An Investigation of the Compressive Strength of Wood, Tyre/Polyester Resin Composite

Rahul Saxena[1], Veer Singh[2]

[1]*Scholar Rama University, Kanpur, Uttar Pradesh, India*
[2]*Assistant professor, Rama University, Kanpur, Uttar Pradesh, India*

***Abstract*—Natural fibers are rich in cellulose, abundantly available and easy to handle and process. Over 55% of paper and paperboard production and 80% of natural fiber reinforced composites are made from wood fibers. The development of nanotechnology and biotechnology in the past 10 years has pushed the research and development of wood fibers. And waste tyre rubber has become a major environmental problem. A huge volume of waste in from of used tyres is generated every year which is not bio-degradable. Here the worlds generate about 13.5 million tons of use tyres annually and about 1 million ton tyre scrap is stockpiled in India. These stockpiles are dangerous from environmental point of view. So utilization of this scrap into a useful product is necessary. Wood fiber are usually cellulosic elements that are extracted from trees and used to make materials including paper .wood fiber can be pressed into hard ,flat panels which can be used as ales expansive alternative to wood or plywood in situation not requiring structural strength. Here, these two constituents mixed and binding with polyester resin in different concentration and analyze the effect on compressive strength of the composite with variation of the concentration of tyre with wood.**

***Keywords*— Wood, Tyre, Composite,Compressive strength**

I. INTRODUCTION

Discarded tyres represent an important contribution of no degradable materials on waste deposits, thus recyclability of these rubbers is environmentally necessary and economically attractive, however the matrix phase in tyres is a vulcanized rubber that cannot be dissolved or molten, limiting their recyclability when it is expected to be used as powdered tyres, most commonly known as waste tyre dust. which has been used as filler in thermoplastics, thermo sets or virgin rubbers Polyethylene and polypropylene are thermoplastics widely reported to prepare waste tyre dust filled compounds, although some others such as ethylene-vinyl-acetate and polystyrene have been also reported. Polystyrene has been the most studied thermoplastic in this topic. The polystyrene and waste tyre composites were prepared by blending in a twin screw extruder. The mechanical properties of the composites were influenced by several factors like the Ultra violet radiation time, waste tyre dust loading and ally amine concentrations. In a general way the mechanical properties of modified waste tyre dust composites were better than unmodified waste tyre .

Dust composites. Waste tyre dust was modified by an ethylene plasma treatment to confer a better affinity between the polystyrene continuous phase and the waste tyre dust dispersed phase.

II. TYRE DUST PREPARATION

Tyre rubber aggregates are obtained from waste tyres using two different technologies: mechanical grinding at ambient temperature or cryogenic grinding at a temperature below the glass transition temperature. The first method generates chipped rubber to replace coarse aggregates. As for the second method it usually produces crumb rubber to replace fine aggregates. Some research has already been conducted on the use of waste tyre as aggregate replacement in concrete showing that rubber aggregates reduces concrete workability and compressive strength. The strength loss is much more profound when coarse rubber aggregates are used which is due to the low adhesion between these wastes. but several authors recommend different treatments to enhance the adhesion of the rubber aggregates.

III. WOODEN FIBRE

Wooden fibre or wooden dust is described as any wood particle arising from the processing or handling of wood, such as cutting, sanding, or milling. It does not include dust from pulp or processed cellulose fibers. It also does not include paper or “cellulose” dust, starches, or other types of dusts that may be at facility. The term “wood dust” also does not apply to large pieces of wood such as wood chips or wood mulch. However, could be smaller wood dust particles that are likely to be mixed in with these larger wood items. Wood dust is generated in a variety of grinding, sanding, cutting, milling, and debarking operations. Wood dust may be generated in production operations or in other areas, such as carpentry shops, where wood is cut. When handling wood waste and cleaning around operations such as those listed above, wood dust that has settled may become airborne. Employees can breathe wood dust whenever it is generated. The nose filters out larger dust particles, but smaller wood particles may be breathed into your lungs. Wood fiber can be used as a substrate in hydroponics (i.e. wood silvers) have been a substrate of choice since the earliest days of the day hydroponics research .wood fiber can be combined with thermoplastic to create strong, waterproof products for outdoor use such as deck boards or outdoor furniture.

IV. POLYESTER RESIN

Polystyrene is one of many types of plastic but it is of particular environmental concern. Production requires significant energy and use of non-renewable resources. There are limited recycling services available and the properties of polystyrene mean that it often escapes from landfill and becomes rubbish .Polystyrene is a type of plastic that is used for a variety of functions including in rigid items such as refrigerator crispers, coat hangers, DVD cases and printer cartridges Polystyrene foam is a derivative of polystyrene known as Styrofoam or expanded polystyrene (EPS).

