TESTING OF THE ACROSS FRAMES OF BUS UPGRADING WITH DIFFERENT QUALITY MATERIALS

Prof. Vasko Stojanovski, PhD, Prof.Vesna Angelevska, PhD
Faculty of Technical Sciences –University "St. Kliment Ohridski", Republic of Macedonia

Abstract: *In this paper an analysis of the experimental testing of across frames of bus T715 upgrading, manufactured from different quality materials, is given. Obtained results were used for impact assessment of the material quality on carrying capacity of across frames.*

Keywords: ACROSS FRAMES, LOADINGS, and DEFORMATIONS

1. Introduction

Increase of the maximum values of vehicles speed, especially of buses, as well as increased need for mobility of the population which is an imperative for the modern way of living, lead to the increase of the number of traffic accidents at global level. Death casualties coming as a consequence of interior deformations in the vehicle, even more impose the need of detail testing of the buses construction and implementation of constructive solutions, which will provide safety area of passenger to stay secure even during the worst cases of traffic accident. To achieve this aim, it is necessary support structures at buses to be projected regarding absorbed energy during turnings over.

Projection of the support structures and constructions links in the buses referring absorbed energy during turnings over, should be done in such a way that frame doesn't jeopardize safety area for passengers.

2. Static testing of buses upgrading

Testing were performed only on one type of passenger bus, making three across frames from different materials: S235JRH according to DIN EN 10025, S355NH according to DIN EN 10131 and x5CrNi810 according to DIN 17455, which are used in the production program of Motor Coach Industry. Before start of the testing, a laboratory testing of materials quality was performed. Results of the testing are given in table 1.

Table 1: Chemical characteristics of the materials

Basic characteriscs of the materials				
	C	**Si**	**Mn**	**P**
S235JRH	0.17	-	1.50	0.04
S355NH	0.22	0.55	0.9-1.65	0.035
x5CrNi1810	0.07	1.0	2.0	-
Basic characteriscs of the materials				
	S	**N**	**Ni**	**Cr**
S235JRH	0.04	0.009	-	-
S355NH	0.03	0.015	-	-
x5CrNi1810	0.03	-	9.5-10.5	17-19

From the testing of across frames, an F-L tables as well as F-L diagrams for adequate types of used materials are obtained.

Giving a determinate force F in the upper part of the across frame directed towards point of impact at the pendulum, a measurements for every new position of the vertical from across frame were made.

2.1. Testing of across frames of buses made of different quality materials

In this part of the paper, a testing of across frames of buses in order to obtain F-L diagrams in elastic and plastic area is elaborated. Namely, a three across frames of the upgrading are made using the following materials: S235JRH, S355NH and x5CrNi810.

The testing is with normal force in the area where simulation of turning over has to be preformed; to be precise, a pendulum impact referring normal force at adequate height from the frame is under the angle of 15°.

2.2. Testing of one across frame field "4" from bus (third across after the driver seat) from material with quality S235JHR

In the first case, an across frame from bus upgrading is used, fourth after the wind field frame (because during the turnings over the greatest deformations are expected in that part), fixed in the lower across belt.

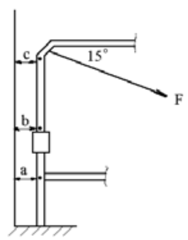

Fig 1: *Measurement points of deformations*

2.3. Testing of one across frame fixed in the basis and in the floor level (field "4" from quality material S355NH)

With purpose of establishing the impact of material quality, an across frame with the same geometric characteristics as the previous one, is manufactured from steel S355NH with increased firmness. For this frame the same equipment has been used, with an only difference that the frame was fixed on the floor level, in order to simulate support structures.

The testing were made in the same way as for the first frame, with static successive burdening on the frame, during which the starting deformations appeared under the same burden compared to the previous frame.

2.4. Testing of one frame field "4" from material quality x5CrNi1810 with enforcement of the critical nodes

The frame is made from un-corroded steel x5CrNi1810, but referring static and geometric characteristics with frame construction made from constructive steel S355NH or S235JHR. On the frame, carriers for seats were placed.

