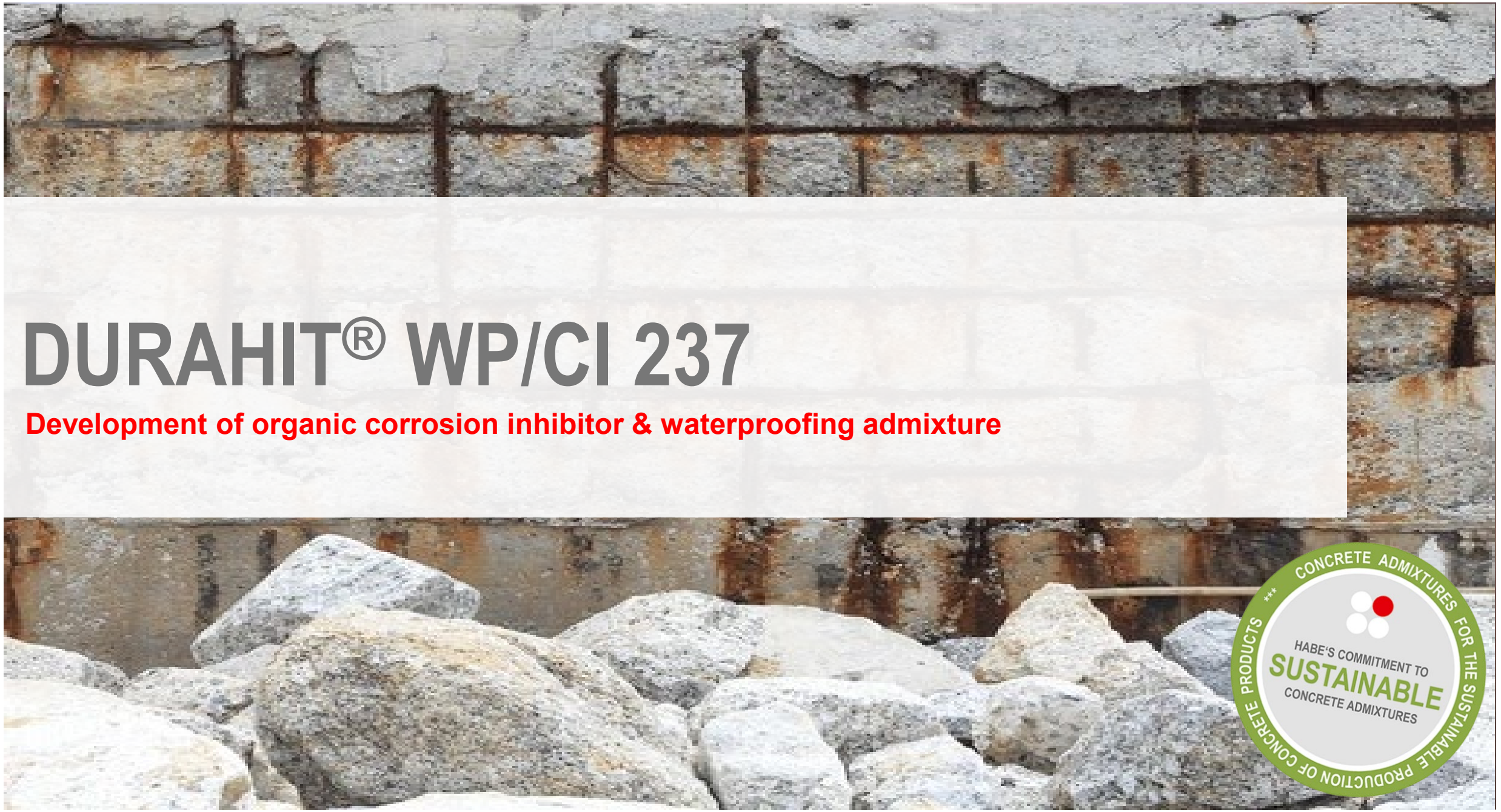
Ha-Be

Making good concrete better

AVINASH RAO

TECHNICAL MEETING
GEORGIA

30.-31.01.2024



DURAHIT® WP/CI 237

Development of organic corrosion inhibitor & waterproofing admixture

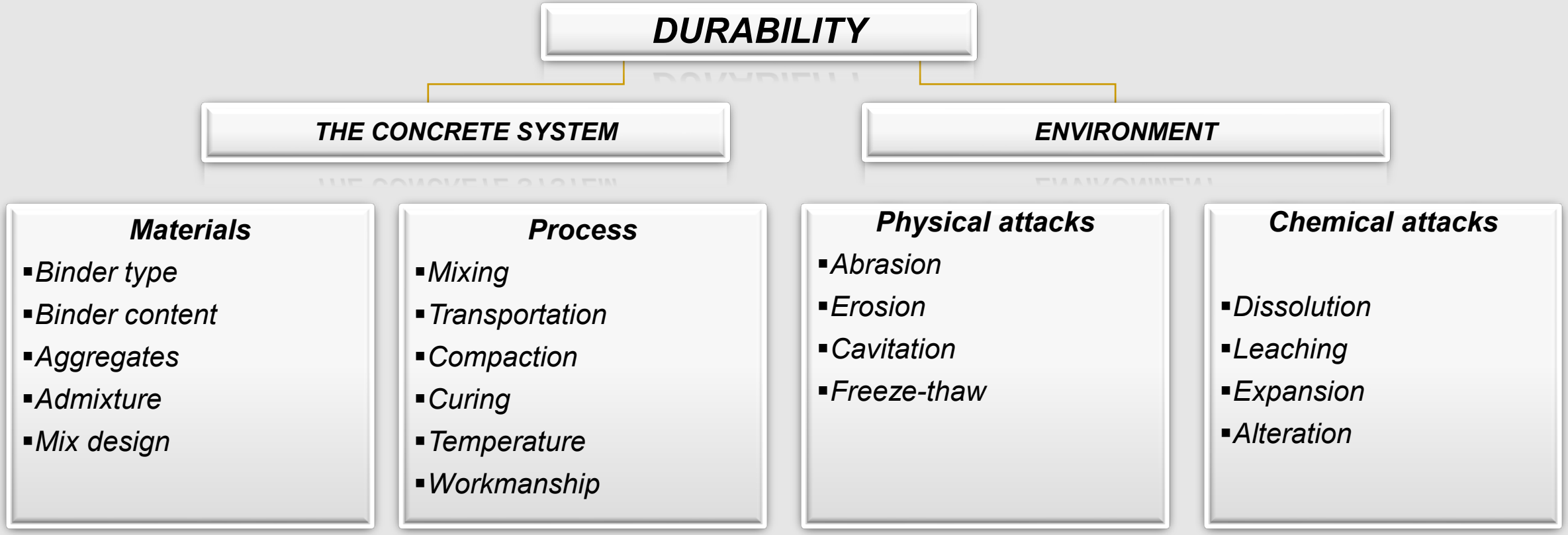
CONTENT

1. PROTECTING THE CONCRETE

BREAKING THE CYCLE OF DEGRADATION

- *Why to even protect concrete?*
- *What is corrosion and what causes corrosion?*
- *How to protect concrete?*
- *Corrosion inhibiting admixtures*

1. PROTECTING THE CONCRETE



1. PROTECTING THE CONCRETE

WHY PROTECT CONCRETE?

- *Concrete is porous*
- *Network of tiny air pores and capillaries*
- *Chlorides and other harmful water-borne chemicals penetrate the concrete*
- *Eventually break or deteriorate concrete through expansion, pressure build up, and/or acidic reactions*

AND WHY TO PROTECT REINFORCED CONCRETE FROM STEEL CORROSION?

- *Corrosion of steel in reinforced concrete is a major cause of repairs for concrete exposed to chlorides from various harsh environments.*

