strength and Slump Tests Results

Table 4.2 summarizes concrete compressive strength and slump tests results for different types of concrete with and without replacement of sand.

Table (4.2): Concrete compressive strength test results

Concrete Grade	Percent replacement (%)	Average compressive strength at 28 days (kg/cm^2)	Slump (mm)
B-150	0.0	159.1	23.0
	25	117.0	24.0
	50	92.4	23.0
	75	69.8	25.0
	100	53.6	24.0
B-200	0.0	178.2	26.0
	25	154.9	25.0
	50	111.4	27.0
	75	77.9	26.0
	100	60.9	28.0
B-250	0.0	290.1	25.0
	25	238.1	30.0
	50	152.5	28.0
	75	102.3	26.0
	100	74.4	27.0
B-300	0.0	313.5	29.0
	25	235.1	30.0
	50	156.0	28.0
	75	98.5	26.0
	100	67.1	29.0
B-450	0.0	472.6	25.0
	25	284.8	30.0
	50	227.7	29.0
	75	144.6	26.0
	100	92.6	25.0

4.4 Density Test Results

Table 4.3 summarizes densities for different categories of PCC with and without replacement.

Table (4.3): Density test results

Concrete Grade	Percent replacement (%)	Density (Kg/m3)
B-150	0.0	2336.0
	25	2196.0
	50	2153.0
	75	2065.0
	100	1961.0
B-200	0.0	2378.0
	25	2214.0
	50	2174.0
	75	2078.0
	100	2002.0
B-250	0.0	2406.0
	25	2258.0
	50	2148.0
	75	2089.0
	100	1949.0
B-300	0.0	2395.0
	25	2259.0
	50	2095.0
	75	2083.0
	100	1941.0
B-450	0.0	2430.0
	25	2190.0
	50	2155.0
	75	2028.0
	100	1949.0

4.5 Water Absorption Test Results

Table 4.4 summarizes concrete water absorption test results for different types of concrete with and without replacement of sand.

Table (4.4): Concrete water absorption test results

Concrete grade	Percent replacement by crumb tires	Saturated surface dry weight	Oven dry weight	Water absorption
-	(%)	(gm)	(gm)	(%)
B-150	0.0	2555.0	2414.4	**5.8**
	25.0	2304.0	2188.7	**5.3**
	50.0	2323.0	2193.5	**5.9**
	75.0	2192.0	2060.6	**6.4**
	100	2094.0	1955.8	**7.1**
B-200	0.0	2664.0	2519.4	**5.7**
	25.0	2420.0	2294.4	**5.5**
	50.0	2395.0	2263.7	**5.8**
	75.0	2203.0	2074.4	**6.2**
	100	2124.0	1986.5	**6.9**
B-250	0.0	2534.0	2392.0	**5.9**
	25.0	2415.0	2295.5	**5.2**
	50.0	2260.0	2134.4	**5.9**
	75.0	2230.0	2101.5	**6.1**
	100.0	2073.0	1940.7	**6.8**
B-300	0.0	2484.0	2347.2	**5.8**
	25.0	2481.0	2349.2	**5.6**
	50.0	2359.0	2230.2	**5.8**
	75.0	2282.0	2152.5	**6.0**
	100.0	2071.0	1941.4	**6.7**
B-450	0.0	2629.0	2485.1	**5.8**
	25.0	2462.0	2334.4	**5.5**
	50.0	2412.0	2275.1	**6.0**
	75.0	2241.0	2100.1	**6.7**
	100.0	2012.0	1861.4	**8.1**

4.6 Abrasion Test Results

Table 4.5 summarizes Abrasion test results.

Table (4.5): Concrete abrasion test results

Concrete Grade	Percent replacement (%)	Average loss (gm)
B-150	0.0	3.0
	25	3.4
	50	4.2
	75	4.9
	100	5.4
B-200	0.0	2.6
	25	2.7
	50	3.0
	75	4.1
	100	4.5
B-250	0.0	2.5
	25	5.7
	50	7.6
	75	7.7
	100	10.3
B-300	0.0	2.0
	25	6.6
	50	6.9
	75	7.2
	100	9.6
B-450	0.0	1.4
	25	3.2
	50	3.8
	75	6.3
	100	7.4

4.7 Modulus of Elasticity Test Results (E)

Table 4.6 summarizes modulus of elasticity test results for various PCC categories.

Table (4.6): Modulus of elasticity test results

Concrete Grade	Percent replacement (%)	Modulus of elasticity E (KN/mm)
B-150	0.0	131.3
	25	100.5
	50	76.2
	75	45.5
	100	24.1
B-200	0.0	143.2
	25	113.4
	50	94.6
	75	60.5
	100	34.2
B-250	0.0	232.0
	25	186.1
	50	122.4
	75	75.9
	100	48.5
B-300	0.0	234.2
	25	196.3
	50	126.3
	75	86.1
	100	53.9
B-450	0.0	379.2
	25	231.6
	50	177.6
	75	120.3
	100	74.6

4.8 Noise Insulation Test Results

Table 4.7 consists of test results of noise insulation in percent reduction of noise as an expression of noise insulation at low and high noise levels for various PCC categories.

Table (4.7): Noise insulation test results

Concrete Grade	Percent replacement (%)	Percent reduction (Low) (%)	Percent reduction (High) (%)
B-150	0.0	14.6	13.7
	25	15.1	13.9
	50	16.3	14.6
	75	17.4	15.1
	100	18.8	17.7
B-200	0.0	14.1	13.5
	25	15.3	14.1
	50	16.5	14.7
	75	17.6	16.4
	100	18.6	17.2
B-250	0.0	13.9	13.5
	25	15.4	13.8
	50	16.7	14.4
	75	17.9	15.5
	100	18.3	17.8
B-300	0.0	14.4	13.3
	25	15.0	13.9
	50	16.1	14.3
	75	16.8	14.9
	100	17.9	17.1
B-450	0.0	14.3	13.6
	25	14.9	14.2
	50	15.8	15.1
	75	17.1	16.6
	100	18.2	18.1

4.9 Thermal Insulation Test Results

Table 4.8 consists of test results of thermal insulation in percent reduction of temperature as an expression of thermal insulation at a constant source of heat for various PCC categories.

Table (4.8): Thermal insulation test results

Concrete Grade	Percent replacement (%)	Percent reduction Of temperature (%)
B-150	0.0	24.3
	25	25.1
	50	27.8
	75	30.5
	100	32.6
B-200	0.0	24.5
	25	25.2
	50	28.0
	75	30.7
	100	32.8
B-250	0.0	22.9
	25	23.6
	50	25.5
	75	27.8
	100	29.6
B-300	0.0	23.3
	25	23.8
	50	26.1
	75	28.6
	100	30.1
B-450	0.0	22.7
	25	24.3
	50	26.2
	75	27.5
	100	29.3

CHAPTER FIVE

ANALYSIS OF RESULTS

CHAPTER FIVE

ANALYSIS OF RESULTS

5.1 Introduction

This chapter aims at analyzing the tests results to show how concrete behavior will change as a result of the volumetric replacement of sand with crumb waste tires when compared to standard mixes of PCC containing no crumb waste tires.

5.2 Compressive Strength

In the analysis of the laboratory results for compressive strength, Figure 5.1 gives the basic relationship of the percentage of replacement by crumb waste tires with the compressive strength for concrete category of B-150.

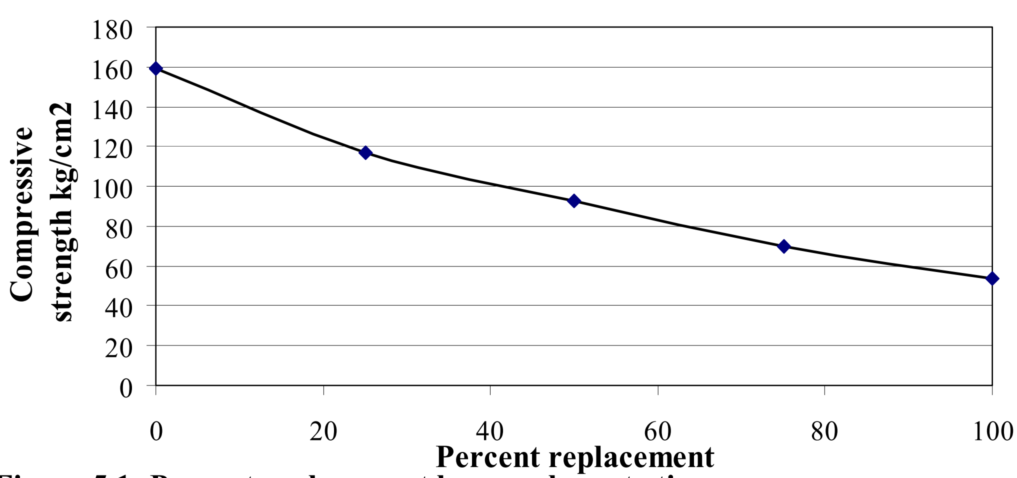


Figure 5.1: Percent replacement by crumb waste tires versus compressive strength for PCC-150

As a result of a volumetric replacement of sand by crumb waste tires, compressive strength decreases as percent of crumb waste tires increases as shown in Figure 5.1, at zero replacement, compressive strength is 159.0 kg/cm^2, while at 25% replacement the compressive strength decreases to 117.0 kg/cm^2 that is a decrease of 26.4%. At 50% replacement, compressive strength is 92.4 kg/cm^2 that is a decrease of 41.9% from the original value. For the replacements of 75 and 100% replacement, the compressive strength drops to 56 and 66.3% respectively from the original reference value.

Figure 5.2 shows compressive strength for concrete grade B-150 and B-200 versus percent replacement by crumb waste tires. For concrete grade of B-200 the compressive strength is 178.2, 154.9, 111.4, 77.9, 60.9 kg/cm2 for replacement values of 0, 25, 50, 75, and 100% respectively. The percentage drop reflecting those percentages is 13, 37.5, 56.3, and 65.8% respectively. In comparison between the concrete grades of B-150 and B-200, it can be noticed that differences are 24.5, 17.1, 10.4, and 12% for 25, 50, 75, and 100% replacements respectively. This implies that as the percentage replacement increases, the percentage difference between the two categories decreases with higher overall drop in compressive strength for concrete category for B-250.

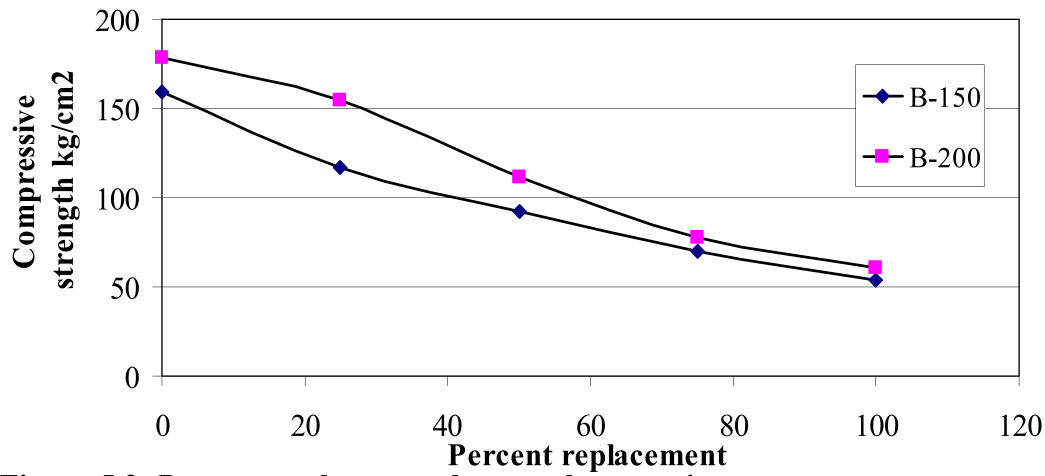


Figure 5.2: Percent replacement by crumb waste tires versus compressive strength for PCC-150+200

Figure 5.3 shows the compressive strength for concrete grades B-150, B-200, B-250, B-300, and B-450 versus percent replacement by crumb waste tires. For concrete grade B-250 with zero replacement the compressive strength is 290.0 kg/cm^2. At 25% replacement the compressive strength is 238.1 kg/cm^2 that is a decreases of 17.9% from the original value, while for 50, 75, and 100% replacement the compressive strength decreases to 47.4, 64.7, and 74.3% respectively.

Comparing B-150 and B-250, B-150 as a reference, for a 25% replacement the compressive strength decreases to 50.9%, while for 50, 75, and 100% replacements, the compressive strength decreases to 39.4, 31.7, and 28% from those of concrete B-250 grade.

For PCC B-300 the compressive strengths are 313.5, 235.1, 156.0, 98.5, 67.1 kg/cm^2 for 0, 25, 50, 75 and 100% replacement respectively, giving decreases in compressive strength of 25, 50, 68.6, and 78.6% respectively from the original value. When comparing B-250 with B-300 it is noticed that at 25, 50, 75, and 100% replacements the difference is 1.3, 2.3, 3.7, and 9.8% respectively. It is also noticed that concrete grade B-250 is slightly better for compressive strength compared to B-300.

For B-450 the compressive strength is 472.6, 284.8, 227.7, 144.6, 92.6 kg/cm^2 for replacements values of 0, 25, 50, 75, and 100% respectively. The percentage drop reflecting those percentages is 39.7, 51.8, 69.4, and 80.4% respectively. In comparing B-300 with B-450, it is noticed that at 25, 50, 75, and 100% the differences are 21, 46, 46.8, and 38.0% respectively.

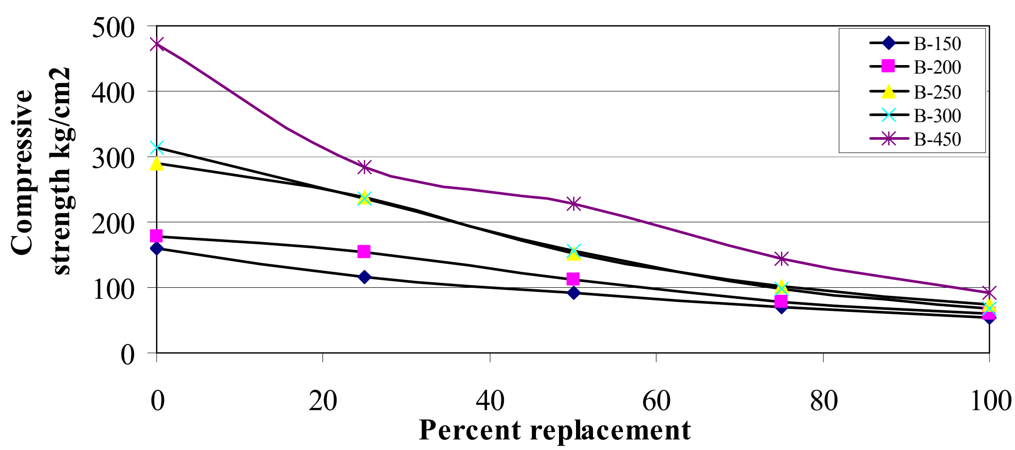


Figure 5.3: Percent replacement by crumb waste tires versus compressive strength for various PCC categories

Figure 5.4 shows also how compressive strength changed with percent of volumetric replacement of sand by waste crumb tires relative to the specified compressive strength.

Notice actual compressive strength at 0, 25, 50, 75, and 100% replacement for grades B-150, 200, 250, 300, and B-450, actual compressive strength differences are less decreased at concrete grades B-150 and B-200 versus replacement, differences of compressive strength increases at concrete grades B-250, 300, and B-450 versus replacement.

As an example; for concrete grade of B-450 the differences between compressive strengths are 39.7, 20.0, 36.5, and 36.0%, while for concrete grade of B-200 the differences are 13.1, 28.1, 30.1, and 21.8%.

