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FEM simulation of bent wood-CFRP beams

*Kawecki Bartosz[1)] and Podgórski Jerzy[2)]

[1), 2)] Faculty of Civil Engineering and Architecture, Lublin University of Technology
ul. Nadbystrzycka 40, 20-618 Lublin, Poland
[1)] b.kawecki@pollub.pl

ABSTRACT

This paper presents numerical studies of wood-CFRP beams bonded with polyurethane (PUR) adhesive, validated with experimental tests. The analyses include two types of CFRP strengthening configurations and pure glue laminated timber beams as a reference.

1. INTRODUCTION

A few studies present FEM modelling of wood-CFRP beams (Glišović et al., 2017; Khelifa et al., 2015; Nowak et al., 2013; Raftery and Harte, 2013). These models neglect several important factors – treat longitudinal compressive and tensile strength of wood as equal and adhesive layers as perfect connections between bonded parts of a composite. The authors of the paper state that distinction between softwood longitudinal compressive and tensile strength (Kawecki and Podgórski, 2020a), as well as including the cohesive stiffness of an adhesive layer (Kawecki and Podgórski, 2020b), significantly influence the obtained results in a FEM model. The first factor leads to a precise prediction of the maximum load bearing capacity, whereas the second one enables to define a proper stiffness of the whole wood-CFRP girder.

2. SPECIMENS PREPARATION

Composite girders were made of C24 class softwood and S&P C-Laminate SM 100/1.4 CFRP tapes, adhesively bonded with Loctite HB 110 Purbond glue. They were prepared under a technological regime, the same as for pure glue laminated timber, according to PN-EN 14080:2013 standard. Fig.1. presents the CFRP reinforcement configurations of the specimens, while Fig.2 a process of gluing the samples in ABIES Poland Ltd.

[1)] PhD. Eng.
[2)] Professor

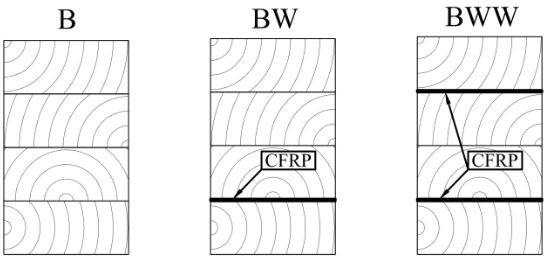

Fig.1 CFRP Reinforcement configurations

Fig.2 Process of gluing the samples in ABIES Poland Ltd.

The preparation consisted of 7 samples for each configuration. Every sample was 2 m long. The average cross-section dimensions are presented in Tab.1.

Tab.1 Average cross-section dimensions of the specimens

Configuration Type	Height (mm)	Width (mm)
B	159.4	93.4
BW	160.8	93.5
BWW	162.1	93.3

3. LABORATORY TESTS

The experiments took place on the Zwick/Roell Z3000H testing machine with constant span between supports, L=1800 mm. The HBM WA/50 mm transducer, mounted at the middle bottom of the specimen, measured the deflection in a linear–elastic range and DIC method was used to measure other needed properties.

A perpendicular set of the camera for DIC inspection enabled to see the front surface between loading points. It allowed to compare the various results for the specimens up to their fracture without exposing the sensors to damage. The experimental setup is presented in Fig.3 and the laboratory results in Fig.4.

