**Military Technical College**
**Kobry Elkobbah, Cairo,**
**Egypt.**

**4th International Conference On**
**Chemical & Environmental**
**Engineering**

**27-29 May 2008**

# APPLICATION OF BY-PASS CEMENT DUST IN ROAD WORKS AND STABILIZATION OF SANDY ROADS

**M. M. Morsi* and M. Salah Eldien****

## ABSTRACT

Large amounts of by pass-cement dust (BCD) are formed by cement plants – which reached 3.3 million ton per year -and disposed in different areas in Egypt. This hazardous dust is expected to increase as a result of increasing cement plants in next few years. Consequently, an increase in the environmental pollution is expected which will affect the health of the citizens, their instruments and tourism in some areas in Egypt. It is important to find different applications to consume this dust as a method to overcome its environmental pollution problems. Curbstones were manufactured on semi-industrial scale at Factory-45 with dimensions 0.3×0.2×0.5 m, each containing 59 kg BCD. They can be used in the central reservation areas of the d roads , in such a case about 944 thousands ton of BCD per year can be consumed. Stabilization of sandy roads was performed in two trial sections nearby 6-October City, by erecting a compact surface layer of 5 cm thickness containing 35 kg of BCD per meter square. Such application can consume 175 thousand ton of BCD per year for stabilization sandy road of one thousand km length and of 5 m wide. An asphalt road of 2 km and 6-8 m width has been paved at Torah Portland Cement Co. In this trial section, special asphalt mixes containing iron slag were designed to be used as the surface, binding and base layers. In the surface layer 5% BCD powders were included while in the base layer 12% BCD were included. When this application is used for the surface layer, and for 25% of base layers, 120 and 345 (thousands) ton of BCD would be consumed per year. The present applications would assimilate about 1.6 million ton of BCD per year

## KEY WORDS

By pass cement dust – Road works – Stabilization – Pavement- Curbstones - Environmental pollution - Hazardous wastes – Cement dust applications.

* Glass Research Dept., The National Research Centre, Dokki, Cairo, Egypt.
** Chairman of Holding Co. for Roads and Bridges, Cairo, Egypt.

## INTRODUCTION

The cement by-pass dust is one of the industrial wastes that due to its ultra fine nature causes serious environmental problems by polluting air, land, and plants. It accumulates annually in large quantities which may reach nowadays 3.3 million ton per year ( considering that the formed BCD represents 10% of the annual cement-production of the Egyptian cement plants). These amounts are expected to increase as a result of increasing cement plants in next few years in different localities in Egypt.

The formed dust is carried away from its precursors to be damped in desert areas around dwelling places. The environmental pollution caused by this waste seems to have indirect loss of the national income as a result of its negative effect on the health of the citizens, their hardware and tourism in some areas in Egypt.

Trials were made to treat the cement dust to be recycled after washing to extract the excess alkali salts or by removing the aforementioned component by thermal energy [1]. An alternative route has been proposed by Morsi [2,3,4].in which the by-pass cement dust can be reused in the form of useful products, This route considers the by-pass dust as a non-conventional raw material and through its “re-using”, other products could be manufactured. It was possible to prepare artificial stones and blocks containing 45 - 100 % by-pass cement dust that are characterized by high crushing strength (330 - 1200 kg/cm2 ) , density 1.89-2.51 gm/$cm^3$ . Glasses containing 45-50 % by-pass cement dust were also prepared.

The application of the by- pass cement dust in glass ceramics in the system diopside -anorthite - orthoclase, was investigated using BCD between 25-37 wt% of the batch constituents. The effects of addition of the nucleating agents $Cr_2O_3$, LiF, and mixture of them on the crystallizability, phase assemblages, and the resultant microstructures were investigated. [5].

The facilities available in the Torah Portland Cement Co. were used in manufacturing of prototypes of high performance tile specimens, containing by-pass cement dust ranging between 32-41 wt%. The tile specimens showed a practical chemical resistance towards acids and alkalis. Abrasion test showed that the tiles have wearing values between 0.38-0.55mm; which represent third to half the permissible values needed for the material to be used as flooring tiles. Specimens of 8 cm diameter and 3.5 cm thickness showed crushing strength between 640 to 2000 kg.$cm^{-1}$, depending on the composition of the samples [6].

Field trials for using the by pass cement dust in road construction were performed [7] , yet the percentage of the added dust was limited to maximum of 5%.

The present work is concerned with presenting the application of by pass cement dust (BCD) in road works :manufacturing curbstones on semi-industrial scale, stabilization of sandy roads and asphalt road pavement in order to assimilate large quantities of this dust to prevent its environmental pollution.

## EXPERIMENTAL AND FIELD WORKS

The by pass cement dust of Tourah Portland Cement Co. has been used The chemical and particle size analysis of this waste materials were made using methods described elsewhere [3. Its chemical analysis revealed that it consists mainly of CaO (39.33-43.21 %), $SiO_2$ (10.95-14.97 %) and chlorides and sulfates salts (9.31-19.93%). It has 84% of its grain size finer than 45 microns.