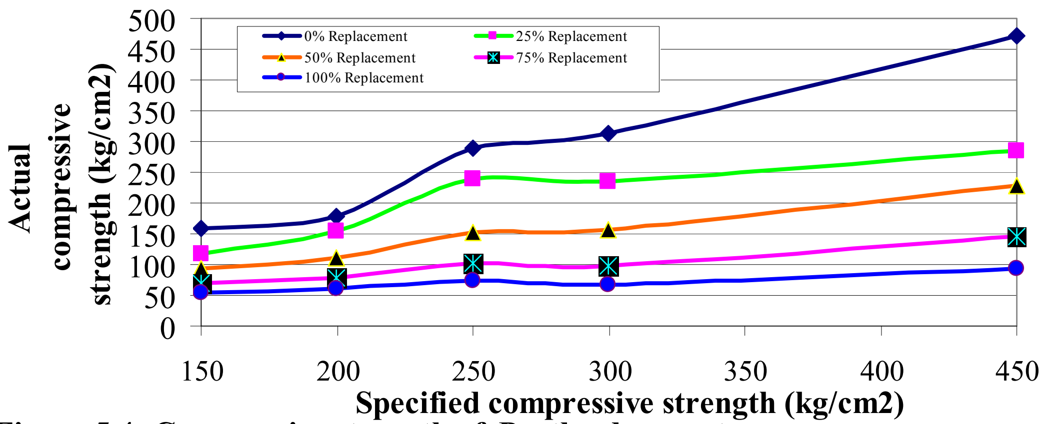


Figure 5.4: Compressive strength of Portland cement concrete for various percentages of replacements of crumbed waste tires

Figure 5.4 shows how actual compressive strength decreased at specified compressive strength with increasing percent of replacement of waste crumb tires. This happened because as replacement increases, bonding between aggregate particles and cement decrease, and because of the weakness of waste crumb rubber particles with comparison to sand.

5.3 Density

Density of concrete also decreases as crumb waste tires increases, see Figure 5.5 which presents how density decreases when crumb waste tires increases for PCC-150.

Densities are 2330, 2196, 2153, 2065, and 1961 kg/m^3 for replacement of 0, 25, 50, 75, and 100% respectively. Those replacement shows decrease of density in which the density decreases to 5.8, 7.6, 11.4, and 15.8% with reference to zero replacement.

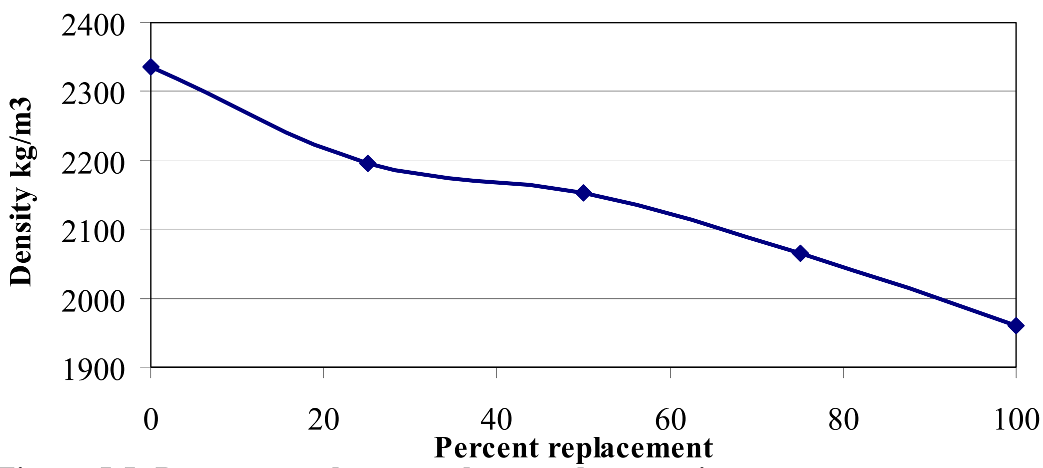


Figure 5.5: Perecent replacement by crumb waste tire versus density for PCC-150

Note that the difference of densities for various PCC versus replacement in Figure 5.6. In addition, Notice the difference between B-150 and B-200, at 0, 25, 50, 75, and 100% replacement are 1.8, 0.8, 0.9, 0.6, and 2.1% respectively.

For B-200 and B-250, the differences are 1.2, 2, 1.2, 0.5, and 2.6%. For B-250 and B300 comparison differences are 0.5, 0.04, 2.5, 0.3, and 0.4%.

Finally for B-300 with comparison by B-450 differences are 1.5, 3.1, 2.9, 2.6, and 0.4%.

Theses differences show slight differences in densities between different PCC categories versus replacement, but the decreases for each type on density reaches between (16-19%) at 100% replacement.

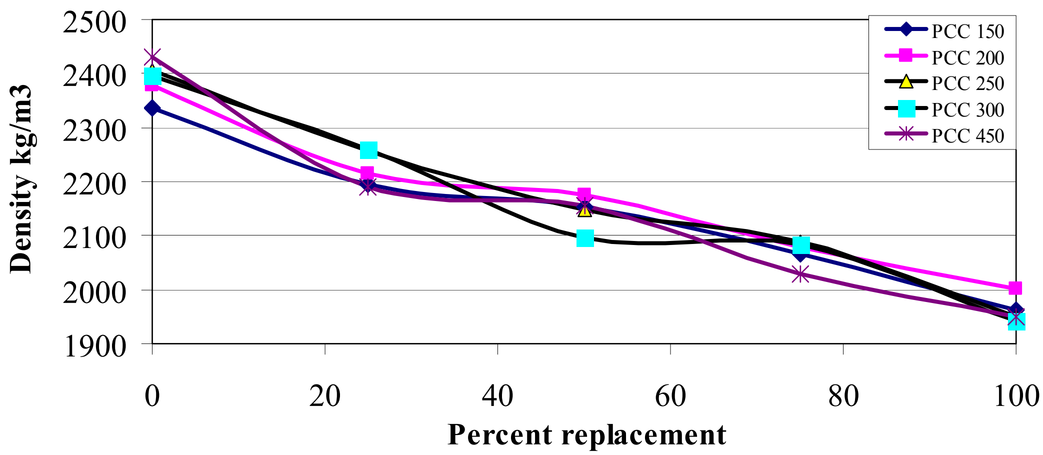


Figure 5.6: Perecent replacement by crumb waste tire versus density for various categories of concrete

Generally, density decreases as percent replacement increases since waste crumb rubber has less specific gravity than sand.

5.4 Water Absorption

To analyze tests results of water absorption see Figure 5.7 that shows the basic relation between water absorption versus percent replacement of waste crumb tires for PCC-150.

Notice how water absorption behaves as replacement increase at 0, 25, 50, 75, and 100.

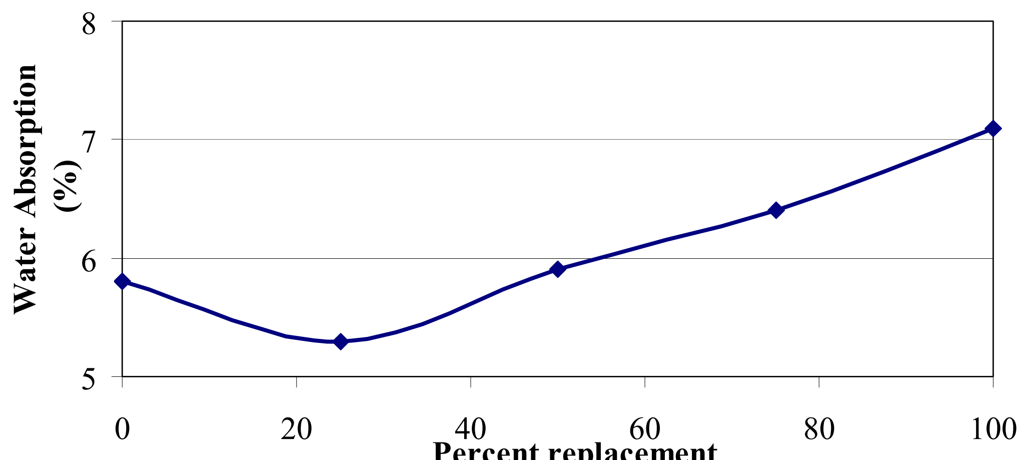


Figure 5.7: Perecent replacement by crumb waste tire versus Water Absorption for PCC-150

Water absorption decreases at 25% replacement and pounces back approximately to its original value at 50% replacement and starts to increase as waste crumb tires increases (see Figure 5.7 for PCC-150).

Figure 5.8 shows the differences between water absorption for different PCC categories versus replacement. For B-150 and B-200 the differences are 1.7, 3.6, 1.7, 3.1, and 2.8% for 0, 25, 50, 75, and 100% replacements respectively.

For B-200 and B-250 differences are 3.3, 5.5, 1.7, 1.6, and 1.4% for 0, 25, 50, 75, and 100% replacements respectively. For B-250 and B-300 differences are 1.7, 7.1, 1.7, 1.6, and 1.5 for 0, 25, 50, 75, and 100% replacement respectively. For B-300 and B-450 differences are 0.0, 1.8, 3.3, 10.4, and 17.3 for 0, 25, 50, 75, and 100% replacement respectively.

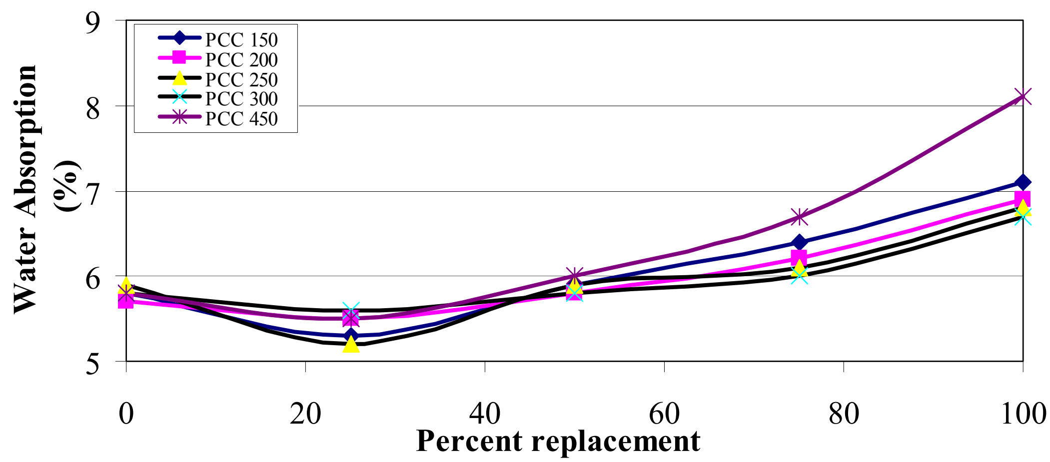


Figure 5.8: Perecent replacement by crumb waste tire versus Water Absorption for various categories of concrete

This leads to the idea that water absorption decreased at 25% replacement since voids are decreased but occasional vacuums existed when waste crumb tires replacement increased which causes an increase in water absorption. In addition, weakness of bonding between particles will increase absorption which permits water to enter through voids in the interface between the crumbs and the cement paste as a result of increasing waste crumb tires. It is worth to note that the waste crumb tires have smaller particle size compared to that of sand as seen in Figure 4.1.

5.5 Slump (Consistency)

Slump is an expression of consistency, as slump increases the concrete blend is more consistent. Figure 5.9 shows slump versus replacement for different PCC categories.

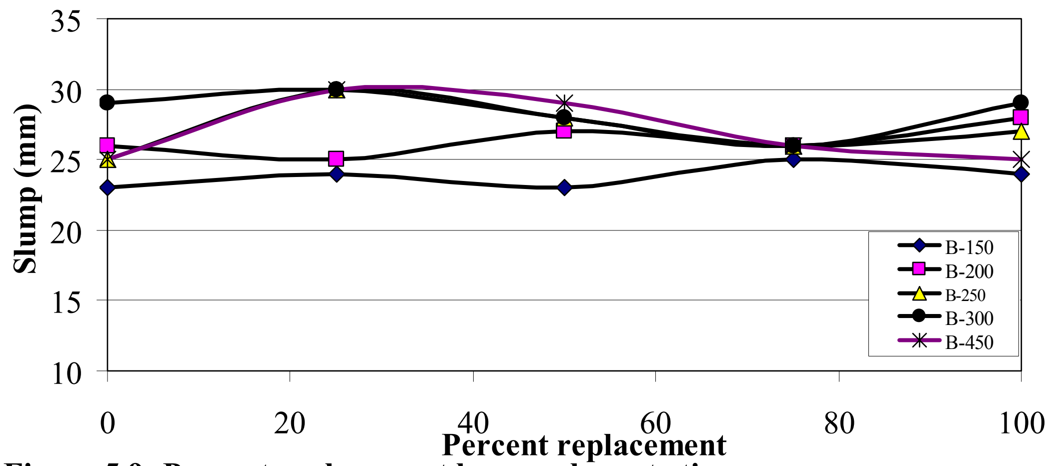


Figure 5.9: Percent replacement by crumb waste tires versus slump for various PCC categories

Slump showed little change in consistency during all mixing; slump ranges from 20-30 mm, there was no effect of increasing waste crumb tires replacement on consistency. This is because of the coarseness of the mixes and the existence of high adhesion forces between waste crumb particles and aggregate particles which prevents mixes to be more consistent.

5.6 Abrasion

Figure 5.10 represents abrasion test results for concrete versus percent replacement for PCC-150.

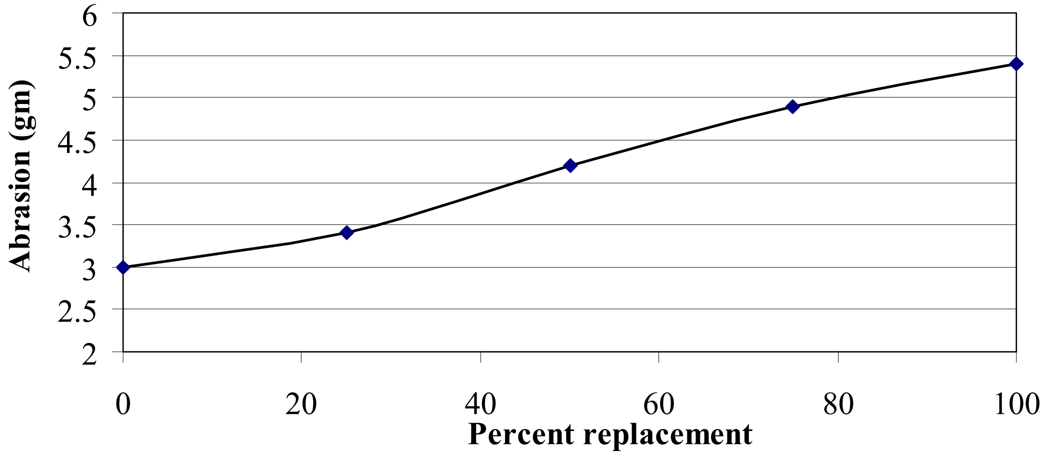


Figure 5.10: Percent replacement by crumb waste tires versus abrasion for PCC-150

It is noticed that abrasion increases when replacement increases for grade B-150, this is because of the increase of waste crumb tires replacement. This happened because of the existing of fine crumb waste tires which has a weak resistance and of the weakness of bonding between the blend particles due to increasing of waste crumb tires percent replacement. On the other hand sand has a coarse surface texture and because of the nature micro structures of sand (silica quarts) that made bonding stronger with comparison to rubber.

For 0, 25, 50, 75, and 100% replacement, the average loss by weight was increasing 13.3, 40, 63.3, and 80% respectively from the zero replacement. Figure 5.11 shows abrasion resistance versus replacement for different PCC categories.

