sustainability

Article

Sustainable Polyester Composites Containing Waste Glass for Building Applications

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Abstract: The ecological construction of the future aims to reduce the amount of waste and minimize energy consumption related to the production and transport of building materials. One way to stop the destructive effects of the excessive exploitation of natural deposits is to implement extensive activities aimed at reusing, preferably multiple times, waste materials. This article describes the results of testing polyester mortars based on the developed experimental plan. It assumed the use of waste glass cullet as a sand replacement in the amount of 0–100% by mass and a variable resin/aggregate ratio in the range of 0.14–0.36. The use of a two-factor central composition plan allowed us to limit the number of research samples and at the same time obtain the necessary scientific information regarding the obtained mortars. Standard tests for flexural and compressive strength and bulk density were performed on rectangular hardened samples. Additionally, the change in the mass of the samples immersed in water was monitored for a period of 165 days. The analysis of the strength test results allows us to conclude that, with appropriately selected proportions of resin-glass waste, composites with a flexural strength of 30 MPa and a compressive strength of 91.4 MPa can be obtained. Including waste in a mortar allows elements with low water absorption to be obtained. At the same time, their production is about 2.5 times cheaper than their epoxy counterparts. The test results were compared with those obtained for epoxy-based mortars and with reference to the requirements set by the manufacturers of prefabricated polymer concrete elements intended for construction applications.

Keywords: polymer composites; polyester mortars; waste glass; mechanical properties; absorbability; sustainability development; prefabricates

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1. Introduction

One of the key trends determining the construction of the future is an issue related to ecology. The sustainable construction of the future is intended to reduce the amount of waste and minimize energy consumption related to the production and transport of building materials. The condition of the world has changed profoundly over the last few decades. Currently, the division of the environment into natural and transformed is beginning to show a galloping decline in the reserves of the former and a painfully burdensome expansion of the latter. The exploitation of natural resources has exceeded their capacity on a global scale to such an extent that there is no longer any doubt about the prospect of their imminent and inevitable exhaustion. Searching for new resources and reducing demand are becoming the main guidelines for remodeling most areas of human life. One of the ways to achieve new qualities while at the same time stopping the destructive consequences is to implement extensive activities to reuse, preferably multiple times, waste materials. This is especially important because there is a shortage of traditional raw materials, including sand, and at the same time, the costs of their extraction, processing, transport and distribution are constantly increasing. Aggregates are currently one of the most desirable materials in construction [1,2]. In 2019, the United Nations (UN) recognized the extraction of aggregates (including sand and gravel) as an issue requiring international protection. The need to seek a common response to such interconnected, dangerous trends as unrestrained consumerism and the drastic shrinking of natural resources was pointed out. It was concluded that demand should be reduced and substitutes should be found. It seems that reusing waste as aggregates for concrete can have positive effects, both due to the possibility of waste recycling and the protection of natural environmental resources.

In this context, it is worth considering the replacement of natural aggregates with waste glass granules [3]. Due to its composition and structure, glass does not pose a threat to the environment but is only a burden because it does not decompose. According to the United Nations, glass waste constitutes about 7% of all solid waste, and due to its non-biodegradability, it takes up a significant part of landfills. At the same time, the glass industry uses significant amounts of natural resources and energy and produces high CO_2 emissions. Theoretically, glass can be recycled many times, but mixing different colored glass waste makes this process difficult and very expensive. The concrete industry may be a possible solution for the environmentally friendly management of glass waste [4]. Scientific publications most often present attempts to include glass waste as an aggregate in concrete or cement mortars. The positive effect of such a modification is described, among others, in works [3,5–10].

Another noteworthy approach is to obtain polymer composites from glass waste, which creates an opportunity to reduce the impact of this type of material on the environment. Importantly, aggregate constitutes approximately 90 percent of the mass of a resin composite, so it has a huge impact on its quality [11–13]. The results of research described in scientific articles show that substituting aggregate with waste glass does not mean accepting worse quality, because even in these cases, it is possible to obtain a composite with the desired properties. Many researchers focus on assessing the impact of glass waste on the properties of epoxy matrix composites. Harry Ku et al. [14] conducted research to obtain the optimal composition of an epoxy–glass composite so that it was possible to obtain the appropriate strength of the material for structural applications at the most favorable price. Heriyanto, Pahlevani and Sahajwall [15,16] also used waste glass to produce epoxy composites. They proved that the technology of the production process plays a huge role in the case of such materials. Epoxy concrete containing glass waste was also tested by Shi-Cong and Chi-Sun [17]. According to the authors, a beneficial effect on the strength parameters of mortars was achieved by additionally introducing metakaolin or fly ash as part of the smallest aggregate fraction. Epoxy composites modified with window glass waste were described in [18]. Depending on the degree of substitution of sand with waste (0–100%), the bending strength is in the range of 27–22 MPa, and the compressive strength is from 96.7 MPa to 68.7 MPa. The composite is also characterized by very low water absorption, the values of which were in the range of 0.2–0.7%, even after seven days of immersing the samples in water. Most of the water absorption results obtained for the tested samples were characterized by values belonging to the lower limit of this range. One article [19] presents the results of testing coatings made of epoxy resin and waste glass flour. It was found that the addition of glass powder in a proportion of 19.4% to the epoxy resin is the most beneficial and increases the peel strength of the mortar. Epoxy coatings modified with glass waste were also obtained by Jana Hodná et al. [20]. Thanks to the use of waste glass as filler, the tensile strength and hardness were improved, and its addition did not negatively affect chemical resistance or adhesion to the substrate.

From an economic point of view, it is worth including glass waste in polyester composites because this resin is much cheaper than epoxy. The results of the research described in [21–23] indicate that, with appropriately selected proportions of polyester resin and powdered glass waste, the strength parameters of resin composites can be improved. Awham M. Hameed et al. obtained polyester–glass mortars with a resin/glass waste ratio of 0.25, which were characterized by very high strength parameters [22]. Mohd Abdul Mubeen et al.

drew attention to the fact that one of the key factors influencing the properties of polyester composites is good adhesion at the interface between the resin and the aggregate [24]. Wan-Ki Kim and Yang-Seob Soh showed that improved strength, reduced shrinkage and good chemical resistance of polyester mortars could be obtained by using fly ash as a filler, with the proportion of fine aggregate at 15% and replacing 50% of the fine aggregate with waste glass [25].

