Lecture 04: Concrete facade repair and retrofitting systems

Thu 14.01.2016
## Previous lecture summary

### Lecture 01:
- Repair terminology
- Concrete repairs – Standards
  - EN 1504 covers the whole concrete repair process, from the initial identification of a problem, through to the works on site.

### Lecture 02:
- Demolition planning
- Demolition methods applicable for concrete repair
- Controlling risks in demolition work

### Lecture 03:
- Corrosion protection of reinforced concrete
- Corrosion prevention methods
Course content

Rak-43.3301 Repair Methods of Structures I

- Deterioration mechanisms
- Condition assessment
- Repair analysis
- Recommended repair methods

Rak-43.3312 Repair Methods of Structures II

- Removal of deteriorated structures
- Repair and protection of reinforcing steel
- Repair of facade structures
- Repair of service systems
- Repair of moisture problems

Service life evaluation

Rak-43.3312 Repair Methods of Structures II (4 cr)
Esko Sistonen & Fahim Al-Neshawy
Suggested readings for this lecture


Suggested pages from 40 to 53

Outlines

- History of concrete building facades
- Typical types of concrete building facades
- Planning of the repair project
- Repair methods for concrete facades
  - Protective repair methods
  - Light repairs
  - Heavy repairs
- Typical types of concrete balconies
- Repair of concrete balconies
History of concrete building facades
History of concrete building facades

• **1920-1940**
  – using concrete in supporting structures
  – Facades with bricks or rendering systems.

• **1940-1960**
  – Concrete elements with thermal insulation
  – Facades with rendering systems
  – Use of sandwich elements.
History of concrete building facades

• **1960-1980**
  - Columns – slab element systems
  - Facades with exposed aggregate surfaces
  - Cladding materials such as brick and clinker slabs.

• **1980-1990**
  - Sandwich elements with ventilation gaps
  - Cladding such as
    • metal sheets
    • Boards
    • Bricks
    • concrete panels.
Types of concrete building facades
Sandwich wall systems
- two concrete panels separated by a layer of thermal insulation
- **load-bearing internal panel** (120 -150 mm)
- **insulation** (100 - 200 mm).
- The **exterior concrete** panel (75 - 80 mm)
- The external panel is connected to the load-bearing panel by **connectors made of high-quality stainless**
Typical types of concrete building facades

1. External concrete panel (75 – 100 mm)
2. Ventilation gap (20 – 40 mm)
3. Wind protection insulation (25 mm)
4. Insulation (100 – 200 mm)
5. Internal concrete panel (120 – 150 mm)
Planning of the repair project
Planning of the façade repair project

**Repair planning:**
- Identification of the extent and causes of deterioration
- Determining the objectives of repair
- Selection of the appropriate repair methods
- Selection of the appropriate repair products and systems.
- Implementation stages of the repair application

**Factors in selection of methods of repairs**
- Type and extent of repairs
- Location of deterioration
- Environmental exposure
- Availability of skill
- Availability of time and access for repairs
- Appearance
- Cost
Planning of the façade repair project

Steps to be taken in the repair process

Condition of the structure

- No damage → No Action
- Damage to be expected → Existing damage

Existing damage

Decision on strategy to be based on:
- Cause of damage
- Degree of damage
- Aggressivity of environment
- Consequences of damage
- Structural aspects
- Timing
- Economy (cost)
- Remaining period of use
- Local availability of the technique and materials considered

Detailed design + choice of materials

Execution including quality control

Assessment of the completed repair work
Planning of the façade repair project

1. **Cause & extent of deterioration**
   - A proper investigation of the deterioration mechanism and its extent should be made.
   - In most cases, the extent of the deterioration will have a significant impact on the decision to repair or replace a component (e.g., a balcony slab).

- The most common type of deterioration encountered in exposed concrete facades is that associated with **corrosion of embedded metals**.
- The second most common cause of deterioration in cold climates is the **freeze-thaw damage** to concrete elements.
- **Coating failures and leakage** through concrete cracks are also common problems.
Concrete façade deterioration (6:00 min video)
Planning of the façade repair project

2. Repair Objectives

- **Improving the aesthetics of the building:** if deterioration do not impact the structural integrity, water tightness, or the durability of the facade.

- **Restoring durability of building components** and significantly reduce the rate of deterioration.

