# Reliability assessments of concrete structures based on Nonlinear Finite Element Analyses: how to codify design methods?

Reporting from action group 8 contributing to the

*fib* Model Code 2020

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# In this presentation

- Introducing the *fib* and the Model Code
- Issues
- Way forward

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# What is the *fib* Model code 2020?

- Short name: *fib* MC2020
- Update of the *fib* MC2010 with added data on “existing concrete structures”
- Will serve as a basis for future codes for concrete structures
- For national and international code committees, practitioners and researchers

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# *fib* Action Groups

- Focussing on a specific topic/section with in the MC2020

- Action group «AG8»: focussing on section «7.11 Verifications assisted by numerical simulations»

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# *fib* Action Group AG8

- 20 members
- A “core team”
  - Giorgio Monti (co-convenor)
  - Diego Allaix
  - Morten Engen (technical secretary)
  - Max Hendriks (convenor)

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# *fib* AG8
# Current status of the work

- Wishes for the MC2020 text of 7.11 have been investigated.

- Working on specifications for the text.

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# «ISSUES»

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# Model uncertainties

- Defined as the ratio of observed load resistance and finite element predictions of the load resistance.
- That is, the main application field is estimating the load resistance of a concrete structure.

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# Model uncertainties

1. There is not one nonlinear finite element approach. Many approaches exist with different choices for the
   - Kinematic equations
   - Constitutive equations
   - Equilibrium methods & conditions

2. Very often the approaches have not documented explicitly

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# Model uncertainties

3. Some finite element models are like "virtual experiments" and simulate failure. Others model "only" the force redistributions and use a "simple" failure criterion.

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# Model uncertainties

4. The application field of the models is wide.

5. The model uncertainty depends on the type of failure mode. That is, it depends on the "brittleness" of the failure.

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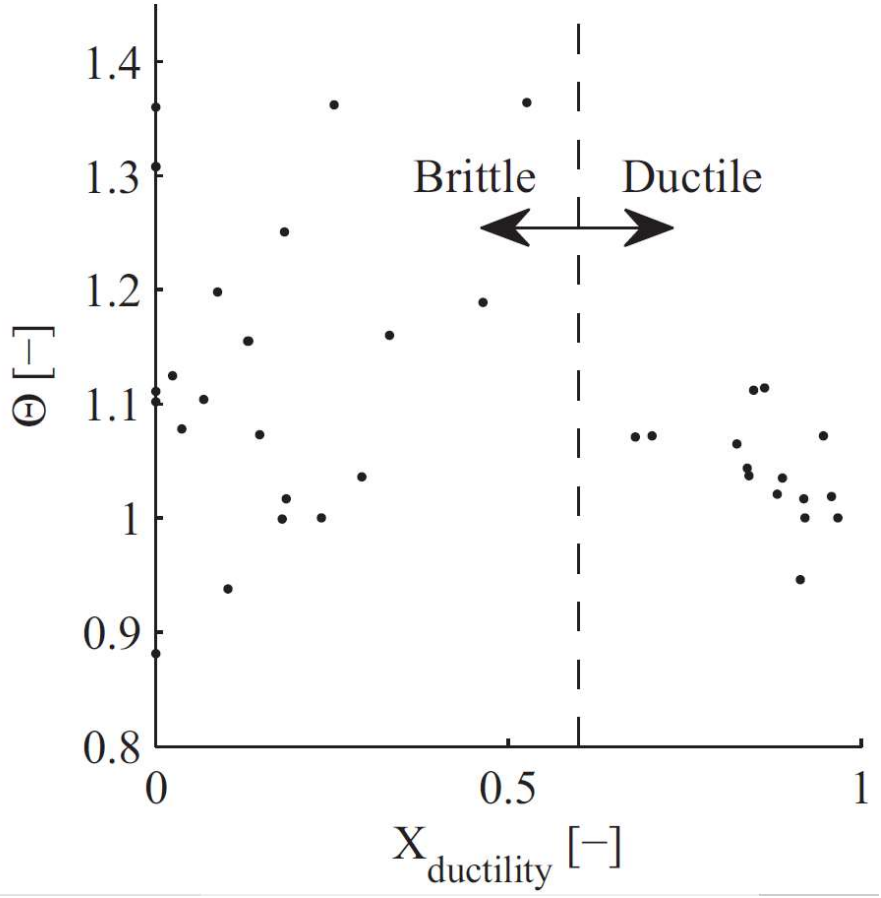
# Model uncertainties




M. Engen et al. / Structural Safety 64 (2017) 1–8

# Model uncertainties

**Table 2-2:** Statistical properties of the modelling uncertainty per failure mode

| Failure mode | Mean | CoV |
|---|---|---|
| Bending | 0.97 | 0.04 |
| Flexural shear in beams | 1.01 | 0.08 |
| Shear in slabs | 1.39 | 0.10 |
| All | 1.15 | 0.19 |

Rijkswaterstaat technisch document 1016-2:2017, 2017

# Model uncertainties

6. Mainly based on lab experiments which are always idealizations of actual structures

7. Hard to unravel from other (material) uncertainties

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# Model uncertainties

8. Sometimes based on "between-model uncertainty" with 1 experimental outcome and multiple model approaches:

$$\theta_{1,i} = \frac{R_{\text{exp}}}{R_{\text{NLFEA},i}}$$

(It describes the obtained uncertainty in the prediction if a model was selected randomly)

Morten Engen, PhD thesis NTNU, 2017



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# Reliability methods

- Semi-probabilistic «safety formats» based on limited calibrations.