The frame was fixed on the floor level.

On the basis on made theoretical analysis [7], it can be stated that a further additional corrections on the support frame is needed, in order to improve its strength deformational characteristics. Theoretically, many constructive solutions are analyzed and improvements on them have been made. On the basis on this analysis a constructive solution is achieved, which predicts adequate enforcement of the frame nodes, which solutions are applied on the experimental model. If these experimental testing are satisfying, their application on the total construction on bus is possible.

The testing methodology is with continuously increase of the force and measurement of the deformations in the points a, b and c.

***Fig. 2**: Transverse frame*

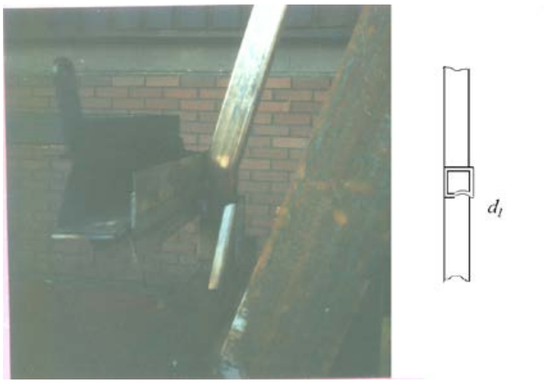

***Fig. 3**: Initial deformations of transverse square tube*

***Fig. 4**: Deformations on link between vertical and roof tube*

3. Results from the frame testing

The first across frame which was tested is made from material S235JHR and with a dimensions that are suitable for the real dimensions of the across frame of the bus. During the tests of the first across frame, successive increases on the force were made, with which a frame was loaded with a 200 [N]. A deformations measurement in the three points a, b and c on the vertical axis of the frame was performed.

After each new given load, the frame was returned in its primary position, and every next load was bigger for 200 [N], compared with the previous one.

The second frame was made from more qualitative material, S355NH, with the same geometric characteristics on the across sections and testing conditions as for the previously tested frame. The results from the testing are given in table 2. Obtained results are insignificantly different from the previous ones, and first plastic yokes and beginning of the crash of the frame emerge on the same spots.

***Table 2**: Results from the testing of the across frame made from quality material S355NH*

F [N]	500	800	1000	1200	1400	1600
a [mm]	0	0	0	0	0	0
b [mm]	1	2	2,5	3	3,5	4
c [mm]	15	23	30	37	44	52
F [N]	0	1600	1800	0	2000	0
a [mm]	0	0	0	0	0	0
b [mm]	0	4	5,0	0	5,5	1
c [mm]	0	52	59	0	66	5

On that spots, the specified pressure grows, and on the links a deformations on the longitudinal pipes from the increased surface pressure appears.

The first noticeable deformations appear in the node "d_1" and "d_2", during a load of 2000 [N] in the longitudinal quadrate pipe, 50x50x2 [mm], which in the same time is a major link between upgraded and lower part of the support structures.

On the third frame, which was made from x5CrNi1810, a testing was performed in the same way. Obtained F-L (abc) diagram in the adequate points, unlike the previous diagrams, here the loads until the first deformations were bigger for 70%.

***Table 3**: Results from the testing of the across frame made from quality material x5CrNi1810*

F [N]	600	800	1000	1200	1400
a [mm]	0	0	0	0	0
b [mm]	0,1	0,5	1,0	1,5	1,5
c [mm]	8	16	24	30	35
F [N]	1600	1800	2000	0	2200
a [mm]	0	0	0	0	0
b [mm]	1,5	2,0	2,5	0	3
c [mm]	40	45	51	0	57

F [N]	2400	2600	0	2800	3000
a [mm]	0	0	0	0	0
b [mm]	3	3	0	3	3,5
c [mm]	63	70	1	79	88
F [N]	0	3200	3400	0	3600
a [mm]	0	0	0	0	0
b [mm]	0	4	4	1	4
c [mm]	6	97	113	20	120
F [N]	3800	0	4000	4150	4300
a [mm]	0	0	0	0	0
b [mm]	4,5	1	5,0	6,0	6,0
c [mm]	156	50	182	225	252
F [N]	4150	4000	3200	2800	
a [mm]	0	0	0	0	
b [mm]	6	7	8	9	
c [mm]	350	405	455	535	

Diagram display of the obtained results, F-b and F-c diagrams for the two characteristic points are given in the figure 5.