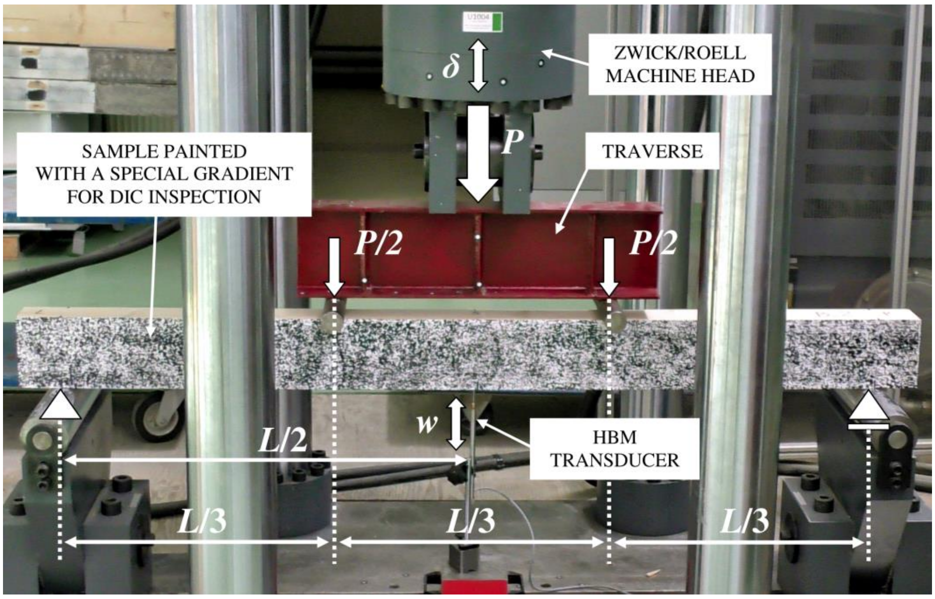

Fig.3 Experimental setup

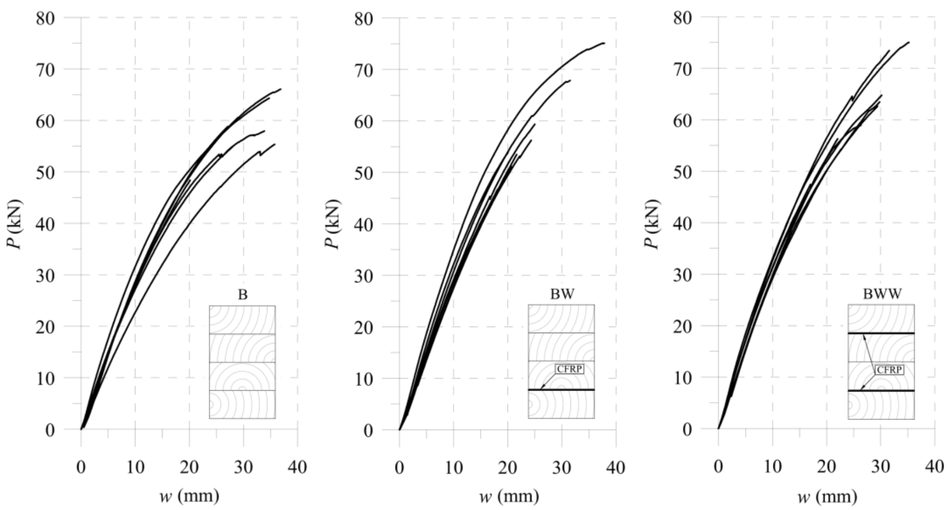

Fig.4 Laboratory results

4. FEM MODELS AND SIMULATIONS RESULTS

FEM models for each configurations are presented in Fig.5. Assumptions were described in details in authors' previous papers (Kawecki and Podgórski, 2020a; Kawecki and Podgórski, 2020b). FEM simulations results comparing to the experimental averages are presented in Fig.6.

