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THE USE OF RECYCLED MATERIALS FROM ELECTRONIC AND GLASS WASTE IN CEMENT CONCRETE RECIPES

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Rezumat. *Lucrarea prezintă două rețete de beton de ciment având în compoziție deșeuri industriale. Prima rețetă utilizează un deșeu rezultat din prelucrarea mecanică a plăcilor electronice, utilizată la realizarea prefabricatelor în construcții și o rețetă care utilizează agregate de sticlă concasată sort 0 – 4 mm, utilizată la realizarea prefabricatelor în construcții. Utilizarea deșeurilor are o importanță deosebită în protecția mediului, iar din punct de vedere economic scad prețurile produselor.*

Abstract. *The paper presents two cement concrete recipes containing industrial waste. The first recipe uses a waste resulting from the mechanical processing of electronic boards, used to make industrial prefabricated and a recipe that uses aggregates of crushed glass sort 0-4 mm, used to make prefabricated products. The use of waste is important in the protection of the environment and from the economic point of view the prices of the products decrease.*

Keywords: Concrete, Glass waste, Electronic waste products

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1. INTRODUCTION

Industrial development in all domains led to realise of many objective, for which were used a wide range of materials which over time with reaching exploitation time, it had to be demolished to build new ones. As a result of the demolition of the old industrial objectives as well as from some specific technological processes, results by products generically called waste.

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This waste becomes a mode of pollution the environment by their very existence and the impossibility of using them in the form in which resulted from various technological processes.
Adequate management of the waste and the reciclate materials can have an important role regarding of sustainability and quality of life.
Therfore, an efficient method of recovering various constructions and demolitions wastes or specific technological processes would be recycling them, thus leading to the development of the economy, economizing raw materials and the energy to allow conserveation the planet's limited natural resources and protect the environment [1].
INCERTRANS S.A. has performed studies and laboratory tests in the field of waste reuse by using them in the construction industry.
This paper presents examples of the use of waste electronic products, as well as glass waste from demolition, at the realization of concrete recipes used in the prefabricated industry.

2. EXPERIMENTAL STUDY

2.1 The use of waste resulting through electronic products recycling

This electronic wastes results by recovery from worn-out electronic equipment at a degree of wear that no longer allows use in normal parameters. Thus it is recovered wastes by recycling electronic circuit boards and other various materials that are part of electronic equipment.
On these materials have been studies regarding the percentage of wastes from electronic materials used to establish a cement concrete recipe Thus, concrete recipes were made in which the part resulting from the recycling of electronic waste replaced a part of the 0-4mm sort of natural aggregates with the 0-2mm sort of electronic waste.
The study presents the results of the tests on preparated specimens from concrete of cement on class 25/30, elaborated according to NE 012-1:2007 [2] using natural aggregates and waste from electronic materials sort 0 - 2 mm, which replaces sand sort 0 - 4 mm in various proportions [3].

Thus, it was elaborated a cement concrete recipe using the same percentage of natural aggregates as in a recipe for a classic concrete and replacing a quantity of sort 0 - 4 mm sort with 0 - 2 mm sort waste representing 5% of the mass of one cubic meter of concrete.

2.1.1. Used materials

Recipe with 5% waste per cubic meter of concrete

Table 1. Materials used in the preparation of the recipe

Nr. Crt.	Materials	Material type and origin
1	Ballast aggregates	Sort 0-4; 4-8; 8-16 – from the source
2	Electronic waste	Sort 0 – 2 mm – from the source
3	Cement	CEM I 42.5 R - from the source
4	Additive	plasticizer – from the source

Table 2. Aggregate granulometry

Material	Sort	Percent passing (%) through the sieves of (mm)							
		0.125	0.25	0.5	1	2	4	8	16
PS	8-16	0,0	0,0	0,0	0,0	0,0	0,2	9,3	98,0
PS	4-8	0,0	0,0	0,0	0,0	0,4	9,5	90,8	100,0
NN	0-4	7,0	23,8	54,5	73,5	84,2	100,0	100,0	100,0
DE	0-2	20,5	35,9	59,2	99,3	100,0	100,0	100,0	100,0