Specimens of pressed BCD powder were made using hydraulic press instrument of Tourah Portland Cement Co. and a cylindrical mould of 50 $cm^2$ area. The CBD powder was pressed at 200 $kg/cm^2$ .The cylindrical specimens obtained were 5 cm height. The same procedure was followed to manufacture curbstones on semi-industrial scale at Factory 45 using a mould with dimensions of $0.3 \times 0.2 \times 0.5$ m. and specially designed hydraulic press made by Factory 45.

For road asphalt pavement and stabilization of sandy road the necessary materials and BCD were transported to the locations of the trial sections. The Nile Co. for Roads and Constructions (one of the companies of the Holding Co. for Roads, Bridges and Land Transportation) constructed the asphalt road in Tourah Portland Cement Co., and the stabilization of sandy roads at the area nearby 6-October City. Pre-experimental measurements for the layers designed to be constructed in the fields are carried out in the Laboratories of the Genera Authority for Roads and Bridges.

## RESULTS AND DISCUSSION

### Curbstone from BCD :

Samples of pressed BCD powder at 200 $kg/cm^2$ showed after seven days an average crushing strength (of ten samples) about 362 $kg/cm^2$.and density of 1.97 gm $cm^{-3}$ . These results encourage the use of BCD for manufacturing curbstones on semi-industrial scale

Curbstones manufactured on semi-industrial scale at Factory 45 contained 59 kg CBD powder per curbstone unit. Fig.1 shows curbstones made on a semi-industrial scale at Factory-45 with dimensions $0.3\times0.2\times0.5$ m . Considering that each kilometer length will need 2000 blocks of this type of curbstone, then the weight of by pass consumed will be 118 ton/ kilometer . In case of erecting curbstones in the central reservation area of the road , the amount of BCD consumed for both sides of this area will be 236 ton. The National Plane of Egypt devotes four thousand kilometer to be paved annually. Hence the use of such curbstones in the central reservation areas the roads will consume 944 thousands ton per year.

### Sandy road stabilization using BCD:

Stabilization of sandy roads was performed for two trial sections nearby 6-October City. Stabilization was performed by erecting a surface layer of 10 cm thickness such that 35 kg of BCD was used per meter square after being mixed with the sands of the road. Fig. 2 (a) shows the location of the sandy road after removing part of the sand from the upper surface and after being wetted with water. Fig. 2 (b) shows the labors during mixing the BCD with the sands. Fig.2(c) shows the upper layer with a thickness of 10 cm after spreading and compaction. Fig.2 (c) shows a trunk moving on the stabilized sandy road without any sign of penetration of the wheels on the fixed road. The present results indicate that the method used is suitable for light and medium traffics.

The second trial for stabilization was performed on a sandy shoulder, of a road, with a length of 100 meters and 2 meters width. Fig.3 shows part of this section after spreading the upper layer with a thickness of 10 cm and during compaction When sandy roads of one thousand km length ,of 5 m wide and 5 cm thickness are to be stabilized each year, this application can consume 175 thousands ton of BCD per year.

**Asphalt road pavement using BCD:**

Laboratory examination tests for a mix of surface layer made of the commonly used pavement aggregates with sand and 5% BCD in place of limestone powder was examined. These tests depict that the layer has stability value (2210 Ib),higher than that of the corresponding layer that contains 5% limestone powder ( 2096 Ib). Special asphalt mixes containing iron slag were designed to be used as the surface and binding layers for pavement a road of 2 km and 6-8 m width at Tourah Portland Cement Co. A special base layer that contains iron slag was also designed for this trial section. In the upper surface layer of thickness 5 cm, 5% of BCD ( 6 kg/$m^2$) was added in place of the limestone powder. The layer exhibits stability of 2274 Ib and dry density 2.38 ton /$m^3$. Special base layers of 25 cm thickness containing 12% BCD ( 69 kg/ $m^2$ ) were tested. The results showed that this base layer has CBR value of 588 and dry density 2.3 ton/$m^3$ in comparison with CBR value 102 and dry density 2.29 ton/ m3 for the corresponding reference base layer made of the granular base materials ( gravels, limestone powder, calcareous stone) [ 7]. Depending on the results of these special mixes, a trail section of 2 km length and 6-8 m width was executed at Torah Co. for Portland Cement.

Fig.4(a) shows the base layer made of BCD and iron slag after spreading and compaction at location of the balance area near by furnaces 8 and 9 at Tourah Portland Cement Co. Fig.4(b) shows spreading the upper layer above the binding layer at the area of the balance. Fig.5 shows examples of trunks passing over the trial section at balance area. The tonnage of cement products and raw materials passing over the trial section reaches about 4 million ton per year. The section is still in very good condition till now after its construction on year 2000. If this application is used for pavement of the surface layer for roads of the National Plan (4000 km per year), 120 thousand ton of BCD will be consumed per year. In case that, only 25% of these roads have the special base layer made of non-conventional aggregates with 12% BCD, then this application can consume 345 thousands ton of BCD per year.

## CONCLUSIONS

A method to get rid of by-pass cement dust has been proposed. It depends on re-using this dust in manufacturing of useful products.