It is used in protective packaging for appliances and in products such as insulated disposable cups, meat trays and panel insulation Polystyrene is a versatile plastic used to make a wide variety of consumer products. As a hard, solid plastic, it is often used in products that require clarity, such as food packaging and laboratory ware. When combined with various colorants, additives or other plastics, polystyrene is used to make appliances, electronics, automobile parts, toys, gardening pots and equipment and more. Polystyrene also is made into a foam material, called expanded polystyrene or extruded polystyrene, which is valued for its insulating and cushioning properties. Foam polystyrene can be more than 95 percent air and is widely used to make home and appliance insulation, lightweight protective packaging, surfboards, foodservice and food packaging, automobile parts, roadway and road bank stabilization systems, and more. Polystyrene is made by stringing together, or polymerizing, styrene, a building-block chemical used in the manufacture of many products. Styrene also occurs naturally in foods such as strawberries, cinnamon, coffee and beef.

A. MECHANICAL PROPERTIES

The mechanical properties of extruded polystyrene foam depend primarily on density, as illustrated in. Generally, strength characteristics increase with density; however the cushioning characteristics of extruded polystyrene foam packaging are affected by the geometry of the molded part and, to a lesser extent, by bead size and processing conditions, as well as density. This unique characteristic allows a packaging engineer to fine-tune cushioning performance by simple processing changes, without the need to redesign or retool. For shock cushioning, the extruded polystyrene packaging industry has developed typical cushioning curves for use by designers of extruded polystyrene transport packaging. Shock cushioning properties of extruded polystyrene are not significantly affected by change in temperature. Recent studies conducted at San Jose University, Packaging Program, have shown that the optimum performance characteristics of extruded polystyrene are not affected by changes between –17 C and 43 C. Packaging engineers should regard the following data as an accurate representation of the performance of extruded polystyrene foam.

B. DENSITY

Packaging density must be considered when choosing the correct level of cushioning needed for the job. In the preliminary design stages, cushion curves developed from dynamic drop testing are used to determine the correct package configuration—foam thickness and density—to adequately protect the product. By varying the density, thickness and shape of the extruded polystyrene foam, the designer can meet the protection requirements of a wide range of delicate products.

C. DIMENSIONAL STABILITY

Dimensional stability is another important characteristic of extruded polystyrene foam. It represents the ability of a material to retain its original shape or size in varying environmental conditions. Different plastic polymers vary in their reaction to the conditions of use and exposure to changes in temperature and/or relative humidity. Some shrink, some expand and some are unaffected. Extruded polystyrene offers exceptional dimensional stability, remaining virtually unaffected within a wide range of ambient factors.

D. THERMAL INSULATION

For construction insulation applications the polystyrene foam industry has developed Standard Specification for Rigid Cellular Polystyrene Thermal Insulation. This standard addresses the physical properties and performance characteristics of extruded polystyrene foam as it relates to thermal insulation in construction applications. There has been no need to develop such a formal document for the packaging industry. Extruded polystyrene is an effective, economical packaging material for produce, pharmaceuticals and other perishables, when these items must be shipped and stored in temperature controlled environments. The uniform, closed cellular structure of extruded polystyrene is highly resistant to heat flow. The thermal conductivity of extruded polystyrene packaging varies with density and exposure temperature.

V. METHODOLOGY

Here we used three types of material size like as 16sieves12 sieves and 06 sieve tyre waste dust and wooden fiber and used polyester resin to combined tyre waste dust and wooden fiber. Till last research papers researches has studied about the properties of individual tyre dust with resins and also wooden fibers with resins and they had taken 100% tyre dust and 100% wood. Now I am taking the combination of these two constituents with different sieves size and percentage combination. But combination of these different factors is typical because this will give the different combinations. So for the optimization of this Taguchi design is used.

A. TAGUCHI DESIGN

A scientific approach to plan the experiments is a necessity for efficient conduct of experiments. By the statistical design of experiments the process of planning and the experiment is carried out, so that appropriate data will be collected and analyzed by statistical methods resulting in valid and optimize results of objective experiment.

An experimental design methodology that allows you to choose a product or process that performs more consistently in the operating environment. Taguchi design recognizes that not all factors that cause variability can be controlled in practice. Taguchi refers to experimental design as “off line quality control”. Because it’s a method of ensuring good performance in the design stage of products and processes.

