Overview of defects on structures

- Identification of **defects** on a structure forms the basis of the BMS.
- **Defects** that have consequences with regards to the safety of users and the structural or functional integrity must be identified and rated.

Types of defects

The main types of defects are:

- Deficiencies:
  - Design deficiencies;
  - Construction deficiencies; and
  - Material performance related deficiencies.
- Damage; and
- Deterioration.

Design deficiencies

Defects associated with errors in:

- Design assumptions
- Analysis
- Design calculations
- Detailing
- Geotechnical assumptions

Construction deficiencies

Defects associated with:

- Incorrect placement of reinforcement
- Lack of cover
- Inadequate curing
- Poor workmanship and quality control

Material performance deficiencies

Normally noticed as:

- Abnormal deflections;
- Cracking; or
- Other problems

soon after or even during construction.

Damage

- Fire
- Natural elements (earthquakes, floods, etc.)
- Foundation settlement
- Impact
- Scour
- Constraint
- Undermining
- Overloading

Deterioration

- Delamination
- Spalling
- Cracking
- Carbonation
- Chloride penetration
- Efflorescence and discolouration
- Alkali-aggregate reaction
- Other chemical attack
- Corrosion and fatigue of structural steel

Delamination / Spalling

- Delamination occurs when a surface layer of concrete separates from the member mass.
- Primary cause is corrosion of reinforcement.
- A spall is formed when delaminated material becomes dislodged.

Cracking

- Reinforced concrete is designed with the knowledge that concrete will crack under tensile stresses.
- In many cases cracking does not present a problem and no treatment is required.

Cracking

Cracks can form before hardening of concrete due to:

- Early frost damage
- Plastic shrinkage
- Plastic settlement
- Construction related movement

Cracking

Cracks can form after hardening of concrete due to:

- Drying shrinkage
- Corrosion of reinforcement
- Alkali-aggregate reaction
- Freeze / thaw cycles
- Thermal contraction
- Structural reasons
- Creep

Crack width ranges for Reinforced Concrete

Hairline	< 0.1 mm
Narrow	0.1 - 0.3 mm
Medium	0.3 - 0.7 mm
Wide	> 0.7 mm

Carbonation

- Corrosion of reinforcement is inhibited in the presence of a strong alkaline environment by the formation of a film of iron oxide on the surface of the embedded reinforcement.
- Carbonation takes place when carbon dioxide in the air reacts with the calcium hydroxide in the concrete to neutralize the alkaline environment.
- The protective layer is neutralized by carbonation.
- The rate of carbonation depends on the permeability of the concrete, relative humidity and concentration of carbon dioxide present.

Chloride penetration

- Normally present in structures exposed to a marine environment
- Use of de-icing salts to melt snow and ice on road surfaces. (Not common in Southern Africa)
- Use of beach sand or sea water to manufacture concrete

Efflorescence and discolouration

- White deposits that sometimes leach out of concrete.
- Results from migration of salts in solution to the surface of the concrete where they crystallize.
- Can be visible as stalactites hanging from the deck soffit.
- Does not influence the durability of the concrete.

Alkali-aggregate reaction

- Occurs when water-soluble alkalis released from the hydrating cement react with the aggregates to form a gel.
- The gel that is formed swells when it absorbs water.
- Concrete cracks if the swell pressure exceeds the tensile strength of the concrete.

Alkali-aggregate reaction

AAR cracking in pier head

AAR cracking in return wall

Chemical attack

- Acid rain is the most common cause of chemical attack in bridge structures
- Is found in heavily air polluted zones where emissions of dioxide react with water molecules in the atmosphere to produce acids
- Accelerated deterioration will occur in concrete surfaces that are exposed to these acids

Corrosion and fatigue of steel

- When corrosion protection systems fail, steel corrodes with the resultant loss of structural strength
- Cyclic loading may cause fatigue cracking which can result in sudden failure with little notice

Ancillary bridge elements

- Expansion joints
- Bearings
- Parapets and end blocks
- Drainage
- Embankment protection

