Concrete Defects

CB 557
Inspection, Maintenance and Repair of Structures

Dr. Karim Helmy
FRESH CONCRETE DEFECTS
Shrinkage Cracks

• Caused by evaporation of mix water in fresh concrete, the extent of which will depend on
  – The amount of water in concrete increasing water in the mix increases cracking
  – The weather conditions (heat, low humidity and wind increases evaporation and therefore cracks)
  – Curing (lack of curing increases shrinkage)
Shrinkage Cracks
Settlement Cracks

• Caused by settlement of concrete due to drying
Movement of formwork
How to minimize fresh concrete cracks

• Do not use excessive water in the mix
• Proper compaction
• Do not cast in hot weather
  – If you have to cast in hot weather use chilled water or crushed ice
• Proper curing
• Proper construction and monitoring of formwork during pouring of concrete
DESIGN AND DETAILING ERRORS
Design Errors

• Not taking into consideration all load cases e.g. temperature, wind, construction loads etc.
• Not taking into consideration order of construction
• Complex details
• Not complying with minimum design requirements like minimum spacing and reinforcement ratios
• Not providing sufficient details specially in cases of irregular geometry or cases where suggested code detail do not apply
Detailing Errors

Insufficient Spacing between bars
Causes honey combs and voids
Distance between bars 1.5 max aggregate size or $\phi_{\text{max}}$
Detailing Errors

Incorrect

At least 1/3 of lower reinforcement should extend to the columns

Correct

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Detailing Errors

Incorrect

Correct

<1.5L

≥1.5L
Detailing Errors

- Sudden change in depth

Incorrect

Correct
Detailing Errors
CONSTRUCTION ERRORS
Construction Errors

• Increasing water in the mix
  – Increased shrinkage
  – Decreased strength
  – Increase void sizes which decrease durability
Insufficient Compaction

- Causes Voids and honeycombs which reduces durability as it exposes the reinforcement to the environment and may reduce the strength of the concrete sections.
Honey Combs and Voids
Construction Errors

• Excessive vibration of concrete
  – Causes bleeding and segregation of concrete
Insufficient tying of reinforcement

- Causes movement of reinforcement
Insufficient chairs and spacers

• Causes sagging of reinforcement which leads to
  – Reduction in concrete cover
  – Reduction in effective depth of sections

Concrete cover

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Improper Casting of long Columns

• Causes segregation of concrete
TEMPERATURE EFFECTS
Drying Shrinkage and Dimensional Changes Caused by Temperature

• Changes in dimensions either due to drying shrinkage or thermal expansion or contraction will cause stresses in restrained structures.

• Cracking will occur due if the stresses exceed the capacity of the concrete this will occur in the following cases:
  – Construction errors leading to excessive shrinkage
  – Poorly designed or constructed expansion joints
  – Design errors
Freezing and Thawing

- Water present in the voids of concrete will expand on freezing causing some internal pressure.
- The repeated cycles of freezing and thawing will weaken the concrete causing cracks and spalling.
- This could be prevented by using air entrained concrete.
CHEMICAL EFFECTS
Alkali Aggregate Reaction

• Alkali aggregate reaction results in deleterious expansive cracking of concrete occurring at later ages after construction. While mostly inert, some concrete aggregates, can react in the highly alkaline environment in concrete resulting in internal expansion that causes deleterious cracking
Alkali Aggregate Reaction

Slabs

Walls and Abutments

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Sulphate Attack

- Solution of the sulfates of various bases including sodium, potassium, magnesium and calcium react with hydrated cement paste forming gypsum or a compound called ettringite (sulphoaluminate) which leads to the expansion and disruption of the concrete and mortar. This process is referred to as sulphate attack.
Sulphate Attack
Corrosion of Reinforcement Steel

- The alkalinity of concrete provides a protective layer that protects the reinforcement from corrosion
Corrosion of Reinforcement Steel

- If the PH of the concrete is reduced below 9 by carbonation for example or if the protective layer is eroded by the presence of chemicals like chlorides or sulphates either from the environment or from within the concrete corrosion will occur.
Corrosion of Reinforcement Steel

• Corrosion is an electro-chemical reaction that requires the presence of
  – Oxygen
  – Water
  – Conductive medium
Corrosion of Reinforcement Steel

- Corroded steel is porous, weak and expansive which allow the progress of the corrosion process also causes cracking of the concrete.
Corrosion of Reinforcement Steel

- Crack patterns slabs
Corrosion of Reinforcement Steel

• Crack patterns beams
Corrosion of Reinforcement Steel

• Crack patterns columns
OVERLOADING
Overloading

• Accidental
• Intentional
  – Change of use
  – Violation of load limits
• Design or construction errors
• During construction
  – Excessive Storage
  – Insufficient shoring
  – Early removal of formwork
Overloading One Way Slabs
Overloading Two Way Slabs
Overloading Beams

Bending

Shear

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Overloading Columns

Shear

Compression

Buckling

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Overloading Columns

Compression

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