



Overview of the Symposium: Future Trends in Concrete Research & Concrete Technology

Dr. J. Silfwerbrand

KTH Royal Institute of Sweden, Stockholm, SE

Nordic Concrete Research Meeting,
Aalborg, Denmark, Aug. 21-23, 2017.



Outline

- Introduction
- Retrospect of Elsinore (Helsingør) 2002
- Statistics
- Personal findings from Aalborg 2017
- Nordic Concrete Research (NCR) Journal
- Concluding remarks



Dirch Bager

(1950 – 2016)

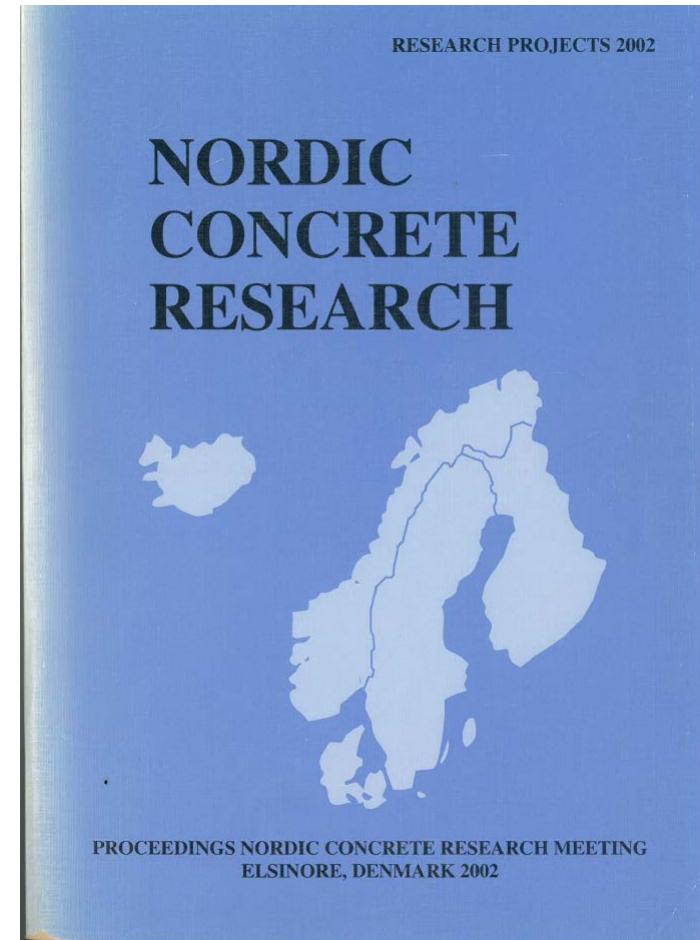


- Aalborg citizen
- NCR editor 199?-2016
- NCF medal recipient in 2008
- Researcher at Aalborg Portland 1986-2009



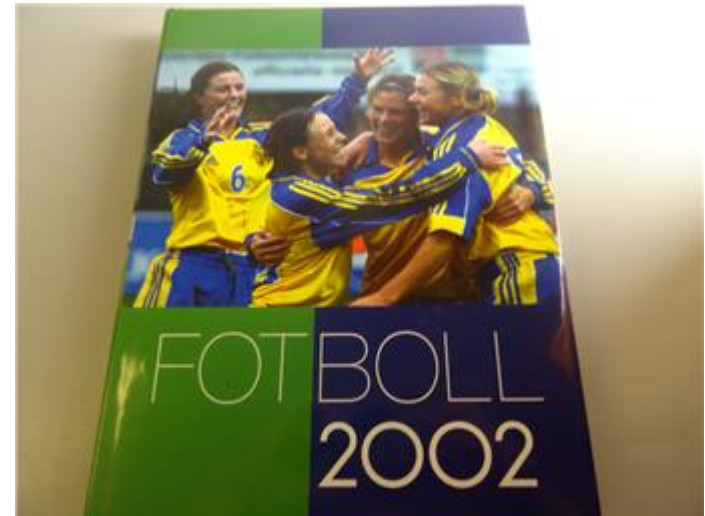
NCR Symposium in Elsinore 2002

- 131 participants
- 92 papers
- New focus: Environment with 15 papers – Danish *Centre for Green Concrete* important actor
- 13 papers on SCC & rheology



