USO DE VIDRIO DE DESECHO EN LA FABRICACIÓN DE LADRILLOS DE ARCILLA

USE OF WASTE GLASS IN THE MANUFACTURE OF CLAY BRICKS

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Resumen

En el presente trabajo se fabricaron y analizaron ladrillos para construcción usando vidrio reciclado en su composición, variando su porcentaje de 0 a 15 % en peso, se utilizaron materias primas del Municipio de Vicente Guerrero, Durango, México, las cuales fueron mezcladas, homogenizadas y amasadas con agua, los ladrillos obtenidos fueron cocidos en hornos tradicionales. Los ladrillos se analizaron por las técnicas de difracción de rayos X y microscopía óptica, también se calculó el porcentaje de contracción lineal y se midieron las propiedades de resistencia mecánica y absorción de agua. De acuerdo con los resultados obtenidos, la introducción de vidrio de 5 a 10 % aumentó la porosidad del producto con respecto a la mezcla con 0 % de vidrio, lo que propició una baja resistencia mecánica y alto porcentaje de absorción de agua. Por otra parte, la composición con 15 % de vidrio presentó una microestructura más compacta, una resistencia a la compresión más alta y un porcentaje de absorción de agua más bajo con respecto a las mezclas con 5 y 10 % de vidrio. De acuerdo con la norma mexicana NMX-C-404-ONNCCE-2005, los ladrillos con 15 % de vidrio tienen uso potencial como materiales para construcción.

Palabras clave: ladrillos de arcilla, vidrio de desecho y resistencia mecánica.

Abstract

In this work were manufactured and used bricks to build using recycled glass in composition, varying in percentage from 0 to 15 wt%, raw materials of the Municipality of Vicente Guerrero, Durango, Mexico, which were mixed, homogenized were used and mixed with water, obtained the bricks were baked in traditional ovens. The bricks were analyzed by the techniques of X-ray diffraction and optical microscopy, the percentage of linear shrinkage was also calculated and the properties of mechanical strength and water absorption were measured. According to the results, the introduction of glass 5 to 10% of the porosity of the product with respect to the mixture with 0% glass, which led to a low mechanical strength and high water absorption percentage. Moreover, the composition with 15% of glass presented a more compact microstructure, resistance to compression, and a higher percentage of lower water absorption compared to blends with 5 and 10% glass. According to the Mexican standard NMX-C-404-2005-ONNCCE, bricks with 15% glass have potential use as building materials.

Key Words: clay bricks, glass waste and mechanical strength

Fecha recepción: Enero 2012 **Fecha aceptación:** Marzo 2012

Introduction

Waste materials have been defined as any kind of material produced by human or industrial activity without a final value. According to Disfani, Arulrajah, Bo and Hankour (2011), the growth in the number and types of waste such as plastics, glass and burnt clay, metals (mainly aluminum, iron and copper), paper, etc., and shortages spaces for deposit and lack of raw materials, emergency MAXIMISING find innovative ways to recycle and reuse waste materials.

Today environmental protection implies the words "recovery" and / or "recycled". Industrialized countries are major producers of waste can not be destroyed simply and quickly. The high costs of waste disposal oblige governments to take measures to minimize such waste and reduce its dependence on raw materials.

Thus, recycling has been practiced by US, German, Japanese industries, Canadian, Danish, French and many other countries for more than 20 years ago, largely because recycle and reuse waste materials can reduce demand for natural resources and lead to a more sustainable environment.

Among the waste materials, recycled glass is a very valuable material, consisting of a mixture of different particles of colored glass, which is often included with a wide range of debris such as paper, soil, metal and food waste. Glass is easily retrievable, namely the glass container is 100% recyclable, that is, that from a new container used can be made one that may have the same characteristics as the first. According to Mata and Galvez (2004), ease of reuse of glass opens a wide range of services for society and the authorities concerned can manage themselves in an easy way in the environment.

Although the presence of different colored glass particles and different types of debris on the glass, such as paper labels, adhesives, food waste, etc., is the main obstacle to re-use recycled glass, this has not prevented the industries try to seize it. Moreover, the production process and the grinding process play the most important in the maximum particle size and form paper, the level of offal, which consequently affects other geotechnical characteristics enabling it to use as material fill in embankments, drainage folders, means for filtering and material for paving roads (Disfani et al., 2011).

One of the most important factors that determines the degree of recycling of a material, is to determine how much the composition varies with recycling. For glass there is little variation in chemical composition from one source to another. In addition to the recycling of waste glass into new glass formation they have been proposed many other applications which are being investigated.