The studies on polyester composites modified with glass waste described in the literature are very diverse. Most often, in addition to glass, the authors also use other modifiers, e.g., in the form of glass fibers or fly ash, or perform tests of other properties. It is also difficult to find articles that present the complete substitution of aggregate with glass waste. This article describes the results of testing polyester mortars containing glass waste, which was a substitute for sand in the amount of 0–100% by mass, respectively. Tests were carried out on the physical and mechanical properties of hardened mortars, such as their flexural and compressive strength, bulk density and water absorption. The research was designed using experimental theory in such a way that it was possible to compare the test results of mortars with a polyester matrix with the test results of epoxy mortars obtained earlier and described in another article. The obtained test results were also presented against the background of the requirements of producers of polymer concrete prefabricates. High strength parameters and low water absorption are very promising in the context of the applications of this type of material, e.g., for industrial floors, quick repairs and, above all, the production of many prefabricated elements, such as bridge cornice boards, curb systems, road drainage systems, pipes and tanks for chemically aggressive liquids. While maintaining the same proportions of ingredients, the obtained polyester mortars can be a very good alternative to epoxy mortars, and at the same time, their production cost is much lower.

2. Materials and Methods

2.1. Materials

The binder in the mortars was an unsaturated orthophthalic polyester resin with low viscosity and medium reactivity, with the trade name Polimal 109–32 K, produced in Poland by Zakłady Chemiczne "Organika—Sarzyna" S.A. Selected properties of the resin are listed in Table 1. The resin was hardened with LUPEROX K1SE hardener (ARKEMA, Lublin, Poland) in an amount of 2% in relation to the mass of the resin. A 1% cobalt accelerator (ILT, Głębocko, Poland) was also used.

Table 1. Typical parameters of Polimal 109–32 K resin.

Parameter	Viscosity (25 °C) mPa·s	Gel Time (25 °C) min	Flexural Strength MPa	Heat Deflection Temperature °C	Barcol Hardness °B	Tensile Strength MPa	Elongation at Break %	Tensile Modulus MPa
Value	230–290	13–20	100	60	40	50	2.5	3900

Standard quartz sand with a grain size of 0–2 mm was used as the aggregate (producer KWARCMIX, Tomaszów Mazowiecki, Poland). Sand was replaced by mass (in the amount of 0–100%, fraction to fraction) with waste glass of similar density resulting from the fragmentation of building glass by crushing and grinding (producer Rominex, Grabica, Poland). An additional modification to the composition of the composites consisted of replacing the largest sand fractions (1 mm and 2 mm) with waste glass with a grain size of 0.5 mm.

2.2. Mixture Design and Preparation of Samples

In order to obtain the most complete information regarding the factors influencing the process of obtaining resin mortars, it would be best to make measurements for every possible experimentally justified combination of input values, e.g., the share of resin or the degree of substitution of sand with glass waste. In practice, however, this is almost never possible due to the high costs and time-consuming nature of such a solution. Measurements carried out on too small a number of samples may, in turn, prevent the formulation of correct conclusions. The mortar composition was therefore designed based on experimental theory using the two-factor polysectional–rotational–quasi-homogeneous design available in the DOE (Design of Experiment) module of STATISTICA 13. The use of experimental planning methods guarantees obtaining full information on the impact of the share of glass waste and resin content in the composite on the physical and mechanical parameters of polyester mortars within a certain assumed range. The adoption of the above test plan allowed for limiting the number of tested mortars to 9 with different compositions, as shown in Figure 1 and Table 2. Symbols #1–#9 indicate individual points of the test plan (they are compatible with those included in Table 2), and the numbers after this marking mean the percentage of waste glass and the resin-to-aggregate ratio.

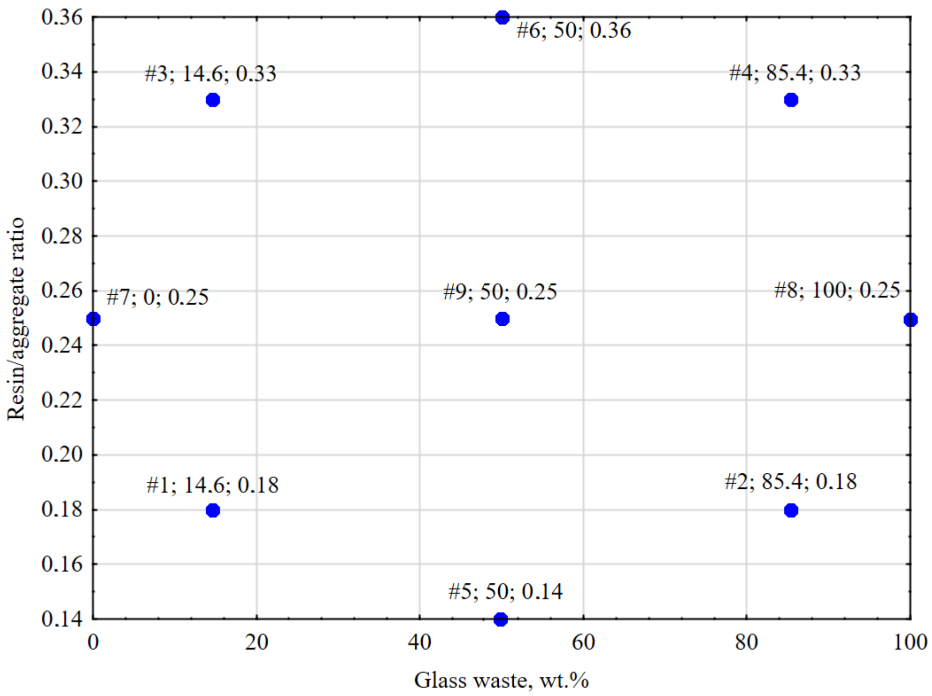


Figure 1. Graphical representation of the research plan adopted for implementation.

Table 2. The mass percentage of ingredients in individual mortar compositions.

