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RESISTANCE OF LASER MADE T RHS JOINTS UNDER COMPRESSION LOAD

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Keywords: static behaviour, T RHS branch-chord lock laser made joints, full scale tests, preliminary design model, axial loaded joints resistance.

Abstract. *Research on simple laser made T RHS joints is presented. Up to now, it is no experimental evidence of such joint behaviour. Natural scale tests of three connections are described. Dimension of rectangular chord section was 100 x 100 x 3 mm. Geometry and material properties of the tested connections are given. The problem of tolerances in preparing the branch-chord lock is undertaken. For each specimen axial-deflection curves are presented. Yield line local push mechanism on front wall chord section is used to the theoretical estimation of the failure load. However, because the slenderness of the chord wall is high the membrane action of the chord loaded wall and buckling of the side walls of chord significantly influence the behaviour and resistance of joints. Preliminary design model for calculation and a prediction of joints resistance is proposed. The comparison between theoretical and experimental results is shown. Finally, some conclusions are given.*

1 INTRODUCTION

The laser technology, figure 1, is used to create such contact area between the chord and branch RHS member which could transfer the joint local stresses only by squash and shear. The socket has been developed in the shape, figure 2, which make possible transfer not only normal but also moment

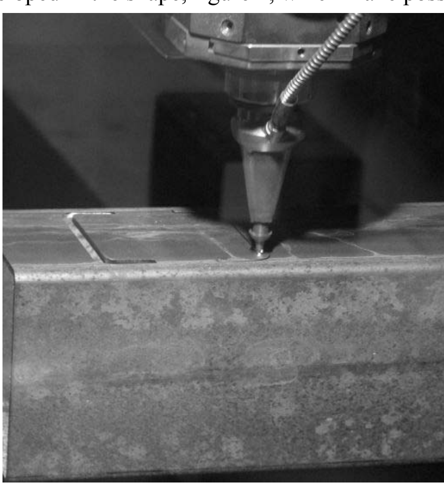


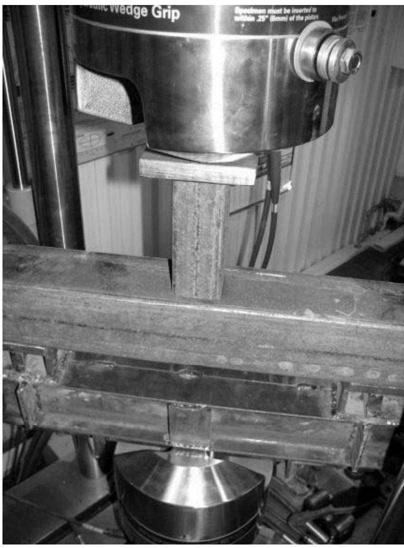
Figure 1: Laser cut of chord lock

Figure 2: Laser cut of chord and branch locks & elements

load from branch to the chord, [1]. Any typical welds are used what is a new idea for such type plug & play type joints. In the paper first three experimental results of T RHS joints resistance are presented. The design formula from other research study [2] and EC-3 [3] for RHS T welded joints is tested to be used to predict the theoretical resistance of laser made non-welded joints.

2 TEST RIG, TEST SPECIMENS AND MEASUREMENTS

Test rig is shown in figure 3 and 4. Three T RHS laser made joints in natural scale were tested here up to failure. In several steps the branch was loaded up to the reach the failure load. After each loading step, the joint was unloaded to measure the permanent deformations of the tested specimen. Typical type of joint failure was the inelastic deformation of the loaded flange, figure 5, and finally the local shear of the connecting "gusset" plate, figure 6. In Table 1 the geometry of the specimens, mechanical properties, and failure load are given. The mechanical properties are the medium value from two tension coupons tests. LVDT gauges were used to measure the displacements, see figure 3.



