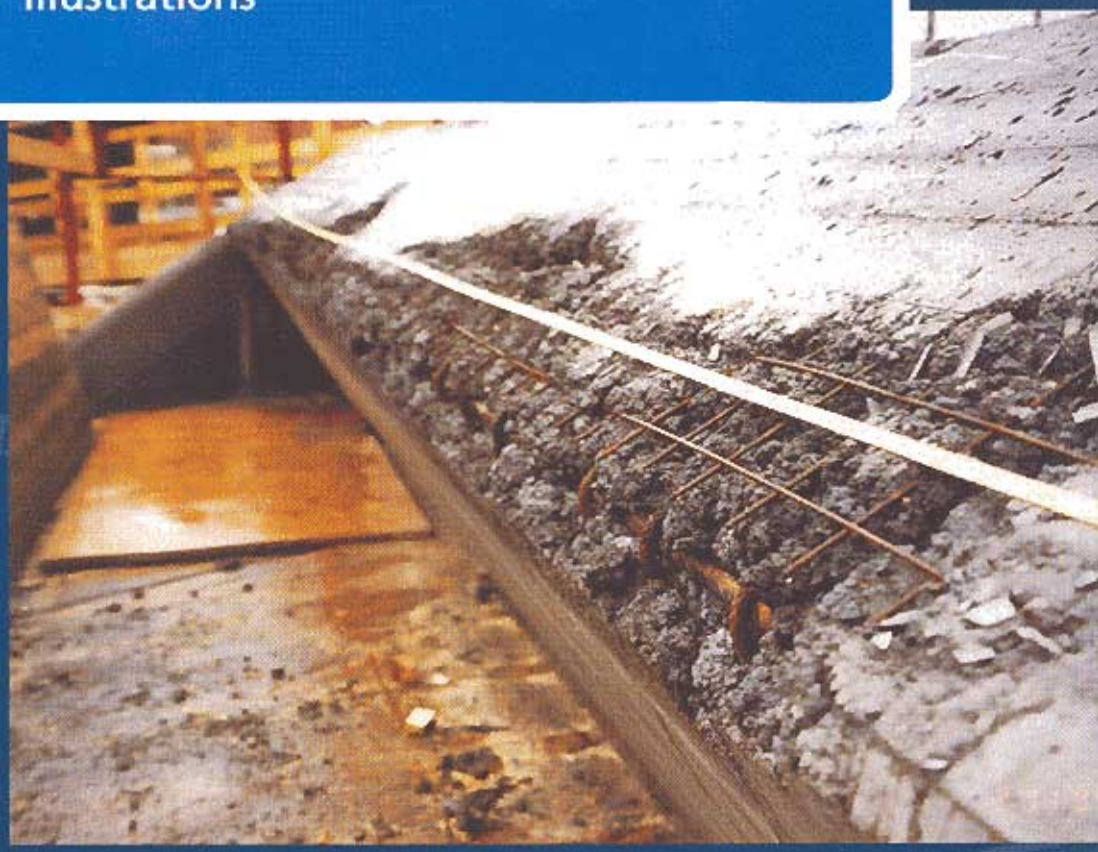
HETEK

Repairs during the Construction Phase
Illustrations



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Titel: HETEK
Repairs during the Construction Phase
Illustrations

Eller på dansk

HETEK
Reparationer i udførelsesfasen
Illustrationer

Auther: Ole Viggo Andersen, Anders K. Christoffersen,
Bent Foverskov.

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Uncontrolled terms: Illustrations

Abstract: The report contains illustrations of defects and non-conformities which were found in the construction phase. It also include observations which were found in the construction phase. The illustrations can be used as an aid to understand and evaluate defects and non-conformities and to plan repairs.

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List of contents

1. Introduction

This report is prepared by Nellemann, Nielsen & Rauschenberger A/S represented by:

Ole Viggo Andersen, Project manager
Bent Foverskov
Anders Kirk Christoffersen

and commented by contractors, represented by
John Christiansen, Otto Christensen & Kaj Sørensen A/S
Jan Ake Anderson, SIAB/NPL
Jørn Asmussen, LANDCON
Peter Kamp Nielsen, LANDCON
Erik Kluge, KLUGE A/S
Flemming Torben, RENESCO A/S

and commented by suppliers,
Jørgen Schou, FOSROC A/S

1.1 Scope

The scope of the report is to illustrate exampels of:

- defects and non-conformities which were found in the construction phase
- observations made on repairs made in the construction phase

The illustrations can be used as an aid to understand the intentions of the Guidelines for Repairs during the Construction Phase (HETEK report re. 4).

The illustrations are meant as an instrument to communicate between the building owner and the contractor's craftsmen.

The defects and non-conformities are discussed with relation to type of defect, assessment of occasion and influence on the quality of the finished structure. The chosen repair methods are also described.

The observations made on repairs concern illustration of the preparation of the repairs, visual observations of cores drilled from the repairs and observations made on thin sections. The illustrations cover both correct and in-correct applications of repairs.

1.2 Background

Specifications of repairs in the construction phase are often described based on working procedures, quality requirements and proporties of materials. In the HETEK report: Guidelines for Repairs during the Construction Phase re. 4. these types of specifications are described. Thus illustrations can say more than words and numbers in situations where pratical problems are to be solved.

The illustrations are collected during the short process of the HETEK project from the current work sites. Many other illustrations may be relevant and this publication should be revised subsequently.

The report also refers to the European Standards prEN 1504 Products and systems for the protection and repair of concrete structures and the HETEK, Repair during the Construction Phase, report concerning foto material, State of the Art and Field studies re. 1-6.

2. Illustrations of defects and non-conformities

Illustrations of defects and non-conformitites are collected according to the principles in the European Standard prEN 1504 re. 6 as demonstrated in this table.

Comments to each illustration include a specification of type of defect or non-conformity, evaluation of defect and describtion of the chosen repair principles. The comments also include recommendations of repair procedures according to the HETEK report: Guidelines for Repairs during the Construction Phase, Re. 4.

The evaluation of defects and non-conformities must always be based on a detailed inspection and survey on the construction site considered by the owner or his representitive before the repair processes are planned.