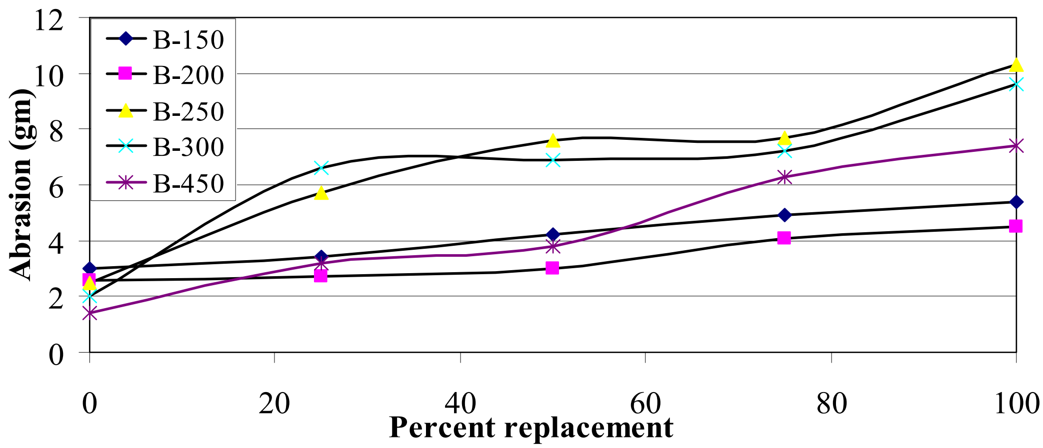


Figure 5.11: Percent replacement by crumb waste tires versus abrasion for various PCC categories

Figure 5.11 shows obviously that abrasion increases as waste crumb tires increase because of the reasons mentioned above.

5.7 Modulus of Elasticity

The modulus of elasticity is a measure of the stiffness of a material, or in this case it is a measure of the deformation of the rubberized concrete. Figure 5.12 shows stress versus strain relation.

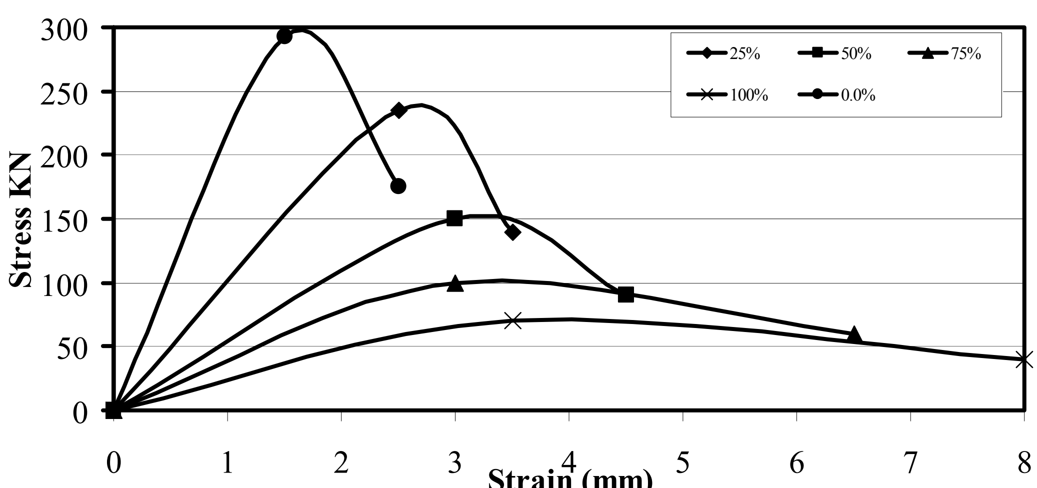


Figure 5.12: Stress versus strain for PCC-300

From the above Figure modulus of elasticity can be calculated by finding the slope which presents stress divided by strain for the first half of the curve, notice how the mode of failure changes when replacement of waste crumb tires increases. This means that the lower the modulus of elasticity of the sample, the lower the amount of deformation it could withstand before breaking.

Figure 5.13 shows modulus of elasticity versus replacement of waste crumb tires for different categories of PCC.

Modulus of elasticity decreased as waste crumb tires replacement increased.

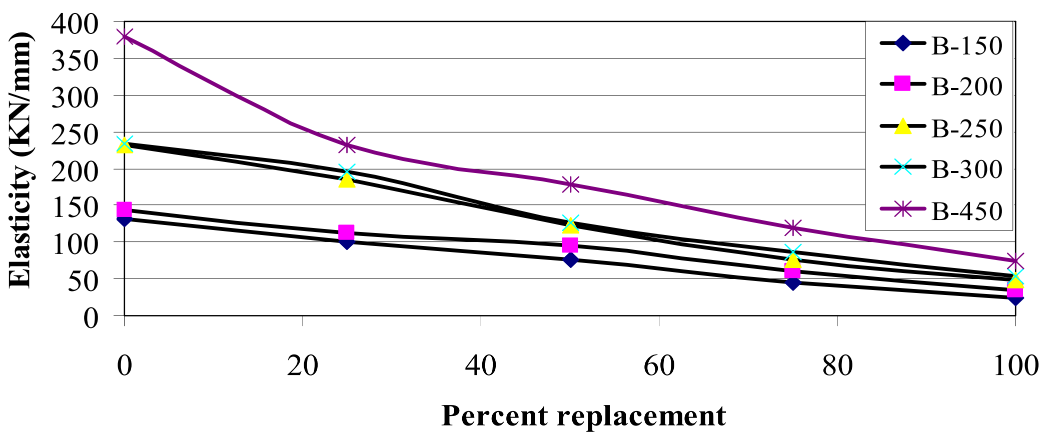


Figure 5.13: Percent replacement by crumb waste tires versus elasticity for various PCC

5.8 Noise Insulation

Figure 5.14 shows results of noise insulation at low level of noise (86.5 dp), this Figure presents percent replacement of waste crumb tires versus percent reduction of noise at low level for various PCC categories.

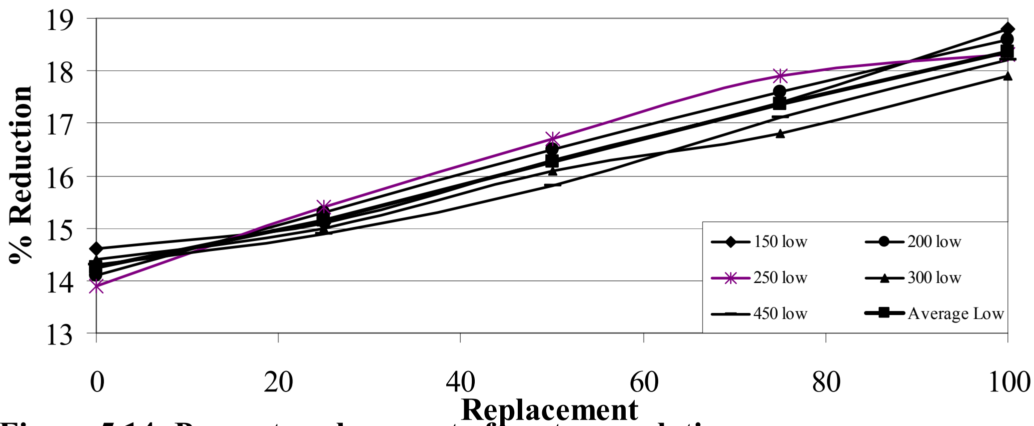


Figure 5.14: Percent replacement of waste crumb tires versus reduction of noise at low level for various PCC categories

Figure 5.14 shows obviously the behavior of noise, as replacement increased, higher reduction of noise, this means that when replacement increased insulation increased.

From the above Figure the reduction increased from 14% at 0% replacement to approximately 19% at 100% replacement.

Figure 5.15 also presents percent replacement of waste crumb tires versus percent reduction of noise at high noise level (98.6 dp) for various PCC categories.

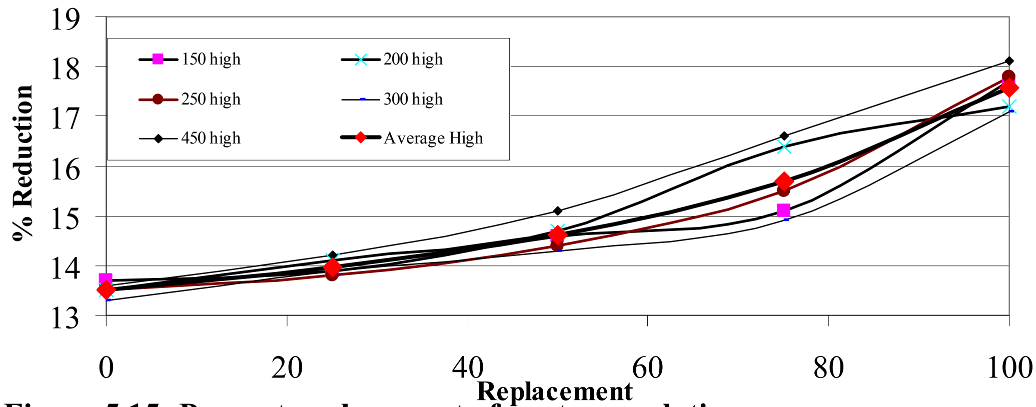


Figure 5.15: Percent replacement of waste crumb tires versus noise reduction at high level for various PCC categories

The above Figure shows the same behavior as low noise level but with less noise reduction or less insulation. Reduction of noise increased from 13.5% approximately at 0.0% replacement to 18% at 100% replacement.

Figure 5.16 shows percent replacement versus averages of noise reduction at low and high levels.

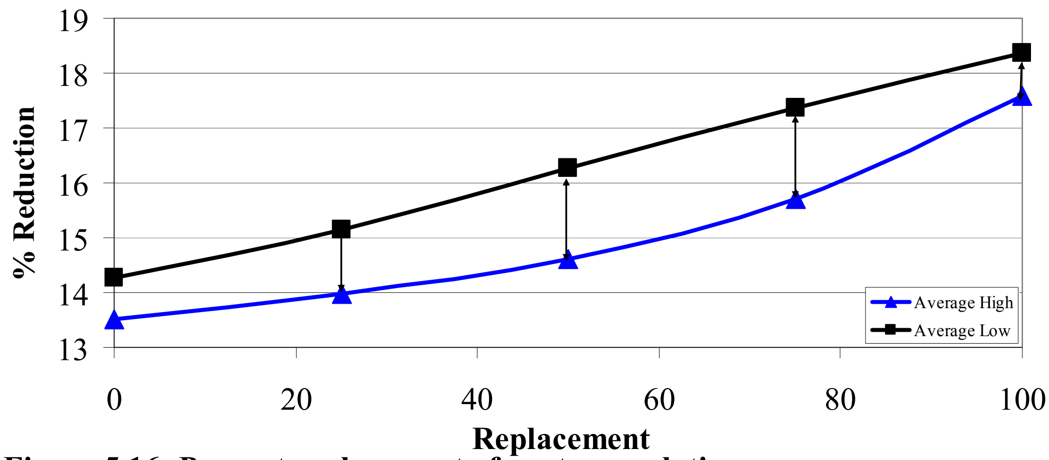


Figure 5.16: Percent replacement of waste crumb tires versus average reduction of noise at low and high level

At low noise level higher insulation of noise occurred than high level of noise which easily noticed from Figure 5.16.

The difference between reduction of noise at low level and high level, at 0, 25, 50, 75, and 100% is 0.74, 1.16, 1.66, 1.66, and 0.78 respectively, that gives higher increasing at low level of 5.5, 8.3, 11.4, 10.6, and 4.4% than the high noise level with an overall average of 8.0%.

The more the material is brittle it will have lower noise insulation; the more the material is elastic it will have higher noise insulation. This means that when percent replacement increased concrete absorption of noise increased.

Concrete with different percent replacement can isolate noise at low level better than high noise level, since concrete can absorb vibration at low level better than high level.

5.9 Thermal Insulation

Figure 5.17 shows results of thermal insulation at a constant source of heat (54 C°), this Figure presents percent replacement of waste crumb tires versus percent reduction of temperature for various PCC categories.

Figure 5.17 shows that percent reduction in temperature increased as waste crumb tires replacement increased, that leads the fact that thermal insulation increased as the percent replacement increased. No significant changes can be noticed between various PCC categories.

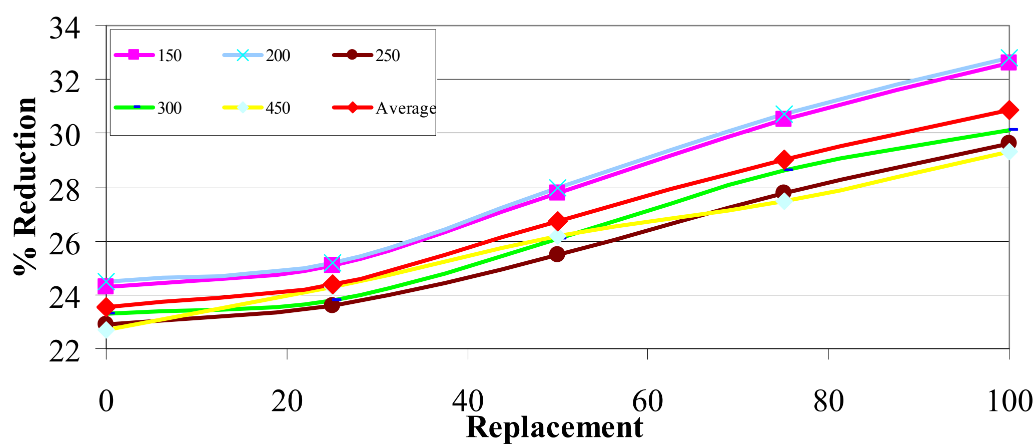


Figure 5.17: Percent replacement of waste crumb tires versus temperature reduction for various PCC categories

Figure 5.18 shows the average percent reduction of temperature versus percent replacement of waste crumb tires for all PCC categories.

Average reduction increased as percent replacement increased, at 0, 25, 50, 75, and 100% replacement percent reduction is 23.5, 24.4, 26.7, 29.0, and

30.9% respectively, which means that thermal insulation increased 3.8, 13.6, 23.4, and 31.5% from zero percent replacement.

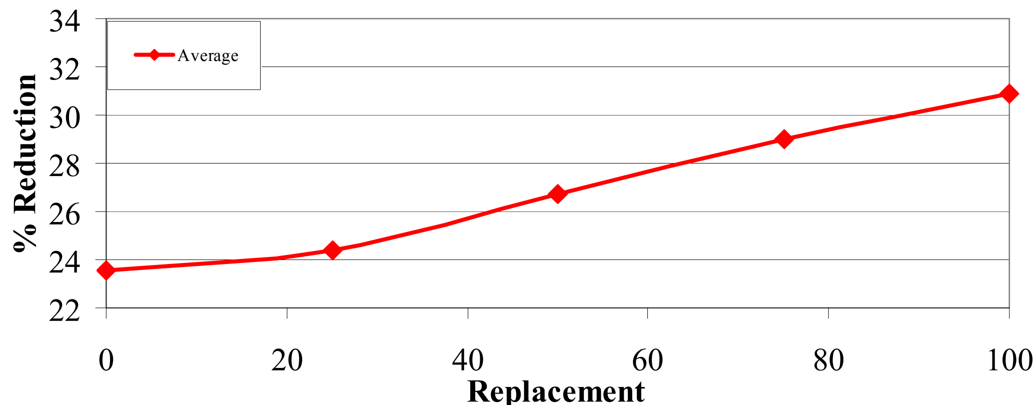


Figure 5.18: Percent replacement of waste crumb tires versus average temperature reduction for various PCC categories

This behavior happened because when the material density is lowered thermal insulation increased, and because of lower conductivity that rubber has with comparison of concrete.

5.10 Particles Distributions

Particles were distributed homogeneously in all mixes for 0, 25, 50, 75, and 100% replacement. In 25% replacement concrete blending was dense. It can be noticed that concrete blending is denser in 75% and 100% replacement, but still with homogeneous distribution of the particles through all percent replacement of mixes (See Figure 5.19).

