Guidance for repair and rehabilitation of concrete transport infrastructures (CTIS)

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European Union
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ATLANTIC AREA
Transnational Programme

Aim of the Activity

To make a critical review of main aspects of CTIS repair, damage, assessment and repair techniques

- Exposure variations
- Types of structures
- Causes of deterioration
- Material degradation models
- Impact of degradation on performance
- Decision on time of intervention
- Establishment of performance requirements
- Repair strategy – methods and materials
- Assessment of repair performance

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Exposure Classes in EN 206

- No risk of corrosion
- Carbonation-induced corrosion
- Chloride-induced corrosion resulting primarily from de-icing salts
- Chloride-induced corrosion resulting from seawater exposure
- Freeze-thaw attack
- Chemical attack

Exposure Classes in EN 206

Class	Environment	Examples
1. No risk of corrosion or attack		
X0	Concrete with no embedded metal (except where there is freeze/thaw, abrasion or chemical attack) For concrete with reinforcement or embedded metal: very dry	Concrete inside buildings with very low air humidity.
2. Corrosion induced by carbonation		
XC1	Dry or permanently wet	Concrete inside buildings with low air humidity Concrete permanently submerged in water
XC2	Wet, rarely dry	Concrete surfaces subject to long-term water contact Many foundations
XC3	Moderate humidity	Concrete inside buildings with moderate or high air humidity, External concrete sheltered from rain
XC4	Cyclic wet and dry	Concrete surfaces subject to water contact, not within exposure class XC2

Exposure Classes in EN 206

3. Corrosion induced by chlorides other than from seawater		
XD1	Moderate humidity	Concrete surfaces exposed to airborne chlorides
XD2	Wet, rarely dry	Swimming pools, Concrete exposed to industrial water containing chlorides
XD3	Cyclic wet and dry	Parts of bridges exposed to spray containing chlorides Pavements, Car park slabs
4. Corrosion induced by chlorides from seawater		
XS1	Exposed to airborne salt but not in direct contact with seawater	Structures near to or on the coast
XS2	Permanently submerged	Parts of marine structures
XS3	Tidal, splash and spry zones	Parts of marine structures

Exposure Classes in EN 206

5. Freeze/thaw attack with or without de-icing agents		
XF1	Moderate water saturation, without de-icing agent	Vertical concrete surfaces exposed to rain and freezing
XF2	Moderate water saturation, with de-icing agent	Vertical concrete surfaces of road structures exposed to freezing and airborne de-icing agents
XF3	High water saturation, without de-icing agent	Horizontal concrete surfaces exposed to rain and freezing
XF4	High water saturation, with de-icing agent or seawater	Road and bridge decks exposed to direct spray containing de-icing agents and freezing. Splash zones of marine structures exposed to freezing.
6. Chemical attack		
Where concrete is exposed to chemical attack from natural soils and ground water is given in Table 3, the exposure shall be classified as given below. The classification of seawater depends on the geographical location; therefore the classification is valid in the place of use of the concrete.		
XA1	Slightly aggressive chemical environment according to Table 3	
XA2	Moderately aggressive chemical environment according to Table 3	
XA3	Highly aggressive chemical environment according to Table 3	

Review of EN206

- BS EN8500 compliment to EN206-1
- IS EN206 Irish Guidelines to EN206-1
- NP EN206-1 Portuguese Guidelines to EN206-1
- French and Spanish guidelines