For example, one is as a component in cementitious materials, which appears to be one of the most lucrative applications because the amounts of waste which may already consumed the amorphous nature of the material with large quantities of silicon oxide (Jin et al. 2000; Karamberi et al, 2004)..

Also, according to Onishchuk et al. (1999), another of the most promising application areas is cullet in the production of heat insulation and decorative coating materials for construction. For example, we work reported by Pavlushkina and Kisilenko (2011) where the recycled glass is used for glazing ceramic tiles and improve the properties of the final article and presentation; those reported by Vorrada et al. (2009) on the effects on the physical and mechanical properties of clay bricks using waste glass as aggregate.

While recycling and use of waste glass is of great importance in areas such as environmental and economic, there are not many research reported so far to focus the development of new ceramic-based mix of clay and glass. Therefore, this is an area of opportunity for the generation of new scientific and technological knowledge to the production of high added value from waste.

Today, the disposal of waste glass has gained much attention from the environmental point of view; on the one hand, the use of cullet in the manufacturing process of new glass produces less pollution, through the reduction in the release of greenhouse gases such as CO2, SO2 and NOx emissions to a minimum. On the other hand, you can reduce the manufacturing cost by about 2.5 to 3% by reducing energy consumption and save fuel, since the processes of formation of silica glass takes place at lower temperatures (Sahar et al. , 2011). In other words, glass recycling requires 26% less energy than the original production, in which to create a kilo of glass about 4,200 kilocalories of energy are needed.

US and many European countries have been collecting glass waste for long using containers for it, this system of collection and storage is known as a selective method, which reduces the cost of significant use for recycling glass manufacturing new industrial processing or manufacturing new products. Although the selective system is absent in Russia, there are many publications of Russian scientists describe numerous experimental and industrial techniques related to the use of recycled glass in the production of building materials (Onishchuk et al., 1999).

However, in Mexico this practice is only just beginning and some companies do, for example, the Monterrey company Vitro, the leading manufacturer of glass containers in the country (Vitro, 2009). Therefore, the key challenge is to improve the culture of recycling among the population. The main source for collecting materials and take them to recycling plants are the collection centers near landfills.

Moreover, today the manufacture of bricks, tiles and other fired clay products has become a serious environmental problem in many cities of Mexico, mainly due to the burning of fuels used for cooking Products such as: wood, tires, used oil, wood, plastics or textiles, among others, giving off a lot of gases into the atmosphere as carbon monoxide, nitrogen oxides, sulfur dioxide and particulate matter. It is therefore a priority to address the problem of sources emitting gases that have caused health problems that arise in the settlers living around the brick (Dávila, 2009).

Suspected toxic pollutants emitted by burning fuels used by the brick can induce the occurrence of serious diseases like cancer, birth defects, fertility problems, among others. Exposure to sufficient levels of toxic substances in the air, can cause cardiovascular, pulmonary, skin, and death (Bradley, 2007) problems.

In any brick factory it carried out a series of standard processes ranging from the choice of clay material to the final packaging. The raw material used for the production of bricks is mainly clay. This material consists essentially of silica, alumina, water and iron oxide variables and other alkaline materials such as calcium oxides and magnesium quantities.

In Mexico, the traditional methods used to manufacture bricks for construction, include a drying step outdoors and cooked or sintering furnaces, which make use of highly polluting combustion processes precarious combustible materials, causing serious problems Pollution, particularly on the ground and in the air, with consequent health risks, both human and ecosystem.

Therefore, it is important to propose alternative solutions to reduce damage to the environment and therefore to humans, plants and animals. Among the proposals that have been presented today to abate this problem, is replacing clay brick concrete walls (as the production process generates no pollution partitions), however, must be taken into account the cement industry is the most polluting, since the amount of heat coming mainly from the burning of fossil fuels required to produce 1kg of cement clinker is around 1750 kJ (Taylor, 1997), with the issuance of the atmosphere of greenhouse gases, so it would not be talking about real environmental benefits.

Moreover, in recent years there has been much research how to recycle and reuse waste materials in order to reduce pollution, in this sense, the present paper reports the use of cullet in the manufacture of bricks to construction using raw materials Durango state.

Methodology

Conditioning the raw material

For brickmaking the following raw materials they were used:

Clay from the municipality of Vicente Guerrero, Durango, Mexico. For conditioning it was passed through a screen to remove impurities and lumps.

Sawdust.

Livestock manure.

Recycled glass. Clear glass bottle pass it off as ground to 50 mesh was used.

