REVIEW ON HIGH TEMPERATURE CONCRETE USING SHOCKWAVE APPLICATION

Sumega.N[a], Oviya.I[b], Jayathilakrajan[c], Selvan.V[d]

ABSTRACT: - The properties of materials used in preparing concrete play an important role on the performance of concrete during its lifetime. Concrete generally provides adequate fire resistance for most applications. However, the strength and durability properties of concrete are significantly affected when subjected to elevated temperature. Terrorist attack, accidental fire breakout and different type of explosions produce a rapid change of temperature for a short period. This study was focused on improving the elevated temperature resistance of normal concrete by inducing shock wave from shock tube. The main objective of this paper is to experimentally study about fire resisting property of shock wave induced concrete. In this shock wave is induced in a freshly prepared concrete of grade M35 by using shock tube apparatus. In addition to that Metakaolin admixture is used in concrete to resist temperature. The test were carried out on concrete subjected to high temperature condition at 100°C, 200°C, 300°C, 400°C, 500°C, 600°C and 700°C for 28 days. The performance of nominal concrete and shock wave induced concrete is compared with compression test. The results enabled us to evaluate the effect of high-temperature conditions on concrete with shockwave and concrete with metakaolin and concrete with both metakaolin and shockwave.

Keywords: Shock wave, Compressive Strength, Compaction, Fire resistance concrete, Shock tube, Metakaolin.

1.0 INTRODUCTION

Concrete is a composite material produced from aggregate, cement, and water. Therefore, the type and properties of aggregate also play an important role on the properties of concrete exposed to elevated temperatures. The strength degradations of concretes are not same under elevated temperatures. Concrete is possibly exposed to elevated temperatures during fire or when it is near to furnaces and reactorsWhen exposed to high temperature, the concrete structure change considerably. The dehydration such as the release of chemically bound water from the calcium silicate hydrate (CSH) becomes significant above about 110°C. The dehydration of the hydrated calcium silicate and the thermal expansion of the aggregate increase internal stresses and from 300°C microcracks are induced through the material. The fire is generally extinguished by water and CaO turns into [Ca(OH)2] causing cracking and crumbling of concrete. Therefore, the effects of high temperatures are generally visible in the form of surface cracking and spalling. Some changes in colour may also occur during the exposure. The alterations produced by high temperatures are more evident when the temperature surpasses 500°C. Most changes experienced by concrete at this temperature level are considered irreversible. CSH gel, which is the strength giving compound of cement paste, decomposes further above 600°C. As a result, severe microstructural changes are induced and concrete loses its strength and durability.

1.1 SHOCK WAVE

A shock wave is a propagating discontinuity in a flow that travels faster than the speed of sound. Shocks are very thin, leading to very large gradients of velocity and temperature. Hence, shock waves are dissipative, irreversible processes that generate entropy and compress the flow. Static pressure, density, and temperature are increased after the shock. Shock waves are generated in a number of ways, creating violent changes in pressure. Shock waves have unique properties that set them apart from sound waves. They travel faster than the speed of sound and also decrease in intensity faster than a sound wave. These properties must be accounted for when designing applications such as transonic diffusers, which use shocks to slow down airflow.

Fig 1.1 Shock Tube

1.1.1 APPLICATIONS OF SHOCK WAVE

- By using shock waves, chemical preservatives in the form of solutions could be pushed into the interior of wood samples which helps in withstanding the microbial attacks. By this method the life of ordinary wood can be increased.
- In the manufacture of pencils, in the industry, the wood needs to be softened by soaking it in a polymer at 700°C for about 3 hours and then dried. It takes days for the wood to dry. In the modern process, the liquid is passed into the wood almost instantaneously by placing it in a liquid and sending a shock wave. The wood is then taken out and it will not take longer time to dry. The treated wood is ready for the next process without any delay.
- Shock wave is used in a therapy to crush the kidney stones into smaller pieces after which, they are passed out of the body smoothly through the urinary tracts.
- Shockwave is also used in agriculture field for transformation of DNA from one plant to other.

1.2 OBJECTIVES

The main objective of this paper is to experimentally study about fire resisting property of shock wave induced concrete. In addition to that Metakaolin admixture is used in concrete to resist temperature. The performance of nominal concrete and shock wave induced concrete is compared with strength properties of concrete. This project is to improve the compressive strength of partially Metakaolin replaced concrete under Shockwave compactor even after exposed to high temperature.

