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Study on the Effects of the Types and Addition Time of Chemical Admixtures on Cement Performance

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The effects of single admixture and combined admixture of Naphthalene Superplasticizer (NFS), Polycarboxylate Superplasticizer (PCC) and Li_2CO_3 and the addition time of superplasticizer on the fluidity, strength and adsorption capacity and other properties of cement paste are studied in this paper. NFS and PCC can significantly enhance the fluidity of cement paste; the greater the dosage of chemical admixture, the longer the initial setting time of cement; the suitable dosage of NFS is 0.4% -0.6%; the overall fluidity is the best, when the content of Li_2CO_3 is 0.01%. The combined admixture of PCC and Li_2CO_3 has little effect on the fluidity of cement paste. The higher the content of Li_2CO_3, the larger the adsorption capacity of cement particles to NFS, while the content of Li_2CO_3 basically does not affect the adsorption capacity of cement to PCC, indicating that Li_2CO_3 has the auxiliary water reducing effect, which can enhance the fluidity of cement paste. With a combined admixture of NFS and Li_2CO_3, Li_2CO_3 will have a great influence on the setting time of cement, and when the content of Li_2CO_3 is 0.35%, the initial setting time of cement is reduced by about 85.9% and the final setting time is reduced about 82.2%. The cement adsorption capacity of cement drops sharply after adding NFS and PCC 5-10 min after cement hydration. After 10 min, superplasticizer is added, and the declining tendency of cement adsorption capacity gradually becomes gentle. When the content of PCC increases from 0.4% to 0.6% and the content of NFS increases from 0.6% to 1.0%, the electronegativity of the surface of the cement shows an overall increasing trend, but when the superplasticizer is added to the cement 5-10min after hydration, the electronegativity is gradually reduced.

1. Introduction

Cement is one of the largest amount of raw materials used in the construction industry in the world, and its consumption is increasing year by year (Zhang et al, 2016; Zhang, Lu and Shen, 2016; Zhang and Kong, 2015). Cement materials will produce the initial cracks and pores when the pouring begins. Meanwhile, in order to ensure the fluidity of cement during construction, excess water is usually added, resulting in increased cement porosity after molding, so that the mechanical properties of cement decline and the durability and life cycle decreases (Aiad, 2003; Yoshioka et al, 2002; Ming et al, 2015).

One of the effective ways to improve the above defects of cement is to add chemical admixtures (Bi et al, 2012; Han et al, 2015). Chemical admixtures can significantly improve the performance of cement materials, reduce the cracks and pores, and improve the durability of cement (Jansen et al, 2012; Hill and Plank, 2004). The use of chemical admixtures can transform the traditional cement-water system into the cement- chemical admixture- water system, and the hydration and hydration products of cement will have new effects, such as adsorption, combinedation and cluster effect. Related studies have shown that the use of a chemical admixture can only improve one aspect of the performance of the cement, so the combined use of various chemical admixtures is inevitable(Plank and Hirsch, 2007; Ran et al, 2009). However, there is a mutual influence among the chemical admixtures, and the effect of multiple admixtures on the cement needs further study (Sowoidnich et al, 2015; Nguyen et al, 2016; Hyung et al, 2007).The effect of addition time of chemical admixtures on cement dispersibility and mechanical properties is also an important branch of the research field of cement matrix materials (Kong, Zhang and Hou, 2013). The types and addition time of chemical admixtures will have a significant effect on the fluidity and setting time of cement (Aiad, 2006; Li et al, 2011).

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But there are still few studies on the effect of admixture addition time on cement performance. On the basis of sufficient investigation of the existing literature, the effects of single admixture and combined admixture of Naphthalene Superplasticizer (NFS), Polycarboxylate Superplasticizer (PCC) and Li_2CO_3 and the addition time of superplasticizer on the fluidity, strength and adsorption capacity and other properties of cement paste are studied in this paper. The results provide a theoretical reference for the use of chemical admixtures in the cement-based composites.

2. Effect of Types of Chemical Admixtures on Cement Fluidity and Strength

2.1 Test materials and methods

Test materials: cement, 3d flexural strength of 7.1MPa, 3d compressive strength of 54.2MPa; superplasticizer, Naphthalene Superplasticizer (NFS) and Polycarboxylate Superplasticizer (PCC); coagulant: carbonic acid Lithium (Li_2CO_3). Test method: cement paste fluidity test and cement water consumption follow *Homogeneity Test Method of Concrete Admixtures* and *Test Method for Water Consumption, Setting Time and Soundness of Cement Standard Consistency* respectively; the amount of cement adsorption was measured by spectrophotometer.

