

Influence of Fly Ash Content and Desert Sand Replacement Ratio on the Static Elastic Modulus of Desert Sand High Strength Concrete

Ning LIU^{1,a}, Tong-Tong YANG^{1,b}, Hai-Feng LIU^{1, c*} and Yong-Gang DU^{1,d}

¹School of Civil and Hydraulic Engineering, Ningxia University, Yinchuan, Ningxia, China

^a1763530176@qq.com, ^b179975752@qq.com, ^cliuhaifeng1557@163.com, ^d1303908308@qq.com

*Corresponding author

Keywords: High Strength Concrete, Fly Ash, Desert Sand, Static Elastic Modulus.

Abstract. In order to study the influence of fly ash content and desert sand replacement ratio on the static elastic deformation of desert sand high strength concrete, experiments on 28d static compression modulus of desert sand high strength concrete with different fly ash content and desert sand replacement ratio were carried out. The regulation on the influence of fly ash content and desert sand replacement ratio on 28d static compression modulus of desert sand high strength concrete was analyzed. Experimental results showed that with the increase of desert sand replacement ratio, 28d static elastic modulus of desert sand high strength concrete increased firstly, then declined. With the enhancement of fly ash content, 28d static elastic modulus of desert sand high strength concrete declined.

Introduction

Fly ash is waster discharged from thermal power plant, which was used as supplement to improve the workability, durability and anti-carbonization ability of concrete [1-2]. China is one of the most serious desertification countries, especially in the northwest region. With the implementation of the "The Belt and Road" strategy, large-scale infrastructures were carried out, which intensified the contradiction between supply and demand of natural sand in these desertification regions. It is necessary to make desert sand concrete suitable for engineering application, which is beneficial to sustainable development in these regions.

At present, scholars at home and abroad had done lots of researches on the mechanical properties of desert sand concrete [3-11]. However, there are few documents on the influence of fly ash content and desert sand replacement ratio on the static elastic modulus of desert sand high strength concrete. In this article, the 28d static compression modulus experiments of desert sand high strength concrete with various fly ash content and desert sand replacement ratio were carried out. The influence of fly ash content and desert sand replacement ratio on the static elastic modulus of desert sand high strength concrete was analyzed, which can provide guidance and reference for the engineering application of the desert sand.

Experimental Materials

The following ingredients were adopted for desert sand high strength concrete. Locally produced ordinary Portland branded as Saima in Ningxia was used. Artificial crushed coarse aggregate was bought from Zhenbeipu town of Ningxia, the particle diameter of which was from 5mm to 20mm. Medium sand was local washed river sand, the fineness modulus of which was 2.95. Desert sand was obtained from the Maowusu desert in Yanchi county of Ningxia, the clay content, void ratio and fineness modulus of which were 0.14%, 40.95% and 0.194, respectively. Grade I fly ash made from Ningxia power plant was adopted, the water content and loss on ignition of which were 0.2% and 2.8%. High performance water reducing agent produced by Beijing Mu Lake was adopted. Water was tap water.

Experimental Program

The mix ratio of desert sand high strength concrete was as following [10]. W/C ratio, the usage of water and sand ratio were 0.24, 180 kg / m³ and 30%, respectively. The content of water reducing agent is 0.4% that of cementing material. There were three level of fly ash content, which was 0%, 15%, 25%. Under the same amount of fly ash content, desert sand replacement ratio was 0%, 20%, 30%, 40%, 60%, 80% and 100%, respectively.

Concrete specimen was cast in moulds with the dimension of 150×150×300 mm. All specimens were demoulded after 24h, then cured in standard curing room for 28d. According to Ref.[12], the static elastic modulus of desert sand high strength concrete was tested by elastic modulus measuring instrument. Each group was prepared with six specimens, three of which was for measuring the axial compressive strength, three for measuring the static elastic modulus.

Experimental Results and Analysis

The static elastic modulus is calculated by the following formula [12].

$$E_c = \frac{(P_a - P_0)}{A} \cdot \frac{L}{\Delta N} \quad (1)$$

where P_0 is the load when the stress at the intersecting surface of specimens reaches 0.5 MPa. A is the area of the intersecting surface of specimens. P_a is the load when the stress at the intersecting surface of the specimens reaches the axial compressive strength. L is gauge length which is equal to 150mm. ΔN is the deformation difference measured by two amesdials when the axial compressive force P_0 and P_a acts on the specimen. The experimental results were shown in Tab. 1.