Taguchi designs are similar to our familiar factional factorial designs. However Taguchi has introduced several noteworthy new ways of conceptualizing an experiment that are very valuable, especially in product development and industrial engineering.

Taguchi design use orthogonal array, which estimate the effect of factors on the response mean and variation. Orthogonal array allow you to investigate each effect independently from the others and may reduce the time and cost associated with the experiment when fractioned designed are used. In classical designed experiments, the primary goal is to identify factors that affect the mean response and control them to desirable levels. Taguchi designs focus on reducing variability, as well setting the mean to target.

B. EXPERIMENTAL DESIGN

It has been observed that the strength is influence by a large number of parameters (factors) such as sieve size, percentage combination of constituents, resin percentage and hardness and the material. All of these factors sieve size and percentage combination of constituents governs the strength. However the interaction of the strength in the presence other factor to this and Taguchi parameter design approach is employed for modeling and analyzing the influence of the selection of control factors. The operating conditions under which strength test were carried out are given in table.

PROCESS PERAMETERS AND LEVELS OF THE EXPERIMENTAL DESIGN

S.NO	PARAMETERS LEVEL	LEVEL 1	LEVEL 2	LEVEL 3
1	Sheave	06	12	16
2	Wood	75%	50%	25%
3	Tyre	25%	50%	75%

C. ORTHOGONAL ARRAY AND VALIDATION

In this study, the Taguchi method based on a L9 orthogonal array with three columns and nine rows was used to reduce number of experiments are required to study the entire parameter space using the L9 orthogonal array.

S.NO	SEIVE	WOOD	TYRE
1	SEIVE SIZE -06	75%	25%
2	SEIVE SIZE -06	50%	50%
3	SEIVE SIZE -06	25%	75%
4	SEIVE SIZE -12	75%	50%
5	SEIVE SIZE -12	50%	75%
6	SEIVE SIZE -12	25%	25%
7	SEIVE SIZE -16	75%	75%
8	SEIVE SIZE -16	50%	25%
9	SEIVE SIZE -16	25%	50%

D.EXPERIMENTAL LAYOUT USING AN L9 ORTHOGONAL ARRAY FOR COMPOSITE

Table shows the orthogonal array and associated experimental results for the composition of constituents. Extensions of the last researchers the factors taken are tyre dust, wooden fibre, sieve sizes and the percentage volume concentration for the combination of composite. For the 100% volume of the composite taken the volume of the constituents are 75%, 50%, and 25%.and remaining volume percentage of the other constituent. This is the gradually percentage combination of the constituents because according to the Taguchi percentage combination of the constituents for mixing be in different ratios gives the array of 99 x3 =297 which is more difficult for practical.

E. EXPERIMENTAL VALUES FOR 9 EXPERIMENTS OF COMPOSITE ARE FOLLOWING FOR COMPRESIVE TEST

S. N O	SIEVE	WOOD	TYRE	RESIN	COBA LT	HARDE NER	COMPRES IVE TESTING
1	O6	75	25	100	10	10	60KN
2	06	50	50	100	10	10	52KN
3	06	25	75	100	10	10	48KN
4	12	75	50	100	10	10	72KN
5	12	50	75	100	10	10	50KN
6	12	25	25	100	10	10	54KN
7	16	75	75	100	10	10	52KN
8	16	50	25	100	10	10	54KN
9	16	25	50	100	10	10	46KN

VI. MANUFACTURING

Firstly tyre and wood dust mixed with each other properly in a rotary grinder and after the resin mixed with the tyre dust and wooden fiber. This mixture mixed properly till to pest and after hardener mixed with the paste and holds them for 24 hour on room temperature ,here different composition of material mixed with each other tyre dust, wood and resin. This temperature range has been taken because at the time of formation temperature has been measured by thermometer. For obtaining higher rate of reaction between polyester resin and hardener a catalyst such as liquid copper may be used.

For testing the compressive strength of material squire frame specimen to be formed there different type of composition material formed. The UTM machine used for testing the compressive strength of specimen. So square shape specimen to form for inspection.

For testing the compressive strength of specimen following size specimen formed. Side of the specimen is 25 mm x 25 mm x 45 mm.

First of all we need to filter of rubber and tyre forms in different grain size. After this wood and tyre mixed in different ratios. When we mix wood and tyre in different ratios, then mixed polystyrene in ratio 10:1. For about 10 to15 minutes, we put together all three in a vessel. Until it gets stronger, after this for testing it takes in U.T.M. Where different material of different ratios gives different strength.