Defects or non-conformities	Principles according to the European Standard prEN 1504 re. 6	Repair procedures according to the HETEK report: Guidelines for Repairs during the Construction Phase, Re. 4.
Holes and honeycombs	Structural and non-structural repairs	Repairs made with mortar (Procedure 5) or repairs made with shotcrete (Procedure 6) or repairs made with concrete (Procedure 7)
Wrong dimensions		Repairs made with mortar (Procedure 5) or repairs made with shotcrete (Procedure 6) or repairs made with concrete (Procedure 7)
Too little cover		Repairs made with mortar (Procedure 5) or repairs made with shotcrete (Procedure 6)
Too much cover		Repairs made with mortar (Procedure 5) or repairs made with shotcrete (Procedure 6)
Depressions/cavities		Repairs made with mortar (Procedure 5)
Cavities around water stops		Repairs made with mortar (Procedure 5) and special procedures
Air voids		Repairs made with mortar (Procedure 5)
Minor surface defects		Repairs made with mortar (Procedure 5)
Clamp holes		Repairs made with mortar (Procedure 5)
Holes from drilled cores, lifting anchors and other testings		Repairs made with mortar (Procedure 5)
Cracks	Concrete injection	Injection of cracks (Procedure 8)
Minor surface defects	Surface protection	Repairs made with coatings (Procedure 9)
Cooling pipes		Injection of cooling pipes (Procedure 10)

Figure 1: *Table with lists of defects and non-conformities and the relations to repair principles and procedures.*

Figure 2.1

Defect: Honeycombs.

Evaluation of the defect: The honeycombs were caused by lack of compaction below the upper formside. The defect was rather serious because reinforcement bars were exposed and the depth of the defect was considerably deeper than the concrete cover.

Repair procedure: The honeycombs were repaired by removal of the defect concrete and cleaning of the surface followed by a filling with repair mortar. In similar situations the repair could be specified according to procedures in Guidelines for Repairs during the Construction Phase see working procedures 1 and 5, alternative 1 and 7.

Figure 2.2

Defect: Honeycombs (same as figure 2.1).

Evaluation of the defect: The honeycombs were caused by lack of compaction below the upper formside. The defect was serious because reinforcement bars were exposed and the depth of defect was considerably deeper than the concrete cover.

Repair procedure: The honeycombs were repaired by removal of the defect concrete and cleaning of the surface followed by a filling with repair mortar. In similar situations the repair could be specified according to procedures in Guidelines for Repairs during the Construction Phase see working procedures 1 and 5, alternative 1 and 7.

Figure 2.3

Defect: Hole.

Evaluation of the defect: Defect arisen from removal of the form. Superficial defect because the hole is small not exceeding the concrete cover.

Repair procedure: The hole was repaired by cleaning of the concrete followed by a filling with mortar. In similar situations the repair could be specified according to procedures in Guidelines for Repairs during the Construction Phase see working procedures 1 and 5.

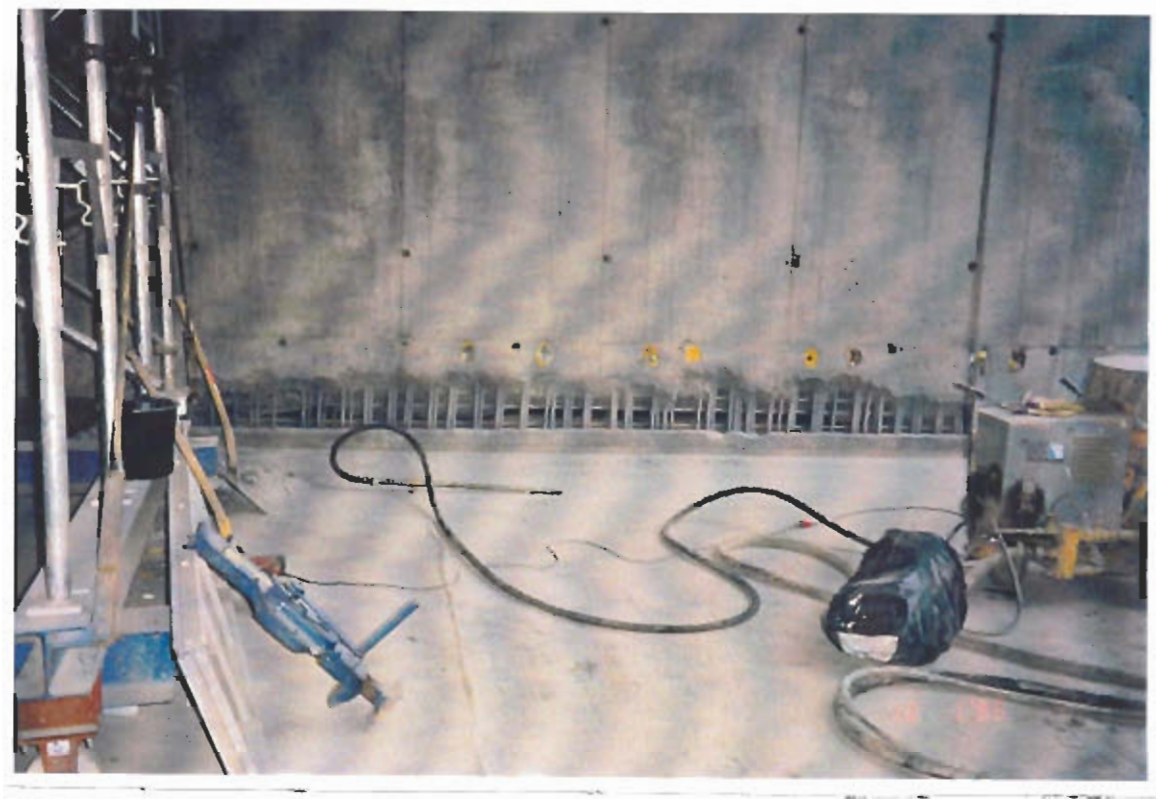

Figure 2.4

Defect: Holes.

Evaluation of the defect: The form was not cleaned properly before casting. Ice and snow was left at the buttom of the form.The defect was serious because reinforcement bars were exposed and the holes went through the construction, the defect might prevent a watertight construction.

Repair procedure: The holes were repaired by removal of the defect concrete followed by filling with concrete and the honeycombs were filled with mortar. In similar situations the repair could be specified according to procedures in Guidelines for Repairs during the Construction Phase see working procedures 1 and 5, alternative 1 and 7.

Figure 2.5

Defect: Hole - close up of figure 2.4.

Evaluation of the defect: The form was not cleaned properly before casting. Ice and snow was left at the buttom of the form.The defect was serious because reinforcement bars were exposed and the holes went through the construction, the defect might prevent a watertight construction.

Repair procedure: The holes were repaired by removal of the defect concrete and sandblasting followed by filling with concrete. In similar situations the repair could be specified according to procedures in Guidelines for Repairs during the Construction Phase see working procedures 1 and 7.

Figure 2.6

Defect: Holes and honeycombs.

