Advances in Engineering Research (AER), volume 82
2016 International Conference on Engineering and Advanced Technology (ICEAT-16)

Orthogonalization analysis of the Dynamic Performance of the Concrete with Additives of Silicon Powder and Ash

Yong ZHANG, Rui ZENG and Hong-wei LIU

Key Protective Materials' Laboratory of The Military 2110 Project, Department of Airport Engineering, Airforce Service College, Xuzhou 221000, Jiangsu, China

Keywords: Static Mechanical Properties; Silica Fume Concrete; Fly Ash Concrete

ABSTRACT: Through SHPB dynamic impact test, the dosage of silicon powder and fly ash in the concrete was researched, then the paper studied silicon powder and fly ash content on the effect of dynamic mechanical properties of concrete. The results showed that: The best group under low speed impact is $J_2G_3F_1S_3$; the best group under immediate speed impact is $J_2G_2F_1S_2$; the best group under high speed impact is $J_1G_3F_1S_3$.

With the increase of the demand of the project construction, conduct the research on the dynamic performance and material characteristics under different strain rate of concrete with silicon powder become important and urgent, which can both help reduce the cost of producing concrete, benefit the environment and the sustainable development of economics and a way to make the limited resources to play a greater economic benefits. Research on the concrete with silicon powder mainly focus on compressive strength, resistance to corrosion, freezing resistance, impermeability and fracture property of the silicon powder[1-12], the research on the dynamic performance of the concrete with silicon powder is conducted by doing experiments of dynamic impact[13-15].The paper using the Φ74mm SHPB tester to do the mechanical property research under the impact load of the concrete with additives of silicon powder and ash, and using the principle of orthogonal test to optimize the best dosage of the silicon powder and the ash under the dynamic load.

1 Experimental program and specimen making

1.1 experiment materials

The experiment uses the common P·O52.5 concrete produced by the Huaihai Zhonglian concrete L.T.D. in XuZhou, the sand is the common river sand, the aggregate meets the continuous grading demand that the maximum particle diameter is 20mm. Water is the drinking water in XuZhou, water reducing agent is the efficient MN water reducing agent produced by the YunLong concrete additive plant in XuZhou, the water reducing rate is 15%-25%. The silicon powder is the TOPKEN920U tiny silicon powder produced by the Tiankai silicon powder materials L.T.D. in Shanghai, as shown inTable1. The ash is from heat-engine plant in XuZhou, the loss on ignition is 5%, the fineness is 17, the density is 2.35g/cm3, belongs to Ⅱash.

The paper considers four factors and three standards,which is water binder ratio, silicon powder, the dosage of the ash, sand coarse aggregate ratio. Conduct a design on the orthogonal test of mixing silicon powder and ash, as shown in Table1, for comparison, the paper also design the comparison experiment on mixing silicon powder, ash only.

Table1 Orthogonal list

Serial number	Water/cement ratio (J)	Silicon powder dosage (G)	Dosage of fly ash (F)	Sand ratio (S)
O-1	0.25	8	10	30
O-2	0.25	12	15	34
O-3	0.25	16	20	38
O-4	0.3	8	15	38
O-5	0.3	12	20	30
O-6	0.3	16	10	34
O-7	0.35	8	20	34
O-8	0.35	12	10	38
O-9	0.35	16	15	30

1.2 specimen making and conserve

The dynamic impact test-pieces use the mold made by self, it is Φ73.5×36.5mm cylinder. Design and conduct the dynamic test-pieces is 19 groups. After unpack the mold, put the test-pieces into the HSBY-40B standard curing box which is produced by the Jingqiang instrument factory in Beijing, keeping the temperature in the box 20℃ and about 95% humidity to maintain the test-pieces. test-pieces handle: before impaction, rubdown the cured test-pieces and air-dry them, we use the SHM-200 double end grinding machine produced by Xingguang mechanical and electrical equipment factory in Jiangyan to rubdown the test-pieces, part of the test-pieces after the process of rubdown and dry. And the measure the size of the test-pieces which will be conducted the dynamic experiment, the concrete is a king of material which is small deformed, accurate measurement cannot cause large errors. The paper uses the vernier caliper to measure the test-pieces, and the precision can reach 0.02mm.

