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A review on study of partial replacement of cement by metakaolin and glenium b233 in self- compacting concrete.

Una revisión sobre el estudio de la sustitución parcial del cemento por metacaolín y glenio b233 en hormigón autocompactante.

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ABSTRACT

Self-compacting concrete (SCC) refers to high strength concrete which will compact under its own weight and does not require external vibration. This paper gives a review on the journals to study the effect of metakaoiln in SCC. The metakaolin is used as a replacement of cement and it is obtained from natural Kaolin clay. Metakaolin helps to increase the compressive strength, spilt tensile strength, flexural strength and also the fresh properties. The use super plasticizer greatly improves pump-ability and the slump value. GLENIUM B233 is a new generation based super plasticizer which is based on modified polycarboxylic ether. The fresh properties such as pump ability and workability and the durability properties of super plasticizer in SCC with metakaolin are discussed.
Keywords: Self-Compacting Concrete, Metakaolin, GLENIUM B233, Superplasticizer, Polycarboxylic Ether.

RESUMEN

El hormigón autocompactante (SCC) se refiere al hormigón de alta resistencia que se compacta por su propio peso y no requiere vibraciones externas. Este artículo ofrece una revisión de las revistas para estudiar el efecto de metakaoiln en SCC. El metacaolín se utiliza como sustituto del cemento y se obtiene a partir de arcilla natural de caolín. El metacaolín ayuda a aumentar la resistencia a la compresión, la resistencia a la tracción derramada, la resistencia a la flexión y también las propiedades frescas. El uso de superplastificante mejora en gran medida la capacidad de bombeo y el valor de asentamiento. GLENIUM B233 es un superplastificante de nueva generación basado en éter policarboxílico modificado. Se discuten las propiedades frescas como la capacidad de bombeo y trabajabilidad y las

propiedades de durabilidad del superplastificante en SCC con metacaolín.
Palabras clave: Hormigón Autocompactante, Metacaolín, GLENIUM B233, Superplastificante, Éter policarboxílico.

INTRODUCTION

In current scenario of construction industries due to demand in the construction of large and complex structures, which often leads to difficult concreting conditions. When large quantity of heavy reinforcement is to be placed in a reinforced concrete (RC) member, it is difficult to ensure fully compacted without voids or honeycombs. Compaction by manual or by mechanical vibrators is very difficult in this situation. That leads to the invention of new type of concrete named as self- compacting concrete (SCC). SCC was developed in Japan in 1980s in order to achieve high- performance durable concrete structures, and with advancements in concrete technology its use has become widespread all over the world (Ozawa et al., 1989). This type of concrete flows easily around the reinforcement and into all corners of the formwork. Self-compacting concrete describes a concrete with the ability to compact itself only by means of its own weight without the requirement of vibration.

SELF- COMPACTED CONCRETE

Self-compacting concrete (SCC), also known as self-consolidating concrete, is one of the most widely used concrete types, mainly because of its self-compacting characteristics and strength. SCC is a highly flowable, non-segregating, special concrete type that can settle into formworks, and encapsulates, heavily reinforced, narrow and deep sections by means of its own weight. Unlike conventional concrete, SCC does not require compaction using external force from mechanical equipment such as immersion vibrators. In addition to these attractive benefits, as a high-performance concrete SCC maintains all of concrete's common mechanical and durability characteristics. (Okamura et. al, 1997). The advantages of SCC in its fresh and hardened states include economic efficiency (i.e. it shortens the construction time as well as it reducing the labour and equipment required), improvement in working and living environment (i.e. it may consume high amount of industrial by-products, it reduces construction noise and health hazards) and enhancement in automation of the construction process (Ozawa et. al, 2003).

SUPPLEMENTARY CEMENTITIOUS MATERIAL- METAKAOLIN

Supplementary cementitious materials (SCM) are finely ground solid materials that are used to replace a portion of the cement in a concrete mixture. These supplementary materials may be naturally occurring or man-made waste. Various types of pozzolanic materials that improve cement properties have been used in cement industry for a long time such as Fly ash, Silca fume and Metakaolin. The metakaolin possesses a high reactivity with calcium hydroxide having the ability to accelerate cement hydration. Metakaolin reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate (C-S-H) gel, it is very effective pozzolanic materials and effectively enhances the strength parameters of concrete.

Metakaolin is a pozzolan, probably the most effective pozzolanic material used in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC. Metakaolin is a valuable admixture for concrete/cement applications. Replacing Portland cement with 8–20% (by weight) metakaolin produces a concrete mix that exhibits favourable engineering properties, including the filler effect, the acceleration of OPC hydration, and the pozzolanic reaction. The filler effect is immediate, while the effect of pozzolanic reaction occurs between 3 and 14 days.

