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Concrete Pavement Surface Repair

- For Seaport and Airport

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  - Current procedure for repair
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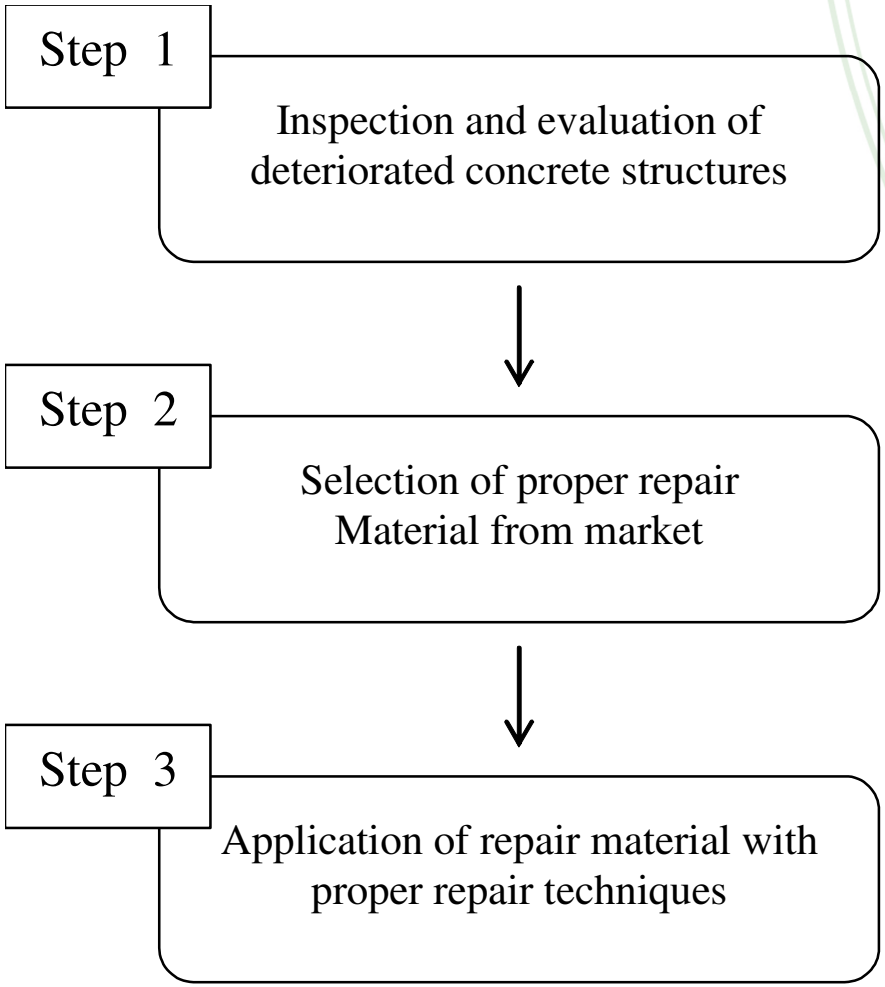
Introduction