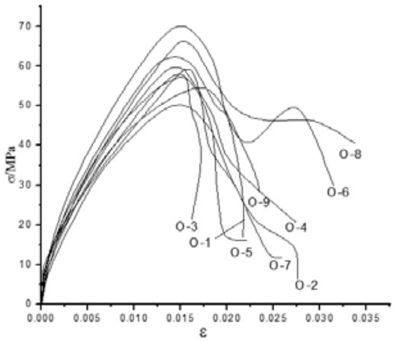
2 Optimization analysis of orthogonal factors

We conduct the impact test under three pressure of the concrete with both ash and silicon powder under 0.2,0.3,0.6MPa, then get the stress-strain curve of the concrete as shown in figure 1,2,3. We can draw that: with the increase of the experimental strain rate, the failure stress in the test-pieces also increase. The strain rate of the concrete is under the range of 87-175/s^{-1}, for concrete with silicon powder and ash, the dosage of group O-6 is best, the top stress of the concrete under 0.6MPa improved 27.1% compared with plain concrete.

Table2 Range calculation results of the each factor of dynamic compressive strength of concrete under the effect of different air pressures' impact

	0.2MPa				0.4MPa				0.6Mpa			
level	J	G	F	S	J	G	F	S	J	G	F	S
1	56.8	60.3	66.5	58	126.1	123.5	138.5	126.7	178.3	166.9	187.3	174.5
2	62.3	58.2	54.8	59.8	133.8	128.3	120.8	127	174.3	175.1	164	171.1
3	60.3	60.83	58	61.5	119.5	127.6	120.1	125.7	168.1	178.7	169.4	175.1
poor	5.5	2.63	11.7	3.5	14.3	4.86	18.34	1.03	10.2	11.8	23.3	4

We can draw the conclusion from the range analysis in table2, under the low, intermediate and high strain rate, the primary and secondary factors that influence the dynamic compressive strength is FJSG，FJGS，FGJS, with the increase of the strain rate, that is the increase of the impact speed, the influence on the dynamic compressive strength of the concrete by the silicon powder also increases, it increase to rank 2 under the high strain rate from the last place in the four factors under the low strain rate, the adulteration of silicon powder have an important effect on the shock resistance, especially under the high-speed impact.



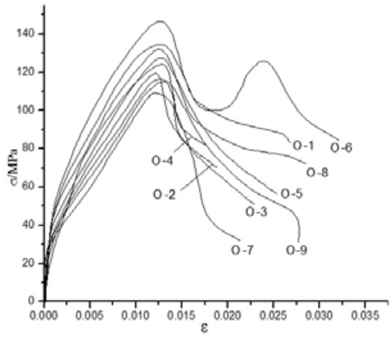
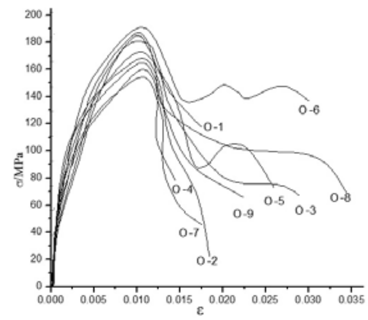


Fig.1 the stress-strain curve of the group O test-pieces under 0.2MPa

Fig.2 the stress-strain curve of the group O test-pieces under 0.4MPa



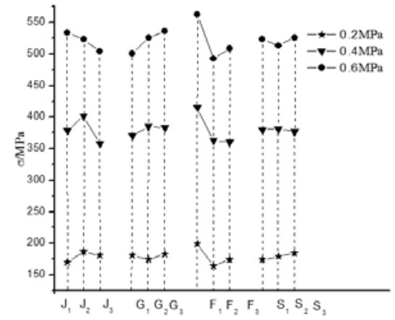


Fig.3 the stress-strain curve of the group O test-pieces under 0.6MPa

Fig.4 Influence of orthogonal factors on dynamic compressive strength

With the impact speed and the strain rate increasing, its influence is more obvious.