NCR Symposium v/s FIFA World Cup 2002 in South Korea & Japan

- June 11: **Denmark** – France 2-0
- June 12: **Sweden** – Argentina 1-1
- June 15: **Denmark** – England 0-3



The Banquet at Hamlet's Kronborg Castle

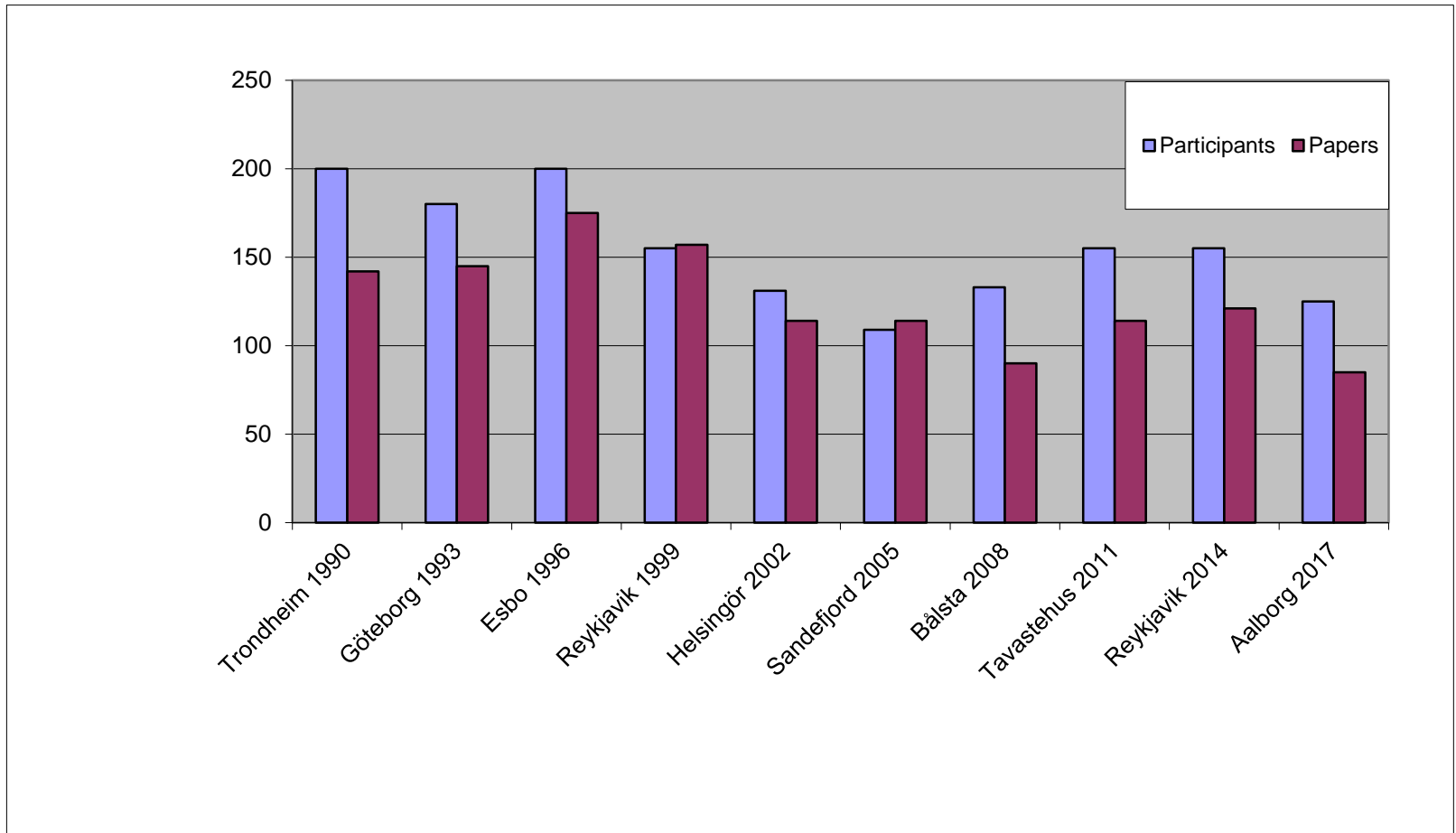


To be or
not to
be...

To be on time or not....



