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# ENVIRONMENTAL PROTECTION THROUGH THE MANAGEMENT OF SBR AND PET WASTE IN THE INNOVATIVE CONCRETE BUILDING BLOCK APS

The article presents the development of an innovative shape of the APS hollow block based on a cuboid, made of a designed recycled concrete mixture with additives of SBR rubber granules of various fractions and PET flakes obtained from recycling giving the possibility to managing this waste and contributing to environmental protection. The newly designed shape of the concrete wall block makes it possible to build foundation and retaining walls easily and quickly. At the same time, the designed curvilinear through-holes and two grooves enable the blocks to be joined horizontally with one another in a so-called 'locking' manner, ensuring horizontal stability and making it possible to meet the requirements for traditional openwork wall blocks. A series of laboratory tests is presented on the basis of designed concrete mixtures with different percentages of additives in the form of recycled waste: SBR rubber granules of different fractions and PET flakes, followed by the production of an openwork block APS from the selected recycled concrete mixture, which was compared with the reference block Alfa.

*Keywords:* Innovative concrete block; rubber granules; polyethylene terephthalate

## 1. Introduction

One of the largest industries is the construction, which pays particular attention to sustainability and environmental protection, which can be achieved, among others, by wase recycling waste and their effective use [1-3]. Rapidly increasing global warming obliges us to pay more attention to environmental protection, including in the sphere of proper waste management on a local and global level [4-7]. The construction industry is making excellent use of this and is introducing new technological solutions for the use of waste in its various sectors, using waste as a cheap or even free component for further processing [8-10]. One such waste is SBR rubber, which is obtained from used car tyres and, after processing, is present in the form of: dust, fines, pellets, abrasive, chips and shreds [11,12]. Another waste analysed is polyethylene terephthalate in the form of coloured PET flakes obtained from used food packaging, which is a thermoplastic polymer with a wide range of applications, and occurs in the form of flakes and granules [13-15]. Referring to the important global problem of the backlog of waste, used car tyres and PET plastic bottles, the possibility of their management in the form of: styrene-butadiene rubber as SBR rubber granules and polyethylene terephthalate as PET flakes in the highest possible quantity in designed concrete mixtures is presented, followed by the making and testing of the basic properties of a novel APS wall block from a selected modified concrete mixture .

## 2. Wastes: polyethylene terephthalate in the form of PET flakes and styrene-butadiene rubber in the form of SBR rubber granulate

The most common waste in the world is plastic, which is present not only in the form of used packaging, but also in the ubiquitous microplastic particles noticeable in the seas and oceans, in the soil and even in the air [16-18]. According to a study by M. Grembecka et al, humans consume about 5 grams of microplastics per week, which negatively affects human health and further affects the condition of the entire environment [19]. It is therefore necessary to look for the most effective solutions to manage this waste. The majority of used plastic food packaging is made of polyethylene terephthalate, commonly known as PET, a polymer from the thermoplastic group, which, depending on its composition, decomposes between 100 and 1000 years [20]. According to Plastics Europe, around 1.5 million tonnes of plastic products were produced globally in the 1950s and significantly more, over 400 million tonnes, in 2022. In Europe, approximately 59 million tonnes of plastics were pro-

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duced in 2022, representing 14.75% of global production [21]. In order to be able to manage this waste, it undergoes recycling processes, giving the possibility to obtain new components in the form of PET pellets or PET flakes. This paper presents the use of coloured PET flakes (Fig. 1a,b), as one of two additives in designed modified concrete mixtures.

Another analysed waste is a used car tire, which does not decompose and is a rubber product that is difficult to process, which directly affects the storage of this waste in landfills [22]. The tyre is made up of more than 200 components, and when processed into individual rubber components: cut tyres, halves, shreds, chips, granules, middlings, dust and others: textile cord, steel cord, it offers the possibility of effective use as a raw material in many sectors of the construction industry [23]. This paper discusses the use of styrene-butadiene rubber in the form of SBR (Sequencing Batch Reactor) rubber granules with the following fractions:, 2÷4 mm, 0.8÷2 mm and 0÷1 mm (Fig. 1c,d,e), as a second additive to the designed modified concrete mixtures.

