



堡泰建築材料工程有限公司
BMS BUILDING MATERIALS & SERVICES LTD.

Concrete Repair Method

Note:

The information used in this powerpoint is extracted from HKCRA and ICRI

By Dennis Choi

Concrete Repair Procedure

Part 1 - Concrete Evaluation

Part 2 - Concrete Repair Method

Part 3 - Quality Control

Part 1 - Concrete Evaluation

- Depends on complexity and size of the job

Before Repair Works

- (Open Up) Visual or RITS (Rapid Infrared Thermographic Survey) and delamination Survey (Hammer Tapping)
- Covermeter Survey - in according with BS4408 Part 1
- Carbonation Depth Measurement
PH of concrete 12.5 – 13.5 drop to 11 or below.
Carbonation coefficient by application of Fick's Law

Part 1 - Concrete Evaluation

Before Repair Works

- Electrochemical Potential (Half Cell)

-Measurement in accordance with ASTM C876-80

Table 4.4 Electrochemical Potential Corrosion Criteria

Electrochemical Potentials (mV) (Referenced to Ag/AgCl Half Cell)	Risk of Active Reinforcement Corrosion at time of Measurement
More positive than -110	5 %
Between -110 and -260	50%
More negative than -260	95%

Part 1 - Concrete Evaluation

Before Repair Works

- Concrete Resistivity Measurement

Table 4.5 Guidelines on Interpretation of Resistivity Readings	
Resistivity (ohm.cm)	Rate of Rebar Corrosion Supported by the Concrete if the Rebar is Corrosively Active
Greater than 20,000	Negligible
20,000 - 10,000	Low
10,000 - 5,000	High
Less than 5,000	Very High

- Chloride Content Determination

<0.06% by weight of concrete sample in accordance with BS 1881 Part 124:1988

- Core Compression Strength Test

100 Diameter concrete core in accordance with CSI:1990 Section 15

Part 1 - Concrete Evaluation

After Repair Works (Q/C)

- RITS
- Covermeter Survey
- Rebound Hammer
- Bond Test (Direct pull-off)
- Others – Similar to the Before Repair Works
(for comparison the result)

Part 2 - Concrete Repair Method

Surface Repair Method

表面修補方法

Patching Method

批/擠壓法

Grouting Method

灌漿法

Spray Method

噴漿法

Full-Depth Replacement Method

全深度替換方法

Concrete Recasting Method

全面翻落混凝土法

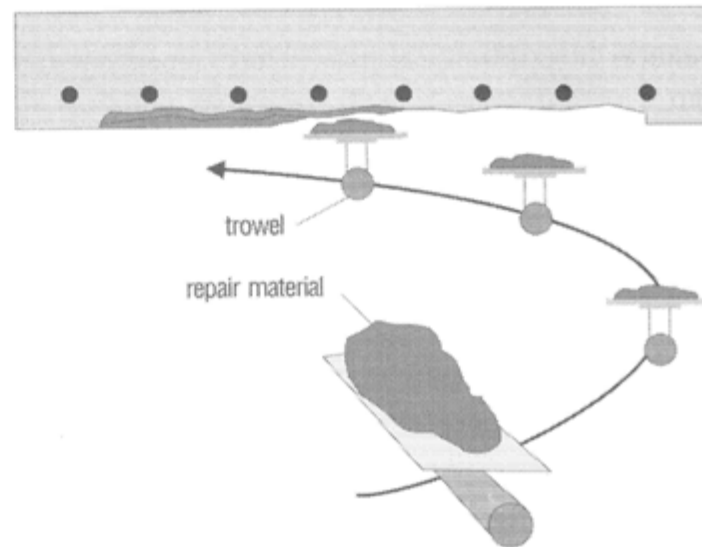
Concrete Repair Method

Trowel applied

General description: Repair material is mixed into a trowelable, non-sag consistency. Trowels or other suitable placing tools are used to transport the repair material to the prepared substrate. The repair material is pressed into the substrate to develop intimate contact without voids.