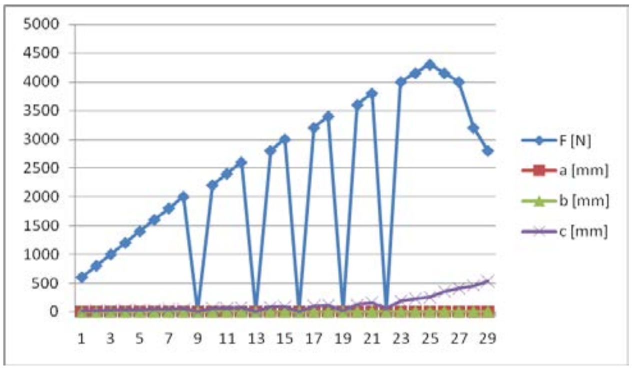

***Fig. 5**: F-L (b,c) diagram*

The first noticeable deformations appear in the node "l_1" (measurement point b), during the load of 2800 [N] on the vertical quadrate pipe, 40x40x2 [mm], immediately above enforcements in that node.

During the load of 3200 [N], a noticeable deformations start in the node "d_1" (measurement point b on the contrary side), on the contrary side of the vertical pipes, 40x40x2 [mm].

With further loading over 3300 [N], deformation growth is bigger, because construction is deformed under another functional dependency.

The stretching in the node "l_1" (measurement point b) continued until the load of 4150 [N], under which the first deformations in the node "d_2" (measurement point b) appeared under the load of 4300 [N], under which deformation growth suddenly increases, the force begins to decrease and construction crash happens.

4. *Conclusion*

Increase of the quality class of basic material from S235JHR to quality S355NH, from which a bus construction is made, increases the power of energy absorption only for 2-3%.

Installment of the basic material from un-corroded steel x5CrNi1818 with increased limit for yield has positive influence on accumulation power of energy, because with an increase of the limit of yield a primal impact is mitigated as well as the effect of the local influences. Therefore, the appearance of leaking, as well as appearance of plastic yokes is with some delay.

The increased price of cost of the bus construction made from basic material with quality x5CrNi1818 is incomparably small compared with the successfulness and the effects which are obtained referring the corrosion protection, longer exploitation period, and smaller weight – mass of the bus in total.

5. *Literature*

[1] Bathe, K.J. et al., Advances in crush analysis, Computers and Structures, Elsevier Science Ltd., USA, 1999.

[2] Buzdugan, Ch.et al., The Materials, Didactic and Pedagogic Publishing, Bucharest, 1979.

[3] Csaba, M., Roll-over resistance of bus superstructures, Conference IMechE, London, GB, 1992.

[4] Gavriloski G.: Nose~kite konstrukcii kaj mehanizacionite ma{ini i vozila, u~ebnik, Univerzitet "Sv. Kiril i Metodij" - Ma{inski fakultet - Skopje, 1995.

[5] Iozsa Daniel, Fratila Gheorghe, Analytical rollover test for bus superstructures using FE method, EAEC European automotive congress, YU, Beograd 2005.

[6] Unusual statistics about rollover accident of buses – VI. Information working document of UN-ECE/WP.29-GRSG, paper No.: GRSG-87-5. p.11. Presented by Hungary, Geneva, 2004.

[7] Васко Стојановски.: „Развој на напреден систем за оптимирање на носечки конструкции кај автобусите во однос на апсорбираната енергија при превртување", Докторска дисертација, Машински факултет Скопје 2009.