Evaluation of the defect: Poorly casting/compaction of the concrete plinth. The defect was minor. The defect might prevent a watertight construction.

Repair procedure: The holes and honeycombs were repaired by cleaning of the concrete surface followed by filling with mortar. In similar situations the repair could be specified according to procedures in Guidelines for Repairs during the Construction Phase see working procedures 2 and 5.

Figure 2.7

Defect: Hole after spalling of.

Evaluation of the defect: Freezing water in cooling pipe has caused the concrete cover to be pushed off and hereby expose the reinforcement bars - thus the defect was considered serious.

Repair procedure: The hole was repaired by cleaning of the concrete surface followed by filling with mortar. In similar situations the repair could be specified according to procedures in Guidelines for Repairs during the Construction Phase - see working procedures 2 and 5.

Figure 2.8

Defect: Wrong dimensions - excessive deformations of the form work.

Evaluation of the defect: The form has not been supported sufficiently during casting, resulting in a deviation in tolerances vertically and horizontally. Depending on the actual size of the deviation in tolerance, whether the reinforcement was placed in its original position, reparing of the defect might variate from none to a major removal of the wrongly placed concrete, followed by a smoothening of the surface.

Repair procedure: The concrete with wrong dimensions was repaired by removal of the concrete followed by filling with mortar. In similar situations the repair could be specified according to procedures in Guidelines for Repairs during the Construction Phase - see working procedures 1 and 5 or 6.

Figure 2.9

Defect: Cavities around water stops.

Evaluation of the defect: Poorly casting/compaction of the concrete plinth. The defect was of serious nature because half of the water stop was not cast in as supposed. The defect might prevent a watertight construction.

Repair procedure: The holes were repaired by cleaning of the concrete surface followed by filling with mortar. Similar situations are partly covered by the Guidelines for Repairs during the Construction Phase - working procedure 2 and 5 but a special repair procedure should be prepared including e.g. the use of injection tubes in the defect casting joint.

Figure 2.10

Defect: Cavities around water stops.

Evaluation of the defect: Poorly casting/compaction of the concrete at bottom of a tunnelslab around water stop and the mandrel. The defect was of serious nature because half of the water stop was not cast in as supposed. The defect might prevent a watertight construction. The mechanical function of the mandrel is reduced.

Repair procedure: The holes were repaired by cleaning of the concrete surface followed by filling with mortar. Similar situations are partly covered by the Guidelines for Repairs during the Construction Phase - see working procedures 2 and 5 but special repair procedures should be prepared including e.g. the use of injection tubes in the defect casting joint.

Figure 2.11

Defect: Cavities around water stops.

Evaluation of the defect: Poorly workmandship in placing the water stop. The defect was of serious nature because half of the water stop was not cast in as supposed and the defect might prevent a watertight construction.

Repair procedure: Special repair procedures should be prepared including consideration of e.g. the use of injection tubes in the defect casting joint.

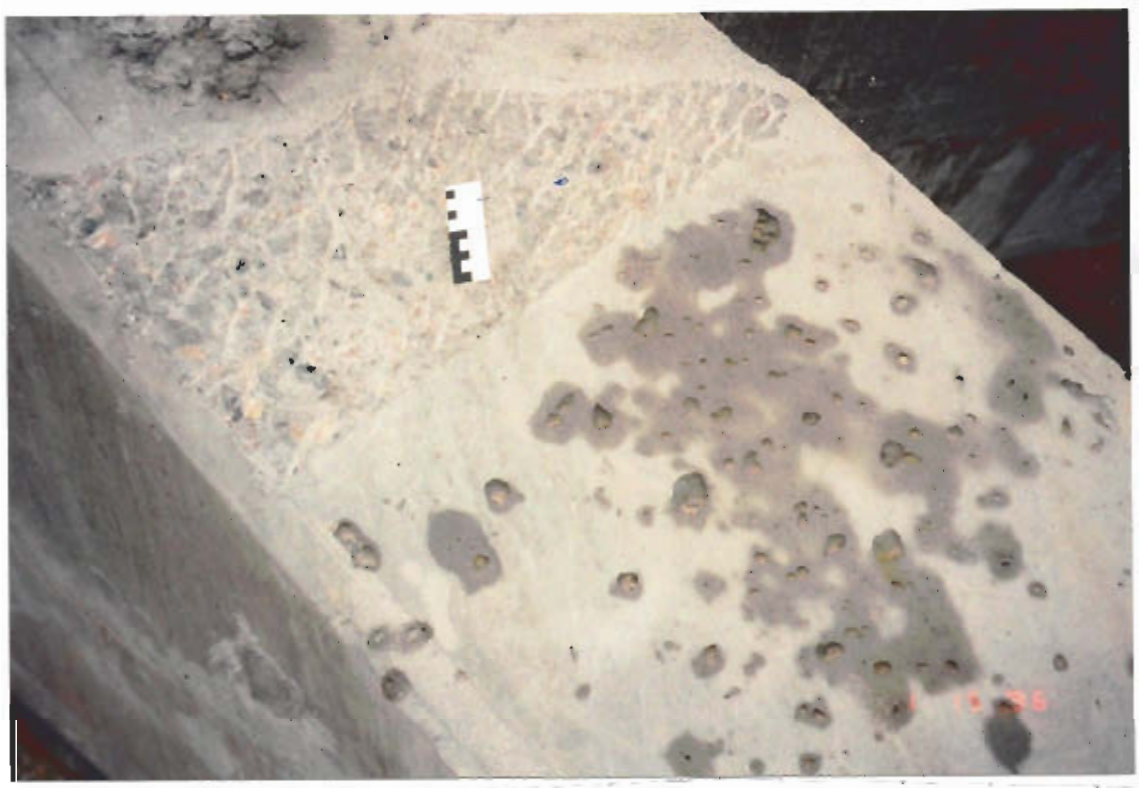

Figure 2.12

Defect: Air voids.

Evaluation of the defect: Lack of compaction. The defects was considered as a superficial defect with only aesthetic consequences.

Repair procedure: The air voids were repaired by cleaning of the concrete surface followed by filling with mortar. Similar situations are specified in the Guidelines for Repairs during the Construction Phase - see working procedures 2 and 5.