Figure 5.19: Particles distribution (0, 25, 50, 75, and 100 % replacement from right to left)

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This thesis aims to investigate the behavior of PCC mixes and the effect of utilizing waste crumb tires in these mixes.

6.2 Conclusions

Based on the results and analysis done as a part of this research thesis, the following can be concluded:

1. Compressive strength decreases as the percent of waste crumb tire replacement increases for various PCC categories.

2. Density decreases as the percent of waste crumb tire replacement increases for various PCC categories.

3. Water absorption decreases at 25% replacement and pounces back approximately to its original value at 50% replacement, and then starts to increase as waste crumb tires increases.

4. Slump test results showed no change in consistency during all mixes; there was no effect of increasing waste crumb tires replacement on consistency.

5. Abrasion increases as waste crumb tires increases.

6. Modulus of elasticity decreases as waste crumb tires replacement increases.

7. Noise insulation increases as percent of crumb waste tires increases. At low noise levels, higher insulation of noise occurred than that of high levels of noise.

8. Thermal insulation increases as waste crumb tires percent increases.

6.3 Recommendations

Based on the conclusions drawn above and the laboratory observations, the following are recommended:

1. Since the addition of crumb tires decreases compressive strength, it is recommended to use waste crumb tires for non structural Portland cement concrete in buildings such as floor slabs, floor ribs, under ground slabs, behind building stones and in partitions etc.

2. It is recommended to use percent of replacements in the vicinity of 25% in the PCC, since compressive strength still within the acceptable range, also good thermal and noise insulation can be achieved.

3. It is recommended to use replacements in an increment of 10% for better identification behavioral changes in the physical characteristics in future research.

4. It is recommended to study the effect of larger sizes of shredded tires on PCC.

5. It is recommended to further test the physical characteristics of PCC through shrinkage limit, permeability etc.

6. It is recommended to explore the effect of other raw materials in these mixes and study the changes in physical characteristics.

7. Using waste crumb tires in the production of concrete blocks, ribbed concrete block, and for paving is strongly recommended.

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APPENDICES

APPENDIX A

COMPRESSIVE STRENGTH TEST RESULTS TABLES

Table 1: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-150)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 0.0% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	الارسالية	الوزن	تاريخ الصب	تاريخ الفحص	العمر	التهدل	حمل الكسر	مقاومة الضغط
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2329	5.12.06	6.1.07	32	20-30	152.0	**155.0**
2		2342					154.0	**157.1**
3		2338					162.0	**165.2**
ملخص النتيجةSummary								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)				**النسبة من المقاومة المطلوبة % of required strength**				
159.1				**106%**				

Table 2: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-150)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 25% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	الارسالية	الوزن	تاريخ الصب	تاريخ الفحص	العمر	التهدل	حمل الكسر	مقاومة الضغط
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2250	3.2.07	3.3.07	28	20-30	125.0	**127.5**
2		2173					104.0	**106.1**
3		2142					109.0	**111.2**
4		2219					120.6	**123.0**
ملخص النتيجةSummary								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)				**النسبة من المقاومة المطلوبة % of required strength**				
117.0				**80%**				

Table 3: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-150)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 50% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2195	3.2.07	3.3.07	28	20-30	90.7	**92.5**
2		2154					88.7	**90.5**
3		2125					92.4	**94.2**
4		2141					90.7	**92.5**
ملخص النتيجةSummary								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)				**النسبة من المقاومة المطلوبة % of required strength**				
92.4				**62%**				

Table 4: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-150)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 75% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2051	3.2.07	3.3.07	28	20-30	68.5	**69.9**
2		2085					67.3	**68.6**
3		2060					71.5	**72.9**
4		2064					66.5	**67.8**
ملخص النتيجةSummary								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)				**النسبة من المقاومة المطلوبة % of required strength**				
69.8				**47%**				

Table 5: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-150)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 100% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	1923	3.2.07	3.3.07	28	20-30	52.9	**54.0**
2		2001					53.4	**54.5**
3		1962					52.6	**53.7**
4		1959					51.3	**52.3**
ملخص النتيجةSummary								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)				**النسبة من المقاومة المطلوبة % of required strength**				
53.6				**36%**				

Table 6: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-200)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 0.0% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2382	5.12.06	6.1.07	32	20-30	180.0	**183.6**
2		2360					174.0	**177.5**
3		2393					170.0	**173.4**
Summary ملخص النتيجة								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)				**النسبة من المقاومة المطلوبة % of required strength**				
178.2				**89%**				

Table 7: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-200)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs			**Standard Method**			PS-55
Concrete Type		Standard mix with 25% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2216	6.2.07	6.3.07	28	20-30	150.5	**153.5**
2		2200					150.8	**153.8**
3		2220					151.9	**154.9**
4		2220					154.2	**157.3**
Summary ملخص النتيجة								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)					**النسبة من المقاومة المطلوبة % of required strength**			
154.9					**77%**			

Table 8: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-200)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs			**Standard Method**			PS-55
Concrete Type		Standard mix with 50% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2206	6.2.07	6.3.07	28	20-30	116.0	**118.3**
2		2173					109.8	**112.0**
3		2166					105.2	**107.3**
4		2150					105.8	**107.9**
Summary ملخص النتيجة								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)					**النسبة من المقاومة المطلوبة % of required strength**			
111.4					**56%**			

Table 9: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-200)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs			**Standard Method**			PS-55
Concrete Type		Standard mix with 75% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	الارسالية	الوزن	تاريخ الصب	تاريخ الفحص	العمر	التهدل	حمل الكسر	مقاومة الضغط
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2097	6.2.07	6.3.07	28	20-30	72.8	**74.3**
2		2089					75.0	**76.5**
3		2041					85.4	**87.1**
4		2083					72.3	**73.7**
Summary ملخص النتيجة								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)					**النسبة من المقاومة المطلوبة % of required strength**			
77.9					**39%**			

Table 10: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-200)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs			**Standard Method**			PS-55
Concrete Type		Standard mix with 100% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	الارسالية	الوزن	تاريخ الصب	تاريخ الفحص	العمر	التهدل	حمل الكسر	مقاومة الضغط
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	1986	6.2.07	6.3.07	28	20-30	58.9	**60.1**
2		2016					59.9	**61.1**
3		2026					57.1	**58.2**
4		1980					63.0	**64.3**
Summary ملخص النتيجة								
معدل المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)					**النسبة من المقاومة المطلوبة % of required strength**			
60.9					**30%**			

Table 11: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-250)

Sample Type								Cubes 10x10x10 cm
Place of Curing	An - Najah Labs			**Standard Method**				PS-55
Concrete Type	Standard mix with 0.0% volumetric replacement of sand							
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	الارسالية	الوزن	تاريخ الصب	تاريخ الفحص	العمر	التهدل	حمل الكسر	مقاومة الضغط
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2414	5.12.06	6.1.07	32	20-30	280.0	**285.6**
2		2405					288.0	**293.8**
3		2398					285.0	**290.7**
Summary ملخص النتيجة								
المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)				**النسبة من المقاومة المطلوبة % of required strength**				
290.0				**116%**				

Table 12: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-250)

Sample Type								Cubes 10x10x10 cm
Place of Curing	An - Najah Labs			**Standard Method**				PS-55
Concrete Type	Standard mix with 25% volumetric replacement of sand							
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	الارسالية	الوزن	تاريخ الصب	تاريخ الفحص	العمر	التهدل	حمل الكسر	مقاومة الضغط
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2285	11.2.07	11.3.07	28	20-30	230.5	**235.1**
2		2246					233.0	**237.7**
3		2234					231.0	**235.6**
4		2268					239.0	**243.8**
Summary ملخص النتيجة								
المقاومة بعد 28 يوماً 28 day strength (kg/cm^2)				**النسبة من المقاومة المطلوبة % of required strength**				
238.1				**95%**				

Table 13: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-250)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 50% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2156	11.2.07	11.3.07	28	20-30	145.0	**147.9**
2		2136					149.0	**152.0**
3		2143					153.0	**156.1**
4		2155					151.0	**154.0**
Summary ملخص النتيجة								
المقاومة بعد 28 يوماً **28 day strength (kg/cm^2)**				**النسبة من المقاومة المطلوبة** **% of required strength**				
152.5				**61%**				

Table 14: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-250)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 75% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2120	11.2.07	11.3.07	28	20-30	100.0	**102.0**
2		2117					102.0	**104.0**
3		2083					98.0	**100.0**
4		2037					101.0	**103.0**
Summary ملخص النتيجة								
المقاومة بعد 28 يوماً **28 day strength (kg/cm^2)**				**النسبة من المقاومة المطلوبة** **% of required strength**				
102.3				**41%**				

Table 15: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-250)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs			**Standard Method**			PS-55
Concrete Type		Standard mix with 100% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	1976	11.2.07	11.3.07	28	20-30	72.0	**73.4**
2		1944					72.0	**73.4**
3		1953					76.2	**77.7**
4		1922					71.8	**73.2**
Summary ملخص النتيجة								
المقاومة بعد 28 يوماً **28 day strength (kg/cm^2)**					**النسبة من المقاومة المطلوبة** **% of required strength**			
74.4					**30%**			

Table 16: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-300)

Sample Type								Cubes 10x10x10 cm
Place of Curing		An - Najah Labs			**Standard Method**			PS-55
Concrete Type		Standard mix with 0.0% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2385	5.12.06	6.1.07	32	20-30	300.0	**306.0**
2		2406					302.0	**308.0**
3		2395					320.0	**326.4**
Summary ملخص النتيجة								
معدل المقاومة بعد 28 يوماً **28 day strength (kg/cm^2)**					**النسبة من المقاومة المطلوبة** **% of required strength**			
313.5					**104%**			

Table 17: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-300)

Sample Type							Cubes 10x10x10 cm	
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 25% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2287	11.2.07	11.3.07	28	20-30	244.0	**248.9**
2		2241					220.0	**224.4**
3		2289					232.0	**236.6**
4		2220					226.0	**230.5**
Summary ملخص النتيجة								
معدل المقاومة بعد 28 يوماً **28 day strength (kg/cm^2)**				**النسبة من المقاومة المطلوبة** **% of required strength**				
235.1				**78%**				

Table 18: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-300)

Sample Type							Cubes 10x10x10 cm	
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 50% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	**الارسالية**	**الوزن**	**تاريخ الصب**	**تاريخ الفحص**	**العمر**	**التهدل**	**حمل الكسر**	**مقاومة الضغط**
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2092	11.2.07	11.3.07	28	20-30	151.0	**154.0**
2		2117					157.0	**160.0**
3		2086					154.0	**157.1**
4		2086					150.0	**153.0**
Summary ملخص النتيجة								
معدل المقاومة بعد 28 يوماً **28 day strength (kg/cm^2)**				**النسبة من المقاومة المطلوبة** **% of required strength**				
156.0				**52%**				

Table 19: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-300)

<table>
<tr><td colspan="7">Sample Type</td><td colspan="2">Cubes 10x10x10 cm</td></tr>
<tr><td colspan="2">Place of Curing</td><td colspan="3">An - Najah Labs</td><td colspan="2">Standard Method</td><td colspan="2">PS-55</td></tr>
<tr><td colspan="2">Concrete Type</td><td colspan="7">Standard mix with 75% volumetric replacement of sand</td></tr>
<tr><td>No.</td><td>Del. No.</td><td>Weight</td><td>Casting date</td><td>Testing date</td><td>Age</td><td>Slump</td><td>Crushing load</td><td>Comp. strength</td></tr>
<tr><td>الرقم</td><td>الارسالية</td><td>الوزن</td><td>تاريخ الصب</td><td>تاريخ الفحص</td><td>العمر</td><td>التهدل</td><td>حمل الكسر</td><td>مقاومة الضغط</td></tr>
<tr><td>-</td><td>-</td><td>(g)</td><td>-</td><td>-</td><td>(day)</td><td>(mm)</td><td>(KN)</td><td>(Kg/cm^2)</td></tr>
<tr><td>1</td><td rowspan="4">-</td><td>2088</td><td rowspan="4">14.2.07</td><td rowspan="4">14.3.07</td><td rowspan="4">28</td><td rowspan="4">20-30</td><td>96.0</td><td>97.9</td></tr>
<tr><td>2</td><td>2080</td><td>95.0</td><td>96.9</td></tr>
<tr><td>3</td><td>2079</td><td>94.0</td><td>96.0</td></tr>
<tr><td>4</td><td>2085</td><td>101.0</td><td>103.0</td></tr>
<tr><td colspan="9">Summary ملخص النتيجة</td></tr>
<tr><td colspan="5">معدل المقاومة بعد 28 يوماً
28 day strength (kg/cm^2)</td><td colspan="4">النسبة من المقاومة المطلوبة
% of required strength</td></tr>
<tr><td colspan="5">98.5</td><td colspan="4">33%</td></tr>
</table>

Table 20: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-300)

<table>
<tr><td colspan="7">Sample Type</td><td colspan="2">Cubes 10x10x10 cm</td></tr>
<tr><td colspan="2">Place of Curing</td><td colspan="3">An - Najah Labs</td><td colspan="2">Standard Method</td><td colspan="2">PS-55</td></tr>
<tr><td colspan="2">Concrete Type</td><td colspan="7">Standard mix with 100% volumetric replacement of sand</td></tr>
<tr><td>No.</td><td>Del. No.</td><td>Weight</td><td>Casting date</td><td>Testing date</td><td>Age</td><td>Slump</td><td>Crushing load</td><td>Comp. strength</td></tr>
<tr><td>الرقم</td><td>الارسالية</td><td>الوزن</td><td>تاريخ الصب</td><td>تاريخ الفحص</td><td>العمر</td><td>التهدل</td><td>حمل الكسر</td><td>مقاومة الضغط</td></tr>
<tr><td>-</td><td>-</td><td>(g)</td><td>-</td><td>-</td><td>(day)</td><td>(mm)</td><td>(KN)</td><td>(Kg/cm^2)</td></tr>
<tr><td>1</td><td rowspan="4">-</td><td>1919</td><td rowspan="4">14.2.07</td><td rowspan="4">14.3.07</td><td rowspan="4">28</td><td rowspan="4">20-30</td><td>65.0</td><td>66.3</td></tr>
<tr><td>2</td><td>1968</td><td>64.0</td><td>65.3</td></tr>
<tr><td>3</td><td>1954</td><td>68.0</td><td>69.4</td></tr>
<tr><td>4</td><td>1921</td><td>66.0</td><td>67.3</td></tr>
<tr><td colspan="9">Summary ملخص النتيجة</td></tr>
<tr><td colspan="5">معدل المقاومة بعد 28 يوماً
28 day strength (kg/cm^2)</td><td colspan="4">النسبة من المقاومة المطلوبة
% of required strength</td></tr>
<tr><td colspan="5">67.1</td><td colspan="4">22%</td></tr>
</table>

Table 21: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-450)

<table>
<tr><td colspan="8">Sample Type</td><td>Cubes 10x10x10 cm</td></tr>
<tr><td colspan="2">Place of Curing</td><td colspan="3">An - Najah Labs</td><td colspan="3">Standard Method</td><td>PS-55</td></tr>
<tr><td colspan="2">Concrete Type</td><td colspan="7">Standard mix with 0.0% volumetric replacement of sand</td></tr>
<tr><td>No.</td><td>Del. No.</td><td>Weight</td><td>Casting date</td><td>Testing date</td><td>Age</td><td>Slump</td><td>Crushing load</td><td>Comp. strength</td></tr>
<tr><td>الرقم</td><td>الارسالية</td><td>الوزن</td><td>تاريخ الصب</td><td>تاريخ الفحص</td><td>العمر</td><td>التهدل</td><td>حمل الكسر</td><td>مقاومة الضغط</td></tr>
<tr><td>-</td><td>-</td><td>(g)</td><td>-</td><td>-</td><td>(day)</td><td>(mm)</td><td>(KN)</td><td>(Kg/cm^2)</td></tr>
<tr><td>1</td><td rowspan="3">-</td><td>2435</td><td rowspan="3">5.12.06</td><td rowspan="3">6.1.07</td><td rowspan="3">32</td><td rowspan="3">20-30</td><td>450.0</td><td>459.0</td></tr>
<tr><td>2</td><td>2465</td><td>480.0</td><td>489.6</td></tr>
<tr><td>3</td><td>2390</td><td>460.0</td><td>469.0</td></tr>
<tr><td colspan="9">Summary ملخص النتيجة</td></tr>
<tr><td colspan="5">المقاومة بعد 28 يوماً
28 day strength (kg/cm^2)</td><td colspan="4">النسبة من المقاومة المطلوبة
% of required strength</td></tr>
<tr><td colspan="5">472.6</td><td colspan="4">95%</td></tr>
</table>

