VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ FAKULTA STAVEBNÍ

# Posudek disertační práce

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**Název práce:** **Analysis of mixed mode I/II failure of selected structural concrete grades**
**Studijní obor:** **P3607 Civil Engineering (nDA)**

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## Aktuálnost tématu disertační práce

Designing and testing new materials is typically limited to strength and stiffness. However, reliability and safety at both structural and material levels strongly depends on the response of material beyond the elastic limits. To this end, identifying parameters governing the onset of failure and the post peak behavior plays an important role. This is the core objective of the present thesis with one important step forward highlighting importance of mode II fracture. In light of this, the presented work deserves attention. The adopted experimental and computational approaches are up to date and in accord with the current state of the art.

Hodnocení:

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| ☐ vynikající | ☒ nadprůměrné | ☐ průměrné | ☐ podprůměrné | ☐ slabé |

## Splnění cílů disertační práce

The goals of the thesis were introduced in the introductory chapter, properly addressed throughout the thesis, and mostly achieved as indicated by the presented results. However, supporting some of the general conclusions would require a considerable extension of the executed experimental program. This opens the door new research directions. The author may wish to briefly address this issue during the thesis defense.

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## Postup řešení problému – metody zpracování

The proposed methodical approach exploits benefits of experimental measurements in the interaction with numerical simulations. This research framework is presented in 6 chapters. The required theoretical background is described in detail in Chapter 2.

Chapter 3 introduces the examined material systems and outlines the proposed experimental program. The principal outcomes of the theoretical work are summarized in Chapter 4 followed by the discussion on experimental results in Chapter 5. Future research objectives are provided in Chapter 6. For better understanding the ordering of chapters, it would be beneficial to mention, e.g., on page 7 in the description of Chapter 4 the application of some of the results in the derivation of results presented in Chapter 5. Otherwise the flow of the thesis is clear and in most parts easy to follow. The results are sound and derived following progressive and up to date methods. Nevertheless, the submitted version would deserve one more reading as it contains a number of inconsistencies, insufficient references and grammatical errors. A few examples are presented for illustration:

- The stress tensor components in Eq. (2.6) should be written as $\sigma_{ij}$.
- Stress $\sigma_{\theta\theta}$ is termed the hoop stress. The term tangential evokes a shear stress.
- First paragraph on page 17 is confusing and deserves revision. The term brittle fracture is not clear to me in this context. I would suggest using the wording Mode I fracture. The term $K_{II}=0$ should be omitted as it drops out because of the condition $\theta = 0$. Otherwise, transition to Eq. (2.34) is confusing, which is just a generalization of Eq. (2.33) for $\theta \neq 0$ and follows simply from substitution of $\sigma_{\theta\theta}$from Eq. (2.8).
- On page 29, the specific fracture energy $G_f$ is term both size-independent and size-dependent, where in my opinion the latter is true. Moreover, $G_f$ is used in many places in Section 2.3 in place of $G_F$.
- Abscissa in Fig. 46 is incorrect. In my opinion, it should read $w_c \frac{f_{ct}}{G_F}$[-], see e.g. Eq. (4.6). The term $G_f/f_{ct}$ is not dimensionless.
- Definition of $\theta_0$ in Fig. 79 is confusing as has in general a different meaning, see Figs. 8 and 74. The results in Fig. 75 do not corresponds to definition of $\theta_0$ in the preceding text and the results in Table 23.
- Reference to Eq. (2.19) in 3rd par. of Sec. 3.1 is incorrect. Last sentence on page 97 – $a/R$ = 0.267.
- I would also recommend to clearly identify in specific places what approach was used to calculate fracture characteristics – FEM vs. WE. This is not always clear.
- It would also be helpful to present the basic mixture components of C50/60 similar to HSC and HPC.

Hodnocení

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## Význam disertační práce pro praxi a pro rozvoj vědního oboru

As already mentioned, there is an ever growing interest in designing new material mixtures with potential use in practical applications. Limiting attention to strength, as is usually the case, is, however, dangerous. Understanding the nonlinear response and the material capacity beyond that of the maximum stress is therefore of paramount importance. Improving the prediction of local stresses considerably contributes in this direction, particularly when analytical expressions can be exploited

in numerical simulations, e.g., using XFEM. In this regard, the thesis offer a potential rout for advancing research towards practice.

Hodnocení:

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## Formální úprava disertační práce a její jazyková úroveň

As mentioned above, the clarity of presentation deserves more attention. Cut and paste is not always the best approach, see i.e. the 2nd and 3rd paragraphs on page 86.

Hodnocení:

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## Hodnocení publikační a jiné činnosti doktoranda

The level of publications is sufficient. Petr Miarka is the coauthor of 10 journal papers with IF. In most of them, he is the first author. Homogeneity of topics consistent with the thesis content is strong.

Hodnocení:

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## Poznámky a připomínky k textu práce

1. How exactly do you differentiate between HSC and HPC? Based purely on strength and stiffness characteristics I cannot make a difference. It would be interesting to compare the impact of aggressive environment on both types of mixtures.
2. Please explain, how you would apply the machinery of LEFM in practice.
3. Please explain in more details, how the resistance curves are calculated. Plotting the experimental results requires the knowledge of shape functions and the T-stress. But I had the impression that T-stress is calculated numerically for all $a/R$ rations for 100N only.
4. Why is it important to consider other values of $G_F$ than just the measured one, i.e., $G_C$?
5. Plane strain state was assumed in numerical analysis to get shape functions $Y_i$ for the calculation of SIF. Why using $r_C$ from plane-stress conditions then?
6. In metals, the specimens have to comply with some geometrical requirements for $K_{IC}$ to be accepted as a material parameter? Is there anything like that for concrete or other quasi-brittle materials? I am not quite sure how to adopt variable $K_{IC}$ provided by BDCN for different $a/R$ ratios. Please make a comment on that?
7. In the text, you promoted the use of chevron notch. Is there any reason for using the central notch instead? Perhaps avoiding a 3D numerical analysis to compare the results provided by experiments and simulations?

## Závěr

Uchazeč zpracováním disertační práce prokázal způsobilost k samostatné tvůrčí vědecké práci ve smyslu § 47 zákona č. 111/1998 Sb. o vysokých školách a změnách a doplnění dalších zákonů.

Doporučuji, aby disertační práce **byla** přijata k obhajobě a aby v případě jejího úspěšného obhájení byl

Ing. Petru Miarkovi

udělen akademický titul „doktor" (ve zkratce „Ph.D." uváděné za jménem).

Datum: 2. června 2021 Podpis oponenta: .....