Table 3. Mineral skeleton study

Material	Percentage	Granularity of the mixture (passes in%)							
		0.125	0.25	0.5	1	2	4	8	16
PS 8-16	30	0,0	0,0	0,0	0,0	0,0	0,1	2,8	29,4
PS 4-8	36	0,0	0,0	0,0	0,0	0,1	3,4	32,7	36,0
NN 0-4	27	1,9	6,4	14,7	19,8	22,7	27,0	27,0	27,0
DE 0-2	7	1,4	2,5	4,1	7,0	7,0	7,0	7,0	7,0
Total	100	3,3	8,9	18,9	26,8	29,9	37,5	69,5	99,4

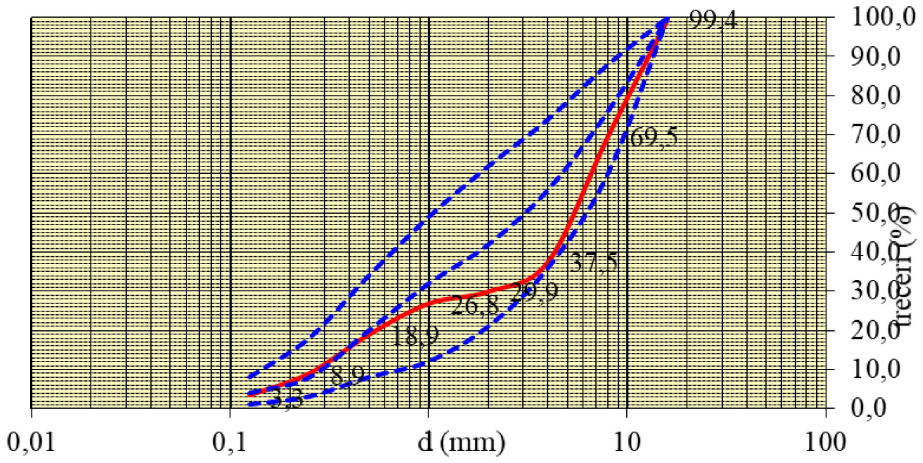

Fig. 1. Granulometry of materials and limits in the normative NE 012-1: 2007

Table 4. Mixture with 5% waste per cubic meter of concrete

Material	U.M.	Quantity
Cement CEM I 42.5 R	kg/m^3	340
Water + additive	l	170
Plasticizer additive (0.7% by mass of cement)	kg l	2.38 2.07
Aggregate	kg	1787
sort 8-16	kg	536
sort 4-8	kg	643
sort 0-4	kg	482
waste sort 0-2	kg	126

2.1.2 Samples preparation

Were made 3 (three) cubic specimens from a mixture of 5% waste per cubic meter of concrete to determine the compressive strength, water absorption and the degree of gelling of the concrete.

2.1.3 Results

The test results after 28 days are shown in the following table:

Table 5. Physical-mechanical characteristics determined for the mixture with 5% waste per cubic meter of concrete

Nr. crt.	Volume (m^3)	Weight (kg)	Apparent density (kg/m^3)	Surface (mm^2)	Force (N)	Compression strength (N/mm^2)
1	0.003375	7,742	2294	22500	801000	35,6
2	0.003375	7,744	2295	22500	787500	35,0
3	0.003375	7,764	2300	22500	789750	35,1
Mean		7,750	**2296**	22500	792750	**35,2**

Table 6. Water absorption

Nr. crt.	Weight saturated (kg)	Weight dry (kg)	Water absorption (%)
1	7860,9	7460,2	5,4
2	7877,2	7470,5	5,4
3	7862,3	7464,1	5,3
	Mean		**5,4**

Table 7. Freeze-thaw resistance after 50 cycles

Nr. crt.	Surface (mm^2)	Force (N)	Compression strength after 50 cycles (N/mm^2)	Compression strength test witness (N/mm^2)
1	22500	776250	34,5	35,6
2	22500	760500	33,8	35,0
3	22500	774000	34,4	35,1
Mean	22500	770250	**34,2**	**35,2**
Loss of strength (%)			**2,8**	