2.0 LITERATURE REVIEW

J.M. Khatib, J.J. Hibbert(2004) performed research on incorporating ground granulated blast furnace slag (GGBS) and metakaolin (MK) on concrete strength. Portland cement was partially replaced with 0–80% GGBS and 0–20% MK. The water to cementitious materials ratio was maintained at 0.5 for all mixes. The incorporation of MK causes an increase in strength, especially during the early ages of curing. However, the use of GGBS in concrete reduces the strength during the first 28 days. Beyond 28 days, the strength increases with the presence of GGBS up to 60% replacement. The decrease in compressive strength during the early ages of curing of GGBS concrete is compensated by the inclusion of MK. The presence of MK in concrete containing GGBS does not cause a decrease in the long-term strength. The test data also showed that in order to use MK efficiently in GGBS concrete a lower percentage of MK below 10% may yield better performance with respect to compressive strength.

M. Saridemir , M.H. Severcan(2014) performed to evaluate the influence of elevated temperature on the strength and microstructural properties of high strength concretes (HSCs) containing ground pumice (GP), and blend of ground pumice and metakaolin (MK) mixture. Twelve different mixtures of HSCs containing GP and MK were produced, water-to-binder ratio was kept constant as 0.20. Hardened concrete specimens were exposed to 250°C, 500°C and 750°C elevated temperatures increased with a heating rate of 5°C/min. Ultrasound pulse velocity (Upv), compressive strength (fc), flexural strength (ffs) and splitting tensile strength (fsts) values of concrete samples were measured on unheated control concrete and after air-cooling period of heated concrete. Elevated temperature also results with crack formation, and increasing target temperature caused more cracks. The experimental results indicate that concrete made with MK +GP blend together as a replacement of cement in mass basis behaved better than control concrete made with cement only, and concrete containing only GP as a cement replacement.

Hossein Mohammadhosseini, Nor Hasanah Abdul Shukor Lim(2018) described the effect of waste polypropylene carpet fibres and palm oil fuel ash (POFA) on the mechanical and microstructural properties of concrete exposed to elevated temperatures was investigated. Concrete samples were exposed to high temperatures up to 800 °C then cooled to ambient temperature before tests. Four mixes containing carpet fibres (0 and 0.5%) and POFA (0 and 20%) were prepared. Mass loss, residual ultrasonic pulse velocity, compressive strength, scanning electron microscopy, X-ray diffraction and differential thermal analysis were performed to investigate the effects of carpet fibres and POFA on the performance of the concrete at elevated temperatures. The results showed that both carpet fibres and POFA were associated with a significant enhancement in the fire resistance and residual compressive strength and also eliminating the explosive spalling behaviour of the concrete at elevated temperatures. Furthermore, the role of carpet fibres and POFA is discussed through the microstructural analysis and fibre matrix interactions as function of heat treatment.

Qingtao Li ,Zhuguo Li (2012) presents the effects of elevated temperatures on properties of concrete containing GGBFS with replacement ratios of 10%, 30% and 50% by weight of cement. The concrete specimens were subjected to six different elevated temperatures from 150°C up to 700°C.Test results indicated that the effect of the temperature on mass loss the GGBFS concrete was less than 8% below 700°C, which was similar to the ordinary Portland cement (OPC) concrete. The effect of temperatures above 400°C on the compressive strength of concrete was more pronounced for concrete containing GGBFS. After exposed to 500°C, the relative compressive strength of concrete with 0%, 10%, 30% and 50% GGBFS was 60%, 62%, 44% and 41% respectively. respectively. The compressive strength of concrete decreased drastically when the temperature reached above 400°CFrom 600°C, the reduction in the compressive strength of concrete was significantly larger.

Ali Sadrmomtazi, Saeed Haghighat Gashti (2019) Evaluated compression strength after exposure at 23, 110, 200, 400, and 600°C.Experimental results showed that the loss of compressive strength of the specimens up to 200°C is almost insignificance, but it will be 40% and 64% when the temperature increases by 400°C and 600°C, respectively. The steel fibers prevent the cracks expansion and contribute to the spalling and mechanical residual strength. However, as temperature increases, the slope of the ascending part (flexural hardness) of the load deflection curves and fracture energy decrease.

MehrdadAbdi Moghadam, RamezanaliIzadifard (2019) investigated the shear strength test was done at temperatures of 100, 200, 300, 400, 450, 500, 600 and 800 °C to derive another equation which predicts the shear strength of concrete based on the compressive strength, the volume fraction of the fiber and the target temperature. It was observed that the inclusion of 0.25 and 0.5% of steel fibers improved the shear strength of plain concrete at the tested temperatures on average by 8.82 and 13.44%, respectively. Meanwhile, it was observed that by increasing the temperature, the shear strength of the concrete decreases and with further increase in temperature to 450 °C they recovered their shear strength and then started to decline sharply.