2.2 Test results and discussions

Figure 1 shows the effect of combined admixture of different content of Li_2CO_3 together with five kinds of contents of Naphthalene Superplasticizer (NFS) and the fixed NFS content of 0.5% on the fluidity of cement paste. As can be seen from the figure, the higher the content of NFS, the greater the initial fluidity of cement paste and the less the fluidity loss. From the test it can be seen that the suitable content of NFS is 0.4% - 0.6%. It can be seen from the figure that with combined admixture of 0.5% NFS and different contents of Li_2CO_3, the fluidity of cement paste increases with the increase of Li_2CO_3, so does the fluidity loss, indicating that the effect of water reduction is more obvious when cement is mixed with NFS and Li_2CO_3, and lithium ion can accelerate the whole hydration process of cement hydration catalyst. As it can be seen from the figure, the overall fluidity is the best when the Li_2CO_3 content is 0.01%.

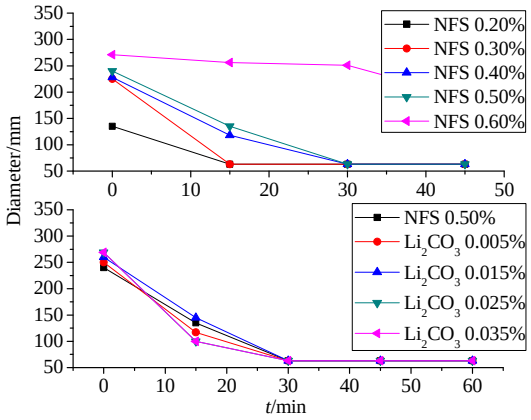

Figure 1: Fluidity of cement with different content of NFS and combined admixture of Li_2CO_3

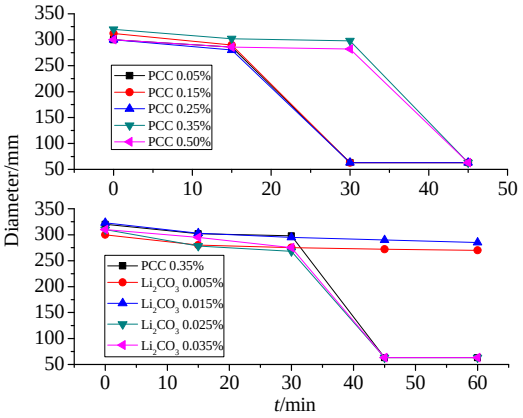

Figure 2: Fluidity of cement with different content of PCC and combined admixture of PCC and Li_2CO_3

Figure 2 shows the effect of combined admixture of different content of Li_2CO_3 together with five kinds of Polycarboxylate Superplasticizer (PCC) at a fixed content of 0.35% on the fluidity of cement paste. It can be seen from Figure 2 that the content of PCC is proportional to the fluidity of cement paste; when the content of PCC is higher than 0.35%, and the content of PCC is inversely proportional when the content is lower than 0.35%. The combined admixture of Li_2CO_3 has little effect on the fluidity of cement paste.

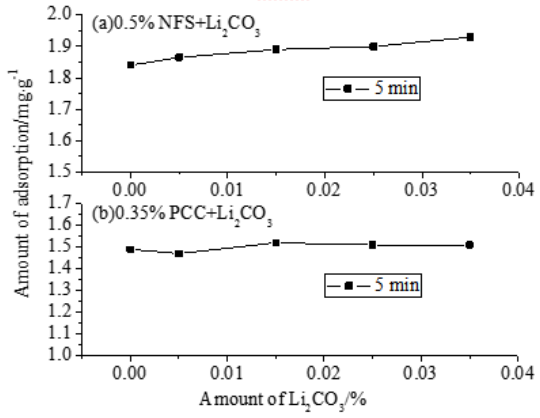

Figure 3: Effect of combined admixture of NFS and Li_2CO_3 and that of PCC and Li_2CO_3 on cement adsorption capacity

Figure 3 shows the effect of combined admixture of different content of Li_2CO_3 together with NFS and PCC at a fixed content of 0.5% and 0.35% respectively on the cement adsorption capacity. It can be seen from the figure that the higher the Li_2CO_3 content is, the larger the adsorption amount of cement particles to NFS is, and the change of Li_2CO_3 content basically does not affect the cement adsorption capacity to PCC. Once again, it shows that Li_2CO_3 has an auxiliary water reducing effect, which can enhance the fluidity of cement paste.