Participation in NCR Symposia 1 (2)

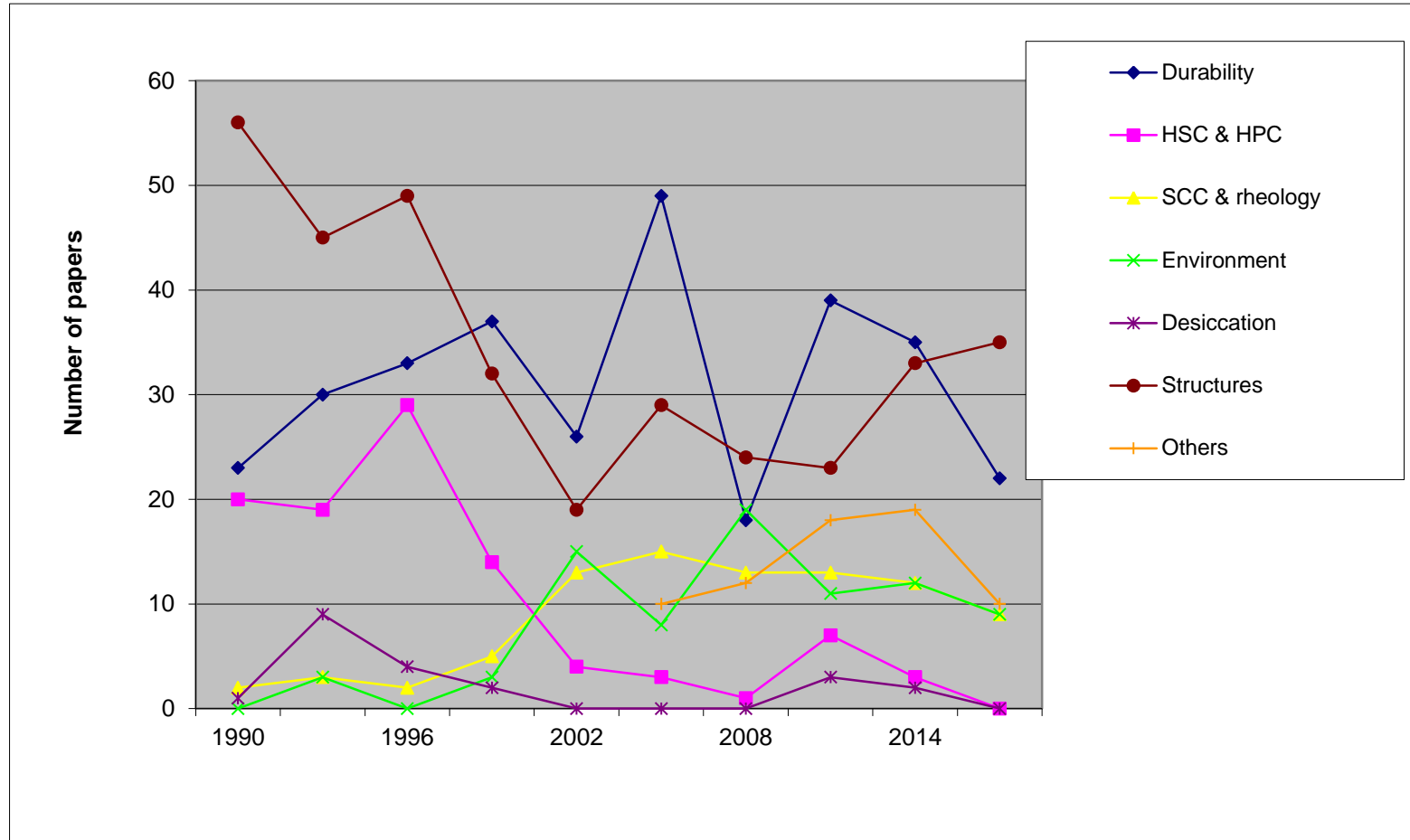




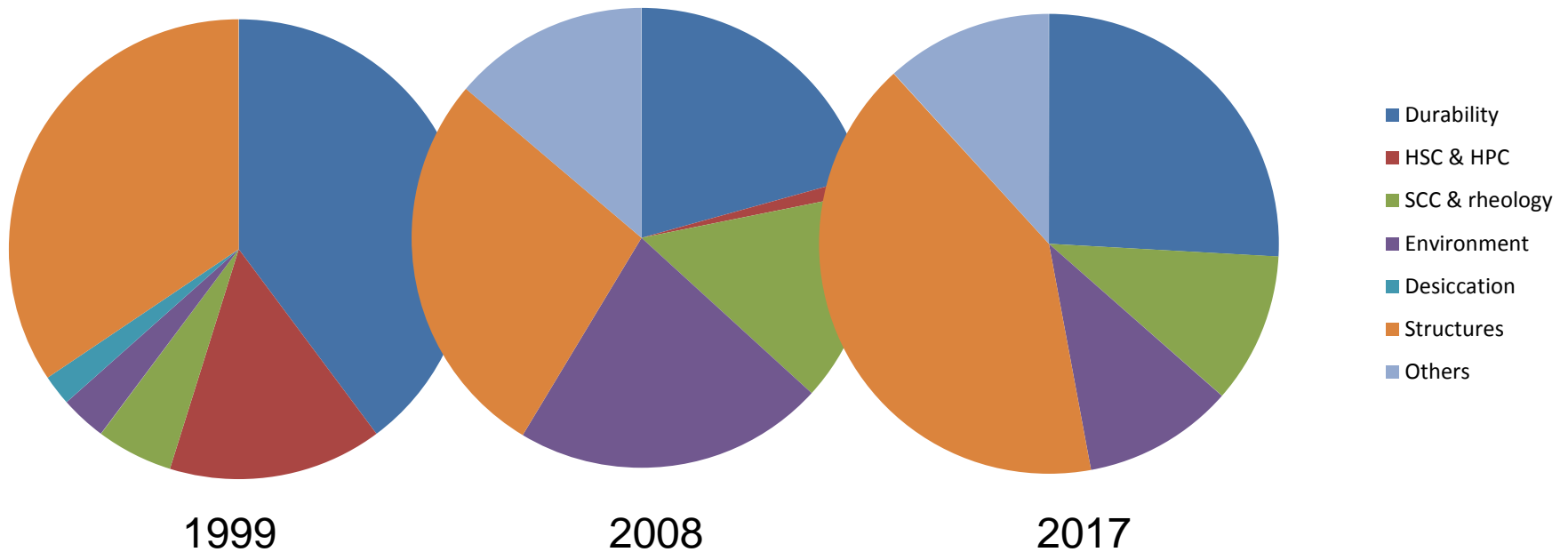
Participation in NCR Symposia 2 (2)

- Number of papers stabilized on a level close to 100.
- Markedly below the numbers in the 1990s ("The Golden Years", according to the Norwegians).

Historic Trends in Nordic Concrete Research 1 (4)



Historic Trends in Nordic Concrete Research 2 (4)





Historic Trends in Nordic Concrete Research 3 (4)

- Research on concrete structures extensive and increasing.
- Research on durability (or deterioration mechanisms) still very strong.
- Rheology, fresh concrete & SCC are continuously devoted to 10-15% of the studies.
- Research in environment & sustainability seems to diminish since 2008: Have we passed “peak environmental research”?



Historic Trends in Nordic Concrete Research 4 (4)

- No paper on desiccation & moisture.
- No paper primarily on HSC & HPC, but mentioned in three (3!) papers.



What Is Hidden by “Others” (10 papers)?

- Tomography studies (3 papers)
- Other laboratory studies on mortar or concrete materials (4)
- Concrete-ice abrasion (1)
- Teaching (2)

Qualities of Concrete

| Advantages | Disadvantages |
|--------------------------|---------------------------|
| Mouldability | CO ₂ emissions |
| Compressive strength | Low tensile strength |
| Stiffness | High shrinkage |
| Durability | Deterioration processes |
| Wear resistance | |
| Fire resistance | |
| Moisture resistance | |
| Thermal mass | |
| Noise reduction capacity | |
| Brightness | |
| Recycling potential | |

Very Few Papers on Advantages

| Quality | Number of papers |
|---------------------------------------|------------------|
| Mouldability | 0 |
| (Utilizing high) compressive strength | < 2 |
| (Utilizing high) stiffness | 0 |
| (Improving) durability | > 2 but < 22 |
| Wear resistance | 1 |
| Fire resistance | 0 |
| Moisture resistance | 0 |
| Thermal mass | 1 |
| Noise reduction capacity | 0 |
| Brightness | 0 |
| Recycling potential | 1 |

Congratulations 1 (2)



Terje Rønning, NO

Recipient of the 15th Nordic Concrete Federation
Medal

Congratulations 2 (2)





New Tools to Study the Concrete Material

- X-ray Computed Tomography
- Digital Image Correlations
- Acoustic Emission
- Could any of these or combinations be the way to increased knowledge on crack development?