Let analyze the experimental dynamic compressive strength value of the same factor under different standards, the experiment designs four factors and three standards, from figure 4 we can see that under low impact speed: when the water binder ratio is 0.3, the dynamic compressive strength reaches the maximum value, so the dynamic compressive strength reaches the maximum value when we use J_2, the compressive strength reaches the maximum value when the sand coarse aggregate ratio is G_3, the compressive strength reaches the maximum value when the fly ash use the 10% dosage, the sand coarse aggregate ratio is 38%, that the best group under low speed impact is $J_2G_3F_1S_3$; the best group under immediate speed impact is $J_2G_2F_1S_2$; the best group under high speed impact is $J_1G_3F_1S_3$, we can see the compressive strength of the $J_2G_3F_1S_2$, that is group O-6 is best, this is in consistence with the four factors that have influence on the dynamic shock resistance. Sum up the above analysis, silicon powder can obviously improve the dynamic shock resistance of concrete, at the same time, with the improvement of the strain rate, silicon powder have a more obvious influence on the concrete.

3 Conclusion

The best group under low speed impact is $J_2G_3F_1S_3$; the best group under immediate speed impact is $J_2G_2F_1S_2$; the best group under high speed impact is $J_1G_3F_1S_3$.

4 Reference

[1] Liu Hai-feng, Ning Jian-guo. Constitutive model of concrete subjected to intense impact loading [J]. Chinese Journal of Solid Mechanics, 2008.29(3):231-238.

[2] SUN Wen-bin. Experimental studies on reinforced concrete (RC) slabs subjected to blast loads [J]. Journal of Liaoning Technical University (Natural Science), 2009.28(2):217-220.

[3] Li Xiao-jun, Zheng Quan-ping, Yang-yi. Local damage effects of steel fiber reinforced concrete plates subjected to contact explosion [J]. Explosion and Shockwaves, 2009.29(4):385-389.
[4] Zhang Jing-fei, Feng Ming-de, Chen Jin-gang. Experimental study on the foam concrete antiknock performance [J].Concrete，2010.22 (10):10-12.
[5] Zhang Hai-ying, Duan Zhuo-ping, Liu Yan, etc. Study of limited thick concrete target internal explosion seismic fall throughout [J]. Beijing Science and Engineering University, 2013.33(5): 441-444,550.
[6] Ha-Won Song, Jong-Chul Jang, Velu Saraswathy. An estimation of the diffusivity of silica fume concrete. Building and Environment, 2007(42): 1358-1367.
[7] Zeng Qing-jun, Mo Hai-hong. Nanometer silicon powder soil corrosion resistance research. Science Technology and engineering，2007 (2):222-225.
[8] Ding Lin, Wang Li-hai. Silicon powder concrete compressive strength of experimental study. Heilongjiang University Journal of Natural Science，2007 (3):336-339.
[9] Li Guang-wei, Zhou Qi-wen. Silicon powder on the inhibitory effect of alkali silica reaction. Commercial Concrete，2008 (5):29-32.
[10]Tongyan Pan, Ph.D., P.E., M.ASCE1and Kaiming Xia, Ph.D., M.ASCE. Micromechanical Evaluation of the Damping Behavior of Modified Silica Fume Admixed Concrete. Journal of Engineering Mechanics. December 2012, Vol. 138, No. 12: 1411-1419.
[11]P. Zhang; Q. Li. Fracture properties of high performance concrete containing silica fume. Australian Journal of Structural Engineering. 2013, Vol. 14 Issue 3:320-327.
[12]Debabrata Pradhan, D. Dutta, Partha Ghosh. Influence of Silica Fume on Different Mechanical Properties of Concrete. International Journal of Engineering Innovations and Research. Volume 2 Issue 5, Sept. 2013:443-446.
[13]Weijun Yang and Qiusheng Li. Study on Dynamic Performance of Silica Fume Concrete. Applied Mechanics and Materials (2012) (Volumes 204 - 208):3782-3785.
[14]Ming Wu. SHPB Dynamic Experiment on Silica Fume Concrete. Advanced Materials Research (2012) (Volumes 631 - 632): 771-775.
[15]Yongbo Shao, Shuguang Hao, Yuping Luo, Jibo Xing and Zhiyong Liu. Study on Impact Resistance of Silica Fume Concrete. Applied Mechanics and Materials (2012) (Volumes 174 -177): 211-214.