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RECYCLING OF DRY DESULPHURISATION GYPSUM AND FLY ASH INTO BUILDING MATERIALS

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Abstract: This research paper present studies on recycling industrial waste from Power Plant: dry desulphurisation gypsum and fly ash. These industrial waste were combined with classical binders (lime and cement) and water to obtain a materials which can be used into building materials industry.

The new materials were kept for 5 years into laboratory conditions and then tested. They have at 5 years age an apparent density between 1070 kg/m^3 to 110 kg/m^3, bending tensile strengths between 0.23 N/mm^2 to 1.75 N/mm^2 and compressive strengths between 1-2.51 N/mm^2. These new materials can be used like pastes, mortars or to obtain thermal insulation materials.

Keywords: dry desulphurisation gypsum, fly ash, new building materials, environment protection.

1. INTRODUCTION

The fly ash is an industrial waste product which is created when the coal is burned into heat and power station. Sometimes, this fine powder is simply hauled to a disposal site near the electric power plant. It is a fine hydraulic powder with spherical shape like showed in Figure 1 [1].

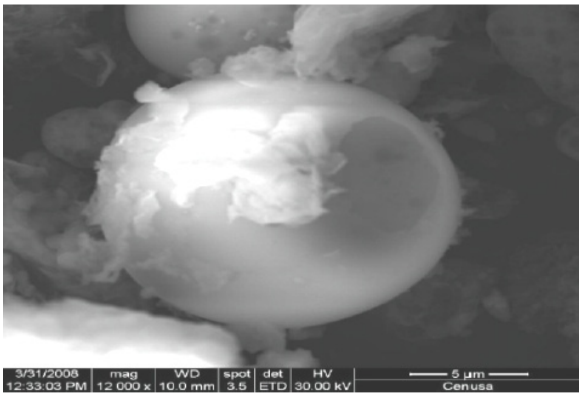

Figure 1. SEM Image of fly ash granule /1/

An be used to obtain building materials like pavement element showed into Figure 2 [2]. The oxides $SiO_2 + Al_2O_3 + Fe_2O_3$ is over 70% from mass which permit to appear the vitreous phases, Ca siliceous and Ca aluminous with good benefit for hydraulic reactions.

The burning gases contain many chemical substances which need treated in special for desulphurisation. Will result a big quantities of dry desulphurisation residues which can be stored in special place [3].

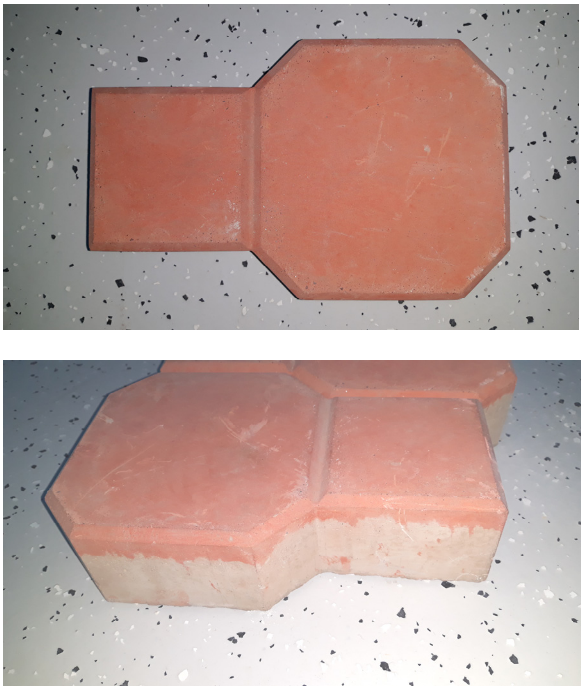

Figure 2. Photography with the pavement elements with ultrafine fly ash /2/

Reuse of dry desulphurisation gypsum and fly ash into building materials is a concern a lot of researchers. The team research Cătălin Badea & co develop some building materials with these types of industrial waste [4].

This type of industrial waste have good properties to be used to obtain thermal insulation materials in accordance with the European requirements regarding reducing of gas emissions [5].

In all research word the recycling of industrial waste education is one of its priority [6].

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The goal of this paper is to present the research program to reuse the industrial waste like dry desulphurisation gypsum and fly ash to obtain new material which can be used into Civil Engineering Industry.

2. EXPERIMENTAL PROGRAM

This research paper presents the studies on materials realised from: fly ash, dry desulphurisation gypsum, aluminous cement and lime. These dry materials are mixed with water and additive.

The fly ash and dry desulphurisation gypsum are industrial waste product. from.

The aluminous cement is hydraulic calcium aluminates. Its role is to reduce of shrinkage of desulphurisation gypsum and to increase technical performance of final materials [6].

The lime is CL 90 type.

The fly ash and dry desulphurisation gypsum are from CET Sud Timisoara Heating Plant (Romania).

Water was from public net. The quantity of water was 60% percentage from dry materials.

The additive was a Romanian retarder additive for plaster (gypsum).

