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Use of Oil-Based Mud Cutting waste in Cement Clinker Manufacturing

Hilal Saif Al-Dhamri[1,2], Leon Black[2]
hilalsr@omancement.com, l.black@leeds.ac.uk
[1] Oman Cement Company SAOG, Muscat, Oman
[2] Institute for Resilient Infrastructure, School of Civil Engineering, University of Leeds, Leeds, LS2 9JT

ABSTRACT

Oil-Based Mud (OBM) cutting waste is generated during the process of oil well drilling. The drilled rocks are removed from deep within the drilled well and pumped to the surface. The portion removed, known as “Cutting”, is a mixture of rocks, mud, water and oil. Most drilling companies store this waste in open yards with no specific treatment solution. The environmental regulations in Oman specify that storage should involve isolation, to prevent penetration of the contamination to surface and underground water. This has made the OBM waste an environmental problem, with an associated cost for oil companies. OBM chemical analysis shows an interesting composition that may be used in cement manufacture. It has high calcium, silicon and aluminum contents, which are the major oxides in cement manufacture. Also the oil contents are useful for reducing the fuel used during the calcining and clinkerization process. In this research, the OBM waste has been analysed and used as a constituent of the raw meal for cement clinker production. The impact of OBM addition on the resultant clinker has also been investigated.

1. INTRODUCTION

Oil-Based Mud cutting, OBM, is a waste generated during the process of drilling an oil well. The drilled rocks are removed from deep within the drilled well and pumped to the surface in circulation. The portion removed, known as “Cutting”, is a mixture of rocks, mud, water and oil. Most drilling companies store this waste in open yards with no specific treatment solution [1]. The environmental regulations in Oman specify that the storage should involve isolation to prevent penetration of the contamination to underground water. This has made the OBM waste an environmental problem with an associated cost for oil field companies in Oman. There is about 150,000 tons of OBM stored in specially constructed yards, with costly monitoring programs [2].

Valorisation of this waste material offers financial as well as environmental benefits. OBM chemical analysis shows a composition which may be applicable for use in the manufacture of cement. The mineral components are rich in calcium, silica and alumina; which are the major oxides used in cement manufacture. Also the oil contents are useful for reducing the fuel used during the calcining and clinkerization processes.

There are three stages to the storage of OBM waste produced from the oil drilling operation, based on the oil and water content. During the initial stage, immediately after extraction from the ground, the material is fluid and has a high moisture content. These wastes are transported direct to the storage yard (Fig. 1).

Figure 1. The storage facility of OBM cutting waste. The figure shows OBM three days after extraction during the oil drilling operation. The high oil content of the OBM is clearly evident.

After three months, direct exposure to sun and heat starts to dry out the waste OBM which becomes more compact and solid (Fig. 2). Finally, after exposure to sunlight for about one to two years the material becomes compacted and dry (Fig. 3). It is at this third stage where the OBM waste can be easily handled and could be used for cement clinker production.

Figure 2. The storage facility of OBM cutting waste. The figure shows OBM cutting waste after storage for three to six months. By this stage the OBM cutting waste is dry with low oil contents.

Figure 3. The storage facility of OBM cutting waste. The figure shows OBM cutting waste after storage for one year. The OBM cutting waste is dry with low oil contents.

In this this research, the OBM waste has been analysed and then blended with the raw materials used for cement manufacture to investigate the effects of the addition of OBM on the resultant clinker.

This project aims to investigate whether OBM can be used as a component of cement raw meal rather than considering it as a waste, without having an adverse effect on the quality of cement produced, and thus solving an environmental problem.

2. EXPERIMENTAL

Syntheses of Portland clinker in the laboratory was carried out in the laboratory by the preparation of three raw mix samples. The raw materials used, limestone, quartzophillite, iron ore and kaolin were obtained from Oman Cement Company quarries. The OBM waste was obtained from an oil-drilling company in Oman (Petroleum Development of Oman [2]).

The first raw mix comprised 0% OBM, while the two further mixes contained either 1, 2 % OBM. All raw mixes were dried for one hour at 105 °C to remove moisture. The mixes were then placed inside platinum crucibles and heated up to 1450 ℃ to produce the clinker. Chemical wet method techniques were carried out to determine the chemical analysis of the resultant clinker. The free lime content was also measured.

3. RESULTS & DISCUSSIONS

The chemical composition of the OBM and limestone is shown in Table 1. The composition of the OBM is such that it shows potential for clinker production. Firstly, it is rich in SiO_2 and CaO; the main oxides needed for clinkerization. Secondly, the high organic content, arising from the oil make the addition of OBM to raw materials beneficial in term of fuel consumption.