1. PROTECTING THE CONCRETE



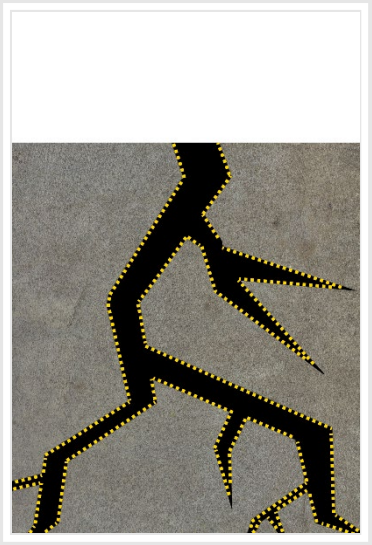

Concrete Protection

AGGRESSIVE ENVIRONMENT

- *As concrete is often exposed to aggressive environments, it is necessary to protect it from degradation and deterioration. Protective treatments for concrete are available for almost any degree of protection required.*

1. PROTECTING THE CONCRETE

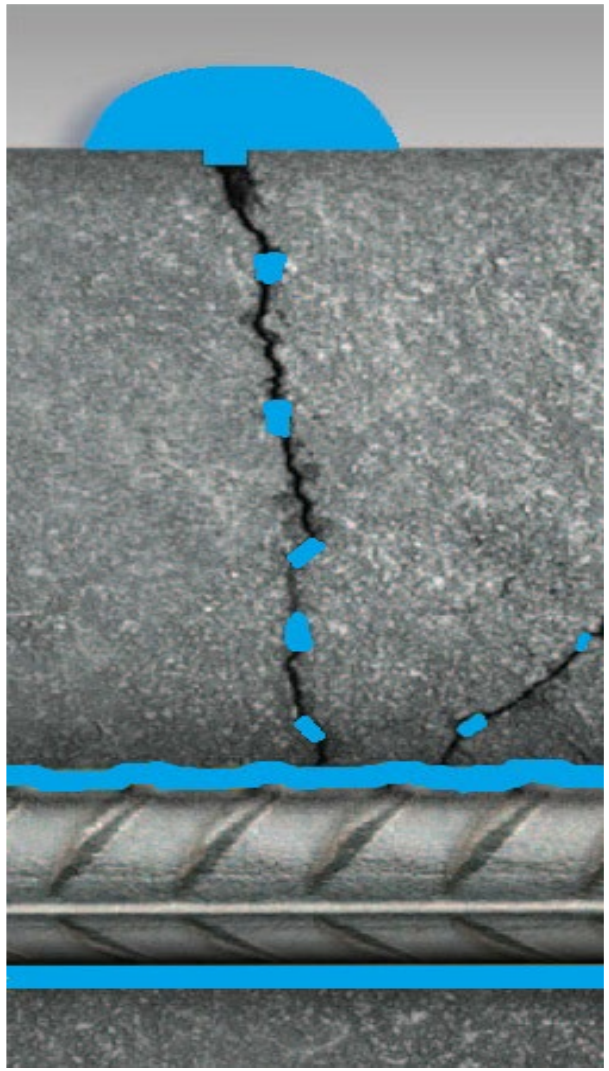
Upon close examination, concrete appears as a porous material containing capillary tracts, micro cracks, and sometimes macro cracks.



A magnified view of a capillary tract in concrete reveals the by-products of cement hydration and un-hydrated cement particles on the walls of the capillaries.

When concrete becomes wet, the capillary tracts become saturated with water. Calcium hydroxide and other soluble by-products of cement hydration dissolve in the capillary water, while un-hydrated cement and other non-soluble materials remain on the walls.