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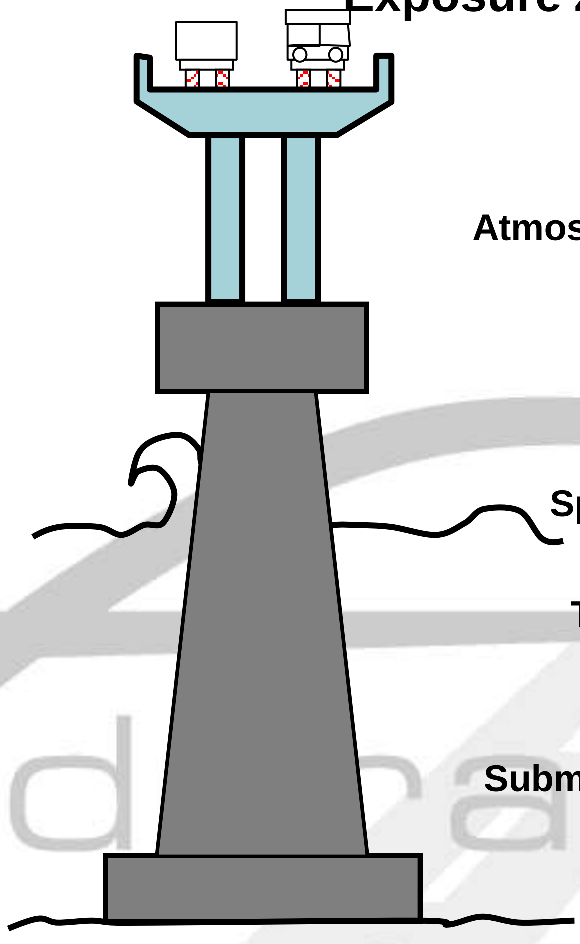
Types of Structure



Exposure Zone	Primary Concerns?
Atmospheric	Corrosion due to air-borne chlorides and carbonation
Splash	Corrosion due to chlorides, Erosion due to wave impact