Taking into account the aspect of environmental protection, an attempt was made to manage, in different quantitative configurations, two wastes simultaneously as additives to modified concrete mixtures: coloured PET flakes and SBR rubber granules with fractions: 2÷4 mm, 0.8÷2 mm and 0÷1 mm.

## 3. Innovative concrete building block APS and reference concrete block Alfa

The traditional concrete hollow block has a wide range of applications in general, land and water construction, in various types of masonry structures, e.g.: in the construction of external and internal above-ground or foundation structural walls, single-layer walls, retaining walls or basement walls; it is also used as lost formwork, replacing typical wooden or metal formwork [24]. Since hollow blocks are a materialwidely used in the construction industry, an attempt was made to produce a new type of wall block from concrete modified with two waste additives: coloured PET flakes and SBR rubber granules. For this purpose, a steel mould made of S355 steel was designed and manufactured to produce a series of innovative concrete wall blocks. The shape of the innovative APS (openwork wall block) was based on a cuboid with A × B × C dimensions of 490 × 240 × 240 mm, respectively, including curvilinear through-holes and keyways (Fig. 2).

As a comparative material for the developed APS hollow block, a concrete block of identical dimensions (490 × 240 × 240 mm) and comparable surface area of through-holes, Alfa 25, which is commonly used in Poland, was adopted for the tests (Fig. 3) [25].


Fig. 1. Waste obtained from recycling: a) colorless PET flakes, b) colored PET flakes, c) SBR rubber granulate, fraction 0÷1 mm, d) SBR rubber granulate, fraction 0.8÷2 mm, e) SBR rubber granulate, fraction 2÷4 mm

