

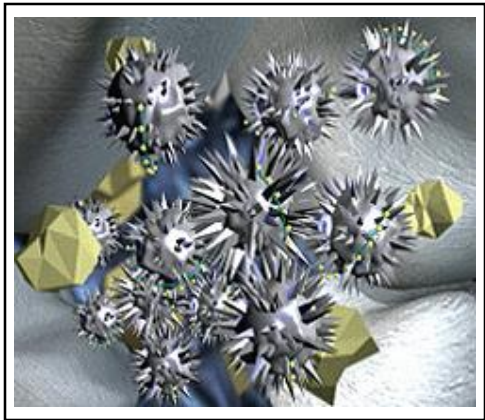


Role of admixtures in concrete durability

Saudi Concrete Conference, May 2016
David Bowerman, RBSM AS & CA, ORA

Presentation objective

To demonstrate how admixture technology can improve the quality of concrete to construct more sustainable structures



Durable concrete?

- » Low water/cement ratio
- » Supplementary cementitious materials
- » Dense reinforcement?
- » Able to pump?
- » Able to place?
- » Able to finish?



Durable Concrete?



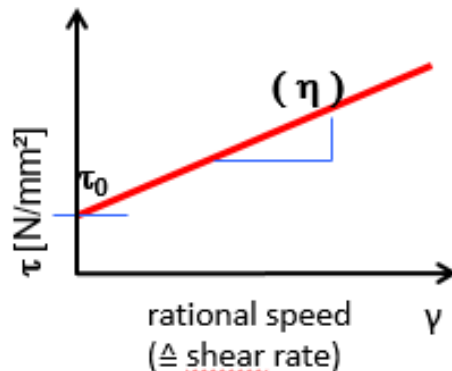
Rheology of Concrete

- » Rheology defines the flow and intrinsic behavior of materials (from Greek *rhéō*, "flow" and *-logia*, "study of")
- » “Rheology retention” expresses the ability to maintain these properties over an extended time.
- » Scientifically the rheology of the concrete is measured using a rheometer



Bingham fluid

$$\tau = \tau_0 + \eta \dot{\gamma}$$

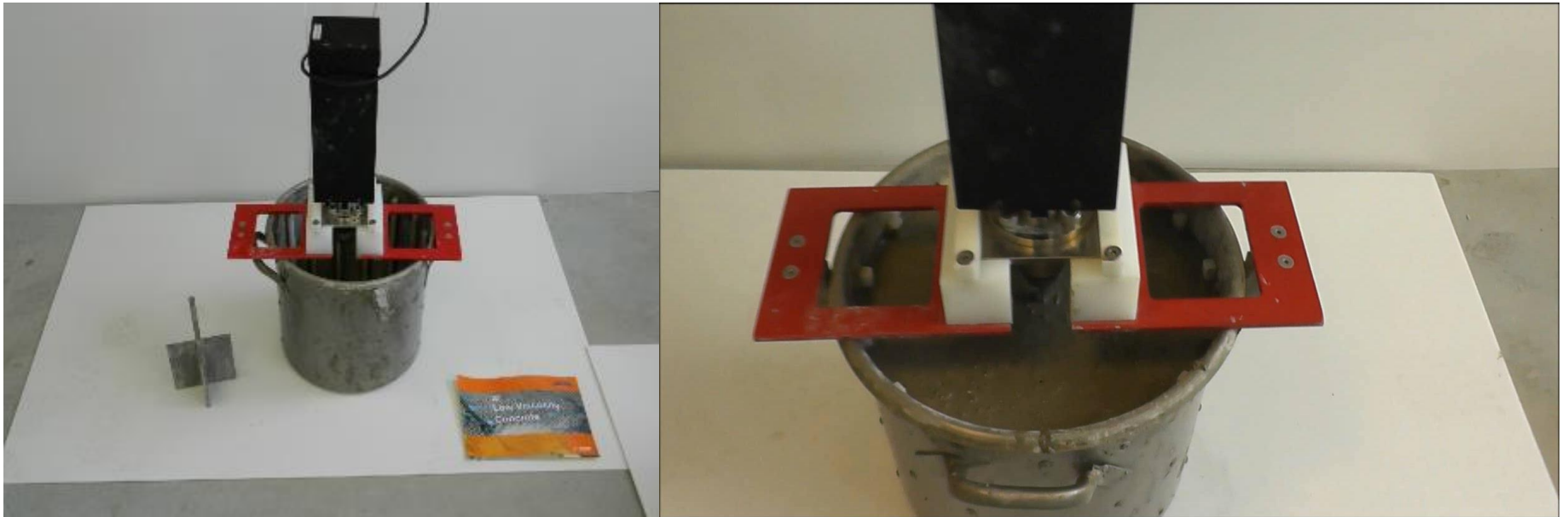


» Intrinsic characteristics

- τ_0 : yield point; minimum shear stress to initiate the flow
- η : plastic viscosity; slope of the shear stress curve vs. shear rate
- τ : Yield stress
- $\dot{\gamma}$: shear rate

