RINDERESU
Revista Internacional de Desarrollo Regional Sustentable
ISSN 2448-5527

New materials used in the construction industry and its Impact to the Environment: A review

Nuevos materiales usados en la industria de construcción y su impacto al ambiente: Una revisión

Sergio A. Zamora-Castro [*1], D. Lastre[1], L. Guzman[3,] R. Salgado[1], J.M. Santamaria-Lopez[1]
[1]Departamento de Posgrado, Facultad de Ingeniería, Universidad Veracruzana
*Autor de correspondencia: szamorac@uv.mx

Recibido 21de septiembre 2018; recibido en forma revisada 20 de noviembre 2018; aceptado 01 de diciembre 2018

ABSTRACT

At present the issue of the environment and sustainable construction are the greatest interest. The objective of this work was analysis of studies carried on in recent years about new, organic as well as recycled materials used in the construction industry, and its impact generated on the environment, looking for new alternatives in order to make a sustainable construction. Our study provided the review of significant results from techniques presented at each one of the studies. Also contains sections with the classifications according to materials properties for the stony (petrous), binder, hybrid, etc. We compared the benefit of recycled materials versus those of common use. In conclusion, we considered the importance of studying the physical modifications inner properties for materials and the benefit that bring to the environment in order to substitution the conventional materials for ecological.

Key words. Environmental impact; construction; sustainability; recycling; innovative materials.

RESUMEN

En la actualidad el tema del medio ambiente y la construcción sostenible son de gran interés. El objetivo de este trabajo fue el análisis de los estudios realizados en los últimos años sobre materiales nuevos, orgánicos y reciclados utilizados en la industria de la construcción, y su impacto generado en el medio ambiente, buscando nuevas alternativas para hacer una construcción sostenible. Nuestro estudio proporcionó la revisión de los resultados significativos de las técnicas presentadas en cada uno de los estudios. También contiene secciones con las clasificaciones de acuerdo con las propiedades de los materiales para piedra (pétreo), aglomerantes, híbrido, etc. Comparamos el beneficio de los materiales reciclados con los de uso común. En conclusión, consideramos la importancia de estudiar las modificaciones físicas de las propiedades internas de los materiales y el beneficio que aportan al medio ambiente para sustituir los materiales convencionales por los ecológicos.

Palabras clave. Impacto ambiental; construcción; sustentabilidad; reciclado; materiales innovadores.

1. INTRODUCTION

The environmental impact produced by the construction industry since the industrial revolution constitutes a debt still pending for society. The industrial revolution represents a great change in the techniques used in the production of building materials, due to the materials were natural, biospheric, coming from the immediate environment, simple fabrications and adapted to the weather conditions of the territory where the building was carried out.

The result of the previously mentioned generated a great increase of the distance between the obtaining of raw materials and the location of its elaboration or construction, as well as the depletion of the natural resources and the increase of the emission of pollutants derived from the construction industry. Additionally, the high demand for construction materials generates the need to extract and process a large quantity of raw materials, to develop new materials and the treatment of a large amount of construction and demolition waste, with the energy cost that it represents.

Therefore the construction industry needs to use construction materials of low environmental impact, since these are the ones that most affect the natural environment, without rejecting other impacts related to energy consumption or waste.

The present document shows an analysis of the use of new materials used in construction and the benefit that provides to the environment and it is divided into organic, binder, metallic, hybrid, artificial and recycled materials. Organic materials are referred to materials purely extracted from nature and as these can replace materials that pollute the environment, as they are processed; the organic materials such as bamboo or wood do not have a production process, which in the same way generates a saving in its use. Binder materials are an alternative in improved cements with regenerating bacteria, which generate less pollution than the common ones, and are designed with different technologies with photo catalytic characteristics to reduce air pollution. When talking about recycled materials, it is generally thought about the use of PET, although it is true that it is the most reused material, here we study the production of concrete with waste from the same, e.g. recycled plastic in concrete manufacturing as a replacement of coarse aggregates generating better resistance.

2. Organic Materials

2.1. Bamboo

Bamboo is one of the materials used from the most ancient times by man to increase comfort and well-being. A large part of humankind uses bamboo every day because it is represented as an alternative to expensive materials and perhaps in the future its use would be massive, as a source of energy and replacement of timber because it is an easily renewable material. More than one billion people live in bamboo houses, reaching in some regions of the world a great importance, this is the case of Bangladesh where 73% of its inhabitants have this type of dwellings with population growth, the housing needs of the world's population will double by the middle of this century. There is particular case like Africa, where it will triple. The United Nations - UN - estimated that at least one hundred million people in the world have no home, it is here that bamboo becomes a true global alternative to fill the need for housing, further fulfilling a purpose to replace the employment of the wood by another material of alternative construction, low cost and indicated for a region of high seismicity. Bamboo for its low cost definitely has great potential for affordable housing solution. The advantages of a home built with bamboo are isolating the cold, the heat and the noise by the air chambers form the bamboo trunks. Bamboo logs are also used to make prefabricated panels, which are more resistant, flexible and lighter than conventional ones (Rodríguez, 2010).