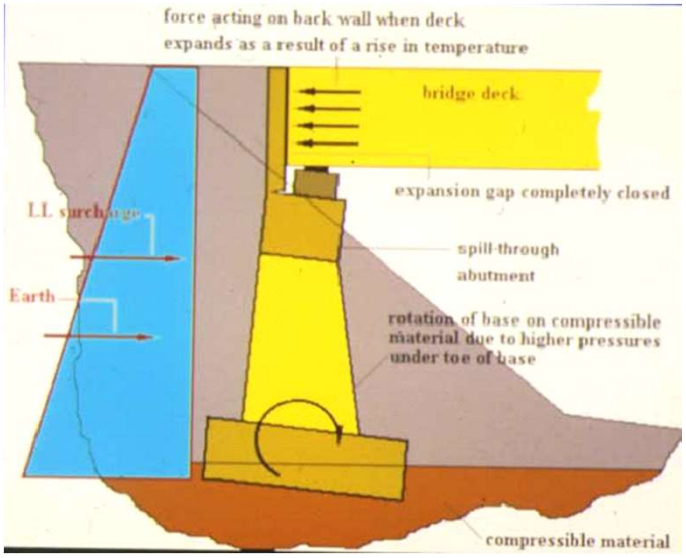
Typical expansion joint defects

- Inadequate allowance for movement
- Poor detail at kerbs and side walks
- Armoured edges of joints not continuous
- Asphaltic plug type (Thorma joints): poor quality materials resulting in segregation of aggregate and binder leaving permeable stone pockets
- “Press fit” joints working out of joint over time
- Epoxy nosing failure (not used anymore)
- Bolt-down type failure

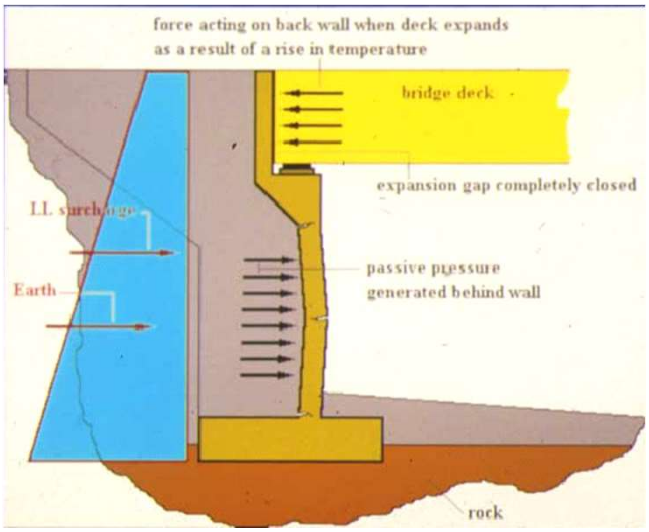
Foundation defects

- Stability of substructure → piled or spread footing and founding material
- Settlement in foundations can be observed by visual sighting along parapet
- Closure of abutment joints expansion joints

Foundation defects



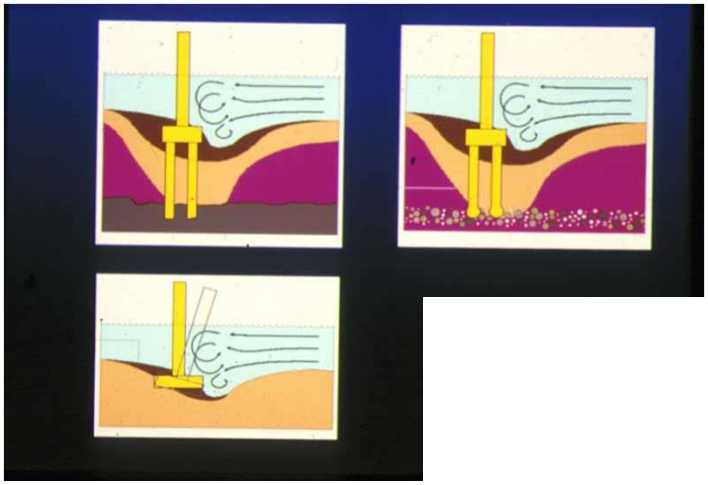
Foundation defects



Scour defects

- The integrity of substructures should not be affected if founded on rock or end bearing piles and have been designed to cater for flood forces and scour.
- The integrity of substructures may be affected if founded on spread footings on erodible material or on friction piles.

Scour defects



Scour defects