SIMPLIFIED METHODS TO OBTAIN EFFORTS IN THE JOINT LINES OF METAL CONNECTORS OF WOOD TRUSS

Nadine Pinto[1], Manuel Braz-César[1,2], António Paula[1,2]

[1] Polytechnic Institute of Bragança, Campus de Santa Apolónia, {a39578}@alunos.ipb.pt, {brazcesar, mpaula}@ipb.pt
[2] CONSTRUCT R&D Unit, FEUP, Portugal

ABSTRACT

This paper presents a simplified method to obtain the distributions efforts in the joint lines in a wood truss node connected by metal plates fasteners, as function on the efforts transferred by each wooden element to the connection node. Although this verification is simple to solve in cases of simple joint geometries and/or symmetrical loading in relation to the node. The problem becomes complex in cases where the connection is composed of more than one joint line, without axis of symmetry and/or cases in which the loads are not symmetrical in relation to the node. This work aims to verify and compare three method to obtain the distribution efforts in the joint lines. Method 1 is based on the static balance between the efforts in anchors and their distribution over the adjacent joint lines. Method 2 (fictitious line) was presented to obtain the distributions efforts in the rupture lines from the distribution of efforts into composite lines (ensuring the balance of efforts on the fictitious line and the transmission of these efforts to the various rupture lines). Method 3 (obtaining the distribution by numerical models, in this case the MEF) allows to obtain the distribution along the line(s) for any configuration and composition of this(s), in addition it also allows to introduce the real stiffness of the plate and consequently a more realistic deformation/stress. The checks are carried out through Eurocode 5 EN 1995-1-1: 2004 [1] and through the CSI (Combined Stress Index), which represents the structural efficiency, in order to conclude the veracity of the method.

Keywords: Metal plate fasteners, Efforts distribution, Fictitious line, Breaking lines.

INTRODUCTION

In connections checks of the wooden truss connected by metal plates, it is necessary to obtain the efforts in the joint line between the wooden elements. Depending on the efforts act in the centre of gravity of each anchoring area of the plate. These joint lines are composed when two or more wooden elements meet. The force and moment acting on the interface generate shear stresses between the plate and the wood.

In this work, tree simple methods are presented to obtain the efforts in the joint lines of metal connectors of wood truss. The Method 1 is based on the static balance between the efforts in anchors and their distribution over the adjacent joint lines. This method is not exact and depends on how the balance between the elements is assumed. On the other hand, in plates with rupture lines that present complex geometry, the application of this method may not be possible by the degree of hyperstability in the balance of efforts [1] and [2]. Method 2 (fictitious line) was developed to obtain the distributions efforts in the rupture lines from the distribution of efforts into composite lines (ensuring the balance of efforts on the fictitious line and the transmission of these efforts to the various rupture lines). It is a simplified methodology that has limitations in its application, namely in defining line length and distributing efforts along it (it is assumed that there is always a continuous distribution of normal stress due to the bending moment along the line, which may not be in accordance with the actual distribution that may have intermediate variations resulting from variations in the angles of the rupture lines). Method 3 (obtaining the distribution by numerical models, in this case the MEF) allows to obtain the distribution along the line(s) for any configuration and composition of this(s), in addition it also allows to introduce the real stiffness of the plate and consequently a more realistic deformation/stress. This analysis needs to use an automatic numerical program and, in this case, springs with elastic behaviour are used instead of springs with plastic behaviour. Assuming this will influence the distribution of stresses in the line (the plate should plasticise, and it would be necessary to obtain the extent of the plasticization).

The different methods of analysis are compared with the effort's distribution from the centre of anchoring area to the rupture lines

CASE STUDY, RESULTS AND CONCLUSIONS

The connection node under study is shown in Fig. 1-(a). Consists of three wooden elements (two diagonal and one vertical) joined by a pair of metal plates presented in Fig. 1- (b). This node presents three anchoring areas. Area 1 is limited by line 1 (inclined) and line 2 (vertical). Area 2 is limited by line 2 (vertical) and line 3 (inclined). Area 3 is limited by lines 2 and 3 both inclined presented in Fig. 1- (b).

