

Investigation of existing foundations and development of decision trees for an economically optimized re-use („REFUND“)

Project	8202
Document	Short report
Funding agency	Bundesinstitut für Bau-, Stadt- und Raumforschung, Referat II 3, Deichmanns Aue 31-37, 53179 Bonn
Funding program	Forschungsinitiative Zukunft Bau
Funding No.	SWD 10.08.18.07-14.02
Period	Juli 2014 – Juli 2016
Date	2017-01-09
Projektleiter	Dr. Ernst Niederleithinger in cooperation with TU Darmstadt (Co-Projektleiter Prof. Dr- Ing. Rolf Katzenbach); SKP Ingenieure, Berlin; Implenia Construction AG, Mannheim; GSP mbH, Mannheim

Der Forschungsbericht wurde mit Mitteln der Forschungsinitiative Zukunft Bau des Bundesinstituts für Bau- Stadt- und Raumforschung gefördert.

(SWD 10.08.18.07-14.02)

Die Verantwortung für den Inhalt des Berichts liegt beim Autor.

Title

Full title: Investigation of existing foundations and development of decision trees for an economically optimized re-use

Introduction

Before re-use in construction project the position, geometry and condition of existing foundations has to be investigated. As they are buried deep in the ground a visual inspection is often out of question. Several testing methods are available. However, the process for planning and testing is not standardized. The capabilities and limitations of the testing methods might not be known to the persons involved.

Tasks

Work package 1: Background and state of the art

WP1 started with an intensive literature review and an analysis of the relevant projects of or industry partners. This was used as a base to develop a detailed concept for the following development steps. The research on previous experiences with re-use projects happened to be quite difficult as only few project have been published and the documentation was often scarce. Specifications for investigation concepts, decision trees and testing methods as wells as catalogues of testing tasks depending on the type of foundation were the final result of WP1.

Work package 2: Decision trees

In work package 2 we have developed an optimized concept for the investigation of existing foundations, including the necessary decision trees, considering technical, economical and practical needs and separately for different types of foundations. We aimed for a continuous iterative process integrating all stakeholders with an optimized information flow.

We started using the results of the project RuFUS (EC 5th framework, 2003-2006) in which BAM and TU Darmstadt had participated. Processes and decision trees have been developed in this project as well, but from an international point of view with a focus on the UK situation. In addition, the investigation methods have been developed further meanwhile.

Considering the results of WP1, the current state of the art and current standards we have developed new process charts for each type of foundations. The charts for foundation slabs are shown in figure 1 (planning) and figure 2 (investigation).

The processes proposed have been tested in cooperation with the industrial partners in the frame of this project as far as possible. With SKP Ingenieure we have investigated a foundation slab below a parking garage in Passau, Bavaria. Data from a parallel study on existing electricity tower foundations were used to test the charts for foundation piles.

Working with the charts has been shown to be effective and target oriented. Some of the iteration loops, which had not been described in enough detail in the first round, were improved based on the experience gathered in the practical tests.

Work package 3: Testing methods

In WP3 we have evaluated and partially optimized several testing methods. The focus was on non-destructive testing methods, including capabilities, limitations and the time budget required for application. We have also worked on using a priori information for an optimized method and parameter selection as well as on data presentation and interpretation readable by civil engineers. If the information provided by literature, standard and recommendations and the experience of the project partners was insufficient for a specific testing task, an evaluation was performed primarily at the BAM-TTs in Horstwalde. A foundation slab with several testing features was constructed specifically for the REFUND project. Implenia and GSP have performed significant parts of the evaluation.

The testing methods considered are as follows:

- 1) Non-destructive methods (state of the art)
 - Rebar detector,
 - Rebound hammer,
 - Radar,
 - Half-cell potential method,
 - Impact-Echo,
 - Ultrasonic-Echo,
 - Low-strain pile integrity testing.