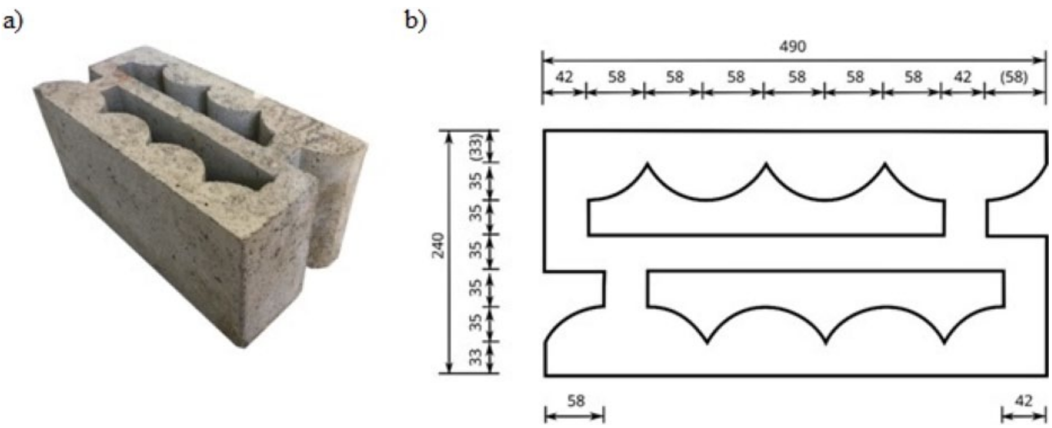


Fig. 2. APS Openwork Wall Block: a) view, b) dimensioned horizontal section

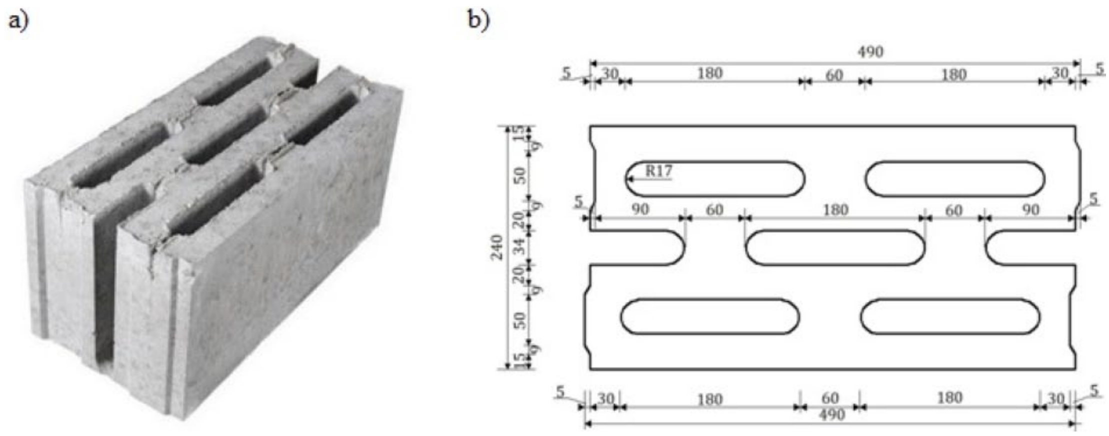


Fig. 3. Concrete block Alfa: a) view, b) dimensioned horizontal cross-section

### 4. Design of control concretes and concretes modified with SBR and PET waste additives

Control concretes were designed for three series: A0.1, A0.2, A0.3 and made using the experimental method (Kuczyński), in which CEM I 32.5 R cement, gravel fraction 2÷8 mm; sand 0÷2 mm, tap water, superplasticiser Stacheplast 202N were used and water-cement ratios (w/c) were adopted: for concretes of series A0.1 = 0.526, for A0.2 = 0.5 and for A0.3 = 0.476. The compositions of the control concretes are shown in TABLE 1. The control concretes of the A0.1, A0.2 and A0.3 series were modified by introducing recycled additives in the form of SBR rubber granules and polyethylene terephthalate in the form of PET flakes in the amount of 10% of the mass of cement, at the same time removing the same volume of washed sand. This yielded modified concretes of the series: A1÷A3 (TABLE 1), in which the composition of the recycled waste mixture was the same: 36% SBR rubber granules of 0÷1 mm fraction and 54% SBR rubber granules of 0.8÷2 mm fraction and 10% coloured PET flakes. The modification scheme for the control concretes is shown in Fig. 4.