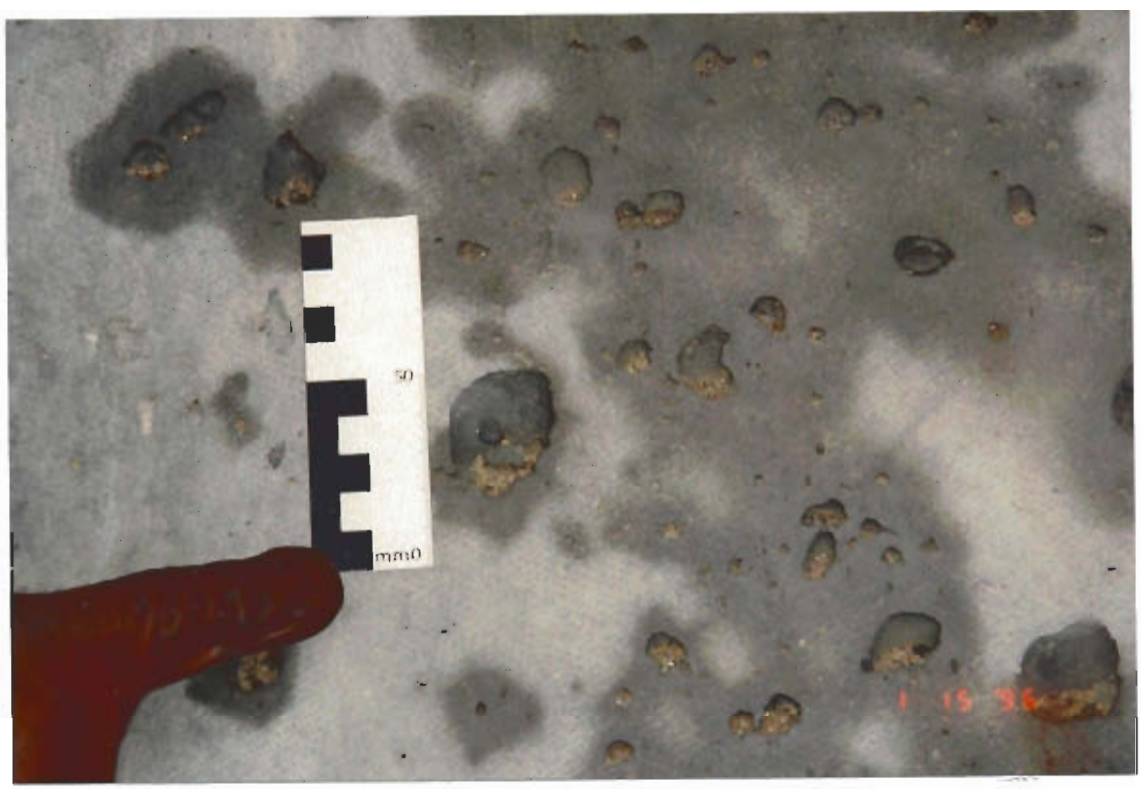

Figure 2.13

Defect: Air voids - close up of figure 2.12.

Evaluation of the defect: Lack of compaction. The defect was considered a superficial defect with only aesthetic consequence.

Repair procedure: The air voids were repaired by cleaning of the concrete surface followed by filling with mortar. Similar situations are specified in the Guidelines for Repairs during the Construction Phase - see working procedures 2 and 5.

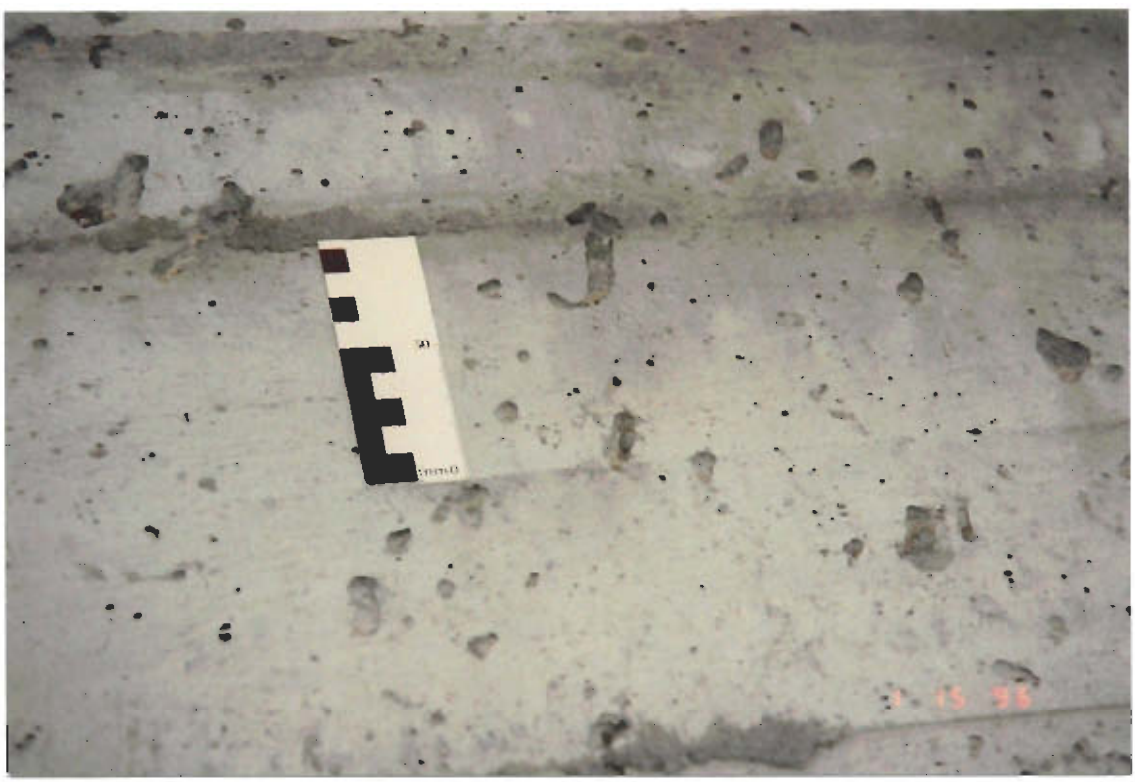

Figure 2.14

Defect: Air voids.

Evaluation of the defect: Lack of compaction. The defect was considered a superficial defect with aesthetic consequence.

Repair procedure: The air voids were repaired by cleaning of the concrete surface followed by filling with mortar. Similar situations are specified in the Guidelines for Repairs during the Construction Phase - see working procedures 2 and 5.