The method used to calculate the fictitious line of method 2 is described in [3]. In this summary only the results obtained by the anchoring area 1 are presented. The efforts of the centre of the anchoring area (see Fig. 1- (c)) were transferred to the centre of the fictitious line and subsequently distributed throughout it (method 2). Efforts were concentrated in the centre of each section of the fictitious line (see Fig. 1- (d)), which has a size corresponding to each real joint line (line 1 and line 2).

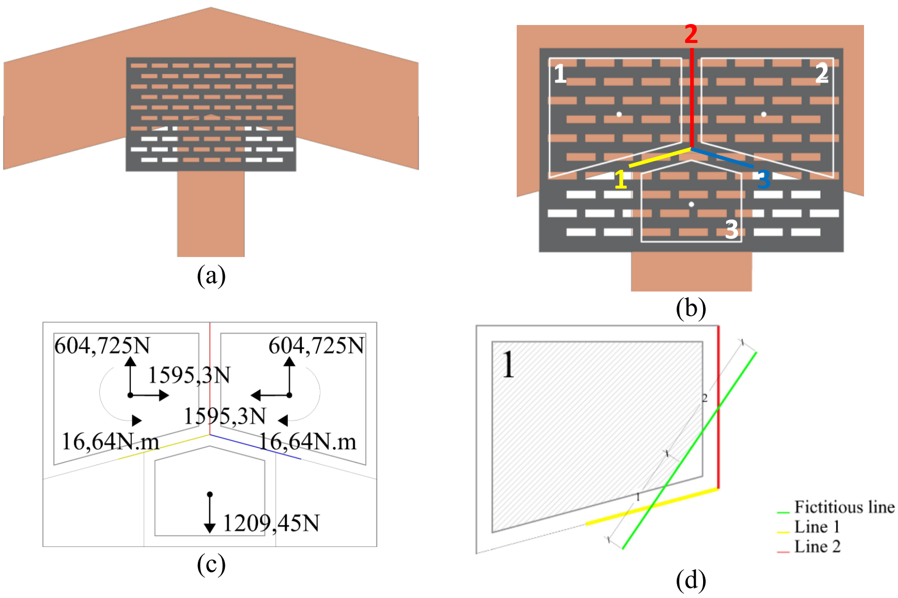

Fig. 1 - Node under study for the development of the fictitious line: a) Metal plate connected wood truss; b) Anchorage areas; c) Efforts at the centre of gravity of the anchorage area; d) Fictitious line (method 1) for anchoring area 1.

The effort values on a joint line, using methods 2 and 3, can be different when looking at different anchoring areas. For method 1 (static balance between the efforts in anchors and their distribution over the adjacent joint lines), looking at different anchorage areas, the efforts obtained for a joint line are the same (or very close), because the static balance must be checked.

Table 1 shows the results of the efforts obtained by the 3 methods, looking at the anchorage area 1 and consequently the values of the efforts obtained for lines 1 and 2. The CSI value is also show, according to [1] and [2].

Table 1 - Difference between the three methods in the efforts obtained in Line 1 and 2, anchorage area 1 (as a percentage)

	Area 1 Line 1			Area 1 Line 2		
	Method 2-1	Method 2-3	Method 3-1	Method 2-1	Method 2-3	Method 3-1
V (vertical force)	56.39%	3.49%	62.05%	100%	6.02%	100%
H (horizontal force)	100%	13.49%	100%	48.07%	6.50%	58.36%
M (moment)	0%	100%	100%	67.68%	61.62%	336.94%
CSI^2	68.97%	201.72%	89.71%	22.02%	59.17%	198.88%
CSI2	44.48%	73.71%	68.04%	10.61%	36.06%	72.98%

The fictitious line method has a simplified methodology that has limitations in its application namely in defining the length of the line and the distribution of efforts along it since it is assumed that there is always a continuous distribution of normal stress due to the bending moment at along the line which may not be in accordance with the actual distribution which may have intermediate variations in the normal stress distribution due to different bending moments resulting from variations in the angles of the breaking lines. However when this method is compared with the numerical modelling which allows to introduce the real stiffness of the plate and consequently obtain a more realistic deformation the fictitious line method obtained values close to this.

REFERENCES

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