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DOSAGE STUDY OF PERMEABLE CONCRETE WITH RECYCLED RCC AGGREGATES

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Abstract: Currently, with urban sprawl, there are two major issues of concern: soil sealing and the generation of civil construction waste (RCC). Soil compaction and asphalting make it difficult for water to infiltrate, which can lead to flooding in lower areas. The waste generated, when disposed of irregularly, causes obstruction of roads, proliferation of vectors, silting of streams and rivers, etc. The use of permeable concrete pavements made with RCC aggregates is an innovative and sustainable solution to this problem. Therefore, this project proposes to incorporate recycled aggregates in the production of structural concrete, for later application in draining pavements. The research is divided into three interconnected stages, namely: 1st) characterization of natural and recycled aggregates and study and definition of permeable concrete traces, varying the proportion of gravel replacement by RCC (for execution during 2021); 2nd) preparation and characterization tests of permeable concrete developed in the previous stage (execution in 2022); and 3rd) production and application of permeable concrete blocks for use in pavements (to be carried out in 2023). The research is supported by the company Mejan Ambiental, with the supply of recycled aggregate. It is hoped, with this work, to contribute to the sustainable development of the country.
Keywords: Dosage, Pervious concrete, Recycled aggregate, Construction and demolition waste.

INTRODUCTION

Concern for the environment is a worldwide issue that motivates numerous researches focused on population growth and urban development; activities that cause environmental problems, such as compromised urban drainage and excess construction waste.

Civil Construction is responsible for the economic and social development of the country, but also for causing various environmental impacts (Fonseca, 2011). Therefore, it is up to this sector to use local, recycled and reusable materials, in addition to practicing techniques that favor the surrounding environment, transforming waste into reused materials (Azevedo, 2006).

Pervious concrete pavements play a key role when it comes to flooding and flooding, as they reduce surface runoff, flattening flood peaks and thus reducing the likelihood of future flooding. Since urban legislation values buildings that respect a certain occupancy rate and soil permeability, this makes it possible for permeable pavement to gain increasing space in the market.

In this context, the purpose of the research is to produce optimal traits so that the RCC can, guaranteeing good performance, be applied in the manufacture of permeable concrete as a sustainable solution.

MATERIAL AND METHODS

In this study, recycled and natural aggregates and CP V – ARI cement were used.

CHARACTERIZATION OF AGGREGATES

The characterization tests respected the aforementioned standards: granulometric analysis: NBR NM 248 (2003), specific mass and water absorption: NBR 16917 (2021), Unit Mass: NBR NM 45 (2006) and Fine material NBR NM 46:2021. Cement characteristics were taken from the manufacturer.

PERMEABLE CONCRETE DOSAGE

The dosage methodology adopted in the research began with the study of the research by Fernandes (2015) and Junior (2019), and considering the IPT/EPUSP dosage method, two proportions 1:m (m=dry aggregates) were chosen, being one equal to 3.5 (rich trait) and the other equal to 5.0 (medium trait). The replacement of the natural aggregate by the recycled aggregate was carried out in the proportions of 25%, 50% and 75%, being, then, determined 8 traces, called: TC - Control Trace, without replacement of the natural gravel; T25 - Trace with 25% of the recycled gravel replacing the natural one; T50 - Trace with 50% of the recycled gravel replacing the natural one; T75 - Trace with 75% of recycled gravel replacing the natural one.

STUDY OF THE WATER/CEMENT RATIO (A/C)

In order to guarantee that the aggregates were involved by the paste, but without excessive amount of it, thus allowing the passage of water and avoiding the production of crumbly mixtures, different w/c ratios were studied for each replacement content evaluated. The w/c ratios verified included the range from 0.5 to 0.8 in the range of 0.05 for the 1:3.5 trace and the range from 0.55 to 0.65 in the range of 0.05 for the trace 1:5.0.

MIXING AND MOLDING PROCEDURES

The initial mixing process took place by making the cement paste in the concrete mixer, using approximately 70% of the water, in order to guarantee the necessary hydration of the grains, since the RCC has a high rate of intrinsic water absorption, as mentioned by Junior (2019). Then half of the aggregate mass was added. After 60 seconds of mixing, the rest of the aggregate and water were added, ending the process with all the aggregate particles surrounded by the cement paste.

RELATIONSHIP RATING:A/C

The verification of the drainage of each mix with the respective w/c ratio was carried out through the visual analysis of the flow of running water through the concrete samples.

