THE USE OF RECYCLED EXPANDED POLYSTYRENE (EPS) IN THE MANUFACTURE OF CONCRETE

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***ABSTRACT**: Expanded polystyrene (EPS) generates an environmental problem as a result of a slow biodegradation process, the idea of this project is to motivate the polluting agents to make an integrated management of solid waste, offering a reuse of this material. This work aims to address the reuse of EPS in the field of construction, in the manufacture of concrete and several materials as a partial substitute for natural aggregates. This material has favorable mechanical and thermal insulation properties for the construction industry and can reduce the use of other materials from exhaustible sources without neglecting the quality of a new product, thus saving natural resources. The new materials that have recycled polystyrene in their composition, being friendly to the environment and having at the same time an economic compensation, can arouse the interest of companies producing construction materials.*

***Keywords:** Expanded polystyrene(EPS); re-use; materials; enviroment;*

Introduction

Global polystyrene production capacity stood at 15.44 million metric tons in 2022. By 2026, a slight increase is expected, with production capacity estimated at 16.75 million metric tons that year. This increase is partly due to the announcement that two new polystyrene plants will start production in Asia during this time frame (1) (Fig. 1).

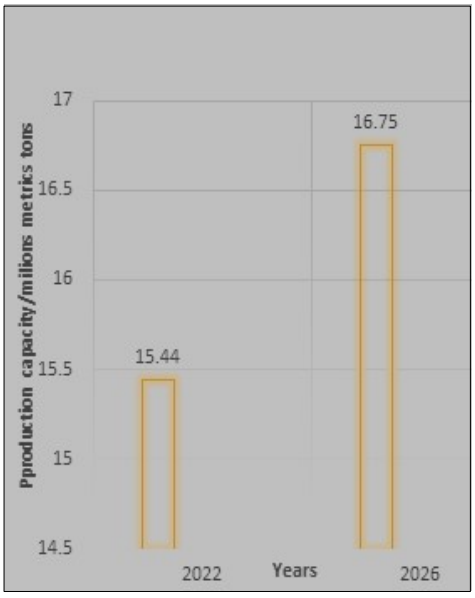

Fig. 1. Expanded polystyrene production in the world

The rate of recycling and recovery of construction and demolition waste for the year 2020 is set at 70%. Currently in Romania, the waste recovery level is far below the set value, the collected waste is mostly disposed of by storage in landfills, without any other recovery or reuse(2).Waste recycling can be defined as a recovery operation through which materials are transformed into raw material in a production process to obtain the initial product or for other purposes. Recycling materials saves this energy because it reduces the number of industrial processes needed to produce them,because the natural resources are limited and constantly decreasing(3). Construction and demolition debris (CDD) constitute one of the massive flows of solid wastegenerated from municipal and commercial activities of modern society (4)

In the framework directive DC2008/98/CE (https://eur-lex.europa.eu) recycling occupies a primary place in the hierarchy of processes, being located before storage and incineration.

The proposed steps in this hierarchy are:

- preventing the appearance of waste;
- preparation for reuse;
- waste recycling;
- energy recovery;
- waste disposal. (5)

For the community, recycling is a very important thing to consider because polystyrene is a material that only biodegrades in hundreds or even thousands of years. Man has the obligation

to take care of the environment, much more so now that the planet is suffering from global warming, hence the desire to find new uses for expanded polystyrene (EPS) waste (Fig. 2).

Fig. 2. Polystyrene waste(6)

Environmental concern for polystyrene revolves around four fundamental elements:

- slow degradation and absence of a substitute;
- production of waste;
- its source of generation is oil, a non-renewable raw material; (5)

It is important to avoid the incineration of expanded polystyrene (EPS) waste produced in different activities or that it ends up in landfills, the best option is to be able to reuse it in a process(7). A process that can be taken under consideration is the reuse of expanded polystyrene (EPS) which will be used as a light aggregate in the composition of concrete. There is a wide range of application of recycled EPS in concrete production, literature studies indicate the use of EPS in the construction sector as coarse and fine aggregate to produce various concrete products(8).

As an alternative, the production of new ecological concrete units composed of cement, sand, water and recycled expanded polystyrene is proposed(9,10).