Evaluation of rheology

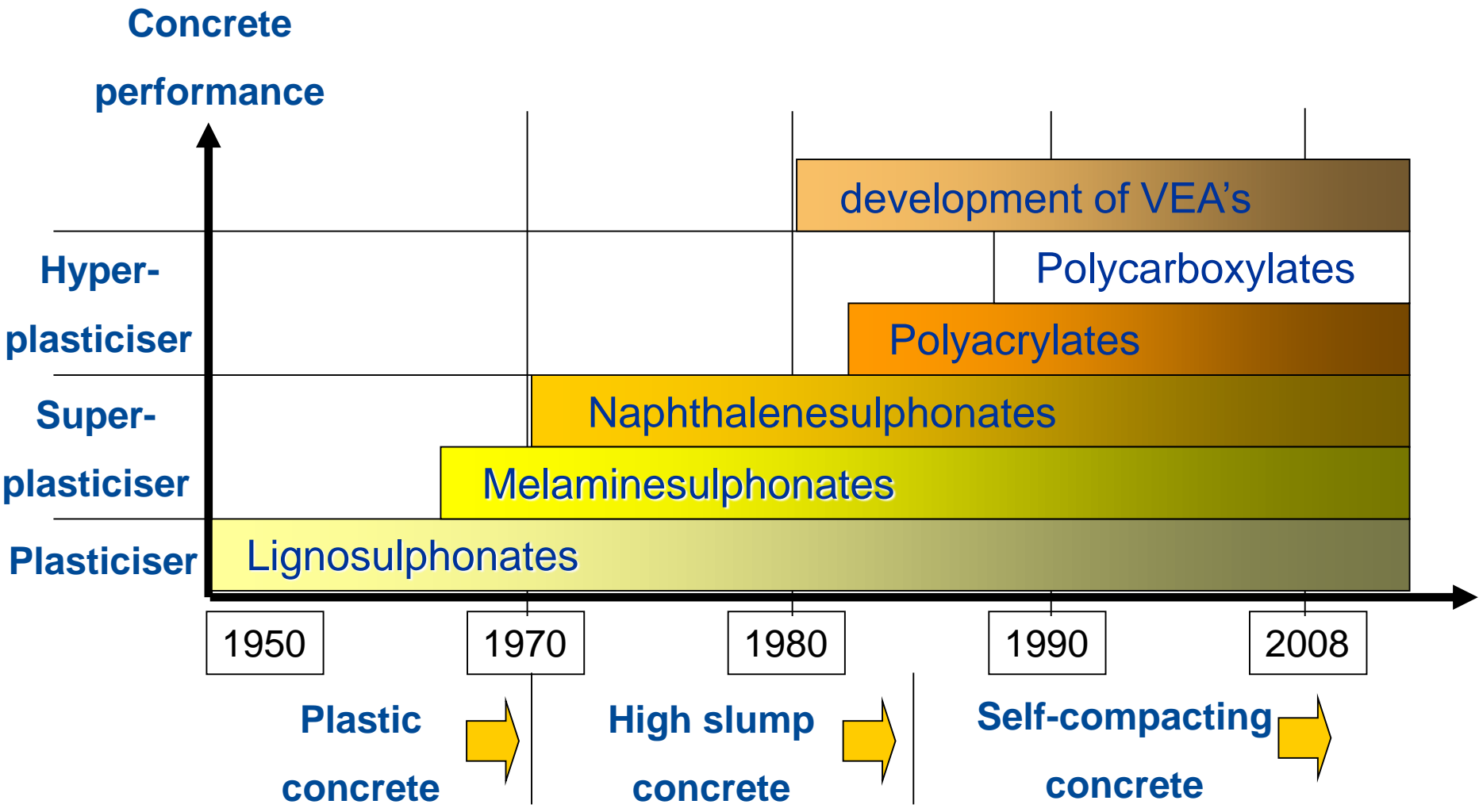
■ ICAR rheometer



» Measuring intrinsic characteristics

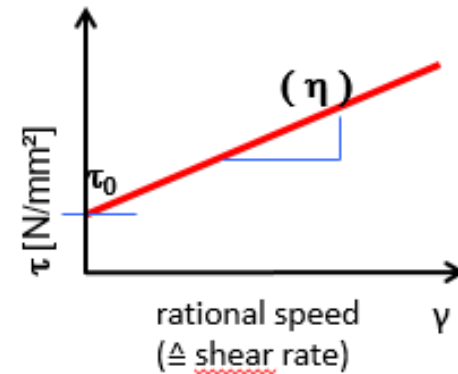
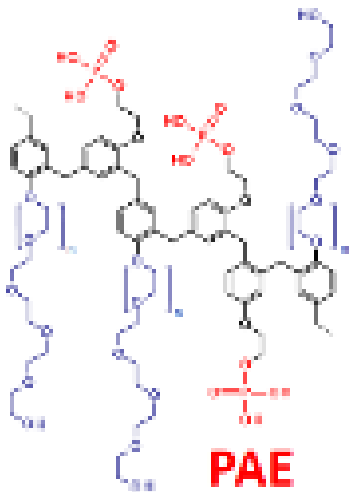
- τ_0 : yield point; minimum shear stress to initiate the flow
- η : plastic viscosity; slope of the shear stress curve vs. shear rate

