

# **Corrosion protection of reinforcing steels**

Technical report prepared by

Task Group 9.7

February 2009

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>Corrosion protection by concrete</b>	<b>5</b>
2.1	Corrosion-protection capacity of concrete	5
2.1.1	Cement hydration	5
2.1.2	Formation of pores	7
2.1.3	Alkalinity of pore solution	9
2.1.4	Conditions for corrosion	10
2.2	Reasons of reinforcement corrosion	11
2.2.1	Carbonation	11
2.2.2	Chloride ingress	13
2.3	Enhancement of corrosion protection	15
2.3.1	Water/cement ratio and type of binder	15
2.3.2	High-performance concrete	19
2.3.3	Self-compacting concrete (SCC)	20
2.3.4	Controlled permeability formwork (CFP)	21
<b>3</b>	<b>Galvanized steel reinforcement</b>	<b>25</b>
3.1	Manufacture of the coating	25
3.2	Properties of coating and of galvanized reinforcement	27
3.2.1	Coating properties	27
3.2.2	Mechanical properties	29
3.2.3	Extreme temperatures	31
3.2.4	Fatigue	31
3.2.5	Weldability	31
3.2.6	The phenomenon of hydrogen evolution	32
3.2.7	Bond behaviour	35
3.3	Current specifications	37
3.4	Corrosion protection behaviour	38
3.4.1	Mode of action	38
3.4.2	Alkaline concrete without chloride	39
3.4.3	Carbonated concrete	40
3.4.4	Chloride-containing concrete	42
3.4.5	Cracks in concrete	46
3.4.6	Cracks in the zinc coating	46
3.4.7	Resistance to galvanic corrosion	47
3.5	Practical experiences with application	47
3.6	Benefits from the use of galvanized reinforcement	50
<b>4</b>	<b>Epoxy-coated reinforcement</b>	<b>55</b>
4.1	Manufacture of the coating	55
4.2	Properties of the coating and of epoxy-coated reinforcement	56
4.2.1	General properties	56
4.2.2	Durability of the coating	57

4.2.3	Protection properties	57
4.2.4	Mechanical properties of the steel	58
4.2.5	Fatigue behaviour of the steel	58
4.2.6	Weldability	58
4.2.7	Bond behaviour	58
4.2.8	Extreme temperatures	60
4.3	Current specifications	61
4.4	Corrosion protection behaviour	62
4.4.1	Results of laboratory and field tests	62
4.4.2	Cracks in concrete	65
4.4.3	Defects/cracks in the epoxy-coating, resistance to galvanic corrosion	65
4.5	Practical experience with application	68
4.5.1	Extent of use	68
4.5.2	Long time performance of coating	68
4.6	Benefits from the use of epoxy-coated reinforcement	70
<b>5</b>	<b>Stainless steel reinforcement</b>	<b>75</b>
5.1	Steel types	75
5.2	Types of corrosion of stainless steel	77
5.3	Production of stainless steel reinforcement	81
5.4	Structural properties	82
5.4.1	Mechanical properties	82
5.4.2	Physical properties	84
5.4.3	Weldability	85
5.5	Current specifications	86
5.6	Considerations of handling and design	89
5.7	Practical experiences with application	90
5.8	Corrosion behaviour	90
5.8.1	Reported corrosion resistance	90
5.8.2	Conclusions from research	106
5.8.3	Resistance to galvanic corrosion	108
<b>6</b>	<b>Cost aspects</b>	<b>113</b>