- **Restoring structural integrity:** to restore deteriorated materials to an acceptable level of structural integrity and functionality

- **Leakage control:** if deterioration of concrete will result in water penetration through the façade components
Planning of the façade repair project

3. Selection of repair methods

If deterioration has just begun and the damage is not widespread:

- Protective repair methods:
  - resealing of element joints with elastic sealants
  - painting over the old paint
  - protective painting after removal of old paint
  - thorough patch repair and protective painting.

If the façade is significantly damaged

- The old structure is covered with additional thermal insulation and new outer layer:
  - external thermal insulation with rendering
  - different facade panel products
  - brick wall
  - new concrete facade elements.
# Planning of the façade repair project

<table>
<thead>
<tr>
<th>If the facade is severely damaged,</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The outer layer and thermal insulation to be demolished</td>
</tr>
<tr>
<td>• The new thermal insulation and new cladding system can be selected from the previous mentioned alternatives.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Selection of repair materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>When selecting a repair mortar for a particular application, one should consider the following attributes of the material:</td>
</tr>
<tr>
<td>• <strong>Compressive strength and modulus of elasticity</strong> similar to those of the substrate material.</td>
</tr>
<tr>
<td>• <strong>Bond characteristics:</strong> Durability of concrete patches greatly depends on their bond to the substrate material.</td>
</tr>
</tbody>
</table>
Planning of the façade repair project

- **Shrinkage**: of the repair material will result in cracks that can adversely impact its durability.

- **Permeability**: lower permeability repair materials will be desirable to reduce the rate of chloride migration to the reinforcing steel.

- **Corrosion protection**: repair materials should provide adequate protection against future corrosion.

- **Coefficient of thermal expansion** should be similar to that of substrate material.

- **Resistance to freeze-thaw deterioration**: specially in colder climates.

- **Aggregate size**: used in the repair mortar should be compatible with the patch geometry.

- **Workability and set time**: should be consistent with the placement methods used.

- **Appearance**: The texture and color of the patch will have to resemble adjacent materials.
Repair methods for concrete facades
### Repairing methods vs condition rating

<table>
<thead>
<tr>
<th>Rating</th>
<th>Status</th>
<th>Definition of rating / condition of building asset</th>
<th>Repairing method</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Excellent</td>
<td>No defects</td>
<td>No action</td>
</tr>
<tr>
<td>4</td>
<td>Good</td>
<td>Minor defects</td>
<td>Protective repairs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some deterioration to finishes</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Fair</td>
<td>Significant defects are evident</td>
<td>Light repairs</td>
</tr>
<tr>
<td>2</td>
<td>Poor</td>
<td>Badly deteriorated</td>
<td>Heavy repairs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potential structural problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Major defects</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Very poor</td>
<td>Building has failed</td>
<td>Demolition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unfit for occupancy or normal use</td>
<td></td>
</tr>
</tbody>
</table>
Protective repairs

- Protective repair methods are suitable mainly for facades where deterioration has just begun.
- Possible protective repair methods for concrete facades are:
  - Façade cleaning
  - Resealing of element joints
  - Painting part of the facade
  - Painting the whole façade over the old paint
Protective coating

Photos. Jolkkonen, K.
Light repairs: Patch repairing

- Patch repair steps:
  1. Identifying delaminated areas
  2. Concrete removal
     - high pressure wash,
     - sandblasting,
     - mechanical jackhammer or
     - ultra-high pressure water jet
  3. Saw cutting patch perimeter and surface preparation
4. Reinforcing steel repairs
   - removing all corrosion products
   - supplemental reinforcing if needed
   - reinforcing steel coatings with epoxy coatings, zinc-rich coatings, or cementitious coating

5. Final Preparation the patch cavity
   - cleaning the concrete substrate
   - making final adjustments to the patch cavity geometry
Light repairs: Patch repairing

6. Forming of concrete patch repairs on high-rise buildings

7. Substrate wetting, patch placement, and finishing

8. Curing of the concrete

9. Coating application to provide a uniform appearance
   • aesthetic advantages,
   • resistance to carbonation
   • decrease surface permeability of the concrete
Light repairs: Patch repairing