Best application: Surface restoration when reinforcing steel is not encountered.

Material requirements: Fine-grained material easily finished, with non-sag properties to stay in place in vertical or overhead applications.



Concrete Repair Method

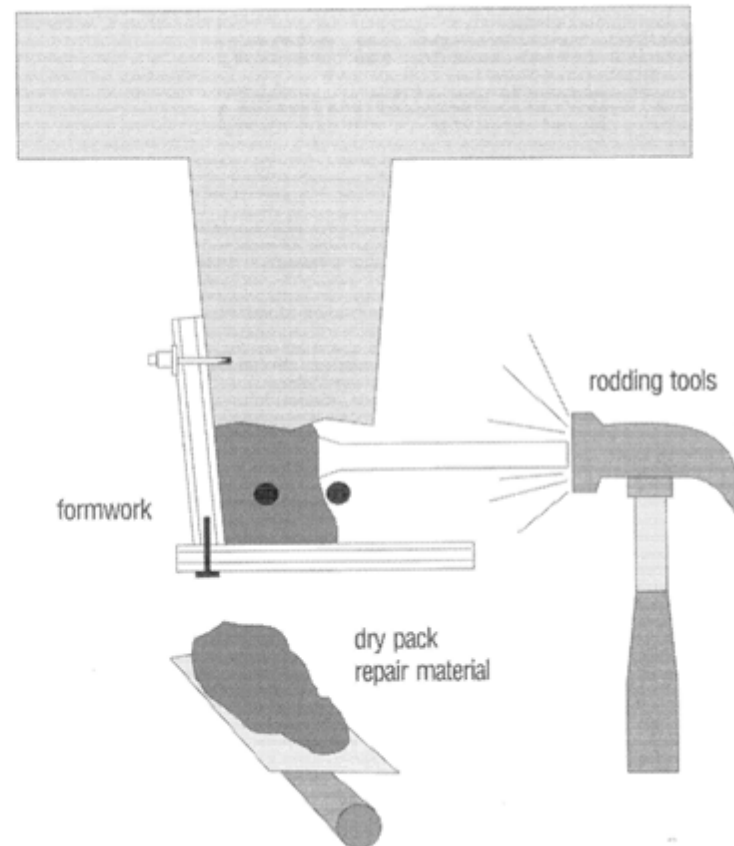
Dry packing

General description: Repair material is mixed into a uniform, cohesive plastic state, then transported to a confined space and compacted with rodding tools to produce a dense repair material.

Best application: Post-tensioning grout pockets; tie holes; pan joist bottoms; waffle pan joists; vertical, overhead and horizontal locations.

Material requirements: Mortar with consistency capable of being molded into a ball without sagging.

Reference: Headquarters, United States Army Corps of Engineers (1995), "Evaluation and Repair of Concrete Structures," EM 1110-2-2002, Washington, D.C.



Concrete Repair Method

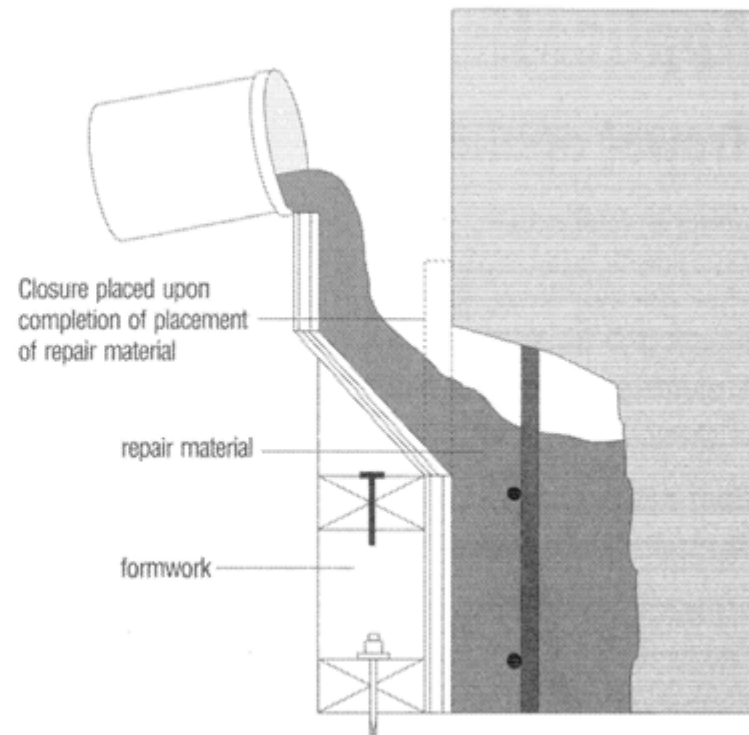
Form and cast-in-place (Partial-depth replacement)