1. PROTECTING THE CONCRETE



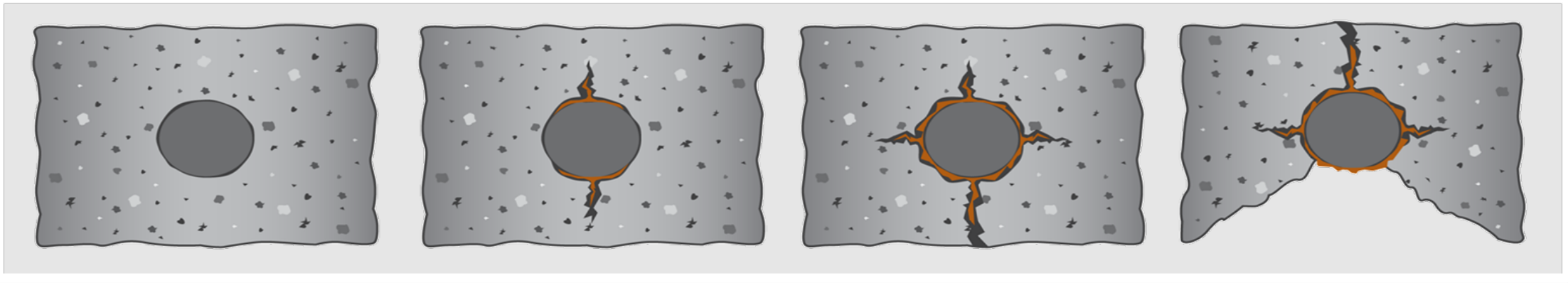
When concrete structures are exposed to chloride contaminated environments…

…chloride ions can penetrate into concrete structure

…where they eventually reach the reinforcing steel.

At a critical concentration of chlorides, providing there is sufficient oxygen and moisture, corrosion will initiate.

1. PROTECTING THE CONCRETE

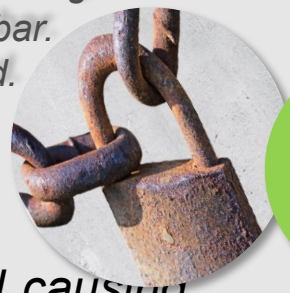


Before corrosion.

Build-up of corrosion products.

Further corrosion. Surface cracks. Stains.

Eventually spalling. Corroded bar. Exposed.



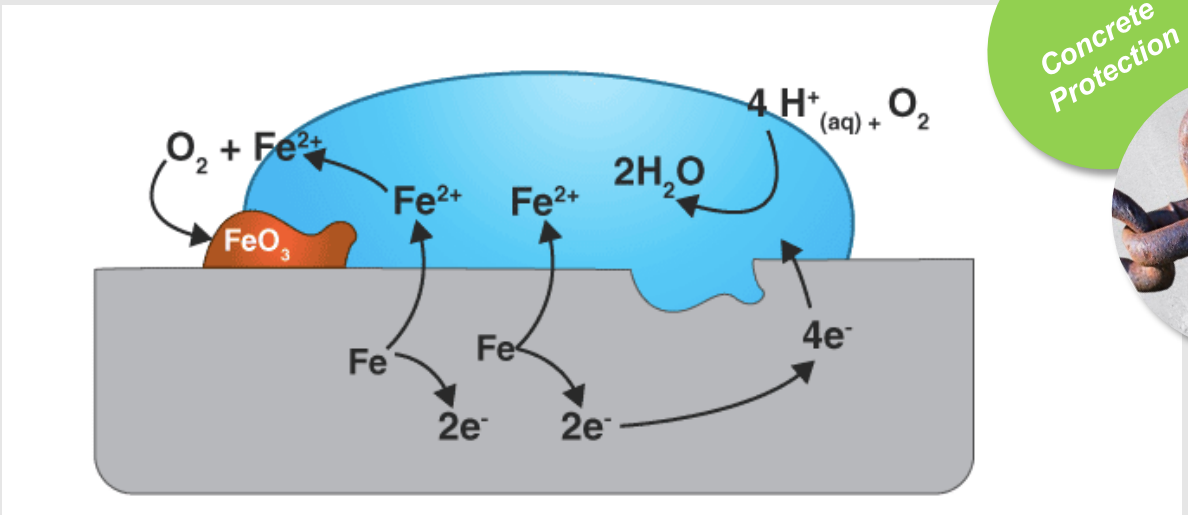
CORROSION CYCLE

- *The corrosion cycle of steel begins with the rust expanding on the surface of the bar and causing cracking near the steel/concrete interface.*
- *As time marches on, the corrosion build up and cause more extensive cracking until the concrete breaks away from the bar, eventually causing spalling.*

1. PROTECTING THE CONCRETE

MECHANISM OF CORROSION IN REINFORCING STEEL

Chemistry of Corrosion The corrosion of reinforcing steel in concrete is an electrochemical process involving iron, oxygen, and water. Corrosion is defined by the American Concrete Institute (ACI) and International Concrete Repair Institute (ICRI) as the 'destruction of metal by chemical, electrochemical, and electrolytic reaction within its environment.



1. PROTECTING THE CONCRETE

MECHANISM OF CORROSION IN REINFORCING STEEL

Corrosion occurs when an electrochemical cell is created, where electrons flow from the anode to the cathode and hydroxyl ions flow back from the cathode to the anode.

