Översikt
Stag och Förankringar

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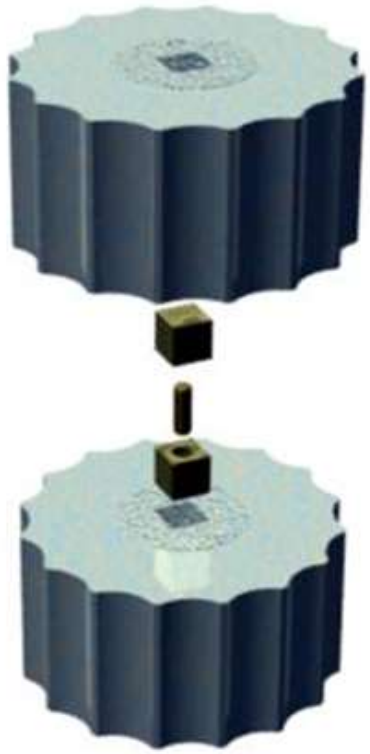
Kraftindustrins betongdag, Älvkarleby 2017-03-22

Disposition

- **Tillbakablick**
- **Vad jobbar vi med idag?**
- **Framtid**



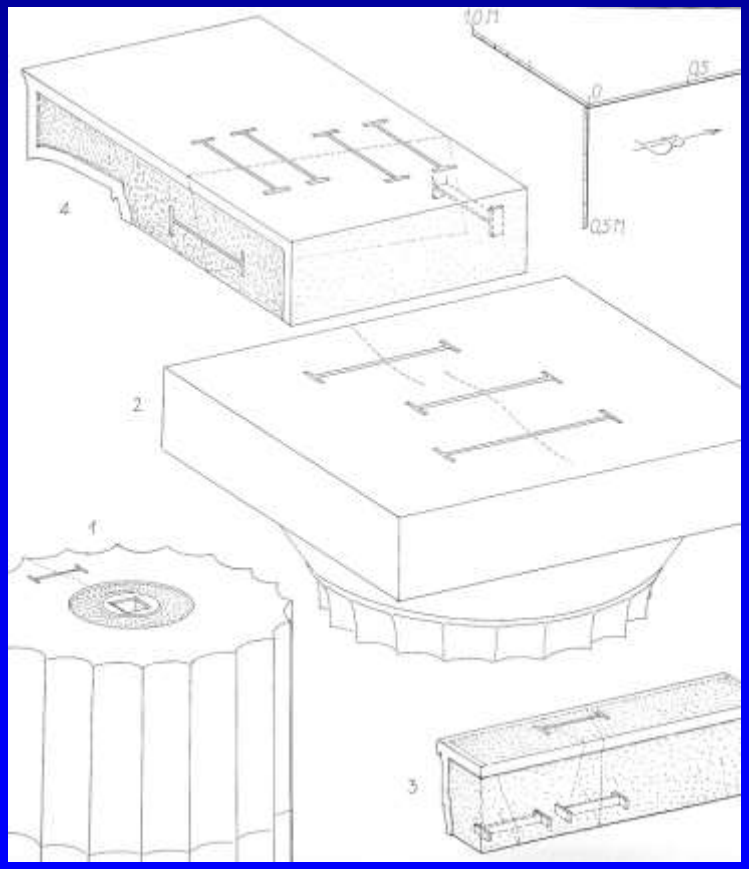
Zeus-templet i Olympia, 472–457 f Kr

Pelarna byggdes upp av skivor med träpluggar som förankring

Rolf Eligehausen

ca. 447 B.C.

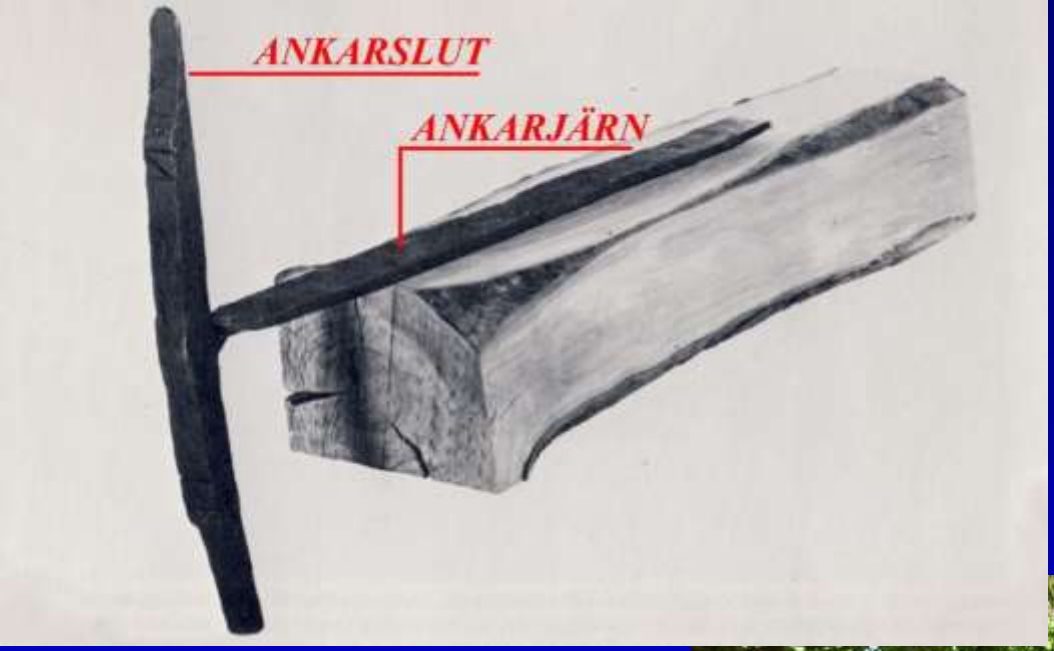
Sprick-hindrande förankringar



Manolis Korres, From Pentelicon to the Parthenon, Publishing House ‘Melissa’, 1995, p. 110