General description: The placement of repair material into a confined space with formwork defining all exposed boundaries. Repair materials are deposited into the formwork and consolidated by rodding or conventional vibration.

Best application: Columns, walls, and exterior slab edges.

Material requirements: Castable concrete or mortar with proper bond properties, low shrinkage, low water/cement ratio, and a highly flowable mixture.

Reference: ACI 304R,^[2] "Guide for Measuring, Mixing, Transporting, and Placing Concrete"



Concrete Repair Method

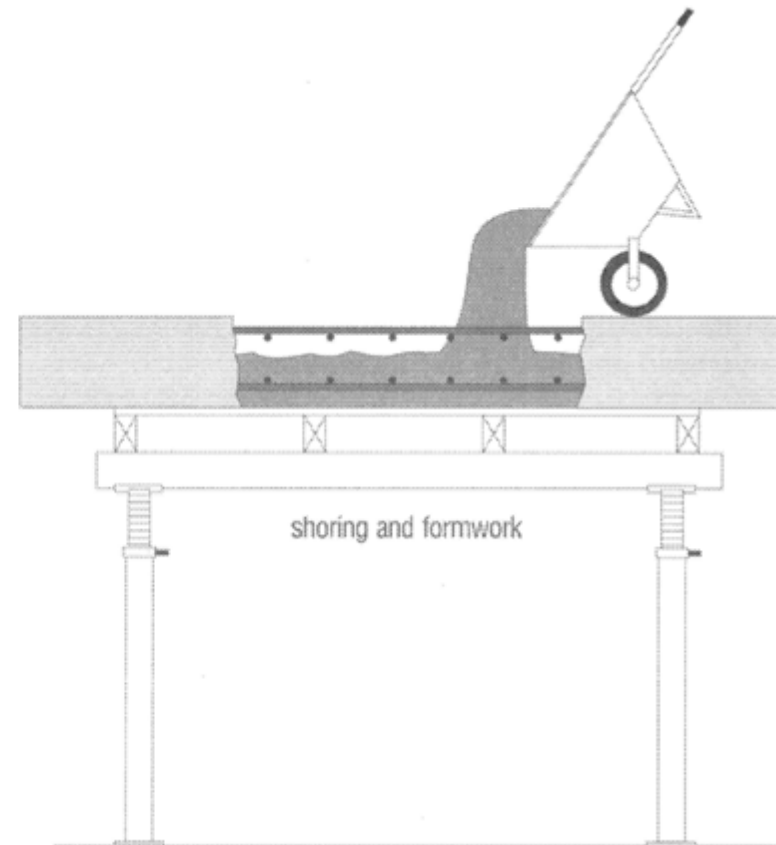
Form and cast-in-place (Full-depth replacement)

General description: In lieu of partial-depth repairs, the member in question can be removed and replaced in total. Placement methods should follow good concrete practice.

Best application: When deterioration is extensive throughout the member.

Material requirements: Conventional cast-in-place concrete with low shrinkage, low water-cement ratio, and a highly workable mixture.