After processing and interpretation of results the following have been established:

- For the mixture with 5% waste per cubic meter of concrete - 93% natural aggregates + 7% waste, cement, water, additive, ratio water / cement 0.5 the following results were obtained:
  - Apparent density of concrete at 28 days ρb = 2296 kg/m^3;
  - Compressive strength after 28 days Rc = 35.2 N/mm^2;
  - Water absorption Ab = 5.4%;
  - Freeze-thaw resistance – loss of compressive strength after 50 freeze – thaw cycles η = 2.8%;

- Cement concrete with 5% waste resulting from the mechanical processing of electronic slabs per cubic meter of concrete falls into strength class C25 / 30.

2.2 The use of waste resulting from the recovery of materials made up of glass when making concrete recipes used in the prefabricated industry

Glass is also a material that when it comes from demolition can be reused by recycling in various industrial fields. Composed of raw materials such as quartz sand, limestone, soda, recycled glass can be used in the production of new containers or by processing glass powder as glass wool in making sounds insulations.

The following study shows the results of the tests on test specimens made of cement concrete class C25 / 30, developed according to NE 012-1: 2007 [2] using natural aggregates and glass aggregates sort 0 - 4 mm, which replaces natural sand sort 0 - 4 mm.

Thus, a cement concrete recipe was elaborated using the same percentage of natural aggregates as in a recipe for a classic concrete and replacing the amount of natural sand sort 0-4 mm with glass aggregates sort 0-4 mm [4].

2.2.1 Used materials

Recipe with sort glass 0-4 mm

Table 8. Materials used in the preparation of the recipe

Nr. Crt.	Material	Material type and origin
1	Ballast aggregates	Sort 4-8; 8-16 – from the source
2	Glass aggregates	Sort 0 – 4 mm – from the source
3	Cement	CEM II A-LL 42.5 R – from the source
4	Additive	plasticizer – from the source

Table 9. Aggregate granulometry

Material	Sort	Percent passing (%) through the sieves of (mm)							
		0.125	0.25	0.5	1	2	4	8	16
PS	8-16	0,0	0,0	0,0	0,0	1,6	12,1	51,9	100,0
PS	4-8	0,0	0,0	0,0	0,0	0,0	36,8	98,5	100,0
NS	0-4	4,0	10,7	32,9	68,4	99,6	100,0	100,0	100,0

Table 10. Mineral skeleton study

Material	Percentage	Granularity of the mixture (passes in%)							
		0.125	0.25	0.5	1	2	4	8	16
PS 8-16	50	0,0	0,0	0,0	0,0	0,8	6,1	26,0	50,0
PS 4-8	13	0,0	0,0	0,0	0,0	0,0	4,8	12,8	13,0
NS 0-4	37	1,5	4,0	12,2	25,3	36,9	37,0	37,0	37,0
Total	100	1,5	4,0	12,2	25,3	37,7	47,8	75,8	100,0