Table 22: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-450)

<table>
<tr><td colspan="8">Sample Type</td><td>Cubes 10x10x10 cm</td></tr>
<tr><td colspan="2">Place of Curing</td><td colspan="3">An - Najah Labs</td><td colspan="3">Standard Method</td><td>PS-55</td></tr>
<tr><td colspan="2">Concrete Type</td><td colspan="7">Standard mix with 25% volumetric replacement of sand</td></tr>
<tr><td>No.</td><td>Del. No.</td><td>Weight</td><td>Casting date</td><td>Testing date</td><td>Age</td><td>Slump</td><td>Crushing load</td><td>Comp. strength</td></tr>
<tr><td>الرقم</td><td>الارسالية</td><td>الوزن</td><td>تاريخ الصب</td><td>تاريخ الفحص</td><td>العمر</td><td>التهدل</td><td>حمل الكسر</td><td>مقاومة الضغط</td></tr>
<tr><td>-</td><td>-</td><td>(g)</td><td>-</td><td>-</td><td>(day)</td><td>(mm)</td><td>(KN)</td><td>(Kg/cm^2)</td></tr>
<tr><td>1</td><td rowspan="4">-</td><td>2181</td><td rowspan="4">14.2.07</td><td rowspan="4">14.3.07</td><td rowspan="4">28</td><td rowspan="4">20-30</td><td>272.0</td><td>277.4</td></tr>
<tr><td>2</td><td>2198</td><td>281.0</td><td>286.6</td></tr>
<tr><td>3</td><td>2183</td><td>275.0</td><td>280.5</td></tr>
<tr><td>4</td><td>2199</td><td>289.0</td><td>294.8</td></tr>
<tr><td colspan="9">Summary ملخص النتيجة</td></tr>
<tr><td colspan="5">المقاومة بعد 28 يوماً
28 day strength (kg/cm^2)</td><td colspan="4">النسبة من المقاومة المطلوبة
% of required strength</td></tr>
<tr><td colspan="5">284.8</td><td colspan="4">63%</td></tr>
</table>

Table 23: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-450)

Sample Type							Cubes 10x10x10 cm	
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 50% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	الارسالية	الوزن	تاريخ الصب	تاريخ الفحص	العمر	التهدل	حمل الكسر	مقاومة الضغط
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2149	14.2.07	14.3.07	28	20-30	230.0	**234.6**
2		2157					223.0	**227.5**
3		2157					219.0	**223.4**
4		2158					221.0	**225.4**
Summary ملخص النتيجة								
المقاومة بعد 28 يوماً **28 day strength (kg/cm^2)**				**النسبة من المقاومة المطلوبة** **% of required strength**				
227.7				**51%**				

Table 24: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-450)

Sample Type							Cubes 10x10x10 cm	
Place of Curing		An - Najah Labs		**Standard Method**			PS-55	
Concrete Type		Standard mix with 75% volumetric replacement of sand						
No.	**Del. No.**	**Weight**	**Casting date**	**Testing date**	**Age**	**Slump**	**Crushing load**	**Comp. strength**
الرقم	الارسالية	الوزن	تاريخ الصب	تاريخ الفحص	العمر	التهدل	حمل الكسر	مقاومة الضغط
-	**-**	**(g)**	**-**	**-**	**(day)**	**(mm)**	**(KN)**	**(Kg/cm^2)**
1	-	2003	14.2.07	14.3.07	28	20-30	133.0	**135.7**
2		2021					143.0	**145.9**
3		2048					149.0	**152.0**
4		2039					142.0	**144.8**
Summary ملخص النتيجة								
المقاومة بعد 28 يوماً **28 day strength (kg/cm^2)**				**النسبة من المقاومة المطلوبة** **% of required strength**				
144.6				**32%**				

Table 25: CONCRETE COMPRESSIVE STRENGTH TEST RESULTS (B-450)

<table>
<tr><td colspan="7">Sample Type</td><td colspan="2">Cubes 10x10x10 cm</td></tr>
<tr><td colspan="2">Place of Curing</td><td colspan="2">An - Najah Labs</td><td colspan="3">Standard Method</td><td colspan="2">PS-55</td></tr>
<tr><td colspan="2">Concrete Type</td><td colspan="7">Standard mix with 100% volumetric replacement of sand</td></tr>
<tr><td>No.</td><td>Del. No.</td><td>Weight</td><td>Casting date</td><td>Testing date</td><td>Age</td><td>Slump</td><td>Crushing load</td><td>Comp. strength</td></tr>
<tr><td>الرقم</td><td>الارسالية</td><td>الوزن</td><td>تاريخ الصب</td><td>تاريخ الفحص</td><td>العمر</td><td>التهدل</td><td>حمل الكسر</td><td>مقاومة الضغط</td></tr>
<tr><td>-</td><td>-</td><td>(g)</td><td>-</td><td>-</td><td>(day)</td><td>(mm)</td><td>(KN)</td><td>(Kg/cm^2)</td></tr>
<tr><td>1</td><td rowspan="4">-</td><td>1952</td><td rowspan="4">14.2.07</td><td rowspan="4">14.3.07</td><td rowspan="4">28</td><td rowspan="4">20-30</td><td>89.0</td><td>90.8</td></tr>
<tr><td>2</td><td>1954</td><td>92.0</td><td>93.8</td></tr>
<tr><td>3</td><td>1925</td><td>94.0</td><td>95.9</td></tr>
<tr><td>4</td><td>1965</td><td>88.0</td><td>89.8</td></tr>
<tr><td colspan="9">Summary ملخص النتيجة</td></tr>
<tr><td colspan="4">المقاومة بعد 28 يوماً
28 day strength (kg/cm^2)</td><td colspan="5">النسبة من المقاومة المطلوبة
% of required strength</td></tr>
<tr><td colspan="4">92.6</td><td colspan="5">21%</td></tr>
</table>

APPENDIX B

STRESS – STRAIN FIGURES

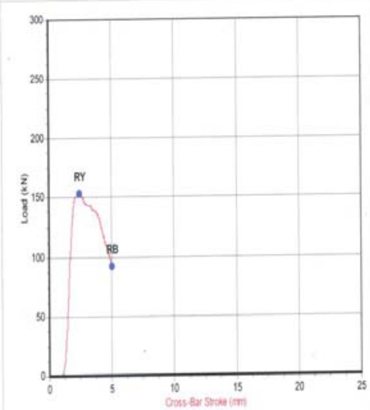
Certificato N. PCC250-25of 15/03/2007 Provetta N. of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	5.02	mm

PCC250-25-1



Tests results

Fm	152.916	kN
σM	15.292	MPa
εM		%
σY	15.292	MPa
εY		%
σB	9.177	MPa
εB		%

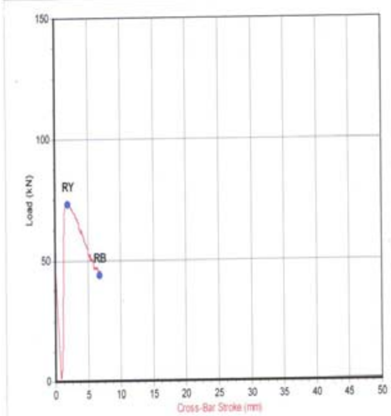
Certificato N. PCC200-75of 07/03/2007 Provetta N. of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	6.87	mm

PCC200-75-1



Tests results

Fm	72.840	kN
σM	7.284	MPa
εM		%
σY	7.284	MPa
εY		%
σB	4.371	MPa
εB		%

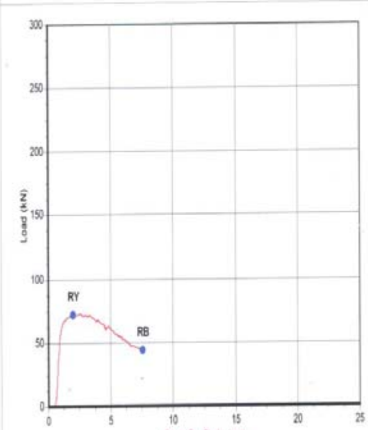
Certificato N. PCC250-10of2 15/03/2007 Provetta N. of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	7.56	mm

PCC250-100-2



Tests results

Fm	72.292	kN
σM	7.229	MPa
εM		%
σY	7.167	MPa
εY		%
σB	4.338	MPa
εB		%

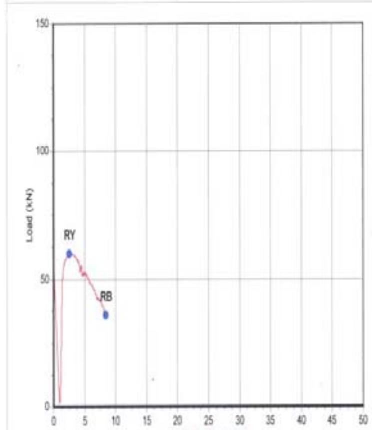
Certificato N. PCC200-10of2 07/03/2007 Provetta N. of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	8.44	mm

PCC200-100-2



Tests results

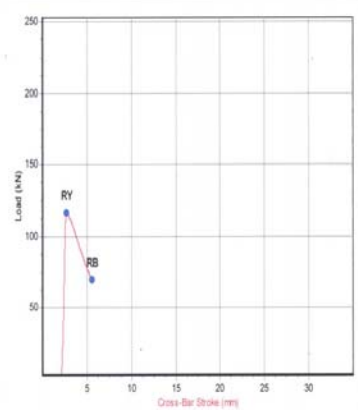
Fm	59.902	kN
σM	5.990	MPa
εM		%
σY	5.990	MPa
εY		%
σB	3.596	MPa
εB		%

Certificato N. PCC200-50of 07/03/2007 **Provetta N.** of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza					
Massa Lineica			**Temperatura Amb.**	20		
Classe (EN 10002/2)			**Posizione Prelievo**	Vertical		
Umidità Relativa			**Direzione Prelievo**	Vertical		
Specimen Square			**Speed 1**	1.00	mm/min	
Width	100.00	mm	**Speed 2**	0.50	mm/min	
Thickness	100.00	mm	**Lo**	.00	mm	
			Le	.00	mm	
Preloading time	.00	sec	**Lc**	.00	mm	
So	10000.000	mm²	**Lu**	5.56	mm	

PCC200-50-1



Tests results

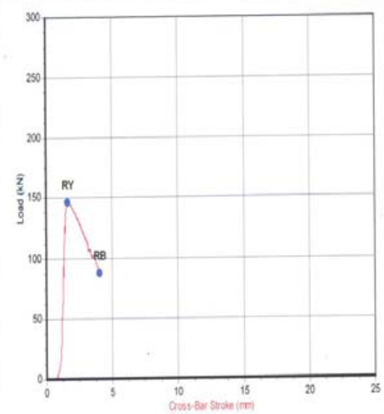
Fm	115.966	**kN**
σM	11.597	**MPa**
εM		**%**
σY	11.597	**MPa**
εY		**%**
σB	6.959	**MPa**
εB		**%**

Certificato N. PCC250-50of 15/03/2007 **Provetta N.** of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza					
Massa Lineica			**Temperatura Amb.**	20		
Classe (EN 10002/2)			**Posizione Prelievo**	Vertical		
Umidità Relativa			**Direzione Prelievo**	Vertical		
Specimen Square			**Speed 1**	1.00	mm/min	
Width	100.00	mm	**Speed 2**	0.50	mm/min	
Thickness	100.00	mm	**Lo**	.00	mm	
			Le	.00	mm	
Preloading time	.00	sec	**Lc**	.00	mm	
So	10000.000	mm²	**Lu**	4.06	mm	

PCC250-50-1



Tests results

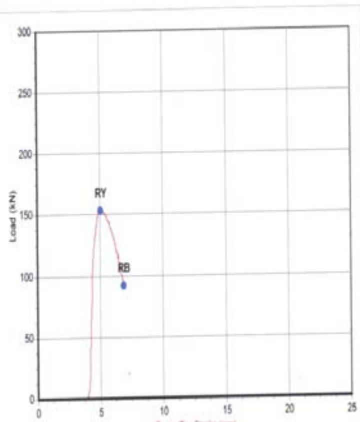
Fm	145.972	**kN**
σM	14.597	**MPa**
εM		**%**
σY	14.597	**MPa**
εY		**%**
σB	8.761	**MPa**
εB		**%**

Certificato N. PCC200-25of 07/03/2007 **Provetta N.** of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza					
Massa Lineica			**Temperatura Amb.**	20		
Classe (EN 10002/2)			**Posizione Prelievo**	Vertical		
Umidità Relativa			**Direzione Prelievo**	Vertical		
Specimen Square			**Speed 1**	1.00	mm/min	
Width	100.00	mm	**Speed 2**	0.50	mm/min	
Thickness	100.00	mm	**Lo**	.00	mm	
			Le	.00	mm	
Preloading time	.00	sec	**Lc**	.00	mm	
So	10000.000	mm²	**Lu**	6.85	mm	

PCC200-25-1



Tests results

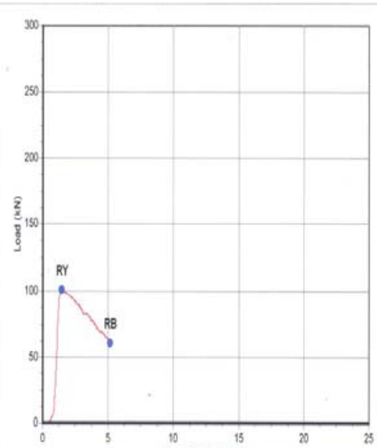
Fm	153.245	**kN**
σM	15.325	**MPa**
εM		**%**
σY	15.325	**MPa**
εY		**%**
σB	9.195	**MPa**
εB		**%**

Certificato N. PCC250-75of 15/03/2007 **Provetta N.** of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza					
Massa Lineica			**Temperatura Amb.**	20		
Classe (EN 10002/2)			**Posizione Prelievo**	Vertical		
Umidità Relativa			**Direzione Prelievo**	Vertical		
Specimen Square			**Speed 1**	1.00	mm/min	
Width	100.00	mm	**Speed 2**	0.50	mm/min	
Thickness	100.00	mm	**Lo**	.00	mm	
			Le	.00	mm	
Preloading time	.00	sec	**Lc**	.00	mm	
So	10000.000	mm²	**Lu**	5.18	mm	

PCC250-75-1



Tests results

Fm	100.324	**kN**
σM	10.032	**MPa**
εM		**%**
σY	10.032	**MPa**
εY		**%**
σB	6.019	**MPa**
εB		**%**

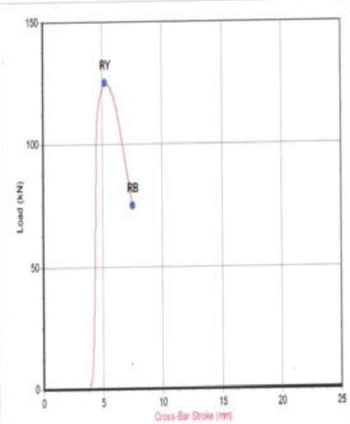
Certificato N. 1 of 04/03/2007 Provetta N. 1 of 04/03/2007