PARTIAL REPLACEMENT OF CEMENT BY METAKAOLIN

The average size of highly reactive metakaolin particle, which is smaller than cement particles, is ranging from 1 to 2 micron and it off white in colour which in return influences the colour of the final product. The replacement of metakaolin was done in a pattern of 0, 5, 10, 15 and 20% of weight of cement. Self – compacting concrete mix of M30 grade was used for the experimental investigation. The slump flow values for different concrete mixes were measured in the range of 660–715 mm (Madandoust R, et.al, 2015). According to EFNARC all concrete mixtures under investigation can be categorized as slump flow class 2. The concrete mixture at this class of slump flow is suitable for many normal applications such as walls and columns. The flowability of the mixtures was reduced with the higher proportion of MK replacement. The MK inclusion made the concretes more viscous; it can be concluded that in the MK, no viscosity modifying agent was needed.

In this study conducted the slump flow, V-funnel, L-box and U-box tests as per the procedure recommended by EFNARC committee. Here the values of slump flow was in the accepted limit of EFNARC. The compressive strength results for mixes prepared with MK of 24% increase in strength at 28 days. The reason for this significant improvement in compressive strength can be associated with the filling effect of MK particles, and the pozzolanic reaction of MK with calcium hydroxide. MK leads in the rise of compressive strength and tensile strength. The optimum results for compressive strength and split tensile strength were achieved at 15% MK. The best results for compressive strength and split tensile strength were achieved for 15% metakaolin replacement (Gill S.A, et.al 2018)

The rheological, mechanical and durability properties of self-compacting concrete (SCC) mixes produced using blended binders containing metakaolin and blast furnace slag are studied. The compressive strength of self – compacting concrete with metakaolin grows very fast during the initial hardening period and remains significantly higher, as compared with the mix with blast furnace slag. Durability properties of the mix containing metakaolin are excellent (Vejmelkova E, et.al, 2011). The durability of Self-Compacting Concrete (SCC) incorporating with metakaolin (5%, 10%, 15% & 20% by weight of cement). The estimated properties (open porosity, sorptivity, water and gas permeability, chloride penetrability) were evaluated against a reference mixture (without MK). The incorporation of metakaolin is improved durability. Metakaolin SCC generally exhibits lower gas permeability compared to the reference concrete mixture. The replacement of cement with metakaolin results in a significant decrease on chloride penetrability. (Badogiannis G.E, et.al, 2015).

The feasibility of using metakaolin and GGBS as a replacement material in the self – compacting concrete production, the cement is replaced by metakaolin and it ranges between 0 - 20 % and GGBS in the ranges between 10% - 30%.The MK lead higher amount of C-S-H gel in presence of higher w/c ratio without affecting the mechanical properties. Metakaolin has a greater effect on the microstructural strength of the transition zone than GGBS. (Bai J, et.al, 2017)

The need for viscosity modifying admixture could be fully avoided at high replacement level of metakaolin, because higher paste volume reduced the friction between the aggregates. Compressive strength of SCC 15% MK mix showed 11.5% increase than the control mixture (Joseph A, et. al ,2017). The behaviour of self - compacting concrete containing self - combusted rice husk ash (SCRHA) and metakaolin (MK) were studied. The OPC was replaced from 0% to 30% by MK. In order to assess the properties of blended self - compacting concrete (SCC), various tests were conducted for fresh state properties (Slump flow test, V-funnel test and L-box test), Strength properties (Compressive strength and splitting tensile strength) and durability properties (Rapid chloride penetration test and potential time study for steel corrosion). The compressive and splitting tensile strength of MK blended concrete was increased 15% replacement of metakaolin (V. Kannan 2018). Studied the effect of Metakaolin as mineral admixture in the concrete and its performance. The metakaolin was replaced with 0, 5, 10, 15, and 20% of weight of the cement. M30 grade concrete mix was used for the experimental investigation. The results indicate that the use of Metakaolin in concrete has improved the strength characteristics of concrete. From the results of considered parameters, it is observed that 15% replacement of cement with Metakaolin showed better performance (Nova John 2013).

The mechanical properties like compressive strength, split tensile strength and flexural strength are conducted and durability properties of drying shrinkage, chloride penetration and chemical resistances are also studied. The compressive strength, split tensile strength and flexural strength are increased in the 15% replacement of metakaolin. Metakaolin was reduced the drying shrinkage and chloride penetration. The results confirm that replacing Portland cement with 15% metakaolin (by weight) provide the optimum improvement for Portland cement concrete on both mechanical properties and durability (A.A Menhosh, et.al, 2018). utilization of metakaolin (MK) and calcite (C), working reversely in workability aspect, as mineral admixture in self-compacting concrete (SCC), was investigated. Study shows that utilizing MK and C as admixtures in concrete separately was possible. However, utilizing both admixtures in concrete together provides a synergy and allows utilizing more amounts of admixtures in concrete which provides better workability in fresh state and high strength, low abrasion, and capillary water absorption value as the durability-related parameter (Fatih Ozcan et.al, 2018). The fresh properties of concrete containing MK were tested, (A.A.A Hassan et.al, 2012) Concrete mixtures with 5 to 10% MK had a slightly higher slump than the control mixture. Even when the replacement level of MK was increased to 15%, the slump was only decreased by approximately 10%.