Composition No	1	2	3	4	5	6	7	8	9
Resin, g	291.6	291.6	534.6	534.6	226.8	583.2	405.0	405.0	405.0
Sand, g	1383.5	236.5	1186.5	236.5	810.0	810.0	1620.0	0.0	810.0
Hardener, g	5.83	5.83	10.69	10.69	4.54	11.66	8.10	8.10	8.10
Accelerator, g	1.17	1.17	2.14	2.14	0.91	2.33	1.62	1.62	1.62
Glass waste, g	236.5	1383.5	433.5	1383.5	810.0	810.0	0.0	1620.0	810.0

Nine series of mortars with different compositions were made. The preparation of samples was carried out in several steps, which are presented in Figure 2. The mass percentage of ingredients in the individual mortar compositions is also presented in Table 2. Initially, for samples not modified with waste (series 7), one mixture contained 1620 g of sand. In the remaining compositions, this amount was replaced by glass waste in accordance with Table 2. The amounts of individual components were appropriate to fill the molds for strength and water absorption tests. Three samples of each composition were made to test flexural strength, bulk density (cuboid samples with dimensions of 40 × 40 × 160 mm) and water absorption (5 × 60 × 60 mm shapes). After determining the flexural strength, 6 halves of samples from each series were obtained, which were intended for compressive strength testing.

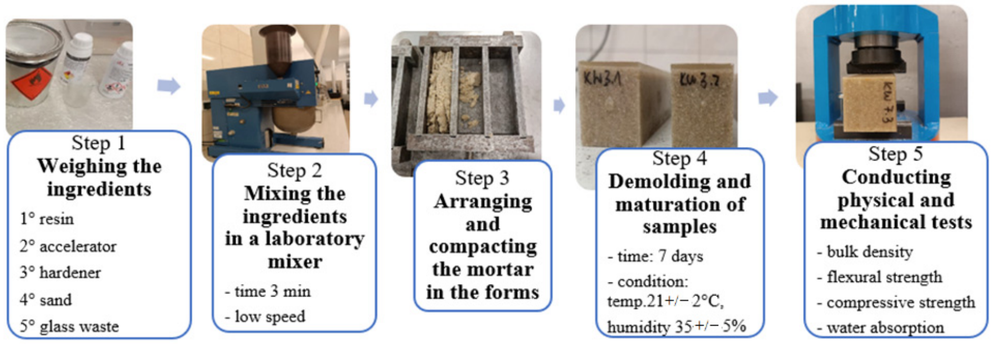


Figure 2. Individual stages of preparation of test samples.

2.3. Test Methods

After the 7-day mortar maturation period, the planned physical and mechanical tests were carried out:

- **Chemical composition of raw materials**

The determination was performed by X-ray fluorescence (XRF) using the Panalytical Epsilon 3X instrument (Ouro Preto, Brazil).

- **Photographs of sand and glass waste**

A Motic SMZ-171 stereoscopic microscope (Motic, Rzeszow, Poland) (Figure 3) was used to take photographs of sand particles and glass waste at a magnification of approximately 100×.

Figure 3. The stereoscopic microscope used to take magnified photographs of sand particles and glass waste.

- **Flexural strength (f_f)**

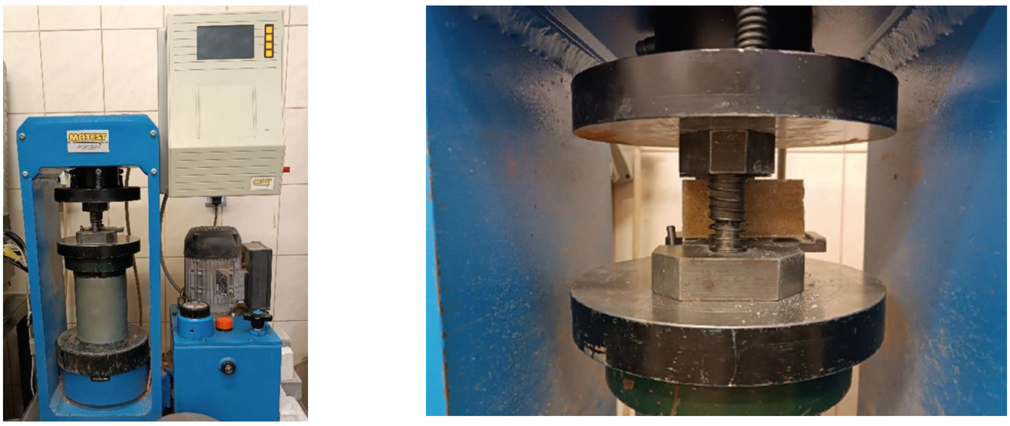
The test was carried out in accordance with the guidelines of the standard PN-EN 196-1: 2016-07 [26] using a 150 kN testing machine (QC505 B1 Cometech Testing Machines Co., Ltd., Taiwan) (Figure 4a) equipped with a flexural system (Figure 4b). The load was applied at a rate of 0.25 mm/min.

(**a**) (**b**)

Figure 4. Machine used to test flexural strength: (**a**) overall view; (**b**) insert equipped with a flexural system.

- **Compressive strength (f_c)**

Each of the beam halves created after the flexural strength test was tested to determine its compressive strength by loading its side surfaces using a hydraulic press (1500 kN C6/4 MATEST, Italy) (Figure 5a) equipped with 40 × 40 mm pressure plates (Figure 5b), in accordance with the standard PN-EN 196-1: 2016-07 [26]. The load was applied at a rate of 2.4 kN/s.



(**a**) (**b**)

Figure 5. Machine used to test compressive strength: (**a**) overall view; (**b**) insert equipped with pressure plates.

- **Bulk density (d_b)**

The samples were weighed, and their masses were recorded. The dimensions of the samples were determined using a caliper, and the volumes of the individual samples were calculated on this basis. The bulk density was calculated as the ratio of the sample's mass to its volume.