Reference: ACI 304R, "Guide for Measuring, Mixing, Transporting, and Placing Concrete"



Concrete Repair Method

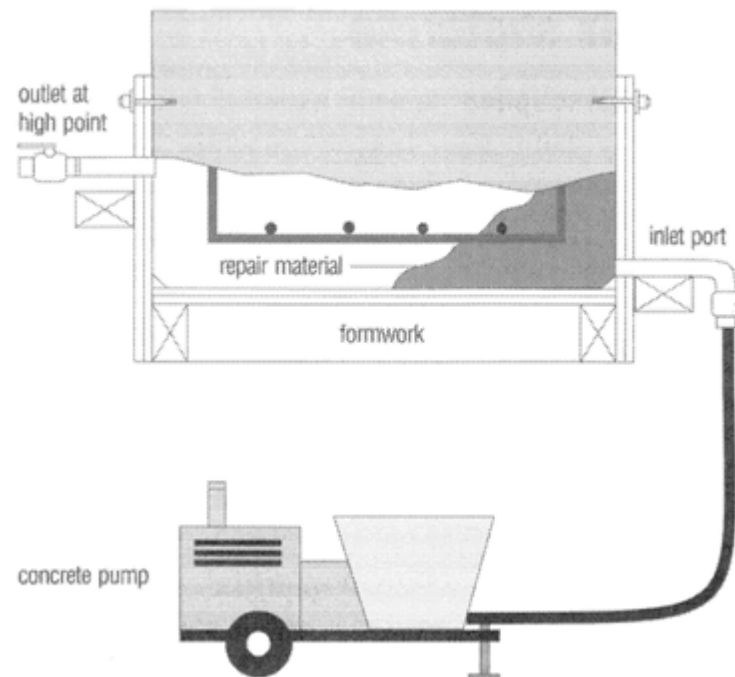
Form and pump

General description: Repair material is mixed and pumped via concrete line connected to the formwork, until the cavity is filled and pressurized. Consolidation and bonding is provided by the internal form pressure.

Best application: Overhead and vertical applications where congested reinforcing is present. Beam bottoms, ribs, slab soffits, or sectionalized areas.

Material requirements: Pumpable, good flow characteristics, self-bonding, aggregate size compatible with size of cavity and space between bars.

Reference: ACI 304.2R, "Placing Concrete by Pumping Methods"



Concrete Repair Method

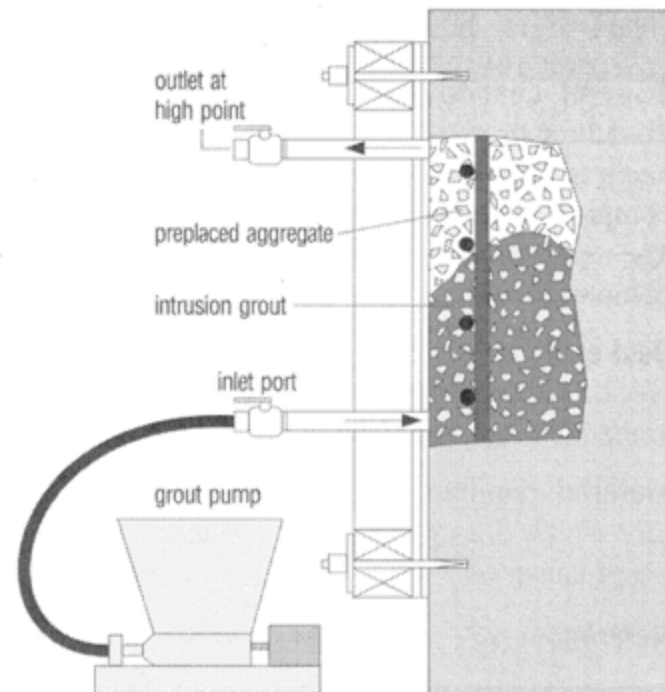
Preplaced aggregate

General description: Gap-graded aggregate is placed into formed cavity. Grout is then pumped into form via grout pump until all voids are filled and pressurized. Shrinkage is minimal because of aggregate contact and volume.

