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Quantitative relationship between concrete neutralization depth and its influence factors

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Abstract

The concrete is a very common building material. It is widely used because of its good fire safety, low cost, convenient production process and no pollution to the environment. According to the pyrolysis process and mechanism of concrete, muffle furnace experiments were conducted. By studying the quantitative relationship of concrete's neutralization depth and its influence factors the paper establishes a mathmatical model of calculation neutralization depth, hoping to provide a reference for future fire investigation.

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Keywords: concrete, neutralization, muffle furnace, mathematical model.

d	neutralization depth (mm)
d_1	mean value of neutralization depth (mm)
T	heating temperature (℃)
t	heating time (min)
m	undetermined coefficient
n	undetermined coefficient
α	undetermined coefficient
β	undetermined coefficient
k_1	undetermined coefficient
k	undetermined coefficient

1.Summary of Concrete Centralized Traces

In concrete molding, gelled material cement and water [1] can have the following reactions:

$$3CaO\cdot SiO_2+6H_2O\rightarrow 3CaO\cdot 2SiO_2\cdot 3H_2O+3Ca(OH)_2$$

$$2CaO\cdot SiO_2+4H_2O\rightarrow 3CaO\cdot 2SiO_2\cdot 3H_2O+Ca(OH)_2$$

$$3CaO\cdot Al_2O_3+6H_2O\rightarrow 3CaO\cdot Al_2O_3\cdot 6H_2O$$

$$4CaO\cdot Al_2O_3\cdot Fe_2O_3+7H_2O\rightarrow 3CaO\cdot Al_2O_3\cdot 6H_2O+CaO\cdot Fe_2O_3\cdot 6H_2O$$

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After concrete becomes hard completely, it has about 5% of its total mass in it. its internal will exist accounted for about 5% of $Ca(OH)2$ in total mass. These the $Ca(OH)2$ becomes CaO after it is dewatered at high temperatures and appears neutralization traces when meeting absolute ethyl alcohol [2]. Much affected by the temperature, in general, concrete dehydration consists of three stages: (1) under 150 ℃, the free water in cement vaporized after being heated. Ca (OH)2 crystal crystalizes further, and those unhydrated hydrates further. All these make concrete hard and dense, and gain in strength; (2) at 150 ℃ ~ 200 ℃, the free water in cement has already been largely evaporated and concrete has lost the physical water absorbed by calcium silicate hydrate (C - S - H) and water in hydrated calcium aluminate, which causes concrete shrinkage; (3) started at 440 ℃ ~ 450 ℃, the paper determines tentatively to 450 ℃, the Ca (OH)2 begins to dehydration at decomposition temperature, and achieves maximum decomposition rate at around 575 ℃ [3].

2.Maffle Furnace Experiment of Concrete

100mm × 100mm × 100mm size of concrete cubes is choosen as the experimental material to conduct constant temperature heating experiments in muffle furnace. 22 kinds of conditions are set, and each condition has three sets of parallel experiments.

After the end of the experiment to be in each group, a stone chisel is used at the top surface of the concrete specimen to help measuring the neutralization depth. Due to the depth is mainly decided by heating temperature and heating time, so a relationship between neutralization depth, heating temperature and time:

$d = k1 \bullet (m \bullet T^{\alpha}) \bullet (n \bullet t^{\beta}) = k \bullet (T-450)^{\alpha} \bullet t^{\beta}$

The Relationship between neutralization depth and heating temperature is shown in Table 1, we can see the depth increase as the temperature growth.

Table 1. Relationship table of concrete neutralization depth and temperature

Heating Temprature (℃)	Heating Time (min)	Mean Value of neutralization Depth(mm)
475	10	1.93
500	10	2.70
525	10	3.00
550	10	3.47
575	10	4.10
600	10	4.40

Considering the practical significance, the paper accounts that Ca (OH) 2 begins to decompose at about 450 ℃, so if the heating temperature is lower than 450 ℃, neutralization depth should be 0 mm. Therefore, when fitting the relationship graph on heating temperature and neutralization depth, the fitting curve should cover (450,0) point. The best fit curve shown in Figure 1, the corresponding mathematical formula shown in equation (1).

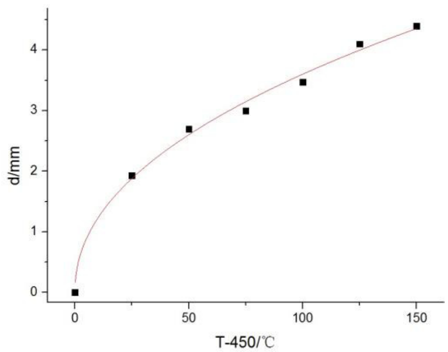

Fig 1 Relationship between neutralization depth and heating temperature