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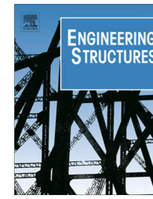

Review article

Experimental study of the post tensioned prestressed concrete corbels

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ABSTRACT

The results of experimental investigation of 6 symmetrical double prestressed corbels of variable shear span to depth ratio and variable location of prestressing bars are presented in the paper. The post tensioned corbels were prestressed with Macalloy 1030 bars of 25 mm in diameter. The results of the tests were compared with the cracking and load carrying capacity of corbels reinforced with passive reinforcement. As a result of the analysis, a formula of calculation of force causing the inclined crack in the central area of the corbel was proposed. Usability of the selected computational schemes applying the truss models, as well as the shear–friction hypotheses, were assessed.

Contents

1. Introduction

In order to increase the span of structural components supported by corbels, as well as increasing loads on beams and roofs, higher of reinforcement ratio is required, and thus larger diameters of reinforcing bars. Quite frequently a designer is not able to rationally design a reinforcement with high number of bars which instead of increased load capacity of a corbel makes it lower and causes cracks sooner. Moreover, it is not always possible to increase cross-section of the reinforcement.

Cracks in reinforced concrete corbels occur very early, most often before the service loading [1–10]. The cracks opening raises more or less justified fear resulted as a rule in recommendation for the strengthening of the corbel itself, or of the corbel together with its supporting structure. Application of fiber-reinforced concrete favorably influences the cracking what was confirmed in the research by Fattuhi [11] and Campione et al. [12] i.e., though it is not a significant influence.

In the case of heavily loaded corbels, the prestressing may become an reasonable alternative, considering both the constructing of the reinforcement itself and the cracking process. Such research was carried on in the past by Chakrabarti et al. [13] and Tan and Mansur [14]. In the first case, very short corbels reinforced with one prestressing bar ∅15.88 with $a_F/d = 0.37$ were tested. The bar was placed in the middle of the corbel with a constant prestressing force. The tests [14] concerned specimens with low amount of reinforcement (9 wires of 5 mm in diameter) with the variable prestressing degree (from 0.1 to 0.8). In both above mentioned tests, the corbels had no stirrups. The research by Nagrodzka-Godycka [10,15] of corbels with prestressing bars as

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strengthening (the degree of prestressing equal 0.5–0.68) demonstrated unquestionable usability of prestressing in the reinforcement of those supporting elements, while the significant influence of prestressing degree on load capacity was not confirmed, what was mentioned in [14].

2. Research significance and the scope of the project

The conducted tests on cracking and load capacity of post tensioned prestressed corbels, and precise strain measurements as a result of using i.e. the wire gauges placed inside the concrete of corbels, made it possible to determine the cracking force at which the inclined crack occurs, often signaling the overload of the corbel.

The load capacity of corbels were analyzed with accordance to the selected methods of computation determining their usability in the case of application of prestressing.

3. Description of the tested corbels

Six symmetrical double corbels with the cross-section at the interface between corbel and column $b \times h$ was 250 × 400 mm were tested. The distance of application of the force F from the edge of the column was variable and equal to a_F = 330 mm for corbels WI-S-1 and WI-S-2, a_F = 200 mm for WII-S-1 and WII-S-2, and a_F = 100 mm WIII-S-1 and WIII-S-2. With the constant height h = 400 mm and effectiveness depth d = 330 mm for each of the corbels, the shear span to depth ratio (a_F/d) was equal respectively 1.0; 0.6 and 0.3. Considering the height of the corbel, the relations were 0.825, 0.5 and 0.25. The shear ratio (a_F/d) and the placement of the prestressing bars (horizontally at the tensioned edge of the corbel, and vertically one above the other) were variable.

The principal reinforcement of the corbels was composed of two prestressing Macalloy bars ∅25 mm, with the tensile strength f_{pk} = 1037 MPa ($f_{p0.1k}$ = 817 MPa). Double-leg stirrups were placed in four levels uniformly distributed along the height of the corbel (Fig. 1). The stirrups were made of deformed bars of ∅8 (f_y = 617.2 MPa) spaced every 60 mm. Corner bars were made of the same steel as the stirrups (two bars ∅8 in each corbel). The corbels geometry and their prestressing and passive reinforcement are presented in Figs. 1 and 2.

The column were reinforced longitudinally with six bars of ∅25 (f_y = 565.5 MPa), and transversally with stirrups ∅6 (f_y = 575.5 MPa) spaced every 60 mm. In the zone of the increased stress of the transmitted load from the hydraulic testing machine to the column, the distance between stirrups was reduced to 20 mm on the distance of 100 mm (Fig. 3). The bearing zone below the plates transmitting the prestressing force to the concrete was additionally reinforced with bar grid of ∅6 and meshes 50 × 50 mm.

