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Properties of Mortars Containing Brick Manufacturing Clays Using Factorial Design

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Abstract –This paper presents the results of an investigation of the properties of mortar in which a fired clay brick waste (CBW) was employed as a pozzolan. The investigation was carried out using a 3^2 full factorial design of experiments. Mortars were prepared using CBW as a pozzolanic partial replacement for cement at replacement levels of 10, 20 and 30 wt. %, with water/cement ratios of 0.45, 0.55 and 0.65. The results showed that the 28-day compressive strength (24 to 35 MPa) remained within the usually specified ranges, thus demonstrating the suitability of the use of CBW in mortar applications.

Most of the properties of cement composites (concretes and mortars) can be improved by incorporating different kinds of materials. There are many lightweight composites that contain polymers, glass, fly ash and crushed clay bricks [1]. In fact, the utilization of industrial waste and by-products in such composites has been attracting attention both due to the efforts for energy reduction and the rise of environmental consciousness.

Statistical design of experiments can be used for optimization of linear and non-linear systems [2]. When non linear effects and interactions of several different variables (factors) are anticipated, factorial designs provide the minimum number of experiments needed to investigate those effects and combine them into a property response model.. A regression polynomial is then fitted to the experimental values obtained and the model is considered valid only when the differences between the experimental and the calculated values (error) are uncorrelated and randomly distributed with a zero mean value and a common variance.

In what follows, the effect of the replacement of natural aggregates in mortar mixtures by CBW particles, on the properties of mortars was investigated. To this aim, two factors (variables) were selected, namely the CBW content and the water/cement weight ratio, which were set at three levels (10, 20 and 30 wt. % and 0.45, 0.55 and 0.65, respectively). By using a 3^2 full factorial design of experiments, the optimum amount of CBW was determined.

Figure 1 is the predicted 28-day compressive strength constant contour plot as a function of CBW content and water/cement ratio. As expected, the replacement of the usual natural aggregate by CBW reduces the 28-day compressive strength of mortars. Figure 1 also shows that the 28-day compressive strength also decreased with the increase in the water-cement ratio. Nevertheless, clay brick waste mortars with more than 33 MPa 28-day compressive strength can be produced using 10-30 wt. % CBW with a 0.45-0.56 water-cement ratio, which demonstrates that partial replacement of cement Portland is a viable and economical reusing alternative for CBW.

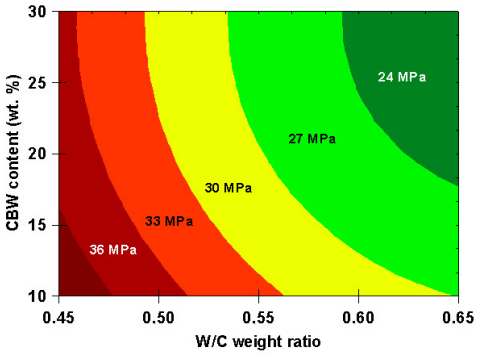

Fig. 1. Predicted 28-day compressive strength constant contour plot as a function of CBP content and water/cement weight ratio.

[1] S. K. Agarwal. Cement and Concrete Research 36 (2006) 1735-1739.
[2] R. H. Myers and D. C. Montgomery. Response Surface Methodology: Process and Product Optimization Using Designed Experiments. John Wiley and Sons, 2002.