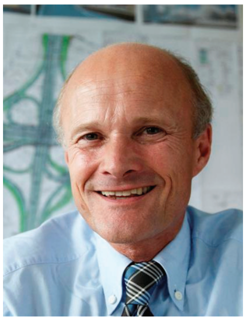
Shear Capacity of Reinforced Concrete Slabs under Concentrated Loads

Karin REISSEN
Research Engineer
RWTH Aachen University
Germany
kreissen@imb.rwth-aachen.de

Karin Reissen, born 1981, received her degree in civil engineering from RWTH Aachen University in 2007. Since 2010 she has been a research engineer at the Institute of Structural Concrete at RWTH Aachen University.

Josef HEGGER
Professor
RWTH Aachen University
Germany
jhegger@imb.rwth-aachen.de

Josef Hegger, born 1954, received his PhD degree from the University of Braunschweig in 1984. He has been a professor at the Institute of Structural Concrete at RWTH Aachen University since 1993.



Summary

The increasing traffic loads in the last decades and changes in design rules may lead to deficits in calculated shear capacity for existing bridges. Most of the present design rules for the shear-bearing capacity of members without shear reinforcement were developed based on empirical evaluations of shear databases consisting of beam tests. So far, only few shear tests on slabs have been conducted. Thus, a research project with an extensive testing programme funded by the Federal Highway Research Institute of Germany (BASt) was carried out at the Institute of Structural Concrete at RWTH Aachen University. This paper presents the experimental results as well as the results of the parametric finite element studies on the shear capacity of slabs without shear reinforcement under concentrated loads. The tests revealed that the experimental bearing capacities were higher than calculated due to an underestimation of the effective slab width.

Keywords: shear, bridge, slab, reinforced concrete, effective width, tests, haunched slab, numerical simulation.

1. Introduction

The requirements for the load-carrying capacity of bridges have increased significantly due to rising traffic loads in the last decades. Furthermore, the design concept of the German codes ([1], [2], [3]) has changed, which leads to higher calculated amounts of shear reinforcement in concrete superstructures. Therefore, a large part of existing concrete bridge decks in Germany is built with less than the current calculated amount of shear reinforcement. Since shear failure and enhanced crack formation in existing bridges was not observed so far, bridges are evidently able to carry the increased traffic loads even though they are designed with less shear reinforcement than required by the current code provisions. After the increase of traffic loads implemented in the changes of the German design codes ([4], [5]), the shear loads will further increase by the introduction of DIN EN 1991-2 [6] with the national appendix [7], which is under construction at the moment. Hence, the determination of the shear resistance of reinforced concrete bridge deck slabs will become even more important soon.

The shear resistance of beams and slabs without shear reinforcement can be calculated according to equation (1) [2]. It depends on the height of the uncracked compression zone (which is proportional to $(100 \cdot \rho_l)^{1/3}$, where ρ_l means the longitudinal reinforcement ratio), the tensile strength of the concrete (which is proportional to $f_{ck}^{1/3}$), the size-effect κ, the influence of the axial longitudinal stresses σ_{cd} and the dimensions of the member, where b_w is the shear carrying width and d the effective depth [8]. The empirical factor $c_d = 0{,}15/\gamma_c$ with $\gamma_c = 1{,}5$ is based on an international shear database consisting almost exclusively of shear tests on beams. So far, only few tests on the shear-bearing capacity of slabs under concentrated loads have been conducted.

$$V_{Rd,ct} = [c_d \cdot \kappa \cdot (100 \cdot \rho_l \cdot f_{ck})^{1/3} - 0{,}12 \cdot \sigma_{cd}] \cdot b_w \cdot d \quad (1)$$

In practical dimensioning of bridge deck slabs, the effective widths for shear and bending are used according to the rules in book 240 of the German Committee for Structural Concrete [9], calculated

https://doi.org/10.2749/222137912805111320
Distributed by structurae