DETERMINATION OF SOME PHYSICAL AND MECHANICAL PROPERTIES OF AN EXPERIMENTAL CONCRETE WITH EXPANDED POLYSTYRENE (EPS)WASTE CONTENT

Assoc.prof. PhD eng. MIRCEA SĂLCUDEAN,
prof. PhD eng. MARIA POPA, stud. LUCIA AURA PINTILIE
"1 Decembrie 1918" University of Alban Iulia, Romania

ABSTRACT: *Concrete is one of the most consumed materials in the world. The use of conventional aggregates from exhaustible natural resources added to the mix is linked to a number of environmental impacts. The use of expanded polystyrene (EPS) in concrete recipes is an effective method because it allows the saving of conventional aggregates and allows the reuse of waste from constructions and demolitions. Although it is a relatively new material, lightweight concrete with expanded polystyrene has been the subject of study in various universities around the world as well as in the laboratories of various companies involved in the field of construction, mainly due to its low specific mass and good thermal insulation capacity.*

Keywords: *aggregates; lightweight concrete; expanded polystyrene;*

Introduction

The use of expanded polystyrene as a light aggregate in concrete can be done by using industrialized pearls or by reusing discarded material, which is previously ground or crushed before being added to the concrete mix. The mechanical properties of the material will depend on a number of factors, largely on the amount of natural aggregates replaced by expanded polystyrene[1]

Expanded polystyrene is among some of the most common materials used in various industries, having multiple uses such as for the packaging of spilled products as well as for thermal insulation of buildings. It is estimated that 47.9% of EPS consumed is used in the packaging industry[2] Polystyrene is the main ingredient used in the production of expanded polystyrene. This is a type of plastic derived from petroleum, which is a non-renewable fossil material.

Polystyrene is formed from the monomer styrene. In addition to this material, air is a key element in the process of making polystyrene, especially since it is produced in proportion to 98% of air[3]. Ceresana investigated the world market for the best-selling insulation material, EPS expanded polystyrene. According to Ceresana, around 7.2 million tonnes of EPS were consumed worldwide in 2022 – half a million tonnes more than five years ago[4]. Approximately 100,000 tons of foam waste from demolition sites are generated each year. Figure 1 shows a waste container from a construction site [5].

The protection of the environment, as well as the improvement of the quality of life, require the application of an appropriate waste management policy. This mainly involves the recovery of raw materials through recycling and the disposal of waste that cannot be reused. The greatest potential for the use of waste is offered by the construction sector[7]. Buildings must be designed, constructed and dismantled in such a way as to ensure the reuse or recycling of materials that can be recovered[8], [9]. There are many reasons to promote the benefits of recycling, a good example is the increasing amount of energy consumed in the manufacture of building materials[10].

Materials and methods

Lightweight concrete containing EPS is commonly used in the interior and exterior of homes and buildings[11]. Lightweight concrete can include different types of natural and artificial aggregates, in this work using expanded polystyrene waste as a partial substitute for part of the natural aggregates. Therefore, lightweight concrete has been introduced and widely adopted in construction applications where weight reduction of structures is a key solution[12].

Figure 1. Waste container from a construction site [6]

In order to present and compare a new recipe for concrete containing polystyrene waste, the standard recipe for concrete C16/20 presented in table 1 was taken as a benchmark.

Table 1. Concrete recipe C16/20
(Source: Own processing according to the standard recipe)

Component	Kg/m³	0,5%(kg)
Cement 42,5 R	295	1,48
Aggregate 0-4 mm 43%	789	3,95
Aggregate 4=8 mm 20%	367	1,84
Aggregate 8-16 mm 37%	679	3,40
Water	170	0,85

For the preparation of a recipe, expanded polystyrene waste was used in figure 2, showing the process of shredding this polystyrene waste (from scraps used in construction and packaging) manually by rubbing on a rough surface, as well as the integration of this waste into the concrete composition operation shown in figure 2.

These used polystyrene waste replaced the 4-8mm lot in proportion of 10%.Incorporation of polystyrene waste was quite difficult due to the very low weight as well as the inability of this material to absorb water.

The concrete resulting from the preparation of the experimental recipe is poured into standard patterns, then it is kept for 24 hours in these patterns, after which it is removed and placed in the sample storage basin for 28 days at a constant temperature of 20 degrees Celsius (figure 3) .

Results and discussion

Or performed compressive strength measurement tests 7 days after their manufacture, as well as 28 days after their manufacture. Tests were done for both the standard recipe and the experimental recipes.

Or made determinations of fresh concrete densities of these samples. Figure 4 shows the compressive strength tests performed 7 and 28 days after sample preparation.

Following the tests performed on the compressive strength at 7 days and at 28 days, as well as the density, the results presented in table 2 were obtained.

Figure 2. EPS shredding and mixing (Source: Own processing)

Figure 3. Concrete samples(Source: Own processing)

Conclusion

The results of the tests carried out on these experimental concrete recipes confirm that the partial replacement of some aggregates with waste is viable and can successfully replace these components of the concrete composition, being able to be used for specific purposes where it is not a question of the resistance structure of a building.

These preliminary results show that concretes containing polystyrene waste have a lower weight and density than the standard C16/20 concrete recipe and can only be used when there are certain buildings that do not need a high loading of some floors higher or for other purposes well determined by the decision-making personnel who deal with the construction or renovation of buildings.

Figure 4.Carrying out compressive strength tests
(Source: Own processing)

Table 2. Results of the tests performed(Source: Own processing)

Concrete type	Cube sample weight 100x 100mm(kg)	Sample density (kg/m^3)	Compressive strength 7 days (kN/m^3)	Compressive strength 28 days (kN/m^3)
C16/20	2,315	2310	11,850	17,410
C16/20+ polystyrene	1,895	1904	3,694	6,430

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