COMPRESSIVE TEST OF MATERIAL SIZE (06) SIEVE

No.	TYRE	WOOD	RESIN	COBALT	HARD-ENER	COMPRES-SIVE TEST
1	100%	0%	100%	10%	10%	38KN
2	75%	25%	100%	10%	10%	48KN
3	50%	50%	100%	10%	10%	52KN
4	25%	75%	100%	10%	10%	60KN
5	0%	100%	100%	10%	10%	74KN

COMPRESSIVE TEST OF MATERIAL SIZE (12) SIEVE

NO	TYRE	WOOD	RESIN	COBALT	HARDENER	TEST
1	100%	0%	100%	10%	10%	30KN
2	75%	25%	100%	10%	10%	35KN
3	50%	50%	100%	10%	10%	36KN
4	25%	75%	100%	10%	10%	64KN

5	0%	100%	100%	10%	10%	64KN
6	50%	75%	100%	10%	10%	72KN
7	75%	50%	100%	10%	10%	50KN

COMPRESIVE TEST ON MATERIAL SIZE (16) SIEVE

NO	TYRE	WOOD	RESIN	COBALT	HARDENER	TEST
1	100%	0%	100%	10%	10%	36KN
2	75%	25%	100%	10%	10%	46KN
3	50%	50%	100%	10%	10%	52KN
4	25%	75%	100%	10%	10%	50KN
5	0%	100%	100%	10%	10%	65KN
6	25%	50%	100%	10%	10%	54KN
7	50%	25%	100%	10%	10%	46KN

VII. RESULT AND DISCUSSION

Stress analysis in compressive test for the specimen of sieve size 06 **[1]**Stress analysis in compressive test for the specimen of sieve size 06 when the tyre and wooden composition ratio are 75% and 25% respectively by volume.

Load sustain by the specimen is 48KN. Then The maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress)} = \frac{LOAD}{AREA}$$

$$= \frac{48KN}{2.5CMX4.5CM}$$

$$= 42666666.7\text{N/M}^2$$

$$= 42.6 \text{ MPa}$$

[2]Stress analysis in compressive test for the specimen of sieve size 06 when the tyre and wooden composition ratio are 50% and 50% respectively by volume.

Load sustain by the specimen is 52KN. Then The maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress)} = \frac{LOAD}{AREA}$$

$$= \frac{52KN}{2.5CMX4.5CM}$$

$$= 46222222.22\text{N/M}^2$$

$$= 46.2 \text{ MPa}$$

[3]Stress analysis in compressive test for the specimen of sieve size 06 when the tyre and wooden composition ratio are 25% and 75% respectively by volume.

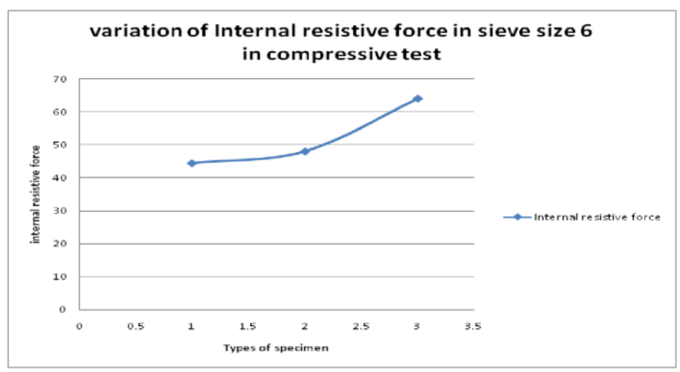
Load sustain by the specimen is 60KN. Then The maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress)} = \frac{LOAD}{AREA}$$

$$= \frac{60KN}{2.5CMX4.5CM}$$

$$= 53333333.33\text{N/M}^2$$

$$= 53.3 \text{ MPa}$$



Stress analysis in compressive test for the specimen of sieve size 12

[1]Stress analysis in compressive test for the specimen of sieve size 12 when the tyre and wooden composition ratio are 75% and 50% respectively by volume.

Load sustain by the specimen is 50KN. Then the maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress)} = \frac{LOAD}{AREA}$$

$$= \frac{50KN}{2.5CMX4.5CM}$$

=44444444.4N/M^2

=44.4 MPa

[2]Stress analysis in compressive test for the specimen of sieve size 12 when the tyre and wooden composition ratio are 25% and 25% respectively by volume.