Tab. 1 Experimental result of static elastic modulus

Group	Static elastic modulus[GPa]	Group	Static elastic modulus[GPa]	Group	Static elastic modulus[GPa]
T001	40.14	T151	39.27	T251	38.00
T002	44.20	T152	41.60	T252	39.26
T003	44.00	T153	40.62	T253	37.59
T004	41.85	T154	39.90	T254	37.40
T005	38.79	T155	38.60	T255	35.59
T006	38.30	T156	38.00	T256	35.00
T007	37.99	T157	37.30	T257	33.70

Note: Symbol ij of T_{ijk} represents fly ash content, in which $ij=00, 15, 25$ respectively represents fly ash content of 0%, 15%, 25%. K represents desert sand replacement ratio, in which $K=1, 2, 3, 4, 5, 6, 7$ respectively represents desert sand replacement ratio of 0%, 20%, 30%, 40%, 60%, 80% and 100%.

Influence of Desert Sand Replacement Ratio on the Static Elastic Modulus of Desert Sand High Strength Concrete

Fig.1 showed the relation between desert sand replacement ratio and static elastic modulus. As shown in Fig.1 and tab.1, when fly ash content was equal to 0%, compared with the static elastic modulus of high strength concrete with the desert sand replacement ratio of 0%, the static elastic modulus of desert sand high strength concrete with the desert sand replacement ratio of 20%, 30%, 40%, 60%, 80% and 100% increased respectively 10.1%, 9.6%, 4.3%, -3.4%, -4.6% and -5.4%. When fly ash content was equal to 15%, compared with the static elastic modulus of high strength concrete with the desert sand replacement ratio of 0%, the static elastic modulus of desert sand high strength concrete with the desert sand replacement ratio of 20%, 30%, 40%, 60%, 80% and 100% increased respectively 5.9%, 3.4%, 1.6%, -1.7%, -3.2% and -5.0%. When fly ash content was equal

to 25%, compared with the static elastic modulus of high strength concrete with desert sand replacement ratio of 0%, the static elastic modulus of desert sand high strength concrete with the desert sand replacement ratio of 20%, 30%, 40%, 60%, 80% and 100% increased respectively 3.3%, -1.1%, -1.6%, -6.3%, -7.9% and -11.3%. Thus, it can be concluded that with the increase of the desert sand replacement ratio, the static elastic modulus of desert sand high strength concrete increased firstly, then declined. When the desert sand replacement ratio was equal to 20%, the static elastic modulus can reached the maximum value.

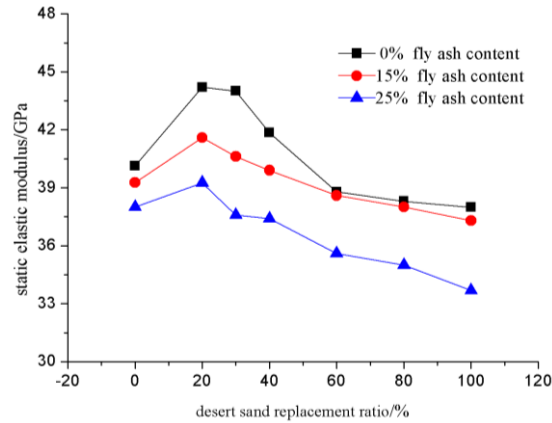


Fig. 1 Relation between desert sand replacement ratio and static elastic modulus

Influence of Fly Ash Content on the Static Elastic Modulus of Desert Sand High Strength Concrete

Fig. 2 showed the relation between fly ash content and static elastic modulus of desert sand high strength concrete. As shown in Fig.2 and tab.1, when desert sand replacement ratio was equal to 0%, compared with the static elastic modulus of high strength concrete with the fly ash content of 0%, the static elastic modulus of desert sand high strength concrete with the fly ash content of 15% and 25% increased respectively -2.2% and -5.3%. When desert sand replacement ratio was equal to 20%, compared with the static elastic modulus of high strength concrete with the fly ash content of 0%, the static elastic modulus of desert sand high strength concrete with the fly ash content of 15% and 25% increased respectively -5.9% and -11.2%. When desert sand replacement ratio was equal to 30%, compared with the static elastic modulus of high strength concrete with the fly ash content of 0%, the static elastic modulus of desert sand high strength concrete with the fly ash content of 15% and 25% increased respectively -7.7% and -14.6%. When desert sand replacement ratio was equal to 40%, compared with the static elastic modulus of high strength concrete with the fly ash content of 0%, the static elastic modulus of desert sand high strength concrete with the fly ash content of 15% and 25% increased respectively -4.7% and -10.6%. When desert sand replacement ratio was equal to 60%, compared with the static elastic modulus of high strength concrete with the fly ash content of 0%, the static elastic modulus of desert sand high strength concrete with the fly ash content of 15% and 25% increased respectively -0.5% and -8.2%. When desert sand replacement ratio was equal to 80%, compared with the static elastic modulus of high strength concrete with the fly ash content of 0%, the static elastic modulus of desert sand high strength concrete with the fly ash content of 15% and 25% increased respectively -0.8% and -8.6%. When desert sand replacement ratio was equal to 100%, compared with the static elastic modulus of high strength concrete with the fly ash content of 0%, the static elastic modulus of desert sand high strength concrete with the fly ash content of 15% and 25% increased respectively -1.8% and -11.3%. Thus, with the enhancement of fly ash content, the static elastic modulus of the desert sand high strength concrete declined gradually.