The technology to prepare the new materials is:

1. manually mixing of dry binders: fly ash, dry desulphurisation gypsum, aluminous cement and lime;
2. the dry binders mixture are mechanical mixed with water and additive to obtain a fluid paste.

The main component from mixture is dry desulphurisation gypsum.

The fluid pastes were introduced into steel mould.

We obtain prismatic sample with dimension 40x40x160 mm.

The compositions of pastes are presented below:

- **Series 1: DDG1**
  - water: 60% from dry materials;
  - dry materials realized from:
    1. desulphurisation gypsum: 600 g;
    2. aluminous cement: 200g;
    3. lime: 200g;
    4. fly ash: 200g;

- **Series 2: DDG2**
  - water: 60% from dry materials;
  - dry materials realized from:
    1. desulphurisation gypsum: 400 g;
    2. aluminous cement: 200g;
    3. lime: 200g;
    4. fly ash: 400g;

- **Series 3: DDG3**
  - water: 60% from dry materials;
  - dry materials realized from:
    1. desulphurisation gypsum: 200 g;
    2. aluminous cement: 200g;
    3. lime: 200g;
    4. fly ash: 600g;

The samples were de-moulding after 1 or 2 days and kept into laboratory conditions (kept at 20 °C and relative humidity around 60 %).

The ages of test were 1 day, 7 days, 28 days and 5 years.

The apparent density and mechanical properties (bending tensile strengths and compressive strengths) are presented into table 1, 2 and 3 and are showed into graphics from Figure 3, 4 and 5.

Table 1

Batch	***Apparent Density*** ρ_a **[kg/m³]**			
	1 day	**7 days**	**28 days**	**5 years**
DDG 1	1515	1335	1151	1150
DDG 2	1508	1296	1142	1133
DDG 3	1464	1210	1114	1070

Table 2

Batch	***Bending Tensile Strength*** f_t **[MPa]**		
	7 days	**28 days**	**5 years**
DDG 1	0.47	0.59	1.17
DDG 2	0.35	0.82	1.75
DDG 3	0.12	0.59	0.23

Table 3

Batch	***Compressive Strength*** f_c **[MPa]**		
	7 days	**28 days**	**5 years**
DDG 1	0.88	3.94	2.38
DDG 2	1.03	4.16	2.51
DDG 3	0.84	1.75	1.00

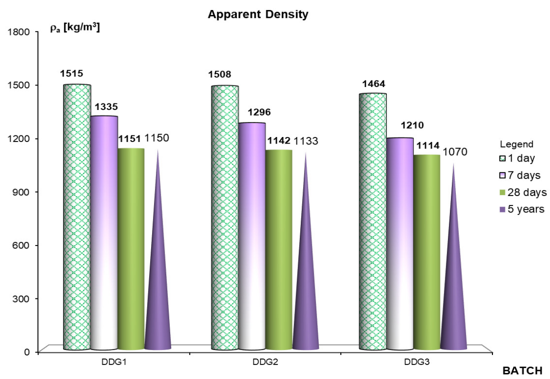

Figure 3. Apparent density

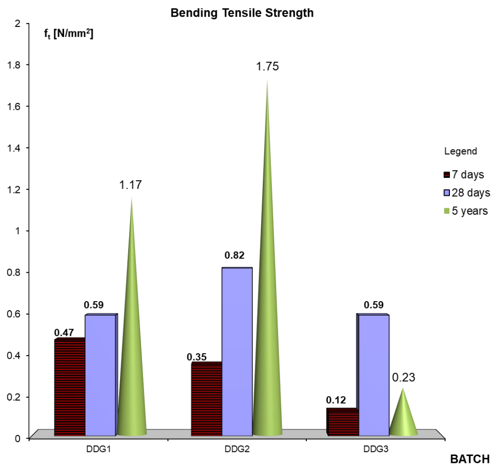

Figure 4. Bending Tensile Strength

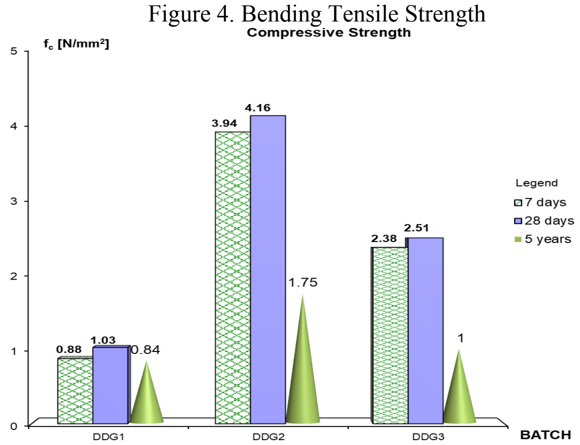

Figure 5. Compressive Strength

At 28 days age, the samples have:

- the apparent density values of (1114 – 1151) kg/m^3 which border the paste into easy mortars/pastes class;
- the bending tensile strengths between 0.59 N/mm^2 to 0.82 N/mm^2;
- the compressive strengths between 1.75 N/mm^2 to 4.16 N/mm^2, values like ordinary mortars.