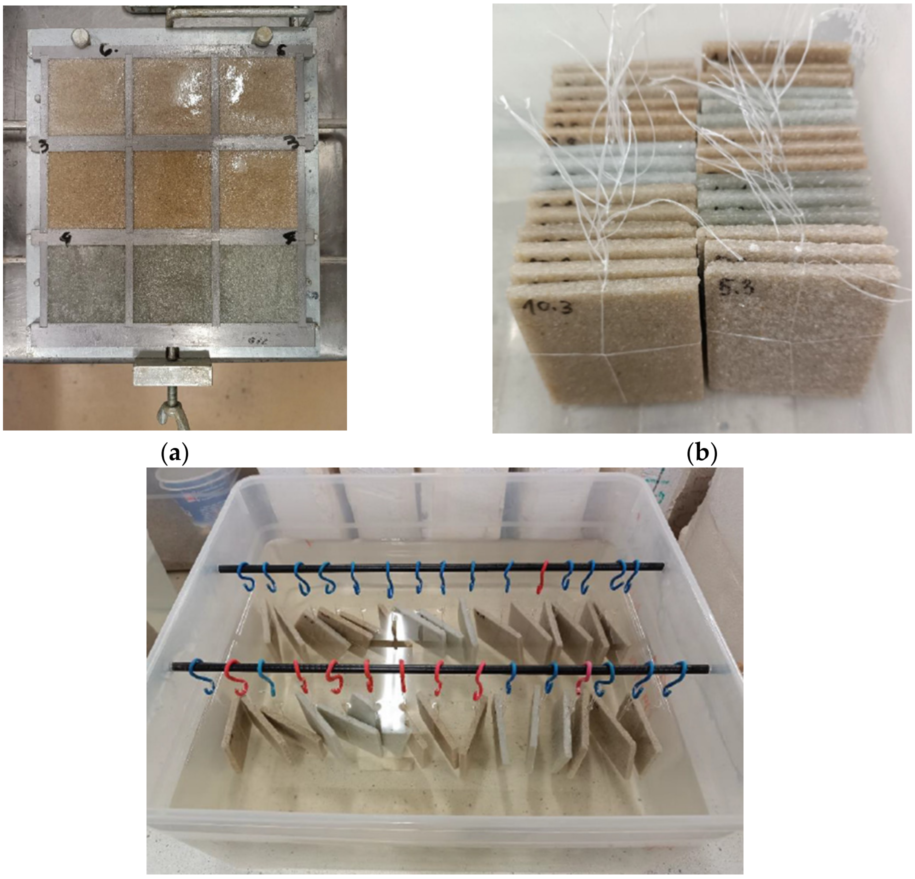
- ***t*-test for independent samples**

The *t*-test is a type of statistical analysis that is a commonly used method for assessing differences between the means of two groups. Comparisons of mean values and measures of variability within these groups can be presented graphically in box plots. These charts facilitate a quick assessment and intuitive visualization of the strength of the relationship between the grouping variable and the dependent variable. In the case of the described analyses, the grouping variable is the type of mortar (polyester or epoxy), and the dependent variables are the flexural strength, compressive strength and bulk density, respectively.

The Basic Statistics module available in the STATISTICA 13 program was used to conduct the analyses.

- **Absorptivity (A_b)**

To carry out the water absorption test, previously prepared shapes with dimensions of 60 × 60 × 5 mm were used (Figure 6a,b), which were weighed after 7 days of maturing. Then, the samples were immersed in deionized water in specially prepared containers (Figure 6c) and weighed 1, 2, 3, 21, 35 and 165 days after immersion. Each time the plates were removed from the water, they were first dried with a paper towel and only then weighed.



(**a**) (**b**) (**c**)

Figure 6. Samples intended for absorbability testing: (**a**) in metal form; (**b**) after demolding; (**c**) after immersion in water.

The absorptivity was calculated using Equation (1):

$$A_b(\%) = (\text{mass after immersion(g)} - \text{initial mass(g)})/(\text{initial mass (g)}) \times 100, \quad (1)$$

3. Results and Discussion

3.1. Chemical Composition

The results of determining the chemical composition of the waste glass are shown in Table 3.

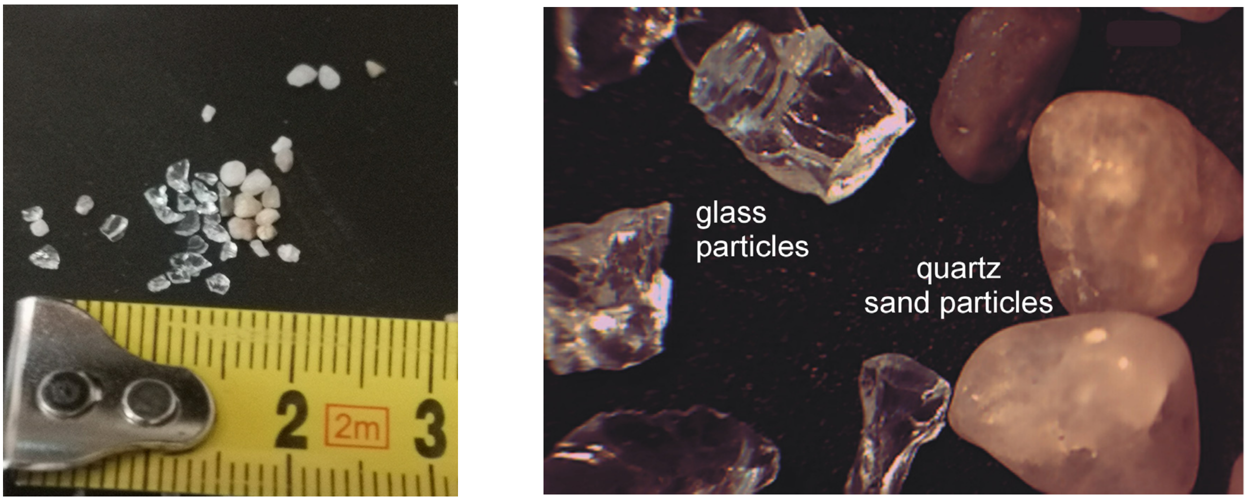
Table 3. Chemical analysis of the glass waste.

