MECHANICAL PROPERTIES OF RICE HUSK ASH GEOPOLYMER CONCRETE PRODUCED IN THE META'S DEPARTMENT, AND STEEL FIBER REINFORCED

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Abstract: With this project the modules of elasticity and relation of poisson are defined, thrown by tests of compression stress, the rupture modules were determined through the tests carried out to flexion and a it was made a comparison between the mechanical properties presented by the Conventional concrete with respect geopolymer concrete based on rice husk ash and reinforced with steel fiber, to verify the improvement of mechanical behavior, (Compression and bending).

In the results obtained, rice husk ash (RHA) increased the compressive strength of concrete by 4.35% compared to conventional concrete. Rice husk-based and reinforced with 0.5%, 1% and 1.5% steel fiber cylinders increased their compressive strength by 4.87%, 5.39% and 4.9% respectively. The modulus of elasticity increased for rice husk-based cylinders with reinforcement of 0.5%, 1% and 1.5% steel fiber compared to conventional concrete by 8.47%, 8.73% and 8.2% respectively, and the poisson ratio decreased at 0.518%, 1.036% and 2.07% respectively. The modulus of rupture of the reinforced joists with 0.5%, 1% and 1.5% increased with respect to conventional concrete by 5.84%, 7.2% and 6.03% respectively, improving the distribution of stresses in the concrete matrix.

Keywords: Rice husk ash, steel fiber, geopolymer concrete, mechanical properties.

Resumen: Se define con este proyecto los módulos de elasticidad y relación de poisson, arrojados por ensayos de esfuerzo a compresión, se determinaron los módulos de rotura por medio de los ensayos realizados a flexión y se llevó a cabo una comparación entre las propiedades mecánicas que presenta el concreto convencional con respecto a las del concreto geopolimero a base de ceniza de cascarilla de arroz y reforzado con fibra de acero, para comprobar el mejoramiento del comportamiento mecánico, (Compresión y flexión).

En los resultados obtenidos, la ceniza de cascarilla de arroz (CCA) aumentó la resistencia a compresión del concreto en un 4.35% respecto al concreto convencional. Los cilindros a base de cascarilla de arroz y reforzados con 0.5%, 1% y 1.5% de fibra de acero aumentaron su resistencia a la compresión en un 4,87%, 5.39% y 4.9% respectivamente. El módulo de elasticidad aumento para los cilindros a base de cascarilla de arroz con reforzamiento de 0.5%, 1% y 1.5% fibra de acero respecto al concreto convencional en un 8.47%, 8.73% y 8.2% respectivamente, y la relación de poisson disminuyó en un 0.518%, 1.036% y 2.07% respectivamente. El módulo de rotura de las viguetas reforzados con 0.5%, 1% y 1.5% aumentó respecto al concreto convencional un 5.84%, 7.2% y 6.03% respectivamente, mejorando la distribución de esfuerzos en la matriz de concreto.

Palabras clave: Fibra de acero, ceniza de cascarilla de arroz, concreto geopolimero, propiedades mecánicas.

1. INTRODUCTION

To date (year 2019), the union of the construction has impacted negatively the environment by altering the nature, emissions (CO2) and production of large amount of dust particles, which is why to reduce the impact caused by the civil works is necessary to use materials with low carbon content.

For 2016, the plains area markedly increased rice production, generating 1,156,460 Tons of this product, being the area with the highest rice production for the same year, and also maintaining the same production for the years following [1]. Due to its high demand and production, large amounts of biomass are generated which is used by many industries in various presentations such lumps husks, raw husks and burned husks.

However, it is much biomass is produced, which is why its implementation is sought in different fields; so, it has been found that the burned husk contains a high percentage of silica, which partially becomes a good substitute for cement, which, in addition to meeting the demand for infrastructure department with use, achieve mitigation environmental impacts generated by conventional concrete, reducing the emission of carbon dioxide and reducing the excessive waste rice hull.

To prevent the mechanical properties may be affected in connection with conventional concrete, the reinforcement of this geopolymer is searched using steel fibers, which provide specific mechanical properties as flexo traction, resistance to impact, durability, ductility, toughness and decreasing cracks; and also have characteristics necessary to disperse in a concrete mix fresh, using traditional methods of mixing.