2.2. Wood

Jacobo (2010) presented a study on the application in the construction of ecological materials based on already used wood residues. Nowadays, the high consumption of fossil fuels and the great environmental contamination forces us to the development of ecological materials applied to the construction industry.

3. Recycled Materials

They are reused materials, in this case within the construction industry, and may be mixed with other materials or by replacing some compounds in hybrid materials or used directly for constructions composed of the material directly. As is the case of Vasconcelos et al. (2013) who presented the results of a research project whose objective is to develop an innovative solution that was based on a block of masonry of an eco-efficient composite material; the composite material used in the production of the blocks results from the combination of three industrial by-products: the desulfurization of gypsum combustion gases, granulated cork and textile fibers resulting from the tire recycling process; from the results obtained, it is possible to conclude that the solution meets all the requirements of the structural stability suitable for this type of interior wall; in terms of performance, the proposed solution presents a positive behavior and the acoustic performance was slightly inferior to the traditional solution. Also in the masonry, it has been created an innovative construction material made with wastes of constructions and industrial waste that are used for the manufacture of hollow blocks with holes that guarantee the properties of isolation and reduction of weight; some samples were produced, hollow rectangular blocks of 365 mm 248 mm 249 mm with a density of 850 kg / m3 to study the mechanical and thermal properties of this wall. The results meet the established standards and the block has a high compression, strength and reliable insulation performance compared to common bricks or other hollow blocks; Due to the excellent self-insulation characteristics, the blocks could be used directly as wall materials without the need for special insulation measures in factory structures, which means that this new type material could reduce the cost of the construction of houses and have wide prospects of application in structures of masonry. Therefore, the use of this block could not only reduce energy consumption, it could also relieve the pressure applied on the environment (Wu et al. 2015).At the same time, masonry can be replaced by plastic, Gaggino (2015 a) proposed to use a material or in the manufacture of construction elements: recycled polyethylene terephthalate (PET) from gaseous bottles to reduce an urban waste whose quantity is important; the new constructive elements developed using recycled PET are a possible alternative for the execution of greener constructions, low cost, light and with better thermal insulation, than the masonry of common bricks of cooked earth that are used traditionally. The recycled PET used in the developed constructive elements partially replaces the aggregates of a conventional concrete for certain specific uses with the following advantages: 1) it has a specific low weight so that the concrete made with them is lighter; 2) has poor thermal conductivity so the concrete made with them provides better insulation; for their low cost and simple technology the constructive elements developed are especially suitable for homes and constructions of social interest. In the use of PET, Ingrao et al. (2014) carried out a projection of the life cycle analysis for the evaluation of the damages derived from the production of 1 kg of Recycled Polyethylene Terephthalate (RPET) based on fiberboard for construction of thermal insulation, it was made according to ISO 14040: 2006 and 14044: 2006; the study showed damage due to the production of quality granulated PET for bottles and the consumption of medium voltage electrical energy during the manufacture of RPET fiber panel. He also concluded that there were environmental benefits due to recycling mainly to avoid emissions; as well as an evaluation of the improvements in order to find solutions aimed at reducing damage from the most impactful phases; on the other hand, the environmental impacts due to the production of the panel based on RPET fiber were analyzed in comparison with other materials with the same insulation function, such as polystyrene foam. On the other hand, Lewis (2010) presented RePlast, which was a block of recycled plastic, used as building material; its manufacture emits 95% less CO2 than the conventional concrete block. It is achieved using a modular platform that serves to compress the recovered plastic; the system converts waste into plastic blocks of different shapes and densities; the result is a resistant material, suitable for construction and provides a great thermal and acoustic insulation; RePlast blocks can help buildings achieve sustainable LEED certification. Also, they can be applied for the construction of walls, and even containment barriers on roads. Trudell (2015) manufactured a brick which was used to build facades that depollute the cities since they are made with a material that cleans the air

through a chemical reaction. The system consisted of two parts: on one side is the concrete brick, and on the other a recycled plastic element, the latter has the function of keeping the bricks aligned, but also serves to bring the air from the outside to the hole in the central part. The faceted design of the outside of the block makes easier the air flow. These pieces also have a cavity, in order to create a structural reinforcement in the wall. Breathe is designed to work with either forced or natural ventilation. Filtered air can be carried into the building with the help of a mechanical system, but also through passive systems. In the tests carried out, this system was capable of filtering 30% of fine contaminating particles, and 100% of coarse particles.

