Mechanical Activated Fly Ash and Mechanism

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Abstract. When the replacement of cement and fly ash strength 28d 3d have the same amount of 10% of the rise. Experimental Comparison of mechanical properties of fly ash by different grinding time when grinding 15min replace an equal amount of 10% of cement, mortar best. And draw 15min when grinding through microscopic analysis, the activity of fly ash to be excited, active SiO_2 reaction was complete. Thus, 15min short time grinding activation can save costs while improving the utilization of fly ash, improve the strength of concrete.

Test

Raw Materials

(1)Cement: The Jilin Yatai Group production of "Tripod Deer" brand ordinary portland cement. Its physical properties are shown in table1:

Project		National Standard	Found
Degree of fineness(%)	R+8µm	≤10.0%	0.8
Setting time(h)	Initial setting	≥0:45	02:00
	Final setting	≤10:00	03:00
Stability	Reye law	≤5.0	Qualified

Tab.1 "Tripod Deer" brand P.042.5R cement physical properties

(2)Sand: coarse, medium and fine quartz sand of different particle sizes. According to the standard for ordinary concrete sand graded area (JGJ/52-1992) to finalize the sand ratio of 1: 4:10, the ratio in the range of standard I district $2.81 \sim 3.78$.

(3)Water: A test using ordinary tap water.

(4)Fly: provide a factory Jilin Province, Ash GBT1596-2005 45µm square hole measuring more than 62.3% according to screen burn vector 0.3%. Provide a factory Jilin chemical composition of fly ash are shown in table 2.

SiO ₂	Al_2O_3	Fe ₂ O ₃	CaO_2	Ca(SiO ₃)	CaSi ₂	Others
58	13	8	5	5	3	8

Test Equipment

This test uses the instruments are:SF-150 type cement fineness vacuum sieve analyzer;F-sorb 3400 surface area and pore size analyzer;KNM-II type fast grinding machine;DKZ-5000 electric bending testing machine cement;YES-2000 pressure testing machine;HY-1600°C high temperature furnace energy efficiency;Mortar consistency meter;SBY-60 standard curing temperature and humidity box;DZ-2BC vacuum drying oven;XRD diffraction;Laser particle size analyzer.

Test Method

The method used in this study: "Fly ash used for cement and concrete" (GB/T1596-2005); "Standard for test method of performance on building mortar" (JGJ/T70-2009);"Methods for

chemical analysis of cement"(GB/T176-2008);"Cement mortar strength test method (ISO method)"(GB/T 17671-1999).

The Physical Properties of Different Grinding Times and Microstructure of Fly Ash

SEM Analysis

Figure 1 comparison of different grinding time fly ash SEM photograph, showing the original gray beads without grinding ball relatively smooth, but the surface attached to a lot of impurities, texture is very loose. After a long grinding, the original particle size larger sphere partially destroyed, the particle size decreases, porous beads have been crushed into fine crumbs, attached to the surface impurities partially reduced adhesions sphere has been cracked. After grinding longer, most of the beads was destroyed, but there are still many small beads exist, which make fly ash to form a good save. Thus, after grinding fly ash is not the case that people are worried about the emergence of beads have all been destroyed. After mechanical grinding of fly ash from the porous glass spheres debris and beads were cracked adhesion composition better shape effects. On the other hand, pulverized fly ash cement and other mineral materials can also play a good micro aggregate effect[1].



Fig.1 Morphology different grinding time fly ash

Physical Properties and Power Consumption Analysis of Fly Ash under Different Grinding Time

By grinding fly ash was observed at different times in the grinding 15min, the fineness of fly ash significantly increased, but did not change the apparent shape. When grinding longer than 30min, because the ball itself temperature, ash particle size smaller than the surface area increases, thus significantly ash agglomeration, and the ball mill wall and stuck to the surface a lot more difficult to remove. And with the growth of the grinding time, the fly ash from the light color becomes darker color. Different physical properties of fly ash grinding time are shown in table 3.

As table 3 shows, with increasing grinding time, increasing the specific surface area of the fly ash, the median particle diameter D_{50} is constantly decreasing, which is due to the destruction of the grinding coarse porous glass spheres and it is crushed into fine crumbs. Vitreous composition of fly ash particle shape irregular, mostly porous spongy, honeycomb, these particles have a strong adsorption capacity. When the average pore diameter in 15min maximum 1.4241nm, the cumulative pore volume of 0.0005ml/g, this time stronger adsorption capacity of fly ash on the impermeability of the mortar has greatly improved.

Grinding time					
Physical properties	0min	5min	15min	30min	60min
The specific surface area of $BET(m^2/g)$	0.5507	0.659	1.4545	1.5803	1.6441
The specific surface area of Langmuir(m ² /g)	0.7852	0.9568	2.1334	2.3207	2.4037
Cumulative pore volume(ml/g)	0.0002	0.0002	0.0005	0.0005	0.0006
The average pore diameter(nm)	1.2693	1.2822	1.4241	1.4114	1.4008
The median particle size $D_{50}(\mu m)$	121.88	67.66	37.32	21.56	11.27
45µ m Sieve residue/%	62.30	44.70	19.30	5.25	2.00
Test power consumption/(kWh/t)	0	20.64	156.58	215.71	253.78
Industrial electricity consumption/(kWh/t)	0	12.9	97.86	134.82	158.61

Tab.3 Under different physical properties of fly ash grinding time

Note: Under the same grinding system power consumption by 1.6 times the experimental industrial power consumption conversion.

Moreover, with the growth of electricity consumption is also increased grinding time. As shown in figure 2, when the power consumption of grinding 15min 156.58kWh/t, is grinding 5min when electricity consumption of nearly 8 times. The electricity consumption of grinding 5min 60min, when electricity consumption is nearly 12 times, which will greatly increase the project cost of fly ash.