In the anodic reaction, iron atoms lose electrons to form ferrous ions, as shown in Equation 1, $Fe \rightarrow Fe^{2+} + 2e^{-}$ *1. where*

Fe = iron atom

Fe2+ = ferrous ion

e - = electrons

1. PROTECTING THE CONCRETE

The electrons are then passed to the cathode, where they interact with available oxygen and water to produce hydroxyl ions,

as shown in Equation 2. $2H_2O + O_2 + 4e^- \rightarrow 4OH^-$ *2 , where,*

H_2O *= water*

O_2 *= oxygen*

OH^- *= hydroxyl ion, The hydroxyl ions produced at the cathode then travel back to the anode, where they react with the ferrous ions to produce ferrous hydroxide* $[Fe(OH)_2]$*, as shown in Equation 3,* $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$

- *The ferrous hydroxide ultimately oxidises into rust.*
- *Rust has a larger volume than the reinforcing steel it was created from, creating pressure in the concrete, which in turn leads to cracking and spalling of the concrete cover*
- *Due to the high pH of concrete, a passive oxide film or thin rust layer forms around the reinforcing steel bars, which protects the reinforcement by slowing the rate of corrosion to an insignificant level. If the passive film remains intact and the pH of the concrete pore solution remains high, significant corrosion of the steel reinforcement will not occur*

1. PROTECTING THE CONCRETE

Chloride Ingress:

The penetration of chloride ions into concrete typically occurs in marine environments, saline soil environments, or from the presence of de-icing salts. Due to the porous nature of concrete, chloride ions can penetrate through the concrete cover, eventually reaching the reinforcing steel. Then the chloride ions at the reinforcing steel exceed a threshold value, called the critical chloride threshold, the passive oxide film protecting the reinforcing steel dissolves causing corrosion to initiate. Further penetration of chloride will result in an increase of the chloride concentration at the steel and accelerating the reinforcement corrosion.

1. PROTECTING THE CONCRETE

Carbonation:

Carbonation is a process whereby carbon dioxide enters concrete and reacts with calcium hydroxide to produce calcium carbonate. The presence of calcium carbonate lowers the pH of the concrete pore solution, which in turn leads to destruction of the oxide film on the reinforcing steel and accelerated corrosion when moisture and oxygen are available. The carbonation of concrete is usually a slow process, so it takes time for the reaction to progress and reach the reinforcement. The actual time that the carbonation process will take to impact on reinforcement varies and depends on several factors including exposure conditions, concrete humidity, binder composition, concrete quality, water content and the depth of cover to reinforcement.

1. PROTECTING THE CONCRETE

HOW TO PROTECT CONCRETE FROM STEEL CORROSION?

- *Eeffects can be mitigated by increasing the concrete cover, reducing the permeability of concrete, using reinforcement that is more resistant to corrosion, and / or using corrosion-inhibiting admixtures:*
  - *Prevent ion entry by **sealing concrete surface***

    Use of Plastics, rubber resins, epoxy resins…
  - *Prevent ion migration by a tighter and **denser concrete***

    Use of supplementary cementitious materials like Silica fume, GGBS, Flyash
  - *Prevent ion migration by a **counter current***

    Use of Cathodic protection
  - *Prevent corrosion by a **protective layer***

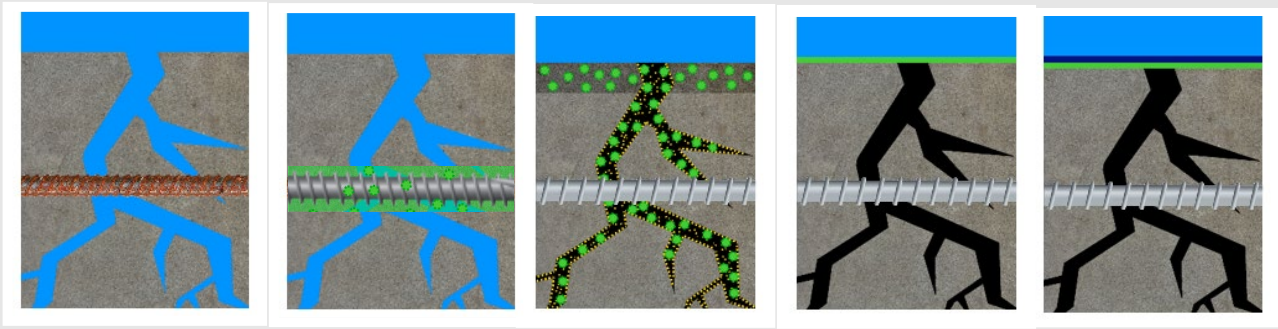
    Use of Cathodic inhibitors such as amino alcohols…
  - *Prevent corrosion by a **passivation layer***

    Use of Anodic inhibitors

1. PROTECTING THE CONCRETE

SO HOW TO PROTECT CONCRETE FROM STEEL CORROSION?

- *Vast number of products and systems are available*



	non-treated	passivation	impregnated	sealed	coated
Water permeability	✓	✓	✓	✗	⊘
Vapor permeability	✓	✓	⊘	⊘	⊘
Corrosion protection	⊘	✓	✓	✓	✓

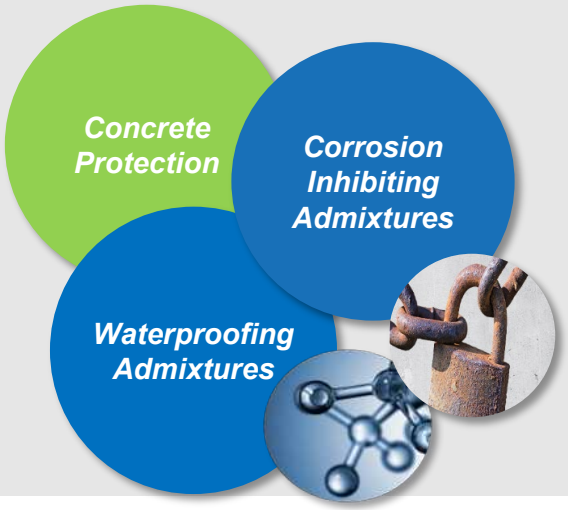
1. PROTECTING THE CONCRETE

CORROSION INHIBITING ADMIXTURES / PERMEABILITY REDUCING ADMIXTURES

- *Huge variety of corrosion inhibiting admixtures & permeability reducing admixtures*
- *Increase the passivation of reinforcement and other embedded steel in concrete = inhibit corrosion*
- *Reduce permeability = waterproof concrete*
- *Different compositions = different types*
- *Concrete exposed to Hydrostatic & Non Hydrostatic conditions (PRAH & PRAN)*