Among other recycled materials, Ricciardi et al. (2014) investigated the performance of insulation panels made from recycled materials. Two panels, composed of paper fibers and textile residues, were bonded together by glue, with a total thickness of 12 mm and 20 mm respectively. The study focuses on the thermal and acoustic characteristics of the panels, in order to provide accurate data for reliable integration in buildings; the thermal performance was evaluated using the hot box device, according to the UNI EN ISO 8990 standard. A good thermal behavior was found for all the panels investigated with values that vary in the 0.034-0.039 w/mK. It is concluded that the panels investigated could be a valid solution instead of classic insulation systems, and that the use of efficient insulating materials reduces the heat losses of buildings and allows energy savings and costs for air conditioning and heating during the life of the building. On the other hand, Dazneel (2016 b) developed ECO board panels that are manufactured from what is called agro fiber, a material from agricultural waste (straw, reeds, etc.) that are milled to form flakes that are then mixed with a resin formaldehyde free. Finally, they are compressed at high temperatures to give them shape and strength. The ECO board material is a healthy and environmentally friendly solution that can be used as a substitute for typical MDF, OSB, and plywood panels for both home construction and furniture manufacturing.

4. Bonding Materials

Binder materials have the property of joining others in the construction industry to bond stone materials to pastes known as mortars and concretes that allow them to be expanded and shaped according to needs before acquiring the solid state. They are classified according to their air need to set, meaning that to choose the type of mortar to be used should be considered the type of binder that composes. Hydraulic bonding materials can be cement, hydraulic lime, concrete, hydraulic tile, etc.

4.1. Use of bacteria in cements

The use of bacteria in cement has been studied in recent years, in most cases, the properties of cement can be strengthened thanks to the use of bacteria, such as Torgal et al. (2013), who performed the study of paper of Bacillus sp bacteria (large bacilli, spore forming and resistant to unfavorable conditions) in the properties of durability and remediation of cracks in cement structures. This reduced porosity by more than 50% in the mortar samples as well as a change in the permeability of the concrete from moderate to very low. Bacteria successfully repaired simulated cracks. The results clearly showed that precipitation of microbiologically induced calcium carbonate can be applied to various building materials and thus repair cracks and improve the durability of building structures. Equally, Dosier (2014) made natural cement from bacterial, mainly extracted from waste resulting in the same resistance, a similar production time and better cost.

For its part, Jonkers et al. (2010) carried out the study of the capacity of self-repair of concrete, which is, the autonomous repair of cracks, as well as the study of the potential of bacteria to act as a self-repair agent in concrete. A specific group of alkaline resistant bacteria-forming spores related to the genre Bacillus that was selected for this purpose; in conclusion, it is stated that spores are formed and they are resistant to alkalis bacteria related to the genre Bacillus and these represent candidates for their application as a self-repair agent in concrete and probably in other cement-based materials. Achal et al. (2013) reviewed current knowledge on the use of bacteria to generate improved durability in concrete; studies the use of bacteria in concrete mix and bio mineralization in concrete surface treatments; and concludes that the materials can lead to a more sustainable construction

industry especially when providing new solutions of low toxicity. Mukerjee (2013) performed the study of the precipitation of calcium carbonate induced, which is a biological process of natural origin that has different applications in rehabilitation and restoration of the range of building materials. In the study, Bacillus sp bacteria develop in durability properties and remediation of cracks in cement.

Bolte (2014) conducted studies on "TioCem" which is a special cement with photo catalytic characteristics, which is used on the surface of buildings to reduce air pollution caused by the exposure of cement to ultraviolet (UV) light. This cement can effectively contribute to the purification of air through the use of numerous concrete components, such as pavement, tiles, facade boards, concrete pavements, etc.

4.2. Gypsum

Gypsum, besides allowing modeling and reinforcing structures, is an ideal thermal insulation, at higher density, greater thermal insulation in the construction; he rougher or smoother finish, plays a key role in this property of insulation. The gypsum absorbs very little heat, so it allows a greater use of the thermal sources in the home being a preponderant material for the interior finishes besides that it is smooth, easy to place and allows a unique view; its acoustic absorption is not as good as that of the bricks, although combined with natural and synthetic materials can increase this capacity; a property in which it stands out is to absorb the humidity of the structure and the environment and then store it and release it when the humidity of the environment is lower than usual. This is why Lachheb et al. (2015) develops a new component integrated in a passive solar energy wall to achieve a high potential of thermal energy storage in building materials; this component was made by conditioning the paraffin within 24 copper tubes, which were inserted and aligned in a gypsum matrix regularly.

4.3. Lime

Lime is a white alkaline substance that upon contact with water is hydrated or extinguished, releasing heat; its major application in construction is as a component, mixed with sand, in the manufacture of bonding mortars or outer or inner lining. Galvan (2013) carried out research on the transitions of the lime cycle materials; Calcium carbonate samples were obtained from a bank near Bernal, Querétaro; Calcium carbonate is the raw material to obtain calcium oxide after a calcination process and calcium hydroxide, after hydration; As the final stage of the lime cycle, the calcium hydroxide interacts with the carbon dioxide in the air to form calcium carbonate again; These results are a contribution to the field of the construction industry, both as a starting point for new applications of calcium hydroxide for current engineering and in processes of conservation and restoration of historical heritage.