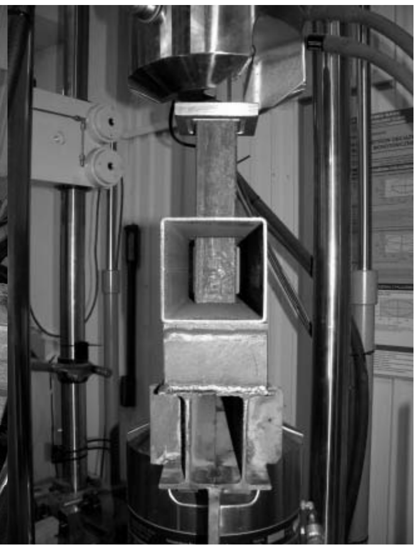


Figure 3: View of specimen in the test rig   Figure 4: Section of specimen in the test rig

Table 1: Geometrical dimensions and mechanical properties.

Geometrical dimensions					Yield stress	Parameters			Ultimate load
No speci men	RHS chord boxho mm	RHS branch bnxhn mm	chord wall thick t_0 mm	branch wall thick t_n mm	chord f_{y0} MPa	β	η	λ_0	Experimen tal failure load N_{exp} kN
WTL1	100x100	40x40	3,0	3,0	334	0,40	0,40	33,3	21,2
WTL2	100x100	60x60	3,0	3,0	343	0,60	0,60	33,3	31,5
WTL3	100x100	80x80	3,0	3,0	335	0,80	0,80	33,3	35,3

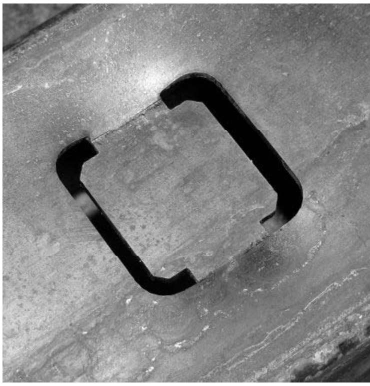


Figure 5: View of chord face failure WTL1

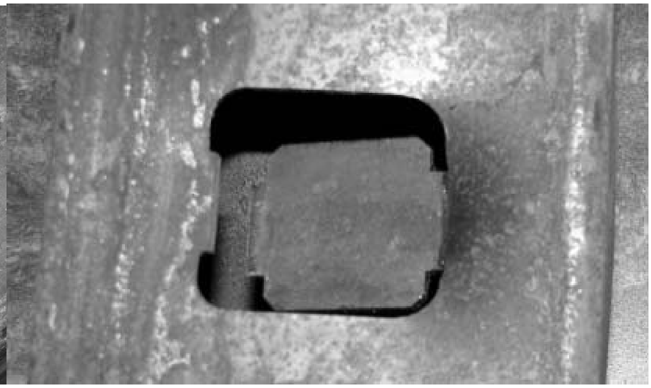


Figure 6: View of chord face failure WTL1 (shear failure)