Element	SiO_2	Na_2O	CaO	MgO	Al_2O_3	K_2O	BaO	Others
Values in mass %	68.25	15.18	7.12	2.61	2.39	1.67	1.43	1.35

The quartz sand used in the research consisted mainly of silicon dioxide (SiO_2—99.5%). The sand also contained small amounts of iron oxide (Fe_2O_3—0.02%) and other compounds (0.48%). Although their chemical compositions are different, no chemical interaction between the sand/glass and the resin was identified. Both sand and glass waste contain large amounts of silicon oxide, but glass waste contains slightly more calcium and magnesium oxides and is over 15% sodium oxide. Due to its higher content of basic oxides compared to sand, it would be worth monitoring the impact of the addition of glass waste on the properties of the obtained mortars over a longer period of time.

3.2. Photographs of Sand and Glass Waste

A photograph of the glass waste and sand particles at 100× magnification is presented in Figure 7. The morphology of the particles may differ depending on the type of sand used. The shape and surface of the grains influence the adhesion of the matrix to the aggregate, which is of key importance in shaping the strength of these composites but also translates into other properties, e.g., water absorption. The grains of standard quartz sand are usually more regular and rounded (spherical in shape) than the angular, uneven, partially flat and smooth grains of crushed glass. However, as our research shows, with the appropriate grain size of glass waste and the appropriate selection of the resin–aggregate ratio, this waste can be successfully incorporated into mortars and even completely replace sand.



(**a**) (**b**)

Figure 7. Photographs of sand particles and glass waste: (**a**) normal view; (**b**) microscope view at approximately 100× magnification.

3.3. Flexural Strength

The average values of flexural strength (f_f) calculated for each type of polyester composition, along with the standard deviation, are shown in Figure 8.

The figure also shows the average values of flexural strength obtained by the authors of article [18] (marked on the chart as EP) for epoxy mortars with a similar composition. The minimum and maximum values declared by the manufacturers of polymer concrete prefabricates were also taken into account. They are presented on the chart as horizontal dashed lines and marked as prod-min and prod-max, respectively. The trend in shaping this strength depending on the composition of the mortar is similar, but for the samples marked as 4 and 8, the flexural strength of the polyester mortars is much higher than that of the epoxy mortars, by 2.5 MPa and 5.9 MPa, respectively. In both cases, the waste content is significant, at 85.4% and 100%. Even a significant substitution of sand with glass waste makes it possible to obtain polyester mortars with high flexural strength that are, at the same time, about 2.5 times cheaper than epoxy mortars. The strength values of 29.2 MPa and 30 MPa obtained for compositions 4 and 8 are also clearly higher than the range of

18–22 MPa required by prefabrication manufacturers. Therefore, the huge role of the matrix and the quality of the resin–filler connection in resin composites were demonstrated. The conclusions presented in [21–23] were also confirmed, stating that, with appropriately selected resin–glass waste proportions, the strength parameters of resin composites can be improved.

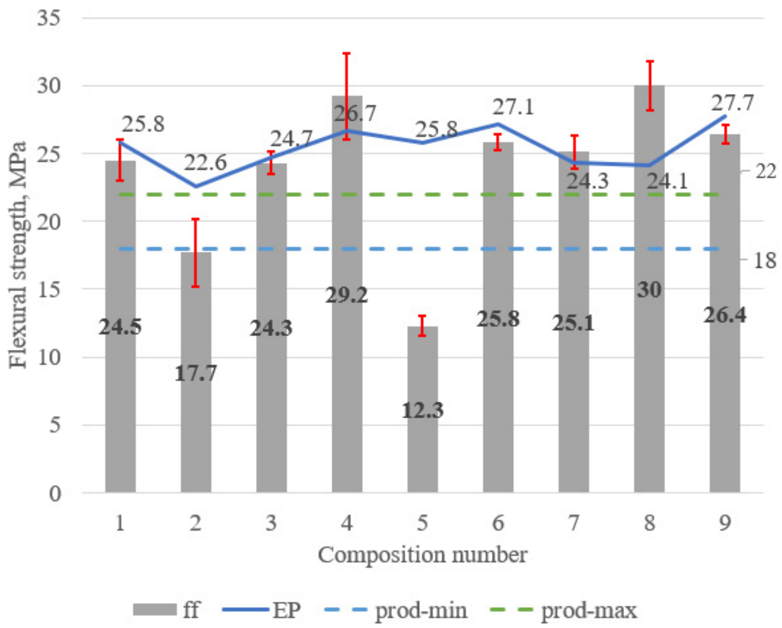


Figure 8. Average values of flexural strength with standard deviation presented against the background of the requirements of prefabrication manufacturers and the average results for epoxy mortars.

3.4. Compressive Strength

As in the case of flexural strength, the average compressive strength (f_c) values calculated for each type of polyester composition, along with the standard deviation, are presented in Figure 9. The figure also shows the average compressive strength values obtained by the authors of article [18] for epoxy mortars (marked on the chart as EP) with a similar composition. The horizontal lines in the chart indicate the minimum (prod-min) and maximum (prod-max) values declared by the manufacturers of polymer concrete prefabricates. The highest compressive strength was 91.4 MPa and was characterized by the polyester composition marked with number 8, in which the share of glass waste in the aggregate was 100% and the resin content was 25%. For an epoxy mortar with the same composition, this strength is much lower (by 22.7 MPa). In this case, this behavior of the mortars could have been influenced by the use of a finer aggregate; in polyester mortars, the highest aggregate fractions (2 mm and 1 mm) were replaced by a 0.5 mm fraction. The lowest values of compressive strength were recorded for compositions No. 5—35.7 MPa and 2—51.1 MPa, i.e., those for which, with a significant degree of substitution of sand with glass waste (50% or 85.4%), the resin content was the lowest (14% or 18%). Only these two compositions did not reach the minimum level of 80 MPa declared by the manufacturers of polymer concrete prefabricates. The increase in glass waste content contributed to higher flexural and compressive strengths in the polyester resin mortars; however, this behavior does not follow the same trend for epoxy resin mortars.

