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EXPERIMENTAL VERIFICATION OF SPRINGING PARAMETRES CHANGES INFLUENCE ON DYNAMIC STRESSES IN TROLLEYBUS STRUCTURE

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The contribution describes application of experimental stress analysis, which made it possible to evaluate and interpret the most suitable set-up of springing parametres of an articulated bus from the point of view of its global dynamic loading.

1. Introduction

The company ŠKODA OSTROV Ltd. has developed a new type of vehicles for city public transport. It deal with low-floor trolleybusses in classic as well as articulated execution (ŠKODA 21 Tr and ŠKODA 22 Tr) and with a low-floor bus (ŠKODA 21 Ab). The central research institute ŠKODA VÝZKUM Ltd. significantly shared the strength solution of these vehicles.

In course of development of these vehicles, the following methods were used: experimental stress analysis, modelling with the aid of final element method, stand tests of vehicle function samples and fatigue tests of important structural parts [1, 2].

In stadium of prototype tests the further possibilities were then looked-for in order to increase the operating reliability and fatigue life of bodyworks of these vehicles:

1) Increase of fatigue life of welded joints of bodywork profiles,
2) Lowering the level of dynamic exciting forces.

In the first case a new reinforced welded joint of door and window columns of bodywork sides were designed and tested. Its dimensions and shape did not disturb either the design of vehicles or the intention to use a technology of glued window fillings.

In the second case it dealt with finding the optimal parametres for springing elements, which would lead to decrease of exciting forces and which simultaneously would fulfil further criteria, e.g. keeping the good running stability and/or the good accessibility of springing elements on industrial market. In this case, the methods of experimental stress analysis asserted themselves to a significant extent again [3].

2. Brief Technical Description of the Experiment

2.1. Measured parts

Influence of springing element parametres changes onto magnitude of dynamic stresses has been followed on a prototype of a low-floor articulated trolleybus ŠKODA 22 Tr. For measuring purposes 20 strain gauges were selected from various structural parts of the trolleybus, which showed highest values of dynamic stresses at previous more detailed measurements.

Structural parts	Number of strain gauges
A - Front part of trolleybus (right-hand side wall)	6
B - Front part of trolleybus (left-hand side wall)	2
C - Rear part of trolleybus (right-hand side wall)	3
D - Rear part of trolleybus (left-hand side wall)	2
E - Beam of articulated part	2
F - Beam of II. axle springing	1
G - Front part of trolleybus (undercarriage frame)	1
H - Guide bars of II. axle	2
I - Rear part of trolleybus (undercarriage frame)	1

2.2. Measuring Chain and Software

The following measuring chain was used for taking measurements:
Strain gauges — Dynamic bridges HBM-KWS — Portable computer with A/D converter Keithley Metrabyte DAS16 and with shock-resistent Bernoulli disc. The programme packet SADKO and own supporting software were used for evaluation of signals measured.

2.3. Simulation of Dynamic Loading

Dynamic loading was simulated by overrun of vehicle over artificial obstacles (segment of a cylinder with basis of 500 mm and height of 60 mm) simultaneously by both wheels of one axle and with a speed of approx. 40 km/h. Measurements were realized with empty vehicle and repeated several times for each investigated condition.

2.4. Investigated Conditions

Measurements of dynamic stresses were carried-out in a series of 7 investigated conditions, in course of which, the springing parametres were gradually changed. Sequence of these changes is shown in Tab. 1.

3. Evaluation of Measured Data

Results of repeated measurements served for calculation of average amplitudes of dynamic stresses "Sa" for excitation of II. or III. axle. Tab. 2 shows values, which have been found-out when exciting the II. axle. Then it was possible to define the condition, at which the lowest amplitude of dynamic stresses "min. Sa" has been reached for each strain gauge. These values are grafically marked-out in Tab. 2.

The highest algebraic sum of all occurrences of minimum values Σ min Sa determines then the optimum condition (which is characterized by set-up of certain springing parametres), at which the dynamic loading of vehicle structure is minimally agressive. Of course, that this access results in global evaluation of data measured, i.e. from the point of view of vehicle construction as a whole. When evaluating the reached level of dynamic stresses (e.g. regarding the fatigue life), it is necessary to respect real values for each individually measured point.

Also from this reason the values measured were processed into graphic representations. A demonstration of this interpretation of results is shown in Figs. 1 and 2. The diagrams graphically demonstrate influence of setting the certain springing parametres onto level of dynamic stresses at concrete points of investigated structural part of the vehicle.

4. Conclusions

On the basis of concrete data an application of experimental stress analysis has been demonstrated, which made it possible to evaluate and interpret the most suitable set-up of springing parametres from the point of view of global dynamic loading of road vehicle for city public transport. In case of the articulated trolleybus ŠKODA 22 Tr was unambiguously using the more suitable air springs (mark TAURUS K - 159) on II. an III. axle.

References

[1] Kepka, M. - Řehoř, P.: Methodology of Experimental Research into Operating Strengh and Fatigue Life of Bus and Trolleybus Bodywork.
International Journal of Vehicle Design, Vol. 13, No. 3, 1992, pp. 242 - 250

[2] Kepka, M.: Complex Approach to Ensure Operational Reliability of Road Vehicles for City Public Transport.
Engineering Mechanics, Vol. 1, No. 2, 1994, pp. 107-113 (in Czech)

[3] Kepka, M. - Ruchař. M. - Kotas. M. - Frémund, J.: Experimental Verification of Springing Parametres Changes Influences on Dynamic Stresses in ŠKODA 22 Tr Trolleybus Prototype Construction
Research Report, ŠKODA VÝZKUM, Plzeň, 1996.

