Evaluation Of The Water Absorption Of Expanded Polystyrene After Different Periods

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ABSTRACT
This work evaluated the results of water absorption tests on specimens of expanded polystyrene (EPS) in the specific masses of 10, 20 and 30 kg/m³ molded in specimens with cubic dimensions of 100 mm. The tests were carried out according to ASTM C272 (2001). Long-term water absorption tests were also performed, which differs from the simple test by the immersion time of the specimens, in which the test bodies were kept submerged for a period of 28 days, seeking to study the behavior of the EPS when exposed or in contact with water for long periods of time. From the results it was observed that the water absorption parameters tend to decrease with the increase of the specific mass, being that the lower density presents significant water absorption, this shows that there is a loss of the beneficial characteristics of the use of EPS with low density. Thus, it is important to provide a waterproofing system in practice that avoids the direct contact of the geofoam with the water, as well as an adequate and efficient drainage system to remove the water in contact with the EPS faster in the construction. It is also worth noting that water absorption represents about 4% of the sample volume and the behavior, both in mass and volume, for immersion in a 24-hour period and 28 days remains similar.

KEYWORDS: Expanded polystyrene (EPS), Water absorption test, Specific mass.

RESUMO
Este trabalho avaliou os resultados de ensaios de absorção de água em amostras de poliestireno expandido (EPS), nas massas específicas de 10, 20 e 30 kg/m³, moldadas em corpos de prova com dimensões cúbicas de aresta igual a 100 mm. O ensaio foi realizado com base na norma ASTM C272 de 2001. Realizou-se também ensaios de absorção de água de longa duração, que difere do ensaio simples pelo tempo de imersão das amostras, neste os corpos de provas foram mantidos submersos por um período de 28 dias, buscando estudar o comportamento do EPS quando exposto ou em contato com a água por longos períodos de tempo. Dos resultados notou-se que os parâmetros de absorção de água tendem a diminuir com o aumento da massa específica, sendo que a menor densidade apresenta significativa absorção de água, isso mostra que há uma perda das características benéficas da utilização de EPS com baixa densidade em aterros, assim, torna-se importante prever, na prática, um sistema de impermeabilização que evite o contato direto do geoexpandido com a água, além de um sistema de drenagem adequado e eficiente para retirar o mais rapidamente a água em contato com o EPS nas obras. Destaca-se ainda que a absorção de água representa cerca de 4% do volume da amostra e o comportamento, tanto em massa quanto em volume, para imersão em um período de 24 horas e de 28 dias se mantém semelhante.

PALAVRAS-CHAVE: Poliestireno expandido (EPS), Ensaio de absorção de água, Massa específica.

1. INTRODUCTION

Expanded polystyrene (EPS) when used for geotechnical applications, receives designation as geofoam. This material stands out for being insulating, resistant and a lightweight material, bringing several benefits. The great differential for its use in works is the significant reduction of the execution time as well as the stress that will reach the ground. Consider for example its various applications in light landfills, foundation for roads on low support soil, widening of highways, light embankments of overpasses and railway embankments, protection of pipelines, pipelines and buried structures, stabilization of slopes as well as many other applications (Avesani Neto, 2008; Sun et al., 2009; Mcguigan and Valsangkar, 2010; Jafari, 2010; Stark et al., 2012; Bartlett, Lingwall, & Vaslestad, 2015).

For being an inert, non-biodegradable and non-dissolvable plastic, it has no nutritive values to host microorganisms and other animals and is not chemically affected in contact with soil and water (Horvath, 1994). Its properties suggest that, if properly applied, can provide adequate performance over the working life.

When used in the presented applications, efficient waterproofing and drainage are required to prevent contact with hydrocarbons and water, the first one dissolves EPS and also can cause damage in the material. In this context, it is necessary to study how contact with water affects geofoam, since in the field it may be subject to this kind of situation.

It should be noted that the water absorption process in EPS is reversible. Long-term field observations indicated seasonal fluctuations in EPS water content, similar to those observed in the vadose soil zone (Horvath, 1994). Beju & Mandal (2017) performed water absorption tests according to ASTM C272 standard test method and test results showed that EPS water absorption property is low and decreases as its specific mass increases. Thus, this paper presents some results regarding the water absorption test in different specific masses of geofoam.