5. Metalic Materials

The vast majority of metals can be found in nature mixed with other elements, which is why we need to undergo some cleaning process before using them. Some of the most common working procedures on metal materials are: casting and molding, deformation, cutting and machining. Metals and their alloys can be found as metallic materials, as well as inorganic substances which are constituted by one or more metallic elements. The metals that are used in the construction must fulfill a series of characteristics as they are easy to obtain, to be moldable and with certain chemical and physical resistances.

Researchers at the Polytechnic School of the University of Sao Paulo (Poli-USP), from the Institute of Technological Research of the State of São Paulo (IPT) and the Institute of Energy and Nuclear Research, have been able to elaborate in the laboratory stainless steels between 15 and 20 times more resistant to cavitation (the appearance of small holes in the surface of the material) than the present ones, improving the quality of these steels, modifying their crystallographic texture (the distribution of the orientations of the grains that form the microstructure of the material) of so as to improve its mechanical, electrical, magnetic properties and resistance to wear and corrosion (Poli-USP, 2012).

6. Hybrid Materials

An organic / inorganic hybrid material arises from the combination of two or more materials of both types; the chemical properties of them are the most important, since the components interact at the molecular level. Within the classification of these materials, Blyberg et al. (2012) carried out a study of three different adhesives (silicone, acrylate and

polyurethane) intended for adhesive bonding to be applied to wood and glass structures by stress and shear testing with a bonding area of 800 mm2. The results include the resistance and the type of adhesive bond failure, as well as the deformation of the bonding lines and a 3D-deformation opticalmeasurement system that are used in combination with finite element modeling in order to obtain detailed information on behavior; of the adhesives tested, the acrylate (SikaFast 5215) provided the greatest strength, both in tensile and cut; the average resistance obtained for this adhesive bond was 3.0 MPa in tension and 4.5 MPa in shear; in addition it was demonstrated that with the optical measurement system and with finite element modeling the distribution of the internal stress at the adhesive joints can be studied; in turn, composite glass-wood beams were analyzed for structural use and shear wall elements where they were investigated for their mechanical behavior and their energy performance. The load bearing components are manufactured using annealed float glass which is adhesively bonded to the wood with different adhesives. The results show that it is possible to join two materials, glass and wood; shear wall elements have the potential to be used as stabilizing elements and load-bearing walls in buildings up to 4 plants in height; it is possible to combine glass and wood in a cutting wall without loss of energy efficiency of a building or without losing the load performance (Blyberg et al. 2014).

For its part, Loss et al. (2016) developed a new versatile construction system in which the main structural elements were made by combining wood with steel, are highly engineered and can be produced in the factory; Research demonstrates the potential of hybrid steel and wood structures in terms of sustainability, providing light and earthquake resistant constructions; As a result it was found that this system shortens on-site construction times and reduces cost.

Another hybrid material that helps greatly in the environment is presented by Chabannes et al. (2014), investigated the innovative development of an insulating concrete that has the same application as concrete but using rice husk and lime base that performs the comparison of new construction material developed with hemp concrete (hempcrete) (Figure 1).

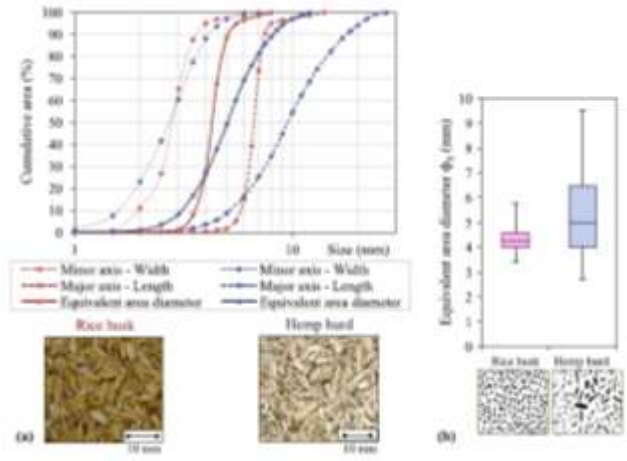

Fig. 1. A comparison between rice husk and hemp concrete.

The compressive strength of the concrete developed with rice husk was 0.33 ± 0.03 MPa after 60 days of creation, and of 0.48 ± 0.02 MPa for the hemp concrete; the mechanical behavior after 2 months was not significantly affected by the outdoor exposure of the concrete specimens according to temperature and humidity variations that were produced for this study. Van et al. (2014) investigated the mesoporous effects of amorphous ash from rice husk (RHA) on the compressive strength, autogenous contraction and internal relative humidity (HR) of ultra-high performance concrete (UHPCs) with and without soil and granulated blast furnace slag (GGBS) under different treatments; due to the mesoporous structure of the RHA particles can absorb the free water, improve the compressive strength of UHPC.

In the use of hybrid materials composed of organic material was Falck (2014), since he presented a project in which trunks (pine wood) were used as beams tied with galvanized wire replacing the lattice of wood to place the tiles. In the project, the cost of the cover was 34% in relation to the cured pine, currently due to the increase of the wood this cost must be lower.