Förankring av järn

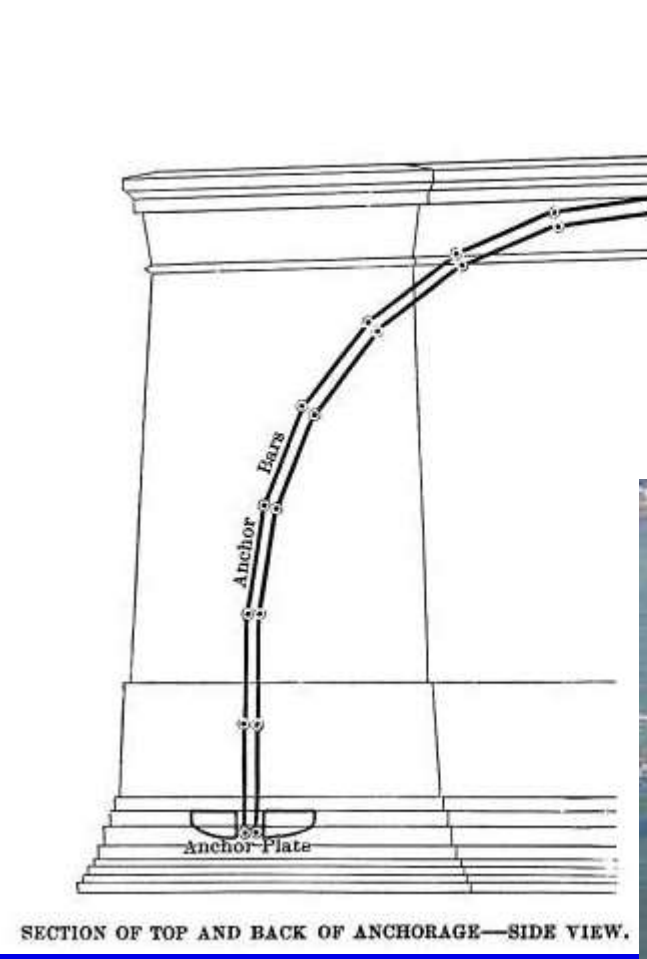
Messenien, Peloponnesos



Medeltida murankare,
smidd i ett stycke
och fastspikad i balkänden

M. Atterberg, Tekniska museet, Stockholm 1963

Ankarslutar utformade som årtal "1598"
i kvarteret Cepheus i Gamla stan



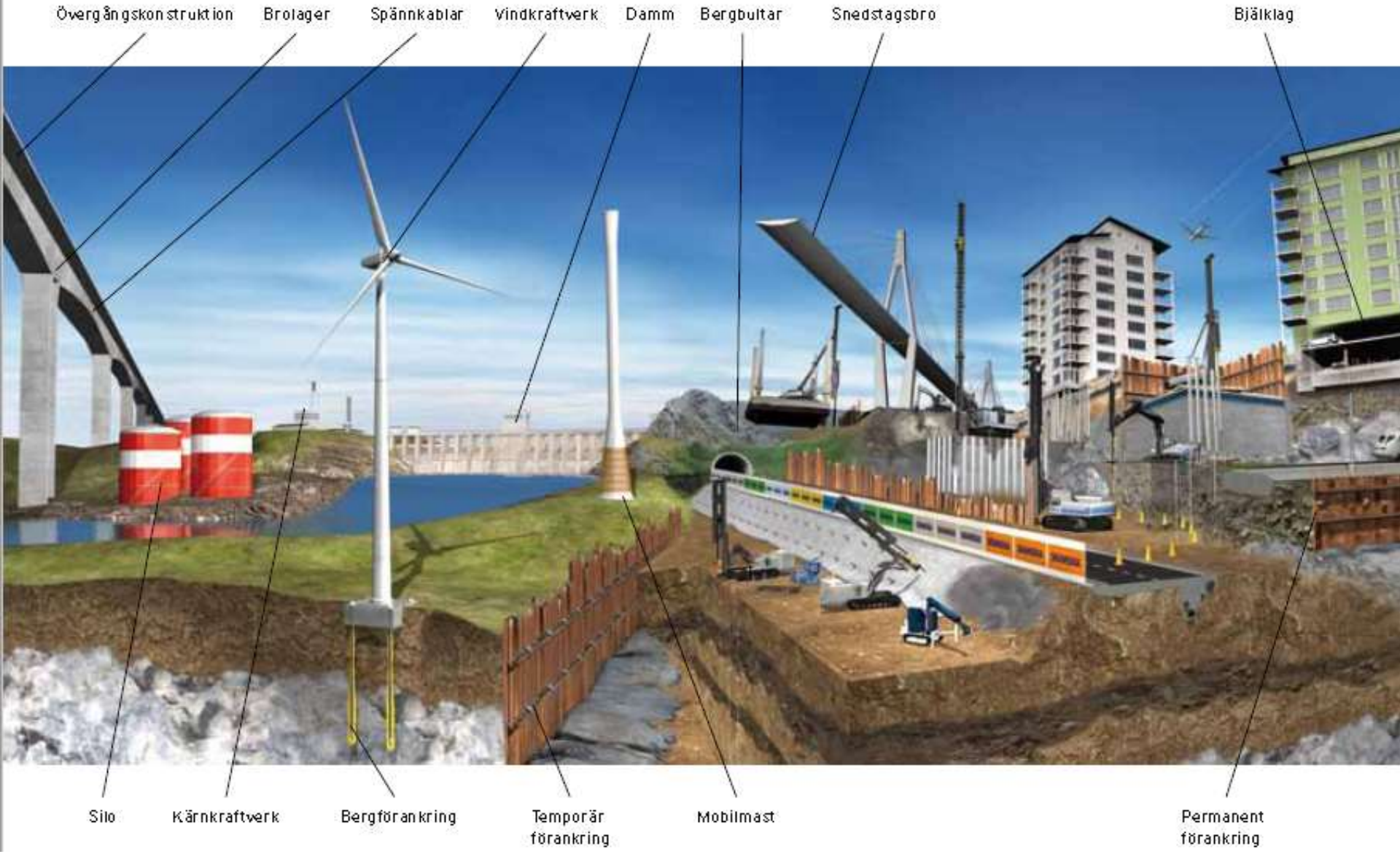
SECTION OF TOP AND BACK OF ANCHORAGE—SIDE VIEW.

Brooklyn Bridge
1883

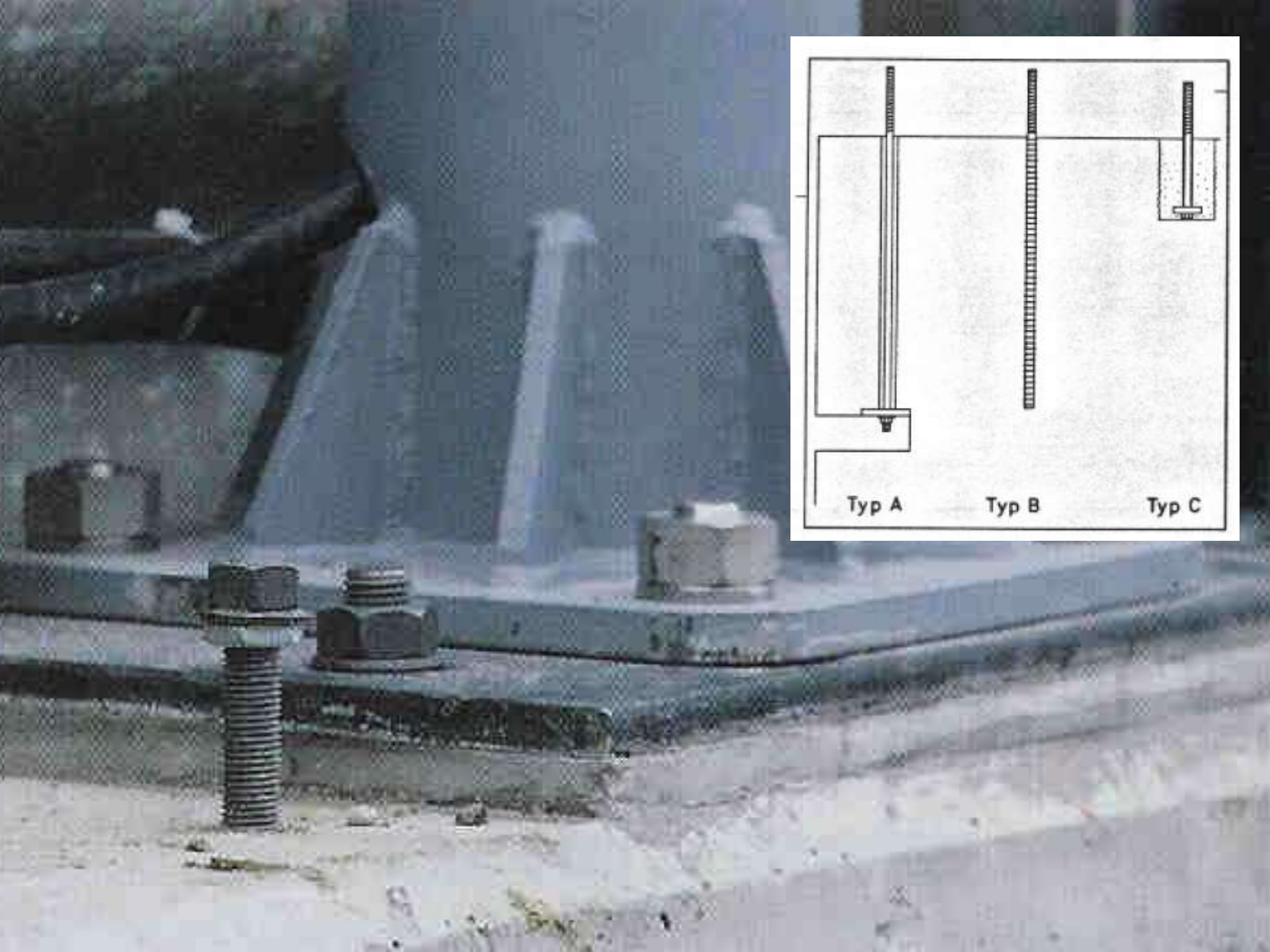
Corrossion damage 2007

Disposition

- Tillbakablick
- Vad jobbar vi med idag?
- Framtid



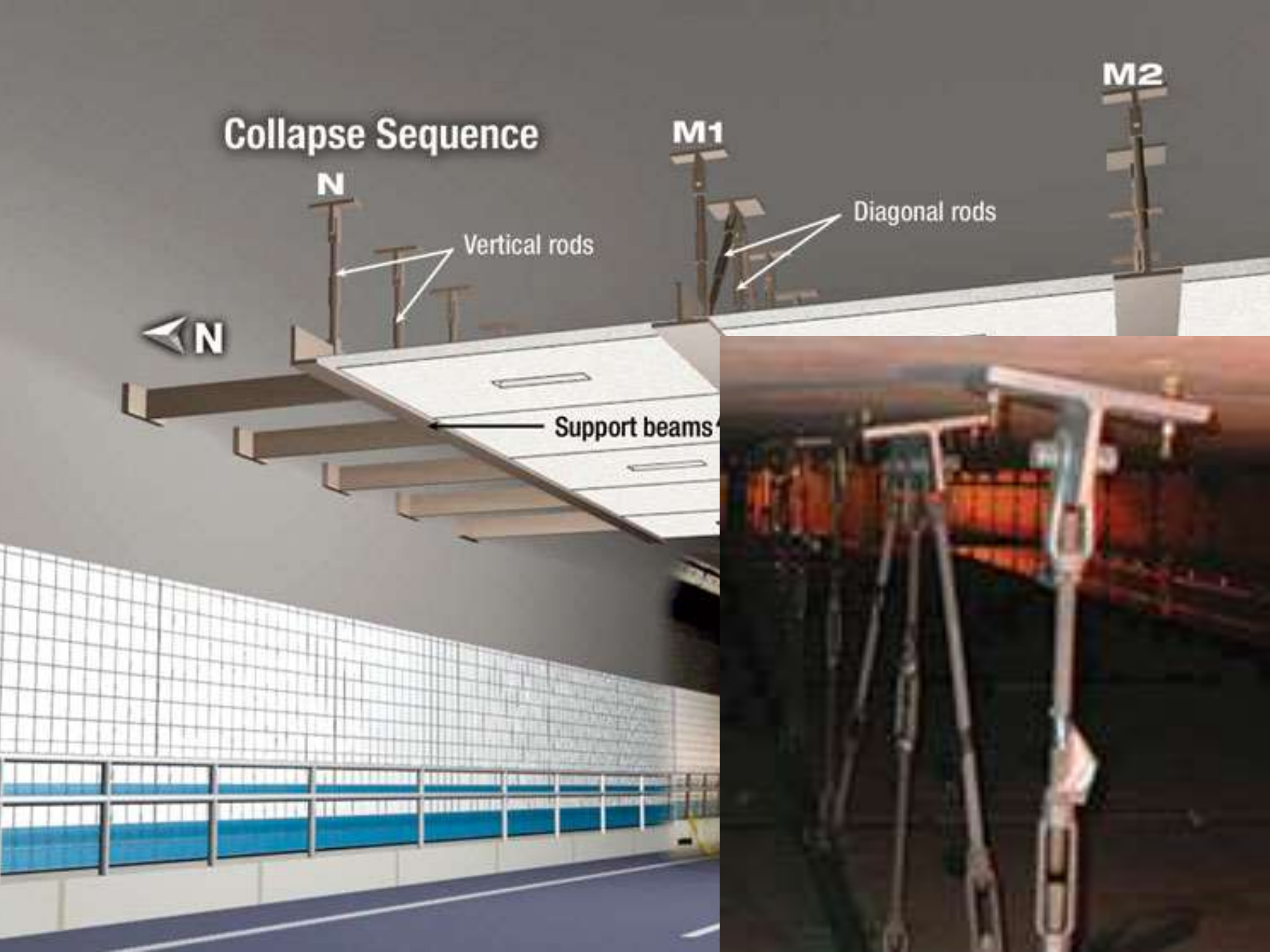
Internordisk Spännarmering AB, www.spannarmering.com


