XV International Conference on Durability of Building Materials and Components
DBMC 2020, Barcelona
C. Serrat, J.R. Casas and V. Gibert (Eds)

Statistical Analysis of Sulfate Attack Resistance of Reactive Powder Concrete

Umut Bektimirova[1], Eldar Sharafutdinov[2], Chang S. Shon[3], Dichuan Zhang[4], and Jong R. Kim[5]

[1] Department of Civil and Environmental Engineering, Nazarbayev University, 53 Kabanbay batyr avenue, Nur-Sultan, Kazakhstan, 010000, ubakhbergenova@nu.edu.kz

[2] Department of Civil and Environmental Engineering, Nazarbayev University, 53 Kabanbay batyr avenue, Nur-Sultan, Kazakhstan, 010000, esharafutdinov@nu.edu.kz

[3] Department of Civil and Environmental Engineering, Nazarbayev University, 53 Kabanbay batyr avenue, Nur-Sultan, Kazakhstan, 010000, chang.shon@nu.edu.kz

[4] Department of Civil and Environmental Engineering, Nazarbayev University, 53 Kabanbay batyr avenue, Nur-Sultan, Kazakhstan, 010000, dichuan.zhang@nu.edu.kz

[5] Department of Civil and Environmental Engineering, Nazarbayev University, 53 Kabanbay batyr avenue, Nur-Sultan, Kazakhstan, 010000, jong.kim@nu.edu.kz

Keywords: *Reactive Powder Concrete, Taguchi Method, Silica Fume, Sulfate Attack Resistance.*

1 Introduction

Compressed air energy storage system incorporated into pile foundation system of the apartment building is proposed to accumulate excess energy from solar panels (Tulebekova *et al.*, 2017, Zhang *et al.*, 2018). Reactive Powder Concrete (RPC) is a concrete that is obtained by removing coarse aggregates from and addition of silica fume (SF) to the concrete with very low water-to-binder ratio (w/b) (Sun *et al.*, 2015). Haufe and Vollpracht (2019) reported that RPC has moderate to high resistance to ESA due to its improved microstructure and reduced porosity. SF content w/b, and concentration of sodium sulfate (Na_2SO_4) solution were selected as primary factors to influence on the compressive strength and expansion of the RPC mixtures exposed to the ESA environment by Taguchi method. Analysis of variance (ANOVA) was used to assess the significance level of experimental parameters.

2 Experimental Program

2.1 Materials

Ordinary Portland cement, SF and locally available quartz sand with specific gravities 3.15, 2.22 and 2.4 correspondingly were used as binder materials in this study. Liquid superplasticizer (SP) Master Glenium ACE 430 and ordinary tap water were used in RPC mixing.

2.2 Mixture Proportion and Levels of Evaluation Variables

Mixture proportioning of RPC mixtures was completed using the absolute volume method.

2.3 Casting, Curing and Maintaining the Samples

Mixing RPC was completed in pan type mixer with total mixing time of 9±1 min.

2.4 Test Methods

The length and mass change tests of RPC were performed in accordance with ASTM C1012. The compressive strength test of RPC was conducted in accordance with ASTM C109.

3 Results and Discussion

3.1 Statistical Analysis

ANOVA was used to observe statistically important parameters of experiments.

3.2 Taguchi Analysis

The "smaller is better" Taguchi's quality loss function for compressive strength, length, and mass change of RPC was used to determine the optimal conditions for both set of factors.

4 Conclusion

Accordingly, the following conclusions can be made:

- The ANOVA analysis showed that compressive strength of RPC exposed to Na_2SO_4 environment is influenced by time factor for both sets of experiment;
- Based on Taguchi analysis, it is possible to suggest that optimal w/b=0.18 and optimal SF content=25 % for all three performance characteristics.

Acknowledgements

This research was supported by the Nazarbayev University Research Fund under Grant (#SOE2017001) "Development of a Renewable Energy Storage System Using Reinforced Concrete Foundations".

ORCID

Umut Bektimirova: https://orcid.org/0000-0002-8910-6631
Eldar Sharafutdinov: https://orcid.org/0000-0002-8320-3780
Chang S. Shon: https://orcid.org/0000-0003-4849-3206
Dichuan Zhang: https://orcid.org/0000-0002-9253-4178
Jong R. Kim: https://orcid.org/0000-0002-8796-3832

References

American Society for Testing and Materials. (2016). Standard Test Method for Compressive Strength of Hydraulic Cement Mortars, ASTM C109, ASTM International, West Conshohocken, PA, USA.

American Society for Testing and Materials. (2015). Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution, ASTM C1012, ASTM International, West Conshohocken, PA, USA.

Haufe, J., and Vollpracht, A. (2019). Tensile strength of concrete exposed to sulfate attack. *Cement and Concrete Research*, *116*, 81-88.

Tulebekova, S., Zhang, D., Lee, D., Kim, J. R., Barissov, T., and Tsoy, V. (2019). Nonlinear responses of energy storage pile foundations with fiber reinforced concrete. Structural Engineering and Mechanics, 71(4), 363-375.

Sun, H., Li, Z., Memon, S., Zhang, Q., Wang, Y., Liu, B., and Xing, F. (2015). Influence of ultrafine 2CaO· SiO2 powder on hydration properties of reactive powder concrete. *Materials*, *8*(9), 6195-6207.

Zhang, D., Kim, J., Tulebekova, S., Saliyev, D., and Lee, D. (2018). Structural Responses of Reinforced Concrete Pile Foundations Subjected to Pressures from Compressed Air for Renewable Energy Storage. International Journal of Concrete Structures and Materials, 12(1), 74.