13th International Brick and
Block Masonry Conference
Amsterdam, July 4-7, 2004

EXPERIMENTS AND ANALYSIS OF HIGH-STRENGTH FLY-ASH MORTAR

Weijun Yang[1], **Jihua Yin**[2], **Minjuan** Yin[3]

Abstract

In this paper, the analysis about contrastive experiments of high-strength fly ash cement mortar and high-strength fly ash lime-cement mortar had been done. Three kinds of basic effect in fly ash cement mortar, such as morphological effect, active effect and micro-aggregate effect, are discussed. The influence on mortar's performance made by fly ash was analysed. Based on those work a reasonable composition of fly ash cement mortar and fly ash lime-cement mortar is put forth.

Key Words

Fly ash, mortar, strength, reasonable composition

1 Introduction

As a building material, fly ash has been used about half century. Its chemical composition is complicated, the content of SiO_2 Al_2O_3 and Fe_2O_3 of fly ash is a dominant indicator to assess function of fly ash using in cement and concrete. When used in cement, fly ash have three kinds of basic effect: morphological effect, active effect and micro-aggregate effect. These effects make fly ash used in cement and concrete very valuable. Some scientists even call fly ash "the sixth composition of concrete" (Chen Yu and Zhou shiqiong, 1999). But there are still many problems when fly ash is used in construction, for example, anti-seismic and anti-leak and so on. So that the analysis about how and how much the fly ash can improve the behaviour of mortar is very important.

2 Fly ash mortar strength and consistency Test

2.1 Test condition and method

In these experiments the fly ash is II grade made in Zhuzhou Power Plant, the tab of the cement is 32.5 , the water is tap water, the medium sand's moisture content is

[1]**W**eijun Yang, **Changsha University of Science and Technology**, mgbyrh@163.com
[2]**Jihua Yin, Changsha University of Science and Technology, ygh1996_2002@126.com**
[3] **Minjuan Yin, Changsha University of Science and Technology,** mgbyrh@163.com

below 5% and its average fineness modulus Mx=2.3– 3.0. The method of measuring mortar's consistency, cure of mortar cube and measuring of the strength are referred from Code for quality checking and accepting to masonry structures (GBJ203-83).

2.2 Test result

There are 12 groups of cement mortar tests (kind A, marked as fiducial mortar), 12 groups of fly ash cement mortar tests (kind B), 12 groups of lime-cement mortar tests (kind C) and 36 groups of fly-ash lime-cement mortar (kind D). There are 12 groups of mortars' strength and consistency are good , these 12 groups of data are selected out and list in Table 1.

Table1 Experiment result

Kind	Intend strength	Ratio of match C: S: W: F: L	Actual strength			Consistency
			3 day	28 day	90 day	
A	15	421:1545:272:0:0	5.62	18.27	27.89	5.6
	20	501:1579:269:0:0	8.71	29.50	42.21	7.1
	25	512:1535:277:0:0	7.85	24.09	29.68	6.0
	30	560:1450:266:0:0	12.33	37.65	45.48	4.7
B	15	316:1485:272:147.4:0	3.47	16.00	26.93	6.8
	20	338:1515:269:158:0	5.0	20.43	32.52	4.5
	25	369:1305:274:278:0	8.28	27.64	39.61	5.3
	30	458:1315:267:200:0	10.82	32.89	45.84	3.4
C	15	397.6:1450:268:0:106.8	6.86	20.84	24.10	5.8
	20	430.3:1270:275.2:0:97.6	7.27	22.70	27.45	7.6
	25	592.3:1132:309.5:0:112.5	12.00	34.84	40.11	7.7
	30	750:935:350:0:115	13.65	37.08	37.64	7.4
D	15	358:1468:277:60:27	4.85	17.61	24.94	5.3
	20	366:1525:275:96:30	6.69	19.63	29.54	4.5
	25	435:1461:272:72:34	7.25	22.69	31.07	4.9
	30	520:1404:290:80:38	10.65	29.47	38.03	5.4

Note: C, S, W, F, L separately delegates cement, sand, water, fly ash, slake lime the unit of strength is MPa and the unit of consistency is cm. In the tests, kind A is taken as fiducial mortar.

3 Analysis of test

3.1 Analysis of the consistency

In the tests, kind A is regarded as fiducial mortar. Taking king B comparison with kind A, we know that fly ash can do two functions. As M15 mortar shows in kind B, when mortars' strength is low, fly ash can improve the consistency apparently. But to high strength mortar such as M20, M25 and M30 mortar in kind B, fly ash even descends the consistency of mortar.

There are three probable reasons are concluded:

(1) The acting of fly ash's lubricant increases mortar consistency.