Once the optimal relationship was defined, both in the rich and medium mixes, new mixtures were carried out in order to submit each mix to a tactile-visual analysis, in order to obtain concretes that formed a "ball in the hand" and whose particles were coated. cement paste, checked for shine. YAP et al. (2018) mention the "ball in hand" formation technique, Ball-in-hand, as the most assertive method for permeable concrete, since it does not produce significant slump.

RESULTS AND DISCUSSION

Results and analyzes obtained are presented below. The confidence level of the statistical analyzes applied to the results was adopted as 95%.

DESCRIPTION

The analysis of the characterization results, in table 1, makes it possible to identify that water absorption is the parameter with the greatest discrepancy between natural and recycled aggregates, a fact already observed in the bibliography. It is also noticeable that the recycled aggregate is lighter than the natural one.

Comparing the granulometric curves of natural and recycled gravel (figure 1), it is observed that the former is better graded than the latter. In this way, it is inferred that a mixture constituted by the RCC gravel will be deficient in the matter of packing the particles, reflecting in lower resistances.

TRACES OF CONCRETES

In the first step, in an analysis of the rich trace (1:3.5), figure 2 shows that, from the w/c ratio of 0.50 to 0.55 and 75% of RCC substitution, it was obtained good drainage and compact form in the mixture ((a) and (b) respectively). With the w/c ratio starting at 0.60, it is noticeable, in (c), an excess of cement

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	Max Diameter. (mm)	Fineness Module	Especific mass (g/cm³)	Loose Unit Mass (g/cm³)	Compacted Unit Mass (g/cm³)	water absorption (%)	Fine Material Index (%)
Natural Aggregate	9,50	6,00	2,90	1,654	1,690	0,00	3,90
Recycled Aggregate	9,50	6,00	2,42	1,130	1,200	8,00	5,30

Table 1. Results of physical characterization tests of natural and RCC pebbles

Source: the author (2021).

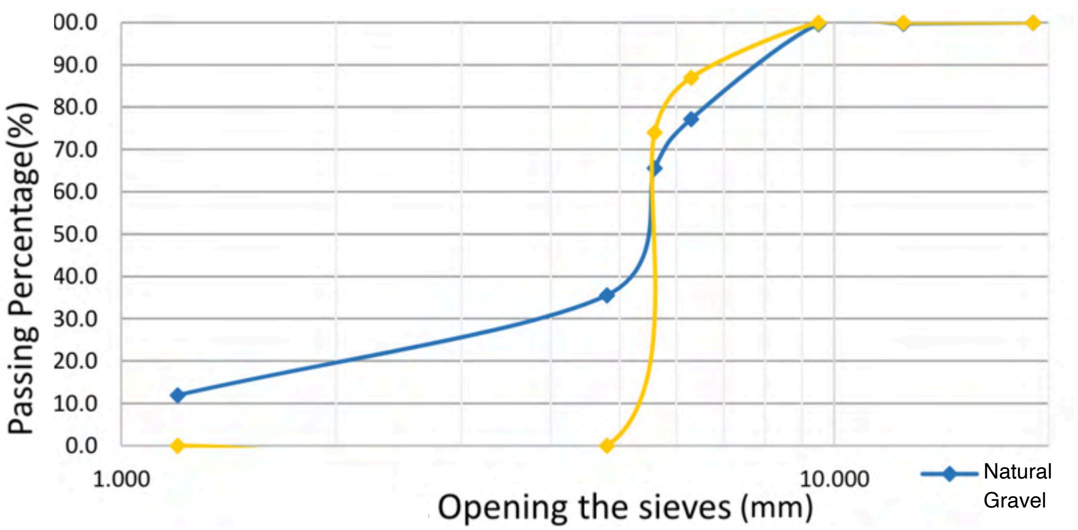

Figure 1. Grain size curves of the aggregates used.

Source: the author (2021)

(a) (b) (c)

Figure 2. Samples of trace T75, with w/c of 0.50, 0.55 and 0.60 respectively

Source: the author (2021)

paste, culminating in a decrease in drainage. For the other RCC replacement percentages (25% and 50%), the analyzed results were equal to the 75% RCC percentage. In relation to the control mix, with 100% of gravel, the w/c ratio of 0.50 to 0.55, there was a small excess of cement paste. In order to maintain the lowest w/c ratio, ensuring a positive impact on resistance, the value chosen, which includes the four replacement ratios (0%,25%,50%, 75%) of the gravel by the recycled aggregate was 0.55.