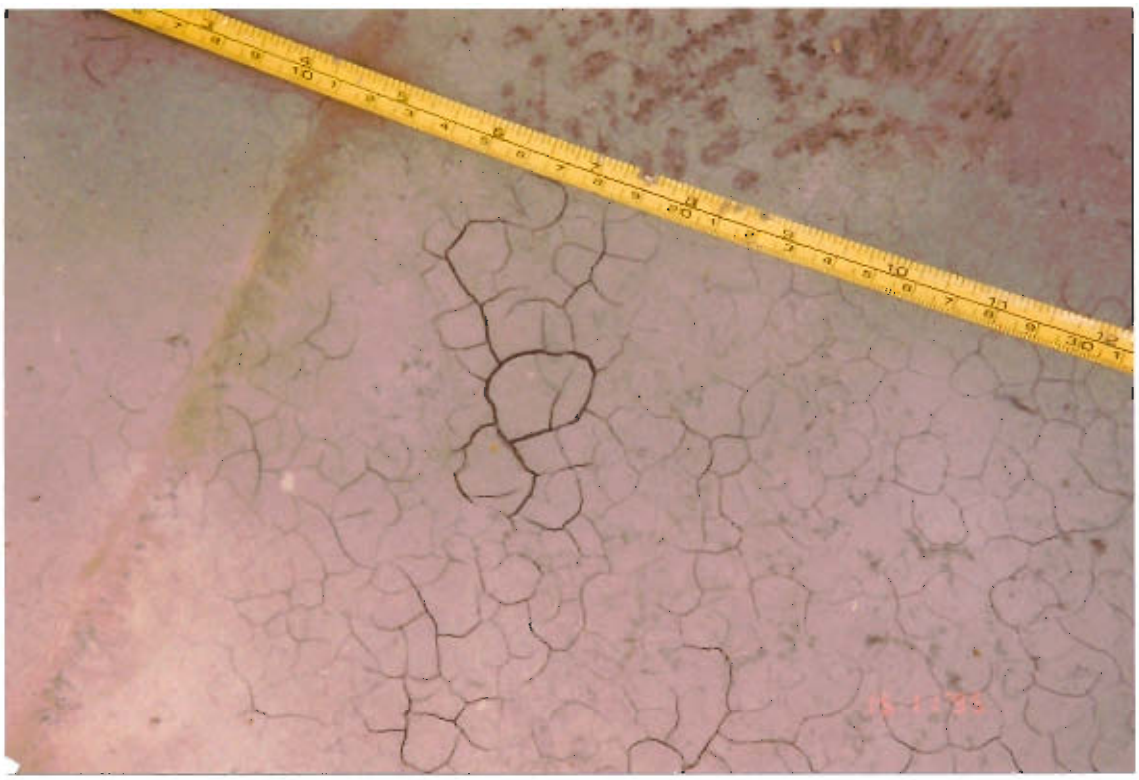

Figure 2.15

Defect: Cracks. Drying cracks in the surface of the concrete.

Evaluation of the defect: The concrete deck surface was exposed to very heavy rain during the casting, and the picture shows the dried wash-out surface of the top of the concrete surface. The defect was of minor importence for the durability of the construction as it was only in the top of the concrete cover.

Repair Procedure: The defect concrete was washed away by high water jet before a membrane was applied. Similar situations are partly covered by the Guidelines for Repairs during the Construction Phase - see working procedures 1 and 5, alternative 1 and 7.

Figure 2.16

Defect: Minor surface defects.

Evaluation of the defect: The surface was damaged because of insufficient formwork without enough formoil. The defects were considered superficial defect with only aesthetic consequence.

Repair procedure: The surface was not repaired and should only be repaired if there is a special need.

Figure 2.17

Defect: Leaking clamp holes and cracks.

Evaluation of the defect: Leaking water from filled in clamp holes and cracks.

Repair procedure: The clam holes and cracks were injected with polyurethane. Similar situations are partly covered by the Guidelines for Repairs during the Construction Phase - see working procedures 4 and 8.

Figure 2.18

Defect: Cracks across an injected cooling pipe of plastic.

Evaluation of the defect: Cooling pipes of plastic may be channels which can lead water through a wall, thus resulting in numerous leaking cracks and holes.

Repair procedure: The cracks were injected with polyurethane. Similar situations are partly covered by the Guidelines for Repairs during the Construction Phase - see working procedures 4 and 8. Thus special considerations should be made before choosing the cooling pipes and placing them in the form.

