

### 3. Results and Discussions

#### 3.1. Mechanical resistance to compression (compression strength)

Five specimens of each composite at the analyzed age were subjected to compression strength tests. Table 2 presents the average and the standard deviation of each developed composite at the age of 1, 3, 7, 14, 28, 60, 90, 180 and 365 days with different rates of paper sludge, wood ash and lime,

TABLE 2.

RESULTS FOR COMPRESSION STRENGTH TESTS OF THE DEVELOPED COMPOSITES, BY AGE.

An analysis of table 2 for specimens of composites 1, 2, 3 and 4 (higher rates of paper sludge and lower rate of lime) indicates that resistance increases up to 14 days and then it begins to fall.

However, for composites 5, 6, 7, 8 and 9, which contain a lower rate of paper sludge and a higher lime rate, the mechanical resistance reaches peaks until the age of 180 days. It should be noted that composite 6, which has an intermediate amount of paper sludge (58%) and lime (12%), has compression strength values that indicate a more linear growth.

The use of the percentages of paper sludge, wood ash and lime of composite 6 in the development of a new civil construction product - the "paper brick" - allows a satisfactory use of waste from paper sludge and lime in its production.

In order to compare the compression strength results found for the composites in this research, the so-called "paper brick", the values used were those recommended by the Brazilian standard NBR-10834 [11], which established a minimum of 2.0 MPa for soil-cement seal blocks.

An analysis of resistance results for the "paper bricks" indicates that the developed composites presented values above those that are recommended by NBR-10834 [11], according to table 2 on one curing day.

Compression strength tests were also carried out with the nine composites at 28 days of age, dry samples at room temperature, and wet samples immersed in water for 24 hours.

Table 3 shows that composite resistance falls 40% on average when subjected to moisture. Nevertheless, even with this sharp resistance drop, the wet composites still have values that are higher than the recommended by the Brazilian standard NBR-10834 [11], which establishes 2.0 MPa as a minimum for soil-cement seal blocks.

TABLE 3.

RESULTS FOR COMPRESSION STRENGTH TESTS, AT 28 DAYS OF AGE, WITH BOTH DRY AND WET SAMPLES OF THE DEVELOPED COMPOSITES.

#### 3.2. Water absorption of composites

As described in Method above, water absorption tests were carried out with composites 3, 6 and 9. These tests were carried out according to NBR 10836 [9], then compared to NBR 10834 [11]. This standard recommends that the average water absorption should be equal to or lower than 20%, and individual values should be equal to or lower than 22% at 28 days of curing.

TABLE 4.

RESULTS OF WATER ABSORPTION TESTS WITH COMPOSITES 3, 6 AND 9, AT 28 DAYS OF AGE.

Table 4 shows that, for composites 3 and 6, both the individual values and the average values found follow the recommendation of the Brazilian standard. However, composite 9 - with a higher rate of lime (20%) and lower rate of the ETE sludge (40%) - does not achieve the recommended values.

### 3.3. Composite gradation

Gradation tests were carried out with composites 3, 6 and 9. The method of sieving 200 grams of sample was used.

Figures 1, 2 and 3 show gradation test results for composites 3 (Sludge (L) = 65%, Ash (C) = 25% and Lime (Ca) = 10%); composite 6 (Sludge (L) = 58%, Ash (C) = 30% and Lime (Ca) = 12%) and composite 9 (Sludge (L) = 40%, Ash (C) = 40% and Lime (Ca) = 20%).

FIG. 1.

RESULT OF GRADATION DISTRIBUTION IN COMPOSITE 3 (L=65%, C=25%, CA=10%).

FIG. 2.

RESULT OF GRADATION DISTRIBUTION IN COMPOSITE 6 (L=58%, C=30%, CA=12%).

FIG. 3.

RESULT OF GRADATION DISTRIBUTION IN COMPOSITE 9 (L=40%, C=40%, CA=20%).

The results allow to conclude that, as the amount of lime is increased and the amount of sludge is reduced, grain diameter decreases and the percentpassing is also less.