Causes and types of defects

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Learning Outcome

At the end of the course students should be able to understand:
• effect of faulty workmanship on reinforced concrete structure
Introduction

• There are so many variables affecting the production of concrete that there is always a potential for something to go wrong

• Following is a flow chart of a typical building process. Each box represent a category of problems that can arise in the building process
BILA KAMU TAK TAHAN LElahnya BElajar, MAKAM KAMU AKAN MENANGGUNG PERITNYA KEBODOHAN

-Imam Syafie-
Improper Reinforcement Placement

Two important reasons of proper placement

1. To carry tensile load (cantilever member)
2. Adequate cover to protect from corrosion
Steel located too low to carry tension loads.

Proper location of Negative Moment Steel

Tension crack may form in this area
Shifted cage, not enough cover

Area of Potential Rebar Corrosion
Improper Post-Tensioned Cable Drape

• Improper placement may result in tension stress, causing the concrete to crack
Proper Drape Location

Drape as Constructed

Crack forms directly above cable drape

Direction of Reaction Force

Toward Midspan

Beam End
Highly Congested Reinforcement

• Lap splices require overlaps of bars and may result in a mat of steel that concrete mix cannot pass through during placement and consolidation

• The result is either a visible, or worse, a latent void around the reinforcement
Congested Reinforcement prevents concrete from filling around bars.
Highly Congested Reinforcement
Highly Congested Reinforcement
Reinforcement
Reinforcement
Improper Bar Placement

Location of Stirrups

- T-section generally supported by inverted T-beam (ledger beam)
- The cantilevered portion of the beam supports the double-T’s stem.
- Critical forces in the cantilever are taken up by stirrups directly beneath the stem location
- Improper placement of the stirrups may result in a failure of the ledger beam support, and the double T may then drop
Typical Precast Parking Structure Configuration

- Ledger Beam
- Improper Stirrup Location
- Proper Stirrup Location
- Double T
- T Stem

Cut-Away View of Ledger Beam Reinforcement
Premature Removal of Forms

• Removal of forms (including shoring) before the concrete has reached its proper strength may result in compression and tension stresses, causing cracking, deflection, and possible collapse.
Cracking at the Slab beam interface is likely.

Premature Removal of Forms and Shoring

Newly Cast Concrete
Support Failure
Early Dismantling of Formwork
Curing of Concrete

Gunny Sack
Improper Column Form Placement

• If column is cast too tall and penetrates the slab/beam concrete, critical shear stresses may occur because of inadequate shear capacity area between the column and the slab/beam
Reduced Shear area between column and slab may result in potential punching shear failure.

Form penetrates Slab system, reducing shear area.
Cold Joints

• Cold joints are places of discontinuity within a member where concrete may not tightly bond to itself (old and new layer)

• To achieve proper bond and watertightness, the surface of hardened concrete must be free of dirt, debris, and laitance
New Placement on Hardened (or Initial Set) Concrete.

Cold Joint

Laitance

Hardened Concrete
Segregation

- Non-uniform distribution of its constituents
- Due to high slump mixes, incorrect methods of handling concrete, and over-vibration
- Upper surfaces have excessive paste and fines, and excessive water-cement ratio
- Concrete lack durability
Segregation

Coarse aggregate falls to bottom

Figure 9.7 Effect of increased water content on segregation. (Photo courtesy of Dr. C. Lysdale)

<table>
<thead>
<tr>
<th>W/C</th>
<th>Top</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.65</td>
<td>0.50</td>
<td>0.50</td>
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</tbody>
</table>

W/C = 0.65

W/C = 0.5
Improper Grades of Slab Surface

• Slab requiring drainage for proper runoff need special attention. Drains should be at low points
• Proper slope for quick runoff
• The quicker the water runs off the structure, the less leakage can occur through joints and cracks
Drain at High Point

Water collects in low points.
Ponding
Structural members that are cast out of tolerance pose aesthetic and structural problems.

May have improper concrete cover and cross section, which may produce eccentric loading.
Alignment
Plastic Settlement Cracking

• Plastic settlement cracking is caused by the settlement of plastic concrete around fixed reinforcement, leaving a plastic tear above the bar and a possible void beneath the bar.

• The probability of cracking is a function of
  – Cover
  – Slump
  – Bar size
• Settlement of plastic concrete is caused by:
  – Low sand content and high water content
  – Large bar
  – Poor thermal insulation
  – Restraining settlement due to irregular shape
  – Excessive, uneven absorbency
  – Low humidity
  – Insufficient time between top-out of columns and placement of slab and beam
  – Insufficient vibration
  – Movement of formwork
As bleed water comes to surface, volume of concrete is reduced.
Plastic Shrinkage Cracking

- Plastic shrinkage is caused by the rapid evaporation of mix water (not bleed water) while the concrete is in its plastic state and in the early stages of initial set.
- Shrinkage results in cracking due to tension stress.
- Rarely fractures aggregate, but separate around the aggregate.
- May lead to points of thermal and dry shrinkage movement, intensifying the cracking.
Rapid loss of water through evaporation causes concrete to reduce in volume. If restrained, tension develops, which may cause cracking.
2.12 Drying shrinkage cracks on wall. Vertical lines indicate the position of reinforcement.
Plastic shrinkage mostly surface cracks, but in a few cases they can penetrate a whole slab. Typical crack widths are of the order of 2-3mm.
Honeycomb and Rock Pockets

• Honeycomb is a void left in concrete due to failure of the mortar to effectively fill the spaces among coarse aggregate particles.