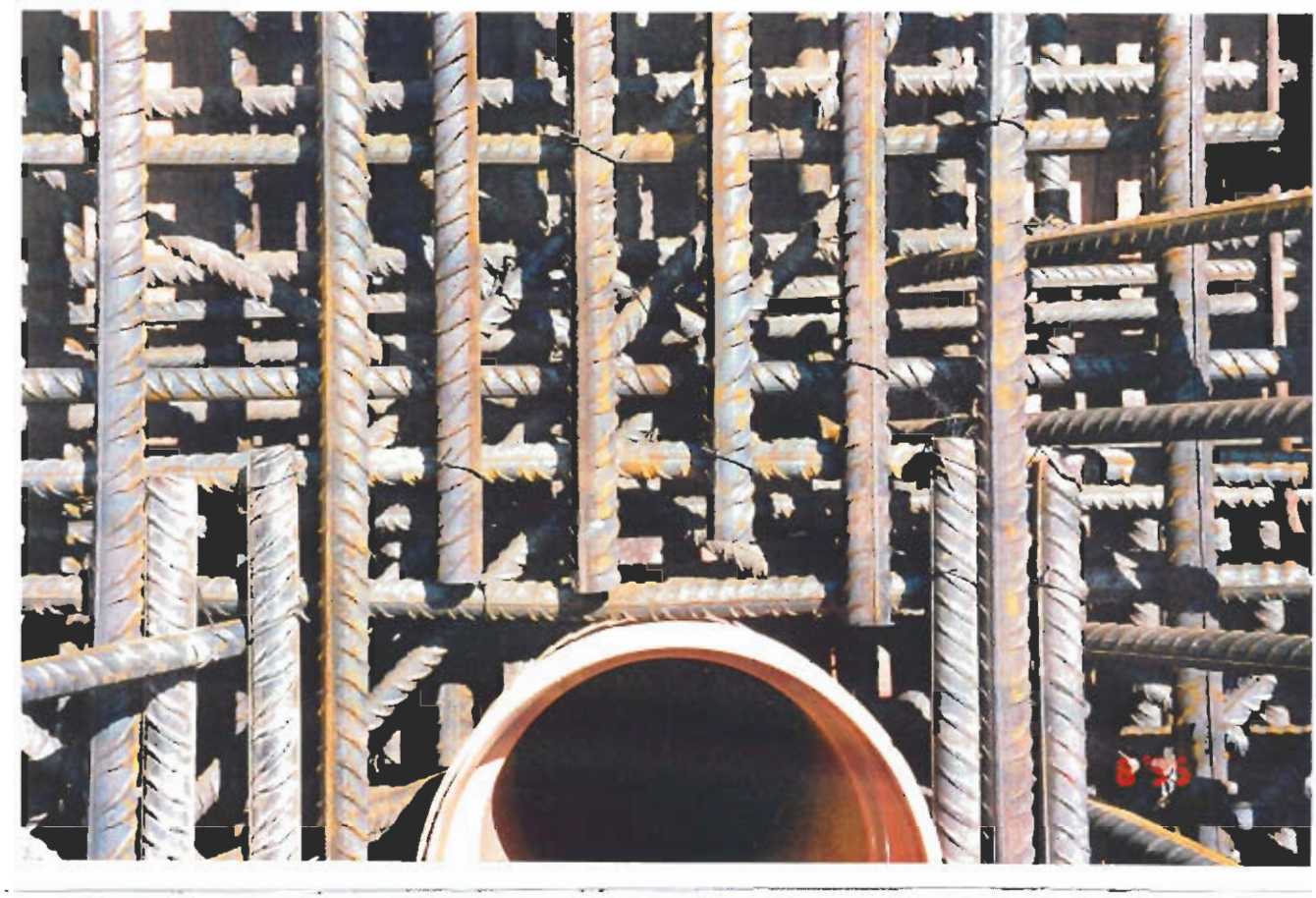

Figure 2.19

Impractical arangement of reinforcement surrounding a drainpipe in a slab. The reinforcement does not leave much space for casting and compaction equipment and there is a great risk of holes and honeycombs in this part of the construction.

3. Illustrations of structural and non-structural repairs

The illustrations of structural and non-structural repairs include the following:
- repair procedures
- visual assessment of cores taken from repairs
- petrographical analyses

3.1 Structural and non-structural repair procedures

The illustrations demonstrate different aspects of the repair processes and exampels of the quality of repairs which have been made on concrete in the construction phase:

- Preparation of repairs with respect to removal of concrete and cleaning of surfaces.
- Casting of repair concrete for filling holes in a wall.
- Repairs with shotcrete and mortar.
- Injection of concrete.

Figure 3.1: Removal of defect concrete. The concrete was damaged by frost expansion of the black cooling pipe behind the reinforcement. Damaged concrete was removed by cutting with pneumatic handheld hammers and the edges of the repair was cut with a diamond saw at an angle of 90° to the surface. Where reinforcement was exposed the concrete is removed min. 20 mm behind the bars, in order to admit materials to surround the reinforcement sufficiantly.

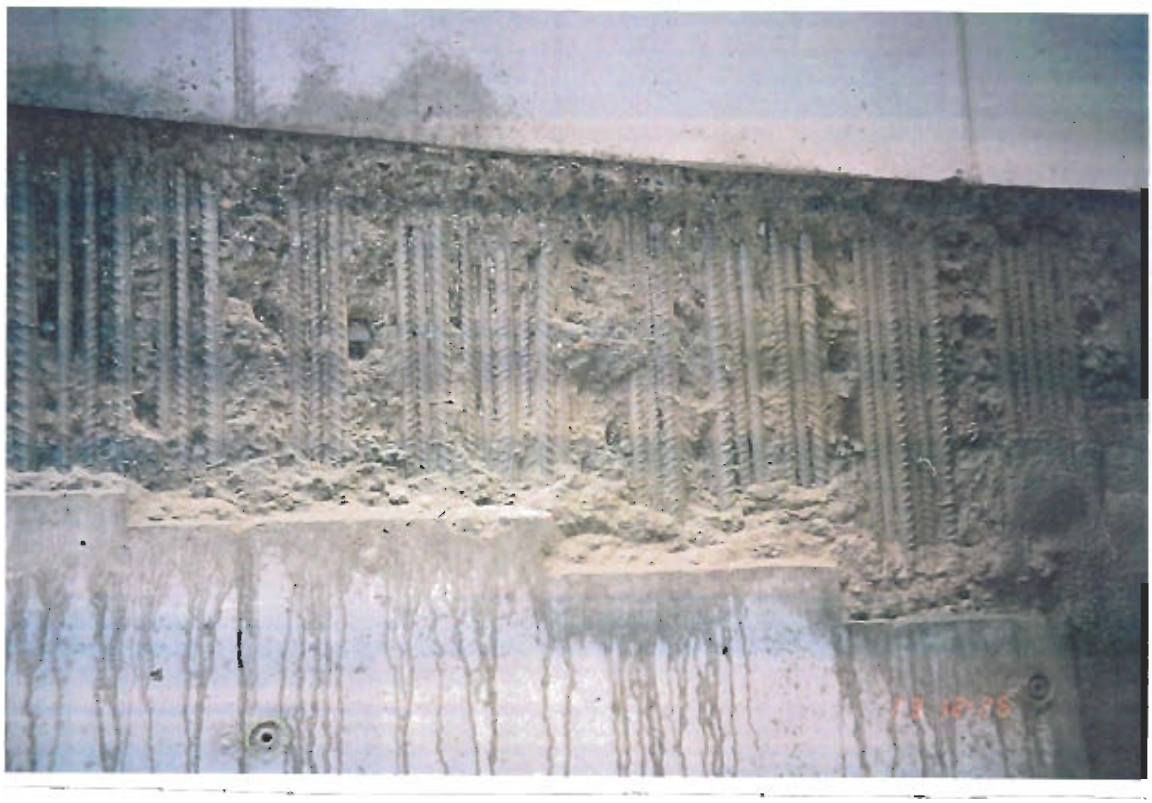

Figure 3.2: Removal of defect concrete. Damaged concrete was removed by cutting with pneumatic handheld hammers and the edges of the repair was cut with a diamond saw at an angel of 90° to the surface. The concrete behind the bars was not removed.

Figure 3.3: Filling out the hole in the lowest part of a wall in a tunnel with repair concrete. The hole in the wall was caused by lack of removal of ice before casting. The formwork for the repair concrete should be higher than the repair. The defect concrete above the repair should be removed before starting the repair process.

Figure 3.4: Repairs made with shotcrete after the first layer was applied. The area around the repair framed in order to avoid shootcrete on the surrounding surfaces.