Next generation polymers



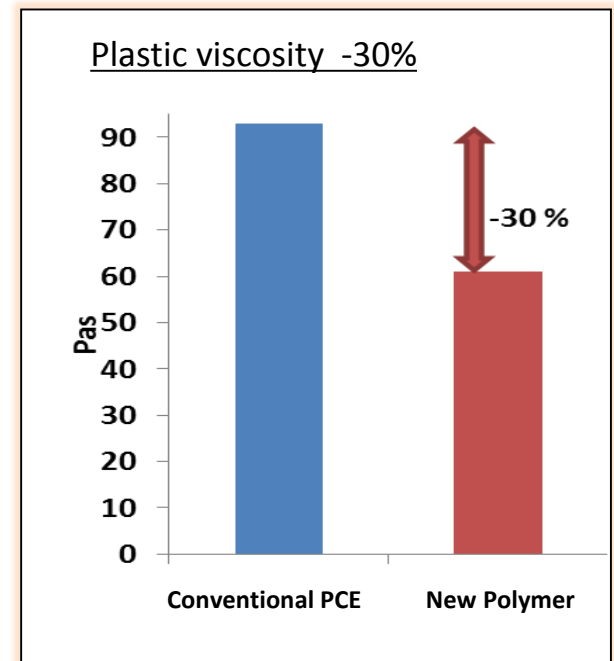
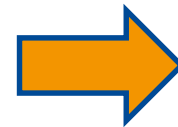
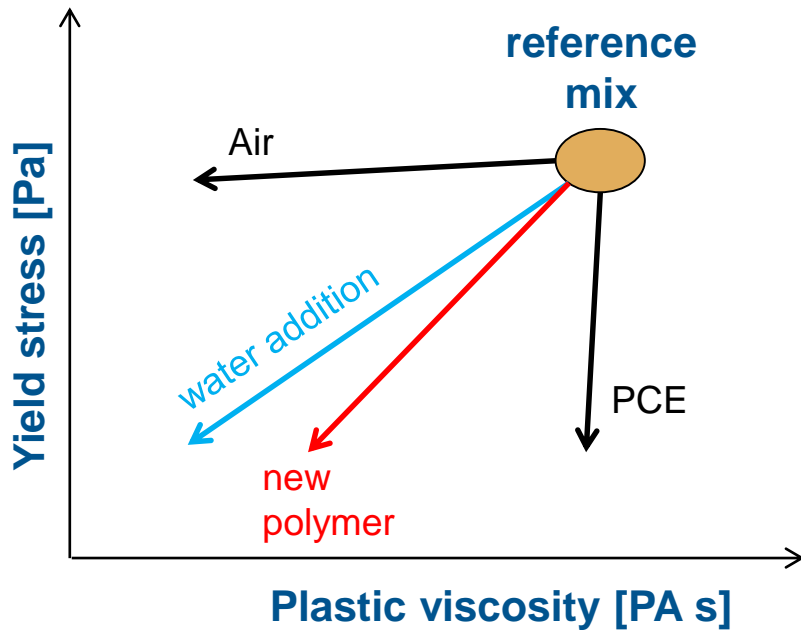
Poly Aryl Ether (PAE)

- » First new superplasticiser technology for 20 years
- » Patented technology
- » Much less sticky than any PCE (improved rheology)



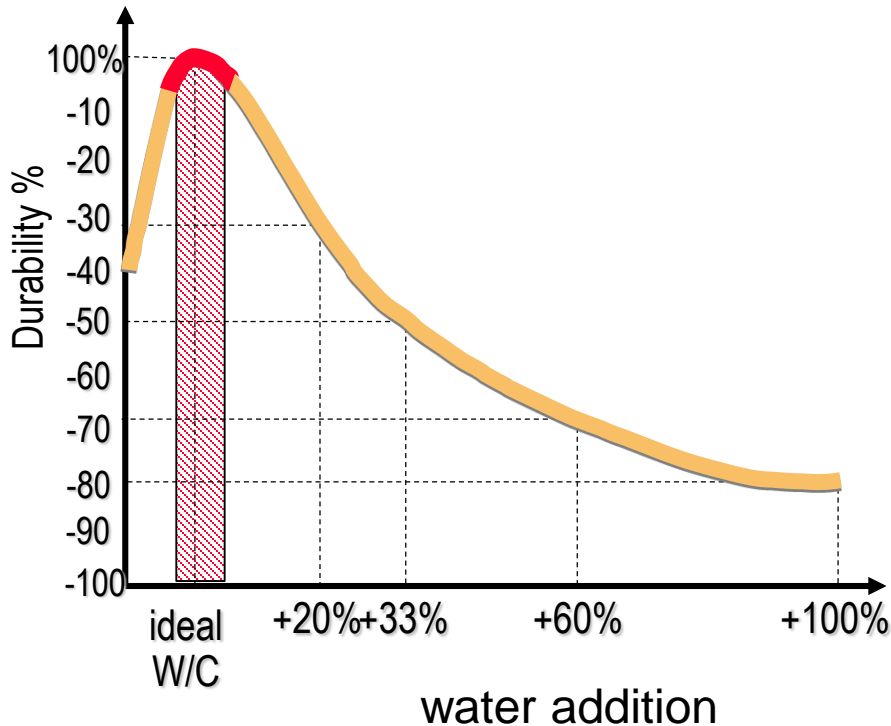
Performance objectives for new polymer

Maintain all the advantages of PCE technology: water reduction, workability retention, early strength, ...
Sharply decreases the yield stress and plastic viscosity of concrete

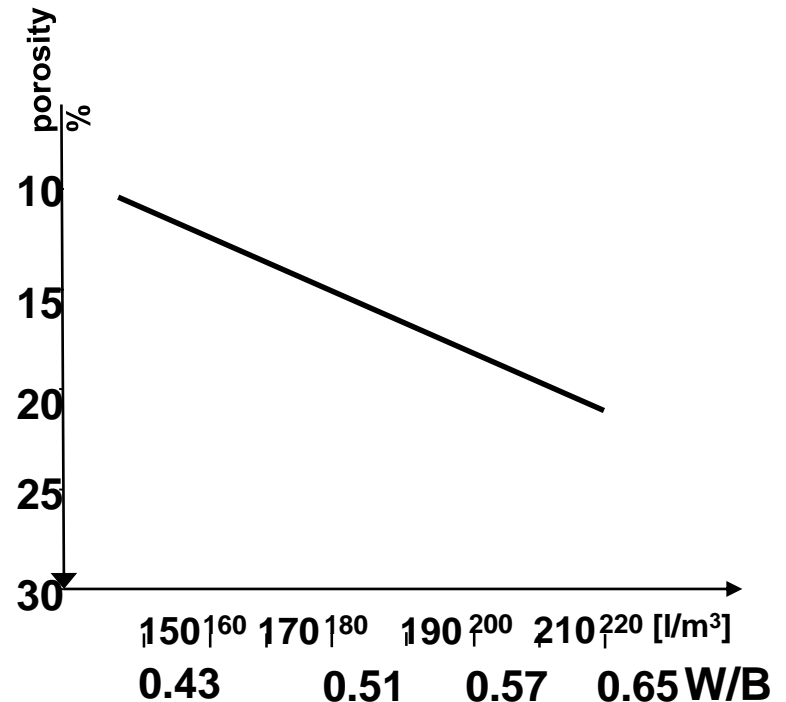


Water is good for rheology but....

