DANSK BETONFORENING

TEKNOLOGISK INSTITUT

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Workshop om nyt koncept for *durability design*

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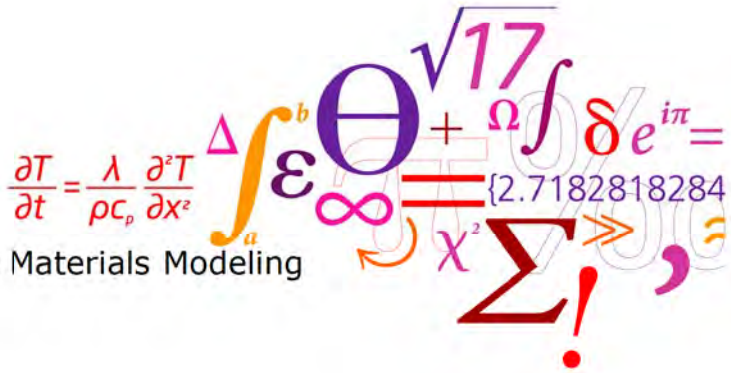


Some comments of the overall concepts

JWG – Durability Report 2014

JWG Durability

JWG 250/104 - N25

Steinar Leivestad, Convenor
2014.02.21

Overall concept

The drive to make concrete more sustainable will lead to cements with lower clinker contents and strong pressure to use recycled and secondary materials, which may have a poor shape. All these changes could have an adverse effect on concrete durability and consequently there is a need to have clearly defined performance criteria as an alternative to limiting values or a requirement when certain limits are exceeded.

A system is needed for the characterisation of the resistance of the concrete in reinforced concrete structures to the major deterioration mechanisms related to;

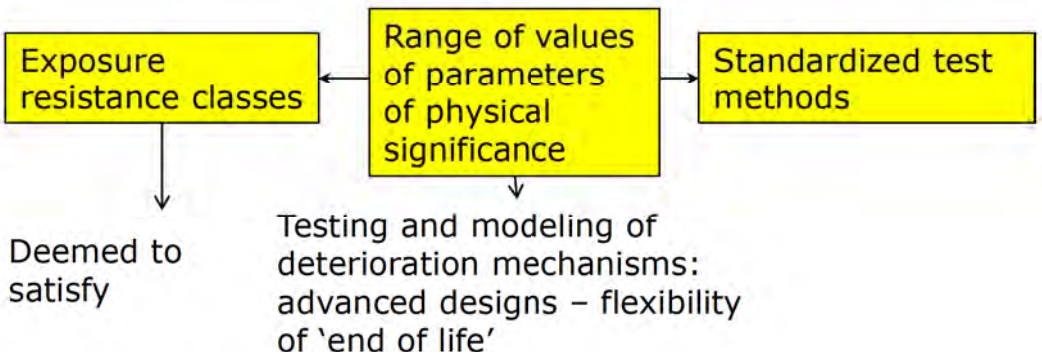
- corrosion of reinforcement i.e. carbonation, chlorides
- deterioration of the concrete i.e. freeze/thaw action, alkali-aggregate reaction and chemical aggressiveness such as sulphate attack

For this purpose it is proposed a system with exposure resistance classes. The definition of a resistance class should be performance based. For implementation in practical daily design deemed to satisfy rules for these classes could be developed, based on experience and calibration with up to date technology and knowledge.

Finally rules are needed for relating design working life and exposure conditions to exposure resistance classes and as a result from that determining the minimum concrete cover.

Overall concept

Yes! In particular:



Deemed to satisfy materials and designs & Possibilities for advanced modeling and non-standard materials and designs in the same framework !

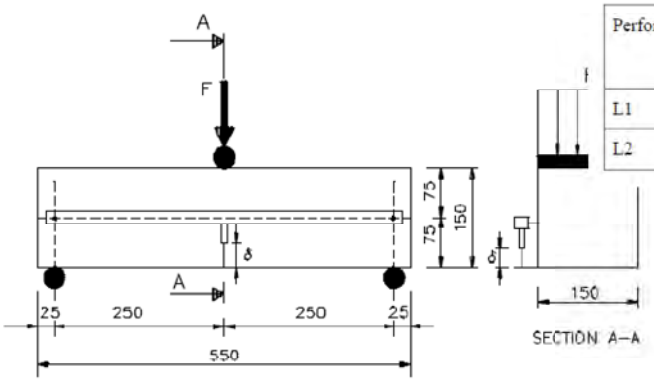
Overall concept – a parallel case

FJERNVARMETUNNELEN, hvor der er benyttet stålfiberbeton, begynder på Amagerværket og slutter på Nørrebro i København. Foto: Polfoto

