
IIIrd INTERNATIONAL
SCIENTIFIC CONFERENCE
Transport Problems 2011
Katowice - Tarnowskie Góry
20 - 22 June 2011
Conference proceedings
Faculty of Transport,
Silesian University of Technology

Silesian University of Technology
Faculty of Transport

Transport Problems 2011

Conference Program

III International Scientific Conference

UNDER THE HONORARY PATRONAGE THE SILESIAN GOVERNOR AND MAYOR OF KATOWICE CITY

Media patronage:
Transport Problems International Scientific Journal
ISSN 1896-0596, The Silesian University Of Technology,
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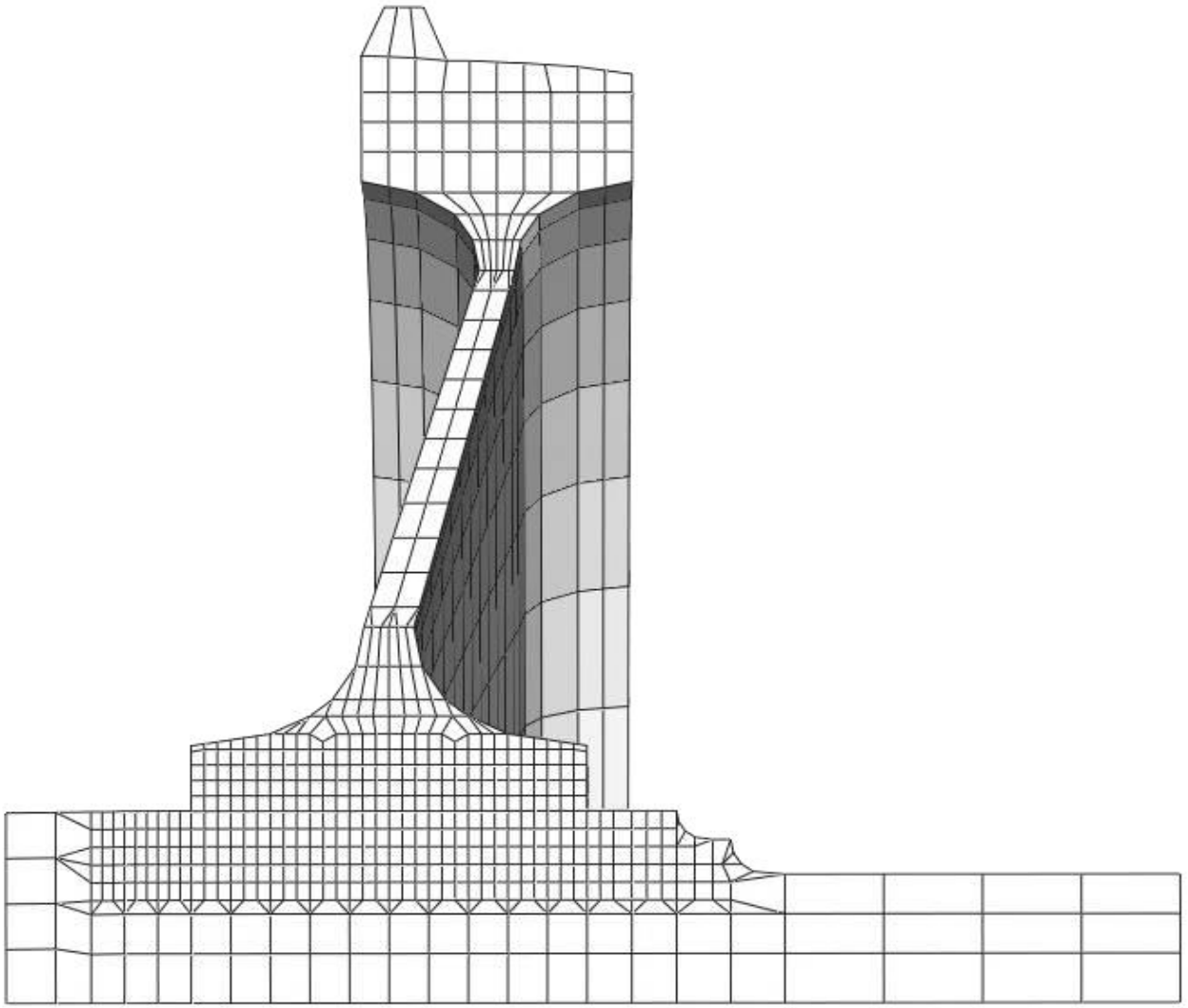
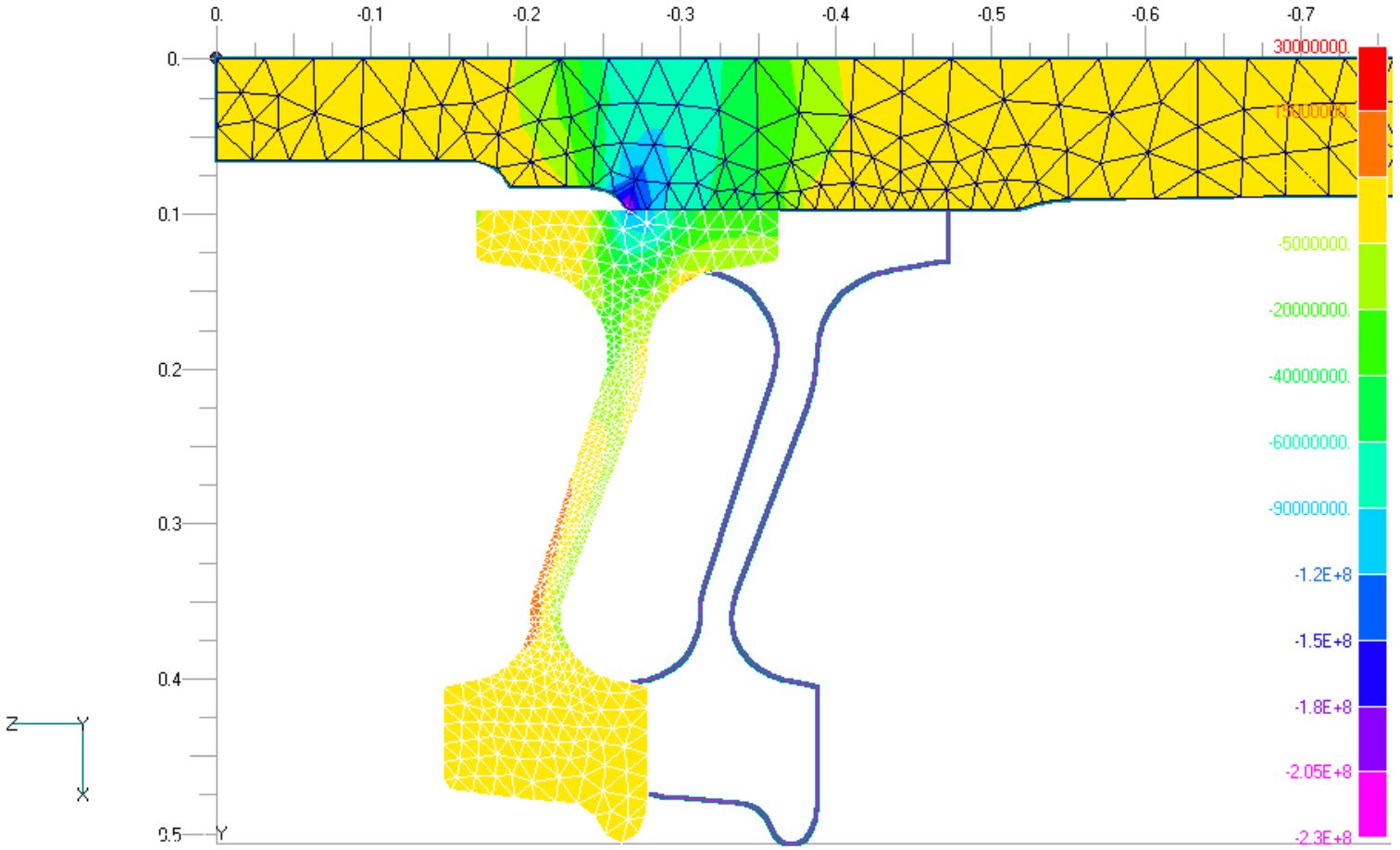
FACTOR ANALYSIS OF BEARING CAPACITY OF THE RAILCAR WHEELSET