Table 1. Chemical composition of the OBM and the Limestone

Compound	OBM waste	Limestone
Moisture	2.30	0.10
Organic	19.35	-
LOI*	39.02	39.51
SiO_2	17.64	8.19
Al_2O_3	2.36	0.89
Fe_2O_3	1.23	0.48
CaO	28.17	49.11
MgO	3.64	1.21
SO_3	3.96	0.11
Na_2O	1.48	0.10
K_2O	0.56	0.15
Cl	1.23	0.01

*Loss on Ignition at 950 °C

Table 2 meanwhile shows the composition of the clinkers prepared with and without the addition of OBM waste. The clinker showed a decrease in the free lime content as the percentage of OBM increased, which reflects the impact of the OBM addition. The organic content of the OBM waste, at about 19%, makes the waste self-sufficient with regards to fuel. Thus the burning temperature during clinkerization was achieved faster compared to samples prepared without OBM addition.

Table 2. The chemical composition of the clinker prepared using OBM waste

Compound	0 % OBM	1 % OBM	2 % OBM
LOI	0.64	0.38	0.42
SiO_2	21.96	21.78	21.49
Al_2O_3	4.19	4.25	4.20
Fe_2O_3	4.39	4.36	4.48
CaO	65.14	65.80	65.97
MgO	2.08	1.34	1.35
SO_3	0.13	0.14	0.52
Na_2O	0.14	0.13	0.10
K_2O	0.67	0.57	0.67
Alk.T	0.58	0.51	0.54
Free Lime	2.83	2.75	2.17

Phase analysis of the prepared clinker, calculated using the Bogue equations, are shown in Table 3. The addition of OBM waste led to an increase in the C_3S content, from 52.33% in the absence of OBM to almost 62% with 2% OBM added to the mix. The increased C_3S content came about with a reduction in both the C_2S and free lime contents (Fig. 4). There was no noticeable change in the C_3A and C_4AF contents.

Table 3. Phase analysis of the different clinker samples, calculated using the Bogue equations.

Phase	0 % OBM	1 % OBM	2 % OBM
C_3S	52.33	56.35	61.78
C_2S	23.48	19.93	15.01
C_3A	3.68	3.89	3.56
C_4AF	13.36	13.27	13.63

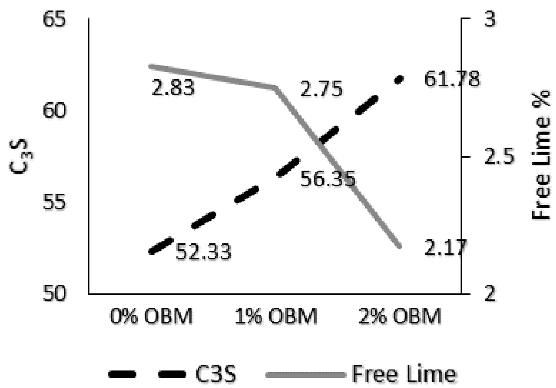

Figure 4. The Free Lime and the tricalcium silicate contents in the clinkers prepared using the OBM.

4. CONCLUSION

The addition of OBM waste as part of the raw mix appears to have a positive impact on the production of Portland cement clinker. These results demonstrate that the OBM waste could be recycled in the manufacture of Portland cement clinker. This could be a solution for disposing of the OBM waste; thus solving an environmental problem. Also, this will reduce the cost of cement production.

Further work will look more deeply into the effects of OBM on clinker formation and subsequent reactivity. Work will investigate whether trace element in OBM can enhance the burnability of raw meal and act as mineralizer [4]. Work will then look at the hydration behavior of the clinker prepared with OBM waste, and ultimately on the performance of concrete prepared from clinker with OBM mixed in the raw materials.

REFERENCES

[1] R. Caenn, G. Chillingar, Journal of Petroleum Science and Engineering, 14, **1996**, 221-230

[2] Petroleum Development Oman Company, Interview with head of Department of Production Chemistry.

[3] Hewlett, P.C. (Ed), Lea's Chemistry of Cement and Concrete, fourth Ed. Butterworth Heinemann, New York, **2001.**

[4] Odler, I.; Abdul-Maula, W., Effect of mineralisers on the burning process of Portland cement clinker. Part II.Mode of action of the mineralisers. Zement-Kalk-Gyps **1980**; no. 6: 278-282.