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# «WAY FORWARD»

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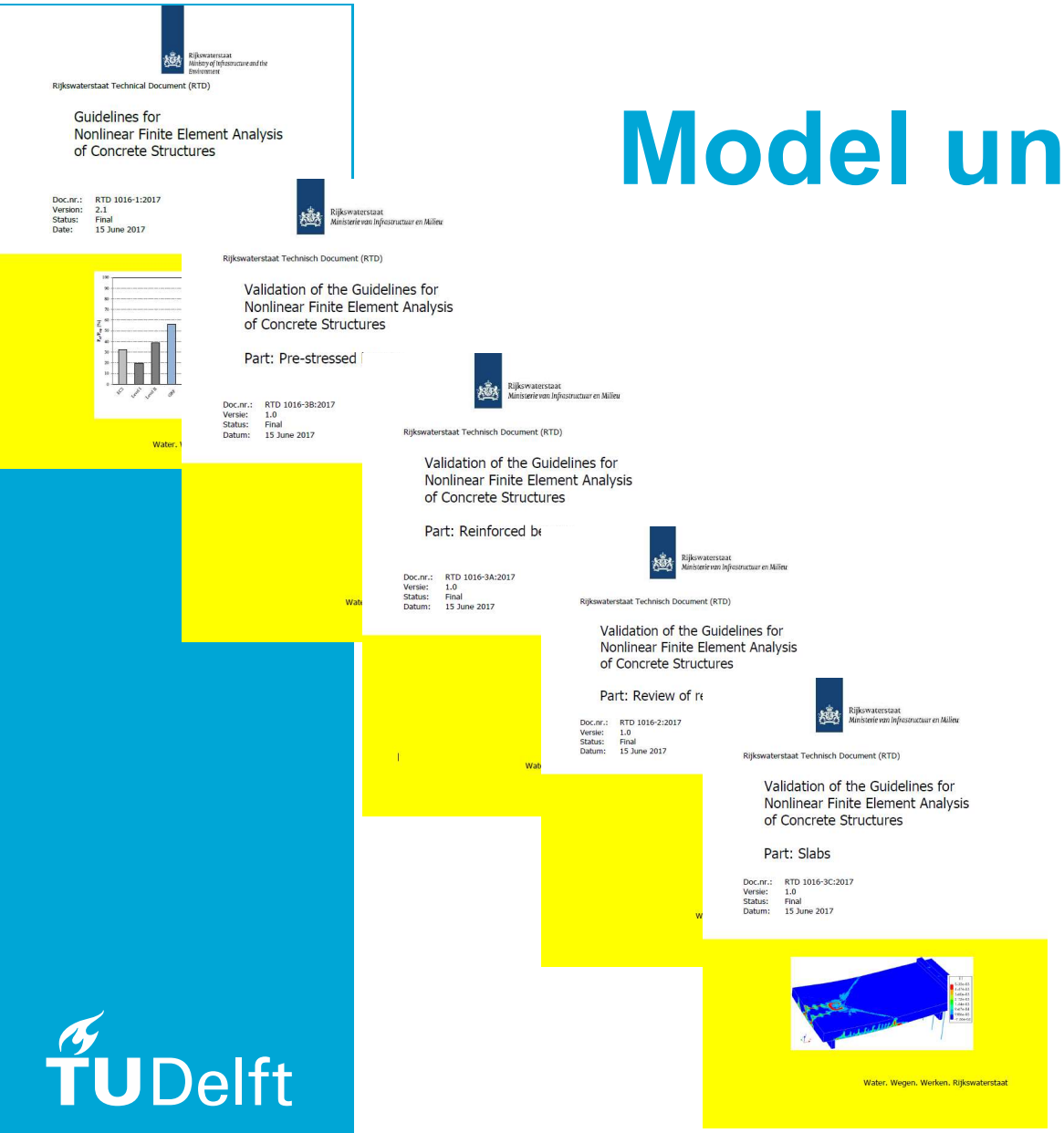
# Model uncertainties

1. Based on a "within-model uncertainty" adopting a fixed modelling approach

$$\theta_{3,i} = \left( \frac{R_{\text{exp}}}{R_{\text{NLFEA}}} \right)_i$$

Morten Engen, PhD thesis NTNU, 2017

# Model uncertainties




2. Use fixed = documented modelling approaches.

E.g. based on guidelines

–or–

on advices from the software program developers (?)

Rijkswaterstaat technisch document 1016-1,2,3:2017, 2017

# Model uncertainties

3. Provide values per “type of failure mode” and per “level of model calibration” (???)
4. Provide the possibility to determine the model uncertainty of a certain modelling approach for a certain application area (?)

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# Reliability methods

1. Provide methods based on response surfaces (???)
   - Attractive from an engineering point of view
   - Can be interpreted
2. Provide methods based on calibrated semi-probabilistic approaches

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# Concluding remark

- Work to do between now and 2020

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