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The Influence of the Dry Density on the Mechanical and Durability Properties of Roller Compacted Concrete Pavement Using the Response Surface Method

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ABSTRACT:
In the current study, the response surface methodology has been used for designing of the experiments. Considering the conventional soil-compaction method, the main factors investigated include cement and w/c contents. The upper and lower levels of the factors of cement and w/c content were 308-392 kg/m^3 and 0.34-0.39, respectively. The dry specific weighs, compressive strengths, permeable voids, and capillary absorption coefficients were determined according to the ASTM D 1557, ASTM C39, ASTM C642 and ASTM C1585 at ages up to 180 days, respectively.
Using the statistical analyses, the prediction models and contours of the durability characteristic and 28 day compressive strength were derived. The analysis of variance (ANOVA) was also performed on the results to estimate the significance of the factors. It could be concluded that the terms of the cement content, w/c and their interaction significantly influenced the responses of the compressive strength, dry specific weight, water absorption and permeable voids. The results also indicated that by obtaining an optimum level of dry density one could reach the lowest level of permeable voids and water absorption into the concrete. This is achieved by adjusting the interaction of cement content and w/c content. However, no meaningful correlation was found between the dry density and capillary absorption coefficient. This indicates that the tortuously and continuously of microstructure may be independent from the dry density. However, similar contour trends were obtained for the dry density and capillary absorption coefficient.

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1- Introduction

Roller Compacted Concrete (RCC) is one of the types of rigid pavements with low maintenance cost which is suggested in many regions. In the current study, the influence of dry density on the mechanical and durability characteristics of RCCP has been investigated using Response Surface Method (RSM). The RSM has been investigated in several studies especially on self compacting concrete [1-7]. Response surface method is used for determination of response using the minimum required mixtures [8].

2- Experimental program

The cement content in this research was between 307 to 392 kg/m^3 and w/c ratio was considered as 0.34 to 0.39. In order to calculate the lack of fit of the model, each mixture was produced two times at different time periods. The dry density was measured according to the standard method ASTM D1557 [10]. The concrete in the cylindrical specimens was compacted as per ASTM C1435 [11] using a 7.9 kg hammer in four layers. The tests carried out in the current study were compressive strength test as per ASTM C39, water absorption at 180 days in accordance to ASTM C642 and capillary water absorption in conformance with ASTM C1585. In this study, statistical analysis software's including mini tab and design expert were employed.

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3- Results

3- 1- Dry density, water absorption, porosity and 28-days compressive strength models

The models derived in this study are as below:

$$\text{Dry Density} = 2356.34 + 9.36\,C - 22.56\,w/c - 22\,C\times w/c - 38.63\,w/c\times w/c - 35.76\,C\times C \quad (1)$$

$$\text{Compressive strength} = 40.467 - 1.57\,C - 3.78\,w/c - 3.5\,C\times w/c - .708\,C\times C + 0.235\,w/c\times w/c \quad (2)$$

$$\text{Water absorption} = 4.503 + 0.19C + 0.27\,w/c + 0.234\,C\times w/c + 38.63\times w/c\times w/c + 0.43\times C\times C \quad (3)$$

$$\text{Permeable voids (\%)} = 10.983 + 0.152\,C + 0.585\,w/c + 0.544\,C\times w/c + 0.622\,w/c\times w/c + 0.829\,C\times C \quad (4)$$

Rate of Absorption of Water = 0.01 × (1.766 – 0.1716C – 0.0865 w/c + 0.1972 C×w/c+ 0.2395 w/c × w/c+ 0.2174 C×C) (5)

In Figure 1, the contours of dry density and permeable voids content are presented. As shown the optimum levels of the permeable voids are near the optimum points of the dry density. Although there is a good correlation between the durability parameters such as permeable voids, compressive strength results have not good correlation with the dry density results (Figures 1 and 2)

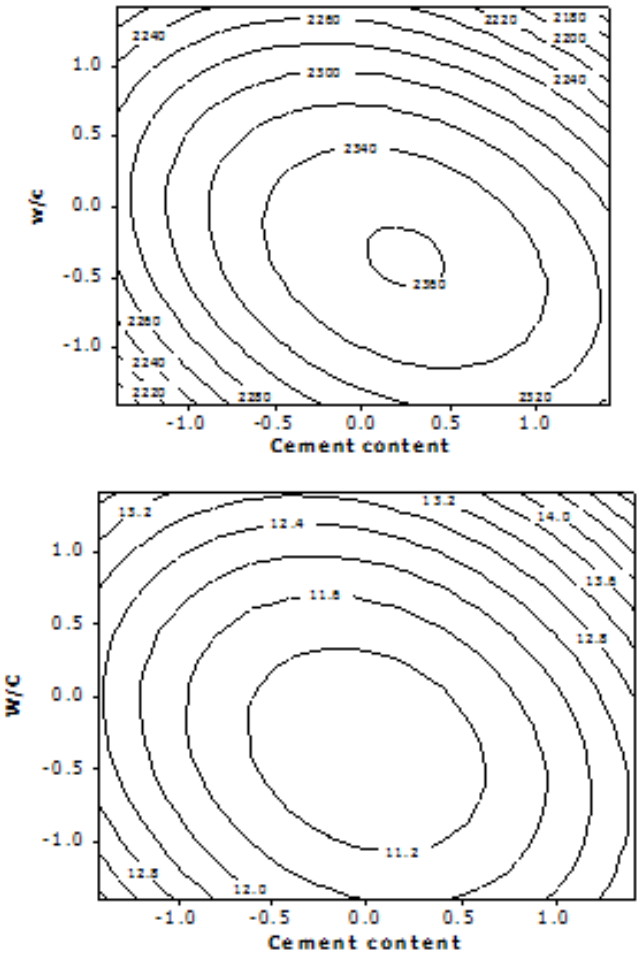

Figure 1. The contours of dry density (top curve) and permeable voids (bottom curve)

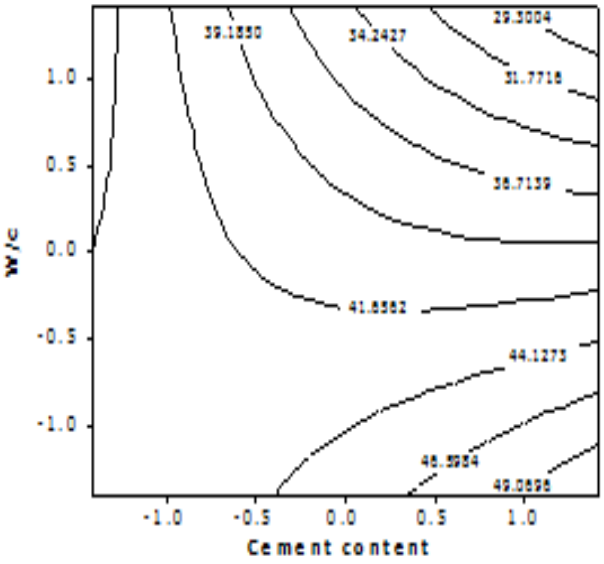

Figure 2. The contour of compressive strength at 28 days

4- Conclusions

1- Using the response surface method, the models for prediction of the compressive strength, permeable voids, water absorption content and capillary porosity coefficient were derived.

2- The response surface method could provide the optimum levels for the durability and mechanical properties of concrete, considering the contours and models.

3- The dry density had a good correlation with the permeable voids and water absorption content, however there was not any good correlation between the dry density and the responses of the compressive strength and capillary absorption.

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