Experimental stress analysis on a wagon model for railway vehicles

T. St. Manescu, N. L. Zaharia, M. D. Stroia, S. D. Avram and M. N. Tiganasu

Abstract— A large number of problems where experimental stress analysis techniques have been of particular value are those involving fatigue loading. One of the main techniques of experimental stress analysis which is often used nowadays and also when it comes to railway vehicles, particular under working conditions, is strain gauges. This paper presents static stress analysis using strain gauges performed on a wagon prototype with four axles as a certification procedure.

Keywords**—**Catman, railway, stress analysis, wagon.

I. Introduction

BEFORE putting in service a railway vehicle, the prototype must be certified. During the certification procedures, tests like experimental stress analysis, safety against derailment, static and dynamic braking is performed according to international standards.

Experimental stress analysis was made to test the strength structure of four axle railway wagon prototype in order to certify its reliability.

For static stress tests at wagons guidelines from following standards were applied:

- EN 12663 – Structural requirements of railway vehicle bodies [3];
- UIC leaflet 577 (UIC = Union Internationale des Chemins de fer) [5];
- ERRI B12/RP17 Report (ERRI = European Rail Research Institute) [4].

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The tests which are presented in this paper were performed at Romanian Railway Authority (AFER) on Stress Analysis Bench Test by Rolling Stock Laboratory – a RENAR (Romanian Accreditation Association, National Accreditation Body) certified laboratory

II. Experimental Research

The measurement points were located in the relevant load areas: on elements of the chassis and at the supports of the tank.

The measurements were performed in 35 points. Hottinger LY11-10/120 strain gauges (TER) were glued on the elements of the wagon with Hottinger Z70 adhesive all made by Hottinger Baldwin Messtechnik GmbH (HBM).

The diagrams of the measurement point location on the frame are shown in figures 1 to 4. Strain gauges glued on chassis and exterior plate of the tank's support can be seen in figure 1. In figure 2 are presented the measuring points of the chassis. In figures 3 and 4 are shown the measuring points located on tank support's elements [10].