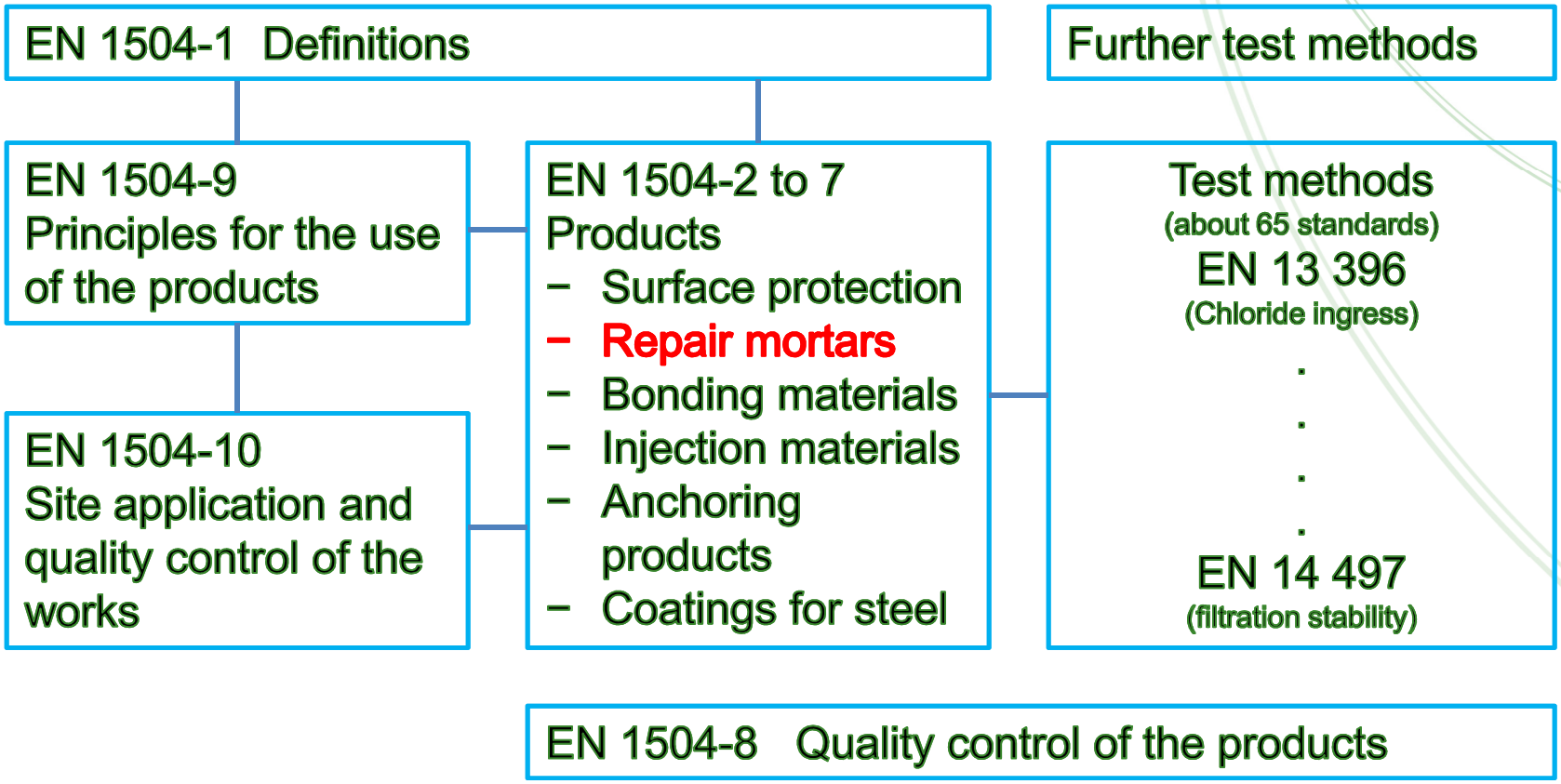
Seaport Road surface repair

- Tried many repair materials from market
- Last less than three months
- Traffic shut-down time for maintenance: 6 hours

Current Procedures for practical repair



Specifications for concrete repair EN 1504



The fields of application covered are in accordance with ENV 1504, part 9

Principle 3	Concrete restoration	Method 3.1	Applying mortar by hand
		Method 3.2	Recasting with concrete
		Method 3.3	Spraying mortar or concrete
Principle 4	Structural strengthening	Method 4.4	Adding mortar or concrete
Principle 7	Preserving or restoring	Method 7.1	Increasing cover to reinforcement passivity with passivity mortar or concrete
		Method 7.2	Replacing contaminated concrete

Performance characteristics of structural and non-structural repair products_EN 1504, Part 3 – Structural and Non-Structural Repair of Concrete Structures

Performance characteristics	Repair principle			
	3	3	4	7
	Repair method			
	3.1; 3.2	3.3	4.1	7.1; 7.2
Compressive strength	●	●	●	●
Chloride ion content	●	●	●	●
Adhesive bond	●	●	●	●
Restrained shrinkage / expansion	●	●	●	●
Durability - carbonation resistance	●	●	●	●
Durability - thermal compatibility freeze / thaw; thunder / shower; dry cycling	□	□	□	□
Elastic modulus	□	□	●	□
Skid resistance	□	□	□	□
Coefficient of thermal expansion	□	□	□	□
Capillary absorption (water permeability)	□	□	□	□

● For all intended uses; □ For certain intended uses.