Non-Destructive Testing

- Extensive research since the 1980s.
- Major Finnish project on NDT aiming at producing a large mock-up for testing & training.
- But when will these methods be tools for the daily assessment of concrete structures?



Are Durability Studies Possible?

- We will design our concrete bridges for 120 years.
- No research projects are longer than the 4-5 years PhD projects (most are shorter).
- Could we trust accelerated tests (enhanced Cl or CO₂) and extrapolation?
- 17 year study of SF shotcrete interesting exception.

Is the PhD student returning as Adjunct Professor the general solution?

Don't Forget the Field Exposure Sites



Frost, chlorides, corrosion,
ASR, cracks & combinations.



Safety Issues & Failure Probability

- Common conclusion in a couple of structural papers: “The design method is conservative.”
- What does it mean?
- Design method should be conservative.
- But are they too conservative?
- Are they causing economic & environmental waste?
- More focus on the safety problem & probability concepts desirable.

Safety in Completed & Temporary Structures

Tjörn bridge 1980



Completed:
 $p_f = 1/30000/50 \text{ yr}$
 $= 7 \cdot 10^{-7} \text{ per yr}$

Ludvika 2017



Temporary:
 $p_f = 1/300/1 \text{ yr} =$
 $3 \cdot 10^{-3} \text{ per yr}$



Missing: Research on Formwork & Temporary Structures

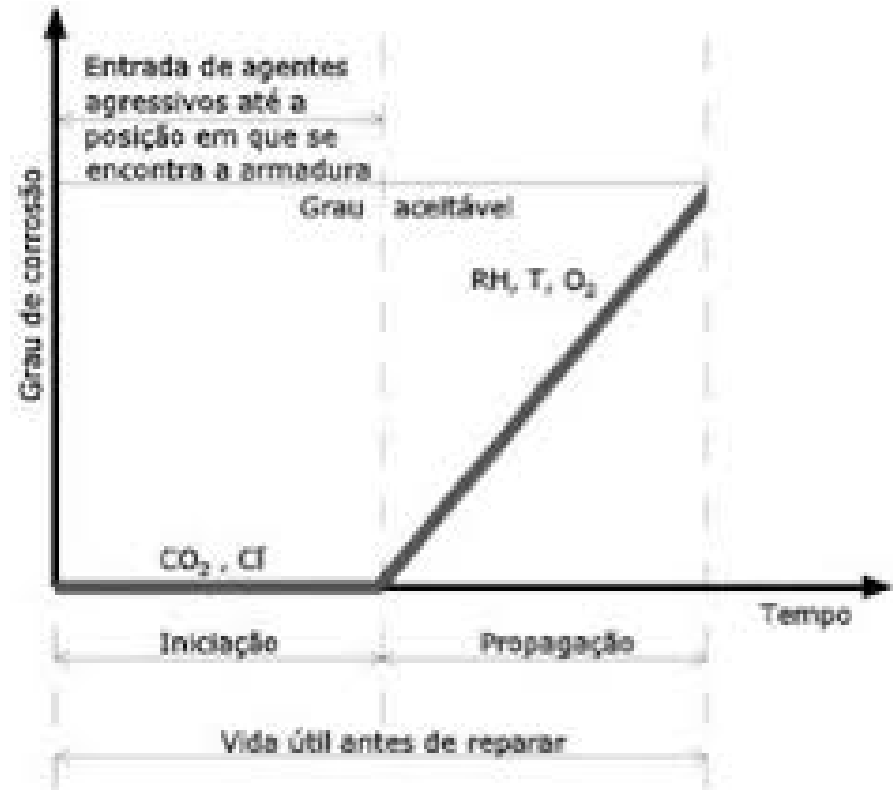
- Aalborg 2017: Award-winning paper on load tests on Kiruna bridge among several other papers on completed structures.
- But: Who is conducting research on temporary structures?
- In Sweden: Ideas of a SCA committee developing a handbook from the 1990s, but still not realized.