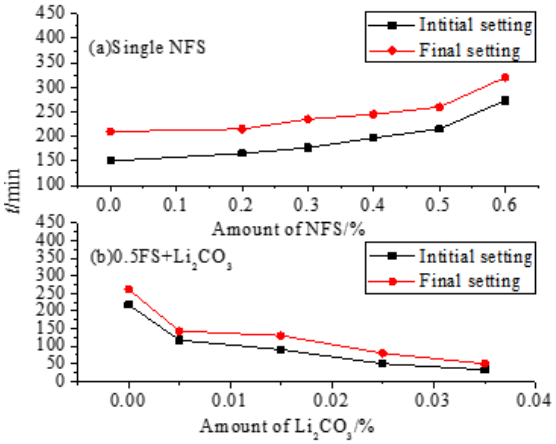

Figure 4: Effect of single admixture of NFS and combined admixture of NFS and Li_2CO_3 on the setting time of cement

The effect of single admixture of NFS and combined admixture of NFS and Li_2CO_3 on the setting time of cement is shown in Figure 4. It is shown from the figure that the initial and final setting time of the cement is proportional to the amount of NFS when the NFS is added alone. When NFS and Li_2CO_3 are added together to the cement, the existence of Li_2CO_3 has a great influence on the setting time of cement. When the content of Li_2CO_3 is 0.35%, the initial setting time of cement is reduced by about 85.9%, and the final setting time is reduced by about 82.2%.

The respective effect of the addition of 0.5% NFS and addition of 0.35% PCC on the flexural strength of cement is as shown in Figure 5. As can be seen from the figure, adding NFS can greatly improve the flexural strength of cement, which increases by about 15% as a whole compared to the flexural strength of cement without the addition. The addition of PCC will reduce the flexural strength of the cement, particularly; the flexural strength of the cement is reduced greatly within 1D.

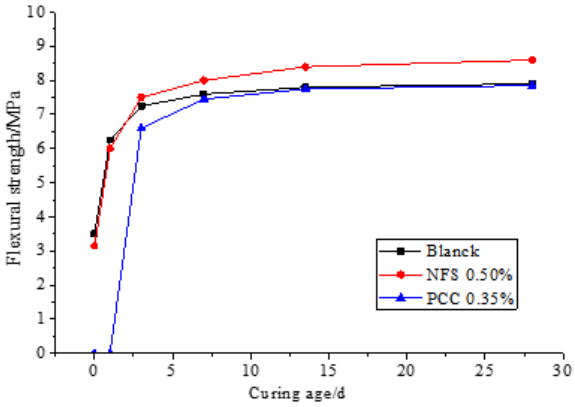

Figure 5: Effect of single admixture of NFS and that of PCC on cement strength

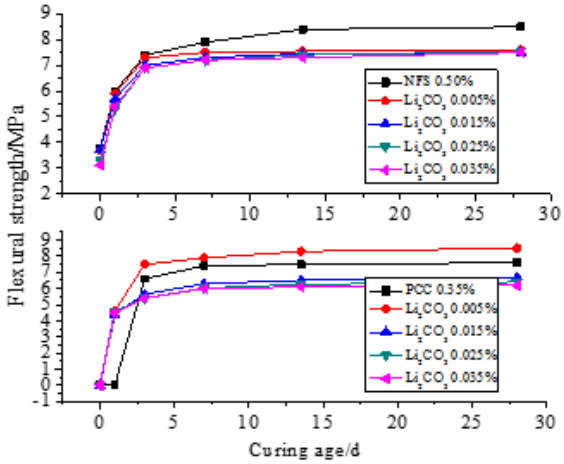

Figure 6: Effect of combined admixture of NFS and Li2CO3 and that of PCC and Li_2CO_3 on cement strength

The respective effect of combined admixture of NFS and Li_2CO_3 and that of PCC and Li_2CO_3 on cement strength is as shown in Figure 6. It can be seen from Figure 7 that within 1d, the combined addition of NFS and Li_2CO_3 will obviously increase the strength of cement, but after 1d the strength will decrease significantly, and the decrease of strength will be proportional to the content of Li_2CO_3. The combined admixture of PCC and Li_2CO_3 will obviously increase the strength of the cement after 1D. Therefore, the combined admixture of PCC and Li_2CO_3 can be used to increase the strength of the cement of the later stage in actual practice.

3. Effect of Addition Time of Chemical Admixtures on the Performance of Cement

With the same test materials and test methods same as in Section 2.1, the effect of the addition time of chemical admixtures on the performance of the cement is further explored. The effect of the addition of NFS (0.4%, 0.6%) and PCC (0.4% and 0.8%) on the adsorption capacity of cement is as shown in Figure 7. It can be seen from the figure that the cement adsorption capacity of cement drops sharply after adding NFS and PCC 5-10 min after cement hydration. After 10 min, superplasticizer is added, and the declining tendency of cement adsorption capacity gradually becomes gentle.