Manufacture of bricks in green

To produce the green brick in the compositions of Table 1 were used four compositions were made varying the total amount of glass from 0 to 15% glass with 5% increase. Raw materials traditionally used in amounts and water were added to a plastic mass producers in that region (approximately 3 kg of clay / ½ kg of sawdust / manure ½ kg) homogenized, manually kneaded to homogenize and allowed to stand outdoors for 5 hours.

Table 1. Compositions brick investigated in this paper.

Composición	vidrio (% peso)
LT	0
LT/5%	5
LT/10%	10
LT/15%	15

Molding parts

Before molding, the mold timber washed to remove remnants of previous mixtures that could affect parts. sand was sieved to sort by size (coarse and fine), then watered thin on the ground for use as a release. With the mixture of clay into a ball that is rolled on the sand to completely cover it. The mixture is then placed in the mold to fill it up, he took over with a spatula and turned to unmold. The piece was exposed to the sun for 3 days to dry.

Cooking Brick

For baking bricks, they were placed in a known as the "workshop" traditional oven. The wood fuel is commonly used. The bricks are arranged so that heat is distributed homogeneously and is much more uniform cooking. The fire furnace is maintained about two days, then allowed to cool to room temperature.

Measuring the contraction of the sintered brick

The percentage of linear shrinkage of the sintered bricks calculated with Equation 1

$$\%\ Contracción = \frac{Li-Lf}{Li} x100 \qquad \text{(Ec. 1)}$$

Donde: Li = Longitud inicial y Lf = Longitud final.

Compressive strength

The performance of the tests was based on the ASTM C67-99a (1992) standard, using a universal testing machine model WFCC PTS-200, using a loading rate of 0.290 kN / sec. The compressive strength was calculated by Equation 2.

$$C = \frac{P}{A} \qquad \text{(Ec. 2)}$$

Where: C = Compressive strength (MPa); P = total load on the specimen at the time of failure (N) and A = area of the specimen surface where the load (m2) applies.

Water absorption

The water absorption tests were performed according to ASTM C67 (1992) standard. First the dry brick weighed, immediately immersed in distilled water, then the water was removed piece, excess water with absorbent paper is removed and weighed immediately. The percentage of water absorbed was calculated by Equation 3.

$$\%\,Absorción = \frac{Pi - Pf}{Pi} x100 \qquad \text{(Ec. 3)}$$

Donde: *Pi* = Peso inicial y *Pf* = Peso final.

Results

Construction bricks manufactured successfully (no cracks or fractures that it inoperable), partially replacing traditional brick mixture (clay, sawdust, manure and water) with 5, 10 and 15 wt% pulverized glass and recycling; Figure 1 shows some finished pieces. All parts manufactured presented reddish, this coloration is caused by impurities in the clay, but mainly by the iron oxide [9].

Figure 1. Photograph showing some sintered bricks.

Figure 2 shows the results of XRD of the samples studied in this work. According to the XRD patterns obtained, the only crystalline phases present in the samples are albite and silicon oxide. It can be seen that as the amount of glass samples is increased, the amount of silicon oxide decreases and albite phase. The decrease in peak intensity of silicon oxide phase indicates that the material becomes amorphous as the glass amount added increases.

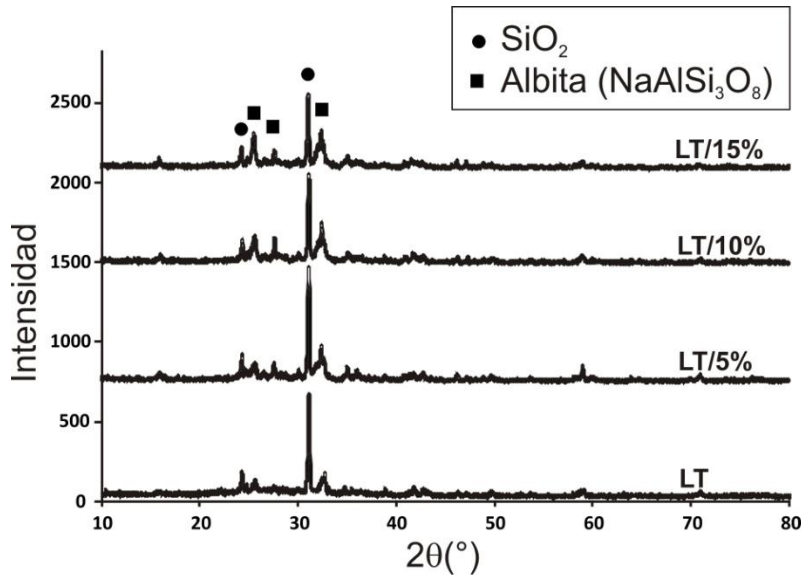

Figure 2. XRD patterns of sintered bricks with percentages of 0-15% glass named as LT, LT / 5% LT / LT 10% / 15% respectively.