• Rock pockets are generally severe conditions of honeycomb where an excessive volume of aggregate is found.
Honeycomb-Primary Causes

• **Design of members**
  – Highly congested reinforcement
  – Narrow section
  – Internal interference
  – Reinforcement splices

• **Forms**
  – Leaking at joints
  – Severe grout loss
• Construction conditions
  – Reinforcement too close to forms
  – High temperature
  – accessibility

• Properties of fresh concrete
  – Insufficient fines
  – Low workability
  – Early stiffening
  – Excessive mixing
  – Large aggregate
• Placement
  – Excessive free-fall
  – Excessive travel in forms
  – Lift that is too high
  – Improper tremie or drop chute
  – segregation
• Consolidation
  – Vibrator too small
  – Frequency too low
  – Amplitude too small
  – Short immersion time
  – Excessive spacing between insertion
  – Inadequate penetration
Cover Thickness

Concrete block (used to support bottom layer)
Wire chairs (used to support top layer)

Plastic support designed for two layers of WWR
Important! Cover Thickness

Concrete cover: nominal value

Concrete cover: half nominal value

Penetration (carbonation, chloride penetration)

Depth: cm

Time: √t

0 2 5 10 15 25 50 100
Erosion and Poor Ground Compaction
Poor Alignment
Column & Wall out of alignment
Column out of alignment
Column of different size
Curved Wall and Column
Structural Assessment & Repair
Say: “If the ocean were ink (wherewith to write out) the word of my lord, sooner would the ocean be exhausted than would the word of my lord, even if we added another ocean like it, for its aid.”

Say: “I am but a man like yourselves, (but) the inspiration has come to me that your God is one God: whoever expects to meet his lord, let him work righteousness, and, in the worship of his lord, admit no one as partner.”

TIPU

TIRU
COMMUNICATION!

BRINGING UP FATHER

By Bill Kavanaugh & Hal Camp

BEFORE YOU GO TO SLEEP TONIGHT, BE SURE YOU PUT OUT THE LIGHT!

OKAY!
عن أبي موسى رضي الله عنه عن النبي صلى الله عليه وسلم قال: مثل ما بعثني الله من الهدى والعلم كمثل الغيث الكثير أصاب أرضًا، فكان منها نقية قبلت الماء، فأنتبئت الكلا والعشب الكثير، وكانت منها أجداب أمستك الماء، فنفع الله بها الناس فشربوا منها وسفروا وزرعوا وأصاب منها طائفة أخرى إمما هي قيعان لا تستسك ماء ولا تنبت كلا، فذللك مثل من فقه في دين الله ونفعه ما بعثني الله به علم وعلم، ومثل من لم يرفع بذلك رأسًا، ولم يقبل هدى الالذي أرسلته به رواه البخاري.
mutiara hadith

Daripada Abu Musa r.a., meriwayatkan bahawa baginda Rasulullah s.a.w. bersabda: Perumpamaan ilmu dan hidayah yang engannya aku diutus oleh Allah SWT adalah seumpama satu hujan lebat yang menimpa bumi. (Bumi terbahagi kepada tiga tanah)
- Pertama ialah tanah baik, lembut dan menyerap air yang kerananya tanah menjadi subur, menumbuhkan tumbuh-tumbuhan yang banyak.
- Kedua ialah tanah yang keras tidak menyerap air tetapi dapat mengumpulkan air bagi keperluan manusia, binatang ternak dan tanam-tanaman yang lain.
- Ketiga ialah tanah yang keras yang tidak menyerap dan tidak dapat mengumpulkan air dan tidak menumbuhkan tanam-tanaman.

(Begitulah dengan manusia yang terbahagi kepada tiga golongan):
- Mereka yang diberi faham agama dan mendapat hidayah. Dengan hidayah itu mereka mengenalikku, mendapat manfaat dengan ilmu yang diberikan Allah SWT kepadaku. Mereka belajar dan mengajarkan kepada orang lain.
- (Golongan kedua) ialah yang tidak mengambil manfaat bagi dirinya tetapi orang lain dapat manfaat darinya.
- (Golongan ketiga) ialah orang yang tidak peduli dirinya dan tidak mendapat hidayah Allah SWT apa yang diturunkan melalui aku.

(Hadis Riwayat Bukhari).
Let's move forward, together, faster
Thank for your kind attention