Lotto di Consegna Dr. Abaza

Natura del Materiale			
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	7.49	mm

PCC 150 25%



Tests results		
Fm	124.921	kN
σM	12.492	MPa
εM		%
σY	12.492	MPa
εY		%
σB	7.496	MPa
εB		%

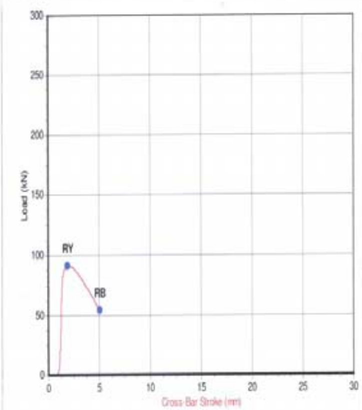
Certificato N. PCC15-50-of 04/03/2007 Provetta N. 2 of 04/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	5.06	mm

PCC15-50-4



Tests results		
Fm	90.712	kN
σM	9.071	MPa
εM		%
σY	9.068	MPa
εY		%
σB	5.446	MPa
εB		%

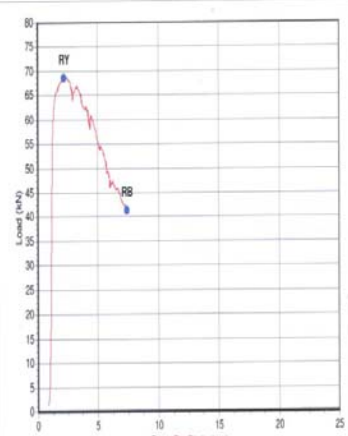
Certificato N. PCC150-75of 04/03/2007 Provetta N. 2 of 04/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	7.43	mm

PCC15-75-1



Tests results		
Fm	68.637	kN
σM	6.864	MPa
εM		%
σY	6.864	MPa
εY		%
σB	4.119	MPa
εB		%

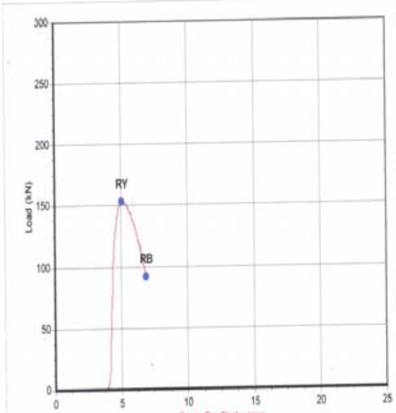
Certificato N. PCC200-25of 07/03/2007 Provetta N. of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	6.85	mm

PCC200-25-1



Tests results	
Fm	153.245
σM	15.325
εM	
σY	15.325
εY	
σB	9.195
εB	

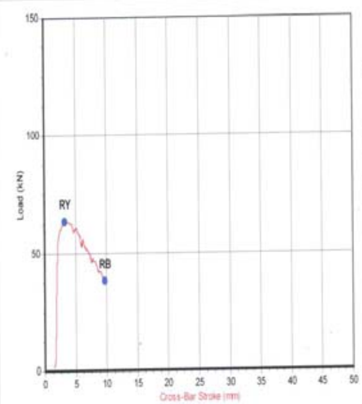
Certificato N. PCC200-10of4 07/03/2007 Provetta N. of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	9.77	mm

PCC200-100-



Tests results

Fm	63.520	kN
σM	6.352	MPa
εM		%
σY	6.337	MPa
εY		%
σB	3.812	MPa
εB		%

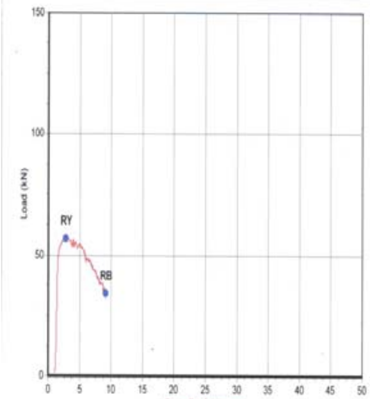
Certificato N. PCC200-10of3 07/03/2007 Provetta N. of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	9.16	mm

PCC200-100-3



Tests results

Fm	57.015	kN
σM	5.701	MPa
εM		%
σY	5.701	MPa
εY		%
σB	3.421	MPa
εB		%

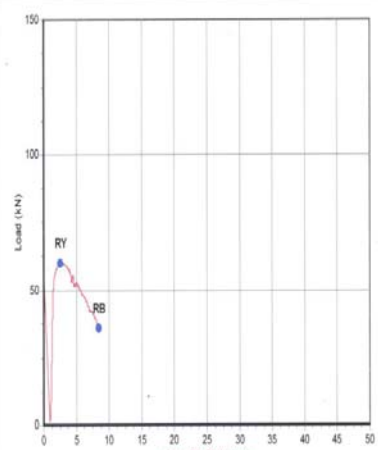
Certificato N. PCC200-10of2 07/03/2007 Provetta N. of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	8.44	mm

PCC200-100-2



Tests results

Fm	59.902	kN
σM	5.990	MPa
εM		%
σY	5.990	MPa
εY		%
σB	3.596	MPa
εB		%

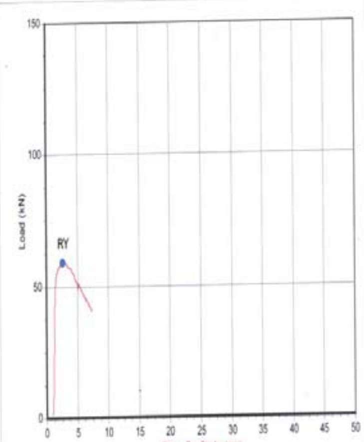
Certificato N. PCC200-10of1 07/03/2007 Provetta N. of 07/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	7.35	mm

PCC200-100-1



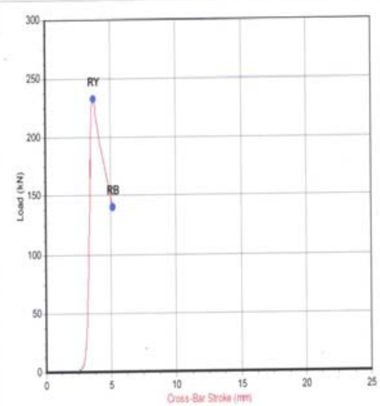
Tests results

Fm	1197.563	kN
σM	119.756	MPa
εM		%
σY	5.899	MPa
εY		%
σB	119.756	MPa
εB		%

Certificato N.	**PCC250-25of 15/03/2007**	**Provetta N.**	**of 15/03/2007**
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		**Temperatura Amb.**	20
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical
Umidità Relativa		**Direzione Prelievo**	Vertical

Specimen Square			**Speed 1**	1.00	mm/min
Width	100.00	mm	**Speed 2**	0.50	mm/min
Thickness	100.00	mm	**Lo**	.00	mm
			Le	.00	mm
Preloading time	.00	sec	**Lc**	.00	mm
So	10000.000	mm²	**Lu**	5.19	mm

PCC250-25-2



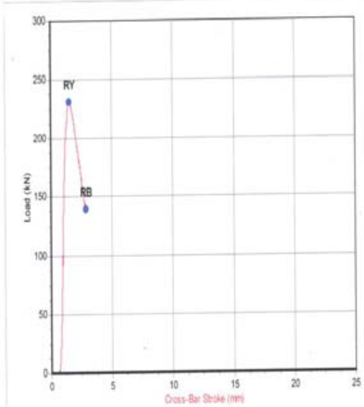
Tests results

Fm	232.554	**kN**
σM	23.255	**MPa**
εM		**%**
σY	23.255	**MPa**
εY		**%**
σB	13.958	**MPa**
εB		**%**

Certificato N.	**PCC250-25of 15/03/2007**	**Provetta N.**	**of 15/03/2007**
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		**Temperatura Amb.**	20
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical
Umidità Relativa		**Direzione Prelievo**	Vertical

Specimen Square			**Speed 1**	1.00	mm/min
Width	100.00	mm	**Speed 2**	0.50	mm/min
Thickness	100.00	mm	**Lo**	.00	mm
			Le	.00	mm
Preloading time	.00	sec	**Lc**	.00	mm
So	10000.000	mm²	**Lu**	2.85	mm

PCC250-25-3



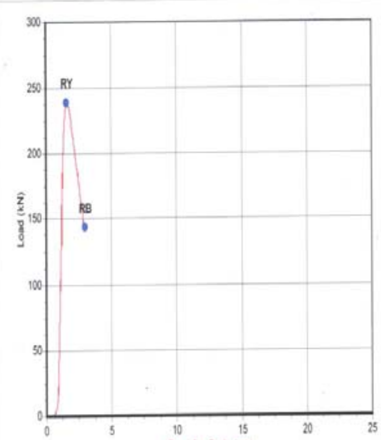
Tests results

Fm	230.763	**kN**
σM	23.076	**MPa**
εM		**%**
σY	23.076	**MPa**
εY		**%**
σB	13.866	**MPa**
εB		**%**

Certificato N.	**PCC250-25of 15/03/2007**	**Provetta N.**	**of 15/03/2007**
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		**Temperatura Amb.**	20
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical
Umidità Relativa		**Direzione Prelievo**	Vertical

Specimen Square			**Speed 1**	1.00	mm/min
Width	100.00	mm	**Speed 2**	0.50	mm/min
Thickness	100.00	mm	**Lo**	.00	mm
			Le	.00	mm
Preloading time	.00	sec	**Lc**	.00	mm
So	10000.000	mm²	**Lu**	2.97	mm

PCC250-25-4



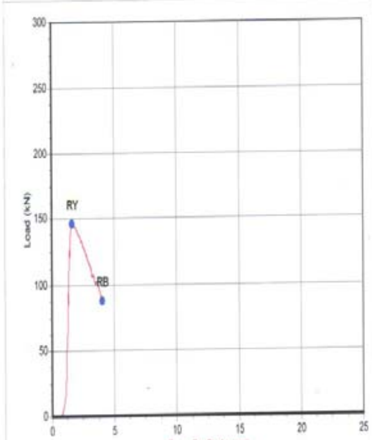
Tests results

Fm	239.060	**kN**
σM	23.906	**MPa**
εM		**%**
σY	23.906	**MPa**
εY		**%**
σB	14.345	**MPa**
εB		**%**

Certificato N.	**PCC250-50of 15/03/2007**	**Provetta N.**	**of 15/03/2007**
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		**Temperatura Amb.**	20
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical
Umidità Relativa		**Direzione Prelievo**	Vertical

Specimen Square			**Speed 1**	1.00	mm/min
Width	100.00	mm	**Speed 2**	0.50	mm/min
Thickness	100.00	mm	**Lo**	.00	mm
			Le	.00	mm
Preloading time	.00	sec	**Lc**	.00	mm
So	10000.000	mm²	**Lu**	4.06	mm

PCC250-50-1

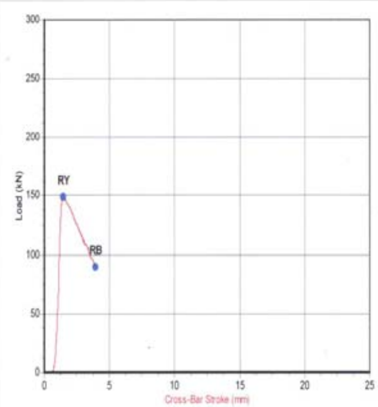


Tests results

Fm	145.972	**kN**
σM	14.597	**MPa**
εM		**%**
σY	14.597	**MPa**
εY		**%**
σB	8.761	**MPa**
εB		**%**

Certificato N.	PCC250-50of 15/03/2007	Provetta N.		of 15/03/2007	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		Temperatura Amb.	20		
Classe (EN 10002/2)		Posizione Prelievo	Vertical		
Umidità Relativa		Direzione Prelievo	Vertical		
Specimen Square		Speed 1	1.00	mm/min	
Width	100.00 mm	Speed 2	0.50	mm/min	
Thickness	100.00 mm	Lo	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	Lc	.00	mm	
So	10000.000 mm²	Lu	3.94	mm	

PCC250-50-2

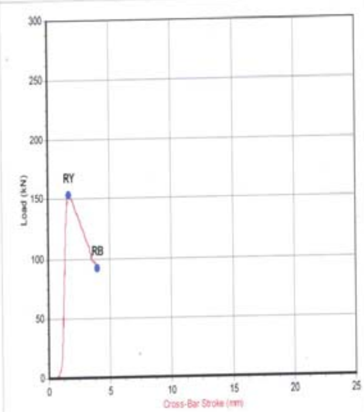


Tests results

Fm	149.042	kN
σM	14.904	MPa
εM		%
σY	14.904	MPa
εY		%
σB	8.947	MPa
εB		%

Certificato N.	PCC250-50of 15/03/2007	Provetta N.		of 15/03/2007	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		Temperatura Amb.	20		
Classe (EN 10002/2)		Posizione Prelievo	Vertical		
Umidità Relativa		Direzione Prelievo	Vertical		
Specimen Square		Speed 1	1.00	mm/min	
Width	100.00 mm	Speed 2	0.50	mm/min	
Thickness	100.00 mm	Lo	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	Lc	.00	mm	
So	10000.000 mm²	Lu	4.01	mm	

PCC250-50-3

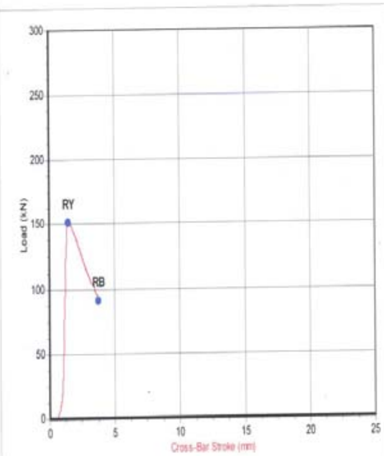


Tests results

Fm	152.733	kN
σM	15.273	MPa
εM		%
σY	15.273	MPa
εY		%
σB	9.166	MPa
εB		%

Certificato N.	PCC250-50of 15/03/2007	Provetta N.		of 15/03/2007	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		Temperatura Amb.	20		
Classe (EN 10002/2)		Posizione Prelievo	Vertical		
Umidità Relativa		Direzione Prelievo	Vertical		
Specimen Square		Speed 1	1.00	mm/min	
Width	100.00 mm	Speed 2	0.50	mm/min	
Thickness	100.00 mm	Lo	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	Lc	.00	mm	
So	10000.000 mm²	Lu	3.76	mm	

PCC250-50-4

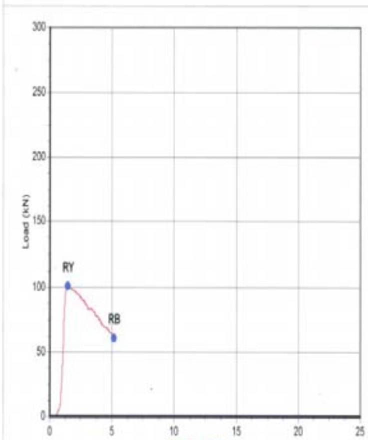


Tests results

Fm	151.308	kN
σM	15.131	MPa
εM		%
σY	15.131	MPa
εY		%
σB	9.078	MPa
εB		%

Certificato N.	PCC250-75of 15/03/2007	Provetta N.		of 15/03/2007	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		Temperatura Amb.	20		
Classe (EN 10002/2)		Posizione Prelievo	Vertical		
Umidità Relativa		Direzione Prelievo	Vertical		
Specimen Square		Speed 1	1.00	mm/min	
Width	100.00 mm	Speed 2	0.50	mm/min	
Thickness	100.00 mm	Lo	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	Lc	.00	mm	
So	10000.000 mm²	Lu	5.18	mm	