Best application: Vertical and overhead applications where extremely low shrinkage of repair material is required; column enlargements.

Material requirements: Gap-graded aggregate (40-50% void ratio), pumpable grout, self-bonding portland cement or resin-based binder. One inch (25 mm) or larger aggregate typically used in cementitious applications.

Reference: ACI304.1R, "Guide for the Use of Preplaced Aggregate Concrete for Structural and Mass Concrete Applications"



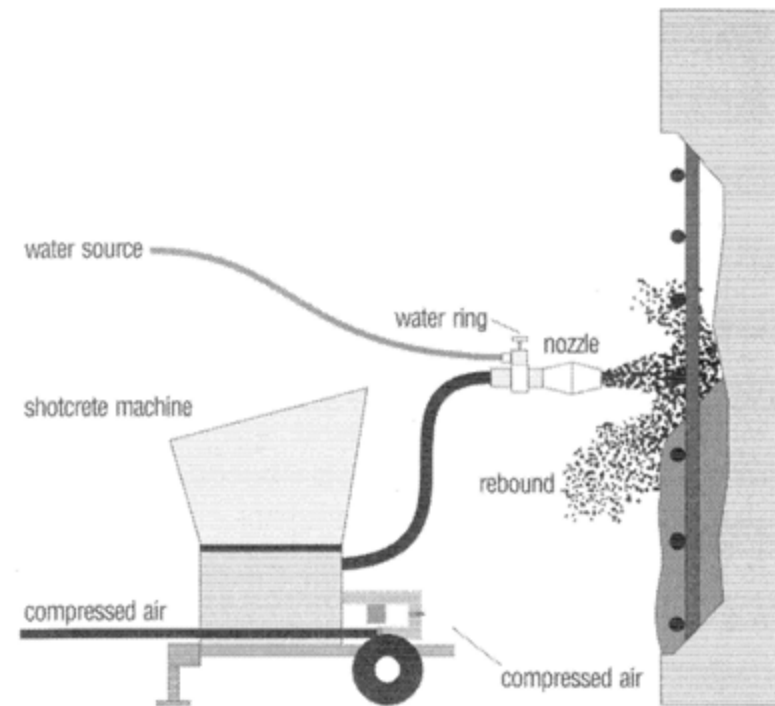
Concrete Repair Method

Dry-mix shotcrete

General description: Repair material is placed dry or slightly damp into shotcrete machine and mixed with compressed air. The mixture is transported via hose to the exit nozzle where water and admixtures, if any, are introduced. The ingredients are propelled onto the prepared substrate by the force of the compressed air.

Best application: Large vertical and overhead areas with small bars, No. 6 (19 mm)^[3] or less, and minimal congestion of embedded reinforcement.

Material requirements: Well-graded aggregate with necessary binders (usually portland cement). Mixture must be proportioned to compensate for rebound losses. Admixtures are frequently used to shorten set time, and/or to allow thicker layers to be built-up in a single pass.