On the other hand, Menna et al. (2015) investigates the behavior of cut of masonry panels reinforced with a system based on the mortar reinforced with a grid of composite material of hemp fiber; the strengthening system consisted of an innovative composite of hemp fiber with bi-directional grid attached externally to each side of the panels by two different mortars, i.e. a

mortar and a pozzolanic, with a layer of mortar of 15 and 40 mm , respectively; the strengthening system was conceived to achieve sustainable goals in the construction industry and to effectively employ natural fiber in structural rehabilitation (Figure 2).

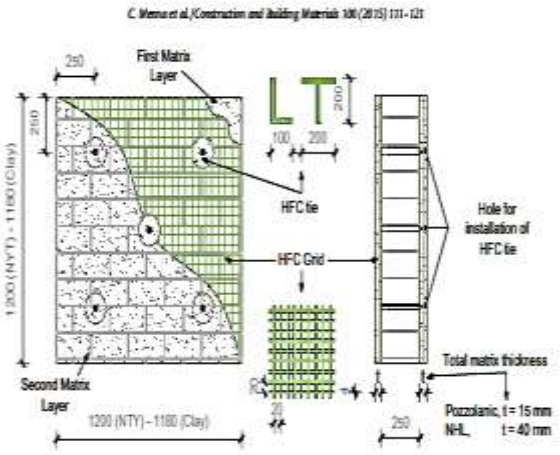

Fig. 2. The masonry panel with composite grid with hemp fiber.

Hernández (2014) presented a study, which was developed in the laboratory a new material of the composite type, ceramic matrix and reinforced with alumina fibers, which are also of ceramic manufacture. This new material was decided to call it Reinforcer and contains as an innovative point, reinforcement with ceramic fibers of alumina, which makes many properties and characteristics of traditional ceramics, especially aspects of mechanical, thermal and acoustic resistance, are improved; which allows us to use it in special and diverse applications in building construction in Mexico. Within the topic of improvement of hybrid materials is a research carried out in Colombia, which has as an objective the analysis of modifying asphalts with natural waxes for the manufacture of warm asphalt mixtures and establishing their mechanical and dynamic behavior; the first stage consisted in the characterization of the materials to be used (granular, asphalt and natural waxes), followed by determination of the percentage of wax addition and optimum asphalt content to make warm mixtures; In the second, the asphalt mixtures were manufactured and compacted at 110, 130 and 150 ° C to evaluate the effect of the modified asphalt on its mechanical and dynamic behavior; Finally the results were analyzed and it was established that the natural waxes used reduce the viscosity of the asphalts and therefore the temperatures of manufacture and compaction of the mixtures, significantly reducing the energy consumption and the generation of greenhouse gases. (Reyes et al. 2013).

La Rosa et al. (2014) developed the study of a new material that has the essential structural properties of the concrete but with a lower thermal conductivity because it reduces the thermal insulation system that consumes less energy for cooling and heating in the phase of use; the thermal conductivity analysis and the environmental analysis of several materials that were destined for use in external walls were carried out and the life cycle analysis was applied to evaluate the environmental impacts of four different proposals; as a result an environmentally friendly material containing cork, flax fibers and bio-based resin as natural materials was produced and tested in order to evaluate the thermal conductivity. The use of the eco-sandwich in the construction of the structure seems to bring several advantages in terms of innovation, good insulation properties and light structures. The results show that in the manufacturing phase the performance is lower compared to other traditional materials, however it is lighter and easier to install so the environmental impact generated by its transportation would be lower.

7. Artificial Materials

Artificial plastic materials are substances of organic origin that are produced by chemical means, capable of acquiring form by heat and pressure and then retaining their great mechanical resistance. Among the most common are plastics and polymers.

7.1. Polymers

They are chemical compounds that possess a high molecular mass and that is obtained through a process of polymerization that consists in the union of several molecules of a compound from the heat, the light or a catalyst, with the mission to form a chain of multiple molecule links and thus get a macromolecule. Fajardo et al. (2015) performs a research on silicon nanoparticles synthesized by a gel prepared from Si $(OC_2H_5)_4$, Nano additives based on silica and C_2H_6O (Tetraethyl orthosilicate and ethanol chemical compounds) with a molar fraction of 0.1051 in an alkaline medium. The tests showed both an increase