- 2) Innovative methods/special testing tasks
 - Automatized measurements with scanning systems
 - Parallel-Seismic method and multi-channel pile integrity testing,
 - Borehole radar,
 - Ultrasonic-Echo and radar to localize voids below foundation slabs,
 - Lean concrete layers below foundation slabs, thickness measurement using Ultrasonic-Echo,
 - Pile integrity testing using temperature measurements
- 3) Destructive testing methods

Figure 3 shows the evaluation of the radar method at the REFUND test slab at BAM-TTS, Horstwalde. Figure 4 depicts the use of the Parallel Seismic method the check the pile length in the frame of one of the test projects mentioned earlier. One of the developed method/task matrices is shown in figure 5.

Conclusions

The objectives of the REFUND project have been met without significant restrictions.

Based on research on previous experiences we have developed processes and decision trees for the re-use of foundations. Several testing methods have been considered, tested and partially optimized. The evaluation was compiled to method/task matrices. The products were tested in two practical projects. The final result is a handbook for practical application.

Not all potential testing tasks can be solved using the methods currently available. This should lead to more research, e. g. concerning voids below foundation slabs.

Project data

Short title:

Investigation of existing foundations (REFUND)

Investigators:

Bundesanstalt für Materialforschung und-prüfung:

Dr. rer. nat. Ernst Niederleithinger (Principal Investigator)

Julio Cesar Galindo Guerreros, M. sc.

Technische Universität Darmstadt:

Prof. Dr.-Ing. Rolf Katzenbach (Co-Principal Investigator)

Dipl.-Ing. Hendrik Ramm

Dipl.-Ing. Jörg Gutwald

SKP Ingenieure:

Dr.-Ing. Andre Molkenhuth

Dipl.-Ing. Stephan Hillmann

Implema Construction AG:

Dipl.-Ing. Michael Willmes

GSP mbH:

Dr.-Ing. Oswald Klingmüller

Dr.-Ing. Matthias Schallert

Total budget:

256.201,46 €

Funding:

134.795,53 €

Period:

24 months

Diagramm IV: Process of investigation for existing slab

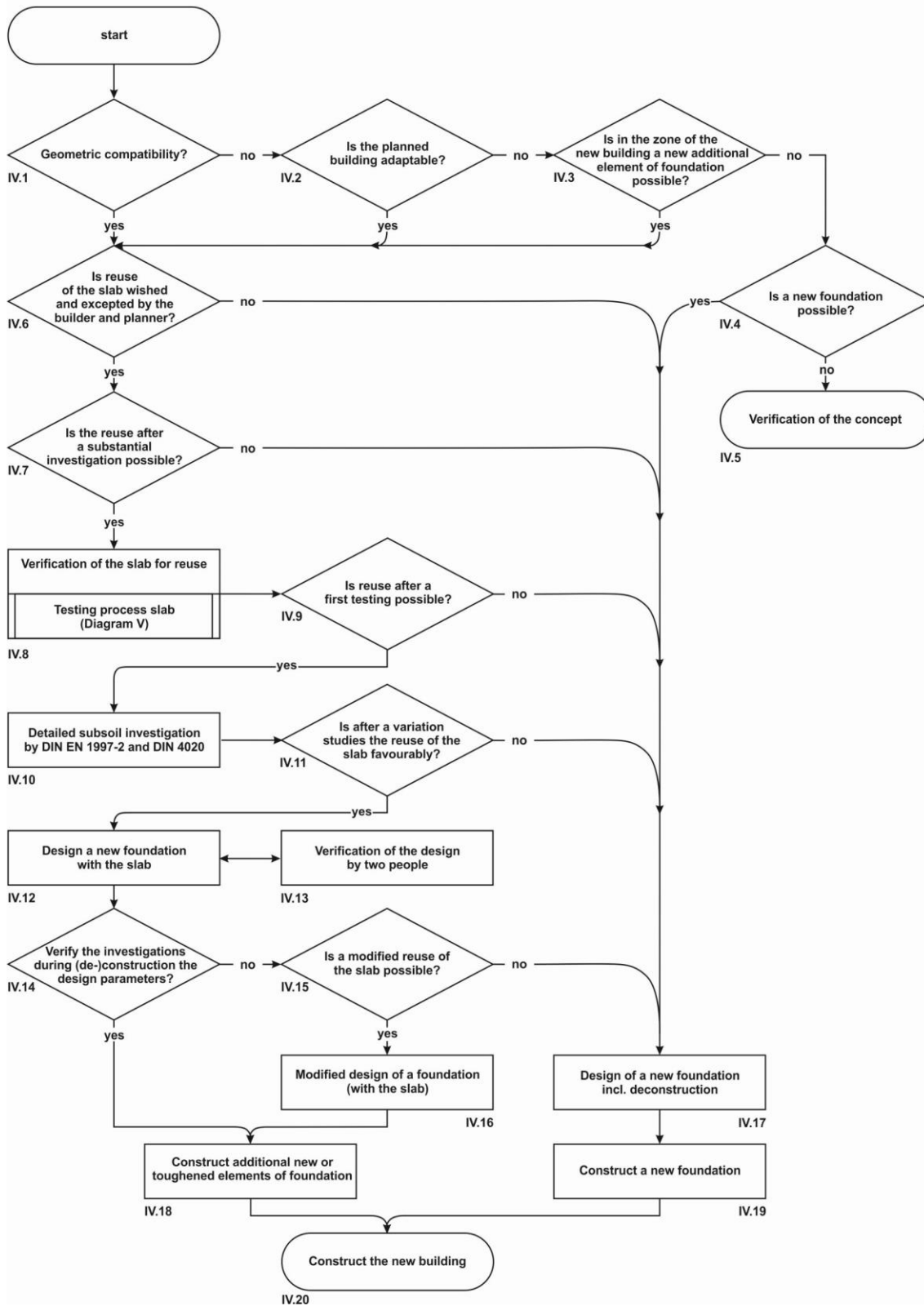


Figure 1: Diagram IV from the handbook: Planning process of re-use projects (foundation slabs).
File: Abbildung1.jpg

