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Application of photoelastic coating technique in tests of solid wooden beams reinforced with CFRP strips

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The paper presents selected results of tests carried out on hundred year old joists strengthened with carbon fibre reinforced polymers (CFRP). Besides the conventional electric-resistance extensometers (ERSG), the photoelastic coating technique (PCT) was used to measure strains in the reinforced (bonded) cross sections. No such attempt to apply PCT has been described in the literature before. The technique requires further studies to verify agreement between its results and the ones obtained by conventional measuring techniques.

Keywords: *timber structures, strengthening, CFRP, rehabilitation, photoelastic coating technique, four-point bending*

1. Introduction

The preservation of historic wooden components covers not only their technical condition, but also the artistic and cultural value of the building as a whole, including its ornamental details (often in the form of original woodcarving and polychrome). According to the Venice Charter, any measures taken with regard to national heritage buildings are to preserve and reveal the historic and aesthetic value the building, respecting the ancient substance and elements constituting authentic documents of the past. It is, however, allowed to strengthen historic buildings using modern conservation, construction and engineering techniques, provided the principles of conservation doctrine are adhered to [1–6].

The advances made in materials technology have significantly contributed to the development of construction and conservation technologies. When high-strength epoxy resins were synthesized in the late 1960s, attempts were made to use them to strengthen building structures. Compositions based on synthetic resins can be used to reinforce structural cross sections, to reproduce cross-sectional geometry and to produce joints bonding the reinforcing element with the reinforced one. The use of resins and gluing is becoming a recognized way of conserving timber structures, except for surface protection [3, 7–8].

The load-bearing capacity of components subjected to bending is usually determined by the cross-sectional tension zone. Wood defects in the tension zone reduce the load-

bearing capacity of the component much more than wood defects in the compression zone. A possible way of strengthening is to use reinforcement in the form of, for example, steel bars and plates and FRP (Fibre Reinforced Polymers) rods and strips [9–13]. Epoxy adhesives are mainly used to bond the reinforcement with the wood [14]. Steel plates and FRP materials are also used to reinforce shearing zones [15–16].

FRP composite materials are increasingly often used to reinforce wooden elements, increasing their load-bearing capacity and stiffness and endowing them with a more uniform structure [17–20]. Moreover, the new materials can be used to strengthen historic components in poor technical condition. FRP composites are usually reinforced with carbon fibres (CFRP), glass fibres (GFRP) and aramid fibres (AFRP).

This paper presents selected results of experimental research aimed at applying CFRP strips to reinforce defective (biological corrosion, inclusions, slope of grain, cracks) wooden beams and restore their load-bearing capacity, with a special focus on a comparison of strains measured by electric-resistance strain gauges with the ones determined using the photoelastic coating technique.

2. Material and method

2.1. Material

Wooden (pine) joists from a hundred (ca) year old building were the subject of the investigations. Different ways of reinforcing the beams with CFRP strips, presented in [e.g. 11, 20–21], were applied. Series A beams were not reinforced and served as the reference. In total, 21 beams (including 18 one hundred year old ones; 7 types, 3 beams in a series), each 4000 mm long and 120×220 mm in cross section, were tested. Test results for the series F beams are presented.

The series F beams were reinforced in the maximum bending moment zone with 400–600 mm long CFRP strips in a horizontal arrangement. The weakening of the tension zone was simulated by a cut out hole 25 mm in diameter (Figure 1).

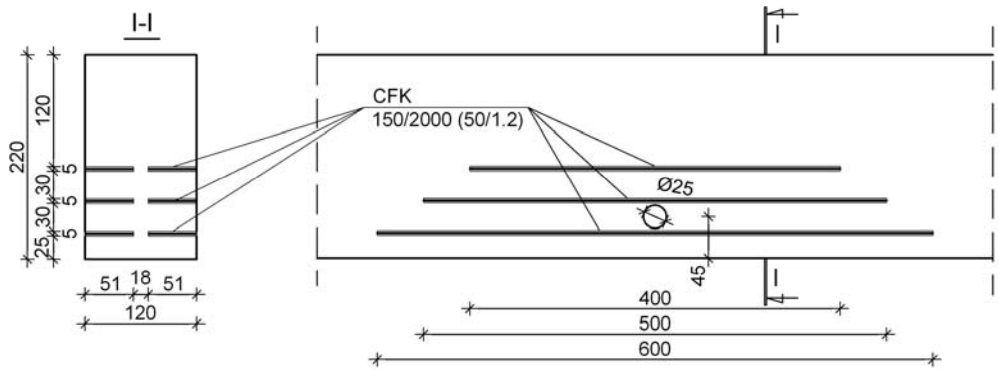

Fig. 1. Reinforcement scheme for beams of series *F* [mm]

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