in electrical resistivity and a significant decrease in the carbonation depth for all SN treated mortars; the results show that it is a promising method in the construction industry as it improves the durability of the concrete. On the other hand, Pisello et al. (2016) carried out a study of the development and creation of an innovative polyurethane membrane for ceilings and thus improve the conditions of thermal comfort in the interior and with this the decrease of the energy demand; the composite membrane showed good workability properties. Optical properties were modified in the surface layer by inclusion of PCM (phase change memory), ie, that additional non-composite polyurethane finishing layer is required to complete the application of this new material in the field of construction; In addition it showed a promising thermal behavior operating as a thermal storage device or passive cooling, a coherent and effective enthalpy change that was recorded with the increase of PCM concentration within the membrane.
The determination of the durability of a stone material and of the conservation treatments is done subjecting them to experiences of alteration, reproducing the environmental conditions in which the construction is found; there is a great variety of consolidation, water repellent, anti-painted, etc. treatments of different nature that have the purpose of preserving the stone from its deterioration. Novais (2014) proposes treatments based on polymers to preserve the stone materials of buildings based on the petrophysical properties of the stone of construction and of the environmental conditions in which it is. Mendoza et al. (2014); studied the effect of the incorporation of short polypropylene fibers in concrete properties in fresh and hardened conditions. The presence of the fibers in the fresh concrete modifies the consistency of the mixture and reduces the plastic shrinkage cracking; in a hardened state, increases toughness and impact resistance and reduces shrinkage through drying and cracking; the other properties remain with no important changes.

The results of an asphalt blend with asphalt modified with icopor (polystyrene) as a result of the shredding of disposable vessels, with the aim of improving the mechanical properties and guaranteeing the durability under the stresses imposed in the period of design; for the design were characterized stone materials, asphalt and polystyrene where the results obtained were contrasted with those of a conventional asphalt mixture. The conclusions of this research are: a reduction of more than 50% in plastic deformation caused by the passage of 13-ton vehicles, an increase in the stability of the asphalt mixture and a lower weight and the possibility of inclusion of these materials that impact the environment but contribute to the strength of a material such as asphalt concrete (Figueroa et al., 2012).

7.2. Plastics

They are products obtained by means of synthetic processes (synthetic resins) and the substances formed by complex molecules of high molecular weight (macromolecules or polymers); The most important feature of plastic materials is that they soften at a certain temperature and remain plastics for a certain period of time; this makes them moldable and stampable in the most diverse and complex forms; the plastics materials do not have a defined melting point, ie, they do not go from the solid state to the liquid at a given temperature, but under heating, lose elasticity and consistency until it becomes a very viscous fluid.
Berreta et al. (2015) presented a new technological alternative for the production of housing of social interest, more economical and more ecological than other traditional construction systems; it is based on an integral recycling of plastics for the manufacture of construction elements, crushed and mixed with Portland cement, replacing the aggregates of a traditional concrete. Nanosilice (NS) is a plasticiser additive that Tobón et al. (2015) studied the effects of the same on porosity, capillary suction. Strength compression (ASTM C 349) and sulfate resistance (ASTM C 1012) being evaluated in mortar made with Portland cement; The samples containing NS showed a significant positive effect on capillary suction and resistance to sulfates; In the case of expansion due to sulphate attack, mortars with 5% and 10% NS decreased expansion by 90% and 95%, respectively, after 2 years of immersion.

The production of concrete generates gases that are emitted to the atmosphere generating a great environmental impact, however the reduction of its production would affect the development of a country; a viable solution to this problem is the sustainable design of the material; the research

proposes the incorporation of plastic as a replacement of the coarse aggregate in the concrete trying to contribute to the care of the environment (Sanchez et al. 2014)

8. Concret

Concrete is the most used material in the construction industry, which is why we have opted for a section only to deal with the modifications to the properties that have been modified for its benefits, as well as the environment. Concrete is commonly composed of aggregates and cements, but Lee-Orantes et al. (2015), presented a research with carbon fiber compounds (CFRP) that were used as reinforcement and at the same time as cathodic protection in elements of concrete with corrosion; different conductive resins were analyzed by varying the amount of carbon fibers and the length of these fibers added to increase the electrical / ionic conductivity of these resins; The results obtained to date have shown that the carbon fiber composite used for reinforcing concrete elements can also function as a cathodic protection system (PC).

Proaño (2014) described the behavior of carbon fiber reinforced concrete structures (CFRP) through the moment-curvature diagrams corresponding to composite sections (concrete-steel-CFRP) subjected to bending; the section experiences an increase in stiffness after creep in which the section has a behavior, pseudo ductile since the steel to fluid. The ultimate capacity of the section before collapse takes values such as 1.5 or 2 more times the value of the ability to creep.

However, carbon fibers can be added to the concrete as well as to other materials, such as Foti (2016), who presented the results of a series of preliminary tests on samples of concrete reinforced concrete PET (Tereftalo de Polyethylene) and CFRP (polymer reinforced carbon fiber); the reinforcement is made with PET and CFRP where they are placed inside the sample, in the same position as the steel bars in an element of reinforced concrete. For both cases it is observed that they limit the presence of cracks and, above all, avoid and / or reduce the corrosion processes in structural elements of reinforced concrete. As can be seen, the recycled material fulfills the same conditions as the carbon fiber. On the other hand, Valdés et al. (2014) determined the viability of the use of recycled aggregates of concrete residues in the manufacture of the same concrete and building blocks in Chile; the first stage of the research consisted in recovering the residues of the concrete, after which, the mixture of the new concrete and its mechanical properties were designed, finally, the use of the residue was made and analyzed; the result established that the strength and density of concrete with recycled aggregates is very similar to concrete with natural aggregates; However in the case of the blocks, the resistance decreases approximately 13% and its content of fines and absorption is slightly lower than that stipulated in the corresponding Chilean standard (1.03%); it is emphasized that although there is a decrease in its resistance, it is viable the use of recycled aggregate in the manufacture of concrete.

