

































pozzolanic reaction degrees of the tuffs in the paste were gradually increased with prolongation of curing time. After 14 days, the pozzolanic reaction degree was grown slowly down, but had been in progress for a long-term. However, the pozzolanic reaction of tuff in the paste of 10% replacement was still not completed at the age of 90 days with about half of the tuff unreacted. The analysis results revealed the consistency of CH consumption and pozzolanic reaction degree, which could be used as indicators to reflect process of pozzolanic reaction for the tuff. Variation of the pozzolanic reaction degree was improved with the bond water content, and relationship between them appeared well linear. The fitting linear regression equation can be applied to mutual conversion between pozzolanic reaction degree and bond water content.

## Acknowledgments

The authors would like to acknowledge the financial support provided by the National Natural Science Foundation of China (Grant No. 51168015) for this work.

## References

- Ahmet Cavdar and Sukru Yetgin (2007), "Availability of tuffs from northeast of Turkey as natural pozzolan on cement, some chemical and mechanical relationships." *Construction and Building Materials*, 21, (12), 2066–2071.
- Alp I., Deveci H., Sungun Y.H., Yilmaz A.O., Kesimal A. and Yilmaz E. (2009), "Pozzolanic characteristics of a natural raw material for use in blended cements" *Iranian Journal of Science & Technology, Transaction B, Engineering*, 33, (B4), 291–300.
- Lam L., Wong Y.L., Poon C.S. (2000), "Degree of hydration and gel/space ratio of high-volume fly ash/cement systems" *Cement and Concrete Research*, 30, (5), 747–756..
- Li S. Roy D.M. and Kumar A. (1985), "Quantitative determination of pozzolanas in hydrated systems of cement or  $\text{Ca}(\text{OH})_2$  with fly ash or silica fume", *Cement and Concrete Research*, 15, (6) , 1079
- Li Yong-Xin (2003), "Study on composition, structure and properties of cement and concrete with steel-making slag powder mineral additive", Ph.D. thesis, China Building Materials Academy, Beijing.
- Mehta P.Kumar and Monteiro Paulo J.M. (1993), *Concrete Structure, Properties and Materials*, (2nd Edition), Prentice Hall, New Jersey, USA.
- Ohsawa S. Asaga K. Goto S. (1985), "Quantitative determination of fly ash in the hydrated fly ash- $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ - $\text{Ca}(\text{OH})_2$  system", *Cement and Concrete Research*, 15, (2), 357.
- Poon C.S., Lam L., Kou S.C., Lin Z.S. (1999), "A study on the hydration rate of natural zeolite blended cement pastes", *Construction and Building Materials*, 13, 427-432.
- Poon C.-S., Lam L., Kou S.C., Wong Y.-L., Wong Ron (2001), "Rate of pozzolanic



- reaction of metakaolin in high-performance cement pastes”, *Cement and Concrete Research*, 31, 1301–1306.
- Rodriguez-Camacho E. and Uribe-Afif R. (2002), “Importance of using the natural pozzolans on concrete durability.” *Cement and Concrete Research*, 32, (12), 1851–1858.
- Turkmenoglu AG, Tankut A (2002), “Use of tuffs from central Turkey as admixture in pozzolanic cements assessment of their petrographical properties.” *Cement & Concrete Research*, 32, (5), 629-637.
- Wong Han Sze and Askury Abd Kadir (2011), “The potential of Lawin Tuff for generating a Portland fly ash cement to be used in oil well Cementing”, *International Journal of Engineering & Technology IJET-IJENS*, 11, (05), 51-55.
- Ye Da-nian and Jin Cheng-wei. (1984), *X-ray diffraction for powder and their use in petrology*, (1st edition), China Science Press, Beijing, China, (in Chinese).
- Yu L.-H. Ou H. and LEE L.-L. (2003), “Investigation on pozzolanic effect of perlite powder in Concrete.” *Cement & Concrete Research*, 33, (1), 76–79.
- Yu L.H. Ou H. and Zhou S.X. (2010), “Influence of perlite admixture on pore structure of cement paste.” *Advanced Material Research*, 97–101, (2), 552–555.
- Zhang Ya Mei, Sun Wei, Yan Han Dong (2000), “Hydration of high-volume fly ash cement pastes” *Cement & Concrete Composites*, 22, 445-452.