CHAPTER 4 VERIFICATION OF CRACKING AT CONSTRUCTION STAGE

4.1 General

If cracking at the construction stage is likely to impair the safety, watertightness, airtightness, durability or appearance of a structure, verification described in this chapter shall be performed.

Verification of cracking due to settlement and cracking due to plastic shrinkage usually may not be required. Verification concerning cracking due to cement hydration and autogenous shrinkage may not be required for the structures that can be deemed safe judging from accumulated construction experience of similar types of structures.

[Commentary] The Standard Specifications for Concrete Structures (Structural Performance Verification) describes verification methods for cracking due to loads acting on an in-service structure, but the specification does not cover methods of checking on the influence of cracking that occurs in a structure at the construction stage on the serviceability and safety of the structure. The influence of cracks occurring in a structure under construction on various performance of the structure during its design service life has not been fully elucidated. Making sure, however, that harmful cracks will not occur at the construction stage goes a long way toward assuring that the required performance will be maintained during the design service life of the structure. Cracks caused by volume changes occurring at the construction stage can be controlled by various means. Those cracks can be controlled, even after mix design or structural details have been determined, by, for example, changing construction procedures or modifying curing methods. Unlike cracks that occur in an in-service structure, cracks that occur during the construction of a structure can be detected easily at the time of the acceptance inspection of the structure. The cracking-related verification methods described in this chapter, therefore, have been designed taking into consideration the possibility of performing such verification independently.

As major types of cracks that occur at the construction stage, this chapter deals with cracks caused mainly by segregation and rapid drying that occurs before newly placed concrete hardens and cracks caused by changes in concrete volume due to hydration and drying. Cracking due to settlement, which typically occurs over reinforcing bars and in members of non-uniform cross section, can usually be prevented by performing tamping at an appropriate time. Cracking due to plastic shrinkage, which often occurs in cases where the rate of evaporation from the surface is higher than the rate of bleeding, can usually be prevented by preventing rapid drying of poured concrete from the surface. Thus, by placing concrete as described in this specification, problematic cracking due to settlement or plastic shrinkage can be prevented. In cases where the methods described in this specification are not used, it is necessary to verify, by an appropriate method, that these types of cracking will not have adverse effects on the structure.

Evidently, for the types of structures that have been constructed in large numbers and have been clearly proved by construction records to be free from harmful cracking, the verifications described in this chapter may not be required.

4.2 Verification of cracking due to cement hydration

4.2.1 General

(1) Verification of the occurrence of cracks due to the hydration of cement shall be made, in general, by finding volume changes due to the temperature distribution calculated through thermal analysis and volume changes due to autogenous shrinkage and verifying that harmful cracks will not be caused by the concrete stresses calculated through stress analyses in which the volume changes mentioned above are taken into account.

(2) In the verification of the occurrence of cracks due to the hydration of cement, structures may be deemed to have been passed if the following criterion is satisfied:

$$I_{cr}(t) \geq \gamma_{cr} \quad (4.2.1)$$

where,

$I_{cr}(t)$: cracking index

$I_{cr}(t) = f_{tk}(t)/\sigma_t(t)$

$f_{tk}(t)$: tensile strength of concrete at age of *t* days

σt(*t*): maximum principal tensile stress in concrete at age of *t* days

γ_{cr}: safety factor for probability of occurrence of cracks. The factor maybe 1.0 to 1,8

(3) In cases where the effect of autogenous shrinkage does not need to be taken into consideration, the cracking index $I_{cr}(t)$ may be calculated using Eqs. 4.2.2 and 4.2.3.

When stresses due to the internal restraint are predominant:

$$\text{Thermal cracking index } I_{cr}(t) = 15/\Delta T_i \quad (4.2.2)$$

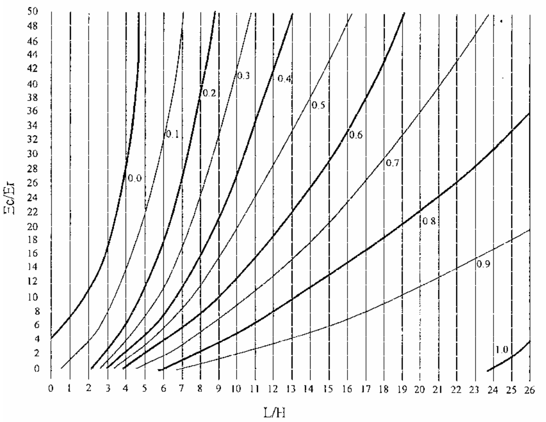
When stresses due to the external restraint are predominant:

$$\text{Thermal cracking index } I_{cr}(t) = 10/(R \cdot \Delta T_o) \quad (4.2.3)$$

