Use Of Waste Gypsum As Construction Low Strength Materials

Seema Karami, Peter Claisse, Essie Ganjian, Homayoun Sadeghi
Department of Built Environment, Faculty of Engineering and Computing, Coventry University, UK

Rosemary Greaves
Department of Chemistry, Imperial College of London

ABSTRACT: Disposing of waste is an environmental issue. Using waste will help reduce land filling. The successful research and development of a new building material, or component using waste as raw material, is a very complex and multidisciplinary task having technical, environmental, financial, marketing, legal and social aspects.

In this paper it has been tried to find a low compressive strength mix with using only waste material include: Red Gypsum, Plaster board Gypsum, Basic Oxygen Slag, and Cement By Pass Dust. The amount of compressive strength and the flow of mixes had measured. The effect of water amount on compressive strength of some mixes has also measured.

1 INTRODUCTION:

"There is a general movement of rural populations to the cities with the rapid industrialization in developing countries. The infrastructure to support these cities, such as buildings for housing and industry, mass transit for moving people and goods, and facilities for handling water and sewage will require large amounts of construction materials. Enhanced construction activities, shortage of conventional building materials and abundantly available industrial wastes have promoted the development of new building materials" [Kumar, 2002].

This paper is about using waste materials in construction. The aims of this paper are:

1- To develop uses for contaminated gypsum.
2- To carry out trial mixes incorporating red gypsum and/or waste plasterboard to see if the Compressive and Tensile Strength properties can be met.
3- To find the optimal percentage of each material in mixes for making bricks and other construction materials.

The following materials have been considered in the research in this paper:

1- Red Gypsum(RG)
2- Plasterboard Gypsum(PG)
3- Basic Oxygen Slag Dust(BOS)
4- Cement By Pass Dust(BPD)

Firstly, the chemical and some of physical characteristics of waste materials were examined. Secondly, the materials were mixed in binary and ternary combinations and the compressive strength was tested and optimised.

2 LITERATURE REVIEW

2.1 *Source of Gypsum*

There are different sources of by-product gypsum:

"Titanium Oxide Pigment Production yields 250Kt of "red" and 84 Kt of clean "white" gypsum per year in the UK. Worldwide production of red gypsum is 1.25 Mt from one producer alone" [Claisse P. et al., 2004]. "This material contains approximately 40% moisture, 16% iron oxides, 0.5% of both MnO and SiO_2 , 0.25 of Al and TiO_2 and many other elements. These render it unacceptable to the plaster and cement industries, principally due to its iron content which may cause staining in plaster products and adversely affects cement clinker chemistry." [Claisse P. et al., 2004]

Waste gypsum also arises from plasterboard off-cuts from construction sites and spent casting cores from foundries and very many areas of chemical manufacturing produce secondary gypsum from acid neutralisation. In order to meet demand, substantial amounts of quarried gypsum are also used in this country and the UK is a net importer of gypsum.

Flue gas desulphurisation at PowerStation is another source of by-product gypsum which is the single largest source of secondary gypsum with 600Kt produced in the UK and 16 Mt in the EC in 2000. After a temporary rise to 1.5 Mt in 2005, UK arisings are expected to fall substantially as domestic coal supplies are replaced with low-sulphur imported coal by 2015.

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2.2 *Source of Slag*

“Steel Slag is a by-product produced from either the conversion of iron to steel in a basic oxygen furnace, or melting of scrap to make steel in electric arc furnace.”[Caijun Shi, 2004]

“The use of iron blast furnace slag as a cementicious material has been practiced in Europe since the late 1800s [Tiifekqi, 1997]. Today SSDs are well characterised and long-term experienced materials mainly used as aggregates for road construction.” [Mozt et al., 2001]

“In the United Kingdom about 1 million tonnes of Basic Oxygen Steel (BOS) slag is produced annually and about 10 million tonnes of BOS slag is held in stockpiles undergoing weathering to allow for hydration of free lime.” [Gurmel S Ghataora et al. ,2004]

2.3 *Source of BPD or CKD*

During the manufacture of Portland cement, a large amount of dust is collected from kiln exhausted gases. While some of this cement kiln dust (CKD) is recycled, a large amount is disposed in landfills. The CKD has cementicious properties that make it an effective material for concrete.