WHAT THEY DO

- *Protect concrete*
- *React integrally*
- *Chemically inhibit corrosion process*
- *Added during production of concrete*

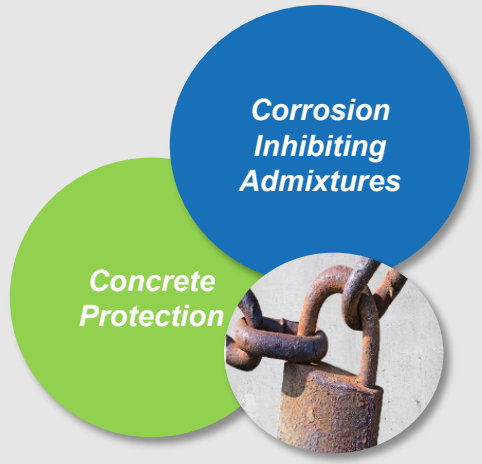


1. PROTECTING THE CONCRETE

CLASSIFICATION ACCORDING TO:

- ***THEIR MAIN APPLICATION METHOD***

  > added to fresh concrete as an admixture.
  > applied on the hardened concrete surface, so-called penetrating corrosion inhibitor (also migrating corrosion inhibitor and surface-applied corrosion inhibitor).
  > added to repair mortars.
  > used as a surface treatment on the reinforcement bars before concreting.



1. PROTECTING THE CONCRETE

CLASSIFICATION ACCORDING TO:

- ***THEIR MECHANISM OF PROTECTION***
  - *Anodic*
  - *Cathodic*
  - *Mixed*

- ***THEIR CONTENT***
  - *Nitrite-based inhibitors*
  - *Organic inhibitors (including various amines, alkanolamines, their salts with organic and inorganic acids and emulsified mixtures of esters, alcohols and amines.)*
  - *Vapour phase inhibitors or migrating corrosion inhibitors (MCIs)*

1. PROTECTING THE CONCRETE

ANODIC INHIBITORS

- *Anodic inhibitors assist in the production of the oxide film on the reinforcement by oxidising ferrous ions to ferric ions, which suppresses the corrosion reaction. During the generation of the passive oxide layer, the anodic inhibitor is consumed*
- *For anodic inhibitors to be effective, they must be present in an adequate concentration relative to the amount of chloride present in the concrete*
- *Anodic inhibitors essentially compete with the chloride ions to oxidise steel, by transforming the ferrous ions required for corrosion into ferric ions (Fe3+) which creates the passive layer*
- *If an insufficient concentration of inhibitor is available, the chloride-induced corrosion will still occur. This leads to concerns that if the amount of inhibitor used is too small, accelerated corrosion and pitting can occur, as well as concerns that the inhibitor may leach out of concrete over long periods of time*
- *Calcium nitrite is the most commonly used anodic corrosion inhibitor, as well as being one of the oldest and most widely used CIAs in concrete. Other anodic inhibitors include calcium nitrate, sodium nitrite, sodium benzoate, and sodium chromate*

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CATHODIC INHIBITORS

- *Cathodic inhibitors act to slow down the cathodic reaction on the surface of the steel reinforcement by reacting with corrosion products (e.g. Fe2+, Fe3+, OH-) to produce salts, which have poor solubility in water, and will precipitate on cathodic sites*
- *The precipitated salts form a layer on the steel surface which works to prevent oxygen from reaching the cathodic zones of the reinforcement*
- *The reduction in oxygen supply to the corrosion process will lower both the corrosion potential and the corrosion rate*
- *Cathodic inhibitors include carbonates, phosphates, polyphosphates and silicates.*

1. PROTECTING THE CONCRETE

MIXED INHIBITORS

- *Mixed inhibitors act on both the anode and cathode, forming a thin film on the surface of the steel reinforcement*
- *Mixed inhibitors work to slow down the corrosion rate without a major change in the corrosion potential*
- *Common mixed inhibitors are organic compounds, such as amines and alkanolamines, with polar groups.*

1. PROTECTING THE CONCRETE

ADVANTAGES OF PROTECTING CONCRETE

- ***DECREASED COST***
  > cost reduction for maintenance and repairs and replacements: Less costly repair works due to a permanent protection

  > environmentally-friendly/energy savings: Increases the durability of concrete and thus supporting a sustainable use of the building material

  > no change in aesthetic appearance of original structure

1. PROTECTING THE CONCRETE

ADVANTAGES OF ADDING CORROSION INHIBITING ADMIXTURES

- ***COMPATIBILITY***

  > compatible with both Portland and blended cement concretes
  > compatible with typically used water reducing admixture

- ***ADDITIONAL BENEFITS***

  > integral corrosion protection
  > environmentally-friendly/energy savings: Increases the durability of concrete
  > no change in aesthetic appearance of original structure
  > properties of fresh concrete remain unaffected, though slightly improved workability
  > capillaries and pores remain “open” and allow concrete to breathe

2. DURAHIT® WP/CI 237

CONCRETE PROTECTION

- *DURAHIT® WP/CI 237*

2. DURAHIT® WP/CI 237

DURAHIT® WP/CI 237 (WATERPROOFING & CORROSION INHIBITOR)

- *Effect*
- *Application*
- *Benefits*
- *Summary*

2. DURAHIT® WP/CI 237

PREVENTS CORROSION, INCREASE DURABILITY

- *DURAHIT® WP/CI 237*
  - *Improves the durability of reinforced concrete at the level of the concrete and the rebar*
  - *Provides two levels of corrosion protection, inhibiting and waterproofing making it the most effective corrosion inhibiting admixture available*
  - *Extends the service life of reinforced concrete by slowing the ingress of chlorides and moisture into the concrete and by forming a strong, durable protective film on the reinforcing steel for a second level of corrosion protection*
  - *Lines the pores of the concrete matrix thus waterproofing and slowing the rate at which chlorides and moisture enter the concrete and denying the corrosion process of its two most important components*
  - *Reduces porosity of the concrete*