The charge density of NFS and PCC is high. The C_3A and C_4AF, the positive charge hydration products of cement, adsorb a large amount of superplasticizer when it is added to the cement at the beginning of hydration. However, when superplasticizer is added to the cement 5-10min after the hydration, C_3A and C_4AF will chemically react with gypsum and water to produce stable AFt and AFm. Their positive electrodes are smaller, thus no larger adsorption will be produced.

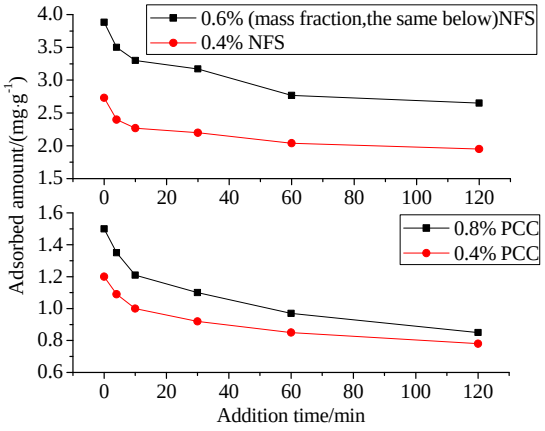

Figure 7: Effect of addition time of superplasticizer on the adsorption capacity of cement

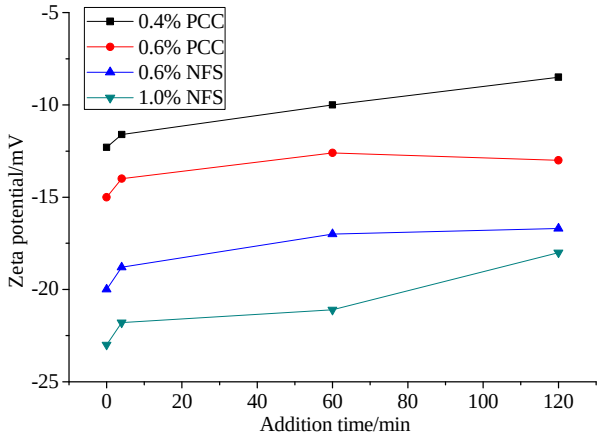

Figure 8: Effect of addition time of superplasticizer on surface potential of cement

The effect of adding different amounts of NFS and PCC on the surface potential of cement particles is shown in Figure 8. As can be seen from the figure, when the PCC content increases from 0.4% to 0.6% and the NFS content increases from 0.6% to 1.0%, the electronegativity of the cement surface tends to increase. However, when superplasticizer is added to the cement 5-10min after hydration, the electronegativity is gradually reduced.

4. Conclusions

The effect of single admixture and combined admixture of Naphthalene Superplasticizer (NFS), Polycarboxylate Superplasticizer (PCC) and Li_2CO_3 and the addition time of superplasticizer on the fluidity, strength and adsorption capacity and other properties of cement paste are studied in this paper. The study results show as follows:

(1) NFS and PCC can significantly enhance the fluidity of cement paste; the greater the dosage of chemical admixture, the longer the initial setting time of cement; the suitable dosage of NFS is 0.4% -0.6%; the overall fluidity is the best, when the content of Li_2CO_3 is 0.01%. The combined admixture of PCC and Li_2CO_3 has little effect on the fluidity of cement paste.

(2) The higher the content of Li_2CO_3, the larger the adsorption capacity of cement particles to NFS, while the content of Li_2CO_3 basically does not affect the adsorption capacity of cement to PCC, indicating that Li_2CO_3 has the auxiliary water reducing effect, which can enhance the fluidity of cement paste. With a combined admixture of NFS and Li_2CO_3, Li_2CO_3 will have a great influence on the setting time of cement, and when the content of Li_2CO_3 is 0.35%, the initial setting time of cement is reduced by about 85.9% and the final setting time is reduced about 82.2%.

(3) The cement adsorption capacity of cement drops sharply after adding NFS and PCC 5-10 min after cement hydration. After 10 min, superplasticizer is added, and the declining tendency of cement adsorption capacity

gradually becomes gentle. When the content of PCC increases from 0.4% to 0.6% and the content of NFS increases from 0.6% to 1.0%, the electronegativity of the surface of the cement shows an overall increasing trend, but when the superplasticizer is added to the cement 5-10min after hydration, the electronegativity is gradually reduced.

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