“A typical Portland cement is manufactured by feeding materials containing appropriate proportions of lime, silica, alumina and iron into the upper end of kiln. The mix passes through the kiln at rate controlled by the slope of the kiln and speed at which the kiln rotates. Burning fuel is forced into the lower end of the kiln where it produces temperatures of 1400-1650 C, changing the raw mix to a cement clinker. During this operation a small percentage of the material in the form of dust (CKD) is collected. The physical and chemical properties of CKD can vary from plant- to- plant, depending on the raw materials used and type of collection process in the plant. However, the dust collected from the same kiln and producing the same cement type will typical have a relatively consistent composition. It is a good practice to frequently test the material to evaluate its characteristics and quality.” [Miller et al., 2000].

2.4 *Use Of waste materials as cement replacement*

Grinding is one of the parameters that can affect material characteristics. The grinding process reduced both the particle size and the crystalline phase of the materials, thus improving binder reactivity. Vibratory grinding for 4 hours provided the most success for mechano-chemical activation among all grinding methods used. [Shah, Wang, 2001]

Ground granulated blast furnace slag has successfully been used with Portland cement to produce high performance cement blends that are more economical and environmentally friendly. The use and effectiveness of CKD as an activator for slag depends upon its physical and chemical characteristics, most importantly, the alkali and free lime content, and the amount of carbonates and sulfates. The effectiveness of the alkali activation of slag will depend on the alkalinity provided by the CKD. It is expected that the high free lime content of the CKD will improve the hydration process by accelerating hydration and forming more crystalline products of hydration. Sulfate ions provided either by alkali salts or anhydrite will expedite the hydration process and accelerate the pozzolanic reaction through the formation of ettringite. [Konsta et al, 2003]

Compressive strength of different kinds of CKD and Slag blends increased with curing time, indicating slag activation by the CKD and the formation, precipitation, and accumulation of products of hydration. [Konsta et al, 2003]

Composite cement pastes of fluorgypsum, blastfurnace slag and metakaolin developed and maintained strength even under water, showing improved properties over commercial gypsum. (Fraire-Luna, et al, 2006)

Adding gypsum to slag reduced the setting time of alkali-activated slag paste (AASP), increased the compressive strength and decreased the drying shrinkage. [Chang, et al 2005]

Investigated by Mum et al in 2006 shows by promoting hydration of GBFS by adding activator, a small quantity of commercial slacked lime, anhydrous gypsum, and limestone powder were applied as activators and filler, sharply increases early compressive strength than that without activator added. Also, it is confirmed that blast furnace slag cement of approximately the same early strength with Ordinary Portland Cement (OPC) is feasible to be manufactured.

Compressive strength increased with curing time according to Figure 1.

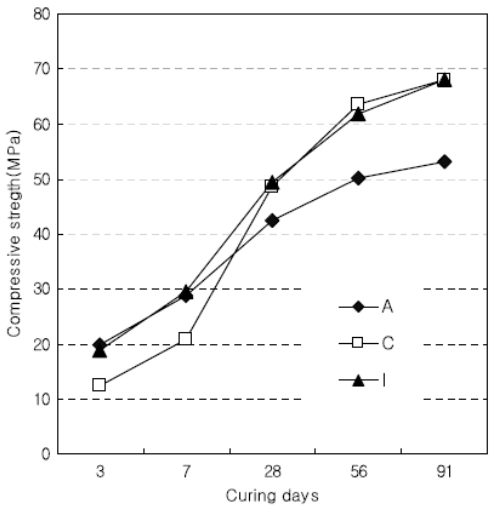


Figure 1- Comparison of compressive strength with added activators (I),without activator (A) and with OPC (C), [Mun et al. 2006]

3 MATERIALS USED IN THIS PROJECT

3.1 *Source of by product Gypsum:*

Red Gypsum and Plaster board Gypsum were used in this research. The source of Red Gypsum was from Titanium Dioxide manufacture at Tioxide Europe PLC and Plaster Board was from Lafarge sites.

