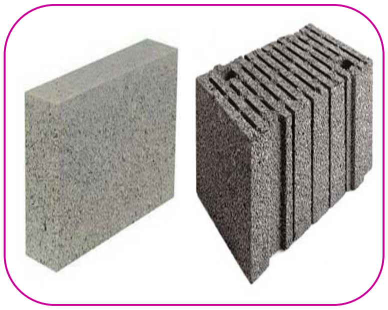
REVIEW OF RESEARCH
IMPACT FACTOR : 5.2331(UIF) UGC APPROVED JOURNAL NO. 48514 ISSN: 2249-894X

VOLUME - 7 | ISSUE - 8 | MAY - 2018

# LIGHT CONCRETE DEVELOPMENT
**(Brazil)**



**Glauber Marcos Cavalcante Duarte[1], Jorge Luiz Melo de Freitas[2], André Soares Mendes[3], Wanderson Araújo Luz[4], Marco Antonio Guerreiro Prado Filho[5], Charles Ribeiro de Brito[6]**

[1] Graduating in Civil Engineering at International Universities Laureates / UNINORTE (Brazil) (2018).

[2] Civil Engineering by Laureate International Universities / UNINORTE (2017) (Brazil).

[3,4] Civil Engineering by Laureate International Universities / UNINORTE (2017)(Brazil).

[5] Master in Industrial Process Engineering - UFPA (2016)(Brazil).

[6] Master's degree from the Federal University of Amazonas - UFAM, Professor at Laureate International Universities / UNINORTE (Brazil).

**ABSTRATCS**

*Concrete is now the second most used material in the world, losing in use only for water, being the most used construction material in the world. With this, the Brazilian Concrete Institute (IBRACON), at its annual congress, promotes student competitions to encourage students to develop and research within concrete technology. This work is the result of researches developed to participate in one of these competitions, concrebol, which aims to develop a sphere of concrete with characteristics determined by an edict. Several traces were tested in order to find the best dosage that met the criteria required by the edict of the concrete. The results obtained were very good, for a first participation in the competition, it was possible to measure light structural concrete that met the norms, both in resistance and in specific mass.*

**KEY WORDS:** *Concrete. IBRACON. Concrebol.*

## 1. INTRODUCTION

Conventional structural concrete accounts for a large part of the weight of any reinforced concrete structure, which results directly in the cost of foundations (Xavier and Bassani, Mendes, 2016). According to Catoia (2012), structural lightweight concrete shows its efficiency by reducing the structure's own weight, and consequently increases the possibilities of use, for technical and economic reasons. In order to have structural application, according to ACI 213 R-03 (2003), lightweight concrete must reach a minimum resistance of 17.2 MPa at 28 days, which is also found by NM 35 (1995). According to Mendes et al. (2017), using lightweight concrete as an alternative material results in a reduction of cost due to the reduction of the weight of the structure, as lighter elements reduce the loads on the foundations, consequently, the final cost of the work is also reduced. The objective of this article was to develop a lightweight concrete for the participation of the Aggregates of the University Center of the North - UNINORTE, in the 14th Concreto 2017 Competition, promoted by the Brazilian Concrete Institute - IBRACON, held during the 60th Brazilian Concrete Congress, happened in the city of Bento Gonçalves - RS.

## 2. METHODOLOGY

In order to perform this work we started with a pre-established trait of Concrete of Post-Reactives - CPR according to (VANDERLEI, 2004), a trait that can be observed in Table 1.

**Table 1 – Trace of Reference**

**TRACE OF REFERENCE**

| **Composition** | **Relation** | **Consumption(kg/M³)** |
|---|---|---|
| **Cement** | 1 | 874 |
| **Sand** | 1.101 | 962 |
| **Quartz** | 0.235 | 205 |
| **Active Sílica** | 0.246 | 215 |
| **Additive 3%** | 0.030 | 26 |
| **Water (w/c= 0.18)** | 0.180 | 157 |

Source: **(VANDERLEI, 2004)**

According to HOLM and BREMNER (1994) apud ROSSIGNOLO (2009), lightweight concretes presented at 80% of the compressive strength observed at 28 days at 7 days.

## 3. MATERIAIS

### 3.1 Cement

Portland cement type CP I-S-40 (Super Resistant), manufactured by Cemex, was used because it is a cement with a lower content of inert and mineral additions, and because it is thin and commercially available.