» An increase in the dosage of water will have a direct impact on the mechanical performance



» There is a directly affect on the porosity



Performance optimisation

Objectives:

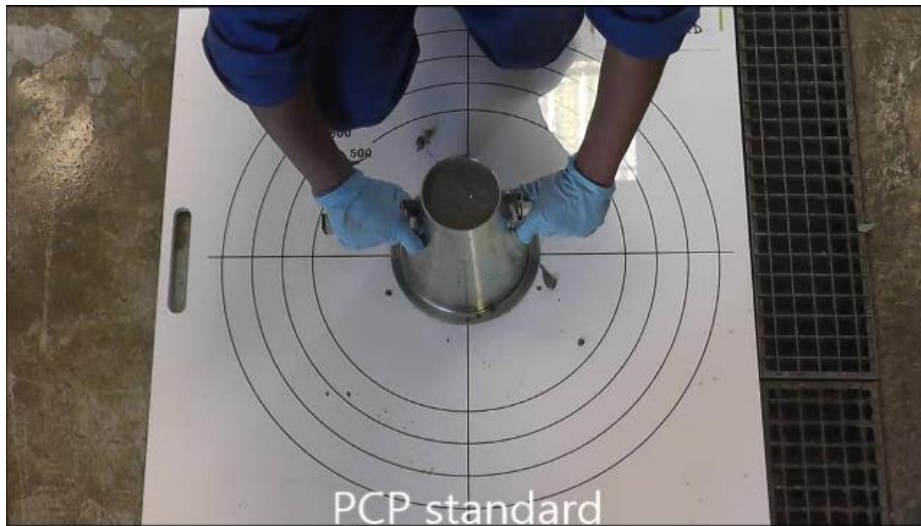
- » Possibility to reduce the w/c ratio without affecting the viscosity of concrete
- » Ensure maintenance of handling and maintaining low viscosity over the entire time of delivery and placement (“rheology retention”)
- » Mix design optimisations without compromising on rheology: Higher SCM usage and/or reduced cement. Use of challenging aggregates.
- » Improved concrete surfaces

Whilst at the same time improving:

- » The robustness of concrete
- » Durability of concrete (strength, shrinkage, porosity, etc)



Low viscosity concrete utilising PAE



Same mix design; same slump/flow

Only difference is admixture

Low viscosity concrete utilising PAE

Identical
mix design



Identical
slump flow



Low viscosity concrete utilising PAE

Identical mix design and identical slump flow



Launch of new polymer



ERMCO
EUROPEAN READY MIXED CONCRETE ORGANIZATION



XVII. ERMCO CONGRESS JUNE 4-5 2015
ISTANBUL - TURKEY

STANDARD PRODUCTION PROCESS GOES HIGHER

Session No	Hall 1 (30 Ajustos Hall)	Hall 2 (İnönü Hall)
Title	<i>Contribution of Concrete to Our Society</i>	<i>Advances in Concrete Production and Use</i>
Chair(s)	TBA	TBA
11:15 - 11:30	PERMEABLE CONCRETE PAVEMENTS - REQUIREMENTS, THE USE AND METHODS OF APPLICATION ALDONA WOISLO	CONCRETE RHEOLOGY CHARACTERIZATION: AN EASY WAY TO DETERMINING IT S.MORO, R.MAGAROTTO, F.MORATTI, G.AYKAN
11:30 - 11:45	DETERMINATION OF TEMPERATURE VARIATION FOR DIFFERENT CONCRETE CLASSES OF AIRPORT RIGID PAVEMENTS USING LABORATUARY STUDIES MEHMET TEVFIK SEFEROGLU, MUHAMMET VEFA AKPINAR, AYSEGUL GUNER, SEFEROGLU	INTRODUCING A NEW CLASS OF SUPERPLASTICIZERS FOR HIGHLY VISCOUS CONCRETE MIXES. JAN KLUEGGEE, GULNIHAL AYKAN
11:45 - 12:00	USE OF ROLLER COMPACTED CONCRETE IN COMPOSITE SOLUTIONS FOR HIGHWAYS STEVE CROMPTON	SYNERGY OF CEMENT + HYDROPHOBIC POLYMERIZING ADMIXTURES MURAT KABADAYI, OGUZ AYDINC, BURHAN MANZAK, ERBIL OZTEKIN
12:00 - 12:15	CONCRETE PAVEMENTS IN TUNNELS: A SUSTAINABLE CHOICE G. MARCHESE	THE EFFECTS OF CEMENT PRODUCED WITH NEW GENERATION GRINDING AIDS (PAAF COMPOUNDS), TO PHYSICAL AND MECHANICAL PROPERTIES OF CONCRETE HAKAN GULSEREN, LUGUR ERSEN SENBIL