Typ A
Typ B
Typ C

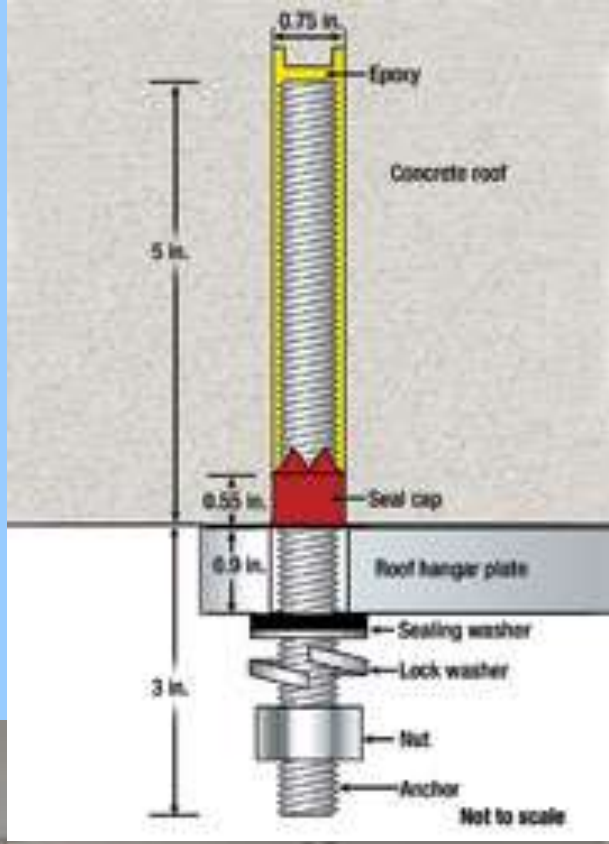
Post-installed Headed Studs

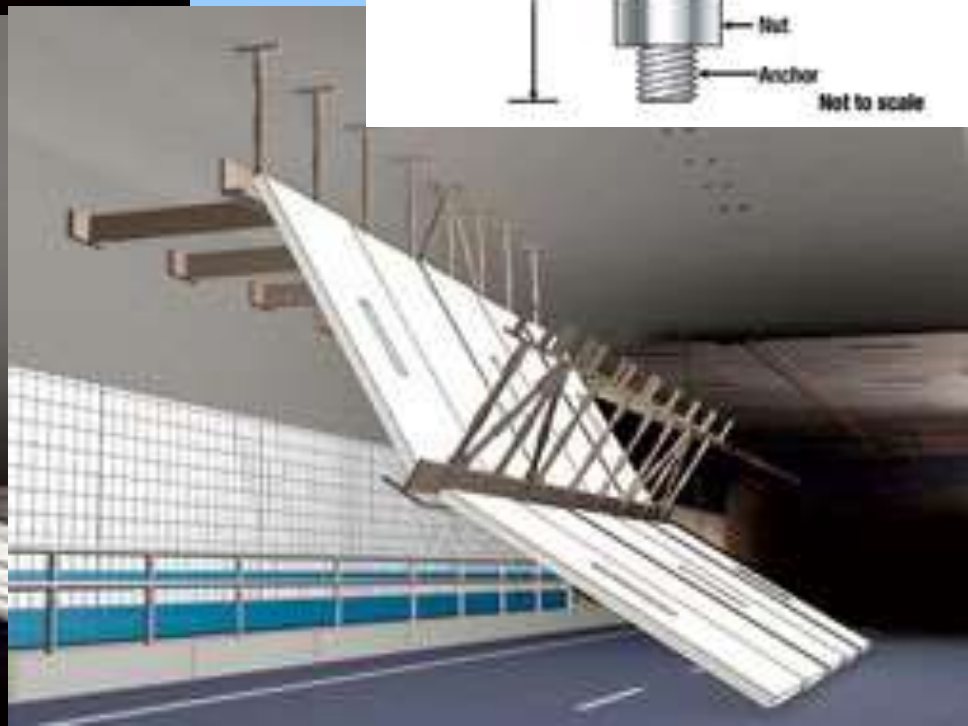
LTU 1979


Boston Interstate 90 Tunnel, July 10, 2006
20 ceiling anchors pulled out
Killed one 38-year old woman


Collapse Sequence
N
M1
M2
Vertical rods
Diagonal rods
N
Support beams


M1
M2


0.75 in.
Epoxy
Concrete roof
5 in.
0.55 in.
Seal cap
0.9 in.
Roof hanger plate
Sealing washer
Lock washer
3 in.
Nut
Anchor
Not to scale