**Figure 1 –Cemex cement, Source: Own author.**


### 3.2 Sílica

The active silica used was supplied by Konkrex. According to the supplier, the physical and chemical characteristics of the active silica used are: specific mass of 2222 kg / m³; spherical particle format; mean diameter 0.2 µm; minimum SiO2 content of 85%; and maximum humidity of 3%. The active silica is a superpozolane, with great reactivity with the calcium hydroxide, product generated in the hydration of the cement. This material also produces C-S-H, such as that generated by clinker, increasing the strength of concrete and acts physically, as a nucleation point. By this, it potentiates the reactions, improving the properties of the mixture.

**Figure2 – Active Sílica ,Source:Own author.**


### 3.3 Pó de quartzo

The quartz powder used was supplied by BRASILMINAS INDÚSTRIA E COMÉRCIO Ltda. According to the supplier, the granulometric composition test showed that 90% of the sample grains had diameters smaller than 37.37µm, 50% had a diameter smaller than 10,80µm and 10% had a diameter smaller than 1.33µm. Because it is a thin material, it increases the compactness and packaging of the granular skeleton, which is beneficial for high strength blends.

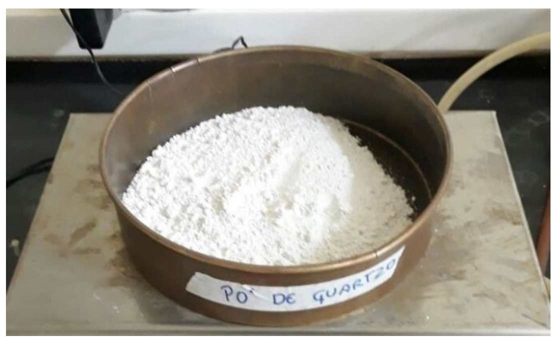


**Figure 3 –Quartz Powder, Source:Own author.**

### 3.4 SmallAggregate

Natural sand from the Manaus region was used, provided by the company Polimix. Their characteristics can be observed in Table 2. The small aggregate was dried in a natural environment after receiving it in the laboratory; afterwards, it was washed for removal of the pulverulent materials, mechanically sieved, and separated into several granulometric fractions (Figure 4). To further increase the resistance, the packing of the small aggregate was carried out, using the analytical method of packing Alfred, pointed out by Castro and Pandolfelli (2015) as one of the most used.

**Figure4 – Sand divided into several fractions, Source: Own author.**

**Table 2 – characterization of the small aggregate**

**PHYSICAL CHARACTERISTICS OF SAND**

| | | |
|---|---|---|
| **SpecificMass (NBR NM 52:2009)** | 2620 | kg/m³ |
| **Unit Mass (NBR NM 45:2006)** | 1560 | kg/m³ |
| **MaximumCharacteristic Dimension (NBR NM 248:2003)** | 1.2 | mm |
| **Classification (NBR 7211:2009)** | AverageSand | |
| **Modulus of Fineness (NBR NM 248:2003)** | 2.5 | |

Source: The Authors, (2017).

## 3.5 EPS

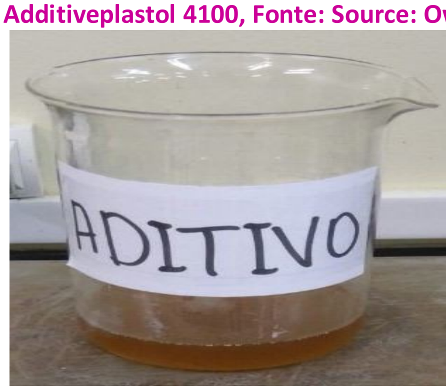
The industrialized EPS was purchased in 5 kg bags, manufactured and supplied by the company Termotécnica da Amazônia. The industrialized EPS has an average characteristic diameter of 0.75 mm and is classified by the company as T570 - MEA, and its specific mass of 26 kg / m³.

**Figure 5 – Pearls of EPS in various particle sizes, Source: Own author.**

## 3.6 ADDITIVE

The additive used was Plastol 4100, supplied by Viapol in 1000 ml bottles. According to the manufacturer is a superplasticizer type II (SP-II N) - (Hyperplasticizer) additive, it is compatible with all types of Portland cement, meeting the requirements of Brazilian standards NBR 11768 (type SP-II N) and ASTM C494 (type F). free of chlorides with a specific mass of approximately 1.1 g / cm³.

**Figure 6 – Additiveplastol 4100, Fonte: Source: Own author.**



## 4. RESULTS

### 3.1 Compressive strength

The axial compressive strength results obtained in this research are set forth in Table 3.

