CHAPTER 3

CONCEPTS OF MODEL TO PREDICT COMPRESSIVE STRENGTH OF CONCRETE CURED AT ELEVATED TEMPERATURE

3.1 General

In engineering analysis, several approaches are used to describe mechanical properties, such as the strength development process. There are many concepts to determine the compressive strength of concrete such as the gel-space ratio concept, the total porosity concept, degree of hydration concept, maturity laws and others. A very good correlation has been recognized between the degree of hydration and the development of strength parameters. Furthermore, for fully compacted concrete, strength is found to be inversely proportional to the water to cement ratio. For brittle material, it appears that the amount of porosity has a close relationship with the strength.

The reliable models were proposed not only to achieve these concepts, but also were in advance to quantify the effects of curing temperature on strength development of concrete. To achieve these concepts and goals, the following models were introduced:

1. The 28-day compressive strength model for conventional concrete: this model takes into account the effect of CaO, w/b and γ. The detail of this model is shown in Appendix A.

2. The empirical function of average degree of hydration: the hydration rate is directly coupling by ages of concrete, curing temperature and water content of concrete. The concepts and detail of the average degree of hydration model will be shown in Chapter 4.

3. The strength development ratio model: the concepts of this model were divided into two parts. The first part considers strength ratio of concrete cured at room temperature condition. The second part, strength ratio of concrete cured at elevated temperature, will be introduced by the concept of the relative pore structure, which can be used to take into consideration the effect of temperature. The detail of strength ratio model will be shown in Chapter 5.

3.2 The Relationship Among the Models

As stated in section 3.1, the prediction of compressive strength is achieved by combining the effect of degree of hydration and strength development to the model. The 28-day compressive strength model at normal curing temperature is used as the based strength for predicting strength at elevated temperature. The reasons why this model is used as based model are: 1) there are more abundant and reliable data for 28-day compressive strength than any other ages; and 2) the 28-day compressive strength model at normal curing temperature has already been constructed and verified by Tangtermsirikul et al. (1999). This model is to be applied with the average degree of hydration model and the strength development ratio model in order to predict compressive strength at any other ages for room cured temperature. Furthermore, the relative pore structure concept is taken into account in the strength development ratio model to consider the effects of elevated curing temperature. Fig. 3.1 shows the process how to predict compressive strength of concrete by using this model. To predict compressive strength of concrete ($f'_c(t,T)$), the 28-day compressive strength model at normal curing temperature and strength ratio function ($\phi(t,T)$) are required. To achieve the satisfactory model, strength ratio cured at room temperature ($\phi(t,30°C)$), the effect of changing in pore structure of concrete (β) and hydration ratio (α_{nav}) are needed to be considered in the strength ratio function ($\phi(t,T)$).

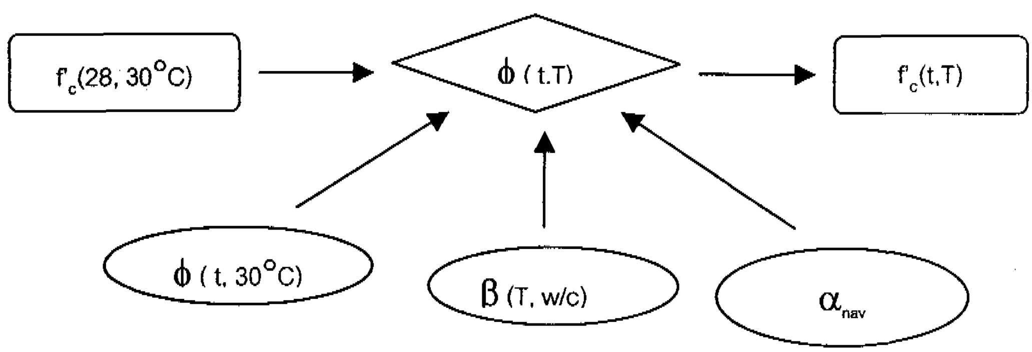

Fig. 3.1 The diagram to predict compressive strength of concrete at any age and any curing temperature

3.3 Equation for Predicting Compressive Strength of Concrete at Elevated Temperature

The form of the equation used to predict compressive strength of concrete at elevated temperature is expressed in Eq. (3.1)

$$f(t,T) = f(28,30°C)\times\phi(t,T) \tag{3.1}$$

$$\phi(t,T) = \phi(t, 30°C)+\beta \tag{3.2}$$

where $f(t,T)$: compressive strength of concrete at any considered age t and cured at any elevated temperature (MPa)

$f(28,30°C)$: the 28-day compressive strength of concrete cured at room temperature (MPa)

$\phi(t,T)$: strength development ratio at any considered age t and cured at any elevated temperature

$\phi(t, 30°C)$: strength development ratio at any considered age t and cured at room temperature

β : the effect of changing in pore structure due to the changing of curing temperature

t : age of concrete (days)

T : curing temperature (°C)