2. MATERIAL AND METHODS

Water absorption test was performed according to ASTM C272 2001. Three specimens (100 mm cubic dimensions) of each specific mass (10, 20 and 30 kg/m³) were used to perform the tests.

Initially, the natural mass (at room temperature) of the specimens stored in the laboratory, according to test method, was measured to obtain the hygroscopic material moisture thereafter. Then the specimens were placed in an oven at a temperature of 95ºC for a period of 24 hours in order to obtain their dry mass. The next step was to obtain saturated mass by immersing the specimens in distilled water for 24 hours. After this time, these specimens were removed from the container and dried to remove excess surface water and then weighed on a high precision balance.

Long term water absorption tests, which differ from the simple one by the immersion time of the specimens, were also performed. In this one, the specimens were kept submerged for a period of 28 days, seeking to study the behavior of the EPS when exposed or in contact with water for long periods of time. Figure 1 illustrates the specimens prepared for the test.

After obtaining all the masses, the water absorption of the material (in percentage) was obtained by the ratio of the mass of water absorbed by the specimen when saturated and the dried mass. Similarly, the hygroscopic moisture content of the material was obtained from the ratio of the water mass absorbed under natural conditions (without saturation) to the dried mass.

Figure 1. Specimens prepared for testing.

3. RESULTS AND DISCUSSION

Water absorption and long-term water absorption values, measured for saturated specimens at 24 hours and 28 days, respectively, of water immersion, were evaluated, as well as the hygroscopic moisture absorption of the material for the EPS specimens.

In the literature, it is common to present the water absorption values regarding to the sample volume; thus, the nominal volume of the cubic specimens with an edge of 100 mm was considered. Table 1 summarizes the water absorption values by volume percentage immersion and the results are shown in Figure 2.

Table 1. Volume of water absorbed by saturated specimens.

	over a 24-hour period			over a 28-day period		
Specific mass (kg/m³)	10	20	30	10	20	30
Nominal volume (cm³)	1000	1000	1000	1000	1000	1000
Dry mass (g)	11.34	18.95	29.45	10.20	17.24	32.85
Saturated mass (g)	49.43	53.59	50.13	53.11	64.34	88.05
Volume absorbed (cm³)	38.09	17.32	6.89	42.91	26.17	16.48
Water absorption of material (%)	3.80	1.70	0.70	4.30	2.60	1.60

It is noted that there is a significant reduction in the percentage of water absorbed with the increase of submerged EPS specific mass after a period of 24 hours, which is due to the greater presence of voids in the smaller specific masses.

In addition, the values of volume water absorption percentages do not exceed 4% of the total sample volume. It was also observed that the hygroscopic moisture content is insignificant when compared to submersion water absorption.

Beju & Mandal (2017) studied the behavior of EPS in terms of water absorption when subjected to a 24-hour period, according to ASTM C272. The results showed an absorption of 4.41%, 3.60% and 2.88% for EPS specimens with 12, 15 and 20 kg/m³ respectively, and these values are very close to the results of this research. They also concluded that EPS water absorption properties are relatively low and decrease with increasing specific mass.

The EPS behavior when placed in contact with water for a long period of time was also studied in order to have a better understanding of the material behavior in this condition. Comparisons between the water absorption volume for periods of 24 hours and 28 days are shown in Figure 2.

Ossa & Romo (2012) studied the influence of a confining stress on the water absorption of EPS, and noted that there is a high influence of the confining stress on the water content variation of EPS specimens. In addition, for unconfined conditions, there is an increase in water content during the first thirty days, reaching values of 3.9% and 4.7% for specimens of 20 kg/m³ and 29 kg/m³, respectively. After this period, the moisture content of the specimen remains virtually unchanged. It is noteworthy that these results are similar to those reported by Duškov (1997) for a specific mass of 20 kg/m³ and tested under unconfined conditions.

The trend lines used showed an excellent fit for the data, both trend lines are polynomial, and can be used to obtain easily the material water absorption as a function of the specific mass.