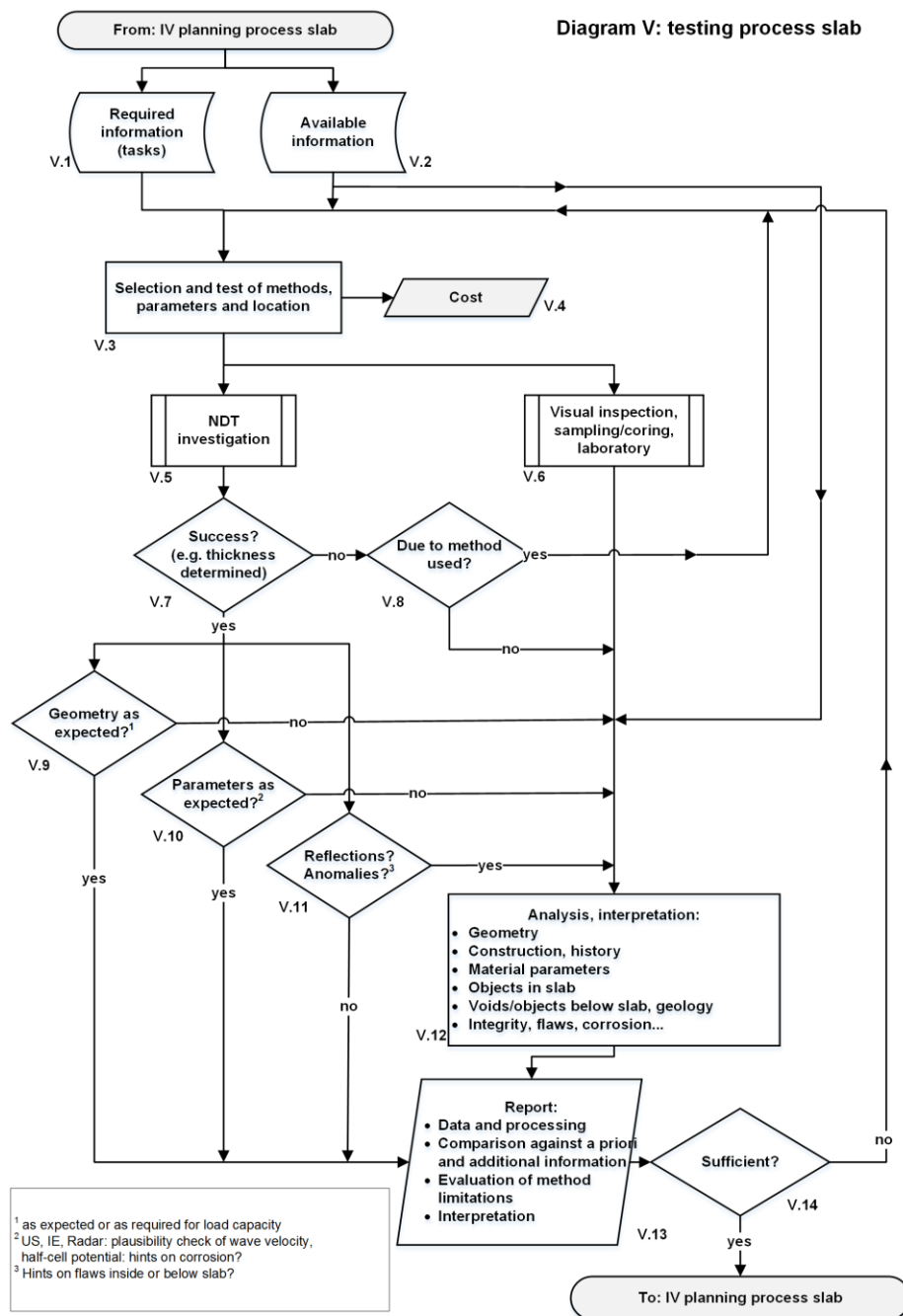


Figure 2: Diagram V from the handbook: Investigation process for foundation slabs.
 File: Figure2.png



Figure 3: Radar measurements by Implenia Construction AG on top of the REFUND test slab (BAM-TTS, Horstwalde) to determine rebar position and slab thickness.
File: Figure3.jpg



Figure 4: Parallel Seismic measurements to determine the length of foundation piles at an electricity tower.
File: Figure4.jpg

	Low-Strain-integrity testing	Multi-channel method	Parallel-Seismic method	Borehole radar	Induction method/ Mise a la Masse	Visual inspection, sampling/coring lab investigations
Task						
File type						++
Length	+	+	++	+	+ ²	
Diameter						++
Shape			o	+		
Concrete strength	o ¹	o ¹	o ¹			o ³
Flaws	+	+	o			o ³
Concrete cover						o ⁴
Range of use						
Concrete piles	++	++	++	++	+ ²	++
Steel piles	++	++	++	++	++	++
Wooden piles	+	+	+	o		++
Pile walls	o	+	++	++	++ ²	++
Sheet walls	o	+	++	++	++	++
Piles below constructions	o	+	++	++	++ ²	o
Remarks						
Access to pile head required	yes	yes	no	no	yes ⁵	yes ⁶
Parallel borehole required	no	no	yes	yes	yes	no

- ++ fully applicable
+ applicable with some limitations
o applicable with significant limitations
1 indirect qualitatively via wave velocity only
2 reinforced part only at concrete piles
3 at excavated parts only
4 at excavated parts with appropriate measurement technologies
5 access to reinforcement required at concrete piles
6 Alternatively coring from top of slab/ girder

Figure 5: Method/task matrix for pile testing (Table 4 from the handbook).
File: Figure5.jpg