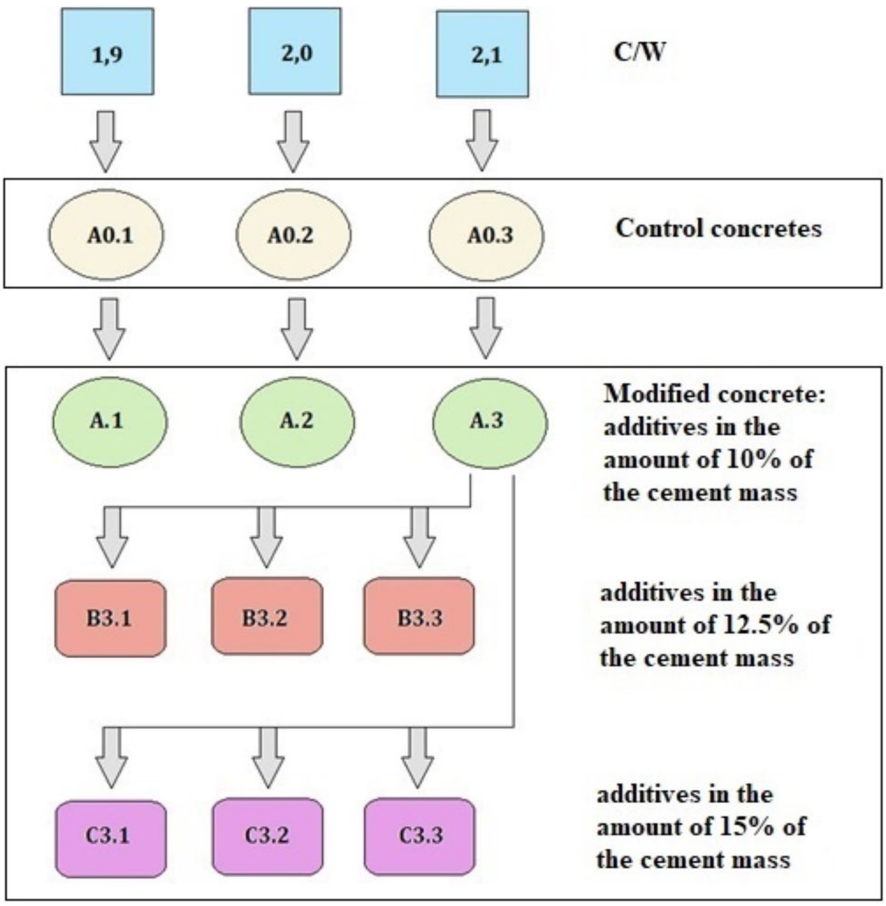


Fig. 4. Scheme of modification of control concretes

Based on the compressive strength tests of control concretes of the series: A0.1÷A0.3 and modified concretes with 10% recycled content of the series: A.1÷A.3, the next step was to modify the concrete of the A3 series to obtain modified concretes of the series: B3.1÷B3.3 and C3.1÷C3.3 (Fig. 4).

A mixture of recycled additives in the amount of 12.5% by weight of cement was introduced into the compositions of concretes of series B3.1÷B3.3 .In concrete of series B3.1, the percentage content of individual additives was identical to that of A3 concrete amounting respectively to 36% for SBR of 0÷1 mm fraction and 54% for 0.8÷2 mm fraction, while in concrete series: B3.2 and B3.3, an additional fraction of 2÷4 mm SBR rubber granules was introduced into the recycled waste mix. In the concrete of the B3.2 series, the volume of SBR rubber granules of 0÷1 mm fraction (9%) and 0.8÷2 mm (27%) and PET flakes (10%) was calculated, while the same volume of sand was included, and the volume of SBR rubber granules of 2÷4 mm fraction (54%) was calculated and the same volume of gravel was included. In B3.3 series concrete, the volume of SBR rubber granules in fractions 0÷1 mm (18%) and 0.8÷2 mm (18%) and PET flakes (10%) was calculated, while the same volume of sand was included, and the volume of SBR rubber granules in fraction 2÷4 mm (54%) was calculated and the same volume of gravel was included. A recycled additive mix of 15% by weight of cement was introduced into the compositions of concretes of the C3.1÷C3.3 series (TABLE 1) in the same way as in the B3.1÷B3.3 series.

## 5. Test methodologies for control concrete mixtures and those modified with SBR and PET waste additives

Based on a literature analysis of the topic, it was found that previous research had not leaned towards the joint use of SBR rubber granules and PET flakes in cementitious matrix materials. Therefore, a research plan was developed and an attempt was made to simultaneously use both recycled wastes in concrete composites, enabling an analysis of their effects on selected characteristics of concrete mixtures and concretes, the results of which contributed to the selection of one modified concrete mixture for the manufacture of the novel APS hollow block.

Testing the consistency of the concrete mixture using the slump test, in accordance with PN-EN 12350-2 [26], was performed for concrete mixtures of the series: A0.1÷A0.3, A.1÷A.3, B3.1÷B3.3 and C3.1÷C3.3 (TABLE 2). It was found that the use of recycled SBR and PET waste increased the liquidity of the tested concrete mixtures. Subsequently, compressive strength testing was carried out for all the aforementioned series of concretes, in accordance with the following standards:, PN-EN 12390-1, PN-EN 12390-2, PN-EN 12390-3 and PN-EN 12390-4 [27-31]. A constant loading rate of 1.0 MPa/s was chosen for the specimens. The average compressive strengths obtained in the study, and the corresponding strength classes, are shown in TABLE 2 and Fig. 5.

Since the smallest decrease in average compressive strength was obtained for the modified concretes of the A.3 series compared to the control concretes of the A0.3 series, the modified concretes of the A.3 series and the control concretes of the A0.3 series, where w/c = 0.476, were adopted for further modifications (Fig. 4).