TEST	INITIAL PARAMETERS		
1	LOADING		EMPTY TROLLEYBUS
	TIRE	type	PIRELLI 11/70 R22.5
		pressure [MPa]	0,8
	AIR SPRING	I. axle	AUTOBRZDY ϕ 340 / 275
		II. axle	AUTOBRZDY ϕ 340 / 275
		III. axle	AUTOBRZDY ϕ 340 / 275
	SHOCK-ABSORBER	I. axle	PT 50 x 175 D - 8800 / 1200
		II. axle	T 50 x 225 - 8000 / 1500
		III. axle	T 50 x 225 - 2700 / 800
SUBSEQUENT MODIFICATIONS			
2	TIRE	type	PIRELLI 11/70 R22.5
		pressure [MPa]	0,75
3	TIRE	type	BARUM 11/70 R22.5
		pressure [MPa]	0,8
4	TIRE	type	BARUM 11/70 R22.5
		pressure [MPa]	0,75
5	TIRE	type	PIRELLI 11/70 R22.5
		pressure [MPa]	0,75
6	AIR SPRING	II. axle	TAURUS K - 159
7	AIR SPRING	III. axle	TAURUS K - 159

Tab. 1: Investigated changes of springing parametres

part of trolleybus	strain gauge	Sa [MPa]						
		TEST						
		1	2	3	4	5	6	7
A	505	35	35	31	35	33	27	**24**
	529	31	26	39	38	32	**25**	31
	530	67	69	60	66	55	55	**54**
	549	70	72	62	66	58	**51**	56
	550	88	83	75	79	77	68	**56**
B	645A	116	108	116	113	102	**78**	85
	646A	61	59	65	62	54	44	**35**
C	5	39	34	37	35	33	28	**27**
	25	28	32	35	37	27	**18**	**18**
	26	20	19	19	21	19	17	**16**
D	105A	64	64	64	62	56	**51**	54
	106A	26	24	24	23	22	**19**	20
E	N1	**28**	31	30	**28**	31	**28**	**28**
	N4	33	32	33	31	32	**29**	31
F	Z1	39	35	38	36	34	**33**	35
G	835	88	87	89	86	79	67	**65**
H	T5	24	26	28	26	**22**	23	**22**
	T8	25	25	25	**22**	26	31	27
Σmin Sa		1	0	0	2	1	9	**11**

Tab. 2: Amplitudes of dynamic stresses at excitation of II. axle

A: FRONT PART OF TROLLEYBUS - RIGHT SIDEWALL

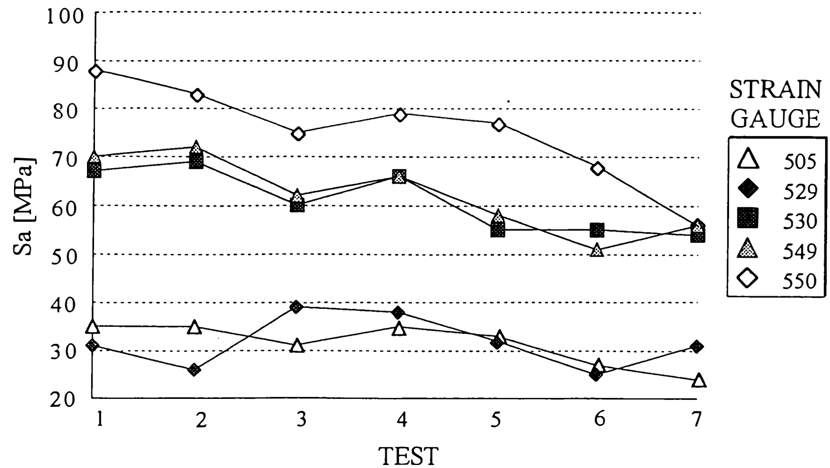

Fig. 1: Influence of springing parametres on level of dynamic stresses (excitation of II. axle)

C: REAR PART OF TROLLEYBUS - RIGHT SIDEWALL

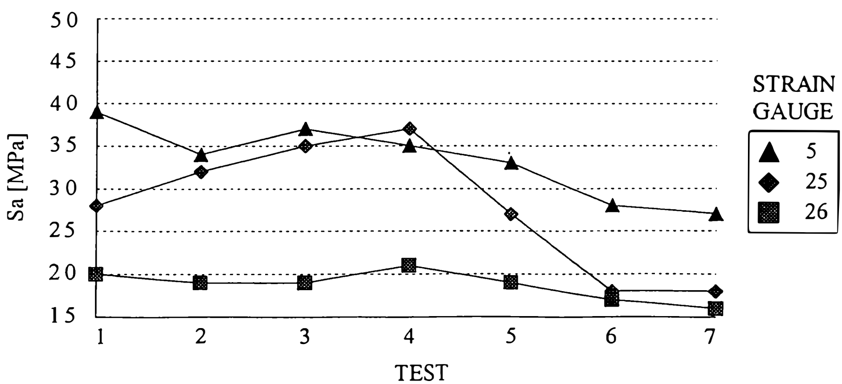

Fig. 2: Influence of springing parametres on level of dynamic stresses (excitation of III. axle)

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