2. EXPERIMENTAL PROCEDURE

2.1 Mix design

To the mix design 20% ash rice husk (RHA) was used as a supplement to cement and percentages of 0.5%, 1% and 1.5% of steel fiber to the respective samples were added, all with the purpose to achieve greater resistance to compression of the reference sample after 60 days of curing.

For the implementation of compression tests we were performed three specimens per sample for concrete curing ages 7, 14 and 28 days, and a single specimen for 60 days curing. Specimens used for performing compression tests were cylinders of 150 mm diameter and 300 mm height, as specified by the NTC 550. For bending test, two specimens were performed for a curing age 28 days the test pieces used were rectangular shirts 150 mm high, 150 mm wide and 545 mm long. All the tests were carried out in the concrete laboratory of Santo Tomas University campus Villavicencio.

2.2 Reinforced beam design

The steel required for each of the beams was calculated by the following equations and the results obtained are showed on the Table I:

$$As = b * d * \rho \qquad (1)$$

$$\rho = \frac{1}{M} * \left(1 - \sqrt{1 - \frac{2MK}{\emptyset Fy}}\right) \qquad (2)$$

$$M = \frac{Fy}{0.85F'c} \qquad (3)$$

$$K = \frac{M}{bd^2} \qquad (4)$$

Table I
STEEL REQUIRED FOR EACH CONCRETE SAMPLES

STEEL REQUIRED		
0.50%	*1%*	*1.50%*
2.0963 cm2	2.0858 cm2	2.0753 cm2
2#4	2#4	2#4

Source: Authors

2.3 Experimental methodology for the preparation of concrete cylinders

For the realization of the cylinders with conventional concrete mixture, with 20% CCA and percentages steel fiber 0.5%, 1% and 1.5% the following procedure was performed:

- For the realization of the mixture was weighted each of the materials as specified in the mix design.

Figure 1. PREPARING FOR CONDUCTING MATERIAL MIXTURE
Source: Authors

- After preparation of the materials, we proceeded to mix in the mixer.

Figure 2. BLENDING PROCESS IN THE MIXER
Source: Authors

- After mixing the materials, shirts were taken and adjusted previously greased cylinders to fill them and form cylinders. As indicated by the standard technique Colombian (NTC 550), filling in layers, each of these with their respective strokes performed.

Figure 2. SHIRTS BEFORE AND AFTER COMPLETION
Source: Authors

2.4 Experimental methodology for making concrete joists

To perform joists with conventional concrete mixture, with 20% CCA and percentages steel fiber 0.5%, 1% and 1.5% the following procedure was performed:

- For the realization of the mixture the same procedure was performed for the preparation of the material and mixing it in the cylinders.
- After making the mixture for each respective slat, proceeded to place the reinforcing steel, in this case, two bars Number 4, according to the steel required calculated in Table I.
- After placing the reinforcing each joist is determined, the filling shirts previously oiled and adjusted, considering compaction method stipulated in Colombian Technical Standard (NTC 550).

3. RESULTS

3.1 Test compression of different concrete samples

For this test were subjected to compression different samples of conventional concrete, 20% CCA, 20% CCA and 0.5% of steel fiber, 20% of CCA and 1% of steel fiber, 20% CCA and 1.5% of steel fiber, with the following results:

Table II
COMPRESSION RESISTANCE OF EACH CONCRETE SAMPLES (MPa)

Sample description	7 days	14 days	28 days	60 days
Design of conventional mixing	11.7	14.62	21.83	24.6
Mix design with 20% RHA	8.64	11.17	17.27	25.67
Mix design with 20% CCA and 0.5% RHA	6.53	8.47	18.56	25,798
Mix design with 20% CCA and 1% RHA FA	6	8.43	15.85	25,926
Mix design with 20% and 1.5% CCA RHA	3.81	7.61	14.67	25.63