The plasterboard gypsum used was obtained from the Lafarge plasterboard recycling plant located in Bristol. Waste plasterboard gypsum is collected from demolition sites.

3.2 *Source of BPD*

Typical analytical chemical composition of two different CKD samples from Rugby Cement and Castle Cement Barrington are given in Table 1. The BPD source was the same in step 1 and 2 reported here but the materials were taken at different times so they may have slightly different chemical and physical characteristics.

3.3 *Source of BOS*

The Basic Oxygen Slag that has been used in this project is from Tarmac UK (from Corus Scuntrorpe plant).

4 CHEMICAL ANALYSIS

The chemical analysis of raw materials is shown in table 1.

Table 1- Chemical analysis of RAW materials

Sample	SSD	RG	PG	BPD
SiO2	11.45	12.71	2.43	6.92
TiO2	0.37	0.39	0.03	0.15
Al2O3	2.32	1.72	0.81	2.73
Fe2O3	27.32	21.26	0.36	0.80
MnO	3.65	2.66	0.00	0.01
MgO	9.32	6.18	0.40	0.77
CaO	37.44	35.89	37.30	36.79
Na2O	0.03	0.00	0.03	1.22
K2O	0.01	0.02	0.24	15.04
P2O5	1.26	1.62	0.02	0.06
SO3	0.28	0.31	53.07	8.25
Total	93.45	89.85	94.69	94.22

5 SAMPLE PREPERATION

This research was conducted by making samples in the lab with a low shear mixer. All samples were left to cure for 3, 7, and 28 days prior to compressive testing. Specimens were cast in 50mm cube moulds. The fresh samples were covered with plastic sheets to prevent evaporation. After 24hr or 48 hr, the samples were removed from the moulds and cured in water.

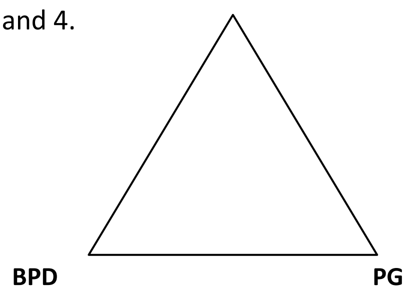
The compressive strength were tested at 3, 28, and 28 days accordance with standard. Each compressive strength value of each mix was the average of two samples.

Flow of mixes was measured by flow table.

5.1 *Optimising Ternary Mixes*

BOS, BPD, RG, and PG were mixed. Each mix is a combination of three different materials. Here, raw materials have been mixed with different percentages. The groups' material has been shown in

Figure 2 and the proportion of each group are shown in tables 3 and 4.



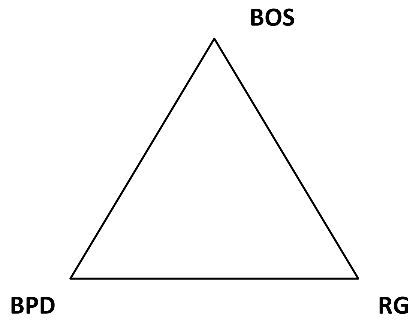


Figure 2- Different groups of mixes

6 RESULTS AND DISCUSSION

Materials in this step still were BOS, BPD, PG, and RG. Different combinations have been used for mixes and the result of compressive strength after 3, 7, and 28 days are shown in Tables 2 and 3.

The results are used to draw graph as contours. The contours in figures 3 to 4 are in fact models to predict the approximate compressive strength of mixes have not been made.