Load sustain by the specimen is 54KN. Then he maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress)} = \frac{LOAD}{AREA}$$

$$= \frac{54KN}{2.5CMX4.5CM}$$

= 48000000N/M^2

= 48.0 MPa

[3]Stress analysis in compressive test for the specimen of sieve size 12 when the tyre and wooden composition ratio are 50% and 75% respectively by volume.

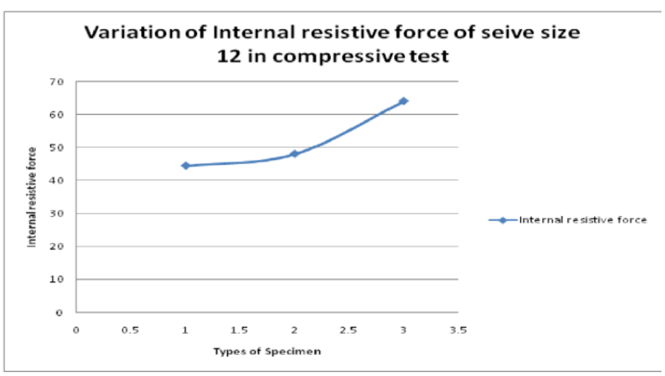
Load sustain by the specimen is 72KN. Then he maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress} = \frac{LOAD}{AREA}$$

$$= \frac{72KN}{2.5CMX4.5CM}$$

=64000000N/M^2

=64.0 MPa



Stress analysis in compressive test for the specimen of sieve size 16

[1]Stress analysis in compressive test for the specimen of sieve size 16 when the tyre and wooden composition ratio are 75% and 75% respectively by volume.

Load sustain by the specimen is 52KN. Then he maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress)} = \frac{LOAD}{AREA}$$

$$= \frac{52KN}{2.5CMX4.5CM}$$

=46222222N/M^2

=46.2MPa

[2]Stress analysis in compressive test for the specimen of sieve size 16 when the tyre and wooden composition ratio are 25% and 50% respectively by volume.

Load sustain by the specimen is 54KN. Then he maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress)} = \frac{LOAD}{AREA}$$

$$= \frac{54KN}{2.5CMX4.5CM}$$

=48000000N/M^2

=48.0MPa

[3]Stress analysis in compressive test for the specimen of sieve size 16 when the tyre and wooden composition ratio are 50% and 25% respectively by volume.

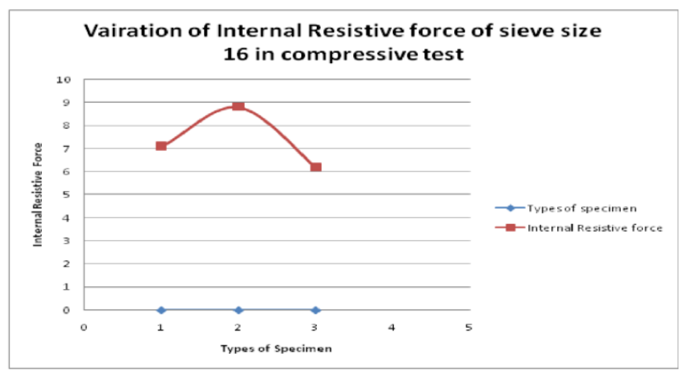
Load sustain by the specimen is 46KN. Then he maximum compressive stress in simple compression test-

$$\text{Internal resistive force (Stress)} = \frac{LOAD}{AREA}$$

$$= \frac{46KN}{2.5CMX4.5CM}$$

=40888888N/M^2

=40.8MPa



VIII.CONCLUSION

From the internal resistive force analysis it has been observed that the compressive and tensile strength is totally depending on the concentration of wooden fibre in the composite. As such as the percentage of wooden fibre increases the internal resistive force also increases. Sieve size 12 gives better result than other sieve sizes that means the inter molecular distance between the fibres of sieve size 12 is very less and has compact structure.

1. With the help of this project we can recycle & re-use the wastage of tyre & wood and formed a composite product.
2. This composite product is light waited so it can use as flooring replace the tiles.
3. Use this composite project in water disturbed venues.

4. We can use this composite product for formation of cricket pitch mat because it used during raining.
5. It can absorb the shocks because it doesn't have brittleness property.
6. This composite product has insulator property.
7. Now these days the ratio of wastage tyre in one year is 13000 million in whole world people burned the wastage of tyre and create polluted environment.