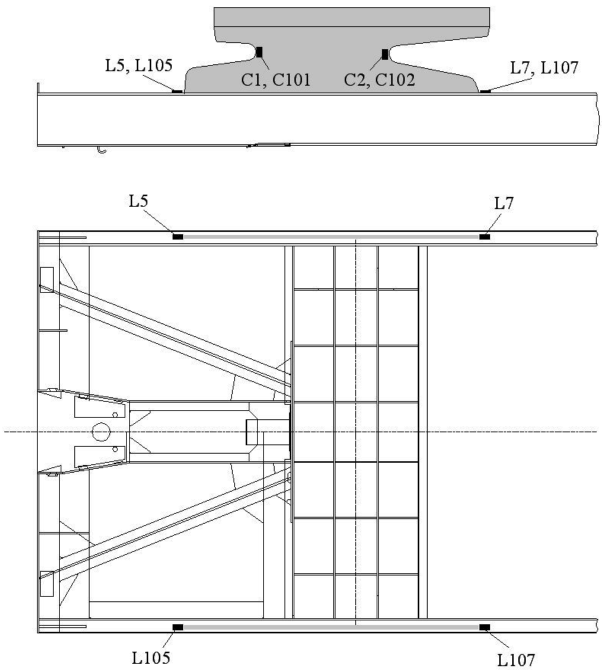

Fig.1 TER glued on chassis and tank support

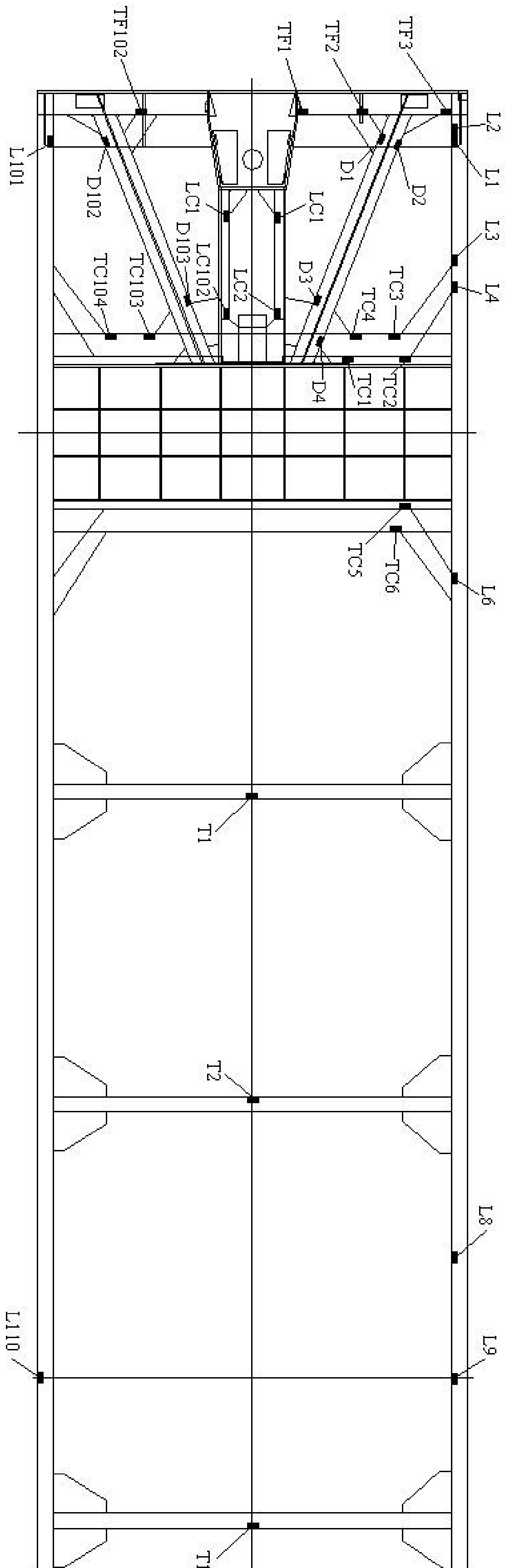

Fig. 2 TER glued on chassis

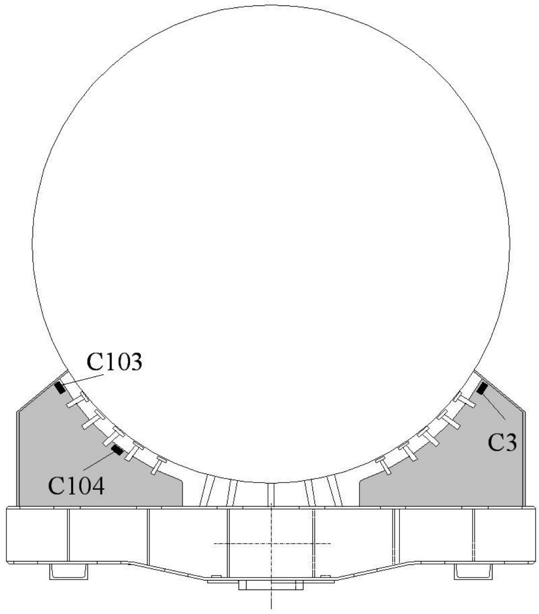

Fig. 3 TER glued on tank support

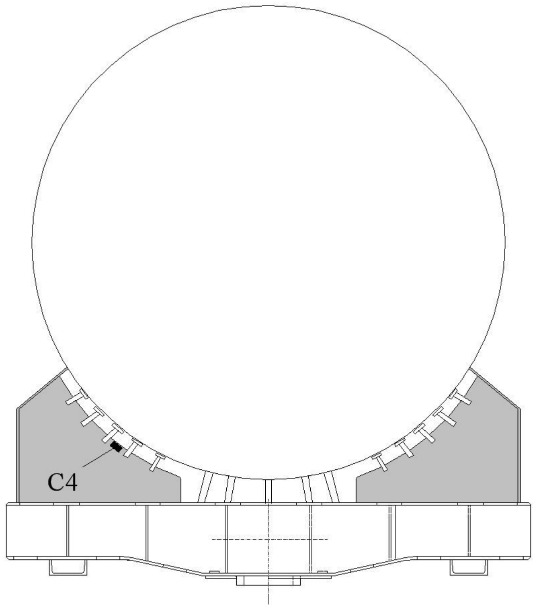

Fig. 4 TER glued on tank support

III. Tests performing

The following tests were performed in accordance with the above mentioned standards:

1) Compressive force at buffer level (CT) with 2 MN/buffer force;
2) Compressive force at coupler level (CA) with 2 MN;
3) Compressive force at 50 mm below buffer (CT50) with 1.5 MN/buffer force;
4) 0.4 MN compressive force applied diagonally at buffer level (CDD and CDS);
5) Tensile force in coupler area (TA) with 1.5 MN;
6) Vertical loads test (V);
7) Lifting at one end of the vehicle (RID);
8) Lifting the whole vehicle (RID4).

Horizontal loads (1...5) were applied at one end of the wagon by means of hydraulic cylinders. The other end of the wagon was leaned at buffer level, coupler level respectively.

The vertical load test (6) was performed by charging the tank with water.

The (7) load was performed lifting the loaded wagon from under the buffer beam until the adjacent bogie got off the rails, with the other bogie still leaned on the rails [6].

The (8) load was obtained fully lifting the wagon from under its lateral supports.

The static test permissible stress is shown in Table I. The units are N/mm^2.

TABLE I
PERMISSIBLE STRESS

			Welding free area	Welding area
Horizontal loads (σ_{aH})			355	309
Vertical loads (σ_{aV})	Class	A	277	
		B	150	
		C	133	
		D	110	

For performing tests, it was used a static analysis device for data acquisition named Centipede 100 made by HMB [7].

Centipede 100 was connected to a laptop; the software interface used for data acquisition was creating in Catman 4.5 software (a HBM software) [1], [2].

For horizontal loads, longitudinal deformations were measured. Vertical flexures for vertical load and lifting tests were also measured. Additionally, combined (between horizontal and vertical loads) tests were performed (CA+V, CT+V, CT50+V, TA+V)

IV. Tests Results

The results are presented in Table II.

In the columns named "Maximum values" are inserted the maximum values for each TER, the test and the percent ratio between that value and the permissible stress.

TABLE II
RESULTS

Maximum values			
TER	**Test**	**[N/mm^2]**	**[%]**
C1	CA	-131	37
C101	CA	-110	31
C102	CT+V	71	20
C103	CA	-288	93
C104	CT+V	44	14
C2	CT+V	88	25
C3	CT+V	-220	71
C4	RID	-141	51
D1	CT50	-158	45
D102	CT50	-121	34
D103	CA	152	49
D2	CT50	-165	46
D3	TA+V	-241	86
D4	CT+V	-63	20
L1	CT+V	-305	99
L101	CT+V	-302	98
L105	RID	-209	68
L107	CA	-119	38
L110	CT+V	-93	26
L2	CT+V	-110	31
L3	RID	-145	47
L4	RID	232	75
L5	RID	-231	75
L6	CT+V	-230	74
L7	CT+V	-142	46
L8	CT+V	-150	42
L9	CT+V	-154	43
LC1	TA	237	77
LC101	TA	249	81
LC102	TA	151	49
LC2	TA	154	50
T1	CT+V	-16	5
T2	CT+V	-13	4
T3	CA	11	3
TC1	CA	-56	16
TC103	TA+V	-111	34
TC104	CA	-119	39
TC2	RID	-80	47
TC3	CT	93	30
TC4	CA	-125	41
TC5	CA	58	19
TC6	RID	-65	21
TF1	CT	-101	33
TF102	CT+V	209	68
TF2	CT+V	176	57
TF3	RID	110	36

At compressive force at buffer level tests, the measured stress value was higher than permissible stress value because of wagon construction. In order to improve the design some angle brackets must be added. The maximum measured stress value appears inside strut at (CT+V) test. The stress from side strut is smaller than permissible stress.

The measured values for longitudinal deformation and vertical flexure after unloading the structure were near zero.

No visible residual strains were observed at tests.

V. Conclusion

The measured stress values shown in Table II were lower than the permissible stress values for most TER.

After the obtained results for four axle railway wagon were submitted to the certificated commission it was concluded that the prototype is appropriate for a serial wagons production with taking into account several minor adjustments.

References

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