It is important to note that expanded polystyrene has excellent thermal properties in addition to its light weight, so it will be feasible to obtain data with information technical(11).

Total replacement of coarse aggregate should be avoided as the strength would be zero. In order to reach tangible results, different types of mixtures must be made, following their behavior through different behavioral research techniques (9,12).

Materials and methods

The physical properties of expanded polystyrene are what make it different from other materials, they are responsible for the versatility of this material, which has led to the use of expanded polystyrene in a large number of activities carried out by people. Among these characteristics we mention:

-**Thermal insulation:** The most important physical property of expanded polystyrene is the extraordinary thermal insulation capacity against cold and heat. The expanded material is made up of 98% air and 2% polystyrene. The trapped air is a fundamental factor in maintaining the insulation capacity, which the extraordinary insulating effect is widely known(13).

-**Mechanical resistance:** An important property for expanded polystyrene is its mechanical resistance under short and long-term stresses, through compression resistance(14).

-**Water absorption:** Unlike many other building materials, EPS is not hygroscopic. This material absorbs only a small amount of humidity(15).Expanded polystyrene concrete is manufactured with different densities depending on the intended use(16). It can be used as blocks or poured into formwork to make walls. Another

frequent use is for concrete slabs where we do not need a large load on the building structure (renovations of existing buildings, roofs, etc.), being very good as a thermal insulator on roofs and external walls (17), (Fig. 3).

Fig. 3. Uses of concrete with polystyrene (18–21)

To find the most suitable proportions it is necessary to have several test samples, which are calculated based on the properties of the materials (22,23). It is known that aggregates are a set of particles of natural or artificial origin, which must be chemically stable and free of organic matter (12). In this case, crushed expanded polystyrene is used as coarse aggregate due to its mechanical strength characteristics and fine aggregate due to the workability of concrete.

Also, the manufacturing process for this type of concrete is not as complex or expensive as others because the amount of labor and specialized equipment is less. In the same way, the benefits of this new technique are satisfactory, both in the construction sector and for the environment, as it reduces pollution by reusing expanded polystyrene (24).

Expanded polystyrene can be added in a significant percentage, partially replacing the aggregate used in the manufacture of concrete in construction(25), therefore the costs and the raw material can be greatly reduced by recycling this material to reuse it, on the other hand, the polystyrene waste introduced in the composition greatly reducing the impact on the environment considering the decomposition of polystyrene waste takes hundreds of years (26).

Among the advantages of using expanded polystyrene in the composition of concrete, we mention:

- Light weight: expanded polystyrene contains up to 98.5% of its volume in air (27).
- The component cells of polystyrene are closed: 1 cm3 of expanded polystyrene contains from 3 to 6 million cells filled with air (28).
- Sealing: Because its cells are closed, this material only absorbs amounts lowercase letters of liquid water. Low coefficient of thermal conductivity: Air at rest inside the cells closed is a very poor conductor of heat; This, together with the low thermal conductivity of the material basic, it offers a very low coefficient of thermal conductivity for the whole.
- EPS is not affected by water/moisture after immersion and does not produce diffusion in the material.
- It can withstand mechanical loads thanks to its special cell structure.
- It is very resistant and does not deteriorate over time.
- It is a harmless material for groundwater, as it does not release any substance(13).

The reuse of polystyrene waste from various sectors is very important to have a healthy

environment because non-renewable natural resources (derived from petroleum) are used to manufacture polystyrene, it is not biodegradable (it takes hundreds of years before it can degrade), uncontrolled incineration generates serious pollution and health problems (14).

Results and discution

The global processes of industrialization and urbanization have allowed a massive increase in cement production in the last three decades, because cement is the most important construction material. Consequently, the cement industry is the second largest industrial emitter of CO_2 (~25% of global industrial CO_2 emissions) globally(15).

One way to maintain balance in sustainable development can be the use of local disposable waste and/or recyclable materials. The alarming level of concrete production worldwide, which involves a large amount of natural resources, shows the need for sustainability through the use of alternative materials. In fig.4., is represented according to Statista the total volume of cement production worldwide which amounted to about 4.4 billion tons in 2021. In 1995, the total global cement production amounted to only 1.39 billion tons, an indica-tion of the extent in which the construction industry has since grown (16).