Tidal	Corrosion due to chlorides, Growth of bio-organisms
Submerged	Corrosion due to chlorides, Change in microclimate due to seafloor sediments

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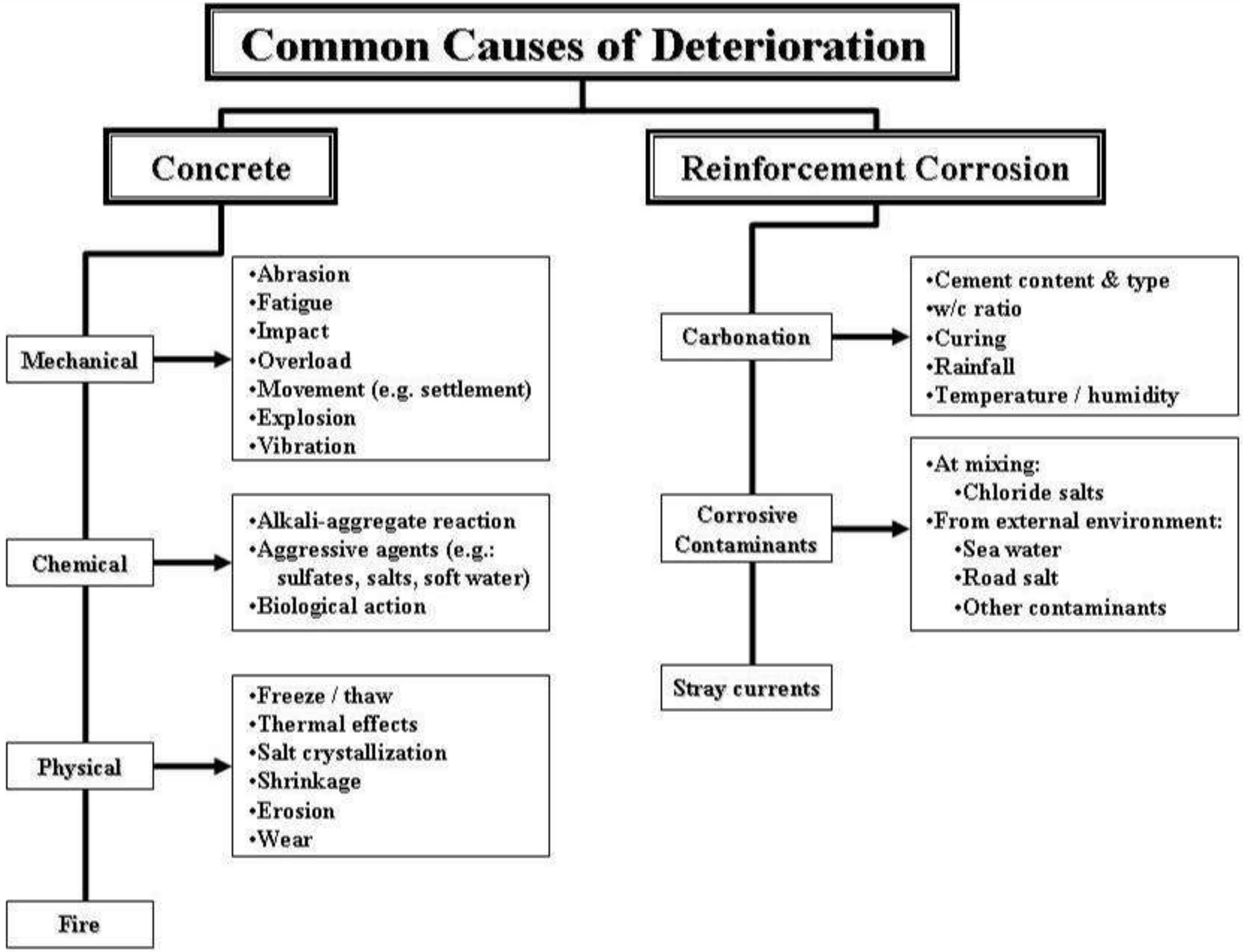
Causes of Deterioration