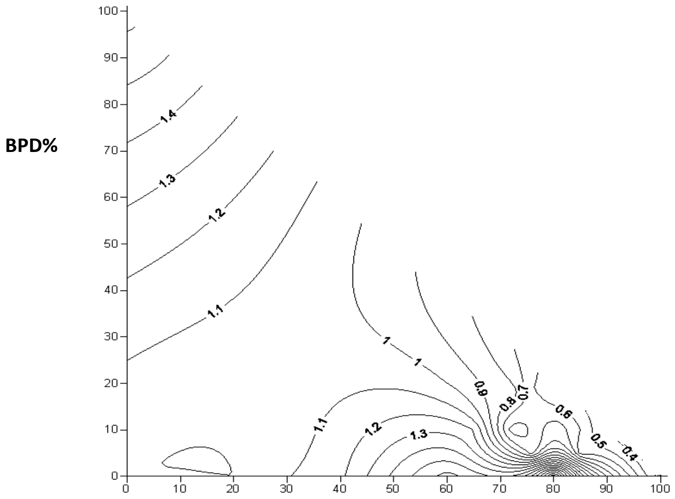
Tables 2 and 3 demonstrate the compressive strength and flow of different mixes with BOS, BPD, RG and PG. In every mixes the compressive strength has been increased by curing time. PG mixes have got more compressive strength compare to RG in mixes with BOS and BPD with the same percentage. There was no significant increase in compressive strength by increasing of BOS.

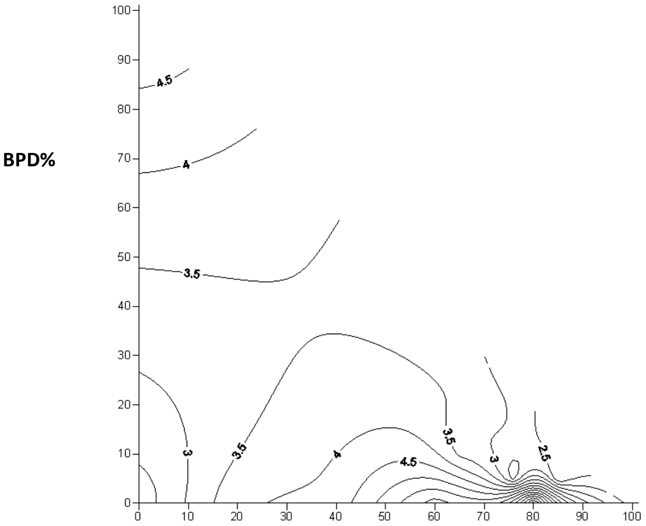
Table 2 Characterisation of BOS,BPD,and RG Mixes

Materials			**Compressive Strength MPa.**			**Flow mm**	**Mixing Time min**
BOS%	**BPD%**	**RG%**	**3 days**	**7 days**	**28 days**		
85	10	5	0.35	0.41	2.50	High Flow	5
85	5	10	0.28	0.40	2.70	High Flow	5
80	10	10	0.45	0.57	3	High Flow	5
76	5	19	0.41	0.83	3.1	High Flow	5
76	19	5	0.20	0.37	1.61	High Flow	5
72	10	18	0.45	0.9	2.3	High Flow	5
72	18	10	0.48	0.87	1.73	High Flow	5
68	15	17	0.20	0.44	2.4	155	5
68	17	15	0.32	0.9	1.9	144	5
65	10	25	0.40	0.92	2.53	86	7
64	20	16	0.26	0.9	3	134	5
60	20	20	0.40	0.65	2.46	No Flow	7

