RILEM TC CCC
WG5

Effects of carbonation on corrosion of concrete with SCMs

Outline: STAR WG 5

1. Introduction
2. Field evidence
   (do we have sufficient field evidence? Climate in different geographic regions, etc) (*K.Imamoto, Fabrizio Moro, Sylvia Kessler, …)*
3. Pore solution chemistry evolution during carbonation (*Fabrizio Moro, Mette Geiker,…*)
   (pH evolution, sulfate/sulfide couple, etc.)
4. Passive film formation and modification in different systems (Sylvia Kessler, …)
5. Depassivation : relevant parameters (Mette Geiker,…)
   (e.g. presence of chlorides)
6. Corrosion rate (Ueli Angst, Mette Geiker,…)
   (depending on exposure moisture conditions)
7. Limit state <-> spalling/cracking
8. Conclusions

Field Survey on Re-bar Corrosion of Carbonated Existing Concrete Buildings in Japan

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No.	Function	Years of constructuion(Age)	Level	Finishing	Location
1	Warehouse	1914(100)	2	M	Hiroshima
2	Warehouse	1918(97)	2	U	Tokyo
3	Office	1926(90)	2	M,P	Gifu
4	House	1929(84)	4	M,F,S	Tokyo
5	School	1935(81)	3	U,M,F	Tokyo
6	Lab.	1935(81)	2	M,P	Tokyo
7	Lab.	1937(80)	2	M,P	Tokyo
8	Arena	1958(58)	5	U,M,F	Tokyo
9	Museum	1959(55)	3	U,M,F	Tokyo
10	Radio tower	1962(53)	2	M,F	Ibaraki
11	Office	1962(54)	8	M,F	Tokyo
12	Radio tower	1963(52)	1	M,F	Nagano
13	House	1965(44)	4	U,M,P	Tokyo
14	House	1965(44)	5	M,F	Tokyo
15	Office	1966(51)	8	M,P	Tokyo
16	School	1967(50)	3	M,P	Tokyo
17	School	1968(47)	6	U,M,P	Aichi
18	School	1968(49)	2	U,M,P,T	Chiba
19	House	1970(42)	7	M,F	Tokyo
20	House	1971(43)	13	U,M,P	Tokyo
21	Radio tower	1972(44)	2	M,F	Gifu

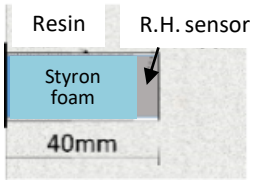
U:Exposed concrete, M:Mortar, P:Paint, F:Multi layer, T:Tile, S:Stucco

1. 1914(100)

3. 1926(90)

9. 1959(55)

8. 1958(56)