Garcia (2014) presented a research based on a new "green" material which respects the environment and fulfills a structural, functional and aesthetic function. This material is conceived as a new type of concrete that we can define as "biological concrete" and that serves as an application for certain parts of the building coverings, in this case the facades. Another important aspect of this new material, besides the beneficial properties for the environment, is that it also acts as an acoustic thermal insulation.

From the conventional concrete block, Daznnel(2013 a) created a new material that includes inside two layers of insulation (expanded polystyrene); it was given the name of "Omni Block" and facilitates the execution of enclosures by not having to add the layer of insulation; this therefore entails a saving of thickness in the walls and time of execution; different pieces of polystyrene are introduced into the blocks as they run the masonry; it should be noted that the outer layer of insulation material is wider than the inner layer; we do not know how this aspect can affect the thermal / acoustic behavior of the walls built with Omni Block and in order to know that it would be necessary to review carefully the certificates of the tests made by the laboratories.

CONCLUSIONS

In recent years new technologies and material discoveries have been developed as well as the incorporation of common and organic materials in the

composition of usual materials benefiting the environment but at present these alternatives have not been developed. It is here where companies producing high consumption materials should become aware and sponsor research for the creation and producing of new materials in order to benefit a low impact on the environment.

Materials with lower environmental impact, for use in the construction industry, should incorporate criteria of environmental sustainability, such as high energy efficiency, durability, recoverability, renewable resources, use of clean technology and waste recovery. Although there is no universally accepted methodology that quantifies the multiple and varied criteria, it is possible to use another methodology such as life cycle analysis, which is the best tool to evaluate the environmental loads associated with a product or activity. In addition, criteria relating to the use of low environmental impact materials should also be taken into account, as well as other thematic blocks relating to, among others, energy efficiency and the management of construction and demolition waste.

REFERENCES

Achal, V., Mukerjee, A., & Reddy, S. (2013). Biogenic treatment improves the durability and remediates the cracks. Elsevier, 48, 1-5.

Berretta, H., Arguello, R., Gatani, M., & Gaggino, R. (2015). Nuevos materiales para la construcción: Los plásticos reciclados.

Blyberg, L., Lang, M., Lundstedt, K., Schander, M., Serrano, E., Silfverhielm, M., y otros. (2014). Glass, timber and adhesive joints – Innovative load bearing building. Elsevier, 55, 470-478.

Blyberg, L., Serrano, E., Enquist, B., & Sterley, M. (2012). Adhesive joints for structural timber/glass applications:Experimental testing. Elsevier, 35, 76-87.

Bolte, G. (2014). Innovative Building Material – Reduction of Air Pollution through TioCem. Heidelberg Cement Technology Center, 1, 55-61.

Chabannes, M., Bénézet, J. C., Clerc, L., & García Diaz, E. (2014). Use of raw rice husk as natural aggregate in a lightweight insulating. Elsevier, 70, 428-438.

Dazneel, A. (2013 a). Omni Block: Bloques de Hormigón con Aislante. Materiales Innovadores.

Dazneel, A. (16 de octubre de 2016 b). Materiales Innovadores. Recuperado el 2 de noviembre de 2016, de http://blog.is-arquitectura.es/

Dosier, G. K. (2014). Biomason. Green Magazine, 10.

Escuela Plitecnica de la Universidad de Sao Paulo(Poli-USP), Instituto de investigaciones Energéticas y nucleares(Ipen). (2012). Revista Pequisa Fapesp. Obtenido de http://revistapequisa.fapesp.br/es/2004/01/01/innovaciones-d-acero-2/

Fajardo, G., Cruz López, A., Cruz-Moreno, D., Valdez, P., Torres, G., & Zanella, R. (2015). Innovative application of silicon nanoparticles (SN): Improvement of the barrier effect in hardened Portland cement-based materials. Elsevier, 76, 158-167.

Falck Nelly, B. (2014). El bambú usado como material de construcción. Memorias del congreso " Superación Sanitaria y Ambiental:El Reto".

Figueroa Infante, A. S., Reyes Lozano, F. A., Hernández Barrera, D., Jiménez, C., & Bohórquez, N. (2012). Análisis de un asfalto modificado con icopor y su incidencia en una mezcla asfáltica densa en caliente. Ingeniería e Investigación.

Foti, D. (2016). Innovative techniques for concrete reinforcement with polymers. Elsevier, 112, 202-209.

Gaggino, R. (2015). Elementos constructivos con PET reciclado. Tecnologia y Construcción.