Performance requirements for cementitious structural and non-structural repair products

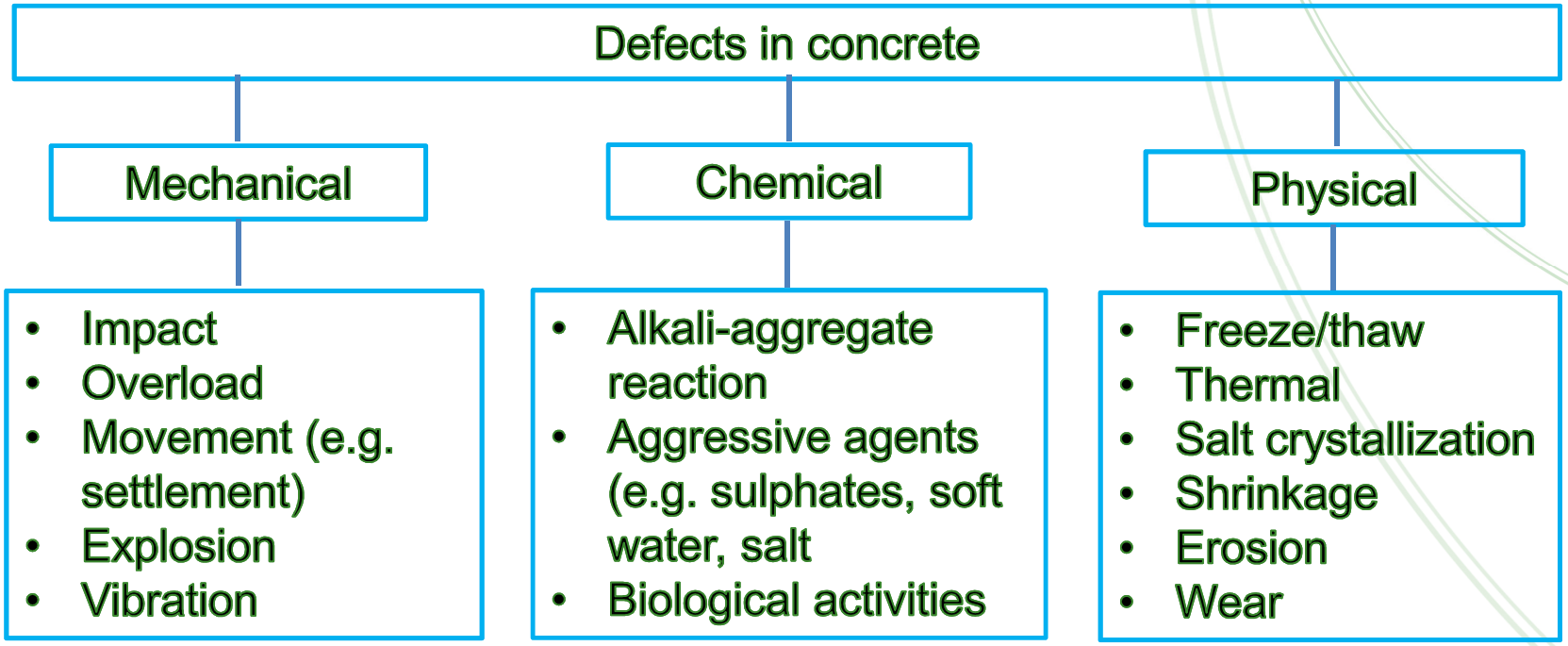
Performance characteristics	Requirement (Table 3 in EN 1504, part 3)			
	Structural		Non-Structural	
	Class R4	Class R3	Class R2	Class R1
Compressive strength	≥ 45 MPa	≥ 25 MPa	≥ 15 MPa	≥ 10 MPa
Chloride ion content	≤ 0.05%		≤ 0.05%	
Adhesive bond	≥ 2.0 MPa	≥ 1.5 MPa	≥ 0.8 MPa	
Restrained shrinkage / expansion	Bond strength after test			No requirement
	≥ 2.0 MPa	≥ 1.5 MPa	≥ 0.8 MPa	
Durability - carbonation resistance	dk ≤ control concrete		No requirement	
Durability - thermal compatibility freeze / thaw	Bond strength after 50 cycles			Visual inspection after 50 cycles
	≥ 2.0 MPa	≥ 1.5 MPa	≥ 0.8 MPa	
Durability - thermal compatibility thunder / shower	Bond strength after 30 cycles			Visual inspection after 30 cycles
	≥ 2.0 MPa	≥ 1.5 MPa	≥ 0.8 MPa	
Durability - thermal compatibility dry cycling	Bond strength after 30 cycles			Visual inspection after 30 cycles
	≥ 2.0 MPa	≥ 1.5 MPa	≥ 0.8 MPa	
Elastic modulus	≥ 20 Gpa	≥ 15 GPa	No requirement	
Skid resistance	Class I: > 40 units wet tested Class II: > 40 units dry tested Class III: > 55 units wet tested		Class I: > 40 units wet tested Class II: > 40 units dry tested Class III: > 55 units wet tested	
Capillary absorption	0.5 kg/m2.h0.5		0.5 kg/m2.h0.5	No requirement