Carbonation depth

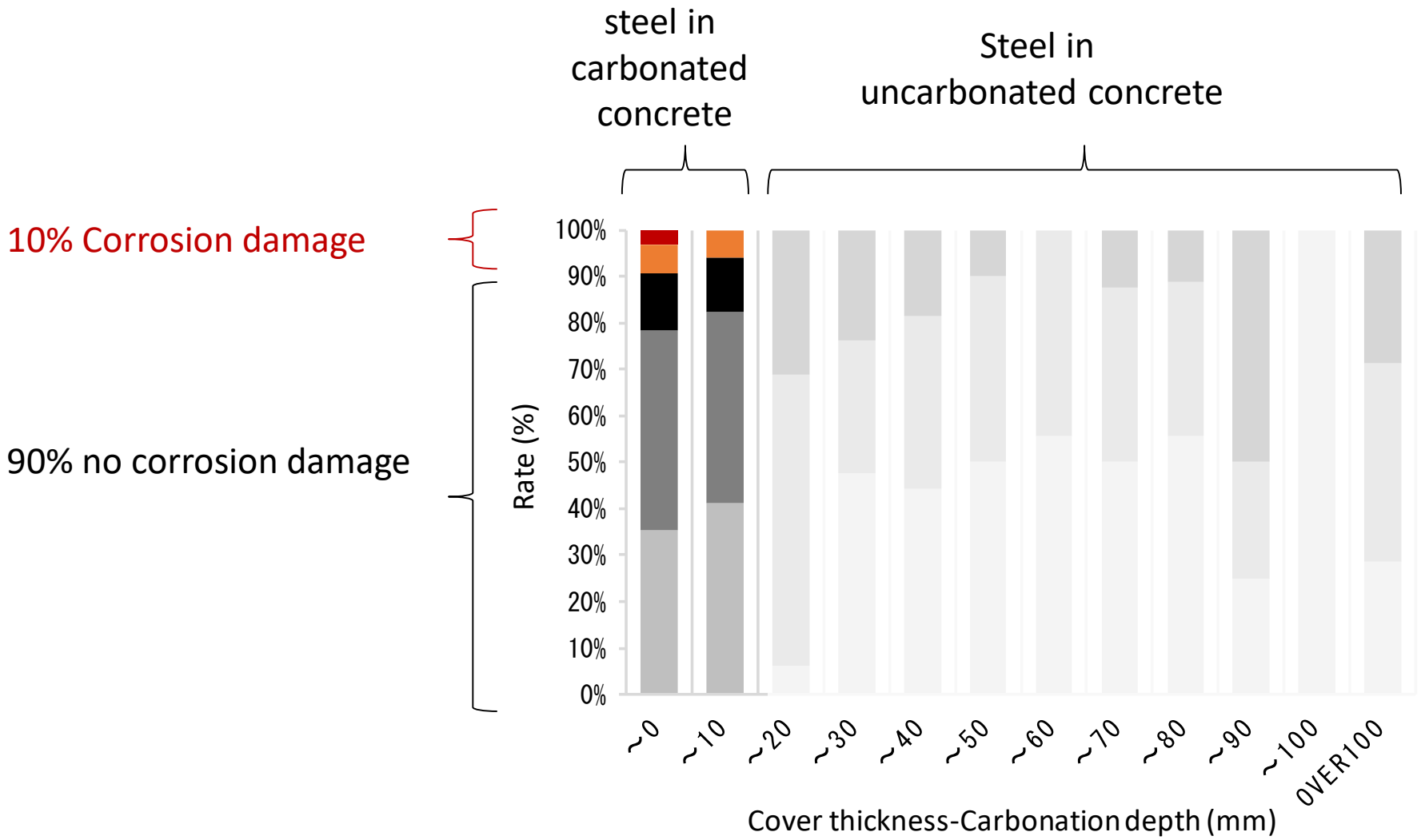
Cover thickness

Re-bar corrosion grade

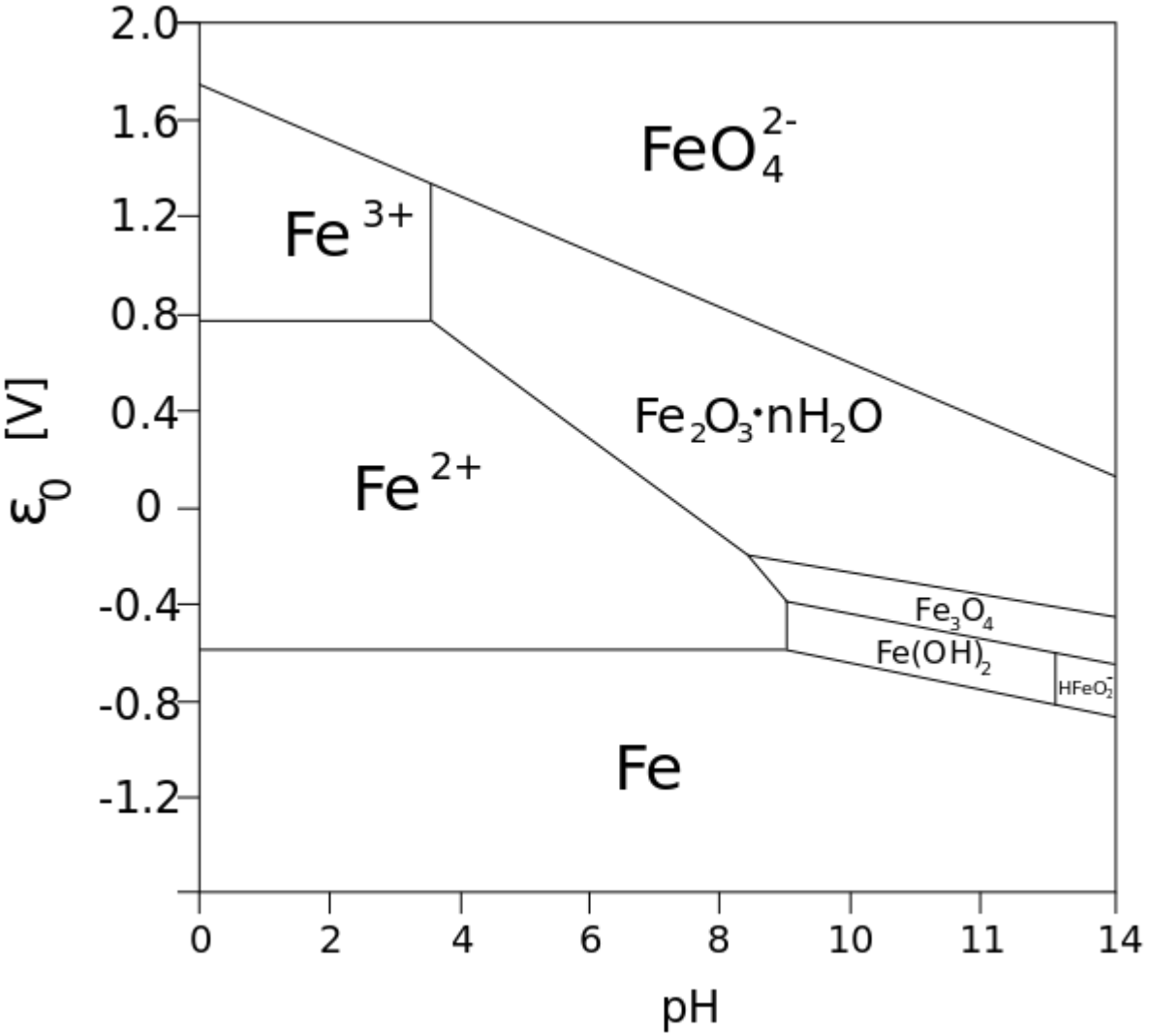
Moisture condition at covercrete

Grade	Corrosion condition	Example
1	No corrosion	
2	Partial slight corrosion	
3	Partial corrosion	
4	Overall corrosion	
5	Serious defect of section	

Field evidence from 21 buildings in Japan:



Passivation and Depassivation Pourbaix Diagramm

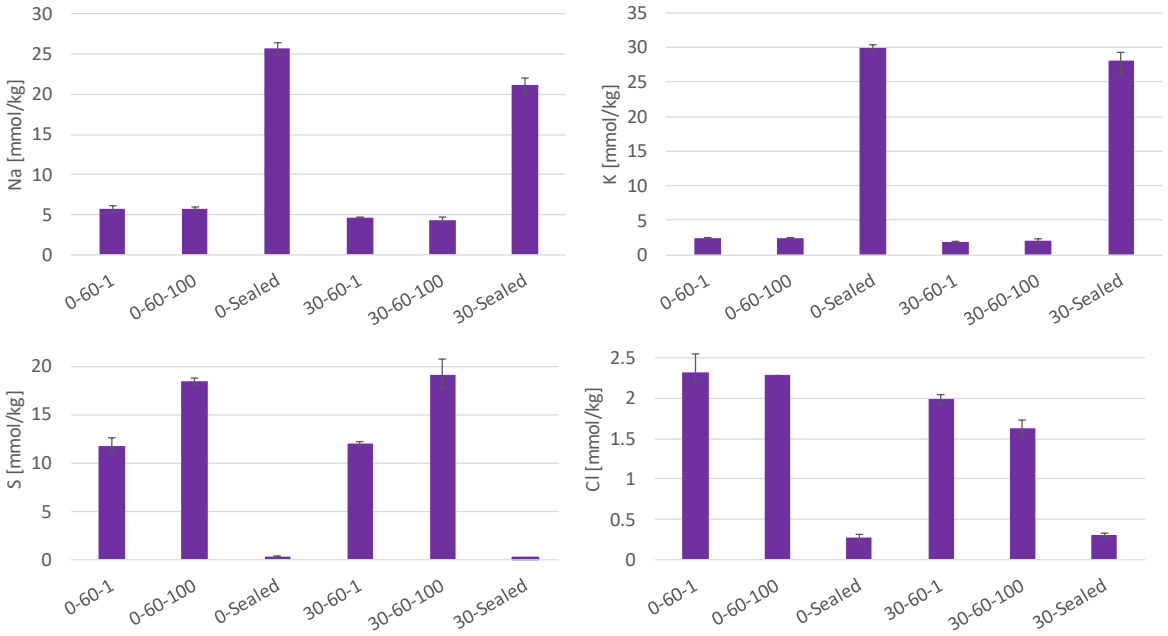


Pore solution of carbonated mortar

Materials (w/c 0.55, 2 weeks sealed)
- CEM I (0% FA)
- CEM II/B-V (30% FA)

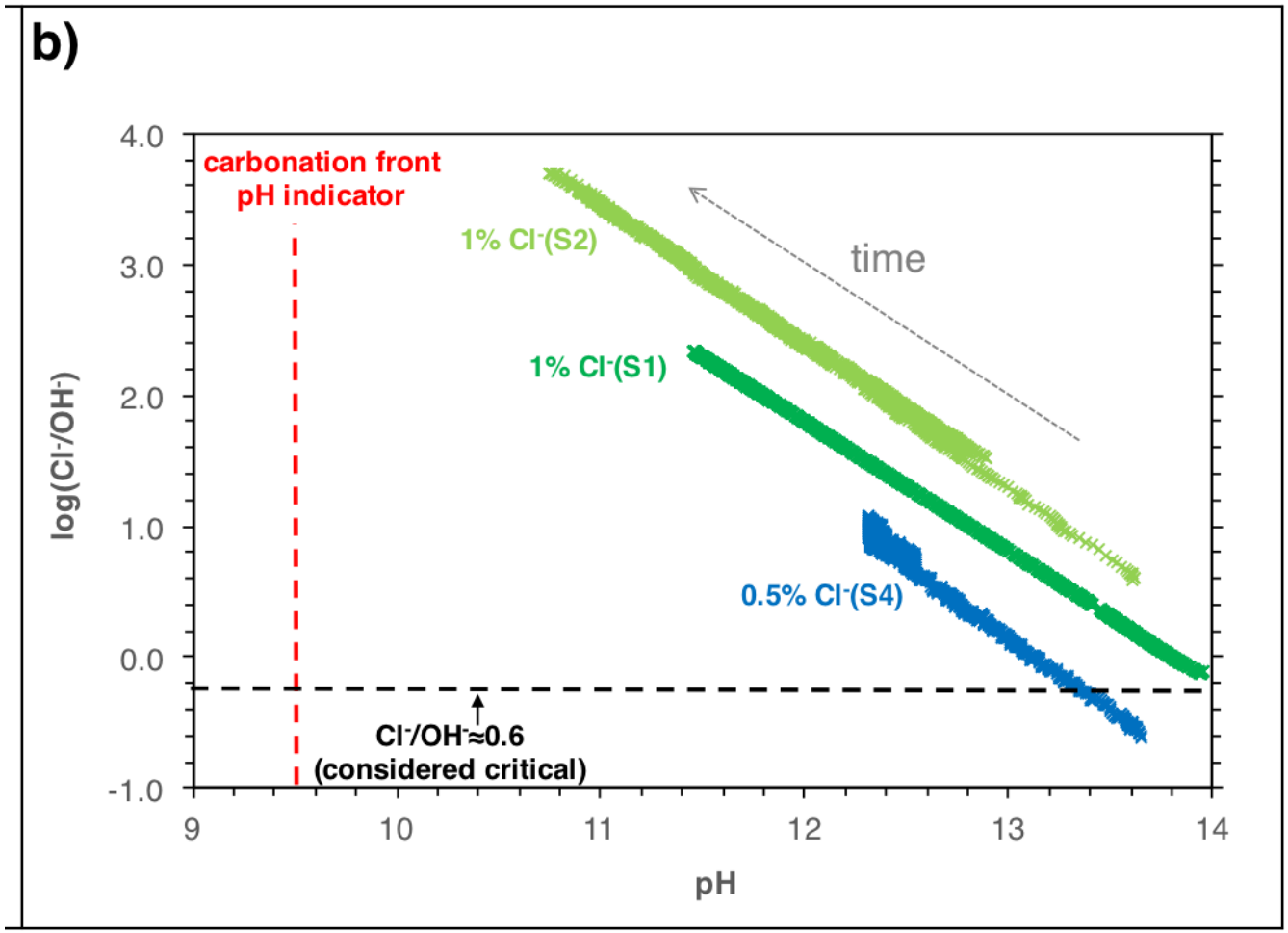
Exposure (for 20 weeks)
- Sealed
- 20°C, 60% RH, 1% CO_2
- 20°C, 60% RH, 100% CO_2