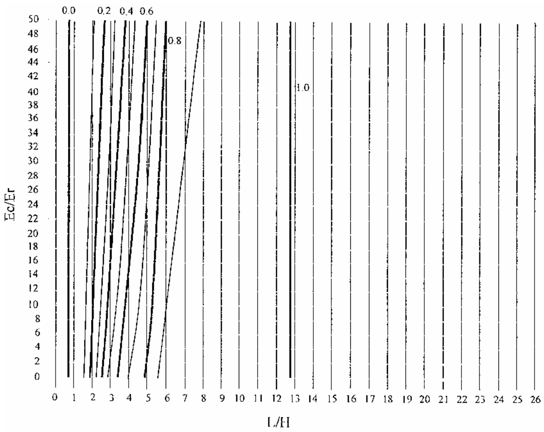
where,

T_i: temperature difference between the inside and outside of the member at the peak temperature (°C),

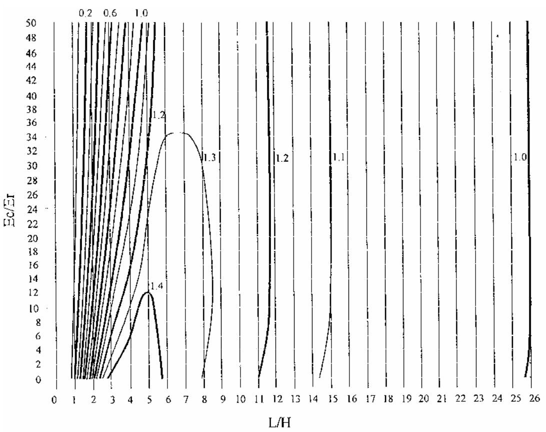
T_o: difference between the maximum average temperature of the member and its



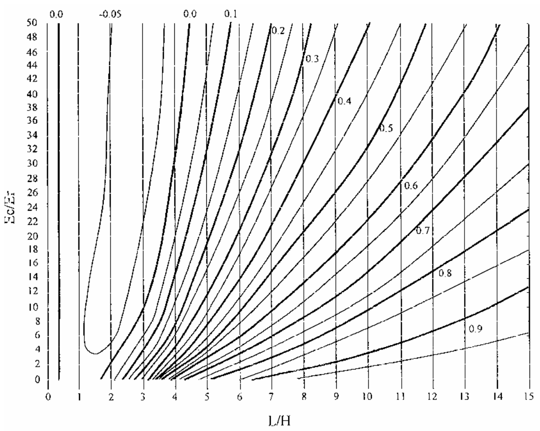
(a) Axial restraint factor R_N
(First lift)



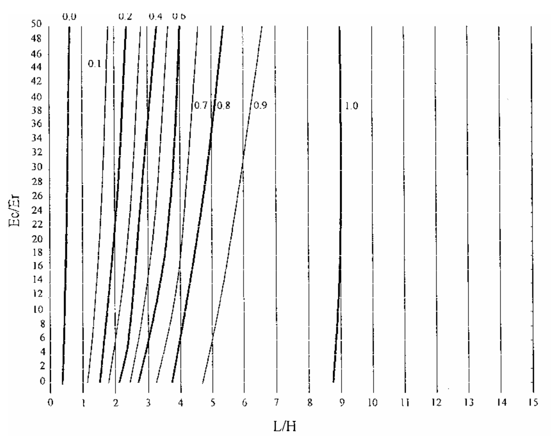
(b) Bending restraint factor R_{M1}
(First lift: Δ Φ before reversing)



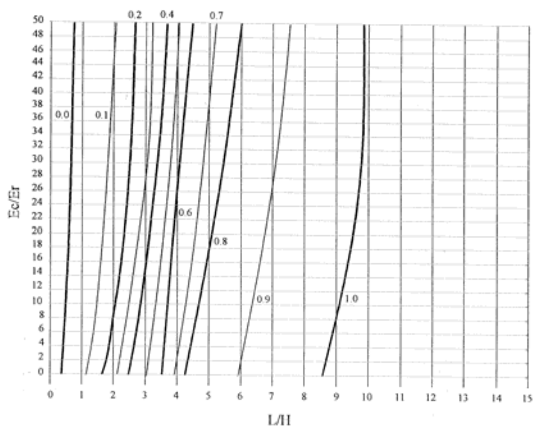
(c) Bending restraint factor R_{M2}
(First lift: Δ Φ after reversing)



(d) Axial restraint factor R_N
(Second lift)



(e) Bending restraint factor R_{M1}
(Second lift: Δ Φ before reversing)



(f) Bending restraint factor R_{M2}
(Second lift: Δ Φ after reversing)

Figure C4.2.6 External restraint factor（Wall structures）