CONCRETE, FRESH:
INITIAL SETTING TIME AND
ACTIVATION ENERGY DURING SETTING

Key words: Concrete, heat development, initial setting

1. SCOPE

This NORDTEST method specifies a method for the determination of the initial setting of fresh concrete by measuring the heat development of the concrete during the first hours. A method of determination of the activation energy during the setting period is also specified.

The setting of concrete normally refers to the start of the growth of strength which is determined for concrete according to NT BUILD 197. The initial setting period is normally finished within eight hours after mixing.

The time for the initial setting of concrete is the age at which 12.5 kJ heat is liberated per kg cement according to Clause 6.3. This age corresponds with the age at which the penetration resistance, as defined in NT BUILD 197, reaches 3.5 MPa.

2. FIELD OF APPLICATION

Since the setting of concrete is a gradual process, any definition of time of setting must necessarily be arbitrary. In this test method, the time required for the concrete to liberate a specified amount of heat is used to define the time of initial setting.

This test method can be used to determine the effects of variables, such as brand, type and content of cementitious material, water content, and admixtures, upon the time of initial setting of concrete. This test method may also be used to determine compliance with specified time of setting requirements.

The setting time of the concrete is a function of the curing temperature. It is necessary to know the activation energy of the setting period, in order to estimate the setting time for temperatures different from +20 °C by calculating the maturity. The activation energy during the setting period is different from the activation energy of the remaining hardening period.

3. REFERENCES

NT BUILD 191: Concrete, Fresh: Sampling.
NT BUILD 197: Concrete, Fresh: Stiffening (Penetration Resistance)
NT BUILD 388: Concrete: Heat Development

4. DEFINITIONS

Time of initial setting: the elapsed time, after initial contact of cement and water, required for the concrete to liberate 12.5 kJ heat per kg cement (cement + fly ash, cement + silica).

5. SAMPLING

The sampling procedure should be as stated in NT BUILD 191.

6. METHOD OF TEST

6.1 Principle

The energy production during the hardening of a concrete sample is calculated on the basis of measured temperatures in the sample and its surroundings depending on one of the methods described in NT BUILD 388. The initial setting time is the age at which 12.5 kJ heat is liberated per kg cement. The activation energy is determined by measuring the heat development starting at three different temperatures.

6.2 Apparatus

- Concrete mixer.
- Thin-walled metal container.
- Temperature conditioning box, which can be either a), b) or c) depending on the method used:
  a) Adiabatic calorimeter
  b) Haybox calorimeter
  c) Insulated mould
- Data collecting equipment adapted to the devices built into the temperature conditioning box.

6.3 Procedure

6.3.1 Determination of initial setting time

The heat development during the hardening of the concrete sample is measured according to NT BUILD 388. The
measured data are transformed by calculation so that the generated heat is presented as a function of time and maturity of the concrete (NT BUILD 388) as described in 6.3.2. The time \( t \) of initial setting is determined as shown in Fig. 1, with a correction for the heat development during the dormant period. The correction is made by using the heat development curve of the dormant period as a base line. The time of initial setting is defined as the point of intersection of the line parallel to the base line, at a distance of 12.5 kJ from the base line, and the heat development curve.

### 6.3.2 Determination of activation energy during the setting period

The heat development during hardening of the concrete is measured according to NT BUILD 388, starting at three different temperatures: \( \Theta < +20 \, ^{\circ}C \) (e.g. \( \Theta = +5 \, ^{\circ}C \)), \( \Theta = +20 \, ^{\circ}C \), \( \Theta > +20 \, ^{\circ}C \) (e.g. \( \Theta = +35 \, ^{\circ}C \)). The measured data are transformed by calculation so that the generated heat is presented as a function of time and maturity of the concrete (NT BUILD 388).

The activation energy used in the calculation of the maturity is given by:

\[
E(\Theta) = E_0 + E_1(20 - \Theta) \text{ J/mol}
\]

\( E_1 = 0 \) for \( \Theta \geq +20 \, ^{\circ}C \).

The activation energy is determined by iteration, calculating the maturity to bring the three heat development curves to coincide at \( dQ = 12.5 \, \text{kJ/kg} \) as shown in Fig. 2. The activation energy \( E_0 \) is determined by bringing the heat development curves from the +20 °C and the +35 °C measurements to coincide. The activation energy \( E_1 \) is determined by using the calculated \( E_0 \) and bringing the heat development curves from the +20 °C and +35 °C measurements to coincide with the heat development curve from the +5 °C measurement.

### 6.4 Expression of results

The elapsed time between initial contact of cement and water and the age at initial setting is to be stated in hours and minutes with the single unit figure rounded off to 0.

### 6.5 Test report

The test report shall include the following information:

a) Name and address of the testing laboratory.

b) Identification number of the test report.

c) Name and address of the organisation or the person who ordered the test.

b) Purpose of the test.

d) Identification of the tested concrete mix.

e) Date of the test.

f) Test method.

g) Test equipment and instruments used.

h) Identification of the test equipment and instruments used.

i) Any deviations from the test method.

j) Test results (in SI units):
   - setting time and corresponding temperature
   - activation energy during setting period
   - maturity at setting

k) Inaccuracy and uncertainty of the test result.

l) Date and signature.