2. DURAHIT® WP/CI 237

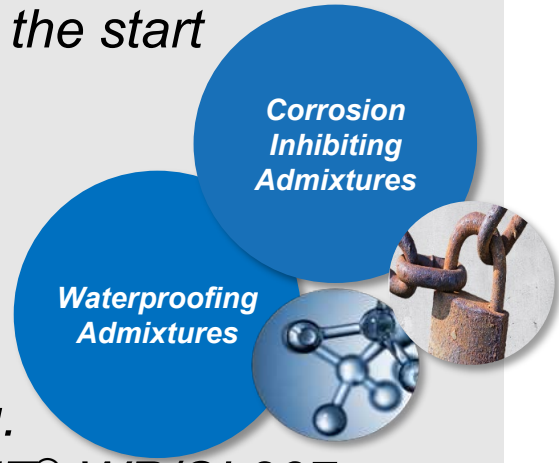
REDUCES CORROSION, INCREASE DURABILITY

- *DURAHIT® WP/CI 237*
  - *Extends the structures lifetime through increased concrete resistance*
  - *Optimum water repellency*
  - *Capillary & pores are not blocked to allow the concrete to breathe*
  - *Improves resistance towards water and chlorides migration*
  - *Expands the effective lifetime and increases the structural safety of constructions*
  - *provides additional protection by adsorbing onto the reinforcing steel to form a corrosion resistant protective film*
  - *Environmental friendly*
  - *Improves the plastic performance of the concrete*

2.1 EFFECTS OF DURAHIT® WP/CI 237

WHAT IS DURAHIT® WP/CI 237

- *Integral water proofing & corrosion inhibiting admixture designed especially for ready-mix concrete projects to increase the durability of concrete passivation of reinforcement and other embedded steel in concrete structures and thus to protect concrete from the start*



HOW IT WORKS?

- *DURAHIT® WP/CI 237 is blended into the concrete mix at the time of batching.*

DURAHIT® WP/CI 237 by inhibiting corrosion at its most critical points. DURAHIT® WP/CI 237 lines the pores of the concrete matrix thus waterproofing and slowing the rate at which chlorides and moisture enter the concrete and denying the corrosion process of its two most important components.

2.1 EFFECTS OF DURAHIT® WP/CI 237

- ***PROTECTIVE LAYERS AROUND REINFORCEMENT***

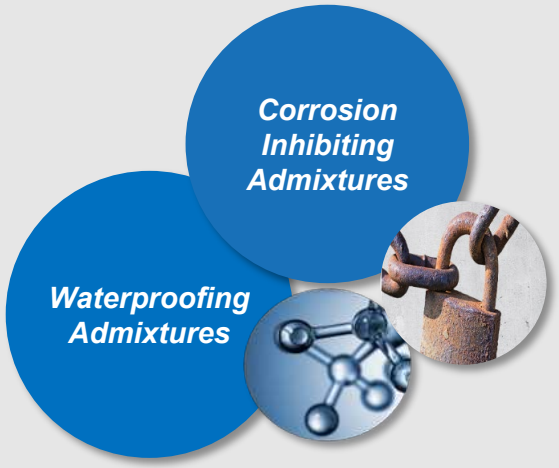
- *Added either to the aggregate at the time of batching or to the initial batching sequence, DURAHIT® WP/CI 237 provides additional protection by adsorbing onto the reinforcing steel to form a corrosion resistant protective film.*
- *The environmentally friendly alternative to nitrite.*
- *The reaction continues over the life of the concrete, serving to protect the steel reinforcements not only at the beginning, but also over time.*

2.2 APPLICATIONS OF DURAHIT® WP/CI 237

WHERE IS IT APPLIED?

- *Having no negative side effect, DURAHIT® WP/CI 237 can be added to any reinforced ready-mixed concrete. However, it is designed for reinforced concrete structures especially at risk, i.e. exposed to a maritime environment or other situations where chloride penetration of the concrete is likely. Such structures include, but are not limited to:*

  - *Buildings and civil engineering structures*
  - *Marine structures, including bridges*
  - *Tunnel and underground construction*
  - *Infrastructure construction*



2.2 APPLICATIONS OF DURAHIT® WP/CI 237

BRIDGES & ROADS

TUNNELING & MINING

COASTAL

INDUSTRIAL

FOUNDATION & FLOORS

AIRORT & RAILWAYS

RECONSTRUCTION&REPAIR

PRECAST ELEMENTS

2.3 BENEFITS OF DURAHIT® WP/CI 237

- ***BENEFITS***
- *Enhanced long-term durability of reinforced concrete*
- *Optimum Water Repellency*
- *Enhanced passivation to the cathodic and/or anodic areas of embedded steel*
- *Decreased steel corrosion*
- *Capillaries and pores are not blocked and allow concrete to breathe*
- *No change in aesthetic appearance of original structure*
- *Economical product*

2.4 SUMMARY

MIX AND MATCH YOUR CONCRETE PROTECTION

3. ASTM STANDARD C1582/C1582M-11

- ***ASTM STANDARD C1582/C1582M-11***

- *Standard specification for admixtures to inhibit chloride-induced corrosion of reinforced steel in concrete.*
- *The specification covers the material for use as chloride-corrosion-inhibiting admixtures for concrete.*
- *Completion of testing upon following conditions reached:*
  - *>Mean integrated macro-cell current in control beam≥ 150 C.*
  - *>Mean chloride ion content ≥ Critical ion content.*