Curbstones with dimensions of 0.3 × 0.2 × 0.5 m made of BCD can be prepared , they are suggested to be used in the central reservation area of the asphalt roads. This application would consume 944 thousands ton of BCD per year.

Stabilization of sandy roads can be performed by erecting a compact surface layer of 10 cm thickness such that 35 kg of BCD is used per meter square. The stabilized sandy road is suitable for light and medium traffics. Stabilization of sandy roads with one thousands km length and of 5 m width per year will consume 175 thousand ton of BCD per year .

Non-conventional aggregates when used for designing mixes of surface , binding and base layers, enable the use of 75 kg BCD per $m^2$ of asphalt roads. This application can consume about 345 thousands ton of BCD per year. It also enable construction of asphalt roads for very heavy traffics.

The present applications present a sustainable solution for assimilating about 1.6 million ton/year of BCD to avoid its hazardous effects on the citizens and environment.

## ACKNOWLEDGMENT

The authors wishes to express his appreciation to the Academy of Scientific Research and Technology for financing stabilization trial sections, Torah Portland Cement Co. for financing asphalt paving road with non-conventional aggregates and to Factory 45 for financing curbstone manufacturing using by-pass cement dust.

## REFERRENCES

[1] Lurgi Report on utilization of cement by pass dust (1985 ).
[2] Morsi M. Morsi, Utilization of cement dust in the preparation of glass , glass - ceramics and artificial stones for different applications, , Application Nor.91110683 (1991) Egyptian Patent Nor.20036 (1996).
[3] Morsi, M. M., Utilization of the Industrial Waste by - pass cement dust in production of economical materials as a method for environment protection, Int. Conference and Trade Fair on Environmental Management & Technology 16-18 Feb, Cairo, Egypt (1997).
[4] Morsi, M. M, Glass and glass ceramics from some industrial wastes as a solution for environment protection, in 18th. Int. Cong. On Glass, San Francisco, USA (5-10 July 1998).

[5] Khater, G. A., Morsi, M. M., Range, K. J., Effect of nucleating agents $Cr_2O_3$ and LiF on crystallizing phases and microstructures of glass ceramics prepared by using some industrial wastes. ( Glastechische Berichte- Glass Science and Technology 74 (7) (2001)192-198.]

[6] Morsi , M. M. Gabrial , N. G., Utilization of the by-pass cement dust in the manufacturing of high performance tiles: preparation of prototypes in torah Portland cement co. ,The Second International Conference and Trade Fair for Environmental Management &Technologies 24-26 November, Cairo, Egypt (1999). ]

[7] Morsi, M.M. and Salah Eldien, M., Utilization of industrial and non-industrial waste materials in road -constructions and balasting for rail ways, Project financed by the Academy of Scientific Research and Technology (1996 ).

Fig.1. Curbstones made of by-pass cement dust at Factory 45 on semi-industrial scale with dimensions of 0.3 × 0.2 × 0.5 m.

( a ) ( b )

(c ) ( d )

Fig. 2. Stabilization of a sandy road :(a) The location after removing part of the sand from the upper surface and after being wetted with water. (b)Labors during mixing the BCD with the sand, (c) The upper layer after spreading and compaction and (d) A trunk moving on the stabilized road without any sign of penetration of the wheels on the fixed upper surface layer of the road.

Fig.3 Stabilization of a sandy shoulder of an asphalt road after spreading of the upper surface layer containing BCD and during its compaction .

( a )

( b )

Fig.4 (a) The base layer made of BCD and iron slag after spreading and compaction, (b) The spreading of the upper layer above the binding layer at location of the balance area near by furnaces 8 and 9 at Tourah Portland Cement Co.

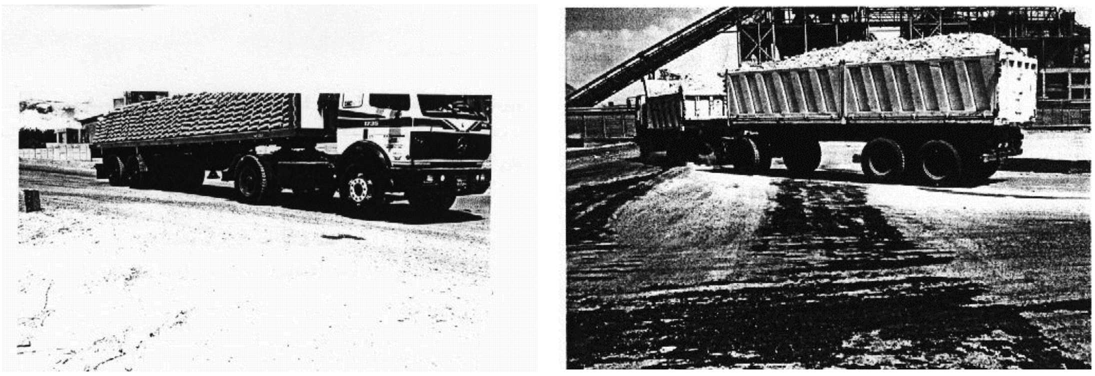

Fig.5 Examples of trunks passing over the trial section at balance area near by furnaces Nos. 8 and 9 at Tourah Portland Cement Co.