Methods
- pH indicator
- TGA
- Cold water extraction (CWE) + ICP



Labelling: <% FA>-<exposure (RH-CO_2)>, e.g. 30-60-1
sample containing 30% FA exposed to 60% RH and 1% CO_2

Cl^-/OH^- ratio


b)
carbonation front
pH indicator
1% Cl-(S2)
time
1% Cl-(S1)
0.5% Cl-(S4)
Cl-/OH-≈0.6
(considered critical)
log(Cl-/OH-)
pH
4.0
3.0
2.0
1.0
0.0
-1.0
9
10
11
12
13
14

Influence of exposure moisture condition on corrosion rate

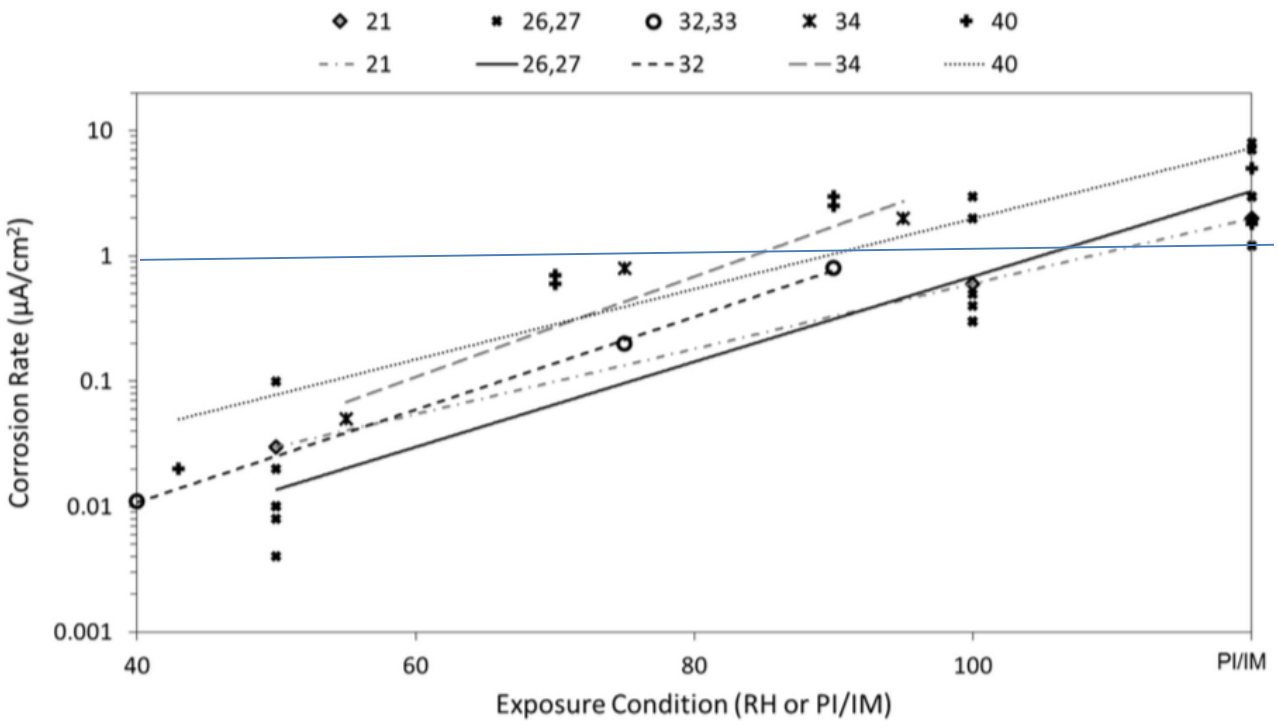
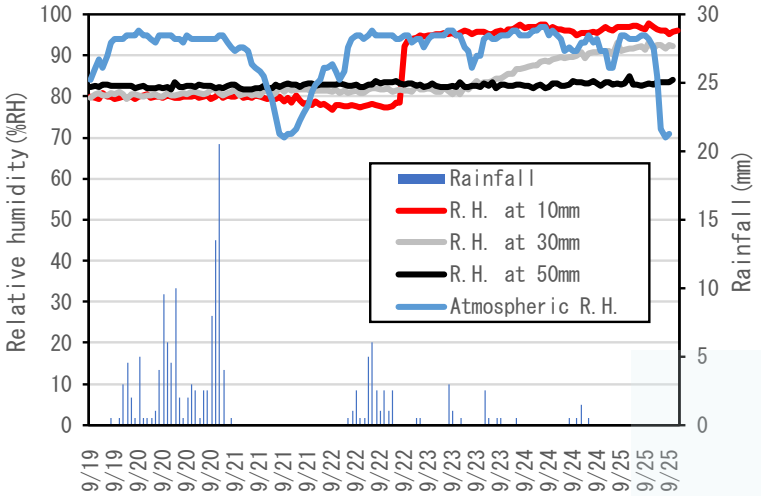