3.1 GENERAL REQUIREMENTS

- ***ASTM STANDARD C1582/C1582M-11***

- *The performance property of chloride-corrosion inhibiting shall consist of time of setting and compressive strength at 3, 7, and 28 days.*
- *Remaining compressive and flexural strength of 80% of the reference sample.*
- *At any age compare to the age before the reduction should not be more than 10%.*
- *Initial and final setting time should not be altered more than 3.5 hours.*
- *The chloride-corrosion inhibitor shall comply with ASTM C494/C494M specification as admixture.*
- *Aggregate origin*

3.1 GENERAL REQUIREMENTS

ASTM STANDARD C1582/C1582M-11

Physical requirements of concrete containing a Chloride-corrosion-inhibiting admixture

Time of setting, allowable deviation from control, h:min

Initial: not more than 3:30 earlier or later

Final: not more than 3:30 earlier or later

Strength

Age	Compressive strength, min. % of control[A,B]	Flexural strength, min. % of control[A,B]
3 Days	80	80
7 Days	80	80
28 Days	80	80
6 Months	80	
12 Months	80	

Length change, max. shrinkage (alternative requirements)[C]

Percent of control	**135**
Increase over control, percentage points	**0.010**

Relative durability factor, min. %

80

ASTM INTERNATIONAL
Standards Worldwide

3.2 REQUIREMENTS ON CI

- ***ASTM STANDARD C1582/C1582M-11***

- *ASTM Test Method G109 or G180*
- *G109 method covers a procedure for determining the effect of chemical admixtures on the corrosion of the concrete*
- *Corrosion potential requirement*
- *>Corrosion current measurement*
- *>Corroded area measurement*
- *>Chloride ion content*

3.2 REQUIREMENTS ON CI

ASTM STANDARD C1582/C1582M-11

Composition requirements by ASTM G109:

- *CEM I 42,5R (EN 197/1)*
- *W/C ≤ 0,5*
- *Air entrainer 6±1%*

Ponding cycle:

- *15 days dry*
- *15 days of ponding (3% NaCl solution)*

4. DURAHIT® WP/CI 237 – TEST DESCRIPTION

LIST OF TEST BEING CONDUCTED BY 3RD PARTY LABORATORY

TEST DESCRIPTION	*TESTING METHOD*
AIR CONTENT	*ASTM C231*
SLUMP	*ASTM C143*
DENSITY	*ASTM C138*
SET TIME	*ASTM C403*
FLEXURAL STRENGTH	*ASTM C78*
COMPRESSIVE STRENGTH	*ASTM C192*
COROSSION PROPERTIES : USED AS A SET RETARDING ADMIXTURE	*EN 934-1:2008*
DETERMINING EFFECTS OF CHEMICAL ADMIXTURE OF CORROSION ON EMBEDDED STEEL REINFORCEMENT IN CONCRETE	*ASTM G109*
CORROSION PROPERTIES	*ASTM G180* *ASTM C1582*

4.1 DURAHIT® WP/CI 237 – PERFORMANCE RESULTS

MEETING REQUIREMENTS ACCORDING TO ASTM (G 109 AND C 1582)

CRITERIA	LIMIT REQUIREMENT	DURAHIT® WP/CI 237
Remaining compressive and flexural strength of concrete containing a chloride corrosion inhibiting admixture	*min. 80%*	*Comply*
Initial and final setting time	*should not be altered more than 3.5 hours*	*Comply*
The chloride-corrosion inhibitor complies with specification as admixture.	*ASTM C494/C494M specification*	*Comply*
Test of the admixture shall be done according to required method	*ASTM G109*	*Awaiting Results*
Integrated macro cell current	*less than or equal to 50 C (Coulomb)*	*Awaiting Results*
Corroded area	*less or equal to 1/3 of the corroded area A)*	*Awaiting Results*

4.1 DURAHIT® WP/CI 237 – PERFORMANCE RESULTS

Test Results

Performance check of durabilty parameters of Durahit WP/CI

INTERNAL

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UAE-TD-FRM-013

Information			Mixdesign											Fresh concrete									hardened concrete					
														Flow/Slump							Temperature							
Trial No.	Date	Concrete classification	Binder type & combi	OPC	GGBS	Micro Silica	Aggregates (20, 10, CS, WS, D/S)	Free water	w/c eq Value required	Admixtures					initial	s30	Flow loss until 30 min.	concrete density	Air Content	concrete initial setting time	concrete	air	testing age	concrete density	compressive strength	Rapid Chloride Permeability (ASTMC1202-2019)	Water absorpation (BS EN 1181 part 122)	Water permmeability (BS EN 12390)
							[%]	[kg/m3]		TYPE	ltr/m³	kg/m³	% o.C.	[mm]			[mm]	[kg/m3]	[%]		[°C]		[hrs./day]	[kg/m3]	[N/mm²]	[coulombs]	[%]	[mm]
4409	31.07.2023	C50/20	OPC	210	210	-	18,0 31,0 19,0 32,0	147	0.35	PANTARHIT® RMC 220 Control mix	5.5 4.8	6.00 5.00	1.43 1.19	Slump	220	170	50	2403	3.4	-	31.0	30.8	1d 7d 28d	2384 2401 2451	25.8 50.3 62.2	- - 1259 (Low)	- - 2.1	- - 12.0
4410										PANTARHIT® RMC 220 DURAHIT WP 500	5.5 4.8	6.00 5.00	1.43 1.19	Slump	230	180	50	2425	2.2	-	31.5	30.7	1d 7d 28d	2394 2425 2451	21.2 52.8 59.7	- - 837 (V.low)	- - 0.8	- - 7.0
4411										PANTARHIT® RMC 220 DURAHIT WP/CI 237	5.5 4.8	6.00 5.00	1.43 1.19	Slump	240	190	50	2426	1.9	-	31.8	30.7	1d 7d 28d	2398 2442 2448	20.6 50.4 60.0	- - 821 (V.low)	- - 0.9	- - 8.0
4412										PANTARHIT® RMC 220 MasterLife CI 222	5.5 4.8	6.00 5.00	1.43 1.19	Slump	240	200	40	2412	2.0	-	31.8	30.7	1d 7d 28d	2396 2451 2456	19.4 54.9 62.0	- - 1057 (Low)	- - 0.8	- - 7.0