(2) According to the principle about ratio of match, after adding the fly ash, if the quantity of S/C is lower than that of fiducial mortar, the consistency of fly ash cement mortar will ascend.

(3) Based on the principle about ratio of match, after adding the fly ash, if the quantity of W/C is lower than that of fiducial mortar, the consistency of fly ash cement mortar will descend.

So, when the phenomenon about reason (3) occurs, the consistency will descend. But when other reasons such as reason (1) and reason (2) take place simultaneously, reason (3) will take the dominant position.

Comparing fiducial mortar with kind C, we can find that the mortar looks good, gooey, lustrous and the consistence increase after lime has been adulterated. But at the same tab, the ratio of C/S in C is larger that in A, and because lime has been adulterated in C, the price of C is higher than A.

Compare D with fiducial mortar, we find that the consistence changes with the amount of lime, fly ash and lime's double function is complicated. But, there has a optimum amount (Chen Enyi, 1993). When the high strength mortar is wanted, tab D can perform more excellent than B. analysising the data about tests, we get to know that the consistence can't attain the utilization requisition when we just add fly ash. But as add a certain radio of lime and fly ash, the consistence will increase. For example, comparing M30 of D with M30 of B, we can find the consistence changes from 3.4 to 5.4.

3.2 Analysis of strength

Compare mortar B with mortar A, we find the strength of mortar B in 3 days is lower about 14.6 percent than A, the strength in 28 days is lower about 4.2 percent, but the strength about 90 days is increase about 6.0 percent than A. The strength of C is lower than that of A, which reveal that lime can't take the place of cement and it is not reasonable to only use lime to improve consistence.Too much of inorganic dose can influence the effect of cement and makes the strength descend excessively. To the same strength tab mortar, the dosage of cement used in C is maximum, so C is uneconomical. When compare D with C, we can find that fly ash improves the strength of mixture mortar apparently and can economize cement. Because in the mortar there is enough lime proceeds live response with SiO_2, Al_2O_3, Fe_2O_3 in the fly ash (Ying Zhifu,1994).

3.3 Analysis fly ash effect

Fly ash can decrease mortar's earlier strength, but do well to the later strength. Now we analyse characteristics of fly ash in mortar.

3.3.1 Active effect of fly ash:

Because the velocity of hydrate reaction of fly ash is slower than cement, the earlier strength of the mortar which have been adulterated with fly ash is low. But after fly ash's live part SiO_2 and Al_2O_3 reacting with $Ca(OH)_2$, the calcium silicoaluminate is got and the liquid alkalinity decrease, so further hydrate reaction has been promoted. In addition, because vitreous councillors' main component is acidity oxidation substance, this acidity oxidation substance can react with $Ca(OH)_2$ in the moist circumstance, the reaction generate hydrate silical gel C-S-H, those hydrate silical gel can strengthen the harden of slurry and raise the later strength.

3.3.2 Micro-aggregate effect of fly ash:

We know that when the grain of fly ash is slimmer, the tiny vitreous ball grain is more, the comparison watch obverse is bigger, so the fly-ash's live composition react with $Ca(OH)_2$ in cement is more easily, the later strength of mortar increases more.

3.3.3 Particle shape effect of fly ash:

The shape of the beading in the fly ash is intact, the beading's surface is smooth , the beading's grain degree is fine and close, little multi-hollow grain has been found in it too. So the capacity of water in the slurry descends, the slurry's earlier fabric is improved and the slurry does not absorb water in large quantity; and then, the Ca^{2+} in the water diffuse into the hollow of fly-ash surface and react in the hollow. In this cause, the hydrate outside the hollow stretches into the hollow, so, the interface strength rises and the later strength of the fly-ash mortar increases (Yu Jianlin,1994).

Fly ash can raise mortar's later strength, but the increment of the strength can't rise unlimited with the increasing of the fly ash, there have a optimum quality.

4 Conclusion

Above all, based on a great deal of experiments and references, we can draw a conclusion that fly ash can decrease the mortar's early strength and can raise mortar's later strength, but. There is a optimum ratio of match when we adulterer fly ash in mortar. The optimum ratio of match in M15, M20, M25, M30 fly-ash cement mortar and fly ash lime-cement mortar has been got. As list in Table 1.

References

Chen Yu, Zhou shiqiong, 1999, Application of Macro-addition Fly-ash Mortar, Building Science Research of Sichuan, China.

Chen Enyi, 1993,Study on the High-strength Mortar Using in the High-rise Small-sized Hollow Brick Building Structure, Tsinghua University, China.

Ying Zhifu,1994, The Strength Test of Grade 3 Fly-ash Replacing Part of Cement in the Building Mortar. Architecture Technology, China.

Yu Jianlin,1994, Fly-ash's Contribution to the Later Strength of Concrete, China Concrete and Cement Products.