Should Compromises Be Used in Design?

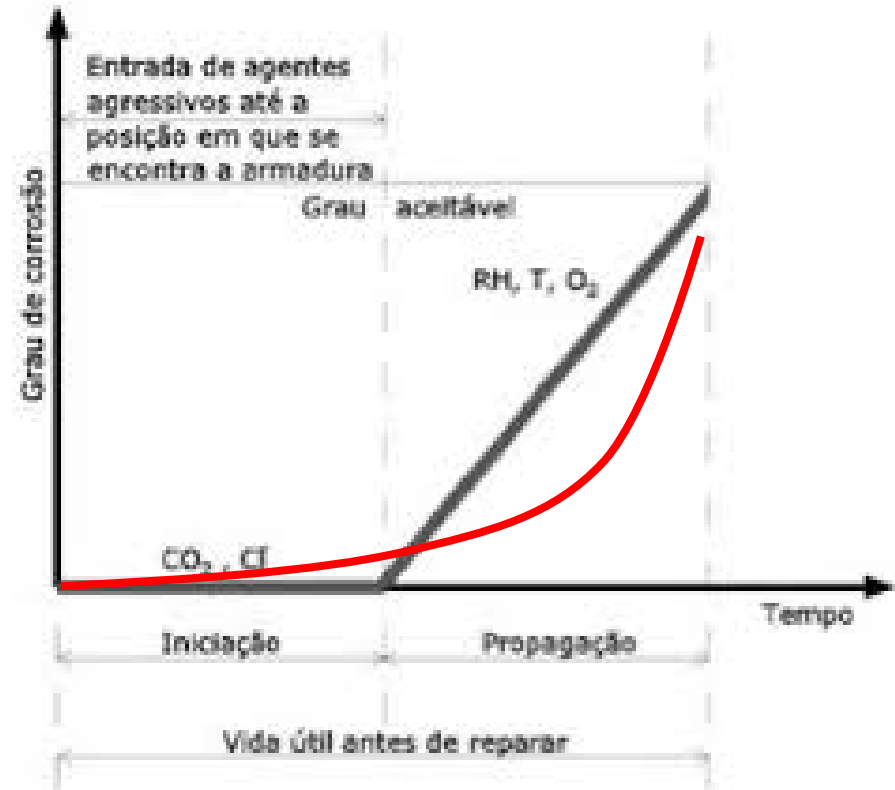
- EC2 model on crack width is a superposition of a slip and a non-slip method (between concrete & steel).
- The first method follows Bernoulli's hypothesis (plane section remain plain) whereas the other does not.
- Could our planet be half flat & half spherical?
- Need for more science and less negotiation in the European standard committees.

Is It Time to Replace Tuutti's Bilinear Curve?



- “Tuutti” + “(1982)” give 42 200 hits on Google.
- So simple that it interests engineers.
- So sophisticated that it interests researchers.

Is It Time to Replace Tuutti's Bilinear Curve?



- Ignoring propagation state underestimates service life considerably.
- Difficult to consider propagation state.
- Coupling initiating & propagation way to success?

Are Thermal Crack Risks Increasing?

- Thermal gradient in Finnish industrial building (“concrete tank”) 6 times larger than anticipated in design.
- Autogeneous shrinkage in FA concrete 7 times larger than that of PC concrete.
- Thermal cracks identified in concrete tunnels despite calculated crack risk $\eta = \sigma_{ct}/f_{ct} = 0.7$.
- ... and we know that tensile strength has a 30 % scatter.
- Great need of further research!

Are We Living on Two Planets?

- On the 1st planet:
- Still numerous studies referring to EC2, CEN and other standards.
- Chloride ingress calculated with Fick's 2nd law + Error function.
- On the 2nd planet:
- Use of multi-field models (mech., + heat + moisture) and other sophisticated numerical models.