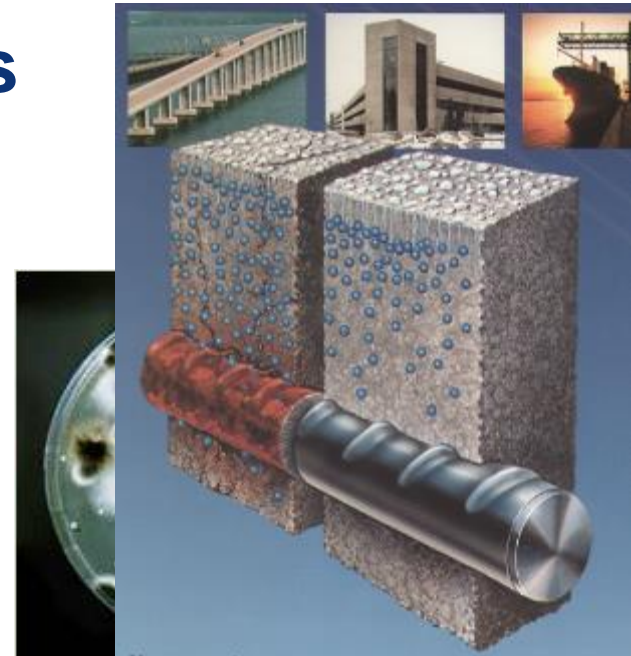
Advantages of PAE

- » Reduces pumping pressure
- » Reduced pumping time
- » Improved truck utilisation
- » Reduced wear and tear on pumps
- » Increased life of pipelines
- » Concrete easier to place and finish enabling the durability designed into the mix to be realised

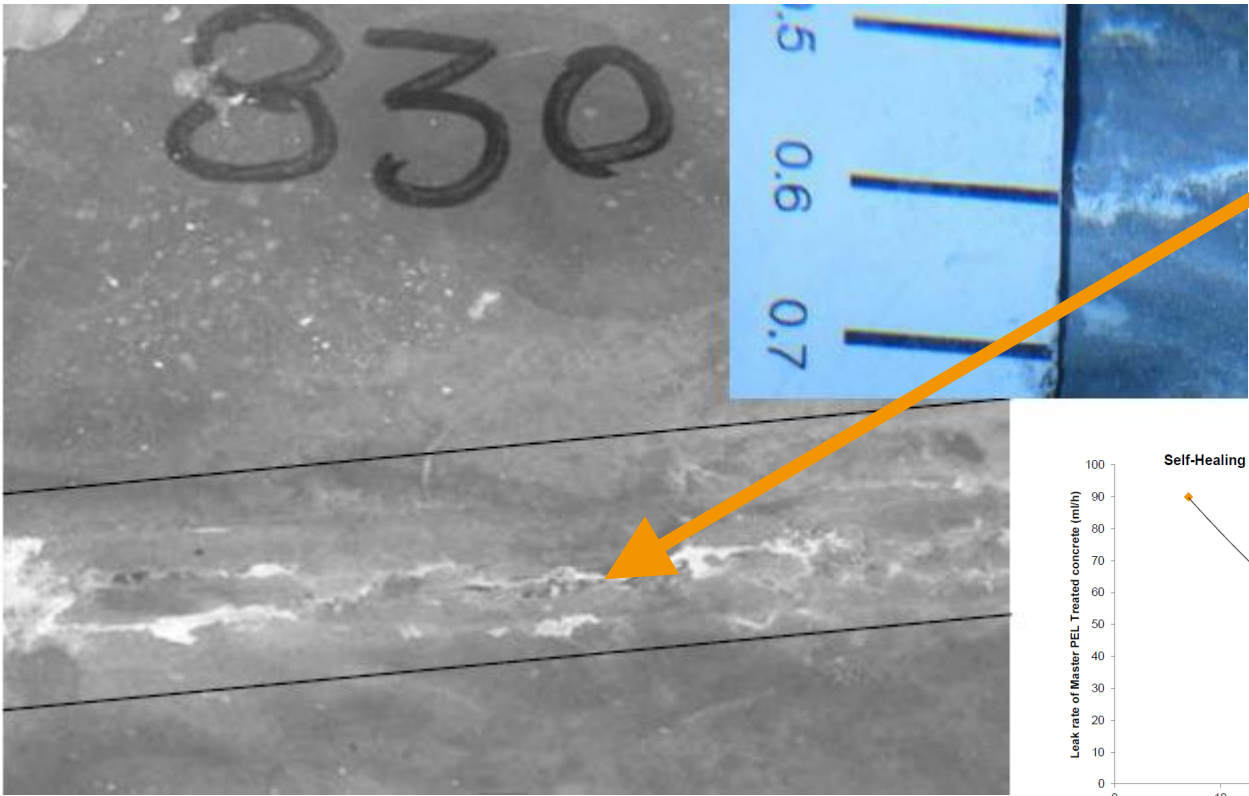


Admixtures for enhanced durability

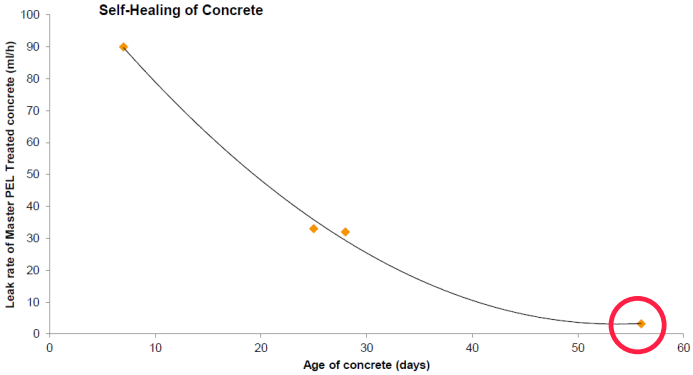
- » Shrinkage reducing admixtures
- » Crack reducing admixtures
- » Corrosion-inhibiting admixtures
- » Anti-microbial admixtures
- » Waterproofing admixtures