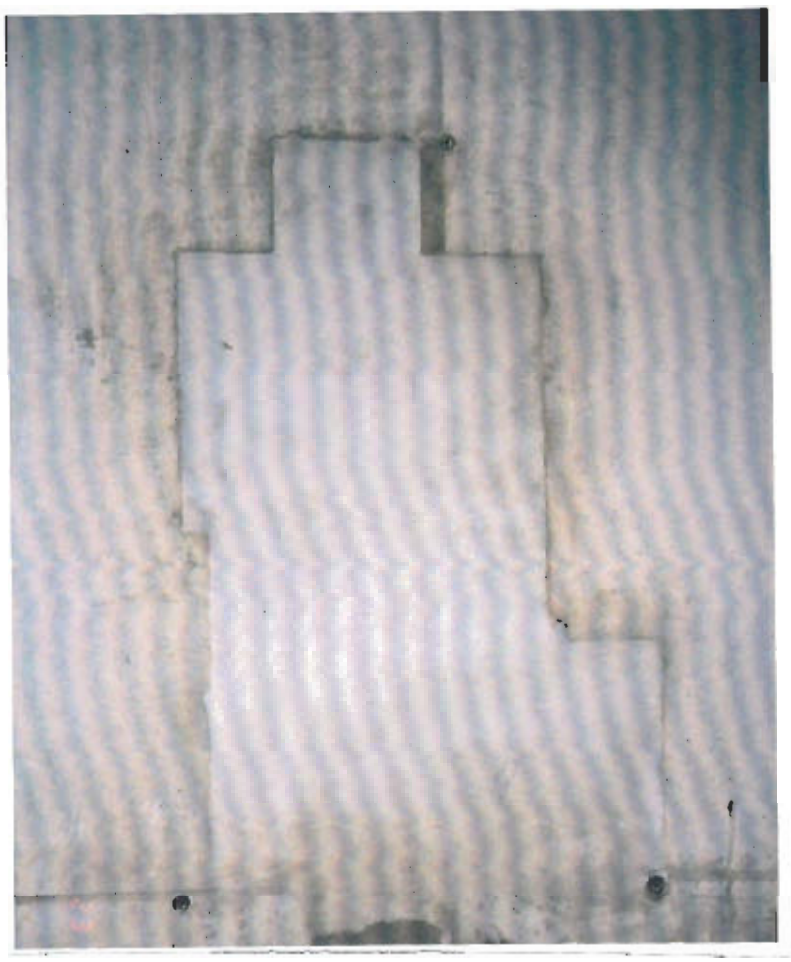

Figure 3.5: Finished repair with mortar. The surface of the repair is without defects. The repair has a surface texture which variates from the construction concrete.

Figure 3.6: Repair with mortar. The surface cracked because of lack of protection against evaporation. The repair should be protected against evaporation for instance by attaching plastic.

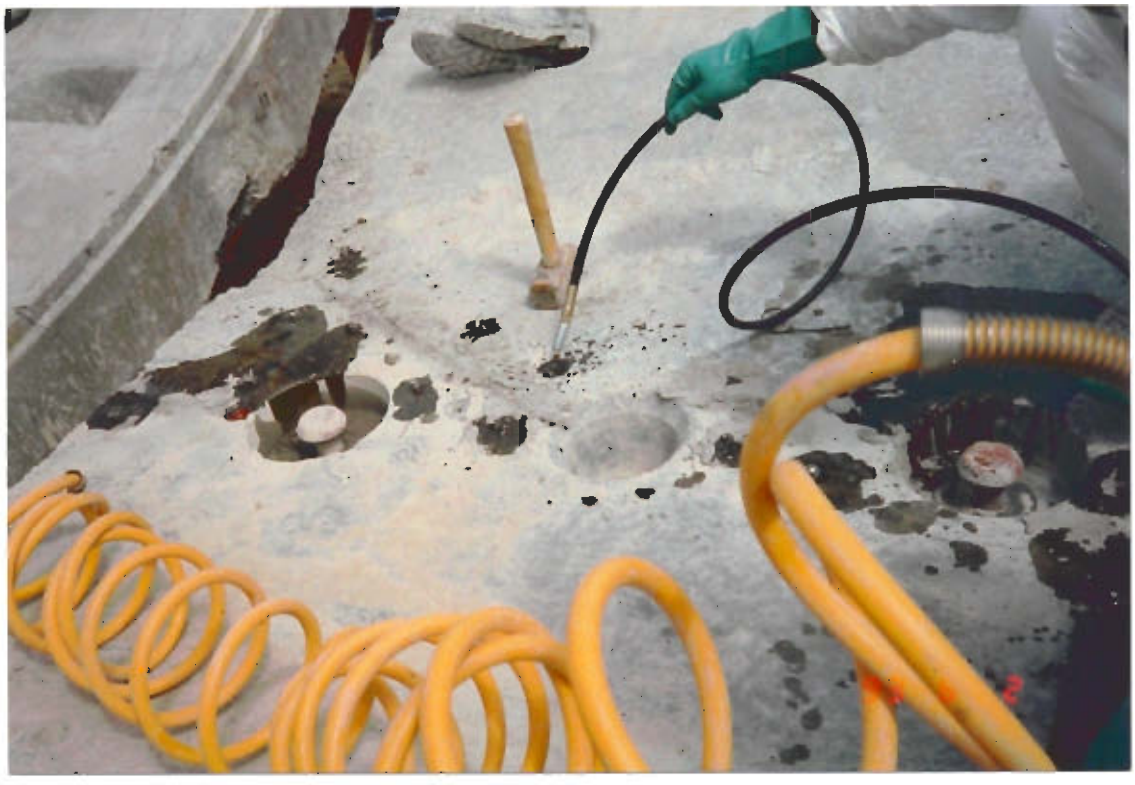

Figure 3.7: Injection of cracks in a tunnel lining element with epoxy through drilled-in packers. The injection should reestablish the structural integrity and fill out the cracks in order to make the element watertight. The packers are drilled from both sides of the crack at an angle of 45-60°

3.2 Visual assesment of cores taken from repairs

Figure 3.8: Core drilled out of a repair with mortar and shotcrete. The mortar has been applied as a finishing layer on top of the shotcrete. The casting joints between the different materials are filled out fully and the materials are well compacted and homogeneous.

Figure 3.9 Core taken from a repaired tunnel wall made with shotcrete. The layer of the spraying is visible. The repaired is homogeneous without defects and there is full adhesion in the casting joint.

Figure 3.10 Core taken from a shotcrete repair af a sidebeam at a bridge. The arrow behind the reinforcement bar indicates air void and bad compaction due to poor workmanship. This will reduce the durability of corrosion protection of the reinfarcement bar.

Figure 3.11 Core taken from repairs made with mortar. The core was located at the casting joint in the surface. There is a large air void in the casting joint, thus is was not visible before drilling the core.

Figure 3.12 Core taken from repairs made with shotcrete. The shotcrete is poorly compacted and there are large air voids in the repair materials. This reduces the durability of the structure.

Figure 3.13 Core from injected crack. The crack was injected with polyurethane.

