Załącznik 2

SYNTHETIC FRC GROUND SLABS SUBJECTED TO A CENTRAL CONCENTRATED FORCE

Abstract

Fiber reinforced concrete (FRC) is increasingly used in industrial ground slabs due to its potential for crack control, post-cracking strength, and improved durability. However, synthetic fibers (SyFs), despite their growing popularity, remain underrepresented in design standards, which limits their broader acceptance in an engineering practice. Specifically, due to the limited number of studies, existing guidelines often apply very conservative assumptions to synthetic FRC (SyFRC), leading to a potential underestimation of its capacity. Moreover, a significant knowledge gap regarding the contributions of SyFs, particularly their addition, type, and dosage on punching shear capacity in ground-supported slabs has been identified. This study aimed to address these existing research gaps through a comprehensive experimental and analytical investigation of SyFRC ground-supported slabs subjected to centrally applied concentrated loading, with a particular focus on punching shear behavior.

The research was conducted in two stages. In the first stage, small-scale specimens were tested to determine the effects of macro SyFs addition, type, and dosage on key mechanical properties, including modulus of elasticity, compressive, flexural, and splitting tensile strength, as well as fracture energy. Five types of SyFRCs, differing in added fiber type (PM, PD, FF) and their dosage (2 and 3 kg/m^3), were evaluated and compared with a reference plain concrete (PC). The results demonstrated that SyFRC significantly enhances post-cracking behavior, including ductility, fracture energy, and residual flexural tensile strengths. The second phase of the experimental campaign consisted of large-scale tests on ground-supported slabs of dimensions 200 x 1200 x 1200 mm aimed to characterize their load-deflection response, crack morphology, deflection profiles, failure mode, and punching cone geometry. A testing setup was designed to simulate subgrade support with 43 cm thick layer of compacted crushed aggregates and racking leg base by centrally applied concentrated static loading of area 100 x 100 mm. The obtained results confirmed that SyFRC slabs exhibit higher flexural cracking and punching shear capacity, more ductile failure mode, and improved load redistribution compared to PC slabs. Notably, increased fiber dosage resulted in longer critical control perimeters and reduced punching shear cone inclination angle.

Furthermore, the inclusion of SyFs altered the punching cone geometry from the nearly cuboid shape observed in PC slabs to an irregular truncated pyramid shape in SyFRC slabs, underscoring the influence of fibers on stress distribution and crack propagation. It was also concluded that the presence of ground support had a significant influence on the mechanical response of SyFRC slabs, resulting in increased load-bearing capacity and additional punching shear cracking, leading to change of the failure mode from flexural to punching, compared to unsupported slabs. This highlights the necessity of conducting distinct analyses for unsupported and ground-supported slabs. The study also included a review and comparison of selected theoretical models, including the Westergaard, Falkner et al., Shentu et al., and provisions of Technical Report 34 (TR34), based on Meyerhof-Losberg approach and Eurocode 2 recommendations, to evaluate their applicability to SyFRC ground-supported slabs. The findings indicated usually significant discrepancies between analytical predictions and observed results, particularly in terms of calculated load-bearing capacities, highlighting the need for analytical model validation. These discrepancies were most likely due to the exclusion or underestimation of enhancing effect of post-cracking strength and fiber contribution while designing according to these models. Moreover, the static scheme of the tested slabs only approximately corresponded to the selected models' assumptions, which may have contributed to the differences between the experimental and analytical results. Nevertheless, among the available standards, the TR34 was identified as the most promising guideline for designing the SyFRC ground-supported slabs, as it accounts for fiber and ground support contributions in the calculations of the load-bearing capacity. Namely, TR34 provided a reasonably accurate prediction of the punching capacity and failure mode, especially when considering the actual location of the critical control section, increased ground contribution, and a greater role of SyFs in load transfer. Ultimately, the dissertation proposed modified recommendations for calculating punching shear capacity, particularly regarding the assumption of the critical control section location and SyFs contribution in load transfer.

While the research provided significant insights, limitations of the dissertation were also acknowledged. The experimental campaign focused on only a few SyFs types and dosages, specified slab geometry, and one loading scenario. Future research should explore broader ranges of SyFs, different loading types, and numerical modeling, complementing the experimental findings. Nevertheless, this study significantly advanced the understanding of SyFs influence of on the behavior of ground-supported slabs and may serve as a basis for future modifications to existing standards as well as the development of practical design guidelines.

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28.08.2025 r.