Summary

ANALYSIS OF THE FLEXURAL REINFORCEMENT ON THE SHEAR STRENGTH OF THE CONCRETE BEAMS WITHOUT TRANSVERSE REINFORCEMENT

The PhD thesis is devoted to the shear of slender concrete beams without transverse reinforcement flexurally reinforced with two types of bars: steel and composite (glass fiber reinforced polymer - GFRP). The motivation to undertake research program was desire to determine an effect of the low elasticity modulus of the longitudinal GFRP bars and their anisotropic structure on the failure mechanism and shear capacity. The main purpose of the work was to analyze the failure mechanism with the flexural GFRP or steel reinforcement without transverse reinforcement and to compare the shear capacity and deformability of the beams. The remaining objectives included: the influence of the following variable parameters on the ultimate loads and failure modes: degree of the longitudinal reinforcement (1.0%, 1.4% and 1.8%), number of bar levels (one, two), number and diameter of bars selected for specified reinforcement ratio and the thickness of the concrete cover (15 mm, 35 mm).

To analyze the cracking pattern of the beams, the digital image correlation system ARAMIS was used, what allowed a detailed registration of the failure mechanism the flexural cracking, through crack development until to the failure. Using the kinetic shear model, the process of beams' destruction was precisely described, with the indication of differences regarding to the location and inclination of the diagonal critical cracks in the all beams.

The research program included thirty three single-span, simply supported T-section beams (b_{eff} = 400 mm, b_w = 150 mm, h_f = 60 mm, h_{tot} = 400 mm) with the axis span of 1800 mm without transverse reinforcement. The three point loaded beams (with the load located at a distance of 1100 mm from the support) had the shear span to depth ratio *a/d* in the range of 2.9-3.0 referring to the slender beams.

Research revealed two failure modes. The first, shear - tension occurred in most of the beams (all RC elements and parts of the GFRP reinforced elements) and the second one relating to the bond loss between GFRP reinforcement and concrete, which occurred in three beams of the II series, reinforced with GFRP rods. The research confirmed the influence of a type of the longitudinal reinforcement on the behavior of beams without transverse reinforcement. The four times lower modulus of elasticity of the GFRP reinforcement revealed a gentle, progressive shear - tensile failure mode, opposite to the to the abrupt failure mode of the RC beams. The difference in the elasticity modulus of both types of reinforcement resulted in increase in the shear capacity of the RC beams in the range between 30% and 66% comparing to the shear capacity of the GFRP reinforced beams with same reinforcement ratio. The increase in a degree of the longitudinal reinforcement reduced cracking pattern, the crack width was reduced with the increase of the beams stiffness that confirmed the higher shear capacity of the beams.

The two-layer reinforcement levels occurred more beneficial only for the GFRP reinforced beams. The influence of the diameter change was more pronounced in the beams with the low reinforcement ratio (about 1%). The influence of the concrete cover thickness was quite small, which confirmed a negligible effect of the dowel action in the elements without transverse reinforcement.

The paper presents a comprehensive analysis of the calculated results in relation to the design shear capacity according to the existing codes and the selected theoretical models. The generalized assessment of computational analysis indicated that the predicted shear capacity values calculated according to Mari's and Muttoni's models gave the closer vales to the experimental ones. The fib Bulletin design guidelines (FIB Task Group 9.3, 2007) and the Italian standard (CNR-DT-203/2006, 2006) gave the best predictions for FRP reinforced beams comparing to the own test results. However, the best predictions of the shear capacity were confirmed for the project Eurocode 2 standards (CEN, 2014) comparing to the test results collected in the test data base (state of the art).