Abstract of Dissertation

Behavior of moisture in mortar and concrete after exposed to high temperature

(高温暴露後のモルタル，コンクリート中の水分挙動)

Daungwilailuk Totsawat

In the case of fire accident, it was found that post-fire concrete structures do not need repairing when they have no spalling and their remaining compressive strength is appropriate for using. Even if it seems not to need repairing, when temperatures in concrete rise highly, chemical compositions and physical structures can be changed, such as dehydration reaction and cracking, resulting in easier ingress of moisture into post-fire concrete.

The aim of the research is to understand how moisture, carbon dioxide (CO_2) and chloride ions penetrate into usable post-fire concrete using electrical resistivity method. The residual calcium hydroxide (CH) is also investigated.

Mortar and concrete specimens with water-to-cement ratios (W/Cs) of 0.35 and 0.45 were prepared for testing. Polypropylene (PP) fiber was applied to the specimens with W/C of 0.35. Five surface of each specimens were covered by insulation materials to ensure that the high temperature could not effect the side of the sides of the specimen. One surface of each specimen was placed on a hot plate and exposed to a temperature of 350°C for 15 minutes with increment of temperature at a rate of approximately 20°C/min. The compressive strength and splitting tensile strength were measured after cooling down of heated specimen. On the other hand, the moisture transfer in the specimens stored at 20°C and 60% relative humidity was immediately assessed by measuring their electrical resistance through a couple of stainless steel rod (two-point uniaxial technique). The penetration of CO_2 and chloride ions was examined in the mortar and concrete specimens. The residual CH was investigated to ensure that the CH was not dehydrated by high temperature and did not produce calcium oxide (CaO), which it can affects carbonation.

After heating, the pore volume of heated mortar specimens was increased due to micro-cracking and melting of PP fiber, which the cracking and melting of PP fiber could be observed in SEM images. The micro-cracking also reduces the residual compressive strength of heated mortar and concrete specimens. The residual compressive strengths of heated mortar and concrete specimens are higher than 70% and 75% of unheated specimen, respectively.

By using two-point uniaxial technique, the electrical resistance of surface regions of the specimens was greater than at greater depths and the unheated specimens had the lowest resistance. It could imply that these regions of the heated specimens with and without PP fibers are drier than those of unheated specimens. It is due to evaporation and migration of moisture under high temperature. The increment of pore water vapor due to vapor migration into inside the mortar and concrete specimen create micro-cracking. The heated mortar specimens exhibited greater penetration of CO_2 and chloride ions compared to the unheated specimens. It could be said that the increment of pore volume and low moisture content in the heated specimen can accelerate carbonation and chloride penetration. PP fibers and high W/C also increased the rate of carbonation and chloride penetration into the mortar and concrete specimens after heating.