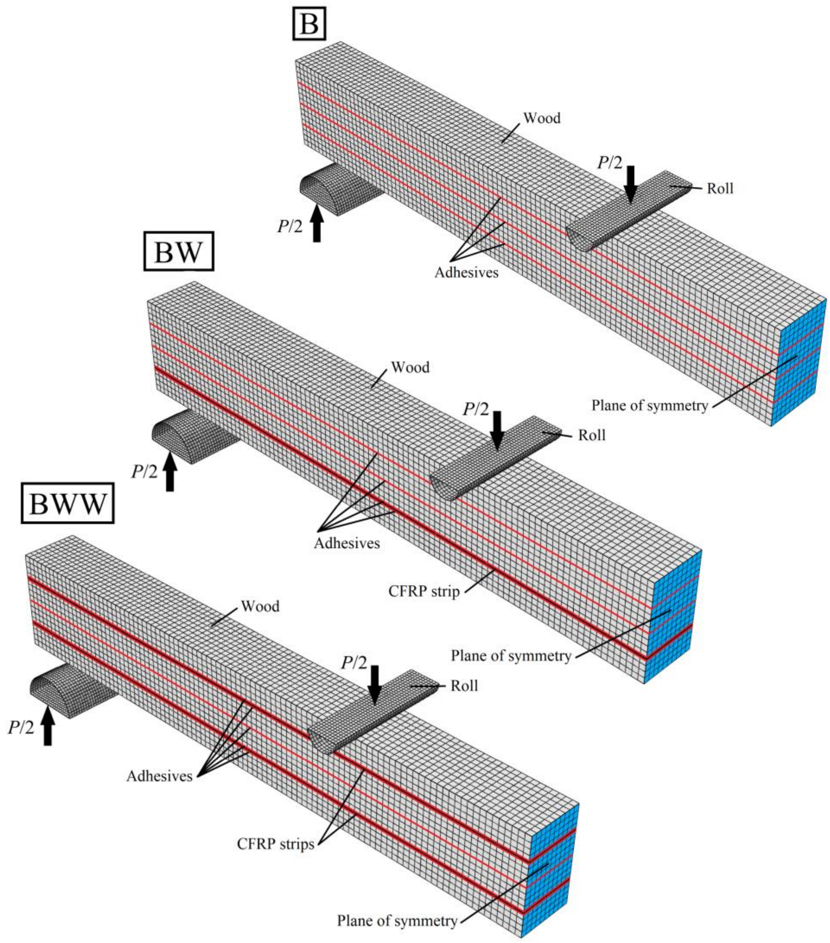

Fig.5 FEM models

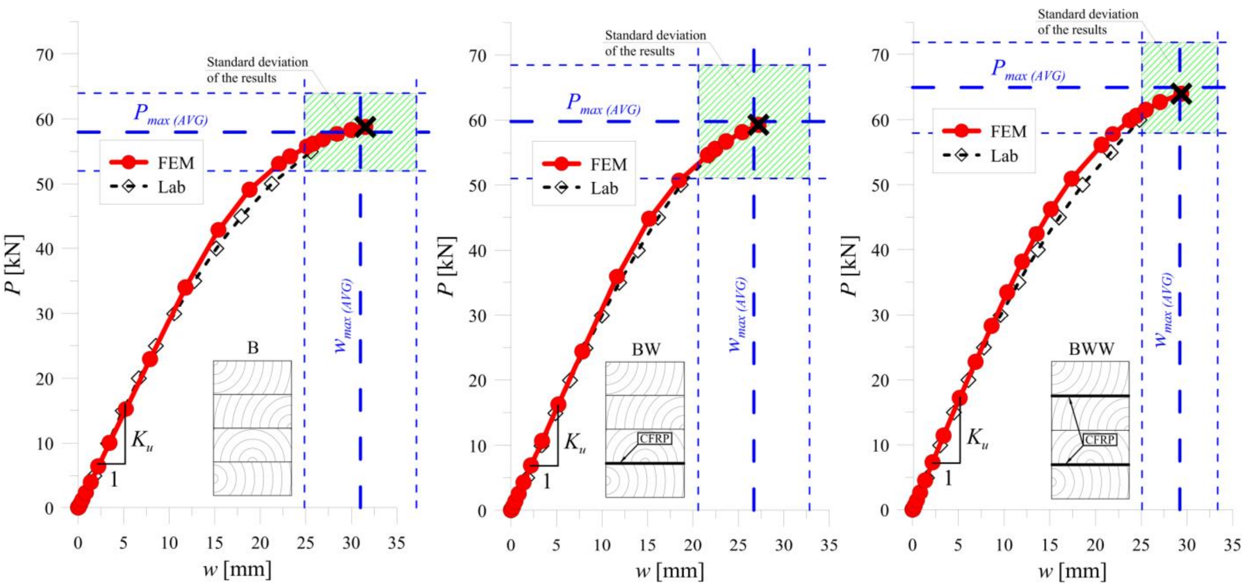

Fig.6 FEM simulations results

5. CONCLUSIONS

The developed numerical model enables to perform a non-linear analysis of full-size girders, reinforced with CFRP tapes. The calculations may be carried out until the fracture of a bottom wooden lamella. The model allows for precise determination of the linear-elastic stiffness of the designed girders and for a relatively accurate prediction of the load bearing capacity. The presented assumptions to the models also allow for the creation and analysis of composites with different reinforcement systems than those presented in this paper, provided that the girders have a full cross-section.

REFERENCES

Glišović, I., Pavlović, M., Stevanović, B. and Todorović, M. (2017). “Numerical Analysis of Glulam Beams Reinforced with CFRP Plates:” *Journal of Civil Engineering and Management*, Vol. 23, No. 7, pp. 868–879.

Kawecki, B. and Podgórski, J. (2020a). “3D ABAQUS Simulation of Bent Softwood Elements:” *Archives of Civil Engineering*, Vol. 66, No. 3, pp. 323–337.

Kawecki, B. and Podgórski, J. (2020b). “The Effect of Glue Cohesive Stiffness on the Elastic Performance of Bent Wood–CFRP Beams:” *Materials*, Vol. 13, No. 22, pp. 1–23.

Khelifa, M., Auchet, S., Méausoone, P.-J. and Celzard, A. (2015). “Finite element analysis of flexural strengthening of timber beams with Carbon Fibre-Reinforced Polymers:” *Engineering Structures*, Vol. 101, pp. 364–375.

Nowak, T.P., Jasieńko, J. and Czepiżak, D. (2013). “Experimental tests and numerical analysis of historic bent timber elements reinforced with CFRP strips:” *Construction and Building Materials*, Vol. 40, pp. 197–206.

Raftery, G.M. and Harte, A.M. (2013). “Nonlinear numerical modelling of FRP reinforced glued laminated timber:” *Composites Part B: Engineering*, Vol. 52, pp. 40–50.