Tomasz Drzymałaa, Wioletta Jackiewicz Rek (2017) evaluated that heating at 300°C increased the compressive strength in relation to the initial value determined at 20°C in the case of air entrained and fibre-reinforced concretes. With a further increase in the temperature a drop of compressive strength was noted for all the tested types of concrete. This said, it needs to be noted that at 450°C the compressive strength of High Performance Concrete(HPC) was either higher than (in the case of air-entrained and reference samples) or almost the same (in the case of fibre-reinforced concrete) as the value measured at 20°C. The compressive strength dropped off after heating at 600°C – to 75% of the initial value in the case of air-entrained HPC, to 65% in the case of fibre-reinforced HPC and to 82% in the case of reference concrete.

RezaAbaeianHamid, PesaranBehbahani (2018) describes about High Strength Concrete(HSC) is also more vulnerable to high temperatures due to its high density and low porosity compared to conventional concrete.The compressive strength of normal concrete in the face of heat was reduced with a slight slope and reduced by 4%, 8%, and 14% when exposed to temperatures of 100, 200 and 300 °C, respectively. Compressive strength of HSC decreased significantly such that its strength reduced up to 7.2%, 14.5%, and 27.5% after exposure to 100 °C, 200 °C and 300 °C, respectively. This proves that the HSC is more susceptible to spalling than normal concrete at high temperatures.

D. AnupamaKrishna[a]R SPriyadarsinI (2019) a wider variation is observed in the temperature range above 500°C.This is mainly because of the variations from different tests using different heating or loading rates, specimen size and curing , testing conditions (moisture content and age of specimen), and the use of admixtures. In ASCE 1992 model the compressive strength of concrete is almost equal to zero at a temperature of 874°C. The model predicted by Chang et al.(2006) and Lie et al. (1986)also traces the same path. The strength in the predicted model from the present study also approaches to zero at a temperature of 800°C. This means that the concrete losses all its compressive strength at a temperature of near to 800°C.

ZhaohuiQin[a], ShengboZhou (2019) explained that the strength increases slowly with increasing curing time to 28 days, and the 1-hour strength can reach about seventy percent of the 28-day strength. The usage of metakaolin indeed increases the middle-term compressive strength, and the highest strength is observed in MPC mortar with 30% MK2. MPC mortar with 30% metakaolin can achieve the 28-day strength of over 60 MPa, about fifty percent higher than that of MPC mortar without metakaolin. More importantly, the increase in compressive strength of MPC mortar with metakaolin from 1 h to 28 days is much higher in comparison to that of specimen without metakaolin.

R.San Nicolas,[abc]M.Cyr (2014) presented the compressive strength of mortars incorporating different percentages of metakaolin (0% to 20%) increases compared to those containing only cement, the optimum being around 20%. It has also been proved that the introduction of metakaolin in the cement matrix has an effect on the pore structure, including its refinement.

CONCLUSION

The main reason for compacting the concrete with shockwave is to increase the compressive strength of concrete. When the shockwave is induced inside the concrete compressive strength of concrete gets increased. This phenomenon is particularly advantageous in case of structure subjected to high temperature condition.

REFERENCE

1. Hugo Caetano, Gisleiva Ferreira,et al.," Effect of the high temperatures on the microstructure and compressive strength of high strength fibre concretes", Construction and Building Materials,Volume 199,28 February 2019,Pages 717-736.

2. D. Anupama Krishna, R S Priyadarsini,et al., "Effect of Elevated Temperatures on the Mechanical Properties of Concrete", Procedia Structural Integrity, Volume 14, 2019,Pages 384-394.

3. Jiarong Shen, Qianjun Xu,et al.," Effect of elevated temperatures on compressive strength of concrete", Construction and Building Materials, Volume 229, 30 December 2019.

4. Jianhe Xie, Zhe,et al.," Coupling effects of silica fume and steel-fiber on the compressive behaviour of recycled aggregate concrete after exposure to elevated temperature, Construction and Building Materials, Volume 184,30 September 2018,Pages 752-764.

5. Metin Husem," The effects of high temperature on compressive and flexural strengths of ordinary and high-performance concrete", Fire Safety Journal, Volume 41, Issue 2, March 2006, Pages 155-163