Crystalline waterproofing admixtures



**Sealing
cracks up to
0.4mm**



Hydrophobic pore-blocking admixtures

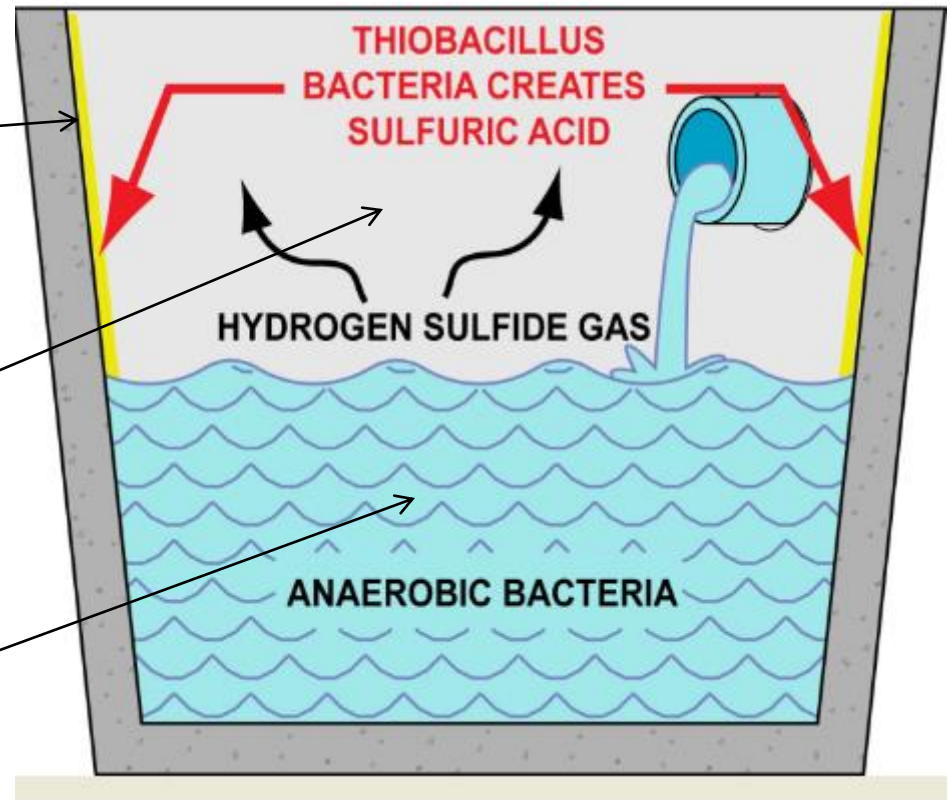
National Dubai, OPC		400	400
Total Free Water (Added + In Admixtures)		160 (157+3)	160 (150 + 10)
Free W / Cm Ratio		0.40	0.40
Superplasticiser dosage l/m ³ (l/100kg Cm)		4.95 (1.238)	5.15 (1.288)
Waterproofer dosage l/m ³ (1/100kg Cm)		-----	8.0 (2.0)
Date of Trial		30-6-02	30-6-02
Concrete Temperature °C		29.0	29.0
Workability by Slump mm	Initial 30min 60min	170 135 100	180 150 115
Air Content %		1.6	2.5
Fresh Wet Density kg/m ³		2515	2490
BS 5075 Set Time hrs : mins	Initial Final	5:15 6:45	6:45 8:00
Compressive Strength N/mm ²	24hrs 3day 7day	27.0 45.0 54.5 61.0	23.0 41.5 49.5 60.0
BS 1881 Pt 122 Water Absorption 7day		2.5 %	0.75 %

Microbiologically Induced Corrosion (MIC)

3. Sulfuric acid (H_2SO_4) is a strong acid that corrodes the concrete structure

2. Air breathing bacteria (Thiobacillus) in the sewerage system convert H_2S into sulfuric acid (H_2SO_4)

1. Non air breathing bacteria in the raw sewerage produce hydrogen sulfide gas (H_2S)



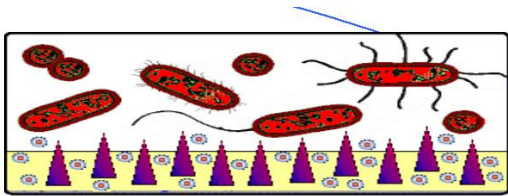
Effects of Micro-organisms on Concrete

Microbiologically Induced Corrosion (MIC)

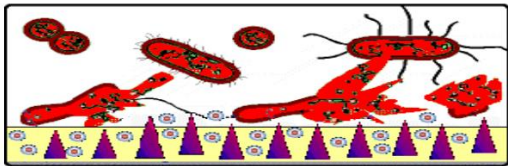


Anti-Microbial Admixture (AMA)

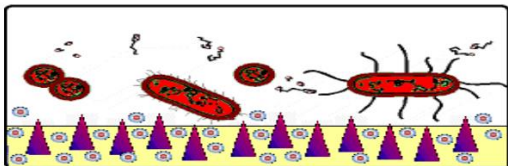
How Does It Work?



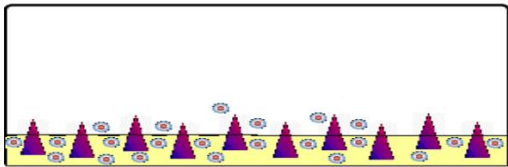
1. Anti-Microbial Admixture (AMA) integrates permanently into the concrete structure