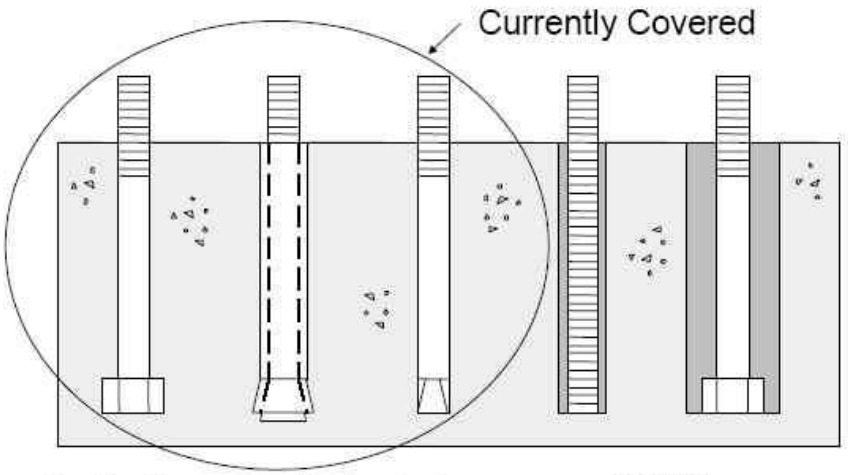
Failure Reason

Creep in the Adhesive

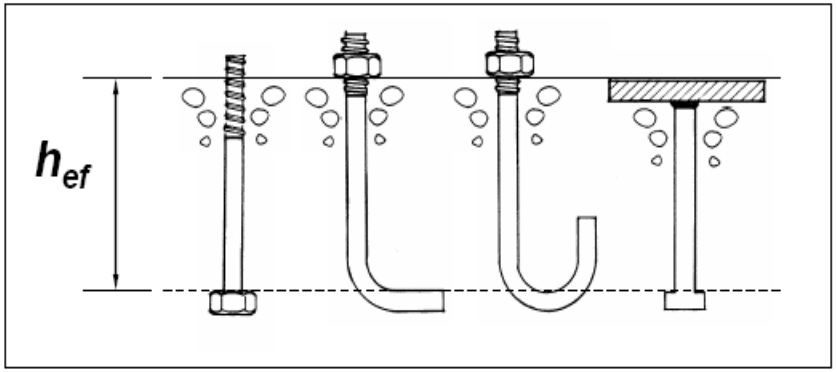
There are different kinds of adhesives

You must use one with controlled low creep tested for long time

Types of Anchors

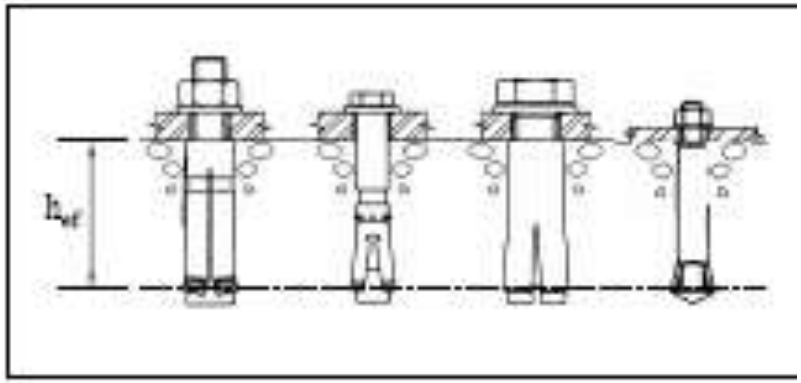


Cast-in-Place Anchors

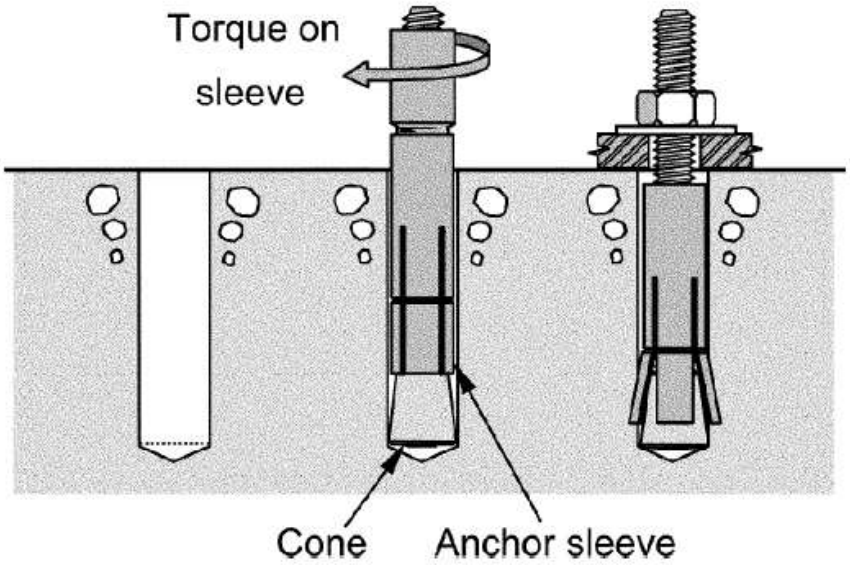


h_{ef} = Effective Embedment Depth

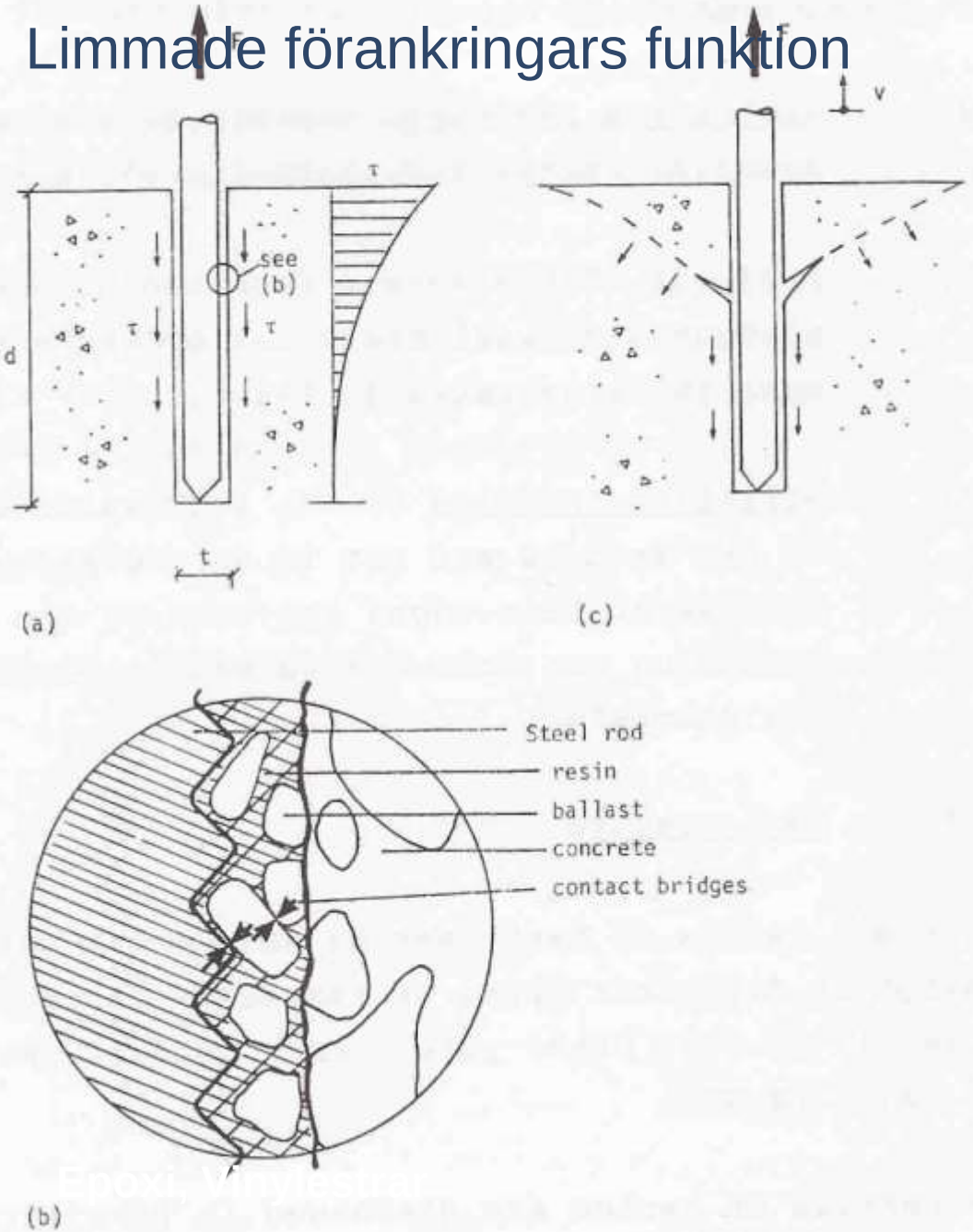
Post-Installed Mechanical Anch



h_{ef} = Effective Embedment Depth



Limmade förankringars funktion



Tension Failure Types

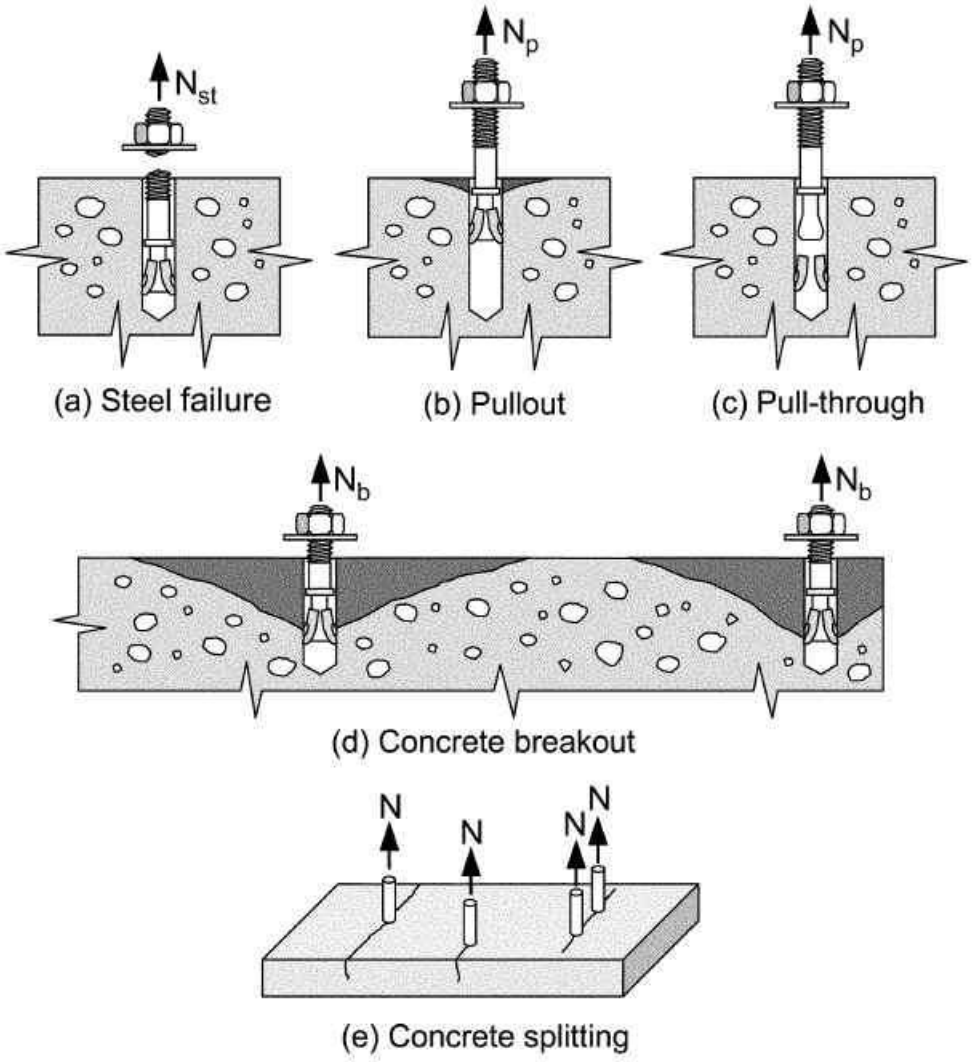
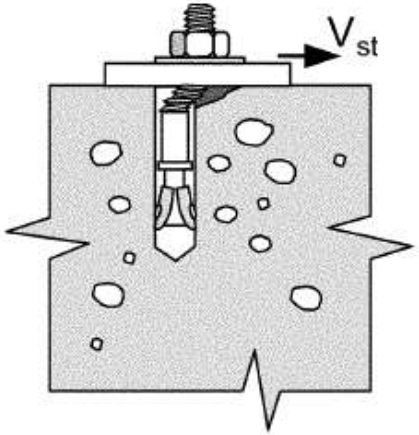