A Ned Disadvantage Identified?

| Advantages | Disadvantages |
|--------------------------|----------------------------|
| Mouldability | CO ₂ emissions |
| Compressive strength | Low tensile strength |
| Stiffness | High shrinkage |
| Durability | Deterioration processes |
| Wear resistance | Radon gas emissions |
| Fire resistance | |
| Moisture resistance | |
| Thermal mass | |
| Noise reduction capacity | |
| Brightness | |
| Recycling potential | |

But A Solution Already Found?

| Advantages | Disadvantages |
|--------------------------|-----------------------------|
| Mouldability | CO ₂ emissions |
| Compressive strength | Low tensile strength |
| Stiffness | High shrinkage |
| Durability | Deterioration processes |
| Wear resistance | Radon gas emissions |
| Fire resistance | |
| Moisture resistance | <i>Inserting a</i> |
| Thermal mass | <i>hydrophobic agent in</i> |
| Noise reduction capacity | <i>the concrete mix</i> |
| Brightness | <i>gives a 35 %</i> |
| Recycling potential | <i>reduction.</i> |



The Workshop on Teaching

- This time focusing on experimental activities in education.
- Interesting model for groups of BEng, BSc & MSs students making master theses at DTU: *Project families*. Groups of 8-10 students sharing subject, supervision, equipment & test set-up.
- DTI inviting students to workshop on green concrete.
- Katja Fridh: “Co-operation between universities & research institutes interesting alternative for (at least) universities without laboratories. Use the students’ work for research.”



Which Is the 2nd Most Important Word in the Concrete Field?



To **Cast** concrete

- Cast – cast – cast
- Gjuta – göt – gjutit
- Stöpa – stöpte – stöpt

- Think of “precast concrete”.

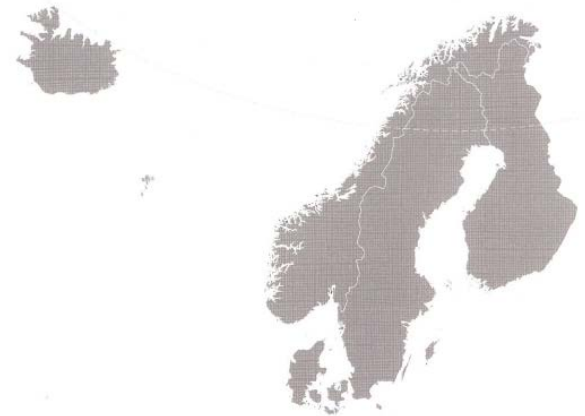


Keep Writing for the Nordic Concrete Society

THE NORDIC CONCRETE FEDERATION 1/2017

PUBLICATION NO. 56

Nordic Concrete Research





Nordic Concrete Research 1 (3)

- Scientific journal since 1982
- Two issues per year
- All papers devoted to concrete or concrete structures with a Nordic connection (Nordic author, Nordic university, field test in any of the Nordic countries or studies on specific Nordic conditions) are welcome
- Rapid process usually less than 6 months between submission & publication



Nordic Concrete Research 2 (3)

- Rigorous review with two independent reviewers.
- Best paper award every NCR symposium.
- Authors of most interesting Aalborg papers will be invited to write extended versions of their 4 page summaries.
- Editor board works hard for scientific recognition.
- E-mail: morten.bjerke@tekna.no or jsilfwer@kth.se



Nordic Concrete Research 3 (3)

No 1/2017:

- S Fahimi et al. (SE): “Replication of Crack Pattern...”
- A Köliiö et al. (FI): “The Role of the Active Corrosion...”
- M-K Olkkonen (FI): “Feasibility Study of Moisture Measurement...”
- G Fagerlund (SE): “The Critical Flow Distance at Freezing of Concrete...”
- J Nilimaa et al. (SE): “Thermal Crack Risk...”
- H Justnes (NO): “Durable Aluminium Reinforced Environmental-friendly Concrete...”
- M Sadagopan et al. (SE): “RE-Concrete – Study on Recycling....”



Concluding Remarks 1 (2)

- Nordic concrete research still very strong.
- Deterioration mechanisms & durability continue to be a strong area.
- Research on concrete structures is coming back.
- Research on environmental issues has dropped slightly but is likely to be very important in the near future.



Concluding Remarks 2 (2)

- More research ought to be devoted to the advantages of concrete.
- The need of more research on formwork structures, scaffolding, and other temporary structures is urgent.
- Better balance between (very sophisticated) theories and practice is desirable.
- Increased involvement with architects (constructability, thermal mass, radon gas)

Thank you! Tusen tack! Mange takk!

- See you in Norway 2020.
- Would Trondheim or Oslo be the hosting city?



Thank you!



Anette Berrig
Chair of the Organizing Committee



Marianne Tange Hasholt
Chair of the Scientific Committee