In the average trace (1:5), it can be seen in image 3 that, for low w/c ratios in T75, the molding process did not culminate in compact blocks. The same occurred in T25 and T50. The control mix, with 0% replacement, molded with w/c of 0.6, despite ensuring good drainage, still leads to brittle blocks. Thus, the value that includes the four replacement ratios (0%,25%,50%,75%) of the gravel by the recycled aggregate, seeking efficiency in the mechanical performance, was adopted at 0.65.

Pereira e Barbosa (2015, apud Paula Júnior, 2019), studied mixtures to meet the requirements of light traffic pavement and developed permeable concretes with different levels of replacement of gravel by RCC. The trait that presented the best results for the authors was the one with 20% RCD, proving to be a viable alternative for the use of the tailings.

Once the w/c ratios were defined, the concrete in the fresh state was evaluated by tactile-visual analysis, which can be seen in Figure 4. Regarding the rich mix, it appears that T50 and T75 presented better performance, as they resulted in mixtures without cohesively bonded excess paste, with all aggregate particles coated with paste. In TC and T25, the slight excess of water was noticeable, which is explained by the low content of recycled aggregate present; responsible for the absorption of water.

In relation to the medium trait, from the tactile-visual analysis, conclusions similar to those of the rich trait were verified, in which the best performances were in T50 and T75. Although the verified performance has undergone variations in the range of 0% replacement to 75%, it was followed with the same w/c ratio for analysis and comparison purposes. In summary, the adopted traits can be seen in table 2.

CONCLUSONS

After evaluating the results, and aiming to obtain optimal mixes of permeable concrete with RCC, it is concluded that the best w/c ratio for the mix (1:3.5) is 0.55 and for the mix (1:5, 0) is 0.65, as they resulted in cohesive and draining mixtures. The tactile-visual analysis test allowed to define the percentages of RCC replacement by natural gravel, being 50% for the rich trace and 75% for the medium one, since in these percentages no excess paste was observed. Using these traits, the following research steps will ensure parameters necessary and required by the norm for the application of mixtures with RCC in permeable concrete blocks.

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(a) (b) (c) (d)

Figure 3. Samples of the average T75 trace, with w/c of 0.55 (a), 0.60 (b), 0.65 (c) and 0.70 (d)

Source: the author (2021)

m(kg)	Trace	a/c	Cc(kg/m³)
3,5	1:3,5:0,55	0,55	485,171
5	1:5:0,65	0,65	373,856

TABLE 2. Concrete traces evaluated and studied in the present research

Source: the authors (2021).

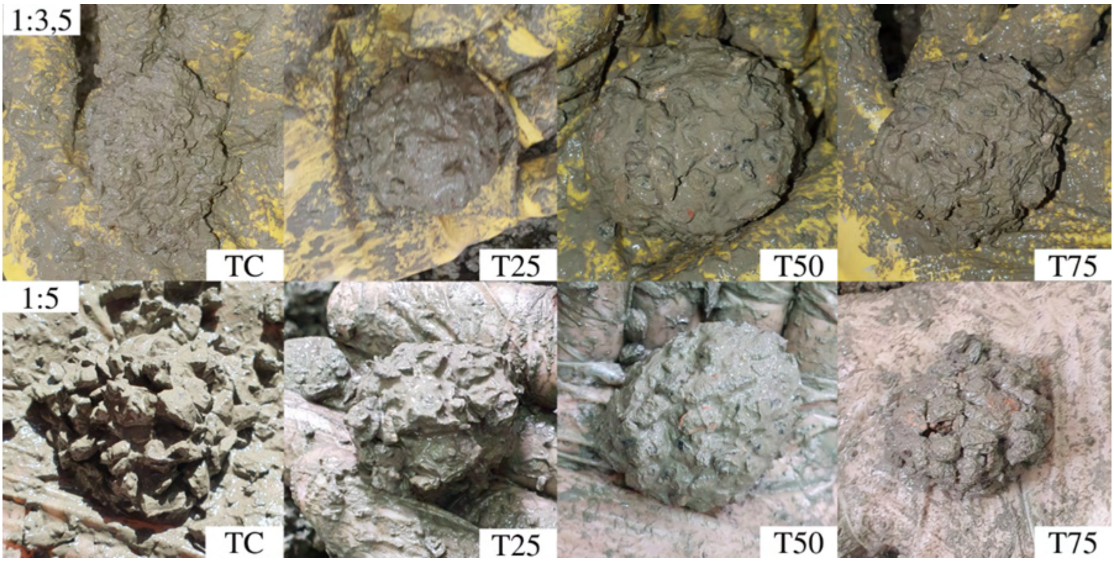

Figure 4. Application of the “ball in hand” method to verify the consistency of the mixtures

Source: the author (2021)

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