PCC250-75-1



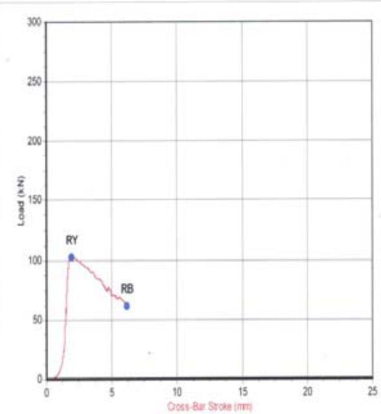
Tests results

Fm	100.324	kN
σM	10.032	MPa
εM		%
σY	10.032	MPa
εY		%
σB	6.019	MPa
εB		%

Certificato N.	PCC250-75of 15/03/2007	Provetta N.	of 15/03/2007
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	6.16	mm

PCC250-75-2



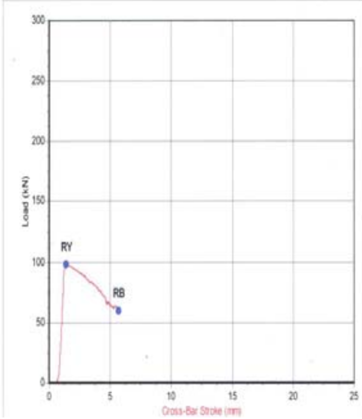
Tests results

Fm	102.480	kN
σM	10.248	MPa
εM		%
σY	10.248	MPa
εY		%
σB	6.151	MPa
εB		%

Certificato N.	PCC250-75of 15/03/2007	Provetta N.	of 15/03/2007
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	5.69	mm

PCC250-75-3



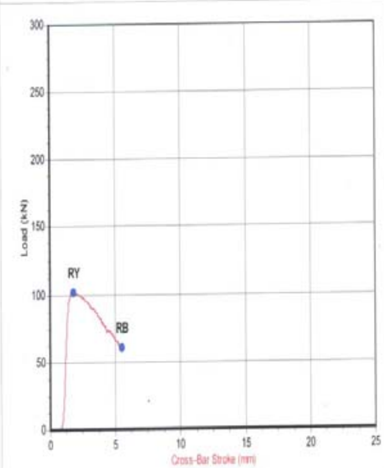
Tests results

Fm	98.387	kN
σM	9.839	MPa
εM		%
σY	9.839	MPa
εY		%
σB	5.910	MPa
εB		%

Certificato N.	PCC250-75of 15/03/2007	Provetta N.	of 15/03/2007
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	5.50	mm

PCC250-75-4



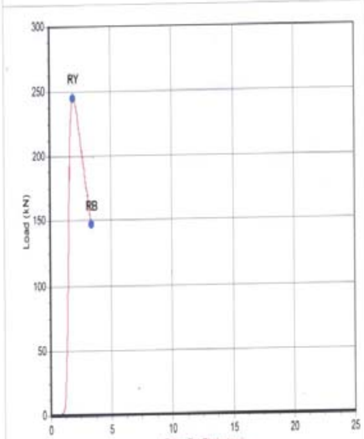
Tests results

Fm	101.091	kN
σM	10.109	MPa
εM		%
σY	10.109	MPa
εY		%
σB	6.067	MPa
εB		%

Certificato N.	PCC300-25of 15/03/2007	Provetta N.	of 15/03/2007
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	3.38	mm

PCC300-25-1



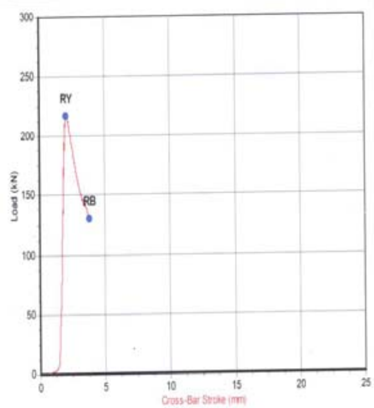
Tests results

Fm	244.688	kN
σM	24.469	MPa
εM		%
σY	24.469	MPa
εY		%
σB	14.681	MPa
εB		%

Certificato N.	PCC300-25of 15/03/2007	Provetta N.	of 15/03/2007
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00 mm/min
Width	100.00	mm	Speed 2	0.50 mm/min
Thickness	100.00	mm	Lo	.00 mm
			Le	.00 mm
Preloading time	.00	sec	Lc	.00 mm
So	10000.000	mm²	Lu	3.81 mm

PCC300-25-2

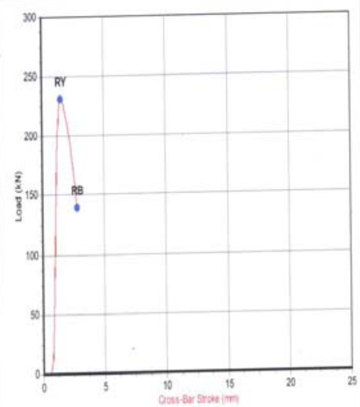


Tests results		
Fm	217.094	kN
σM	21.709	MPa
εM		%
σY	21.709	MPa
εY		%
σB	13.026	MPa
εB		%

Certificato N.	PCC300-25of 15/03/2007	Provetta N.	of 15/03/2007
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00 mm/min
Width	100.00	mm	Speed 2	0.50 mm/min
Thickness	100.00	mm	Lo	.00 mm
			Le	.00 mm
Preloading time	.00	sec	Lc	.00 mm
So	10000.000	mm²	Lu	2.84 mm

PCC300-25-3

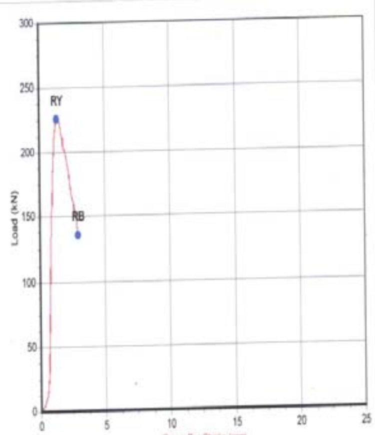


Tests results		
Fm	231.165	kN
σM	23.117	MPa
εM		%
σY	23.117	MPa
εY		%
σB	13.877	MPa
εB		%

Certificato N.	PCC300-25of 15/03/2007	Provetta N.	of 15/03/2007
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00 mm/min
Width	100.00	mm	Speed 2	0.50 mm/min
Thickness	100.00	mm	Lo	.00 mm
			Le	.00 mm
Preloading time	.00	sec	Lc	.00 mm
So	10000.000	mm²	Lu	2.93 mm

PCC300-25-4

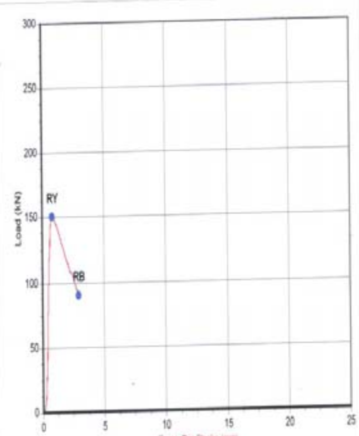


Tests results		
Fm	225.427	kN
σM	22.543	MPa
εM		%
σY	22.543	MPa
εY		%
σB	13.526	MPa
εB		%

Certificato N.	PCC300-50of 15/03/2007	Provetta N.	of 15/03/2007
Lotto di Consegna			
Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00 mm/min
Width	100.00	mm	Speed 2	0.50 mm/min
Thickness	100.00	mm	Lo	.00 mm
			Le	.00 mm
Preloading time	.00	sec	Lc	.00 mm
So	10000.000	mm²	Lu	2.93 mm

PCC300-50-1



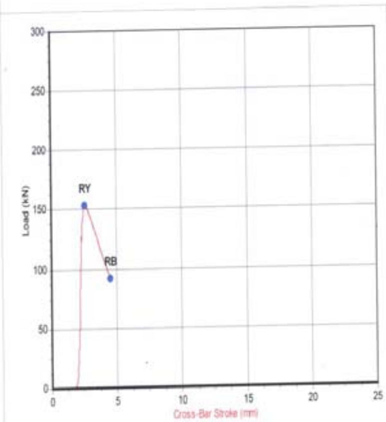
Tests results		
Fm	150.650	kN
σM	15.065	MPa
εM		%
σY	15.065	MPa
εY		%
σB	9.042	MPa
εB		%

Certificato N. PCC300-50of Provetta N. of

Lotto di Consegna

Natura del Materiale	Dr.Abaza				
Massa Lineica			Temperatura Amb.	20	
Classe (EN 10002/2)			Posizione Prelievo	Vertical	
Umidità Relativa			Direzione Prelievo	Vertical	
Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	4.53	mm

PCC300-50-2



Tests results

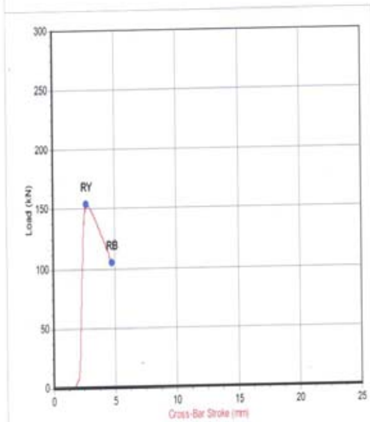
Fm	153.428	kN
σM	15.343	MPa
εM		%
σY	15.343	MPa
εY		%
σB	9.206	MPa
εB		%

Certificato N. PCC300-50of 15/03/2007 Provetta N. of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza				
Massa Lineica			Temperatura Amb.	20	
Classe (EN 10002/2)			Posizione Prelievo	Vertical	
Umidità Relativa			Direzione Prelievo	Vertical	
Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	4.78	mm

PCC300-50-3



Tests results

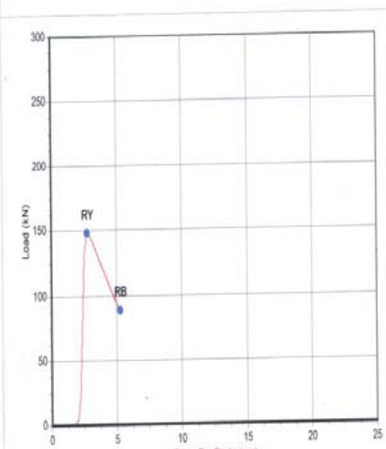
Fm	153.793	kN
σM	15.379	MPa
εM		%
σY	15.379	MPa
εY		%
σB	10.471	MPa
εB		%

Certificato N. PCC300-50of 15/03/2007 Provetta N. of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza				
Massa Lineica			Temperatura Amb.	20	
Classe (EN 10002/2)			Posizione Prelievo	Vertical	
Umidità Relativa			Direzione Prelievo	Vertical	
Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	5.25	mm

PCC300-50-4



Tests results

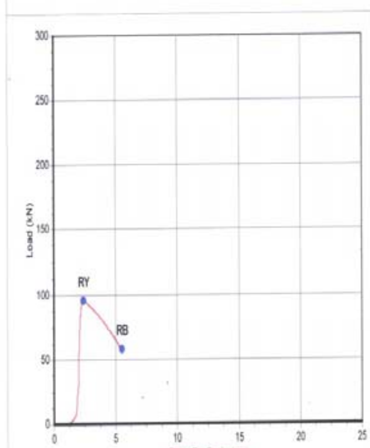
Fm	147.580	kN
σM	14.758	MPa
εM		%
σY	14.758	MPa
εY		%
σB	8.856	MPa
εB		%

Certificato N. PCC300-75of 15/03/2007 Provetta N. of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza				
Massa Lineica			Temperatura Amb.	20	
Classe (EN 10002/2)			Posizione Prelievo	Vertical	
Umidità Relativa			Direzione Prelievo	Vertical	
Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	5.54	mm

PCC300-75-1



Tests results

Fm	95.609	kN
σM	9.561	MPa
εM		%
σY	9.561	MPa
εY		%
σB	5.738	MPa
εB		%

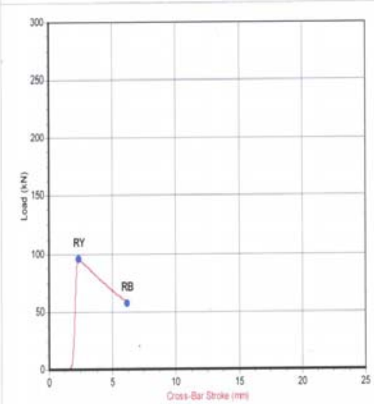
Certificato N. PCC300-75of 15/03/2007 Provetta N. of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	6.17	mm

PCC300-75-2



Tests results

Fm	95.098	kN
σM	9.510	MPa
εM		%
σY	9.510	MPa
εY		%
σB	5.709	MPa
εB		%

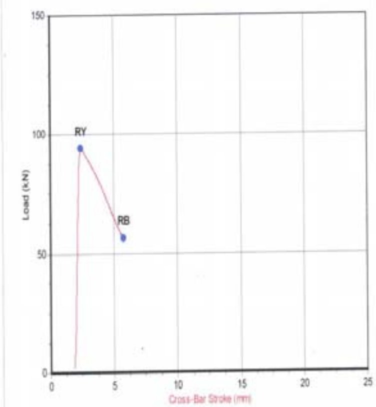
Certificato N. PCC300-75of 15/03/2007 Provetta N. of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	5.74	mm

PCC300-75-3



Tests results

Fm	94.001	kN
σM	9.400	MPa
εM		%
σY	9.400	MPa
εY		%
σB	5.643	MPa
εB		%

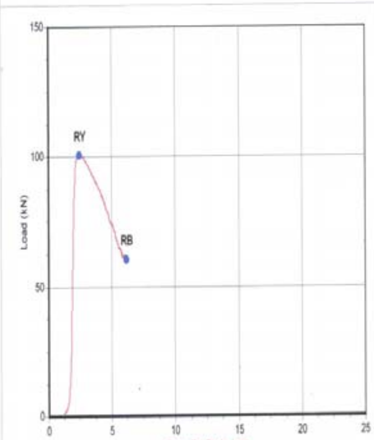
Certificato N. PCC300-75of 15/03/2007 Provetta N. of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	6.15	mm

PCC300-75-4



Tests results

Fm	100.689	kN
σM	10.069	MPa
εM		%
σY	10.069	MPa
εY		%
σB	6.041	MPa
εB		%

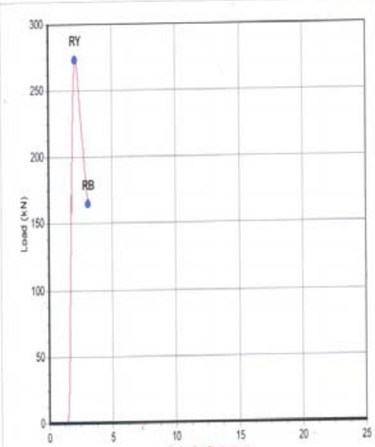
Certificato N. PCC450-25of Provetta N.