Source: Authors

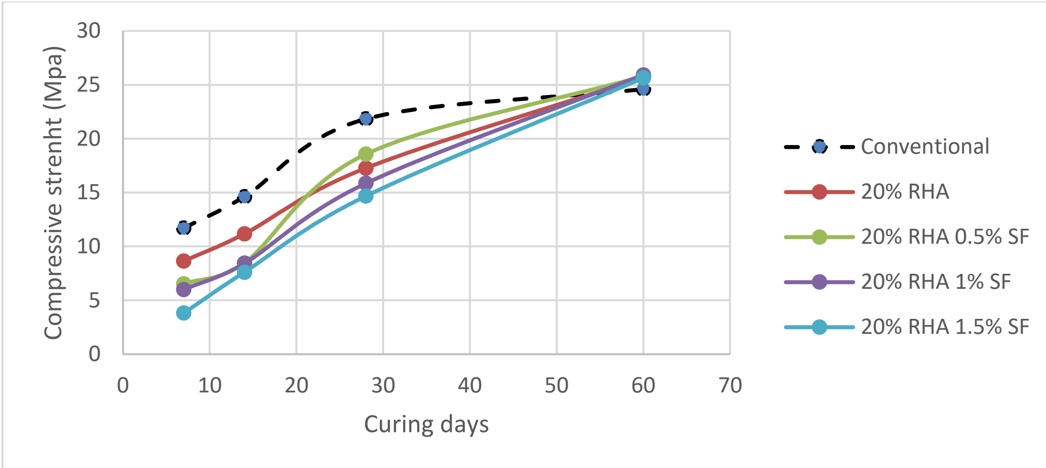

Figure 3 RESULTS OF DIFFERENT COMPRESSION CONCRETE SAMPLES
Source: Authors

The compressive strength of the cylinders 50 is determined by the process set forth in ISO 673 standard.

According to the results provided in Table II herein, it is apparent that the cylinders supplemented with 20% ash rice husks with and without fiber reinforcement steel 0.5%, 1% and 1.5% at ages 7, 14 and 28 days had a decrease in the compressive strength of the cylinders of conventional concrete, but at the age of 60 days was observed that these same cylinders exceeded resistance understanding cylinders conventional concrete.

After 60 days curing cylinders reinforced with 0.5% and 1% of steel fiber they increased by an insignificant percentage compression resistance. Cylinders reinforced with 1.5% of steel fiber did not exceed the compressive strength of cylinders only contained 20% ash of rice husk, since the higher is the percentage of steel fiber, decreases the compressive strength this is due to its high percentage of oxide aluminate which in the steel fibers is in about 25% compared to the cement which is between 4% to 7% and husk in which is less than 1%. The presence of a high C3A content leads to a more porous cylinder which thus loses compression strength,

The small increase in compressive strength due to the different percentages of fiber steel was because although these diminish the presence of cracks occurring by the alkali-silica ratio between cement and rice husks in the process which make hydration being randomly distributed is adhered and generate a confinement effect, improving the performance of the composite matrix, thus achieving better distribute the stresses.

Ash rice husks, contributed to the small increase in compression as the fact that content pozzolanic is greater add to contribute mixture increased production of cement gel (CSH) which reduces pore size and increases the main components increases compressive strength (C3S and C2S).

3.2 Modulus of elasticity and Poisson's ratio

Modulus of elasticity was obtain according to the ASTM C469 and was the relationship between the stress (dσ) applied to the unit strain (dδ):

$$E = \frac{d\sigma}{d\delta} \qquad (5)$$

Table III
MODULUS OF DIFFERENT SAMPLES CONCRETE

ELASTICITY MODULES (MPA)	
Conventional mixing	21812.24
20% RHA mix	22956.07
20% RHA-0.5% SF mix	23660.17
20% RHA-1% SF mix	23717.39
20% RHA-1.5% SF mix	23600.6

Source: Authors

Table IV
POISSON RATIO OF THE DIFFERENT SAMPLES OF CONCRETE

Mix type	Vertical deformation	Horizontal deformation	Ev/Eh
Conventional mixing	0.00517	0.001	0.193
20% RHA mix	0.00520	0.001	0.192
20% RHA-0.5% SF mix	0.00520	0.001	0.192
20% RHA-1% SF mix	0.00523	0.001	0.191
20% RHA-1.5% SF mix	0.00529	0.001	0.189

Source: Authors

The elastic modulus and Poisson's ratio correspond to cylinders with an age of 60 days. In samples with steel fiber content decreased seen in poisson ratio because these seek to confine the concrete matrix, rigidifying and generating the poisson ratio decreases.