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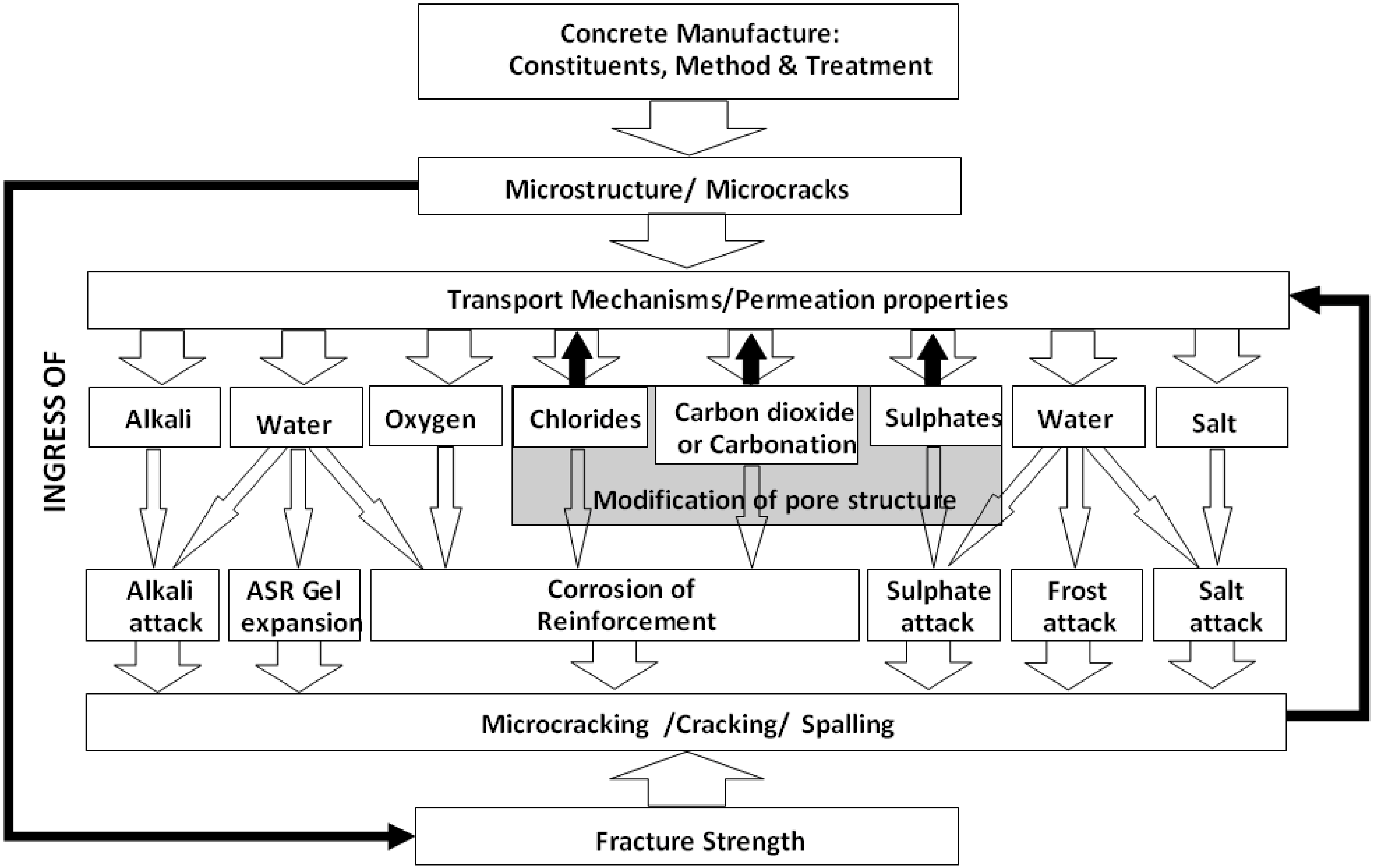
H_2O CO_2 O_2 Cl^- SO_3^-
Ingress from the environment
Sorptivity
Permeability
Diffusivity
Cover Concrete