Figure 7: View of chord face failure WTL2

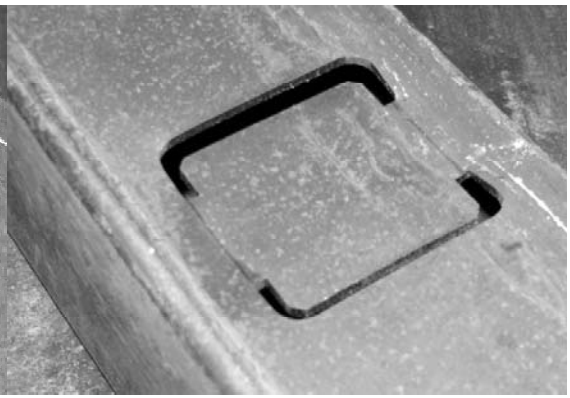


Figure 8: View of chord face failure WTL2

Figure 9: View of chord webs failure WTL3

Figure 10: View of chord face and webs failure WTL3

Figure 11: Longitudinal section of WTL1

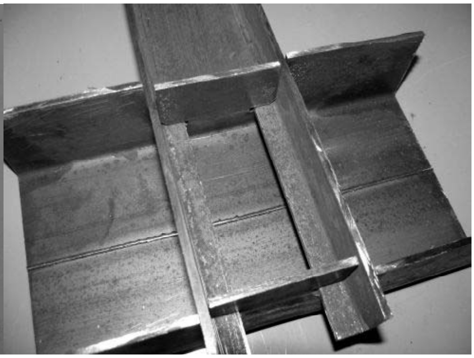


Figure 12: Longitudinal section of WTL1

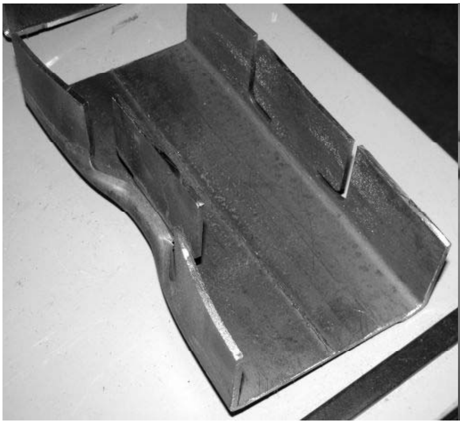


Figure 13: Longitudinal section of WTL3 (horizontal)

Figure 14: Longitudinal section of WTL3 (vertical)

Figure 15: Section of WTL2

Figure 16: Tensile samples for tests of material properties

Registrations of the results were made permanently during the full loading and unloading process, up to failure. After each loading step the joint was unloaded to measure the permanent deformations.

3 THEORETICAL ESTIMATION OF THE JOINTS RESISTANCE

For prediction the theoretical strength of joints, from the observations which were done during experimental tests, the following assumptions are adopted:

1. Yield line mechanism, which is created on the face wall of chord, is decisive. Erasing inelastic deformations leads finally to situation that flange or flange and webs of chord failed.
2. Inner zone the joint is almost absolutely stiff, figure 6, 8, 11, 14. So, for the simplicity could be assumed that this part of joint is compact.
3. Local shear of the connecting “gusset” plates, figure 6, is analysed separately.

Eurocode 3, gives the formula to predict the welded T RHS joint resistance:

$$N_{1,Rd} = \frac{f_{y0} t_o^{\,2}}{(1-\beta)}\left(2\beta + 4\sqrt{1-\beta}\right) \qquad (1)$$

In Table 2 the theoretical predictions (1) and the experimental strength of three tested joints are presented. Typical mode of failure was very large deflections of loaded face of chord section, figures 11, 12, 13 and 15. In case the WTL3 joint ($\beta = 0{,}8$) the significant webs failure has been observed, where membrane action increase the strength of the joint, see figure 19.

Table 2: Comparison between theoretical and experimental strength of joints.

No speci men	Theoretical prediction (1) $N_{1,Rd}$ kN	Experimental strength N_{exp} kN	N_{exp} / $N_{1,Rd}$	Mode of failure
WTL1	19,53	21,18	1,08	face wall deflection larger then $3t_0$ (9mm)
WTL2	28,78	31,49	1,09	face wall deflection larger then $3t_0$ (9mm)
WTL3	51,09	35,31 (51,67)	0,69 (1,01)	face wall deflection larger then $3t_0$ (9mm) and webs failure (maximum load)

4 COMPARISONS OF EXPERIMENTAL RESULTS AND THEORETICAL ESTIMATIONS

In figures 17, 18 and 19 the axial force - deflection curves (N - δ) for each tested joints are presented. They are shown not only loading but also unloading curves registered by LVDT gauges. Unloading curves gives possibility to obtain the end of its elastic behaviour and show how arising the joints permanent deformations. Joint failure limit deformation was adopted from welded joint and it has been assumed $3t_0$. Theoretical prediction of joints resistance obtained from formula (1) and shear failure load for the connecting “gusset” plates, figure 6, are also given. As could be observed theoretical prediction (1) rather good estimate the real joint strength for the joints with parameter $\beta = 0{,}4$ and $\beta = 0{,}6$. However when $\beta = 0{,}8$ this prediction is too optimistic compared with joint failure limit deformation $3t_0$. Permanent deformations of loaded face of chord arise very quickly on the loading path;