Then, for the control concrete of the A0.3 series and selected series of modified concretes: B3.1÷B3.3 and C3.1÷C3.3, the following tests were performed: the test of the depth of penetration of water under pressure was performed based on PN-EN12390-8 [32], the test of absorbability of concretes according to PN-EN 206:2014-04 [33], the test of volumetric density of concretes based on PN-EN 12390-7:2019 [34], the test of frost

TABLE 1

Compositions of control concretes of the series: A0.1÷A0.3 and concretes modified with a mixture of recycling additives: SBR rubber granules and PET flakes (series: A.1÷A.3, B3.1÷B3.3 and C3.1÷C3.3) per volume of 1 m$^3$ of concrete mixture

| Concrete series | C/W | W/C | Cement CEM I 32,5 R [kg/m$^3$] | Water [l/m$^3$] | Washed sand [kg/m$^3$] | Gravel 2÷8 mm [kg/m$^3$] | Superplasticizer Stacheplast 202N in quantity 1.2% of cement weight [l/m$^3$] | Percentage of additives in the cement mass [%] | Rubber granules SBR [kg/m$^3$] | | | PET flak es [kg/m$^3$] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 0÷ 1 mm | 0,8÷2 mm | 2÷ 4 mm | |
| A0.1 | 1,9 | 0,526 | 378 | 194,5 | 486 | 1300 | 4,54 | 0 | — | — | — | — |
| A0.2 | 2,0 | 0,5 | 402 | 196,2 | 492 | 1320 | 4,82 | 0 | — | — | — | — |
| A0.3 | 2,1 | 0,476 | 416 | 193,1 | 469 | 1256 | 4,99 | 0 | — | — | — | — |
| A.1 | 1,9 | 0,526 | 378 | 194,5 | 299 | 1300 | 4,54 | 10 | 13,61 | 20,41 | — | 3,78 |
| A.2 | 2,0 | 0,5 | 402 | 196,2 | 291 | 1320 | 4,82 | 10 | 14,47 | 21,71 | — | 4,02 |
| A.3 | 2,1 | 0,476 | 416 | 193,1 | 261 | 1256 | 4,99 | 10 | 14,98 | 22,46 | — | 4,16 |
| B3.1 | 2,1 | 0,476 | 416 | 193,1 | 209 | 1256 | 4,99 | 12,5 | 18,72 | 28,08 | — | 5,2 |
| B3.2 | 2,1 | 0,476 | 416 | 193,1 | 333 | 1129 | 4,99 | 12,5 | 4,68 | 14,04 | 28,08 | 5,2 |
| B3.3 | 2,1 | 0,476 | 416 | 193,1 | 333 | 1129 | 4,99 | 12,5 | 9,36 | 9,36 | 28,08 | 5,2 |
| C3.1 | 2,1 | 0,476 | 416 | 193,1 | 157 | 1256 | 4,99 | 15 | 22,47 | 33,69 | — | 6,24 |
| C3.2 | 2,1 | 0,476 | 416 | 193,1 | 306 | 1107 | 4,99 | 15 | 5,65 | 16,85 | 33,69 | 6,24 |
| C3.3 | 2,1 | 0,476 | 416 | 193,1 | 306 | 1107 | 4,99 | 15 | 11,23 | 11,23 | 33,69 | 6,24 |

TABLE 2

Compressive strength test results after 7, 14 and 28 days for control concretes of the series: A0.1÷A0.3 and modified concretes of the series: A.1÷A.3, B3.1÷B3.3 and C3.1÷C3.3

| Concrete series \ Type tests | | | Testing the consistency of the concrete mix | | Compressive strength test | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Slump test [mm] | Consistency class | Average compressive strength, $f_{cm}$ [MPa] | | | Concrete strength class |
| | | | | | After 7 days | After 14 days | After 28 days | |
| Control concretes | | A0.1 | 38 | S1 | 41,2 | 42,3 | 46,7 | C30/37 |
| | | A0.2 | 35 | S1 | 42,5 | 44,7 | 49,6 | C35/45 |
| | | A0.3 | 40 | S1 | 44,0 | 49,1 | 53,6 | C35/45 |
| Modified concretes, additives in the following amounts: | 10% cement mass | A.1 | 44 | S1/S2 | 27,2 | 31,6 | 36,3 | C25/30 |
| | | A.2 | 42 | S1/S2 | 34,4 | 37,0 | 40,4 | C25/30 |
| | | A.3 | 54 | S2 | 36,9 | 40,1 | 45,7 | C30/37 |
| | 12,5% cement mass | B3.1 | 61 | S2 | 30,7 | 35,6 | 38,8 | C25/30 |
| | | B3.2 | 57 | S2 | 35,0 | 38,1 | 39,4 | C25/30 |
| | | B3.3 | 50 | S2 | 36,0 | 38,7 | 42,8 | C25/30 |
| | 15% cement mass | C3.1 | 65 | S2 | 27,0 | 32,4 | 37,7 | C25/30 |
| | | C3.2 | 59 | S2 | 31,2 | 36,1 | 39,2 | C25/30 |
| | | C3.3 | 48 | S1/S2 | 34,0 | 37,5 | 39,8 | C25/30 |