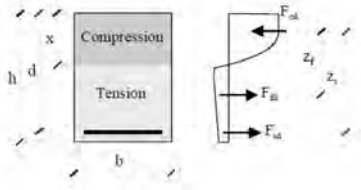
Fiberbeton vinder frem

B h a v A P e ß p S r b ß

ger, som netop forskerne på DTU for-



Performance class	Verification in	$CMOD$ values determined according to Part 3 of this guideline
L1	SLS	$CMOD_{L1}$ = 0.5 mm
L2	ULS	$CMOD_{L2}$ = 3.5 mm



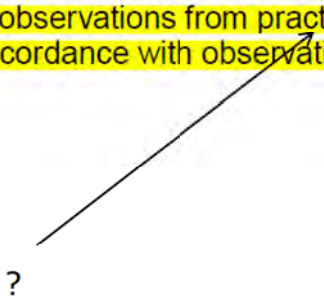
Questions… Is this all??

The basic parameters to consider in a system for practical design of concrete for durability are;

- characterisation of exposure conditions
- characterisation of resistance characteristics of concrete
- rules for relating resistance to exposure
- requirements for relating minimum concrete cover to exposure intended working life and resistance
- requirements to behaviour under service conditions e.g. cracking etc.

Questions... Definition of resistance classes

The definition of the classes should be performance based, that will allow technology development without a need to amend the classes. The definition should also be related to exposure conditions defined in the system of exposure classes, and with requirements corresponding to realistic requirements while not necessarily being the final requirement(s). This would allow use of experience and observations from practice to calibrate requirements, and to adjust concrete specifications in accordance with observations from real structures under normal service conditions.



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Questions... Coupled issues: e.g. crack and the presence of cracks

The basic parameters to consider in a system for practical design of concrete for durability are;

- characterisation of exposure conditions
- characterisation of resistance characteristics of concrete
- rules for relating resistance to exposure
- requirements for relating minimum concrete cover to exposure intended working life and resistance
- requirements to behaviour under service conditions e.g. cracking etc.

Table 2 Definition of exposure resistance classes

Corrosion of reinforcement						Deterio
Carbonation Resistance Class			Chloride Resistance Class			Freeze/t Class
RC (Low)	RC (Medi-um)	RC (High)	RSD (Low)	RSD (Medi-um)	RSD (High)	RF (Medium)
Definition of class is 50-years of exposure to XC3 (Rh 65%) with 10%-probability of carbonation front exceeding (mm)			Definition of class is 50-years of exposure to XS2, with 10%-probability of chloride concentration exceeding 0,5% at depth (mm)			Definitio years of with 10% scaling l (kg/m^2)
40	30	20	75	60	45	10

The concept of resistance classes is based on un-cracked concrete

Concretes of the same resistance class could have very different strengths and cracking behaviour

How to link cracking requirements, exposure and resistance???

Questions... End of Service Life

splitting stresses due to bond etc. utilized in the mechanical design of the structures. From the statistical distribution of cover, carbonation rate or chloride diffusion coefficient as well as aggressiveness of the environment this criterion will not exclude a certain level of corrosion on a limited percentage of the reinforcement. The criterion has also to be modified, or the target reliability, in exposure conditions where the propagation period is very long e.g. X0 and XC1.

When assessing existing structures and their remaining service life, however, the criteria shall be based on assessed/observed performance on a case by case basis, taking due account of the effect of observed deterioration on structural strength and safety etc.

How flexible could the applied 'end of service life' be?

Corrosion rate in stead of onset of corrosion

Why difference with respect to the methodology for new and existing structures?

Questions – Probabilistic approach

Table 2 Definition of exposure resistance classes

Corrosion of reinforcement						**Deterioration of concrete**			
Carbonation Resistance Class			**Chloride Resistance Class**			**Freeze/thaw Resistance Class**		**Chemical Aggressiveness Class** (for later)	
RC (Low)	**RC** (Medium)	**RC** (High)	**RSD**	**RSD**	**RSD**	**RF**	**RF**	**RCA**	**RCA** (High)
Definition of class is 50-years of exposure to XC3 (Rh 65%) with 10%-probability of carbonation front exceeding (mm)			Definition of class is 50-years of exposure to XS2, with 10%-probability of chloride concentration exceeding 0,5% at depth (mm)			Definition of class is 50-years of exposure to XF4, with 10%-probability of scaling loss exceeding (kg/m^2)		Definition of class is 50-years of exposure to XA3, ground water with SO^2_4 6000mg/l and 10%-probability of loss exceeding (g/m^2)[??]	
40	30	20	75	60	45	10	2	?	?

Guidelines for a full probabilistic approach?