1. KORROOSIO
2. PIKKAUS
3. HIEKKAPUHALLUS,
   PUHDISTUS,
   KASTELU
4. KARB-
   VYÖHYKE
5. PRIMERI-
   LAASTI
6. TÄYTTÖ
   KERROKSITTAIN
7. OIKAI SU
8. JALKIHOITO
   RH 100 %
9. PINTA-
   KASITTELY

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Esko Sistonen & Fahim Al-Neshawy
Patch repairing and painting video (2:55 min)
Light repairs: Element joint renewal and repair

Reasons for joint refurbishment may include:

- Failures in workmanship
- Use of unsuitable type of sealant
- Sealant reached end of its life cycle
- Compatibility issues with adjacent materials
- Exposure to aggressive chemicals
- Insufficient surface preparation (loss of adhesion)
Sealant reached end of its life cycle

http://www.homerepairtutor.com/concrete-expansion-joints/
Light repairs: Element joint renewal and repair

Renovation in case of wrong joint dimensioning

- Using sealant with higher movement capability
- Re-sealing joints with rubber profiles (stripes) or tapes. (If the joint dimensions cannot be changed or sealants with a movement capability high enough to accommodate all loads are unavailable)

http://www.homerepairtutor.com/concrete-expansion-joints/
Heavy repairs: External thermal insulation with rendering

- External Wall Insulation involves:
  - externally cladding a building with insulation boards
  - applying a layer of basecoat render and then a
  - final decorative finish.

- The overall result is not only a highly insulated, energy efficient home but one that is visually transformed on the outside.

http://www.structherm.co.uk/Refurbishment/External-Wall-Insulation.aspx
Heavy repairs: External thermal insulation with rendering

**Thin Rendering**
- Thermal insulation
- Mechanical fasteners
- Rendering + plastic-coated glass fibre reinforced mesh
- Finishing layer (thin rendering)


**Thick Rendering**
- Thermal insulation: one or two layers
- Mechanical fasteners
- Three separate lime cement based rendering layers + net attached through the thermal insulation layer to the supporting structure
Heavy repairs: Different facade panel products

Facade panels

1. Leveling corbel
2. U-shaped profile
3. Facade material
4. Insulation
5. Wind-proof membrane
6. Ventilated gap 40-60 mm

http://www.insiholding.com
Heavy repairs: Different facade panel products

Metal Siding

1. Leveling bracket
2. U-channel
3. INSI external sheeting
4. Fired pin
5. Insulation
6. Wind-proof film
7. Ventilated gap 40-60 mm

http://www.insiholding.com

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Heavy repairs: Different facade panel products

Fiber cement boards

- lightweight concrete and synthetic fiber
- eco-friendly cladding material
- The outer ceramic layer can be of various textures and colors.
- Imitate various materials: stone, rocks, tiles, brick, stucco etc.
- Used for façade cladding of private houses, residential and social buildings, trade and business centers.

http://www.insiholding.com
Heavy repairs: Brick wall

- A brick wall absorbs water
- To keep water away from the insulation, a proper ventilation gap is needed
- The gap must be solid, open and finless
- To ensure proper ventilation of the structure, leave every third vertical seam of the second lowest layer of bricks open
- Design the wall must so that penetrating water can be led out from the structure.


Ventilation gap ≥ 30mm
Brick masonry
External thermal insulation with rendering or cladding video (7:04 min)
Repair methods for concrete balconies
Repair of concrete balconies

Balcony structures are typically:

1. Cantilever structures.
2. Self-supported element structures “towers” outside the building.
3. Containers supported with different lifting beams to the building framework.
## Repair of concrete balconies

### Balcony repair solutions:

- Protective coatings
- Rust inhibitors
- Switching railing mounting method from embedded to surface
- Patching/chipping away old concrete and adding new concrete
- New aluminum railing installation (when steel railings have or are corroded)

### Additional methods:

- Cathodic protection (a process which raises the pH level and lessens the acid around steel reinforcements using a low voltage electrical current)
Repair of concrete balconies

Structure before repair  After removal of loose  After repair mortar application

Repaired with Zinc Layer Anode (ZLA)  After two coats  Decorative finish


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Summary

Teaching event summary

- History of concrete building facades
- Typical types of concrete building facades
- Planning of the repair project
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- Typical types of concrete balconies
- Repair of concrete balconies

Next teaching event

- Renovation of water and sewerage piping pipes
- Heating systems
- Ventilation systems
- Electrical and telecom systems
- Renew bathroom and kitchen