Market available products for such applications

Properties		Product A	Product B	Product C
Setting time (min)	Initial	20	15	11-14
	Final	40	20	15-17
Compressive strength (MPa)	1 hour			10
	2 hour	20		
	3 hour			25
	4 hour	40	25 (6 hrs)	
	24 hour	50	30	40
	3 days	55		45
	28 days	60	40	55
Flexural strength (MPa)	1 days		5	4
	28 days		10	5
Pull out bond strength (MPa)	7 days	> Tensile strength of concrete	/	1.5
	28 days		/	2.0
Fresh Wet Density (kg/m3)	(with 10mm aggregates)	2300	1900-2000	1980-2050

- These market available products may satisfy the relevant specification, but may not perform well in a specific service environment
- Chemilink™ SS-123 is a fast setting non-shrinkage repair mortar and not recommended for this application

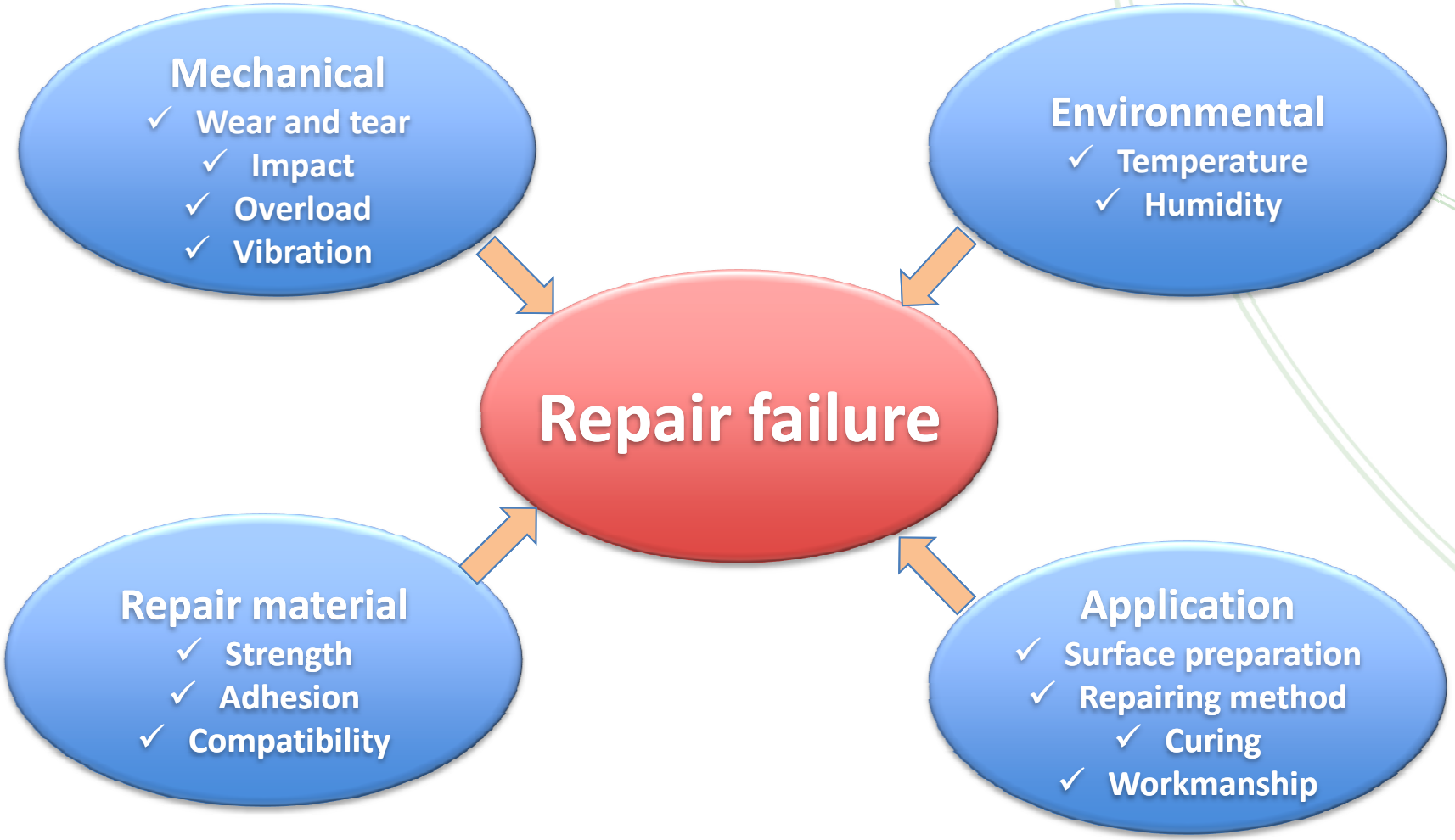
Common causes of concrete defects



Causes of seaport concrete defects

- Wear and Tear
- Impact
- Overload
- Vibration
- Thermal
- Shrinkage
- Erosion
- Wear

Main causes of seaport repair failure



Causes of repair failure

Mechanical

- ✓ Wear and tear
- ✓ Impact
- ✓ Overload
- ✓ Vibration

Causes of repair failure

- High early strength

  →

  – High modulus of elasticity
  – Low flexibility and toughness

  →

  – Low cracking resistance
  – Susceptible to fracturing from impact loads

Causes of repair failure

Adhesion is mainly affected by:

- Repair material (Formulation design)
- Substrate surface preparation
  - Removal of concrete using violent means may cause damage to the substrate concrete that is Intended to remain in place and reduces the adhesion of repair materials
  - Selection of concrete removal techniques: effective, safe, economical, and less damage to the substrate concrete
- Substrate surface texture and moisture content

Causes of repair failure - General requirements for patch repair materials for compatibility

Property	Relationship of repair material (R) to concrete substrate (C)
Shrinkage strain	R < C
Creep coefficient (for repairs in compression)	R < C
Creep coefficient (for repairs in tension)	R > C
Thermal coefficient of expansion	R = C
Modulus of elasticity	R = C
Poisson's ratio	R = C
Tensile strength	R > C
Fatigue performance	R > C
Adhesion	R > C
Porosity & resistivity	R = C
Chemical reactivity	R < C