**Table 3 – Compressive Strength Results**

**COMPRESSIVE STRENGTH**

| **Trace** | **Dosageof EPS (g)** | **AverageCompressionTesion(MPa)** | **SpecificMass (Kg/dm³)** | **Efficiency Factor (MPa.dm³/Kg)** |
|---|---|---|---|---|
| **T-0** | 0 | 92.7 | 2.367 | 39.163 |
| **T-45** | 45 | 9.8 | 1.249 | 7.846 |
| **T-35** | 35 | 15.5 | 1.376 | 11.265 |
| **T-25** | 25 | 24.2 | 1.629 | 14.856 |
| **T-20** | 20 | 32.1 | 1.765 | 18.187 |

Source: The Authors, (2017).

It was observed that in increasing the amount of EPS in the reference traces of CPR, the concrete resistance tended to decrease, a fact observed both at work Mendes et al. (2017), and Xavier, Bassani and Mendes (2016). According to ACI 213 R-03 (2003) and NM 35 (1995), only T-20 can be considered a structural lightweight concrete.

**Figure 7 - Compression resistance test, Source: Own author.**

### 4.2 Specific Mass

The specific mass results obtained in this research are set forth in Table 4.

**Table 4 – Specific Mass Results**

**SPECIFIC MASS**

| **Trace** | **Dosageof EPS (g)** | **AverageCompressionTesion(MPa)** | **Specific Mass (Kg/dm³)** | **Efficiency Factor (MPa.dm³/Kg)** |
|---|---|---|---|---|
| **T-0** | 0 | 92.7 | 2.367 | 39.163 |
| **T-45** | 45 | 9.8 | 1.249 | 7.846 |
| **T-35** | 35 | 15.5 | 1.376 | 11.265 |
| **T-25** | 25 | 24.2 | 1.629 | 14.856 |
| **T-20** | 20 | 32.1 | 1.765 | 18.187 |

Source: The Authors, (2017).

Table 5 presents the minimum and maximum limits of light concrete according to some standards and technical publications.

**Table 5 – International normative documents for specific mass of a Lightweight Structural Concrete - CLE**

| Reference | Specific Mass(Kg/m³) |
|---|---|
| RILEM (1995) |  < 2.00 |
| CEB-FIP (1977) |  < 2.00 |
| NS 3473 E (1992) | 1.20 <  > 2.20 |
| ACI 213R-87 (1997) | 1.40 <  < 1.85 |
| CEN prEN 206-25 (1999) | 0.80 <  <2.00 |

Source: Rossignolo, 2009.

According to the results obtained and according to the norms and technical publications of table 5 in this research all traces with addition of EPS can be considered light concrete.

### 4.3 Efficiency Factor

The concrete efficiency factor (FE) consists of the ratio between the compressive strength and the apparent specific mass. There is currently no parameter for lightweight structural concrete only for high performance lightweight concrete which, according to Spitzner (1994) and Armelin et al. (1994), should be greater than 25 MPa.dm³ / kg. The values obtained in this research regarding FE can be observed in table 5.

**Table 6 – Efficiency Factor Results**

**EFFICIENCY FACTOR**

| Trace | Dosageof EPS (g) | AverageCompressionTesion(MPa) | Specific Mass (Kg/dm³) | Efficiency Factor (MPa.dm³/Kg) |
|---|---|---|---|---|
| **T-0** | 0 | 92.7 | 2.367 | 39.163 |
| **T-45** | 45 | 9.8 | 1.249 | 7.846 |
| **T-35** | 35 | 15.5 | 1.376 | 11.265 |
| **T-25** | 25 | 24.2 | 1.629 | 14.856 |
| **T-20** | 20 | 32.1 | 1.765 | 18.187 |

Source: The Authors, (2017).

According to the results presented in table 6, none of the features of this research can be considered with high-performance lightweight concrete, since the only trace that reached the mark of 25 Mpa.dm³ / kg was T-0 which cannot be considered light, due to its high specific mass.

## 5. CONCLUSIONS

It can be concluded, through the above, that the objective of the research was to reach, therefore, the University Center of the North - UNINORTE, in its first participation in the contest Concrebol obtained the 11th of a total of 32 teams, being ahead of traditional institutions that already had a history of participating in the contest. In addition to the successful participation of the contest, this article also confirmed that the greater the addition of EPS, the lower the resistance of the concrete. The results of this research also show that it was possible to produce a concrete that could be classified as lightweight in accordance with the regulations.

## 6. ACKNOWLEDGMENTS

First of all, thank God, my family, my friends André Mendes, Daniel Almeida, EloadirBrasil, Gustavo Campos, Jéssica Muniz, Paulo Antônio and Wanderson Araújo for all the support during these months of research, and UNINORTE Laureate International Universities.

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**Main Picture:** lightweight concrete
Available: http://www.civileblog.com/lightweight-concrete/