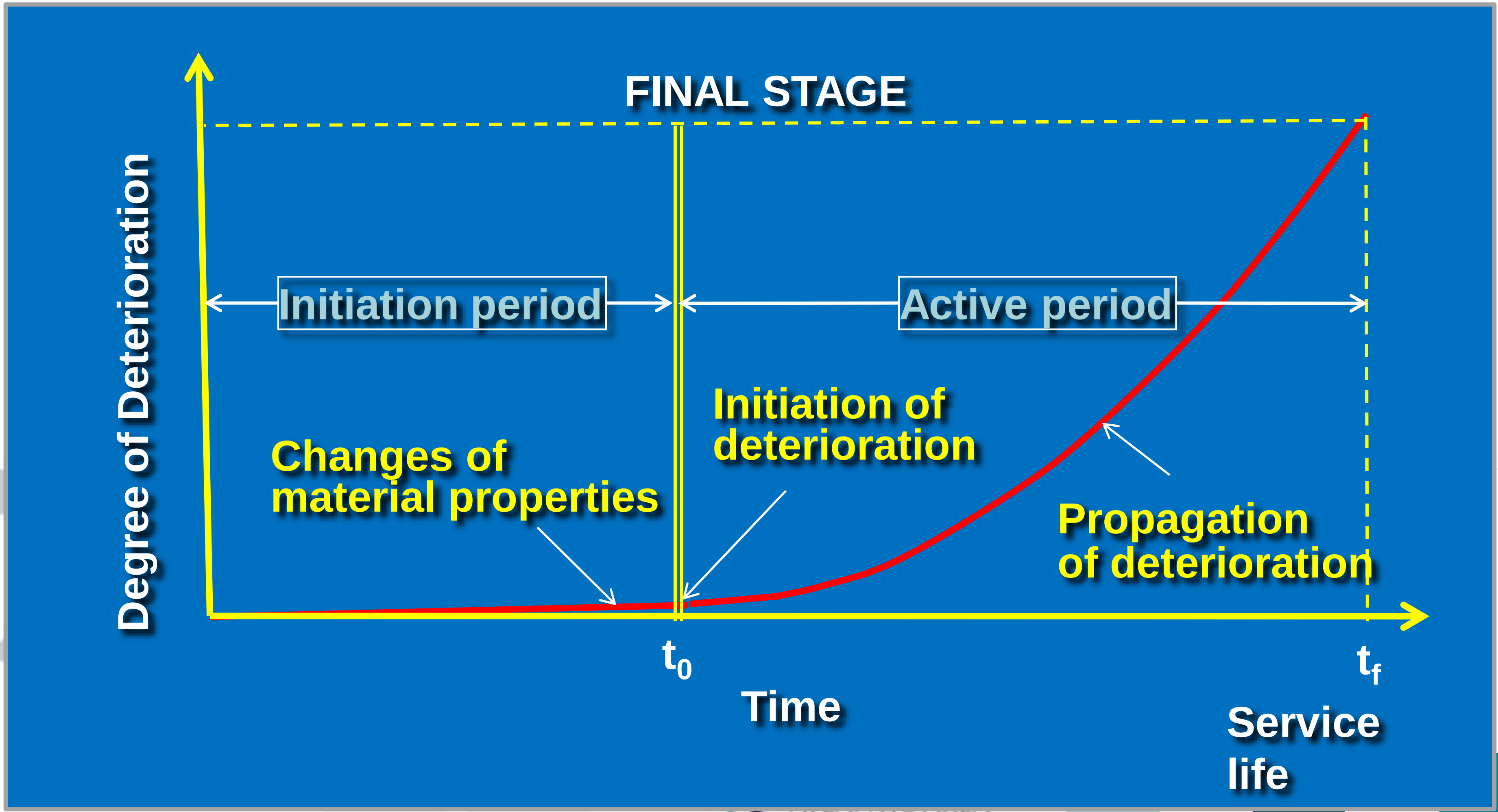
Interdependence between concrete microstructure, transport mechanisms, exposure and mechanisms of deterioration