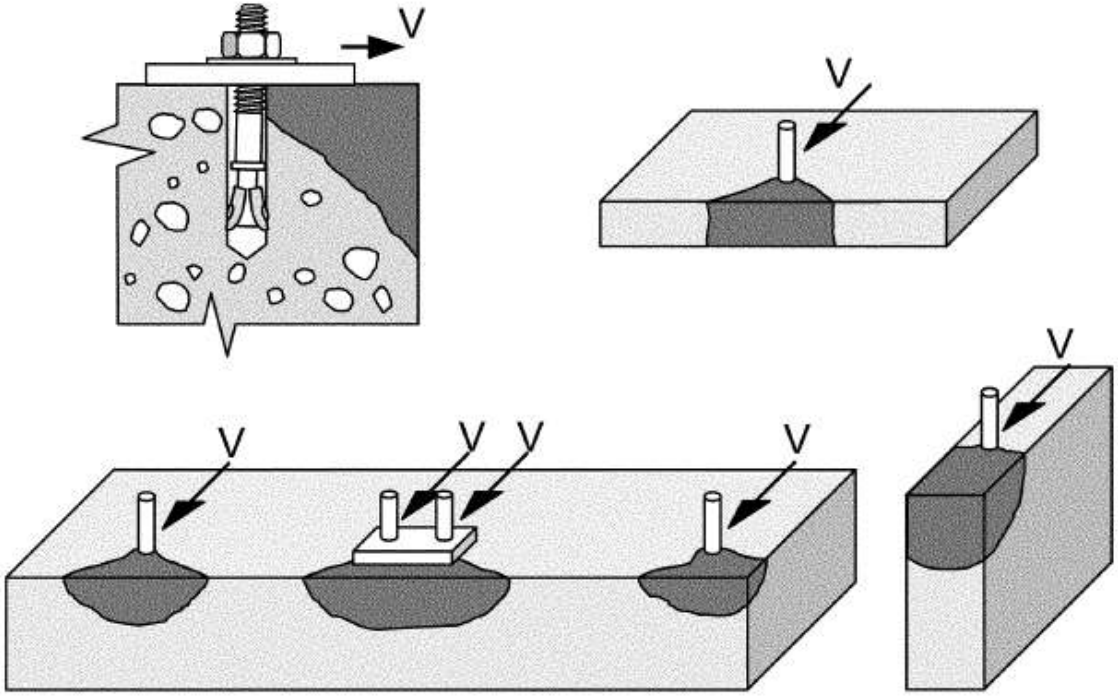
Fig. 5.3—Failure modes for anchors under tensile loading.

ACI 355 (2007)

Shear Failure Types



(a) Steel failure proceeded by concrete spall

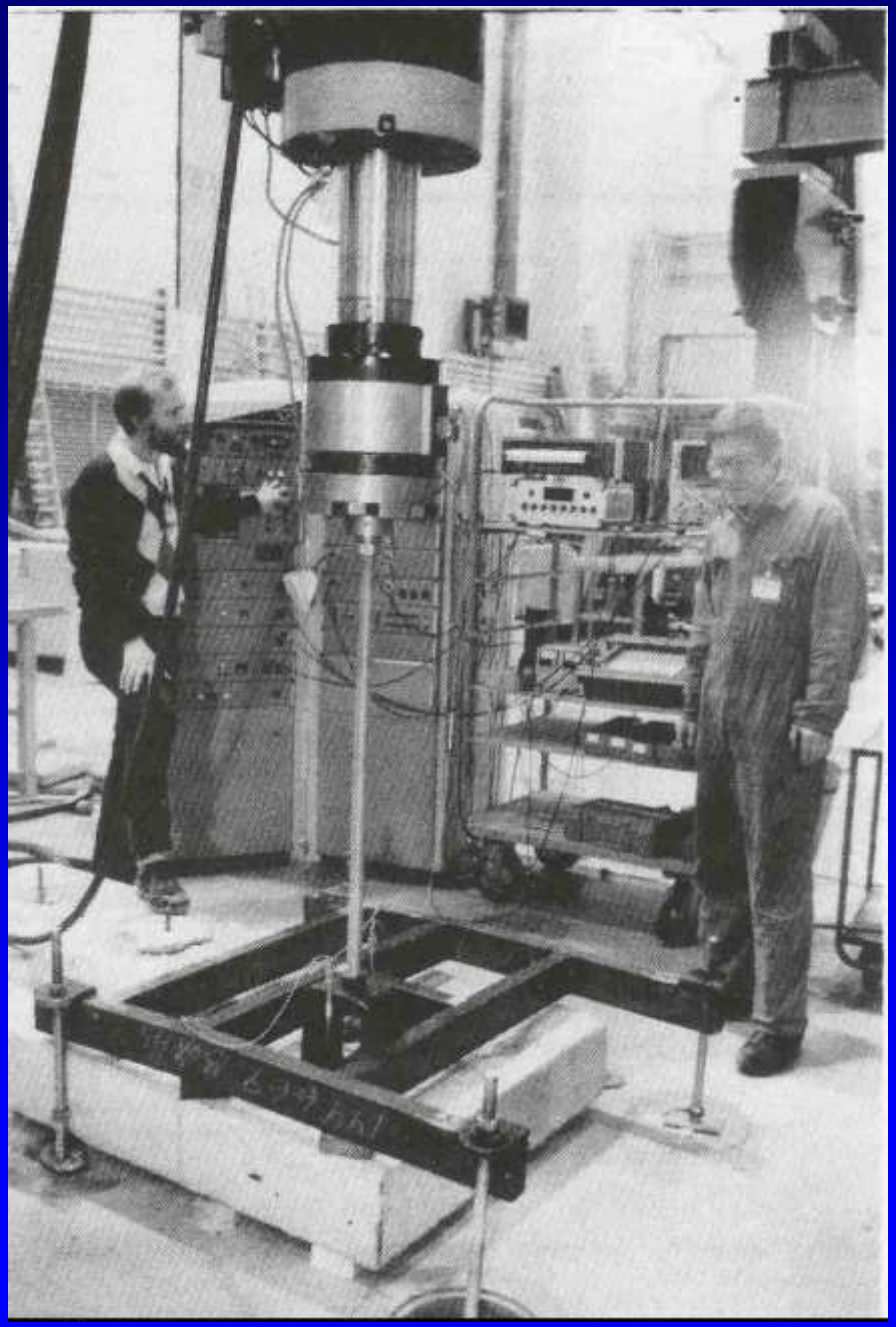


(b) Concrete breakout

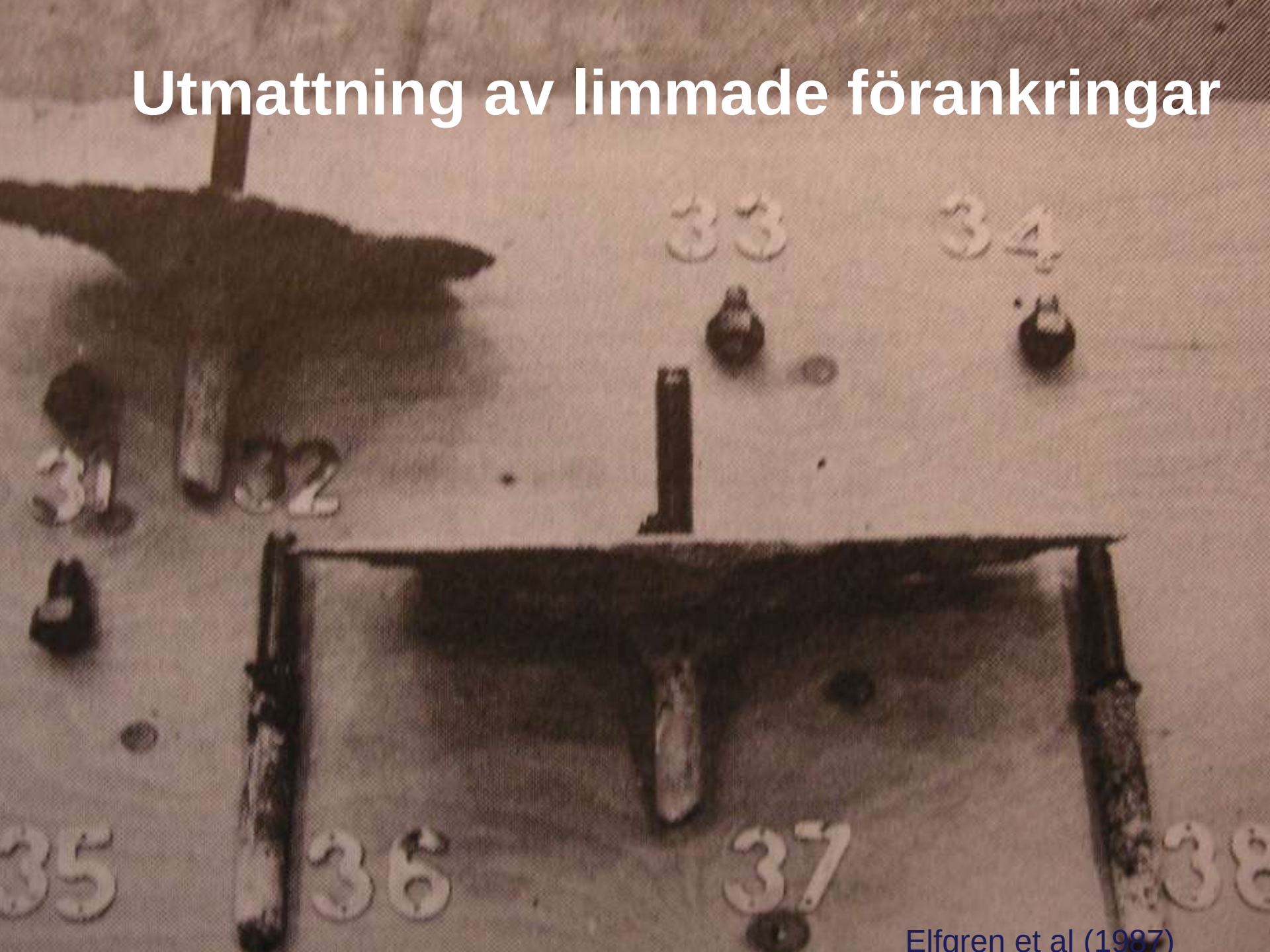
ACI 355 (2007)