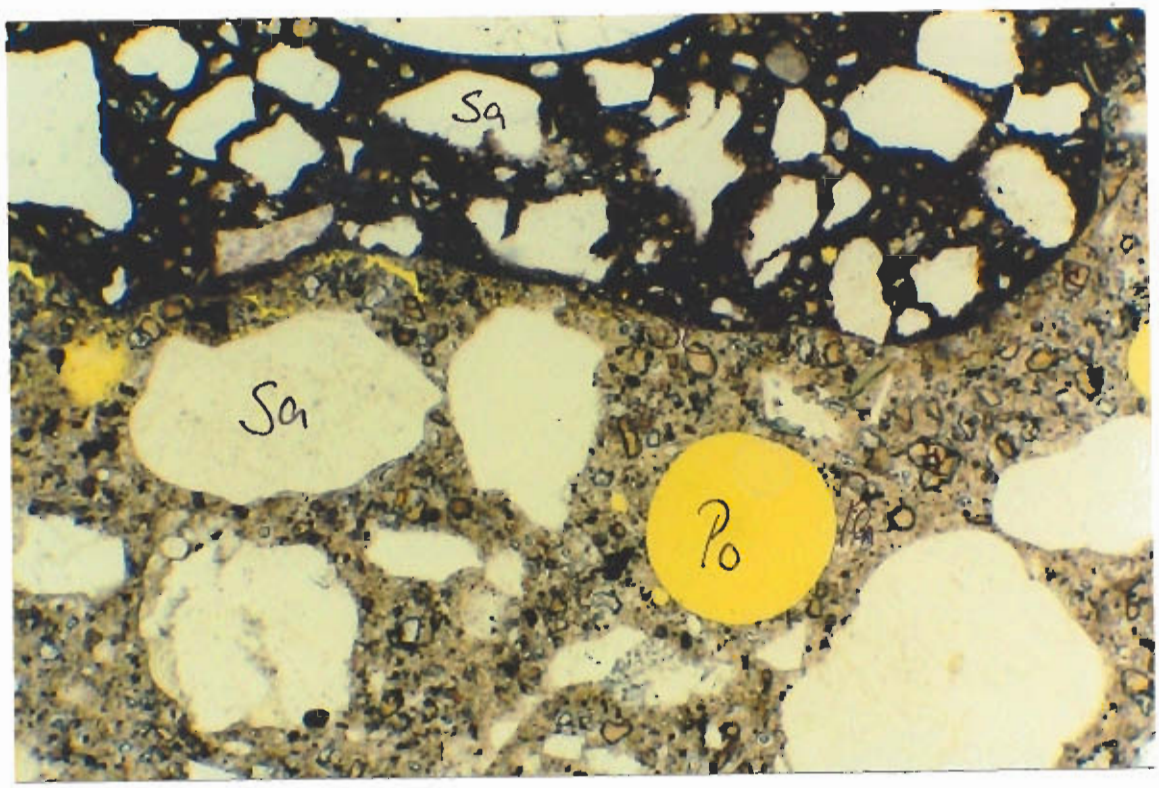

Figure 3.14 The illustration covers a thin section of app. 3x4 mm of a concrete core sample. In the middle the casting joint between mortar at the top and construction concrete at the bottom. The mortar is of good quality without inhomogenities and with full adhesion and no cracks in the joint.

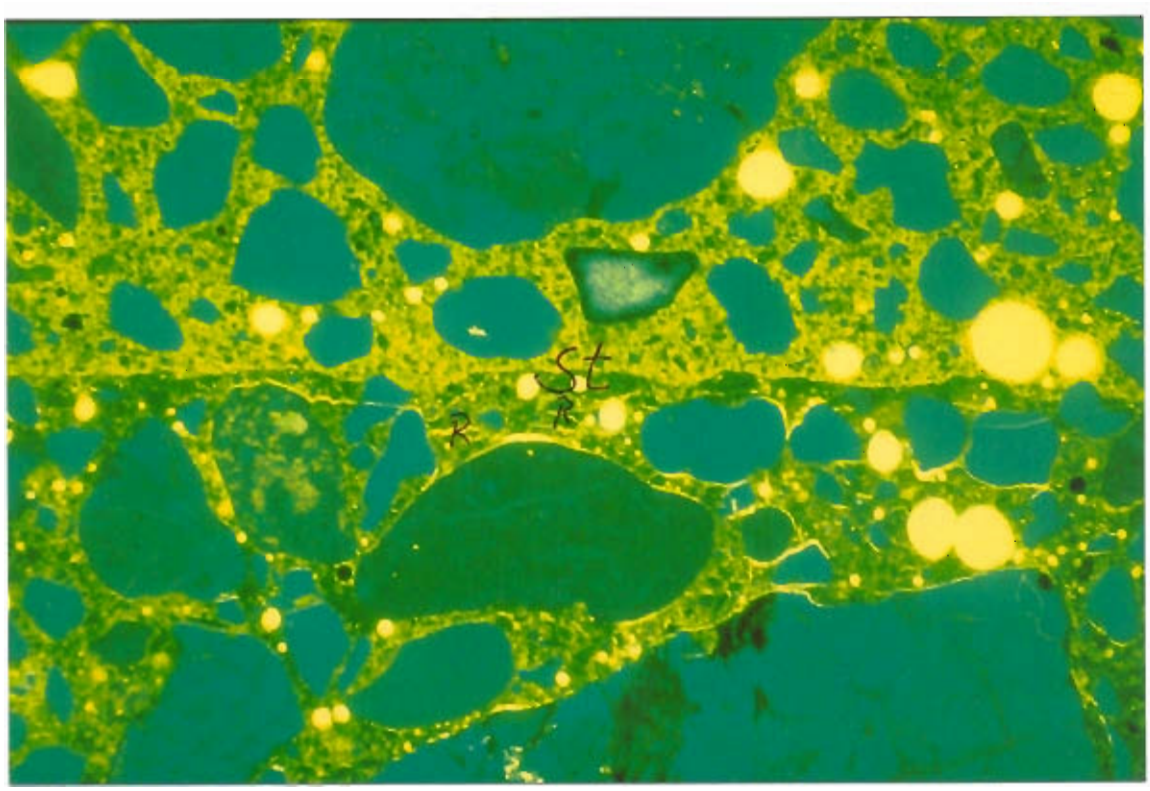

Figure 3.15 The illustration covers a thin section of app. 3 x 4 mm of a concrete core sample. In the middle of the picture is a joint between shotcrete repair materials.There is dust and dirt in the joint and the surface of the construction concrete was damaged due to the cutting with a pneumatic hammer.

4. References

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