The corbels were made of concrete of mean compressive strength f_c = 40.5 MPa tested on cylinders 150/300 mm (variation coefficient ν = 9.6%). The tensile strength determined with the method of cylinders splitting was f_{ct} = 3.32 MPa (ν = 15.9%). The composition of concrete mix for 1 m^3 was following: cement CEM I 42.5R (360 kg), aggregate and sand jointly 1845 kg (sand point 36%), water 160 kg, fly-ash 10% of cement mass. The w/c was equal to 0.43. The corbels were prestressed with constant tensile strength using the professional set. The value of the tensile force was controlled (apart from force gauges) with electric resistance wire strength gauges of 10 mm base. In Tables 1 and 2, the

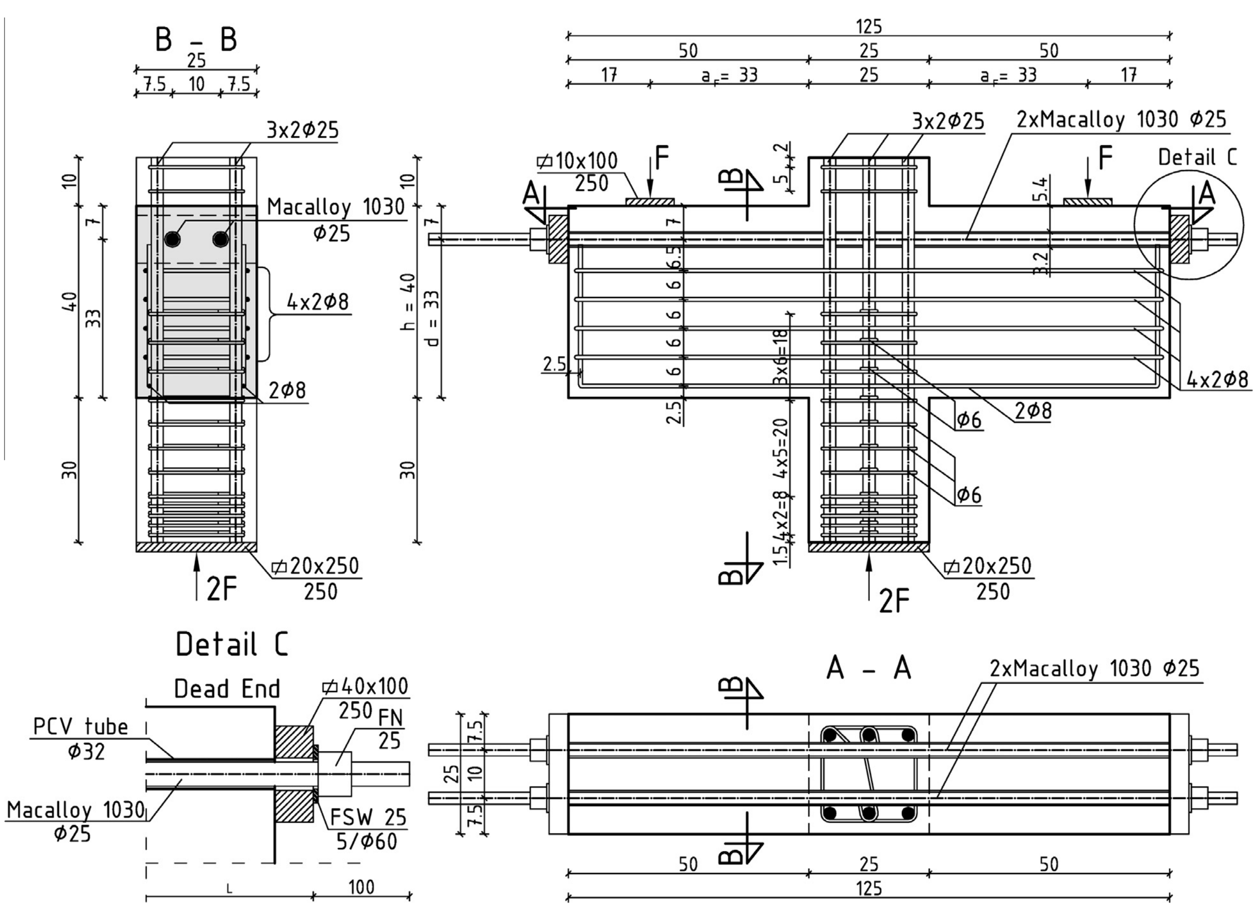

Fig. 1. Geometry and reinforcement of the corbel WI-S-1.