Provning av limmade förankringar

SP, Borås, 1982

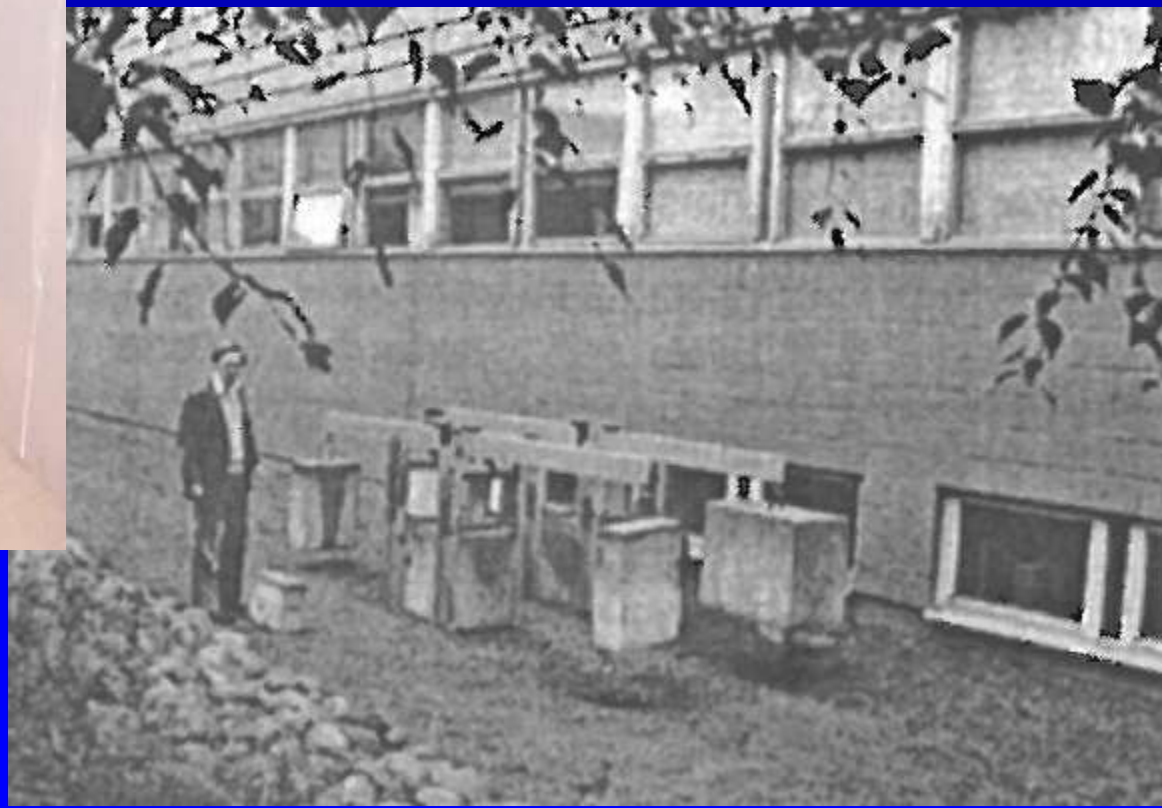


Utmattning av limmade förankringar

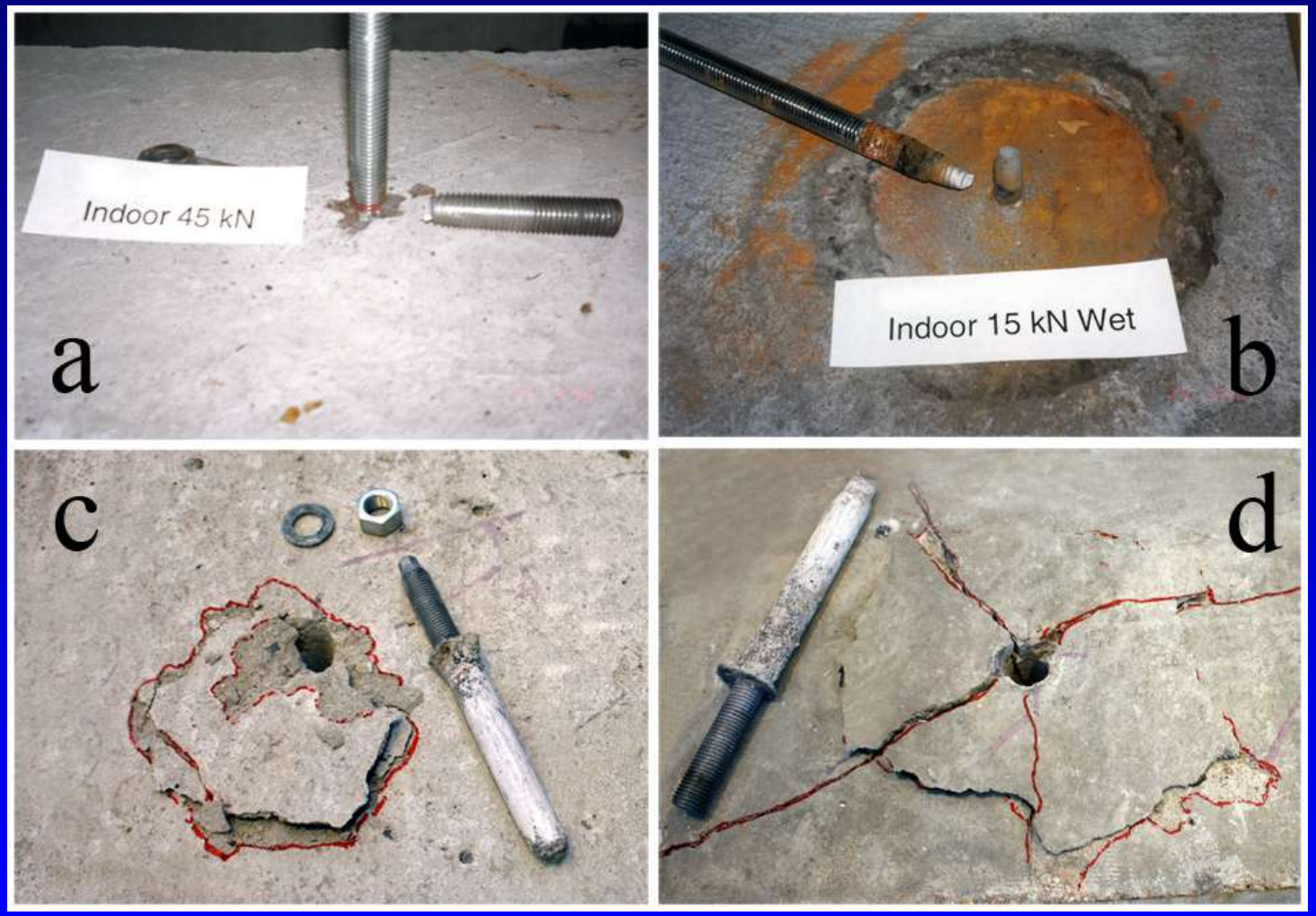


Elfgren et al (1987)