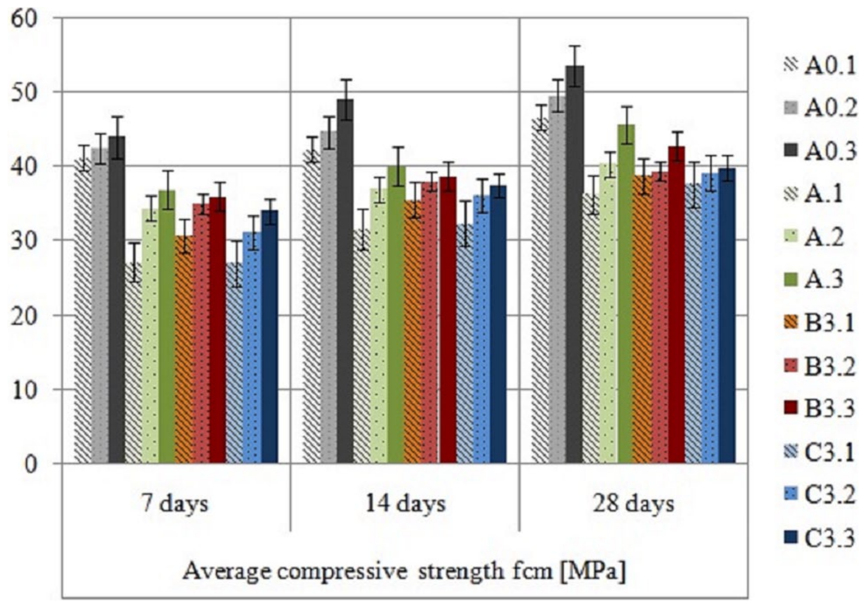


Fig. 5. Average compressive strength values after 7, 14 and 28 days for control concretes of the series: A0.1÷A0.3 and modified concretes of the series: A.1÷A.3, B3.1÷B3.3 and C3.1÷C3.3

resistance based on PN-B-06265:2018-10 [35]. Based on tests of the depth of penetration of water under pressure, concretes with the addition of recycled SBR and PET waste obtained higher values compared to the control concrete. The introduction of SBR rubber granule fractions of 2÷4 mm resulted in lower maximum water penetration depth values for the B3.2, B3.3 and C3.2, C3.3 series of concretes compared to the B3.1 and C3.1 series (TABLE 3).

In the case of the concrete absorbability test, the introduction of the modified concrete series: B3.1÷B3.3 and C3.1÷C3.3 additives in the form of a mixture of recycled waste SBR and PET resulted in lower average soakability values compared to the control concretes of the A0.3 series, due to the partial replacement of sand and gravel with SBR rubber granules and PET flakes, and the properties of the rubber granules such as lack of pores, non-absorption of water resulted in lower soakability values of the modified concretes. The results are shown in TABLE 3. The bulk densities of concrete made for the control concretes of the A0.3 series and the modified concretes of the B3.1÷B3.3 and C3.1÷C3.3 series of the tested samples were in the range of 2000÷2600 kg/m$^3$, defining the density class of all concretes as ordinary concretes. The recycling additives SBR and PET in the modified concretes caused a slight decrease in their average densities compared to the average density of concrete without additives, ranging from 2.16% to 3.96% (TABLE 3). The frost resistance of the concretes was determined for the control concretes of the A0.3 series and the modified concretes of the B3.1÷B3.3 and C3.1÷C3.3 series, where partial replace-