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		Temperatura Amb.	20
Classe (EN 10002/2)		Posizione Prelievo	Vertical
Umidità Relativa		Direzione Prelievo	Vertical

Specimen Square			Speed 1	1.00	mm/min
Width	100.00	mm	Speed 2	0.50	mm/min
Thickness	100.00	mm	Lo	.00	mm
			Le	.00	mm
Preloading time	.00	sec	Lc	.00	mm
So	10000.000	mm²	Lu	3.12	mm

PCC450-25-1

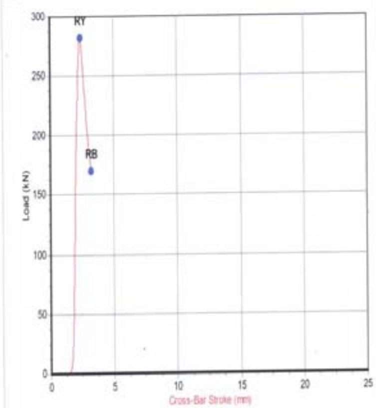


Tests results

Fm	272.903	kN
σM	27.290	MPa
εM		%
σY	27.290	MPa
εY		%
σB	16.443	MPa
εB		%

Certificato N.	PCC450-25of 15/03/2007	Provetta N.		of 15/03/2007	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		Temperatura Amb.	20		
Classe (EN 10002/2)		Posizione Prelievo	Vertical		
Umidità Relativa		Direzione Prelievo	Vertical		
Specimen Square		Speed 1	1.00	mm/min	
Width	100.00 mm	Speed 2	0.50	mm/min	
Thickness	100.00 mm	Lo	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	Lc	.00	mm	
So	10000.000 mm²	Lu	3.21	mm	

PCC450-25-2

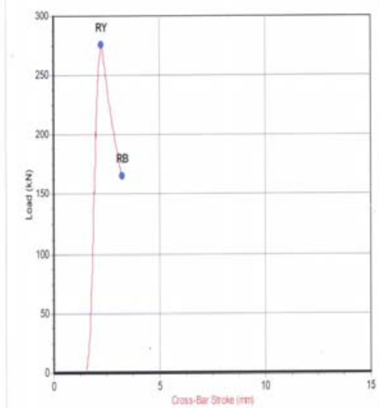


Tests results

Fm	281.674	kN
σM	28.167	MPa
εM		%
σY	28.167	MPa
εY		%
σB	16.940	MPa
εB		%

Certificato N.	PCC450-25of 15/03/2007	Provetta N.		of 15/03/2007	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		Temperatura Amb.	20		
Classe (EN 10002/2)		Posizione Prelievo	Vertical		
Umidità Relativa		Direzione Prelievo	Vertical		
Specimen Square		Speed 1	1.00	mm/min	
Width	100.00 mm	Speed 2	0.50	mm/min	
Thickness	100.00 mm	Lo	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	Lc	.00	mm	
So	10000.000 mm²	Lu	3.23	mm	

PCC450-25-3

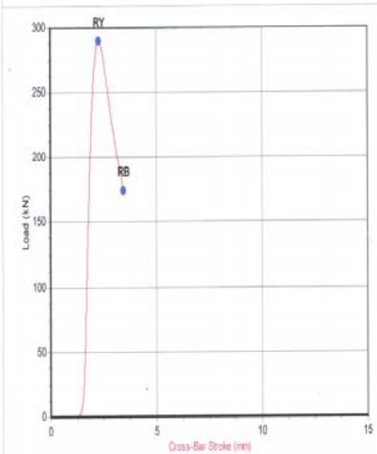


Tests results

Fm	275.352	kN
σM	27.535	MPa
εM		%
σY	27.535	MPa
εY		%
σB	16.523	MPa
εB		%

Certificato N.	PCC450-25of 15/03/2007	Provetta N.		of 15/03/2007	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		Temperatura Amb.	20		
Classe (EN 10002/2)		Posizione Prelievo	Vertical		
Umidità Relativa		Direzione Prelievo	Vertical		
Specimen Square		Speed 1	1.00	mm/min	
Width	100.00 mm	Speed 2	0.50	mm/min	
Thickness	100.00 mm	Lo	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	Lc	.00	mm	
So	10000.000 mm²	Lu	3.46	mm	

PCC450-25-4

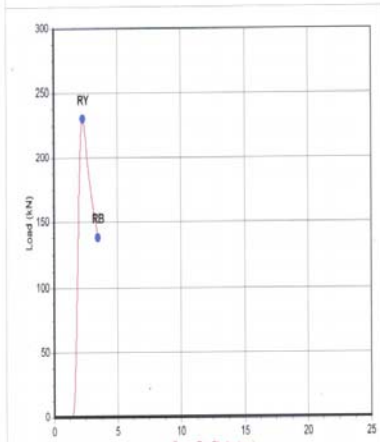


Tests results

Fm	289.642	kN
σM	28.964	MPa
εM		%
σY	28.964	MPa
εY		%
σB	17.433	MPa
εB		%

Certificato N.	PCC450-50of 15/03/2007	Provetta N.		of 15/03/2007	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		Temperatura Amb.	20		
Classe (EN 10002/2)		Posizione Prelievo	Vertical		
Umidità Relativa		Direzione Prelievo	Vertical		
Specimen Square		Speed 1	1.00	mm/min	
Width	100.00 mm	Speed 2	0.50	mm/min	
Thickness	100.00 mm	Lo	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	Lc	.00	mm	
So	10000.000 mm²	Lu	3.48	mm	

PCC450-50-1



Tests results

Fm	230.288	kN
σM	23.029	MPa
εM		%
σY	23.029	MPa
εY		%
σB	13.826	MPa
εB		%

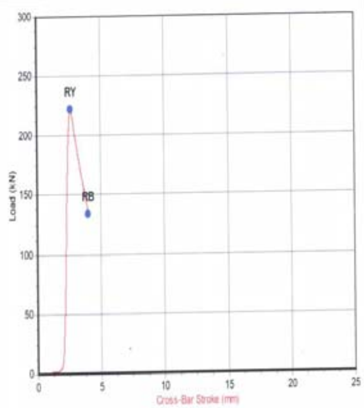
Certificato N. PCC450-50of 15/03/2007 **Provetta N.** of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		**Temperatura Amb.**	20
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical
Umidità Relativa		**Direzione Prelievo**	Vertical

Specimen Square			**Speed 1**	1.00	mm/min
Width	100.00	mm	**Speed 2**	0.50	mm/min
Thickness	100.00	mm	**Lo**	.00	mm
			Le	.00	mm
Preloading time	.00	sec	**Lc**	.00	mm
So	10000.000	mm²	**Lu**	4.01	mm

PCC450-50-2



Tests results

Fm	222.540	**kN**
σM	22.254	**MPa**
εM		**%**
σY	22.254	**MPa**
εY		**%**
σB	13.358	**MPa**
εB		**%**

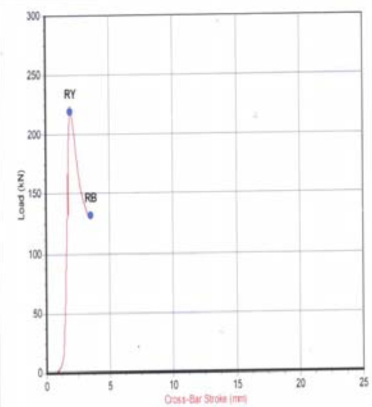
Certificato N. PCC450-50of 15/03/2007 **Provetta N.** of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		**Temperatura Amb.**	20
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical
Umidità Relativa		**Direzione Prelievo**	Vertical

Specimen Square			**Speed 1**	1.00	mm/min
Width	100.00	mm	**Speed 2**	0.50	mm/min
Thickness	100.00	mm	**Lo**	.00	mm
			Le	.00	mm
Preloading time	.00	sec	**Lc**	.00	mm
So	10000.000	mm²	**Lu**	3.51	mm

PCC450-50-3



Tests results

Fm	219.506	**kN**
σM	21.951	**MPa**
εM		**%**
σY	21.951	**MPa**
εY		**%**
σB	13.172	**MPa**
εB		**%**

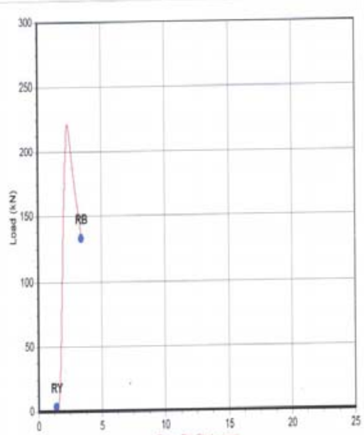
Certificato N. PCC450-50of 15/03/2007 **Provetta N.** of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		**Temperatura Amb.**	20
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical
Umidità Relativa		**Direzione Prelievo**	Vertical

Specimen Square			**Speed 1**	1.00	mm/min
Width	10.00	mm	**Speed 2**	0.50	mm/min
Thickness	100.00	mm	**Lo**	.00	mm
			Le	.00	mm
Preloading time	.00	sec	**Lc**	.00	mm
So	1000.000	mm²	**Lu**	3.41	mm

PCC450-50-4



Tests results

Fm	221.297	**kN**
σM	221.297	**MPa**
εM		**%**
σY	3.911	**MPa**
εY		**%**
σB	133.034	**MPa**
εB		**%**

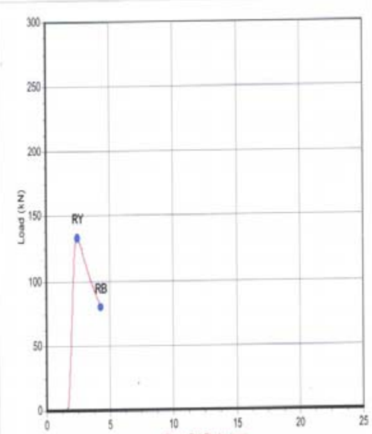
Certificato N. PCC450-75of 15/03/2007 **Provetta N.** of 15/03/2007

Lotto di Consegna

Natura del Materiale	Dr.Abaza		
Massa Lineica		**Temperatura Amb.**	20
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical
Umidità Relativa		**Direzione Prelievo**	Vertical

Specimen Square			**Speed 1**	1.00	mm/min
Width	100.00	mm	**Speed 2**	0.50	mm/min
Thickness	100.00	mm	**Lo**	.00	mm
			Le	.00	mm
Preloading time	.00	sec	**Lc**	.00	mm
So	10000.000	mm²	**Lu**	4.30	mm

PCC450-75-1

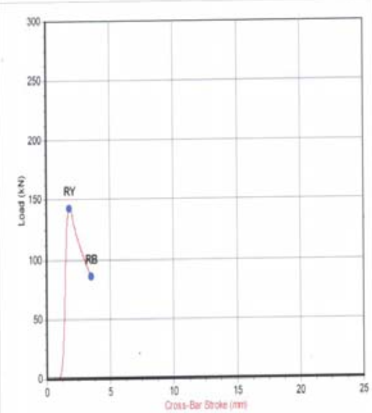


Tests results

Fm	133.144	**kN**
σM	13.314	**MPa**
εM		**%**
σY	13.314	**MPa**
εY		**%**
σB	7.989	**MPa**
εB		**%**

Certificato N.	**PCC450-75of 15/03/2007**	**Provetta N.**		**of 15/03/2007**	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		**Temperatura Amb.**	20		
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical		
Umidità Relativa		**Direzione Prelievo**	Vertical		
Specimen Square		**Speed 1**	1.00	mm/min	
Width	100.00 mm	**Speed 2**	0.50	mm/min	
Thickness	100.00 mm	**Lo**	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	**Lc**	.00	mm	
So	10000.000 mm²	**Lu**	3.54	mm	

PCC450-75-2

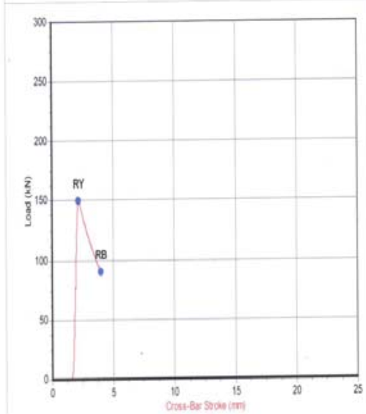


Tests results

Fm	142.683	**kN**
σM	14.268	**MPa**
εM		%
σY	14.268	**MPa**
εY		%
σB	8.567	**MPa**
εB		%

Certificato N.	**PCC450-75of 15/03/2007**	**Provetta N.**		**of 15/03/2007**	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		**Temperatura Amb.**	20		
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical		
Umidità Relativa		**Direzione Prelievo**	Vertical		
Specimen Square		**Speed 1**	1.00	mm/min	
Width	100.00 mm	**Speed 2**	0.50	mm/min	
Thickness	100.00 mm	**Lo**	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	**Lc**	.00	mm	
So	10000.000 mm²	**Lu**	4.00	mm	

PCC450-75-3

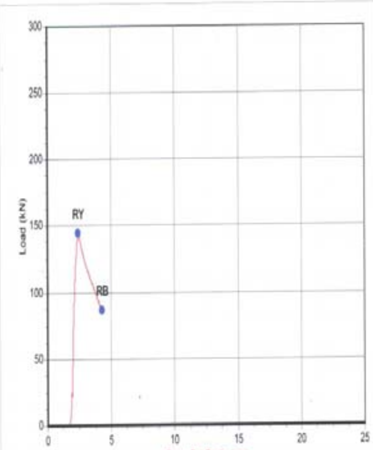


Tests results

Fm	149.517	**kN**
σM	14.952	**MPa**
εM		%
σY	14.952	**MPa**
εY		%
σB	8.976	**MPa**
εB		%

Certificato N.	**PCC450-75of 15/03/2007**	**Provetta N.**		**of 15/03/2007**	
Lotto di Consegna					
Natura del Materiale	Dr.Abaza				
Massa Lineica		**Temperatura Amb.**	20		
Classe (EN 10002/2)		**Posizione Prelievo**	Vertical		
Umidità Relativa		**Direzione Prelievo**	Vertical		
Specimen Square		**Speed 1**	1.00	mm/min	
Width	100.00 mm	**Speed 2**	0.50	mm/min	
Thickness	100.00 mm	**Lo**	.00	mm	
		Le	.00	mm	
Preloading time	.00 sec	**Lc**	.00	mm	
So	10000.000 mm²	**Lu**	4.31	mm	

PCC450-75-4



Tests results

Fm	143.999	**kN**
σM	14.400	**MPa**
εM		%
σY	14.400	**MPa**
εY		%
σB	8.647	**MPa**
εB		%

جامعة النجاح الوطنية
كلية الدراسات العليا

استخدام الإطارات المطاطية العادمة في إنتاج باطون للأغراض غير الإنشائية

إعداد
سليم محمد سليم اشتية

إشراف
د. أسامة أباظة

قدمت هذه الأطروحة استكمالا لمتطلبات درجة الماجستير في هندسة الطرق والمواصلات بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.
2007

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الملخص

تهدف هذه الأطروحة بشكل عام للبحث في إمكانية استخدام الإطارات المطاطية العادمة في الخلطات الخرسانية من أجل إنتاج خرسانة لاستعمالات غير إنشائية، ودراسة تأثير المطاط على سلوك الخرسانة، والمساعدة جزئياً في حل المشكلة البيئية الناجمة عن التخلص من الإطارات العادمة.

لقد تم فحص المواد الخام (الركام الخشن والناعم) المستخدم في هذه الأطروحة، وتم استبدال الركام الناعم (الرمل) حجمياً بالإطارات المطاطية العادمة المطحونة بنسبة 0، 25، 50، 75، و100% في خلطات خرسانية مختلفة الدرجات 150، 200، 250، 300، ودرجة 450 كغم/سم^2. تم عمل فحوصات مختلفة على الخرسانة الطازجة والمتصلبة من حيث مقاومة الضغط، التهدل، امتصاص الماء، الكثافة، مقاومة الإهتراء، معامل المرونة، والعزل الصوتي والحراري.

تبين النتائج أن مقاومة الضغط والكثافة ومعامل المرونة تقل بزيادة نسبة الإطارات المطاطية العادمة المطحونة، أما امتصاص الماء يقل في البداية ثم يبدأ بالزيادة بزيادة نسبة المطاط، وتبين النتائج كذلك أنه لا يوجد تغير ملحوظ في التهدل. وفيما يتعلق بمقاومة الإهتراء والعزل الصوتي والحراري تزداد بزيادة نسبة المطاط العادمة.

أخيرا" فإنه يوصى باستخدام الإطارات المطاطية العادمة في الخلطات الخرسانية لاستعمالات غير إنشائية، مثل الأرضيات، باطون خلف حجر البناء، الطوب الخرساني واسعمالات غير إنشائية أخرى.