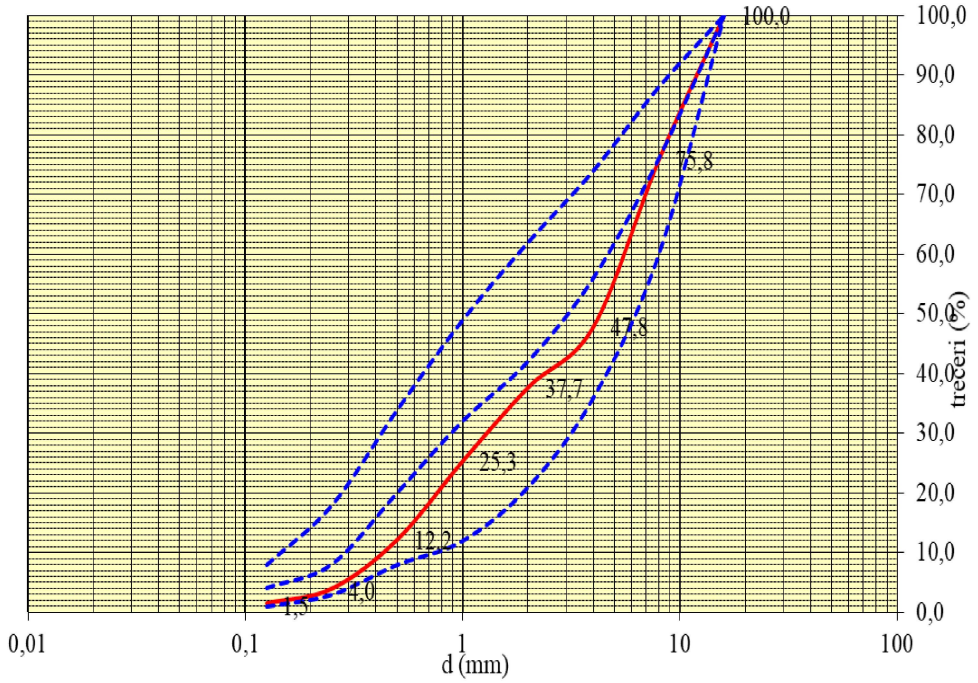

Fig. 2. Granulometry of materials and the limits from the normative NE 012-1: 2007

Table 11. The mixture with glass sort 0-4 mm per cubic meter of concrete

Material	U.M.	Quantity
Cement CEM II A-LL 42.5 R	kg/m^3	320
Water + additive	l	160
Plasticizer additive (0.7% by mass of cement)	kg l	2.24 1.95
Aggregate	kg	1832
sort 8-16	kg	916
sort 4-8	kg	238

sticlă sort 0-4	kg	678

2.2.2 Samples preparation

Were made 3 (three) cubic specimens from a 0-4 mm sorted glass mixture to determine the compressive strength, water absorption, and gelation of the concrete.

2.2.3. Results

The test results after 28 days are shown in the following Table12.

Table 12. Physical-mechanical characteristics determined for the mixture with 0-4 mm sort glass

Nr. Crt.	Volume (m^3)	Weight (kg)	Apparent density (kg/m^3)	Surface (mm^2)	Force (N)	Compression strength (N/mm^2)
1	0.003375	7,801	2312	22500	700500	31,1
2	0.003375	7,756	2298	22500	673325	29,9
3	0.003375	7,808	2313	22500	685740	30,5
Mean		7,789	**2308**	22500	686521,7	**30,5**

Table 13. Water absorption

Nr. crt.	Weight saturated (kg)	Weight dry (kg)	Water absorption (%)
1	7827,7	7495,8	4,4
2	7836,2	7526,3	4,1
3	7954,7	7598,5	4,7
	Mean		**4,4**

Table 14. Freeze-thaw resistance after 50 cycles

Nr. crt.	Surface (mm^2)	Force (N)	Compression strength after 50 cycles (N/mm^2)	Compression strength test witness (N/mm^2)
1	22500	662667	29,5	31,1
2	22500	658520	29,3	29,9
3	22500	668523	29,7	30,5
Mean	22500	663237	**29,5**	**30,5**
Loss of strength (%)			**3,3**	

After processing and interpretation of results the following have been established:

- For the mixture with sort 0-4 mm glass – natural aggregates + sort 0-4 mm glass, cement, water, additive, water / cement ratio 0.5 the following results were obtained:
  - Apparent density of concrete at 28 days ρb = 2308 kg/m^3;
  - Compressive strength after 28 days Rc = 30.5 N/mm^2;
  - Water absorption Ab = 4.4%;
  - Freeze-thaw resistance – loss of compressive strength after 50 freeze – thaw cycles η = 3.3%.
- Cement concrete with recycled glass falls into strength class C25/30.

3. CONCLUSIONS

By using waste resulting from demolition work or recovering materials from obsolete products and equipment from old buildings and waste resulting from technological production processes, ways are made to protect the environment.

Protecting the environment has a special role to play in creating a relationship between these products and maintaining the quality of life, so that the capacity of the biosphere and human civilization coexist.

By ensuring a controlled relationship between industrial development and the way of collecting and removing waste products, civilization contributes to maintain the sustainable development of society.

R E F E R E N C E S

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