Furthermore, Figure 3 shows the results of light microscopy without bricks and glass with different percentages. It can be seen that the glass is uniformly distributed throughout the material. Likewise, note that no samples glass had a higher porosity, but with fine pore size as compared with the samples with 5 and 10% of glass that had larger pores. Also, it can be seen that the samples with 15% glass had a less porous microstructure compared to the other.

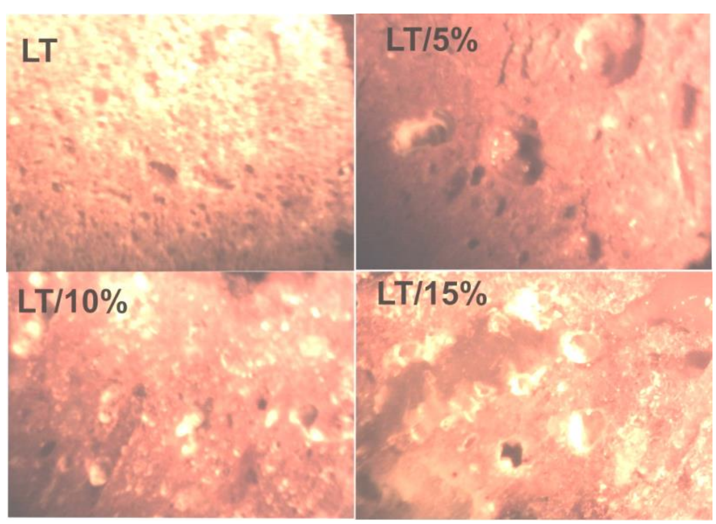

Figure 3. Micrographs: brick samples with and without glass taken at 20X.

The linear shrinkage is usually an important factor in determining the degree of densification during firing, however, a large linear shrinkage might increase the risk of fractures and cracks in the bricks. Table 2 presents the results of linear shrinkage of bricks with 0. 5%, 10% and 15% glass. It can be seen that all the bricks showed linear shrinkage similarly also these values (length and width) are consistent with those reported for mixtures of ball clay and up to 40% by weight of glass (Vorrada et al., 2009), and whose values are in the range of 8.5% to 10.5%.

Composición	**% de contracción**		
	ancho	**alto**	**largo**
LT	8.2	14.0	9.5
LT/5%	7.4	14.5	9.4
LT/10%	7.7	14.5	9.3
LT/15%	7.4	14.5	9.1

Table 3 presents the results of compressive strength. Compositions with 0% glass had the highest resistance, while compositions with 5% and 10% had the lowest values. When the amount of glass was increased to 15%, it increased material strength. This is consistent with the results of the microstructure they showed that the samples in which the LT / LT 5% / 10% had greater porosity bricks (large pores) compared with bricks LT / 15% presented a less porous microstructure .

Tabla 3. Resistencia promedio de los ladrillos

Composición	**Resistencia (MPa)**
LT	13.78
LT/5 %	5.81
LT/10 %	4.14
LT/15 %	9.73

Table 4 shows the results of water absorption. Three repetitions were made per sample and the average was calculated, the standard deviation was also calculated. Considering that water absorption is directly related to the open porosity presents material [10]; we can explain why traditional brick mix has a water absorption% much lower with respect to all other (smaller pores). % An increase in absorption in bricks with 10% glass with respect to having 5% glass, and then return to decrease in bricks with 15% glass is also observed. These results showed the same trend as resistance to compression, explained by the porous microstructure of the parts.

Table 4. Results of water absorption% of the sintered bricks

Composición	% absorción de agua
LT	14.2
LT/5 %	23.6
LT/10 %	27.7
LT/15 %	20.6

Conclusions

As could be seen, the microstructure of the samples was determined on the resulting properties in the bricks. Porosity increased by adding up to 10% glass to a traditional mixture, however, with the introduction of 15% glass, the porosity decreased; above it influenced the mechanical properties and water absorption. According to the Mexican Standard NMX-C-404-ONNCCE, (2005), applied to such materials where resistance to high compression 6 MPa, bricks with 15% glass specified may be used as materials construction, as these had average strength of 9.73 MPa.

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