Långtidsförsök med limmade förankringar i Borås och Luleå 1983-2011



Brottmoder



(a) stålbrott, (b) korrosion, (c), (d) vidhäftning

First Ed. 1997
Rev. 2011

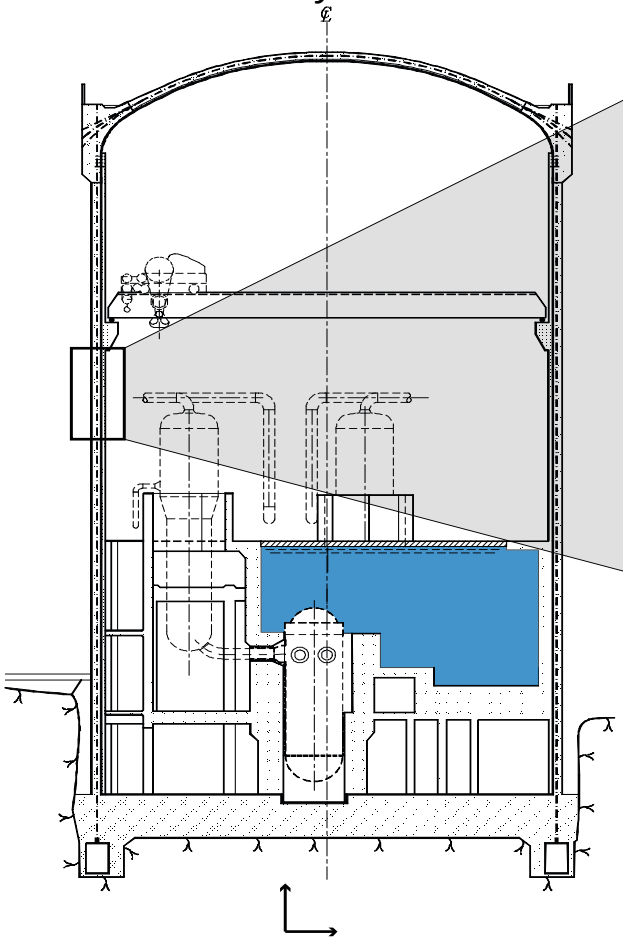
Fib Group on Fastenings
Abisko 2010

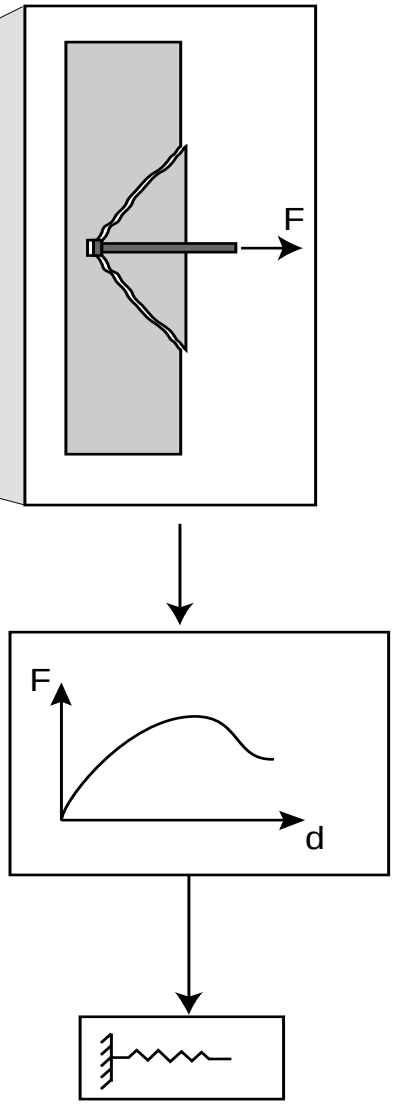
Rolf Eligehausen
Stuttgart

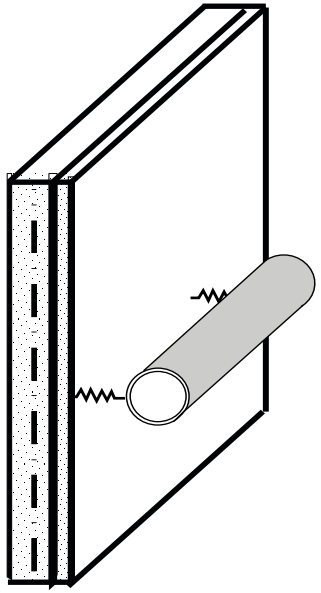
Step 1: Global seismic analysis

Step 2: Pull-out (static & dynamic)

Step 3: Updated global seismic analysis incl piping and anchor stifness





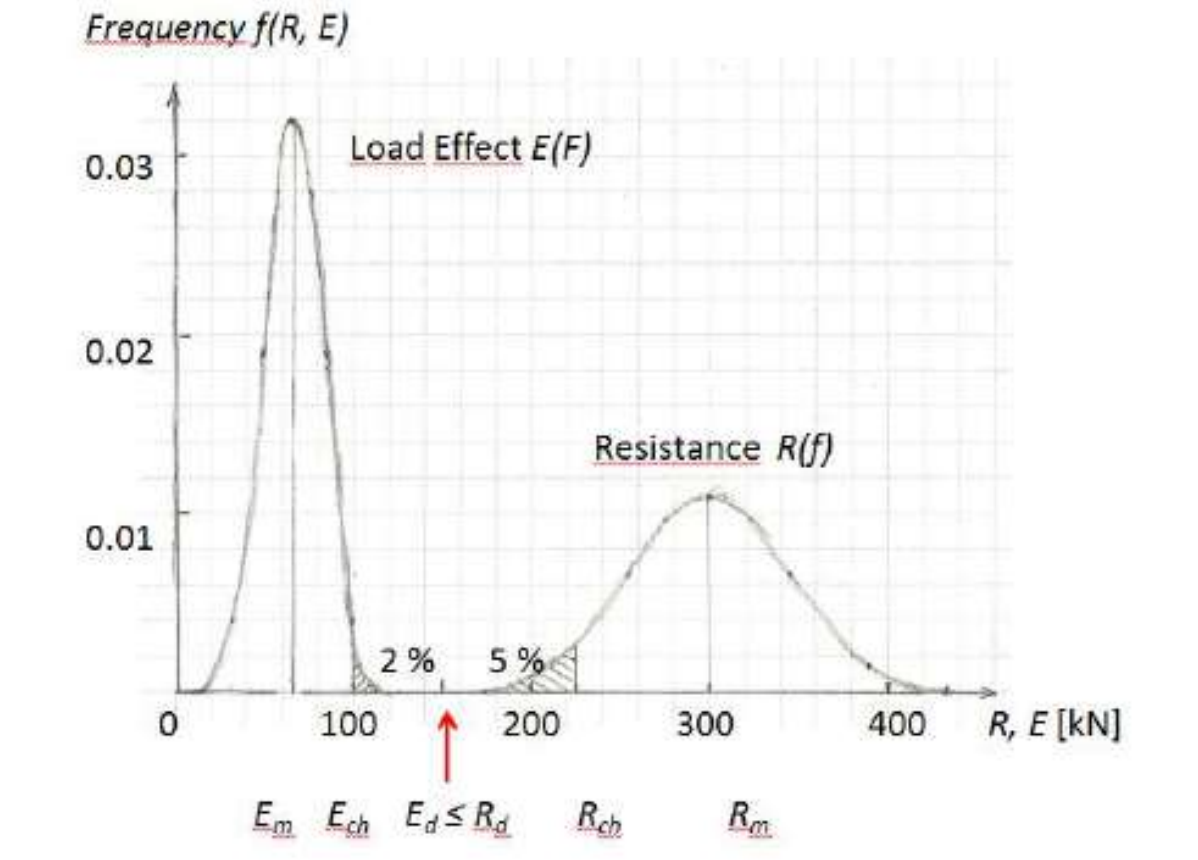


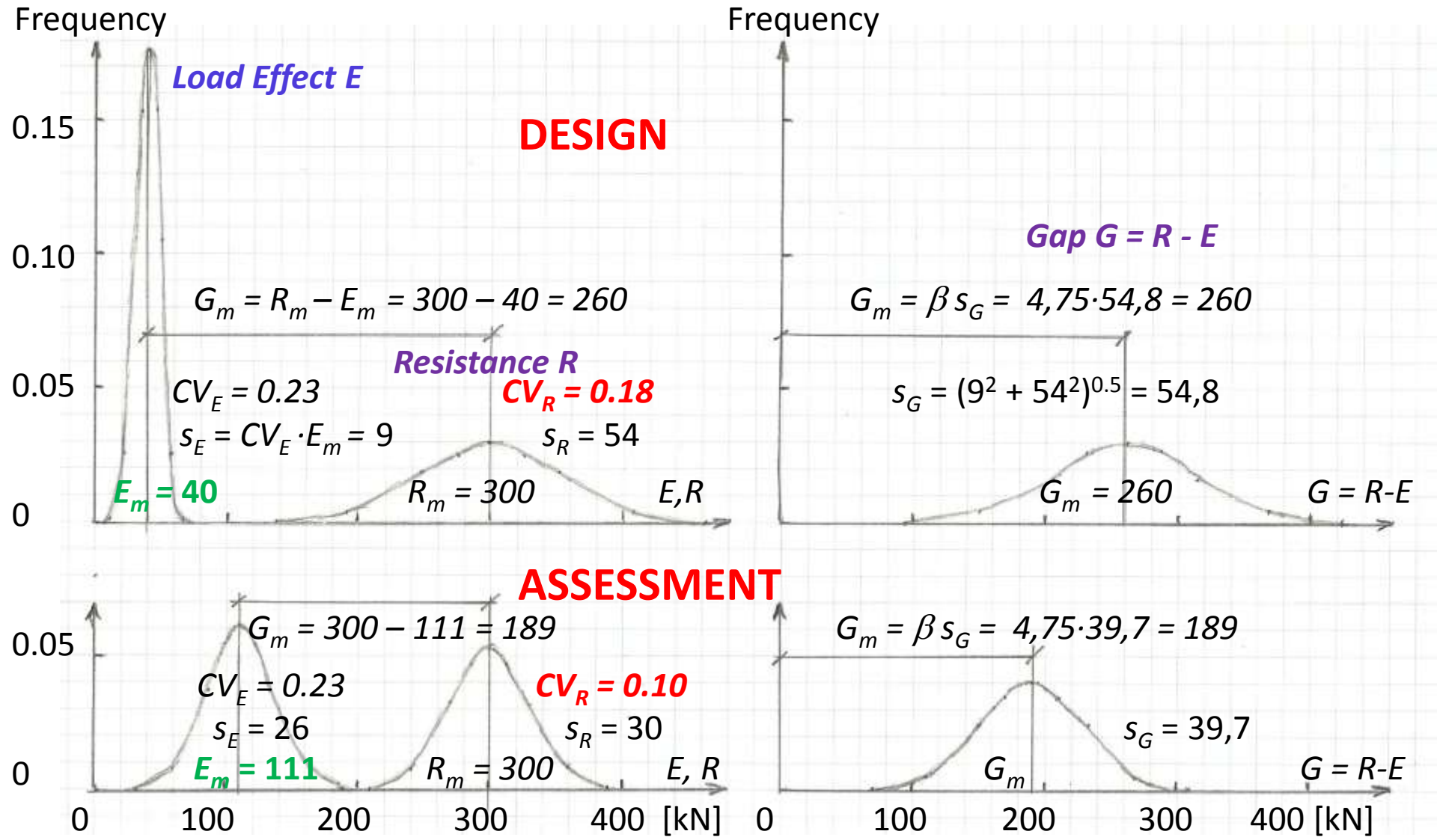
Assessment of as-built anchorages

fib TG 2.9 Fastenings to Structural Concrete and Masonry

WP 10 Evaluation of Existing Anchors

Members: John Silva, Thierry Guillet, Longfei Li, Lee Mattis, Rolf Eligehausen, Giovanni Muciaccia, Akashu Sharma, Muneomi Takahashi, Rasoul Nilforoush, Matsuzaki, Jörg Asmus, Roman Wendner,Giova Genesio, Jürgen Stork, Anders Bergkvist, Martin Nilsson, Lennart Elfgren (convener)