It must be taken into account that the main components of concrete, especially binders and aggregates, represent approximately 10-15%, respectively 60-80% of its total volume. World-wide quarrying, which aims to produce coarse aggregates, has greatly altered the ecological balance. Consequently, it is essential to find sustainable substitutes to supply both the binder and the aggregates normally used in the concrete industry, in order to reduce the adverse environmental effects resulting from the extensive use of natural raw materials. Currently, many wastes are thrown away and remain unused. A n example of such waste is construction and demolition waste, which could be recycled and used as an aggregate in concrete. With a simple calculation related to the consumption of aggregates necessary for the manufacture of concrete worldwide, which represents between 60-80% of the composition of concrete, a partial replacement of them with waste expanded polystyrene (EPS) leads to a significant saving in the consumption of aggregates. This greatly reduces the impact on the environment, firstly by reusing these categories of waste and secondly by reducing the consumption of aggregates from mining (17).

Conclusions

The main benefit of expanded polystyrene in the production of modified concrete is its reuse leading to a decrease in the negative impact on the environment generated by the poor disposal of this waste, because the degradation of this material is long-term and this represents a deterioration of the environment and ecosystems.

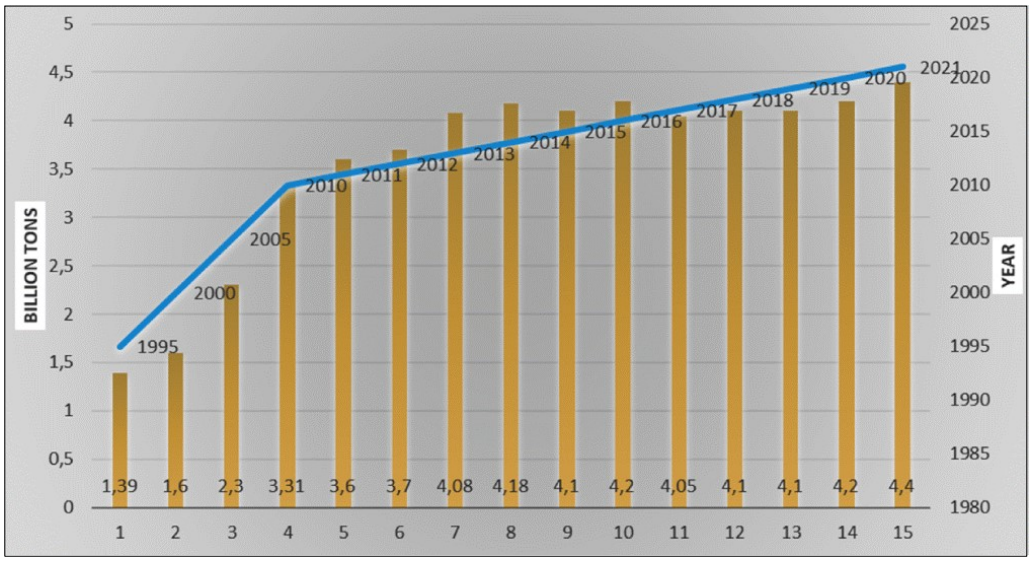

Fig. 4. Cement production worldwide from 1995 to 2021(29)

Thanks to the recycling of expanded polystyrene, one of the benefits it offers us is the reduction of the volume of waste thrown into urban and suburban landfills, and indirectly this improves the quality of life of the people who live in and surround these areas. Any idea related to recycling that provides a benefit to the environment should be saved, studied and implemented. From the review and analysis of the state of the art and the study of the results obtained in each investigation, it can be deduced that the addition of expanded polystyrene changes the mechanical properties of concrete, cataloging it as a highly functional component of lightweight concrete, offering many advantages to the construction industry.

Following the partial replacement of the aggregates with expanded polystyrene, important features such as the homogeneity of the mixture and the absence of segregation or floating of the expanded polystyrene (EPS) in the fresh concrete can be observed.

According to the analysis carried out on the results of different articles and investigations of concrete modified with expanded polystyrene as a replacement in different percentages of fine and coarse aggregate, it can be concluded that this material has a high functionality as lightweight concrete is a replacement alternative for fine and coarse aggregates as long as long as the mechanical properties do not show significant changes.

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