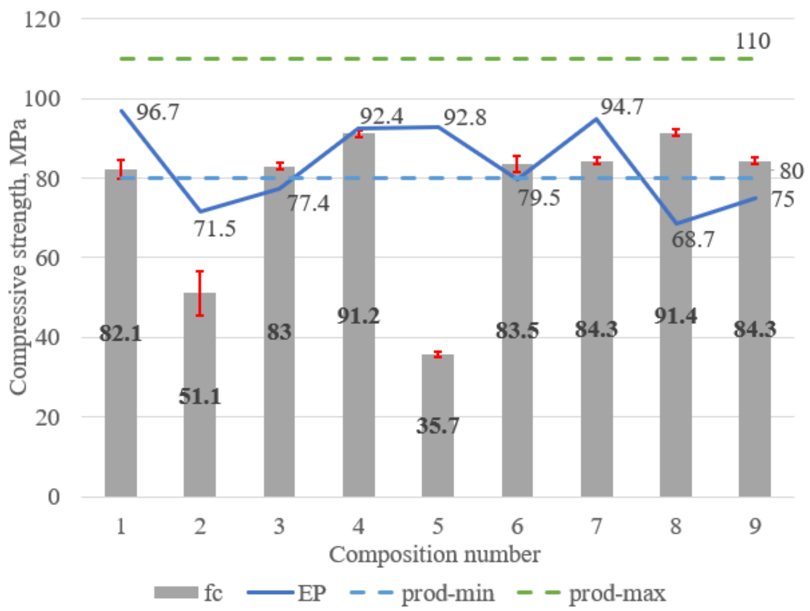


Figure 9. Average values of compressive strength with standard deviation presented against the background of the requirements of prefabrication manufacturers and the average results for epoxy mortars.

3.5. Bulk Density

Based on the chart in Figure 10, it can be seen that for polyester mortars the bulk, density ranges from 1.85 g/cm^3 to 2.085 g/cm^3. The test results for this feature presented in article [18] for epoxy mortars (EP) range from 1.783 g/cm^3 to 2.03 g/cm^3. The differences are therefore small and result mainly from the amount and viscosity of the resin used. In the case of both types of mortars, these values are lower than the bulk density of 2.3 g/cm^3 which appears in the declarations of the manufacturers of prefabricated polymer concrete elements.

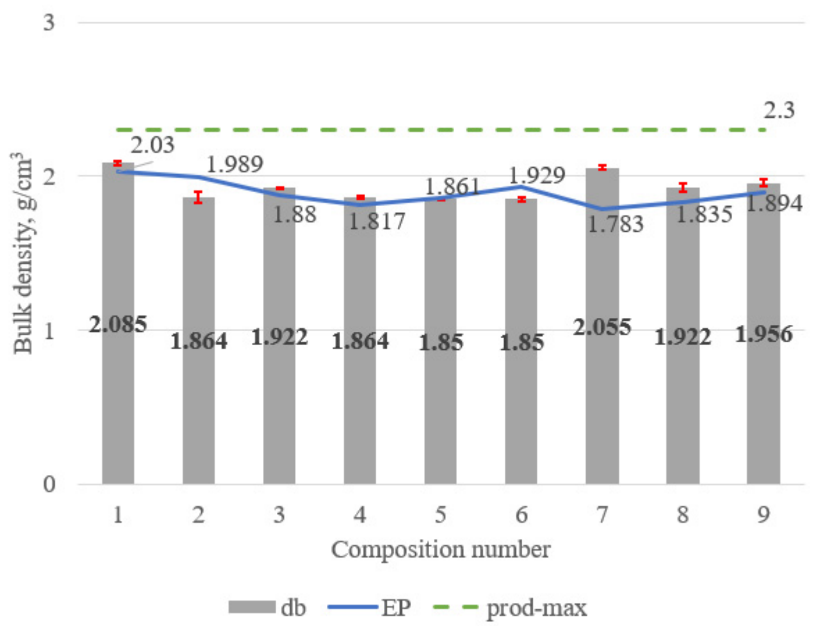


Figure 10. Average values of bulk density with standard deviation presented against the background of the requirements of prefabrication manufacturers (prod-max) and the average results for epoxy mortars (EP).

3.6. *t*-Test for Independent Samples

To demonstrate whether there are significant differences between the average values of the determined strength and bulk density characteristics for the polyester and epoxy mortars, the *t*-test for independent samples was used, which is available in the Basic Statistics module of the STATISTICA 13 program. The results of this test are presented graphically in Figures 11–13 and Table 4.

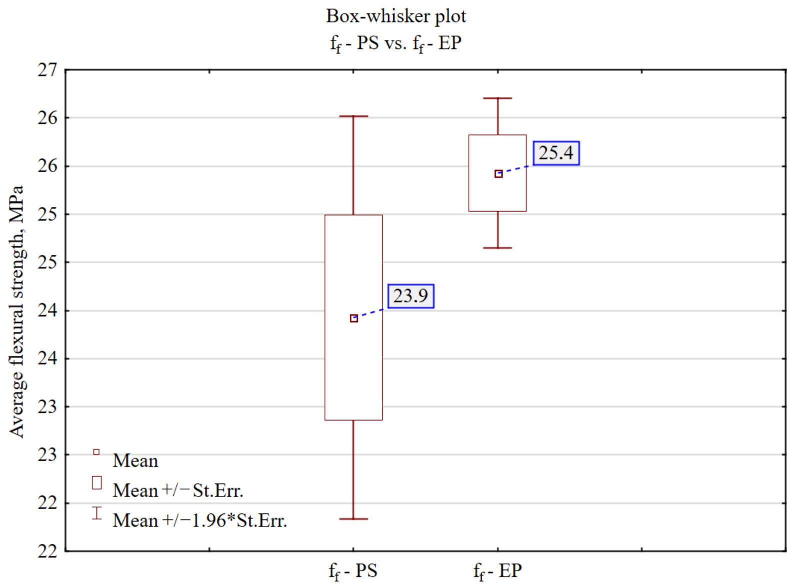


Figure 11. Results of the *t*-test presented graphically in the form of box-and-whisker plots for flexural strength.