FUTURE SCOPE OF WORK

1 In future we can mix the metal powder in tyre & wooden fibre and formed another composite material for high strength.

2 Wastage of plastic and polyethene also can be used in future for making the other composite material.

3 Disposal material also can be use n future for making other composite material.

REFERENCES

[1]. Scrap tyre to oil production: a project file by SMB environment project pvt. Ltd. 2013.
[2]. Srddique,, R,, NAIK..” Properties of concrete containing scrap-tyre rubber – “an overview”
[3]. Skripkiunas G” grinysA, miskinis K , “ damping properties of concrete with rubber waste additives” material science vol. 15, NO 3,266-272,2009.
[4]. Novoa Paulo J.R.O. Ferreira Antonio J.M.and marques Antonio Torres.“Mechanical performance of unsaturated polyester resin modified with powder from scrap tyre rubber”. Material science forum voles.514-516,662-665, 2006.
[5]. Malik A.K. “Principles of vibration control” .2010 pp70 – 71.
[6]. Mishra A. “dry sliding wear behavior of epoxy rubber dust composites”. World academy science , engineering and technology 67,579-584,2012.
[7]. Hyo Lee et al. reported the surface modification of wtd with uv treatment in presence of ally amine.
[8]. D. DAI and M. FAN, Wood fibers as reinforcements in natural fiber composites: structure, properties, processing and applications.
[9]. Properties performance and design fundamental of expanded polystyrene packaging.
[10]. M. Awang, H. Ismail, M.A. Hazizan, Polypropylene-based blends containing waste tire dust: effects of trans-polyethylene rubber (TOR) and dynamic vulcanization.
[11]. F. Azevedo, F. Pacheco-Torgal gives aboutfiber.
[12]. Kotresh k.m1, Mesfingeta hunbelachew study on waste tyre rubber as concrete aggregates.
[13]. Zornberg, costa, vollenweider [2000] conducted a field in-visitation to assess the mechanical behavior of an experimental embankment fill built with tyre shreds and cohesive soil.
[14]. B.K CHAURASIA and J. BHASKAR, structural properties of wastes tyre composites.
[15]. A. Ibrahim, A. Ashram, S .Chesom, Composites of natural rubber with linear low-density polyethylene.
[16]. Kate Pitt1, Omar Lopez1, Austin D. Lafferty2, Iain Todd2, Kamran Mumtaz1, Investigation into the material properties of wooden composite structures with in-situ fibre reinforcement using additive manufacturing.
[17]. Maciej Sienkiewicz*, Helena Janik, KajaBorzędowska-Labuda, JustynaKucińska-Lipka Polymer Technology Department, Chemical Faculty, Gdansk University of Technology Gabriela Narutowicza Street 11/12, 80-233 Gdansk, Poland Environmentally friendly polymer-rubber composites obtained from waste tyres.
[18]. NELSON FLORES MEDINA, DARÍO FLORES MEDINA, F. HERNÁNDEZ- LIVARES, M.A. NAVACERRADA Mechanical and thermal properties of concrete incorporating rubber and fibres from tyre recycling.
[19]. FRANK RIEDEWALD1,*, KIERAN GOODE1, AIDAN SEXTON2, MARIA SOUSA- GALLAGHER3 Scrap tyre recycling process with molten zinc as direct heat transfer and solids separation fluid: a new reactor concept.
[20]. Eshmaiel Ganjian a,*, Morteza Khorami b, Ali Akbar Maghsoudi c Scrap-tyre-rubber replacement for aggregate and filler in concrete.
[21]. F. Azevedo, F. Pacheco-Torgal ⇑, C. Jesus, J.L. Barroso de Aguiar, A.F. Camões Properties and durability of HPC with tyre rubber wastes.
[22]. S V Kulkarni, J S Rice, B W Rosen, An investigation of the compressive strength of Kevlar 49/epoxy composite.
[23]. Marisa L. Kreider, Julie M. Panko, Britt L. McAtee, Leonard I. Sweet, Brent L. Finley Physical and chemical characterization of tire-related particles: Comparison of particles Generated using different methodologies.
[24]. Kline and Company, Inc, Little Falls, NJ, Opportunities for Natural Fibers in Plastic Composites (2000)
[25]. T.W. Frederick, W. Norman, Natural Fibers Plastics and Composites, Kluwer Academic Publishers, New York (2004).
[26]. P. Flodin, P. Zadorecki, in E. Seferis and B. Stark (eds), Composite Systems From Natural and Synthetic Polymers, Elsevier (1986) 59.
[27]. GRESZCZUK, L.B. failure mechanics of composites subjected to compressive loading. AFMI-TR-72-107