Concrete Repair Method

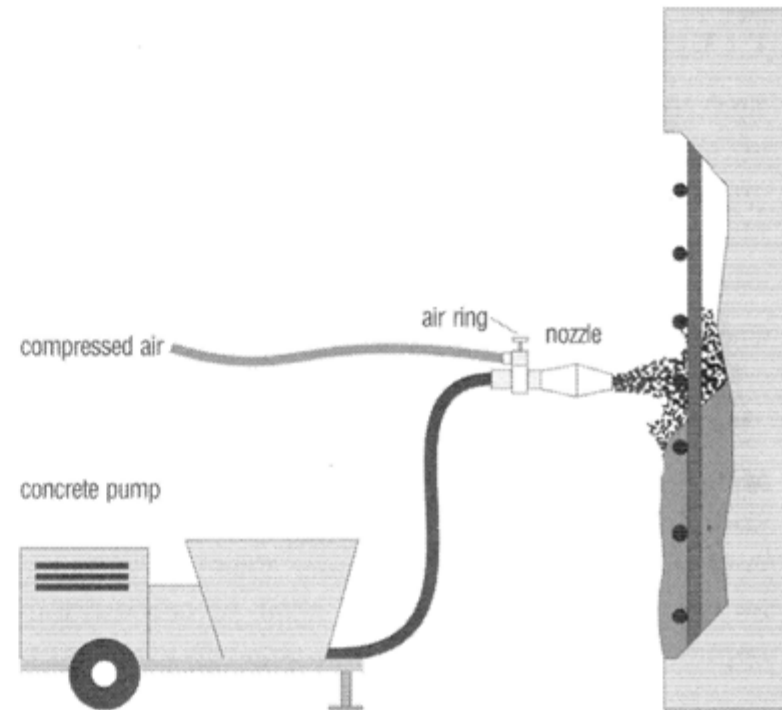
Wet-mix shotcrete

General description: Pre-batched and thoroughly mixed repair material is placed into a concrete pump and transported via pump line to an exit nozzle where compressed air and admixtures, if any, are introduced. The repair material is propelled onto the surface by the compressed air.

Best application: Large vertical areas with small bars, No. 6 (19 mm)^[3] or less, and minimal congestion of embedded reinforcement.

Material requirements: Pumpable, low-slump mixture which does not sag when impacted on the prepared substrate.

Reference: ACI 506.2, "Guide to Shotcrete"



Part 2 - Concrete Repair Method

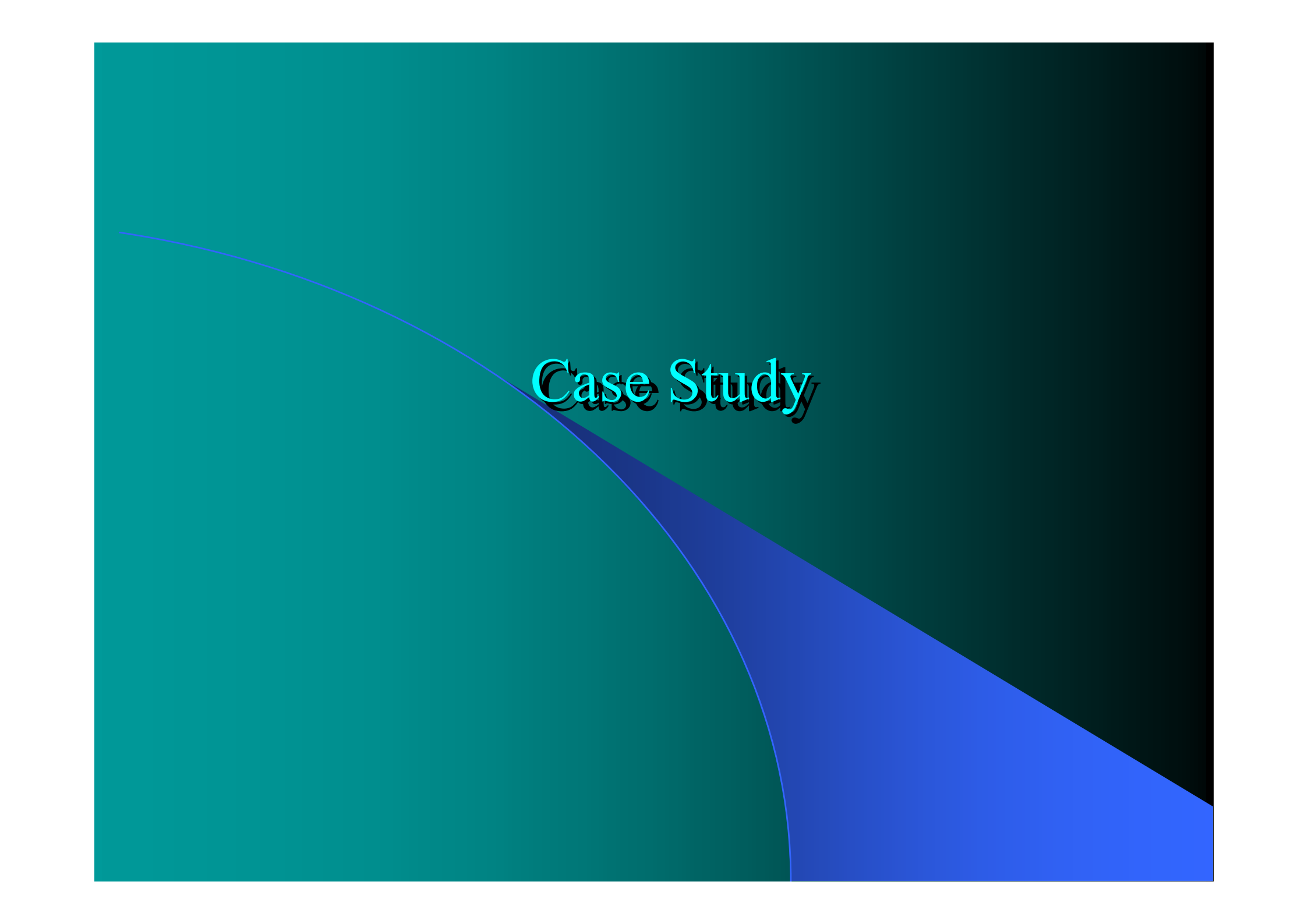
Extracted from the ICRI Concrete Repair Manual,
emphasis the following items