Galván Ruíz , M., & Velázquez Castillo , R. (2013). Cal, Un antiguo material como una renovada opción para la construción . Ingeniería. Investigación y Tecnología.

García, J. A. (2014). El hormigón como soporte biologico natural y su aplicacion en fachadas. Actas del I Congreso Internacional de Construcción Sostenible y soluciones eco-eficientes, 1, 351-357.

Hernández Moreno, S. (2014). Cerámica Reforzada con Fibras de Alúmina; Material para Aplicación en la Construcción. Acta Univerisitaria.

Ingrao, C., Giudice, A. L., Tricase, C., Rana, R., Mbohwa, C., & Siracusa, V. (2014). Recycled-

PET fibre based panels for building thermal insulation. Elsevier, 493, 914-929.

Jacobo J, G. (2010). Tecnología de la construcción. Universidad Nacional del Nordeste.

Jonkers, H. M., Thijssen, A., Muyzer, G., Copuroglu, O., & Schlangen, E. (2010). Application of bacteria as self-healing agent for the development. Elsevier, 36, 230-235.

La Rosa, A., Recca, A., Gagliano, A., Summerscales, J., Latteri, A., Cozzo, G., y otros. (2014). Environmental impacts and thermal insulation performance of innovative composite solutions for building applications. Elsevier, 55, 406-414.

Lachheb, M., Nasrallah, S. B., & Karkri, M. (2015). Development and thermal characterization of an innovativegypsum-based composite incorporating phase change material as building energy storage system. Elsevier, 107, 93-102.

Lee- Orantes, F., Torres Acosta , A., & Martinez Madrid , M. (2015). Refuerzo y protección catódica en elementos de concreto dañados. Ingenieria de Construccion.

Lewis, P. (2010). RePlast: Bloques de Plástico Reciclado. Materiales Innvovadores, Sostenibilidad.

Loss, C., Piazza, M., & Zandonini, R. (2016). Connections for steel–timber hybrid prefabricated buildings. Part II:Innovative modular structures. Elsevier, 122, 796-808.

Mendoza, C. J., Aire, C., & Davila, P. (2014). Influencia de las fibras de Polipropileno en las propiedades del concreto en estado fresco y endurecido. Conceto y Cemento. Investigacion y desarrollo.

Menna, C., Asprone, D., Durante, M., Zinno, A., Balsamo, A., & Prota, A. (2015). Structural behaviour of masonry panels strengthened with an innovative. Elsevier, 100, 111-121.

Mukerjee, A. (2013). Biogenic treatment improves the durability. Elsevier, 5.

Novais, J. A. (2014). Polimeros sinteticos para la conservacion de materiales pétros. Progrma MATERNAS.

Pisello, A., Fortunati, E., Mattioli, S., Cabeza, L., Barrechene, C., Kenny, J., y otros. (2016). Innovative cool roofing membrane with integrated phase changematerials: Experimental characterization of morphological, thermaland optic-energy behavior. Elsevier, 112, 40-48.

Proaño, R. (2014). Comportamiento de Vigas de Concreto Armado Reforzadas con Fibras de Carbono.

Reyes Ortíz, O. J., Fuentes Pumarejo, L. G., & Moreno Torres, O. H. (2013). Comportamiento de mezclas asfálticas fabricadas con asfaltos modificados con ceras.

1) Ricciardi, P., Belloni, E., & Cotana, F. (2014). Innovative panels with recycled materials: Thermal and acoustic. Elsevier, 134, 150-162.

Rodríguez Romo , J. (2010). El bambú como material de construcción. Conciencia Tecnológica.

Sanchez Soloaga, I., Oshiro, A., & Positieri, M. (2014). The use of recycled plastic in concrete. An alternative to reduce the ecological footprint. Revista de la Construcción.

Tobón, J. I., Payá, J., & Restrepo, O. (2015). Study of durability of Portland cement mortars blended with silica nanoparticles. Elsevier, 80, 92-97.

Torgal, F. P., & Labrincha, J. (2013). Biotech cementitious materials: Some aspects of an innovative approach. Elsevier, 40, 1136-1141.

Trudell, C. (2015). Bloque descontaminante para crear fachadas en los edificios. Architec Magazine.

Valdés Vidal , G., Reyes Ortíz , O., & Gonzáles Peñuela , G. (2014). Aplicación de los residuos de hormigón en materiales de construcción. Ingeniería y Desarrollo.

Van, V.-T.-A., Robler, C., Bui, D., & Ludwig, M. (2014). Rice husk ash as both pozzolanic admixture and internal curing agent in. Elsevier, 53, 270-278.

Vasconcelos, G., Lourenco, P., Mendoca, P., Camoes, A., Mateus, R., Braganca, L., y otros. (2013). Proposal of an innovative solution for partition walls: Mechanical,. Elsevier, 48, 961-979.

Wu, J., Bai, G.-L., Zhao, H.-y., & Li, X. (2015). Mechanical and thermal tests of an innovative environment-friendly hollow block as self-insulation wall materials. Elsevier(93), 342-349.