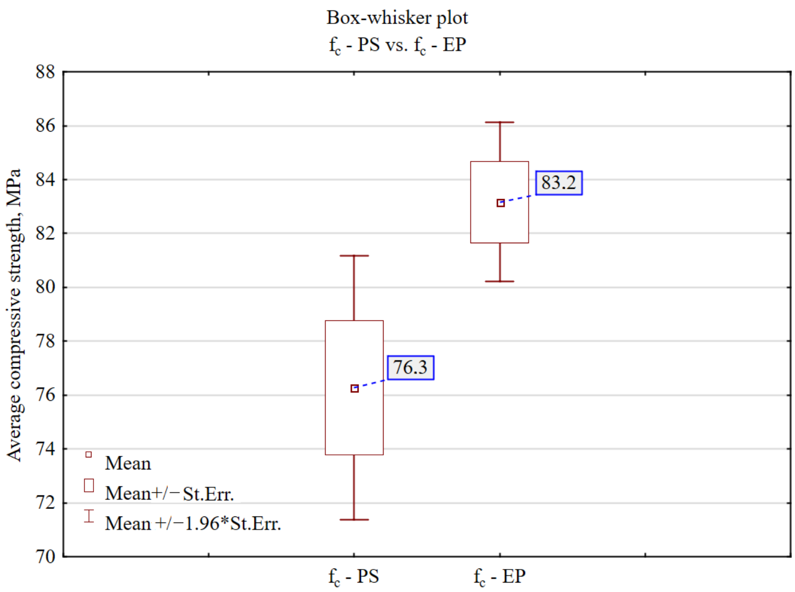


Figure 12. Results of the *t*-test presented graphically in the form of box-and-whisker plots for compressive strength.

Taking into account the average global values (the average calculated for the results obtained for all nine types of compositions) of the flexural and compressive strength and bulk density, based on the *t*-test for independent samples (Table 4), taking into account polyester and epoxy mortars, it can be concluded that statistically significant differences (at the assumed significance level of 0.05) occur only in the case of compressive strength. Much higher average values of this strength can be obtained for epoxy mortars. However, the analysis of the results for the individual compositions shows that there are polyester mortar compositions for which the strength is much higher than that of epoxy mortars. Particularly noteworthy in this context is composition No. 8, in which the glass content is 100% and the resin content is 25%. The figure also shows the average values of this strength obtained by the authors.

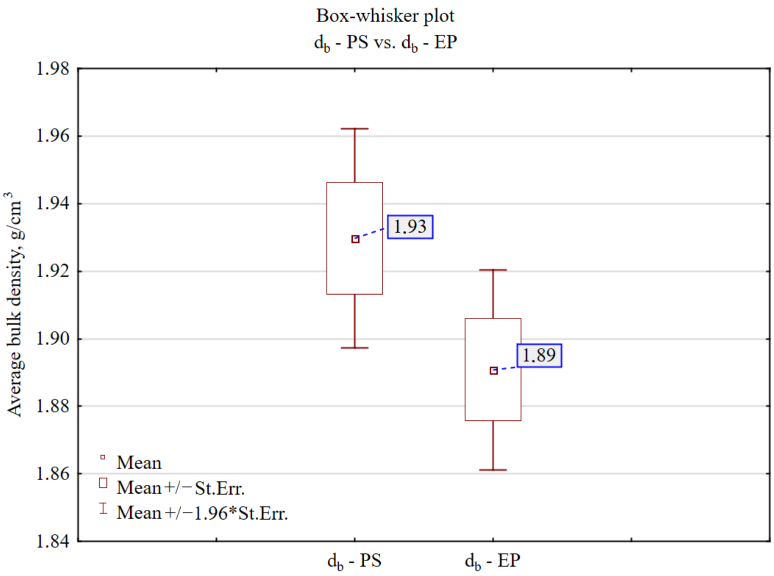


Figure 13. Results of the *t*-test presented graphically in the form of box-and-whisker plots for bulk density.

Table 4. Summary of the shares of resin and waste in individual compositions.

Group 1 vs. Group 2	Independent Samples *t*-Tests										
	Mean 1	Mean 2	*t*	df	*p*	N 1	N 2	St.dev. 1	St.dev. 2	F Var.	*p* Var.
ff-PS vs. ff-EP	23.929	25.428	−1.317	52	0.194	27	27	5.541	2.062	7.225	0.000
fc-PS vs. fc-EP	76.023	83.274	−2.365	106	0.019	54	54	18.341	11.061	2.749	0.000
db-PS vs. db-EP	1.930	1.891	1.737	52	0.088	27	27	0.086	0.078	1.197	0.649

Note: Variables Are Treated as Independent samples. Marked Effects Are Significant with $p < 0.05$.

3.7. Absorptivity

Figure 14 shows trend function graphs generated for the water absorption of each polyester mortar composition depending on the increasing immersion time in water. In all cases, a logarithmic function of the general form (2) can be fitted:

$$y = a * \log(x) + b, \quad (2)$$

The values of the coefficients of these functions, along with the coefficient of determination obtained for the individual compositions, are listed in Table 5.

Table 5. List of values of determination coefficients and trend function coefficients for water absorption.

Composition No	1	2	3	4	5	6	7	8	9
a	0.685	2.073	0.481	1.040	2.584	0.634	0.491	1.246	0.911
b	0.155	1.990	0.071	0.339	3.098	0.163	0.053	0.565	0.213
R^2	0.973	0.961	0.921	0.963	0.957	0.970	0.966	0.976	0.976

In all cases, the values of the coefficients of determination are very high, ranging from 0.921 to 0.977, which proves that the functions fit well to the measurement results. In order to compare the obtained average absorbability results of the obtained polyester mortars modified with waste glass cullet with those described in [18] for epoxy mortars, one part of Figure 14 in the area of up to 8 days of immersion has been enlarged and presented in Figure 15. Additionally, in Figure 15, the range from 0.2% to 0.7% was marked, which characterized the epoxy mortars containing glass waste described in [18]. For the 7th day of exposure to water, a vertical dashed line is drawn in Figure 15, which allows for the observation that only three polyester mortar compositions (marked as 3, 6 and 7) are characterized by water absorption in the range describing epoxy mortars.