2. Micro-organisms come into contact with the concrete surface and are destroyed



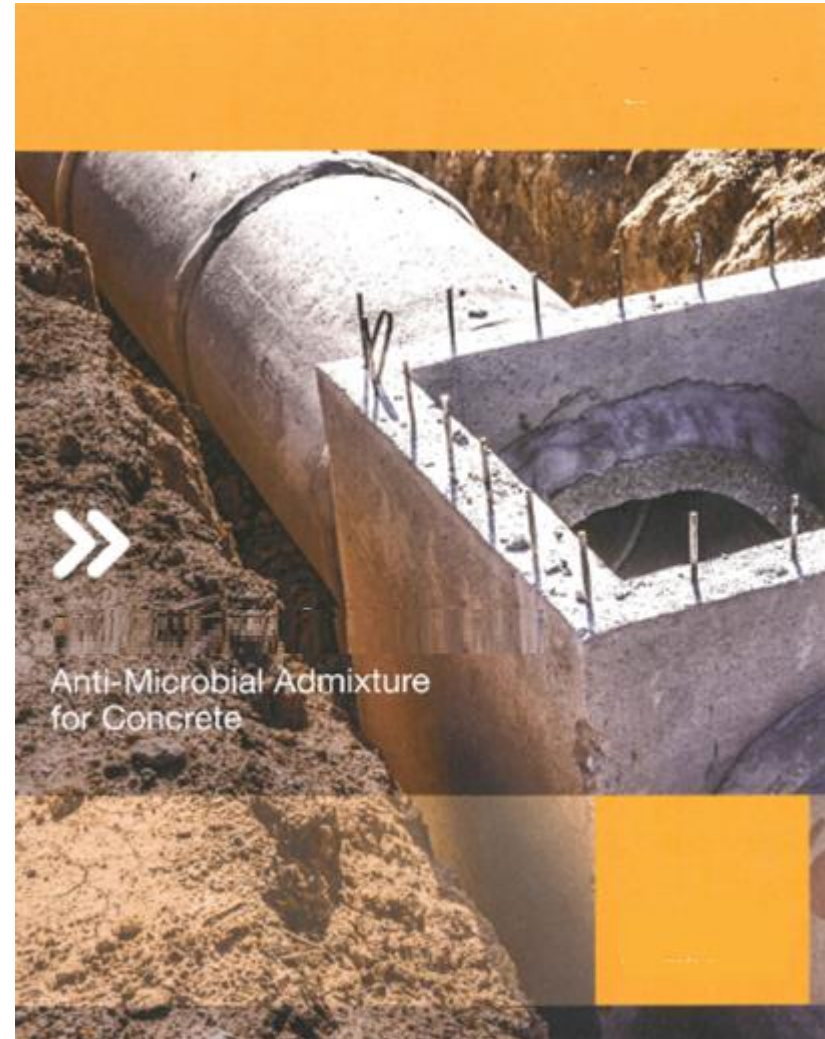
3. The AMA prohibits further growth of micro-organisms



4. The result - a clean concrete surface free of the growth of mold, algae, fungus, viral, and bacterial organisms for the life of the concrete

Features & Benefits

- » **Water-based, non-flammable**
- » **Not harmful to the environment, safe for producers and contractors to handle**
- » **Can be used in all concrete applications to prevent growth of micro-organisms (precast, manufactured concrete products, cast-in-place, shotcrete, underground constructions, etc.)**
- » **No impact to plastic or hardened concrete properties (air, set time, strength, etc.)**
- » **U.S. EPA Registered**
- » **Compatible with other admixtures for concrete**



Why do we need corrosion inhibiting admixtures?

**Concrete frequently fails to meet its design life;
especially in marine environments.**



What is a corrosion inhibitor?

- » An inhibitor is a substance which retards or slows down a chemical reaction. Thus, a ***corrosion inhibitor*** is a substance which, when added to an environment, decreases the rate of attack by the environment on a metal.