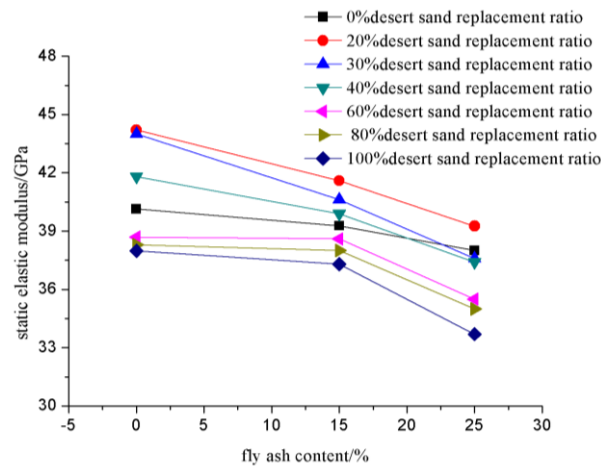


Fig. 2 Relation between fly ash content and static elastic modulus

Conclusions

In this article, experiments on 28d static compression modulus of desert sand high strength concrete with different fly ash content and desert sand replacement ratio were carried out. The regulation on the influence of fly ash content and desert sand replacement ratio on 28d static compression modulus of desert sand high strength concrete was analyzed. Experimental results showed that with the increase of desert sand replacement ratio, the static elastic modulus of the desert sand high strength concrete increased firstly, then declined. When desert sand replacement ratio was equal to 20%, the static elastic modulus can reach the maximum value. With the enhancement of fly ash content, the static elastic modulus of desert sand high strength concrete declined gradually, which can provide guidance and reference for the application of desert sand in engineering.

Acknowledgments

The support of National Natural Science Foundation of China (No. 51368048 and 11162015) and National University Innovation Research and Training Program (201510749012 and G201610749024) are gratefully acknowledged.

References

- [1] Lu L H, Pan G H, Chen S L, et al. Strength of concrete with different contents of fly ash. *Journal of Shenyang University of Technology*. 1(2009): 107-111.
- [2] Wang X, Wang Y B, Yang L S, et al. High-performance high-volume fly ash concrete. *Bulletin of the Chinese Ceramic Society*. 3(2013): 523-527.
- [3] Ma J R, Liu H F, Yang W W. Study on the mechanical behaviors of desert sand concrete from Muus desert. *Science Technology and engineering*. 15(2015): 267-272.
- [4] Yang W W, Chen Y L, Liu H F, et al. Research on the mechanical properties of desert sand high strength concrete. *Concrete*. 11(2014):100-102.
- [5] Liu J H, Jin D M, Bao W Z, et al. Research on the mechanical properties of desert sand concrete. *China Concrete*. 9(2013): 66-6.
- [6] Song J X, Wang C B, Wang D P, et al. The determination of Maowusu fine sand concrete intensity formula. *Ningxia Engineering Technology*. 1(2010):16-18.

- [7] Chen Y L, Ma J R, Liu H F, et al. Influence of fly ash and desert sand content on the compressive strength of high strength concrete. *Concrete*. 7(2014): 80-84.
- [8] Zhang G X, Song J X, Yang J S, et al. Performance of mortar and concrete made with a fine aggregate of desert sand. *Building and Environment*. 41(2006): 1478–148.
- [9] Zhang G X, Song J X, Yang W W, et al. Effects of different desert sand on properties of cement mortar and concrete. *Journal of Ningxia University (Natural Science Edition)*. 24(2003): 63-65.
- [10] Fu J, Yang D, Liu H F, et al. Influence of fly ash dosage and desert sand replacement ratio on the mechanical properties of high strength desert sand concrete. *Science Technology and engineering*. 15(2015): 238-242.
- [11] Fu J, Ma J R, Liu H F. Influence of fly ash dosage and desert sand replacement ratio on the mechanical properties of desert sand concrete. *Journal of Guangxi University: Nat Sci Ed*. 40(2015):93-98.
- [12] China Academy of Building Research. GB/T 50081-2002, Standard for test method of mechanical properties on ordinary concrete. Beijing: China Architecture and Building Press, 2002.