TABLE 3

Test results for the A0.3 control concrete series and those modified with SBR and PET recycling waste: B3.1÷B3.3 and C3.1÷C3.3

| Type tests \ Concrete series | | | Control concretes | Modified concretes, additives in the following amounts | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 12,5% cement mass | | | 15% cement mass | | |
| | | | A0.3 | B3.1 | B3.2 | B3.3 | C3.1 | C3.2 | C3.3 |
| Testing the penetration depth of water under pressure | Maximum water penetration depth under pressure [mm] | | 49 | 102 | 78 | 80 | 118 | 87 | 85 |
| Water absorption test | Average water absorption concrete $n_w$ [%] | | 4,95 | 4,80 | 4,70 | 4,68 | 4,81 | 4,65 | 4,6 |
| Bulk density testing | Average bulk density of concrete $D$ [kg/m$^3$] in a dry state | | 2252,4 | 2188,6 | 2201,2 | 2203,7 | 2163,6 | 2169,8 | 2197,3 |
| | Concrete density class | | Plain concrete | | | | | | |
| Frost resistance test | Average decrease in compressive strength after freezing cycles and defrosting $\Delta mF_i$[%] | $i = 25$ | 7,9 | 4,9 | 4,7 | 4,0 | 4,2 | 4,1 | 3,5 |
| | | $i = 100$ | 18,8 | 18,0 | 17,6 | 15,8 | 17,3 | 16,2 | 15,9 |

ment of the aggregate with recycled additives SBR and PET resulted in concretes more resistant to cyclic freezing and thawing (TABLE 3). Based on the laboratory tests carried out and their results for the modified concrete mixtures of the B3.1-B3.3 and C3.1-C3.3 series and the control concrete A0.3, concretes of the C.3.3 series were used to make the new type of APS building block (TABLE 1).

## 6. Test methodology for analysed concrete wall blocks

The concrete block Alfa 25 was used as a reference block for the study. The engineered concrete mix of C3.3 series modified with additives from recycled SBR and PET waste in the amount of 15% by weight of cement was used to make the novel concrete wall blocks APS. The following tests were carried out for the concrete blocks: the reference Alfa and the innovative APS made from the modified concrete of the C3.3 series: determination of dimensions, shape and structure based on standards: PN-EN 771-3 and PN-EN 772-16 [36,37], compressive strength testing according to PN-EN 772-1 [38], gross density testing according to PN-EN 772-13 [39], water absorption testing according to PN-EN 772-11 [40], frost resistance testing for 25 freeze-thaw cycles based on standards: PN-70/B-12016 and PN-B-12012:2007 [41,42].

The actual dimensions of 490 mm × 240 mm × 240 mm and the dimensional deviations of +3/–5 mm for the APS block, fall within category D1. The following are acceptable for a masonry element: shape, indentations, joint system, roundness and sharp edges, all of which are met by the concrete block of the new type. Compressive strength fn was tested for the analyzed Alfa concrete blocks ($f_{n1} = 21.0$ MPa, $f_{n2} = 22.9$ MPa, $f_{n3} = 23.0$ MPa, $f_{n4} = 21.5$ MPa, $f_{n5} = 21.9$ MPa, $f_{n6} = 22.1$ MPa, $f_{n7} = 20.7$ MPa, $f_{n8} = 22.2$ MPa, $\mathrm{f}_{n9} = 21.9$ MPa, $f_{n10} = 22.3$ MPa) and APS blocks ($f_{n1} = 22.9$ MPa, $f_{n2} = 22.6$ MPa, $f_{n3} = 24.0$ MPa, $f_{n4} = 21.5$ MPa, $f_{n5} = 22.9$ MPa, $f_{n6} = 23.9$ MPa, $f_{n7} = 23.3$ MPa, $f_{n8} = 22.0$ MPa, $f_{n9} = 21.9$ MPa, $f_{b10} = 23.1$ MPa), a linear interpolation of the shape coefficients for the masonry elements was performed (for Alfa $f_B = 21.95$ MPa, for APS $f_B = 22.81$ MPa). The aspect ratio $\delta = 1.17$ was calculated and based on the results of compressive strength tests for Alfa type blocks and APS openwork blocks, it was found that the normalized compressive strength for the Alfa block was $f_b$ = 25.68 MPa, for the APS openwork wall block it was higher and amounted to $f_b$ = 26.69 MPa. Both the reference Alfa block and the innovative APS block obtained strength class 25. The gross density test was performed for APS wall blocks, their average constant dry mass and volume were determined, and their gross dry density $\rho_{(g,u)} = 1624$ kg/m$^3$ was calculated. On this basis, the use of the blocks was determined for use in unprotected and protected masonry as an HD element ($\rho_{(g,u)}$ above 1000 kg/m$^3$). The initial water absorption test was carried out on the APS wall blocks, which was $c_{w,s} = 5.19$ g/m$^2$-s at 60 seconds. A frost resistance test was carried out for the APS blocks, where the average decrease in compressive strength after 25 freeze-thaw cycles for the APS openwork wall block was 6.2%, thus defining the blocks as frost resistant.