At 5 years age, the samples have:

- the apparent density values of (1070 – 1150) kg/m^3 the same as at 28 day age (laboratory humidity affect the measurement);
- the bending tensile strengths between 0.23 N/mm^2 to 1.75 N/mm^2, that means the result increased for DDG1 with 98%; for DDG2 with 113% and for DDG1 reduced with 61% compared with 28 days age;
- the compressive strengths between 1.00 N/mm^2 to 2.51 N/mm^2, that means the result reduced with 39% and 42% compared with 28 days age;

The same behaviour we can see from graphics showed into Figures 1, 2 and 3.

A comparation between Series 1 DDG1 (3 parts of dry desulphurisation gypsum and 1 part of fly ash) with Series 3 DDG3 (1 part of dry desulphurisation gypsum and 3 parts of fly ash) is showed into Figure 6 and Figure 7.

We observe that:

- regarding bending tensile strengths:
  - at 28 days age, the samples have the same values;
  - at 5 years age, the samples the with high quantity of dry desulphurisation gypsum show us increased values compared with 28 days age, almost with 100%;
  - at 5 years age, the samples the with low quantity of dry desulphurisation gypsum present reduced values compared with 28 days age, over 100%;

  Conclusion: for bending tensile strength a high quantity of dry desulphurisation gypsum.
- regarding compressive strengths:
  - at 28 days age, the samples with low quantity of dry desulphurisation gypsum present increased values over 100%;
  - at 5 years age, the samples the values have reduced and have close the same values;

  Conclusion: for compressive strength, the big quantity dry desulphurisation gypsum will present reduced values at 28 days age and approximatively the same values at 5 years age.

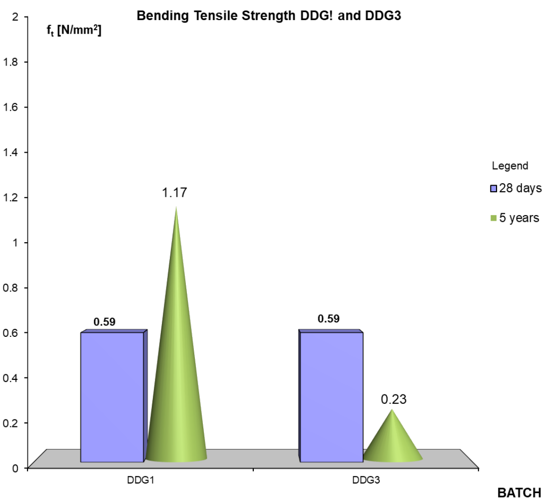

Figure 6. Bending Tensile Strength between DDG1 and DDG3

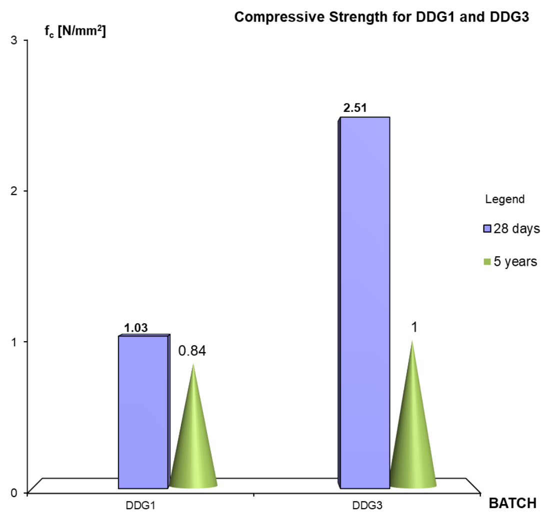

Figure 7. Compressive Strength between DDG1 and DDG3

3. CONCLUSIONS

The bending tensile strength increased at 5 years age compared with 28 age for samples with more dry desulphurisation gypsum and low fly ash quantity (DDG 1 and DDG2) and reduced for samples with low dry desulphurisation gypsum and high fly ash quantity (DDG3). This phenomenon is possible to be produced by slow hydration of fly ash in time.

The hydration of dry desulphurisation gypsum with humidity from air will continue in time. Is possible to grow the existing crystals which affect favourable bending tensile strength and not favourable for compressive strengths.

The compressive strength reduced at 5 years age compared with 28 age for all samples with big values.

This phenomenon can be produced by low hydration of fly ash in time or by reaction between hydration mineralogical components of aluminous cement with dry desulphurisation gypsum.

We can see that in time, compressive strength will be reduced.

The mechanical properties of new materials at 5 years are the same as mortars/pastes class.

Because these materials are made from powder materials will result a paste which can be used to industrial wall rendering.

Due to low apparent density, these types of materials can be used to obtain thermal insulation materials.

In the same time, the recycling of industrial waste like fly ash and dry desulphurisation residues into new building materials can perform:

- building materials with cost reduced;
- a good strategy regarding the conservation and the protection environment;
- more positive aspects for human life.

In European Union concern regarding energy saving, the recycling of industrial waste education is one of its priority.

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