By the Figure 2, it can be seen that the absorption of water increases when compared the periods of 24 hours and 28 days, however this increase is not very significant for the shortest specific mass, increasing from 4.0% to 4.3% in volume, which represents an increase of 12.7%. However, when we look at the other specific masses (20 kg/m³ and 30 kg/m³) there is a greater influence on the water absorption time, increasing 51.1% and 139%, respectively.

This difference shows that the larger specific masses are more influenced than the smaller ones when in contact with water for longer periods of time. It happens because the lower the specific mass, the greater the presence of voids and, consequently, the easier for the water to fill these voids in a short period of time. The samples with higher specific masses, due to the fact they have smaller voids, present greater difficulty for the water to penetrate these voids, thus, with a longer immersion time, the water can penetrate the voids that had not been filled in the first moment.

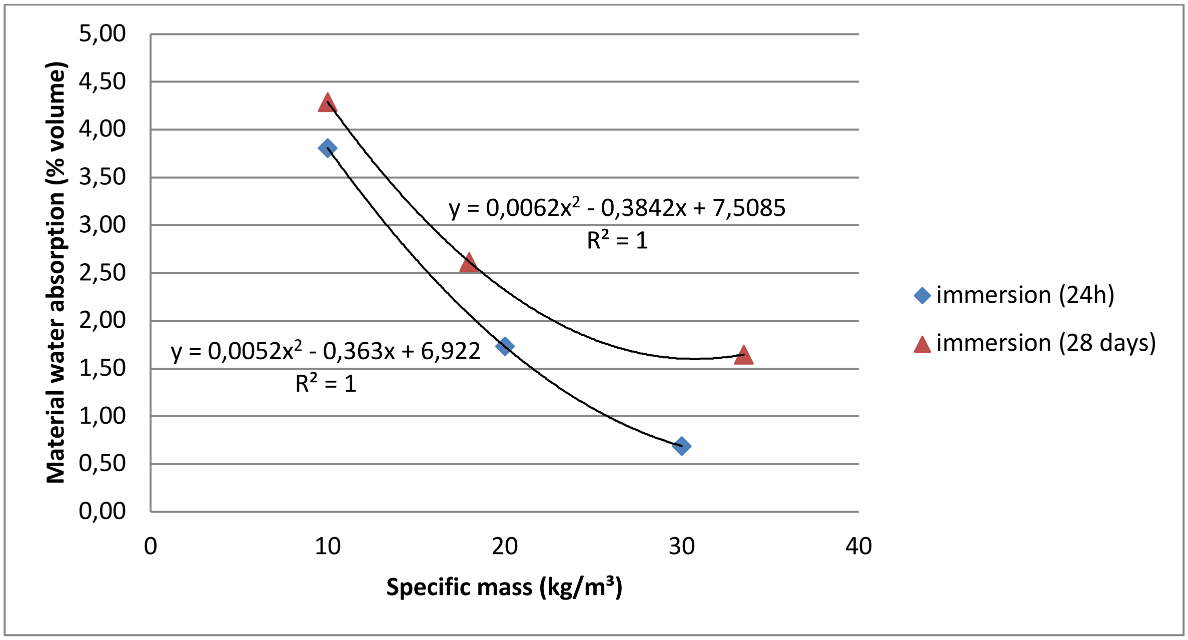

Figure 2. Comparison of the relationship between specific masses and percentage of volume water absorption for 24 hours and 28 days immersion.

It is worth mentioning that in these tests the samples did not suffer any type of physical damage, if this had happened, the EPS beads could break, allowing water to enter the cells, increasing their absorption, a situation that could occur if the material was subjected to compression, for example.

4. CONCLUSIONS

From the results of the water absorption tests, it was observed that water absorption after immersion for 24 hours represents about 4% of the sample volume and there is a significant reduction in the percentage of water absorbed with the increase in EPS specific mass due to the greater presence of voids at lower specific masses, besides that, the hygroscopic moisture content of the material is insignificant. The water absorption of the material when immersed for 28 days presents a small difference in the volume of water absorbed for the shortest specific mass, however the water absorption for the biggest ones increases along the time of immersion, being able to increase by more than 100% compared to immersion in 24 hours. This reinforces the need to provide efficient protection and drainage systems where there is a possibility of EPS contact with water in geotechnical works.

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