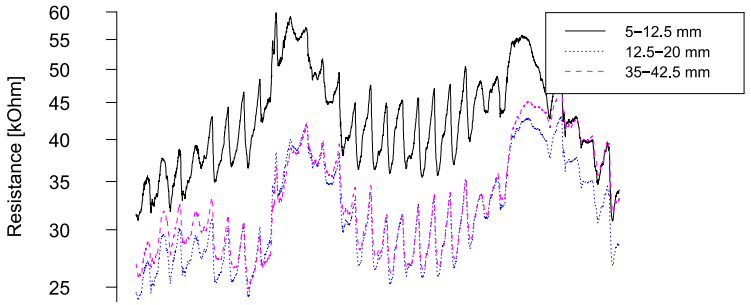


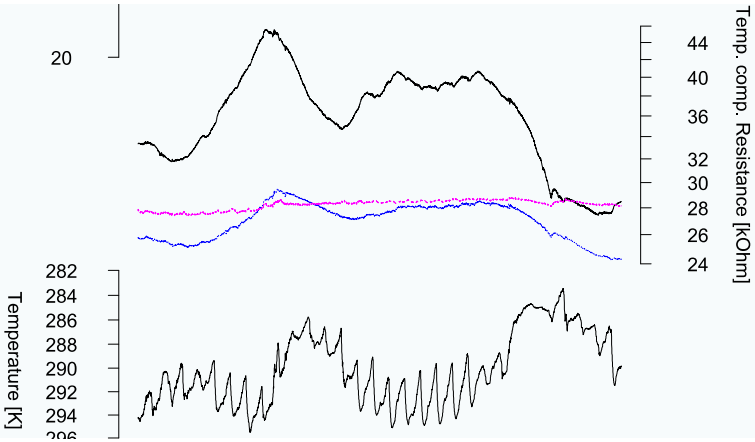
Fig. 8. Compilation of data showing the influence of the water content (exposure condition) on the corrosion rate. For immersed conditions an arbitrary value of RH higher than 100% was chosen.

0.01mm/year

Changes in R.H. in various cover depth







Outlook

- Corrosion damage in carbonated concrete – field data/case studies (*Imamoto*)
- Pore solution chemistry of uncarbonated and carbonated concrete
- Monitoring: exposure and corrosion