Fig.2 Fly newborn specific surfacearea and power consumption curves

According to Piqiang Yao[2], who studies have shown that the specific surface area of fly ash and grinding newborn electricity consumed rises exponentially relationship, in the known specific surface area ratio fly conditions, according to the estimates of the amount of power consumed by the following formula.Figure2: Fitting the relationship between the two based on the formula of the curve:

 $y = k e^{nx}$

y- unit power consumption, kWh/t;

x- Fly newborn specific surface area, cm²/kg

k and n and fly a constant related to the original fineness, 13.793 and 0.2547, respectively.

The Incorporation of Ground Fly Ash Mortar Performance

Mix

No fly ash mortar mix ratio A0:m(cement):m(sand):m(water)=1:2.5:0.48; grinding the same amount of time different fly ash replace 10% of cement, in mix the same situation, the incorporation

of different grinding time table changes the physical properties of fly ash table 4 and figure 3, figure 4.



Tab.4 different grinding time changes in physical properties of fly ash

Fig.3 different grinding time of strength diagram Fig. 4 different grinding time of bending strength

Analysis of Test Results

As shown in table 4, with the ratio in the case of constant, grinding time with the same amount of different fly ash were substituted with 10% of cement. From the grinding time 0min to 5min, the mortar consistency at increasing, 5min reached 72.5mm. On the one hand, fly ash smooth spherical vitreous played a role in lubricating rolling mortar, electric double layer structure of particles due to the adsorption of the emergence of further strengthened this role. Thus, the workability of the mortar has been improved, reducing water demand. On the other hand, short grinding and did not make a lot of fly ash specific surface area increases, thus work ability has been enhanced, consistency was increased. But with the growing grinding time to 60min, the consistency of mortar reduced from 72.5mm to 67mm. This is because over a long period of grinding, fly ash smooth spherical glass beads are crushed into fine crumbs, continuous particle size decreases, the constantly increasing surface area, increasing water demand, so consistency is obviously reduced.

In general, with the increase in the amount of fly ash adding early strength mortar will be significantly decreased[3], the latter will gradually increase the intensity. This is closely related to the nature of the fly ash, because ash is mainly composed of spherical glass body composition early hydration rate is very slow, it is generally incorporated into the early strength of fly ash mortar will be significantly reduced. While the latter due to the hydration of cement clinker product contains a lot of OH⁻, so that under the action of alkaline fly ash particles in the environment protection film surface is damaged and precipitation activity Si0₂, Al₂O₃, these ash active Si0₂, Al₂O₃ occurrence and OH⁻ second hydration reaction of CSH gel and hydrated calcium aluminate[4], which has greatly improved the strength of late.

As shown in table 4, compared to the other five groups specimens and specimen A0, 3d and 28d strength are higher than the intensity A0, indicating that you can improve the strength of mortar of fly ash the same amount of 10% replacement of cement. Strength Looking at figure 3, figure 4,28d

the margin of increase was significantly greater than 3d strength, indicating that fly ash mortar, the higher the longer the strength. When the strength of the mortar grinding 15min highest, on the one hand is the second hydration reaction of fly ash; on the other hand, the water in the mortar part of the cement hydration process that must be consumed, and the other part of the water present in the mortar Unicom voids among. This part of the water left after evaporation pores, make mortar strength. The pulverized fly ash particle size becomes smaller than the surface area increases, can be a very good presence in the mortar pores absorb excess water, form a water film on the particle surface, this water film between the friction far much larger than before, so that between the particles closer together, thus strength. 60min when grinding mortar strength decreased, partly due to prolonged grinding, mechanical temperature, ash produced reunion, which makes fly ash can not be uniformly dispersed in the mortar, is not conducive to participation hydration; another hand, in the water-cement ratio unchanged, since the specific surface area is too large, increasing water demand of mortar, consistency smaller, fluidity, fly ash active factor Si0₂, Al₂O₃ hydration is not complete, and therefore strength decreases.

Microscopic Analysis

SEM Analysis

Compare three samples 28d SEM photograph, as shown. A1000 sample texture is very dense, ash give full play to the role of micro-aggregates, but did not see the obvious surface of fly ash hydration products. Visible, without grinding fly ash hydration reaction rarely involved. It is seen from figure 5, after 15min Fly surface after grinding has more hydration product formation, and therefore, when the activation of fly ash grinding 15min activity best, more hydration occurred.



LW of the sample Ao SE

Fig.5 A0, A1000 and A1015 SEM photograph of sample 28d

XRD Analysis

Figures 6 and 7 are A1005 and A1015 of XRD energy spectrum. Figure 6 is a peak hydration products $CaCO_3$, another peak in the fly ash of amorphous SiO_2 . Since the grinding time is short, the activity of fly ash not excited, did not participate in most of the amorphous SiO_2 hydration. Compare seen in Figure 7, the grinding of mortar 15min amorphous SiO_2 basic reaction is complete, only a peak hydrates $CaCO_3$. Thus, the activity of fly ash grinding 15min to get excited, active factor hydration completely.



Fig.6 XRD energy spectrum of the sample A1005 Fig.7 XRD energy spectrum of the sample A1015

Conclusions

(1) Short-term mechanical grinding can fly activity increases, increased hydration products, strength. Tests show that when the optimum grinding time 15min. Relatively low power consumption, low cost activation. And proved by microscopic means higher at this time of activation, fly ash active SiO_2 respond more fully.

(2) When the same amount of 10% fly ash cement replacement, 3d and 28d are improved strength, with the longer term strength increases the more obvious.

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