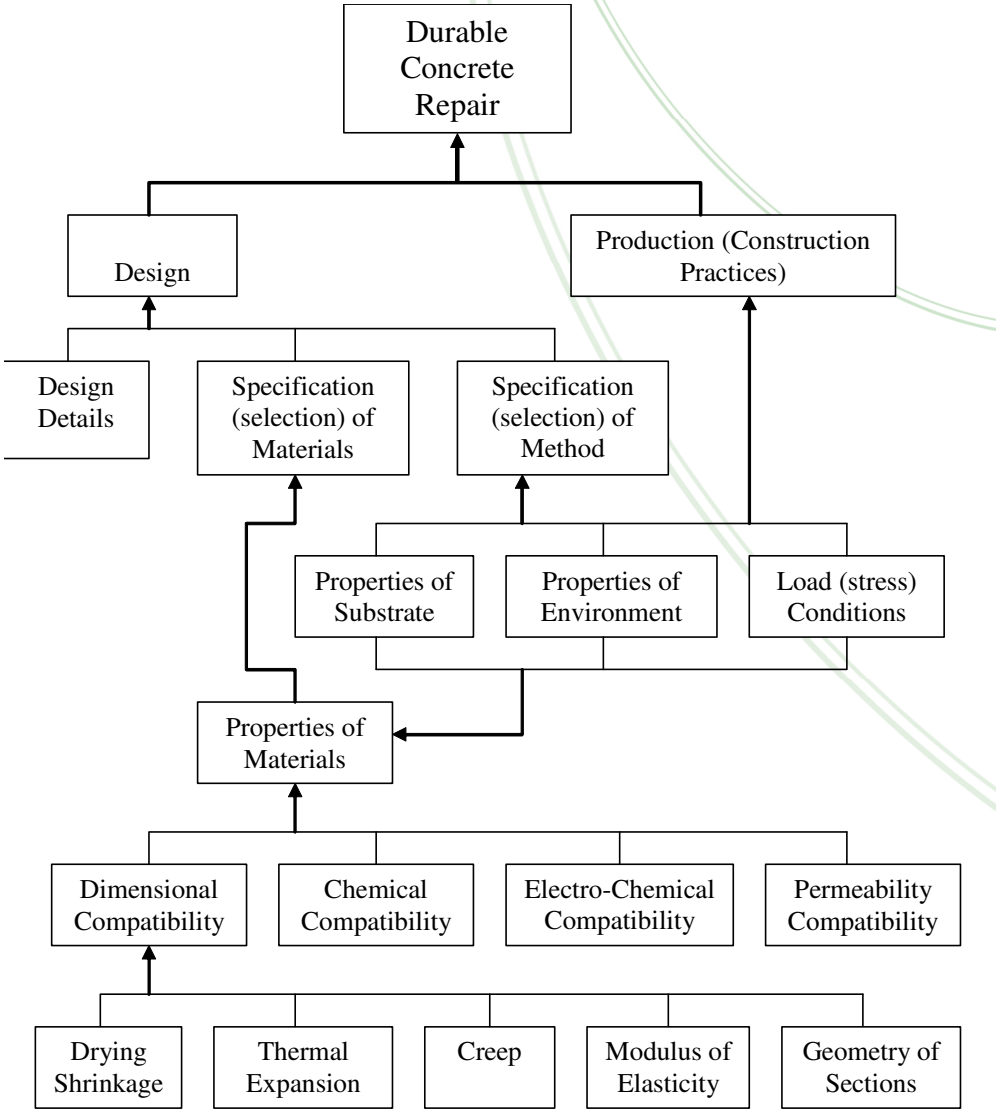
Repair Failure Process

1. Local Debond
   - Poor adhesion
   - Incompatibility with substrate
   - Wear and tear
   - Impact and vibration
2. Crack
   - Overload
   - Wear and tear
   - Impact and vibration
   - Differential shrinkage
   - Thermal shock
3. Pop-out
   - Impact and vibration
4. Debond and cracks in surrounding areas
   - Wear and tear
   - Impact and vibration

Chemilink methodologies
Performance–based repair material design

Procedures for performance-based product design

- Case study
  - Site visit
  - Cause analysis
- Product design
  - Formulation design
  - Lab trial
  - Site trial
- Product launch



Our products under development

- Product Chemilink SS-132
  for concrete surface repair/restoration

- Product Chemilink SS-132ST
  for concrete surface rejuvenation

Product Chemilink SS-132 for concrete surface and patch repair/restoration

- Features
  - Designed for thin section repair: 5-30mm
  - High early strength: Minimum disruption to traffic (15-25MPa/2hrs)
  - High final strength: suitable for high loading situations (35-50MPa/28days)
  - High bond strength
  - High impact resistance and crack resistance
  - High abrasion and chemical resistance

- Package
  - Powder Part: 25 kg/bag
  - Liquid Part: 4kg/pail

Application trial of product Chemilink SS-132

- Prepare the repaired surface to a rough profile
- Pre-wetting the surface thoroughly
- Remove the standing water from the surface
- Mix and apply the repair mortar
- Load trial after two-hours curing
- No cracking, debonding and other defects were found after one month.

Product Chemilink SS-132ST for concrete surface rejuvenation

- Features
  - Specially designed for supper thin section repair: 3-5mm
  - High final strength: suitable for high loading situations
  - High bond strength
  - High impact resistance and crack resistance
  - High abrasion, erosion and chemical resistance
  - Good workability and easy to apply

- Package
  - Powder Part: 25 kg/bag
  - Liquid Part: 4.3 kg/pail

Clarifications

1. High early strength? need to be back to service in 4-6 hours?
2. Durability? Expected to last how many years?
3. Color match to existing substrates?
4. Surface texture
5. Application method