Table 3 Characterisation of BOS,BPD,and PG Mixes

Materials			**Compressive Strength MPa.**			**Flow mm**	**Mixing Time min**
BOS%	**BPD%**	**PG%**	**3 days**	**7 days**	**28 days**		
85	10	5	0.25	0.67	3.1	High Flow	5
85	5	10	0.45	0.57	2.85	High Flow	5
80	10	10	0.48	0.87	1.75	High Flow	5
76	19	5	0.31	0.53	2.8	High Flow	5
76	5	19	0.45	1.53	4.5	134	5
72	18	10	0.45	0.87	3.3	High Flow	5
72	10	18	0.20	0.56	3.2	High Flow	5
68	17	15	0.30	0.87	3	155	5
68	15	17	0.20	0.44	2.9	150	5
65	10	25	0.34	0.97	2.43	86	7
64	20	16	0.24	0.95	3.2	144	5
60	20	20	0.35	0.75	2.52	110	7





A

B

BOS%

BOS%

Figure 3 (A and B)- BOS+BPD+PG strength (MPa) after 7 and 28 days

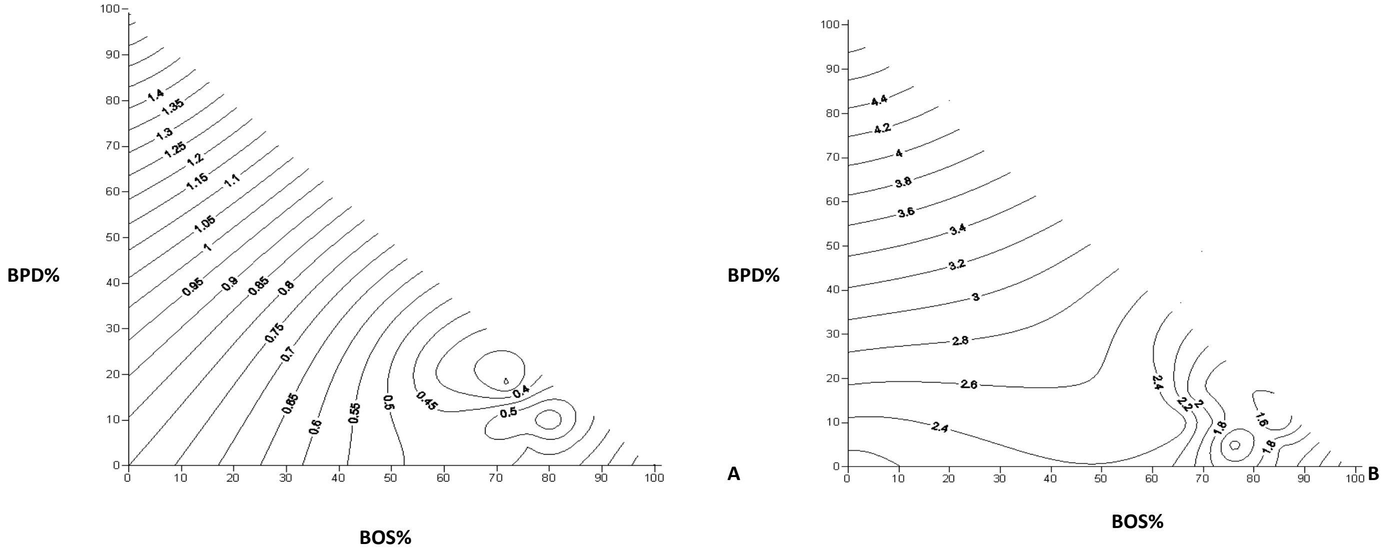


Figure 4 (A and B)- BOS+BPD+RG strength (MPa) after 7 and 28 days

7 CONCLUSIONS

- Flow decreases by increasing the amount of RG or PG.
- The compressive strength increases by time. It means the 28 days old samples have higher compressive strength than 7 and 3 days old samples.
- Since the chemical and physical characteristics of BPD is different in any batches it is recommended to uses BPD in mixes as less as possible to have better conclusion on mixes.
- BPD can do as a good activator and help mixes to get more compressive strength in 3, 7, and 28 days.
- In both mixes graphs show, the mixes could get higher compressive strength after 7 days could get higher compressive strength after 28 days.
- It would be possible to use wastes for low construction products.
- Mixes contained PG can get higher compressive strength after 28 days compare the same mixes which have RG.

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