There is a great positive effect of increasing metakaolin content on the compressive and tensile strength at 7 and 28 days age for self-compacted concrete. The maximum strength obtained by using 15% of metakaolin as adding or replacing percentage by weight of cement (H. M Ibrahim et. al, 2016).

GLENIUM B233- SUPERPLASTICIZER

GLENIUM B233 is a new generation based super plasticizer which is based on modified polycarboxylic ether. The product has been primarily developed for application in High performance concrete where highest durability and performance is required. It is free of low chlorine and low alkali content & compatible with all types of cements. The results of an experimental investigation into the properties of self-compacting concrete mixes having varying dosage of high-performance superplasticizer (GLENIUM B233) (0.5%-3.0%). The slump flow increases with the increase of the superplasticizer dosage. For the slump flow range from 500 to 700 mm, the superplasticizer (Glenium B233) dosages were 0.39% and 0.54% for a better self-compacting concrete (Ali Hussein Hameed 2012).

CONCLUSION

On the basis of predictive models presented in this paper, It is desirable to use SCC because of its advantages like faster rate of construction and superior level of finish and also it can be used in congested reinforcement very well. The metakaolin in SCC improved the strength parameters with the addition of 15% metakaolin. The higher compressive strength of MK mixes can be attributed to: (i) the filling effect of MK particles, (ii) acceleration the cement hydration and (iii) the pozzolanic reaction of MK with calcium hydroxide. The use superplasticizer Glenium B233 improves the fresh properties. From this paper it was clear that the partial replacement of cement by metakaolin and the modified superplasticizer helps to increase the fresh and hardened properties of SCC. So this type of SCC can used in situations where the castings are difficult due to congested reinforcement, difficult to access etc.

REFERENCES

A.A.A Hassan, M. Lachemi, K.M.A Hossain (2012), Effect of Metakaolin on the Rheology of Self- Consolidating Concrete, ACI Material Journal, Vol. 109, no. 06.

A.A. Menhosh, L.A. Nelson, Y. Wanga (2018), Long Term Durability Properties of Concrete Modified with Metakaolin and Polymer Admixture, Journal of Construction and Building Materials, Vol.172, pp 41 - 51.

Ali Hussein Hameed (2012), Effect of Superplasticizer Dosage on Workability of Self Compact Concrete, Diyala Journal of Engineering Sciences, Vol. 05, pp 66-81

E. Vejmelkova, C.R Erny, M. Keppert, S.B. Ski, S. Grzeszczyk (2011), Properties Of Self-Compacting Concrete Mixtures Containing Metakaolin and Blast Furnace Slag, Journal of Construction and Building Materials, Vol.25, pp 1325 – 1331

Fatih Ozcan, Halil Kaymak (2018), Utilization of Metakaolin and Calcite: Working Reversely in Workability Aspect-As Mineral Admixture in Self-Compacting Concrete, Advances in Civil Engineering, Vol. 2018, pp 120-133.

G.E Badogiannis, G.K Trezos, G.S Tsivilis, P.I Sfikas, (2015), Durability Of Metakaolin Self-Compacting Concrete, Journal of Construction and Building Materials, Vol. 82, pp 133 - 141.

Hajime Okamura, Masahiro Ouchi (2013), Self-Compacting Concrete, Journal 0f Advanced Concrete Technology,Vol. 1, pp5 -15

H.M Ibrahim, M.A Arab, A.M Faisal (2016), Feasibility of Using Metakaolin as a Self-Compacted Concrete Constituent Material, Vol. 25, pp 65-70.

H. Okamura (1997), Self-Compacted Concrete, Concrete International, Vol. 19, pp 50-54.

H. Okamura, K. Ozawa, M. Ouchi,(2003), Self-Compacting Concrete, Structural Concrete, Vol. 1, pp 3-17

Joseph, A.L. Mathew (2017), Performance of Metakaolin on High Strength Self Compacting Concrete, International Journal of Science Technology & Engineering, sVol.3, pp 110 - 114

J. Bai, S. Dadsetan (2017), Mechanical and Microstructural Properties of Self - Compacting Concrete Blended with Metakaolin, Ground Granulated Blast-furnace Slag and Fly Ash, Journal of Construction and Building Materials, Vol.146, pp. 658 - 667.

John Nova (2013), Strength Properties of Metakaolin Admixed Concrete, International

Journal of Scientific and Research Publications, Vol.3, pp 1 – 7.

R. Madandoust, S. M Yasin (2015), Fresh and Hardened Properties of Self Compacting Concrete Containing Metakaolin, Journal of Construction and Building Materials, Vol.35, pp 752 - 760.

R. Siddique, S.A. Gill (2018), Strength and micro-structural properties of self compacting concrete containing metakaolin and rice husk ash, Journal of Construction and Building Materials, Vol. 2, pp 323 – 332.

V Kannan (2018), Strength and Durability Performance Of Self Compacting Concrete Containing Self – Combusted Rice Husk Ash and Metakaolin, Journal of Construction and Building Materials, Vol. 160, pp 169 - 179.

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