- General description (limitation of different methods)
- Best application condition
- Material selection requirement (available of different material in local market)

Part 2 - Concrete Repair Method

Other Consideration

- Time Constraint
- Serviceability requirement (upgrade/resume)
- Cost saving (value added)
- Efficiency of works
- End result - durability, appearance, clients' satisfaction...etc)



Case Study

Concrete Repair - Patching



Concrete Repair - Patching



Form & Dry Packing Method



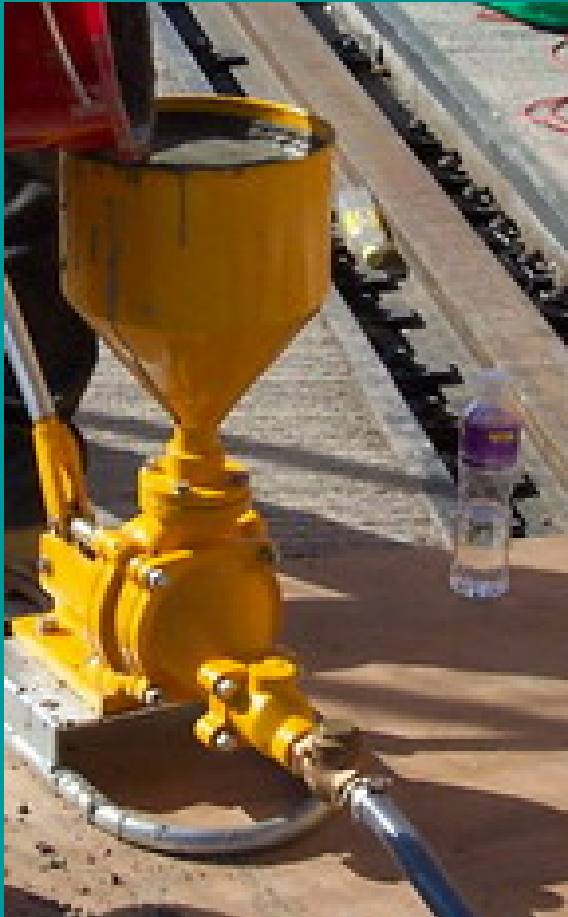
Concrete Repair -Spray



Concrete Repair -Spray



Concrete Repair -Grouting



Concrete Repair -Grouting