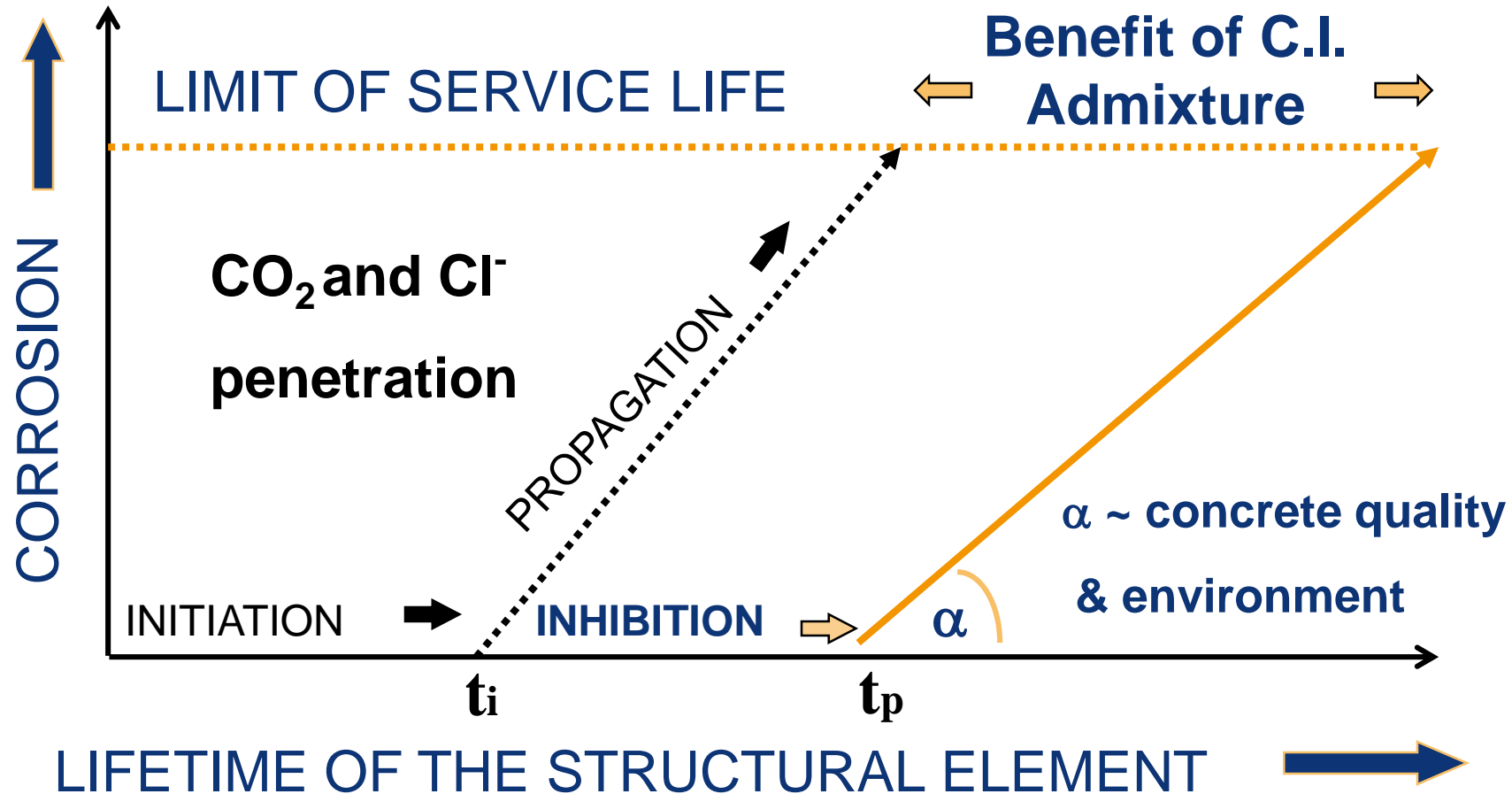
Corrosion Basics, *An Introduction*

pub. National Association of Corrosion Engineers (NACE)

Corrosion inhibiting admixtures

- » Give protection against corrosion of steel in reinforced concrete structures
- » Good for structures exposed to cycles of wetting and drying (e.g. structures in a marine environment)
- » *Do not prevent corrosion completely*
- » *Do delay the time when corrosion starts*
- » *Do delay the rate at which corrosion occurs*

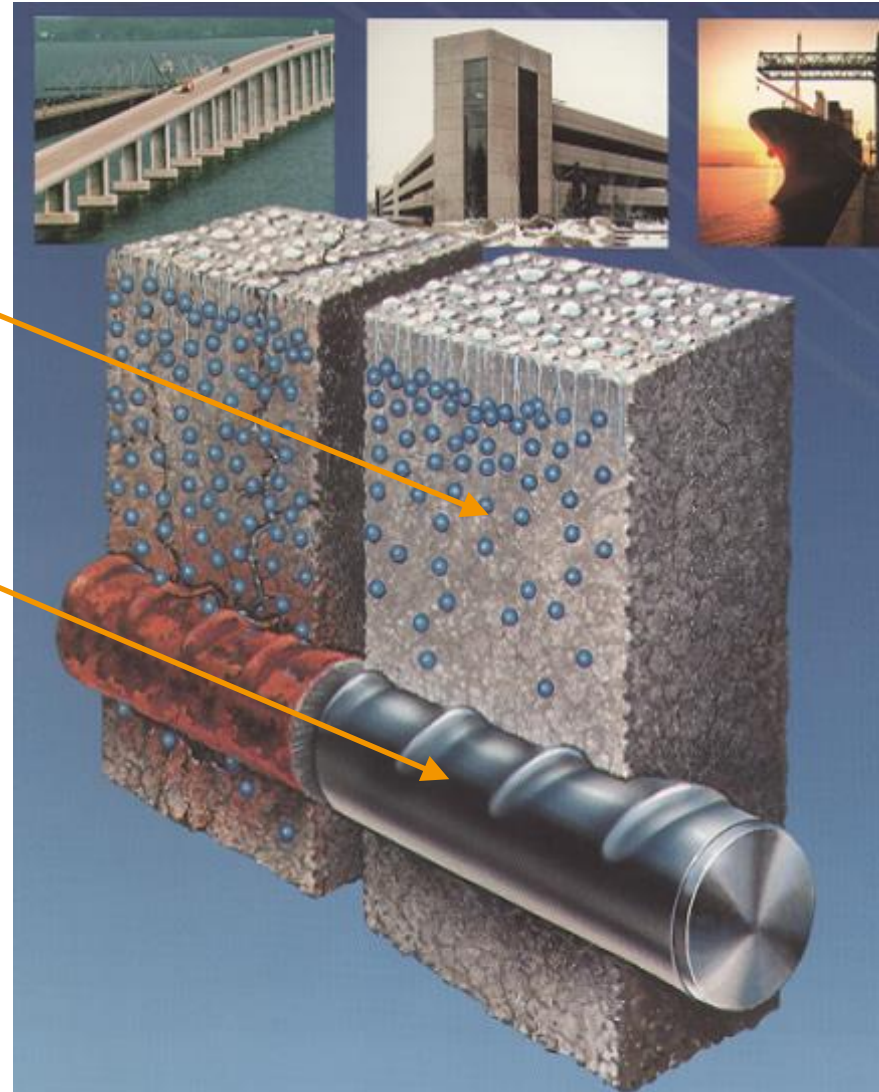
Service life of a reinforced concrete structural element



Dual mechanism organic corrosion inhibitors

- 1) Reduce permeability of concrete
- 2) Form a pacifying layer on steel

Single dosage independent of chloride level



Life-cycle modelling



<http://www.life-365.org/download.html>

Summary

- » **Yes; specify durable concrete. But...**
- » **Enhance the rheology to make the mix :**
 - **Easier to pump**
 - **Easier to place and compact (preferably SCC)**
 - **Easier to finish**
- » **Then extend the service life of the structure by adding durability-enhancing admixtures.**

»» Thank you for your attention.