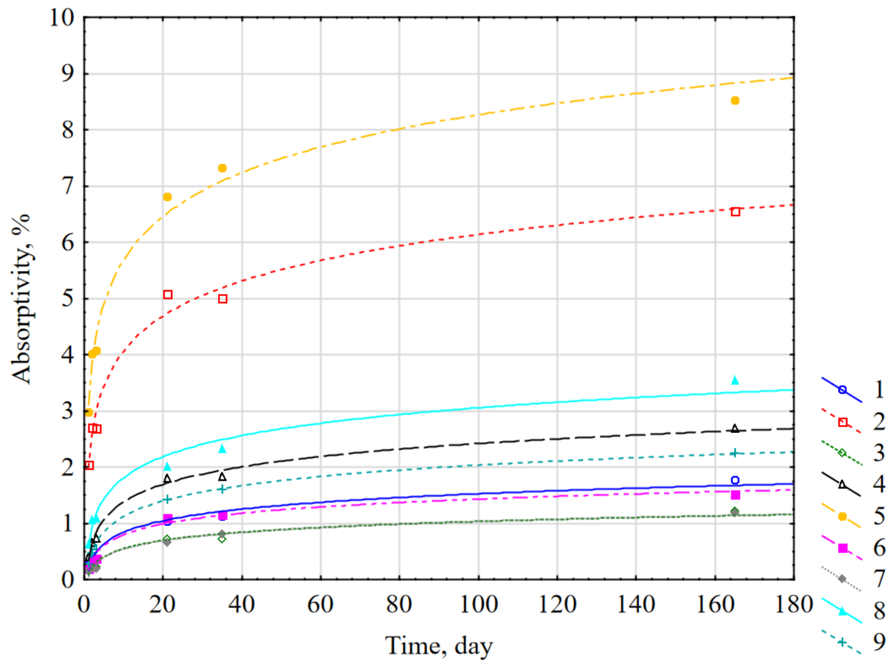


Figure 14. Dependence of the absorbability of mortar samples on the time of immersion in water.

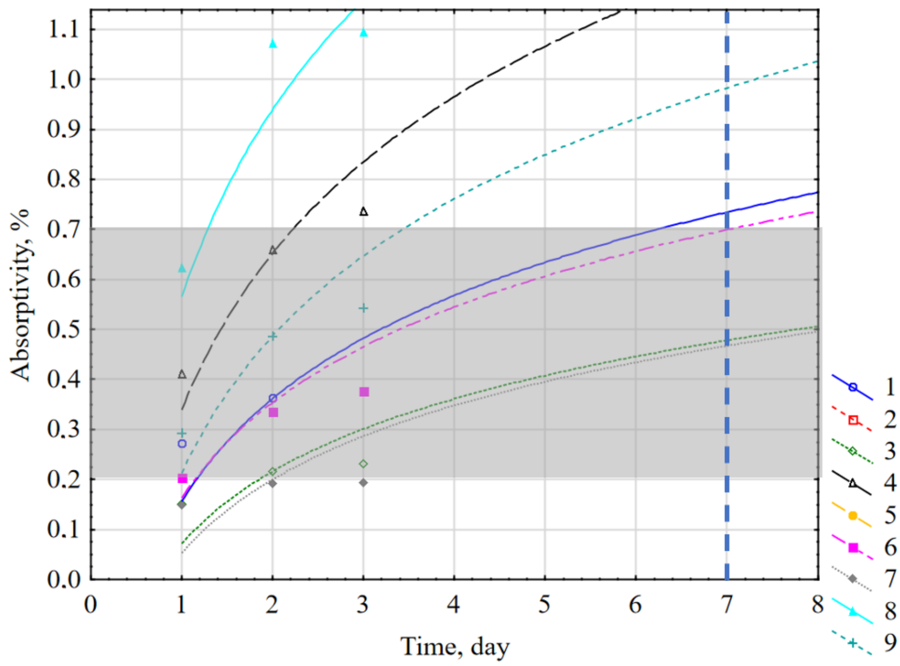


Figure 15. Absorption of mortar samples after the first 7 days of immersion in water compared to the range typical for epoxy mortars (gray rectangle).

In the case of the polyester mortars, there is a much greater variation in the average water absorption values depending on the composition of the composite. The lowest and very similar water absorption values were characteristic of the mortars marked as 7 and 3, in which the resin-to-aggregate ratio was 0.25 and 0.33 and the glass waste content was 0% and 14.6%, respectively. After 7 days of immersion in water, the absorbability of these mortars did not exceed 0.5% and was within the marked range of epoxy mortars. Compositions 2 and 5 achieved by far the highest water absorption, which may be due to their low resin/aggregate ratio of 0.14–0.18 with glass waste contents of 50% and 85.4%, respectively. Such results prove that only with appropriately selected proportions can a material with low water absorption comparable to that of epoxy mortars be obtained. At the same time, due to the lower viscosity of the polyester resin, with its appropriate share, it is able to wet the surface of the waste aggregate grains much better and thus influence the final value of the tested physical and mechanical properties.

4. Conclusions

Including glass waste in the composition of concrete and polymer mortars may be an interesting alternative to the drastically decreasing resources of natural aggregates, including sand. Manufacturers of prefabricated polymer concrete elements most often use polyester resins as a binder, which is associated with much lower costs compared to composites with an epoxy matrix. The research described in this article concerned polyester mortars modified with glass waste. The results are very promising and can be summarized as follows:

- The highest values of flexural strength of 30 MPa and compressive strength of 91.4 MPa were obtained for mortars in which 100% of the sand was replaced by glass waste. It is important to maintain an appropriate resin–aggregate proportion of 0.25 and use a waste glass cullet with a grain size of 0–0.5 mm.
- The absorbability of the polyester mortars modified with glass waste varies greatly, but with the appropriate selection of the composite composition, it does not exceed 0.5% after 7 days of immersion in water.
- While maintaining similar proportions of ingredients, the obtained polyester mortars have approximately 2.5 times lower production costs compared to epoxy mortars, and at the same time, in selected cases, the strength parameters are at a comparable or even higher level.
- Polyester mortars containing glass waste are a valuable material alternative for producers of prefabricated polymer concrete elements for applications consistent with the idea of sustainable, low-emission construction.

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