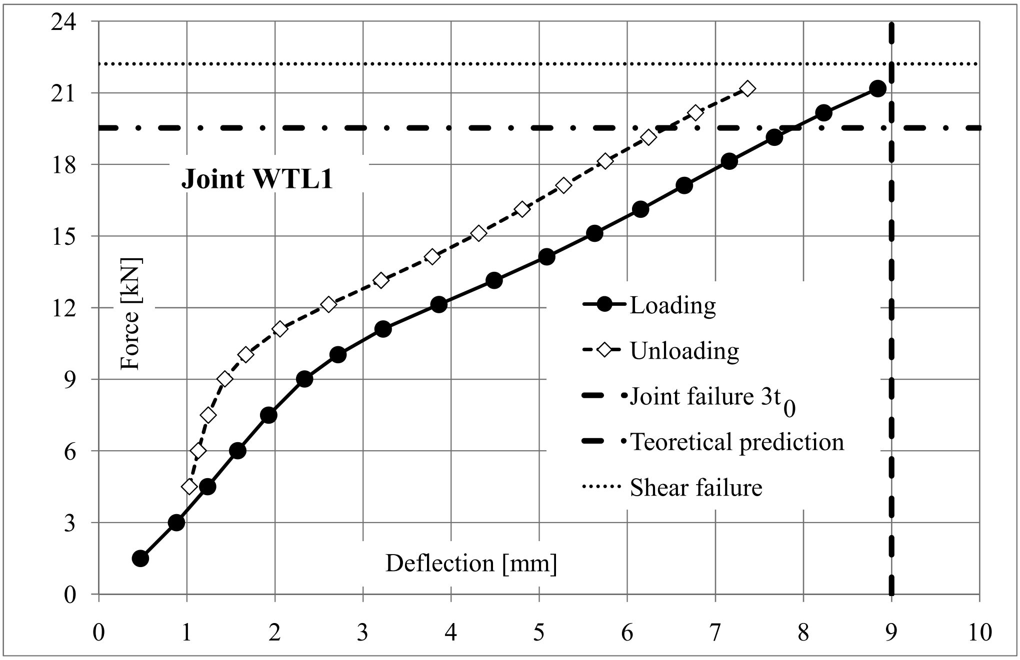


Figure 17: Axial force-deflection diagram for WTL1 joint ($\beta = 0,4$)