To summarise the research carried out for the novel APS concrete blocks, in which more than 1.23 kg of recycled waste was managed, the APS block was compared with the reference Alpha concrete block and the results are shown in TABLE 4.

## 7. Conclusions

The article presents an innovative APS concrete wall block made from a concrete mixture modified with waste: styrene-butadiene rubber in the form of SBR rubber granules obtained from used car tires and polyethylene terephthalate in the form of colored PET flakes obtained from used food packaging. This made it possible to utilise approximately 1.11 kg of SBR rubber granules in the following fractions: 0÷1 mm, 0.8÷2 mm and 2÷4 mm, and 0.12 kg of colored PET flakes per 1 APS concrete block weighing 43.8 kg, while at the same time reducing its weight by 2.2 kg in comparison with the reference APS concrete block. One used passenger car tire allows for the recovery of rubber in the form of SBR granulate in the amount of approximately 2 kg to 3 kg, depending on the tire size. On the other hand, about 25-30 used plastic bottles with a capacity of 1 liter can yield about 1 kg of PET flakes. For 1 m2 of foundament wall we use

TABLE 4

Test results for concrete hollow blocks: the reference Alfa and the innovative APS

| Concrete blocks | | Alfa | APS |
|---|---|---|---|
| Dimensions real | Lenght | 490 mm /+3–5 mm | 490 mm /+3–5 mm |
| | Width | 240 mm /+3–5 mm | 240 mm /+3–5 mm |
| | Height | 240 mm /+3–5 mm | 240 mm /+3–5 mm |
| Shape and structure | | Group 2 by EN 1996-1-1 | Group 2 by EN 1996-1-1 |
| Element mass | | 46 kg | 43,8 kg |
| Mass of waste SBR | | 0 kg | 1,11 kg |
| Mass of waste PET | | 0 kg | 0,12 kg |
| The sum of the weight of SBR and PET waste per block | | 0 kg | 1,23 kg |
| Compressive strength (perpendicular to the laying surface 490 mm × 240 mm) | | 25 N/mm$^2$ | 26,7N/mm$^2$ |
| Average gross density | | 1600 kg/m$^3$ | 1624 kg/m$^3$ |
| Water absorption | | 5,5 g/(m$^2$s) | 5,19 g/(m$^2$s) |
| Durability (freeze/thaw resistance) | | Frost-resistant | Frost-resistant |

8.5 pcs. of APS blocks, which means we can use almost 9.5 kg of SBR rubber granulate and over 1 kg of PET flakes. If we take a five-story multi-family building with an underground garage measuring 60 m × 15 m, then to construct approximately 500 m$^2$ of foundation walls we will use 4.75 tons of SBR rubber granulate and 0.51 tons of PET flakes. Considering that mechanical shredding of both car tires and plastic bottles is the least invasive form of recovery, we protect the environment by favoring its natural ecological conditions. The tests carried out on modified concretes in comparison with control concretes showed the effectiveness of the developed solution in the management of waste materials: SBR rubber granules and coloured PET flakes in concrete mixtures as full-value components. Subsequently, the presented innovative concrete hollow block APS made from modified concrete of the C3.3 series with a recycled additive content of 15% by weight of cement showed that it fulfils the conditions in terms of concrete hollow blocks as a building material compared to the reference hollow block Alfa.

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