Importance of Cover and Its Quality

Cover Concrete is the Achilles Heel of Concrete !

Degradation models and impact of degradation on structural performance



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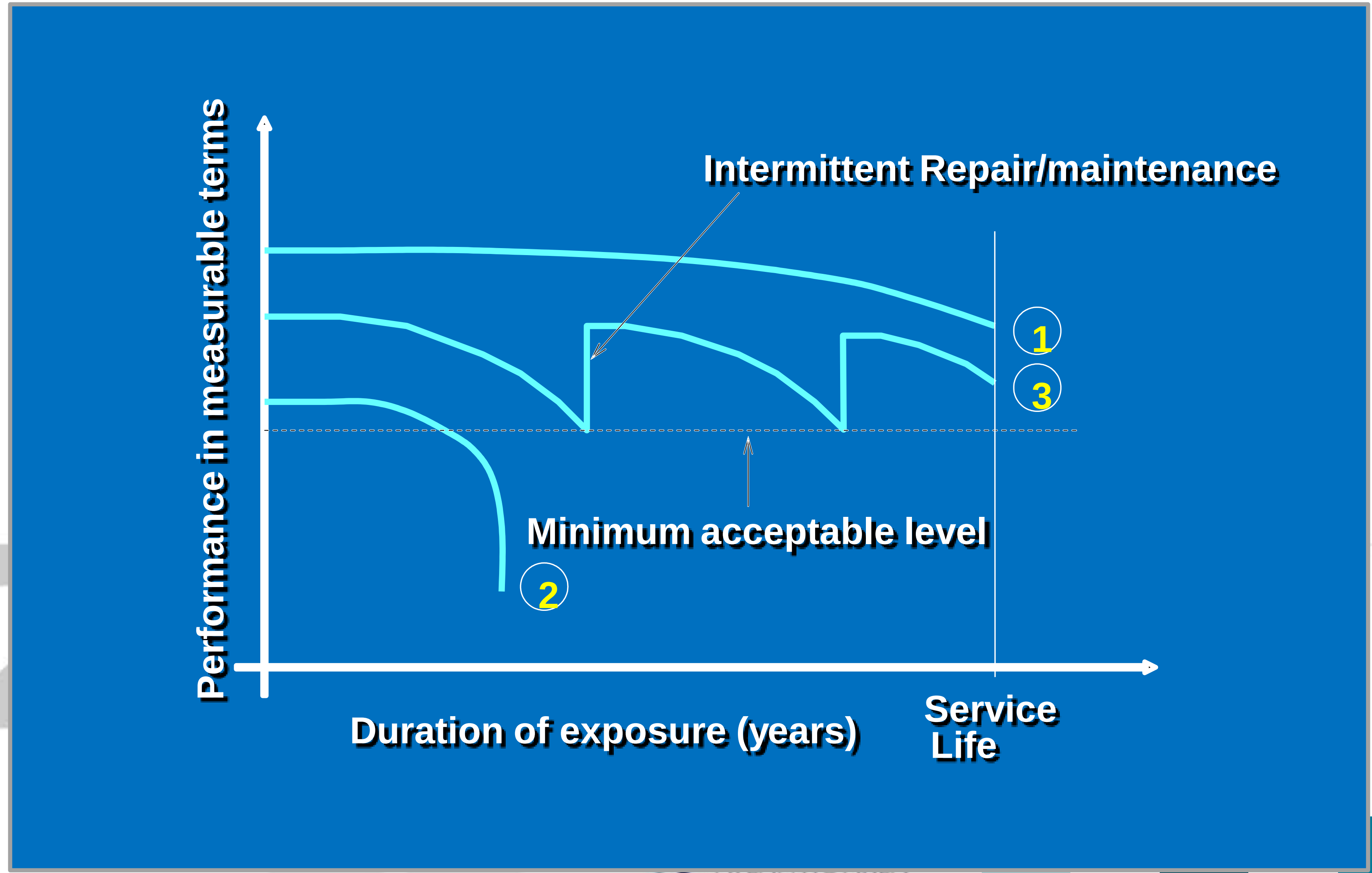
Decision on Time of Intervention