4.1 DURAHIT® WP/CI 237 – PERFORMANCE RESULTS

Test Results

TO MONITOR THE SETTING TIME OF DURAHIT WP/CI 237

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UAE-TD-FRM-013

Information			Mixdesign										Fresh concrete									hardened concrete		
													Flow/Slump							Temperature				
Trial No.	Date	Concrete classification	Binder type & combi	PIONEER OPC	GGBS	Micro Silica fluid	Aggregates (20, 10, CS, WS, D/S)	Free water	w/c eq Value required	Admixtures				initial	s30	Flow loss until 30 min.	concrete density	Air Content	concrete initial & final setting time	concrete	air	testing age	concrete density	compressive strength
							[%]	[kg/m3]		TYPE	ltr/m³	kg/m³	% o.c.	[mm]		[mm]	[kg/m3]	[%]		[°C]		[hrs.]	[kg/m3]	[N/mm²]
4619	31.07.2023	C90/20	OPC IGGBS I	210	210		18,0 31,0 19,0 32,0	106	0.27	PANTARHIT® RMC 220 CONTROL MIX	5.5	6.00	1.43	Flow	700	700	40	2462	2.0	11 hrs, 30 min 13 hrs, 30 min	30.5	29.7	1d	2435	25.80
														Slump	220	180							7d	2450	50.30
4621										PANTARHIT® RMC 220 DURAHIT WP/CI 237	5.5	6.00	1.43										28d	2465	62.20
											4.8	5.00	1.19	Flow	680	670	30	2449	1.8	13 hrs, 35 min 16 hrs, 15 min	30.1	29.0	1d	2433	20.60
														Slump	240	210							7d	2447	50.40
																							28d	2466	60.00

4.2 ASTM G109 RESULTS

SETTING TIME

- *According to ASTM requirements:*
  >Time of setting, allowable deviation from control
  >Initial: not more than 3:30 earlier or later
  >Final: not more than 3:30 earlier or later

Setting time	*Dosage 0% - Control Sample*		*Dosage 5 Litre DURAHIT® WP/CI 237*		*ΔT*		*Criteria*		
(hh:mm)	*Initial*	*End*	*Initial*	*End*	*Initial*	*End*	*ΔT < +/-*	*Initial*	*End*
C 50/20 OPC GGBS	*10:45*	*13:00*	*11:45*	*14:00*	*01:00*	*02:00*	*03:30*	*Complies*	*Complies*

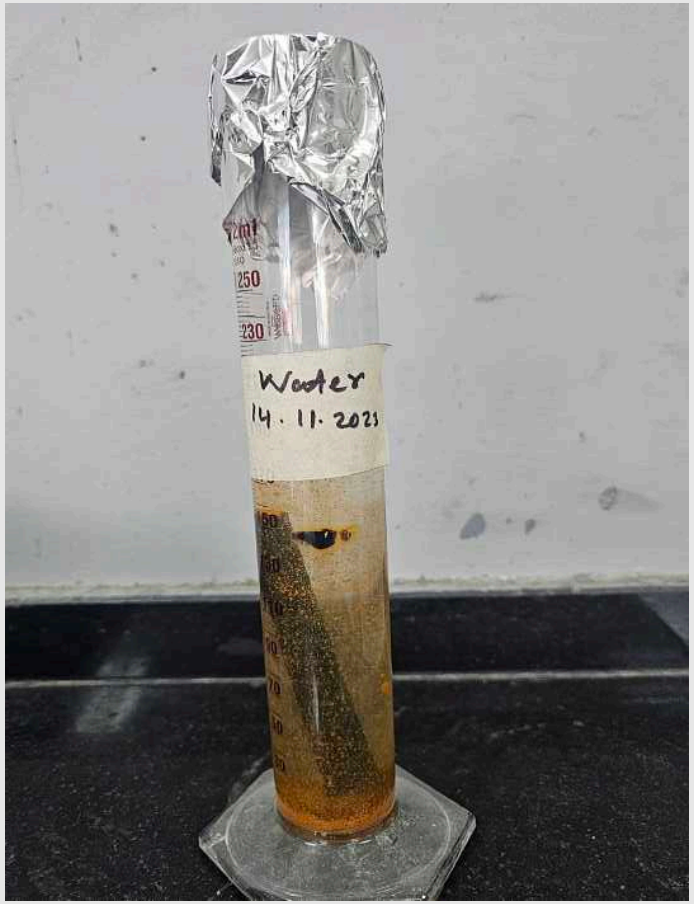
4.2 ASTM G109 RESULTS

COMPRESSIVE & FLEXURAL STRENGTH

- *According to ASTM requirements:*
  >Compressive strength & flexural strength minimum remain 80% of control

Compressive Strength	*Dosage 0% - Control Sample*		*Dosage 5 Litre DURAHIT® WP/CI 237*		*Percentage*	
Days	*7 Days*	*28 Days*	*7 Days*	*28 Days*	*7 Days*	*28 Days*
C 50/20 OPC GGBS	*50.3*	*62.2*	*50.4*	*60*	*101%*	*96.4%*

4.3 SUMMARY – LAB OBSERVATIONS



Steel Rod immersed in Water
Date : 14.11.23

4.3 SUMMARY – LAB OBSERVATIONS

Steel Rod immersed in DURAHIT® WP/CI 237
Date : 14.11.23

4.3 SUMMARY – LAB OBSERVATIONS

Steel Rod immersed in DURAHIT® WP 500
Date : 14.11.23

4.3 SUMMARY – LAB OBSERVATIONS

Steel Rod immersed in NITCAL
Date : 14.11.23

Ha-Be

Making good concrete better

THANK YOU