Application trial of product Chemilink SS-132ST

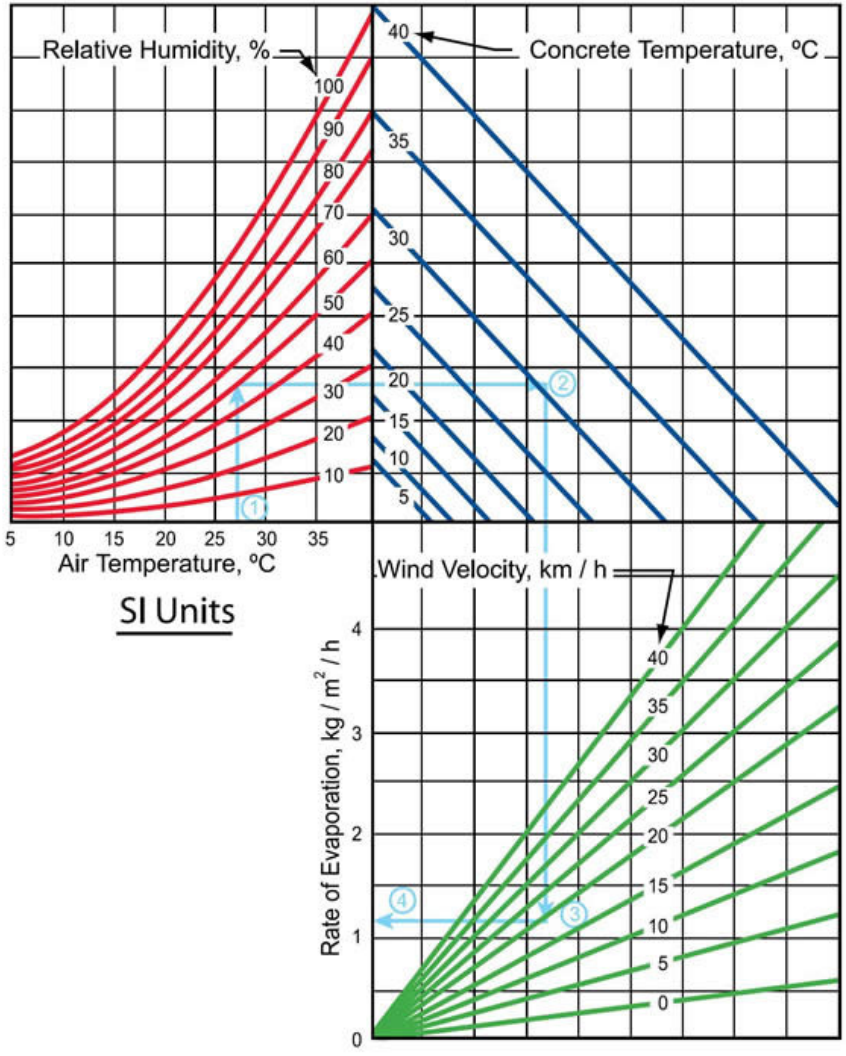
- Clean the repaired surface
- Pre-wetting the surface thoroughly
- Remove the standing water from the surface
- Mix and apply the repair mortar
- Broom the surface for texture
- Curing for the first 48 hours
- No cracking, debonding and other defects were found.

Tips for successful surface repair

- Shrinkage and cracking control:
  - Thin, cementitious surface repairs are susceptible to plastic shrinkage cracking because their high surface-to-volume ratio promotes rapid evaporation under hot weather conditions in SEA
  - Also, because these materials usually have low water-cement ratios, there is little bleed water to replace evaporated water
  - It is recommended the placements to be done in the early morning or late at night to avoid weather conditions which will aggravate this drying
  - Prewetting the concrete substrate is recommended
- Adhesion enhancement
  - Roughening the substrate surface will enhance the bond
  - Intimate contact: Intimate contact can be achieved by vibration, pneumatic application, high fluidity, and troweling pressure
- The anti-slip *surface* texture can be obtained by stroking a *broom* over *freshly* placed *concrete.*
- Normal curing procedures should be applied for the first 24 to 48 hours

Estimating Evaporation Rates to Prevent Plastic Shrinkage Cracking

- *To use these charts:*
- Enter with air temperature and move *up* to relative humidity;
- Move *right* to concrete temperature;
- Move *down* to wind velocity; and
- Move *left* to read rate of evaporation



Conclusions

- Concrete surface repair is a system, and the success of the repair is affected by many factors, like load condition, environment, substrate preparation, performance of repair materials and workmanship

- Chemilink has the abilities to design and manufacture different repair materials based on their performance required

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Thank You for Your Attention!

About Bonding Agent

- Types of bonding agent: epoxy-based, latex-based and cement based
- Bonding agent is suitable for most non-structural repairs
- Application of the bonding agent to the prepared substrate must be done with care and must be timed to the placement of the repair material.
- Bonding agents applied to substrates may begin to set or cure prematurely creating a bond breaker with the new repair material.
- Bonding materials create a moisture barrier between the existing substrate and the repair material.
- Under certain conditions a moisture barrier could result in failure of the repair, when moisture is trapped in the concrete directly behind the moisture barrier.