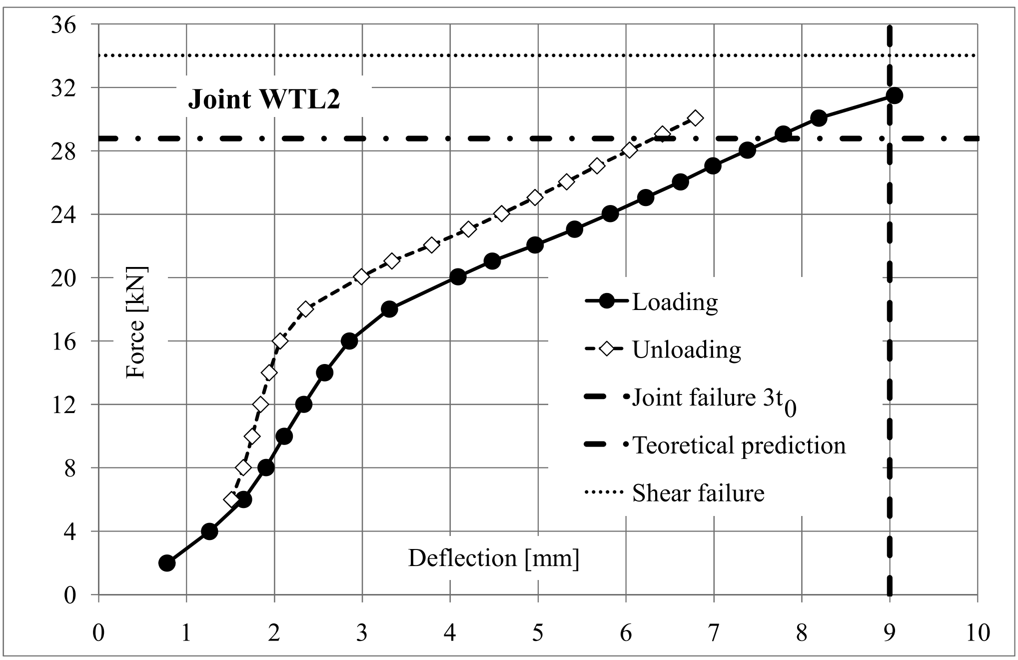


Figure 18: Axial force-deflection diagram for WTL2 joint ($\beta = 0,6$)

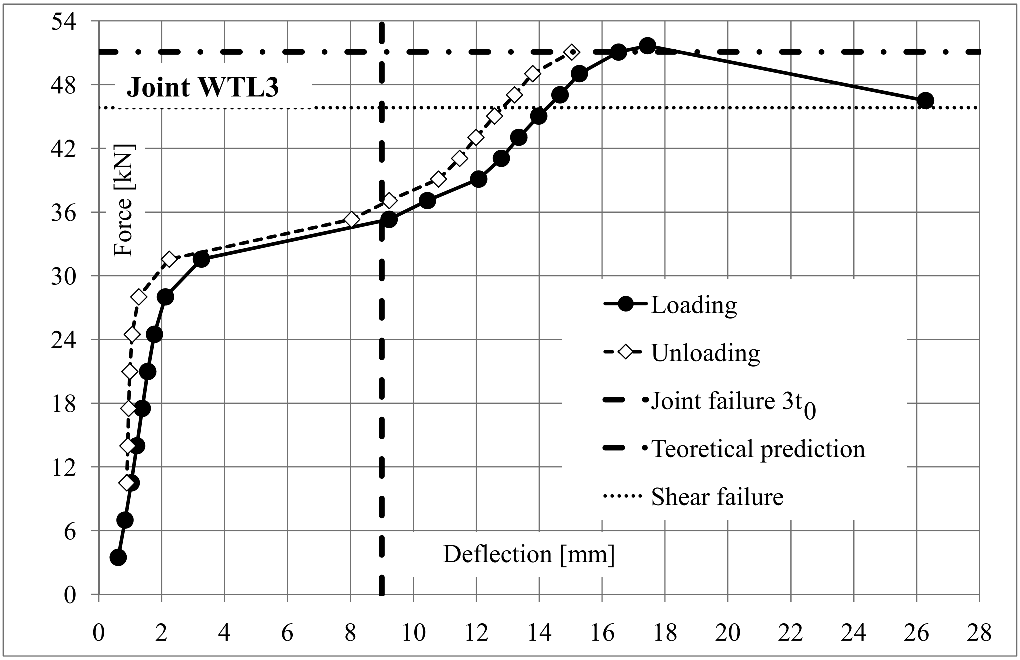


Figure 19: Axial force-deflection diagram for WTL3 joint ($\beta = 0,8$)

see figures 17, 18 and 19. So, the reduction coefficient for the theoretical prediction (1) ought to be adopted if next experimental data confirms that observation.

5 CONCLUSION

In order to keep a competitive position the costs of manufacturing steel connections need to be reduced as much as possible. Author starts to research one of the types of "plug and play" joints. Laser has been used to cut the proper locks. From the first experiments, which results are presented in this paper the preliminary conclusions could be given:

1. For the joints where the branch is smaller than the chord member ($\beta \leq 0,8$) the design formula use in Eurocode 3 [3] for the welded joints could be used to T RHS branch-chord lock laser made joints
2. Shape and dimensions of the lock should be such design then it to be at least as strong as the face plate of chord.
3. For the presented lock shear of face plate has not be decisive.
4. Permanent deformations of the loaded face of chord arise very quick

Further experimental and theoretical studies are going on.

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