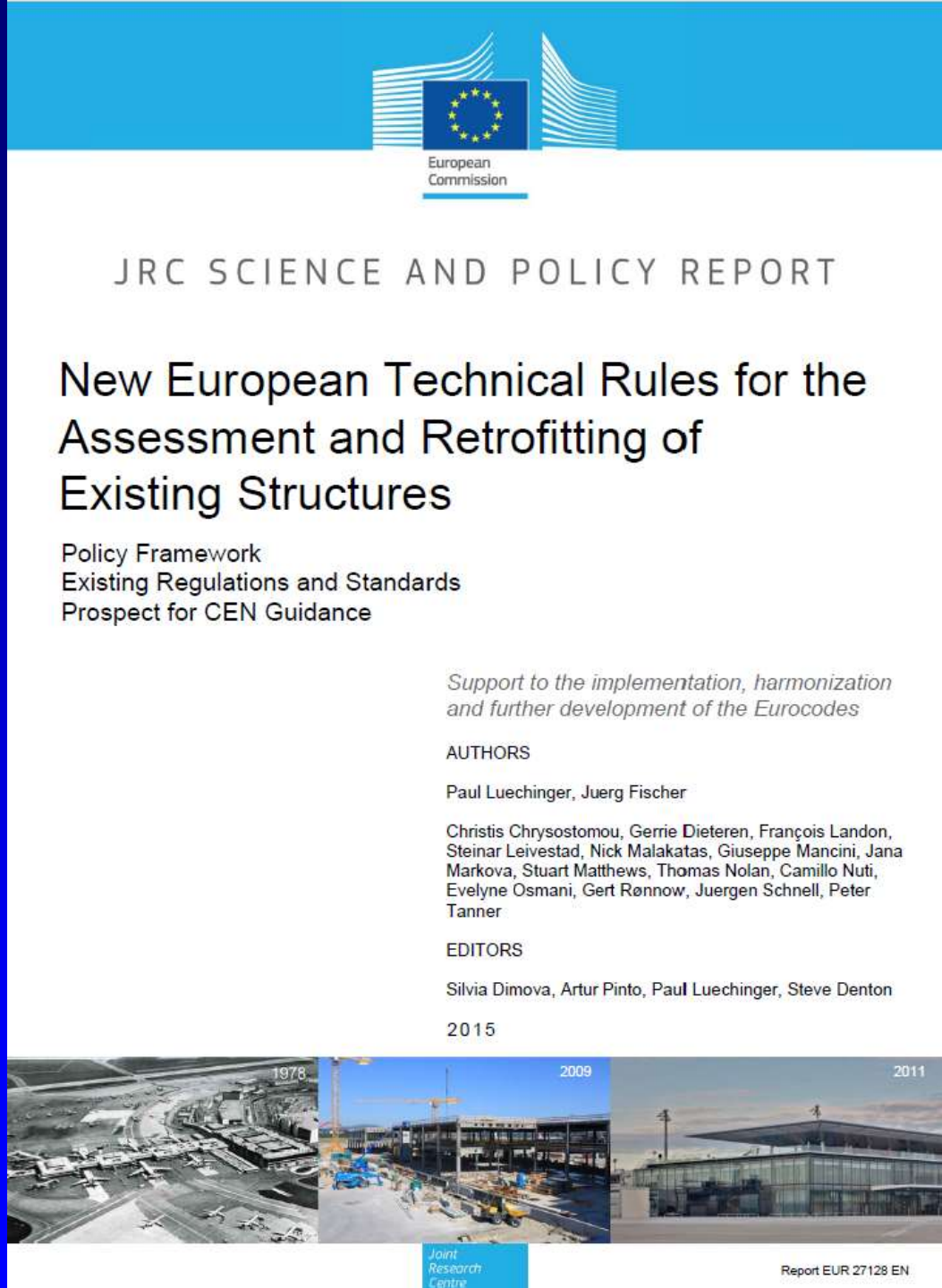



Frequency
Load Effect E
DESIGN
0.15
0.10
0.05
0
$G_m = R_m - E_m = 300 - 40 = 260$
Resistance R
$CV_E = 0.23$
$CV_R = 0.18$
$s_E = CV_E \cdot E_m = 9$
$s_R = 54$
$E_m = 40$
$R_m = 300$
E,R
Frequency
Gap G = R - E
$G_m = \beta s_G = 4{,}75 \cdot 54{,}8 = 260$
$s_G = (9^2 + 54^2)^{0.5} = 54{,}8$
$G_m = 260$
G = R-E
ASSESSMENT
0.05
0
$G_m = 300 - 111 = 189$
$CV_E = 0.23$
$CV_R = 0.10$
$s_E = 26$
$s_R = 30$
$E_m = 111$
$R_m = 300$
E, R
$G_m = \beta s_G = 4{,}75 \cdot 39{,}7 = 189$
$s_G = 39{,}7$
G_m
G = R-E
0
100
200
300
400 [kN]
0
100
200
300
400 [kN]

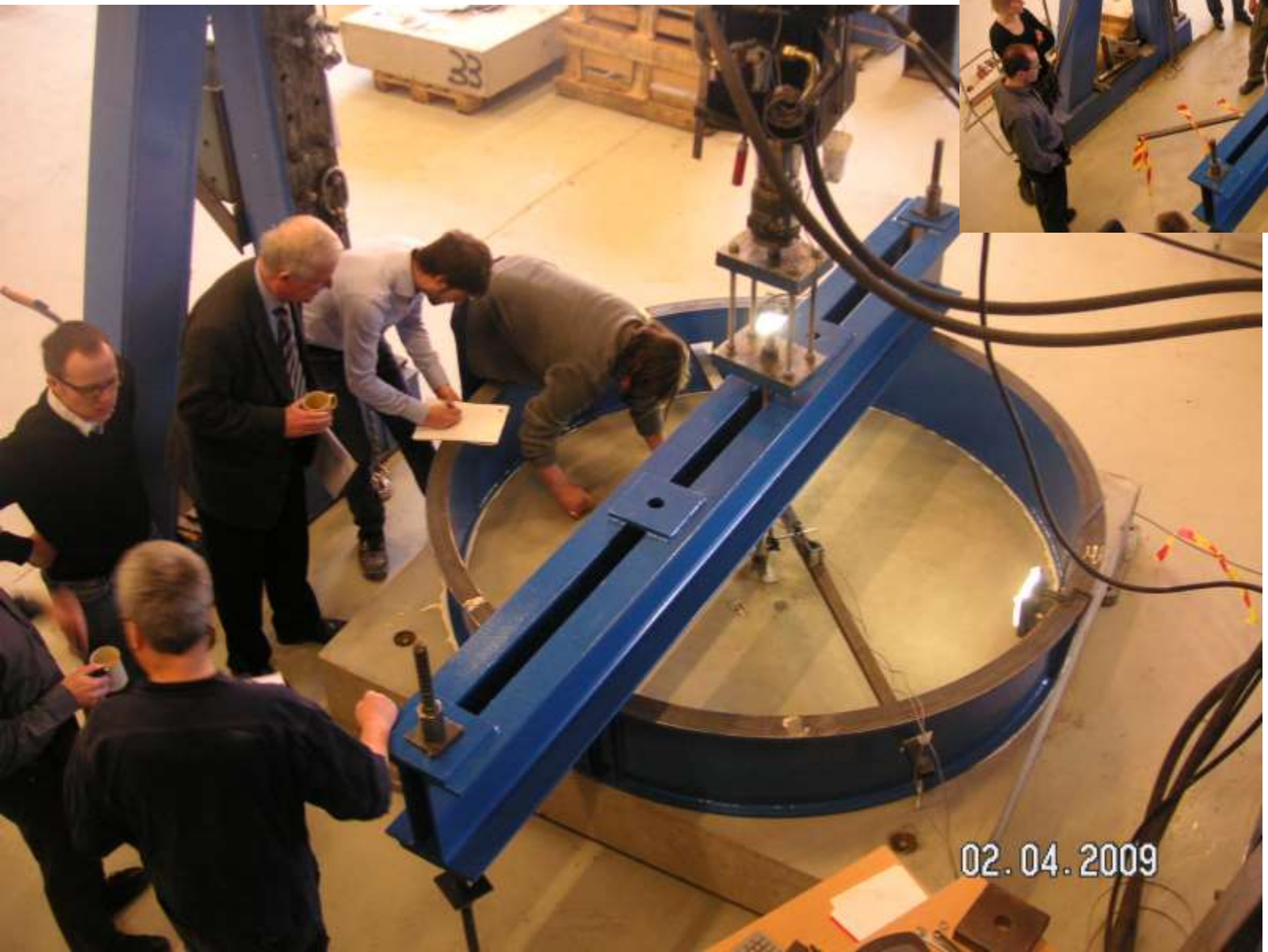
European Work

A special Eurocode for the assessment of structures is now under preparation by CEN/TC 250/WG2.

https://ec.europa.eu/jrc



Boundary Conditions – Larger Ring




OKG 21

Disposition

- Tillbakablick
- Vad jobbar vi med idag?
- Framtid

Framtid

Nya material (t ex rostfritt stål och kolfiber)
Nya förankringstyper (mer förspänning)
Bättre vidhäftningsegenskaper
Bättre långtidsegenskaper för lim
Bättre beräkningsmodeller, digitala ”tvillingar”
Sensorer som mäter stagens kondition

Stag och infästningar behövs !

Behov

Forskning och utveckling beträffande:

- Nedbrytning
- Livscykelkostnader
- Brottmoder (Fullskaleförsök & modellering)
- Seghet (flytförmåga)
- Förstärkningsmetoder

Tack för Er uppmärksamhet!

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Division of Structural Engineering at Luleå University of Technology
Chair Prof. Dr. Andrzej Cwirzen
www.ltu.se/research/subjects/Konstruktionsteknik?l=en