The modulus of elasticity of cylinders fiber increases steel, this means that this type of concrete can reach high stresses without leaving its elastic zone, having the ability to return to its normal state, unlike conventional concrete which obtained a modulus of elasticity less than all other samples.

3.3 Modulus of Rupture of beams

Table V
Modulus of Rupture of different samples CONCRETE

JOISTS SPECIFICATION	MODULE OF RUPTURE (Mpa)
20% RHA mix	5.30
20% RHA-0.5% SF mix	5.44
20% RHA-1% SF mix	5.51
20% RHA-1.5% SF mix	5.45
Conventional mixing	5.14

Source: Authors

The bending test conducted was in four points with a configuration of L / 4, this means that the beam was supported at two points and load the transmitted two points at the top in the central region of the beam which was subjected to uniform tension obtained constant bending moment in this area.

From the results of flexural testing of different types of girders, was evident that the module increases rupture joists reinforced with steel fiber, the type of fault that presented these reinforced joists, was a failure to bending, was observed in the joist containing 20% hull ash and rice hull was reinforced with 1% fiber breaking some fibers steel.

4. CONCLUSIONS

The mix design that was raised in this investigation was appropriate because a physical characterization of materials was made to use and it was possible to obtain a greater resistance to the desired minimum of the cylinder conventional concrete at the age of 28 days, and based on this design they were obtained that of other specimens, thus achieving comparing the mechanical behavior of each type of specimen.

From the results obtained compression is concluded that the use of steel fiber provides a percentage insignificant to increasing compressive strength of the concrete, however, the use of more than 1% of steel fiber decreases this resistance. At early ages, concrete geopolymer based ash rice hulls and fiber reinforced lower obtained steel resistance regarding conventional concrete, but after 28 days of curing, a significant increase is observed in its compressive strength.

In Poisson's ratio it was observed that the cylinders with 20% hull ash reinforced percentages of 0.5%, 1% and 1.5% of steel fiber had a decrease of the 0.518%, 1.036% and 2.07% respectively, compared to conventional cylinders, which is very positive because retains a bit more the original dimensions of the elements.

Regarding the modulus of elasticity, the cylinders with 20% ash of rice husk reinforced percentages of 0.5%, 1% and 1.5% of steel fiber, had an increase of 8.47%, 8.73% and 8.2% respectively, of the which it concludes that the modulus of elasticity of concrete with 20% ash of rice hulls and fiber reinforced steel is greater and hence the maximum load which can be subjected again this particular type without suffering an irreversible deformation is greater than that of conventional concrete, the faults which have cylinders with 20% ash and rice hull fiber reinforced columnar steel although not exhibit brittle fracture as presented cylinders conventional concrete.

The modulus of rupture obtained concrete with 20% ash of rice hulls and fiber reinforced steel in percentages of 0.5%, 1% and 1.5% was higher than conventional concrete one 5.84%, 7.20% and 6.03% respectively. The problems that in the joists with 20% ash of rice hulls and fiber reinforced steel were not so sudden as presented in conventional concrete, this is because the fibers located randomly prevented the growth of internal cracks, and when subjecting the beam to the load, the voltage generated at the bottom which tried to produce an effect of tearing of the concrete, was carried by the fibers which to being attached to the concrete trying to prevent fracture of the material.

Comparing the concrete geopolymer based ash rice hulls and fiber reinforced steel compared to conventional concrete, the first shows a higher performance in all mechanical properties analyzed in this investigation (compressive strength, modulus of rupture, Module elasticity and Poisson's ratio), but this only happens between 28 and 60 days old, which is where the potential increase of their properties is displayed.

ACKNOWLEDGMENT

We thank God for being our guide and strength on our way.

To our parents for being a fundamental part of our development, by the values instilled in us and be our emotional and financial support in our path.

To our thesis director Engineer Emiro Andres Lozano, who was our guide and we shared many of his great knowledge in the area of structures to carry and provide us carry this research project his critical view on the implementation of this project his unconditional support and advice at all times.

To Santo Tomas University for the opportunity to grow entirely on their campuses, for all those the tools bring to our professional and personal growth, and financially support for conducting this research project.

To all those who accompanied us on our way and we provided support at every stage of this process.

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