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Controlling Durability during Construction

- Examples, Case Studies

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1. Introduction

One substantial problem of the durability of reinforced concrete structures is the protection of reinforcement against corrosion, This protection is normally ensured by the basic (that is: hydroxyl ion concentration) nature of the concrete. However, this basic environment surrounding the reinforcement bar can be destroyed by carbonation, i. e. the reaction of atmospheric carbon dioxide with the calcium hydroxide of the concrete.

In the face of this fact two outstanding factors have emerged as protection against corrosion:

- the thickness of the concrete covering and
- the density of the concrete covering.

The concrete covering is the concrete layer between the surface of the reinforcement bar and the outer surface of the concrete. In addition to securing a sufficient protection against corrosion of the reinforcement the covering also serves in

- taking up bond strength
- providing an effective fire protection.

2. Measures for increasing the durability of the concrete structure by increased protection against corrosion during construction

2.1 Thickness of concrete covering

The thickness of concrete covering is, generally speaking, influenced by the following factors:

- measurements of the bent and suspended reinforcement
- clearing width of the form work
- amount of dislocation of the reinforcement cage during concreting.
- height/thickness of spacers

On the basis of a research projekt it became evident that, provided the influencing factors are independently and normally distributed, a standard deviation of concrete covering of approx. 8 mm is to be expected.

Consequently, on construction sites the following checks are carried out routinely or at least randomly:

- inspection of the measurements of bent and suspended reinforcement and rejection of those reinforcement bars that deviate in their lengths from the values of table 1.

- inspection of form work struts and rechecking of the clearing width of the form work immediately prior to concreting.

In order to avoid dislocation of the reinforcement cage during concreting a sufficient number of spacers must be used. The spacers must have sufficient bearing strength and be resistant

against deformation and tilting. Their height/thickness must correspond to the minimum concrete covering and include an allowance that takes into account all inevitable deviations.

2.2 Density of the covering

The density of the concrete covering is largely influenced by the following two factors:

- the water/cement ratio of the concrete
- the degree of hydration, i. e. the curing of the concrete

By using concrete plasticizers it is nowadays no problem to produce and use a concrete with a sufficiently low water/cement ratio.

Because of the greater human factor involved it is definitely more difficult to achieve sufficient curing under site conditions. However, when using a minimum of discipline there are enough curing methods on hand today to suit every specific site and purpose.

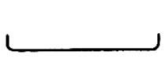
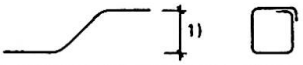
The effectivness of curing can be checked under site conditions. This may be done either by testing the permeability towards air by means of a vacuum or by the rate of water absorption of the concrete near to the surface.

3. Summary

The two parameters, thickness and density of the concrete covering, are the determining factors for durability of concrete structures as far as corrosion of reinforcement is concerned. Defect preventing methods are recommended that explain how the two parameters can be controlled during construction.

In the long run so-called "Trade-off-methods" may become feasable. These methods pre-suppose that quality is a constant while the two factors concrete thickness and concrete density can have variable values.

Stablänge l (m)	≦ 5,0	> 5,0
Abmaß Δ l (cm)	± 1,5	± 2,0
bei Paßlängen Δ l (cm)	± 0,5	± 1,0

Biegeform					
Stab Ø (mm)	bis 14	über 14	bis 14	über 14	bis 10	über 10
Abmaß Δ l (cm)	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
	− 1,5	− 2,5	− 1,0	− 2,0	− 1,0	− 1,5
bei Paßlängen Δ l (cm)	+ 0	+ 0	+ 0	+ 0	+ 0	+ 0
	− 1,0	− 1,5	− 1,0	− 2,0	− 0,5	− 1,0

[1]) Bei Festlegung dieses Maßes Abmaß der zugehörigen Bügel beachten (Passung)