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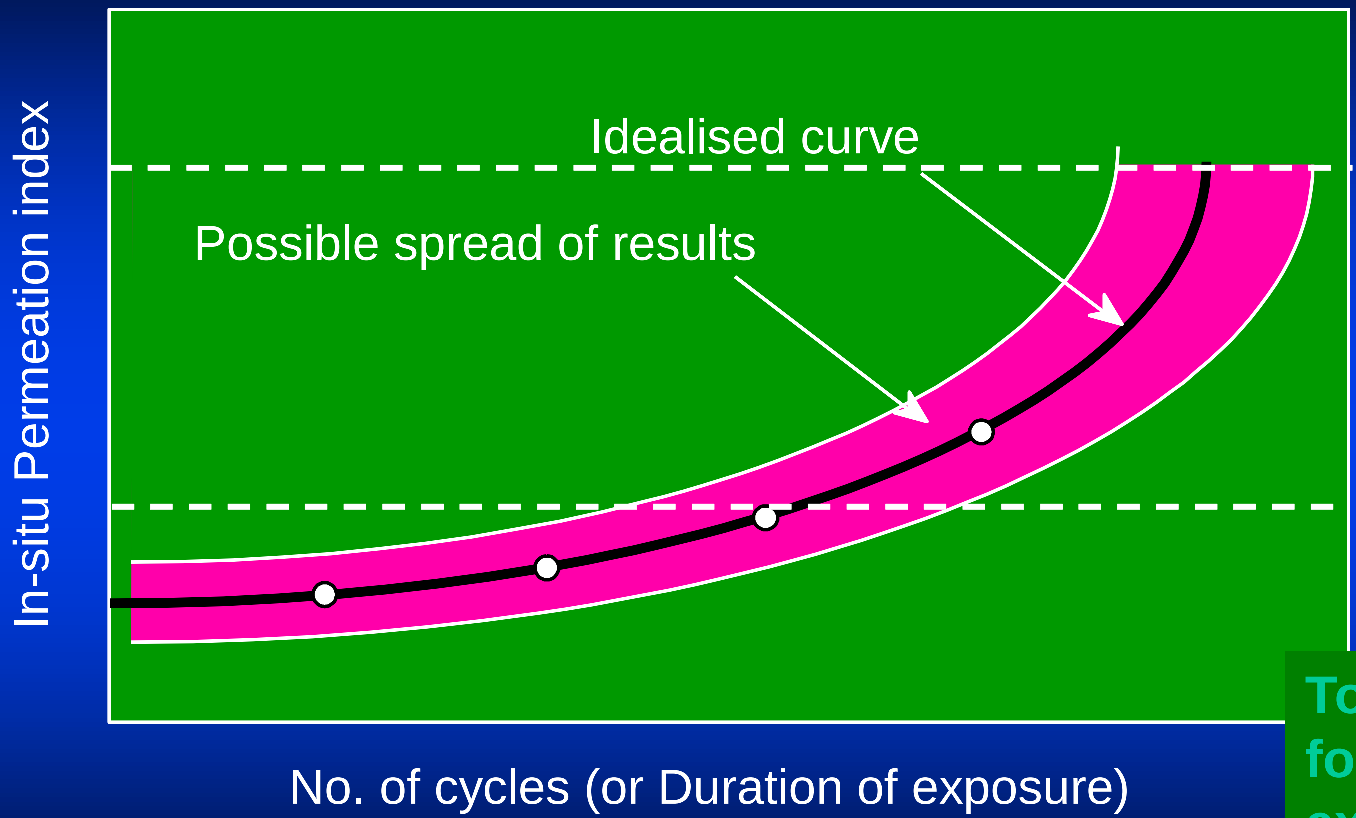
Ensuring Durability – Current Situation

	Design	Practice	Control
Cover Thickness	Specify Minimum Cover 	Careful placement and fixing	Covermeter survey 
Quality of Cover (= Transport Properties)	f'c Min. CC Max. w/c 	Concrete production	Tests on standard cubes/ cylinders 
		Execution • Placement • Compaction • Finishing • Formwork removal • Curing • Surface treatments	Core tests  Site Tests? 

Ensuring Durability – Performance Based

	Design	Practice	Control
Cover Thickness	Specify Minimum Cover	Careful placement and fixing	Covermeter survey
Quality of Cover (= Transport Properties)	Specify Concrete Class and k_{max}, D_e	Concrete production	Tests on standard cubes/ cylinders
		Execution • Placement • Compaction • Finishing • Formwork removal • Curing • Surface treatments	Core tests (Optional) Site Tests: permeability, sorptivity & ion migration

Use of Performance Based Approach for Repair



Not fit for service?

Carry out repair?

To be agreed for different exposure conditions

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Repair Strategies

Defects in Concrete	Reinforcement corrosion
1. Protection against ingress	7. Preserving or restoring passivity
2. Moisture control	8. Increasing resistivity
3. Concrete restoration	9. Cathodic control
4. Structural strengthening	10. Cathodic protection
5. Physical resistance	11. Control of anodic areas
6. Resistance to chemicals	

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Activities

Review of requirements of concrete durability

Task Leader: QUB

- Mechanism and types of damage in reinforced concrete
  Task Leader: U. La Rochelle
- In situ inspection techniques – specifications and comparisons
  Task Leader: U. Bordeaux
- Repair techniques for concrete structures
  Task Leader: LNEC

Time plan for deliverables

Activity		Final submission
3.1	Requirement of durability	Feb 2010
3.2	Mechanisms of damage	June 2010
3.3	Assessment of condition	Feb 2011
3.4	Inspection techniques; equipments; understanding results; interpretation of data	June 2011

Thank You