Sergey Krotov, Aleksander Sładkowski, Viktor Krotov

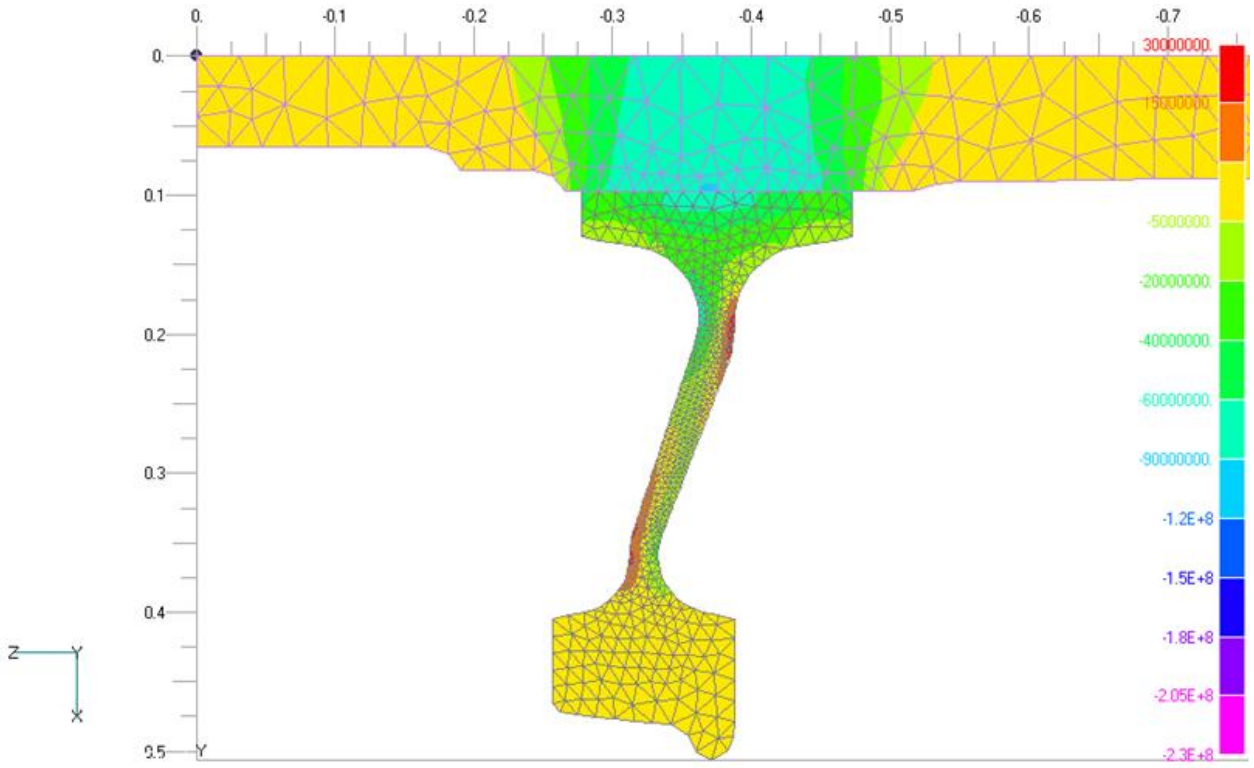
FEM MODELING OF WHEEL-AXLE ASSEMBLY



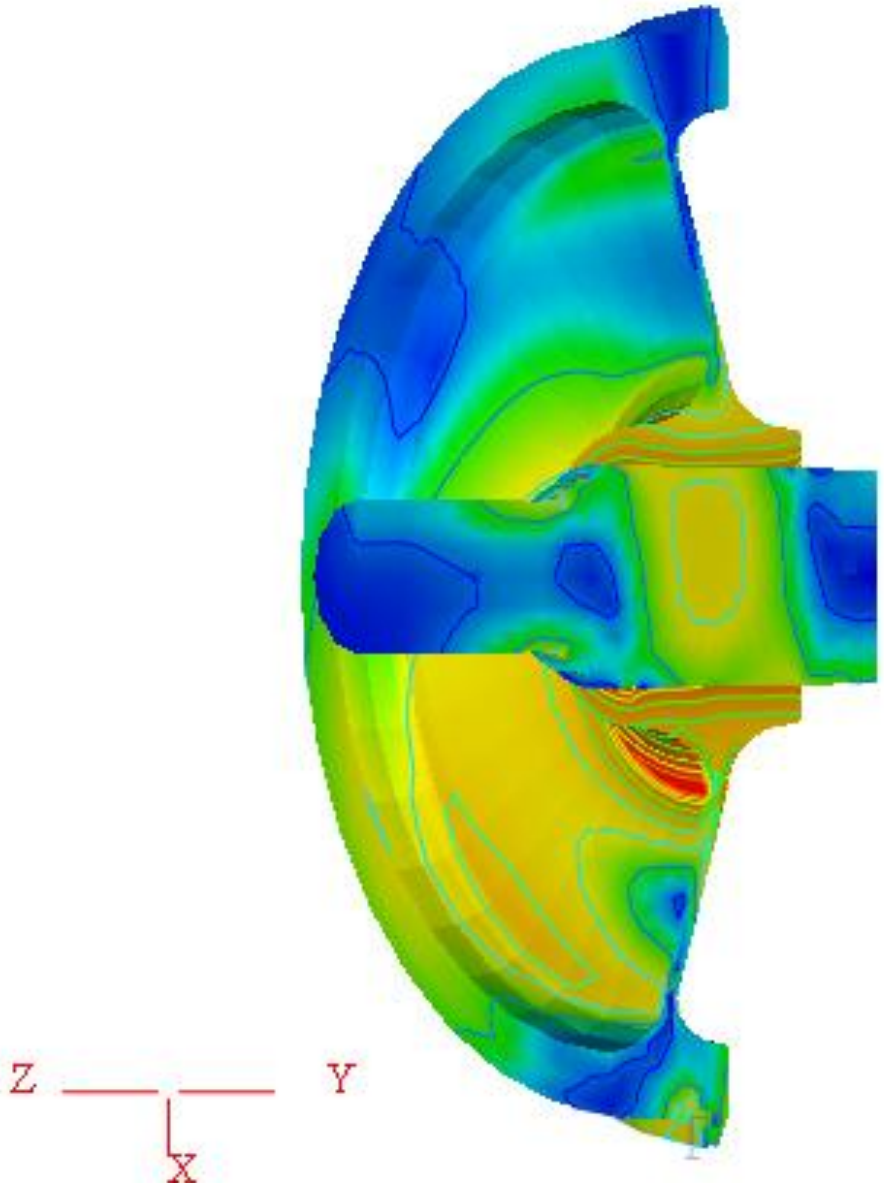
MOUNTING WHEEL ON THE AXLE (BEGIN)



MOUNTING WHEEL ON THE AXLE (END)



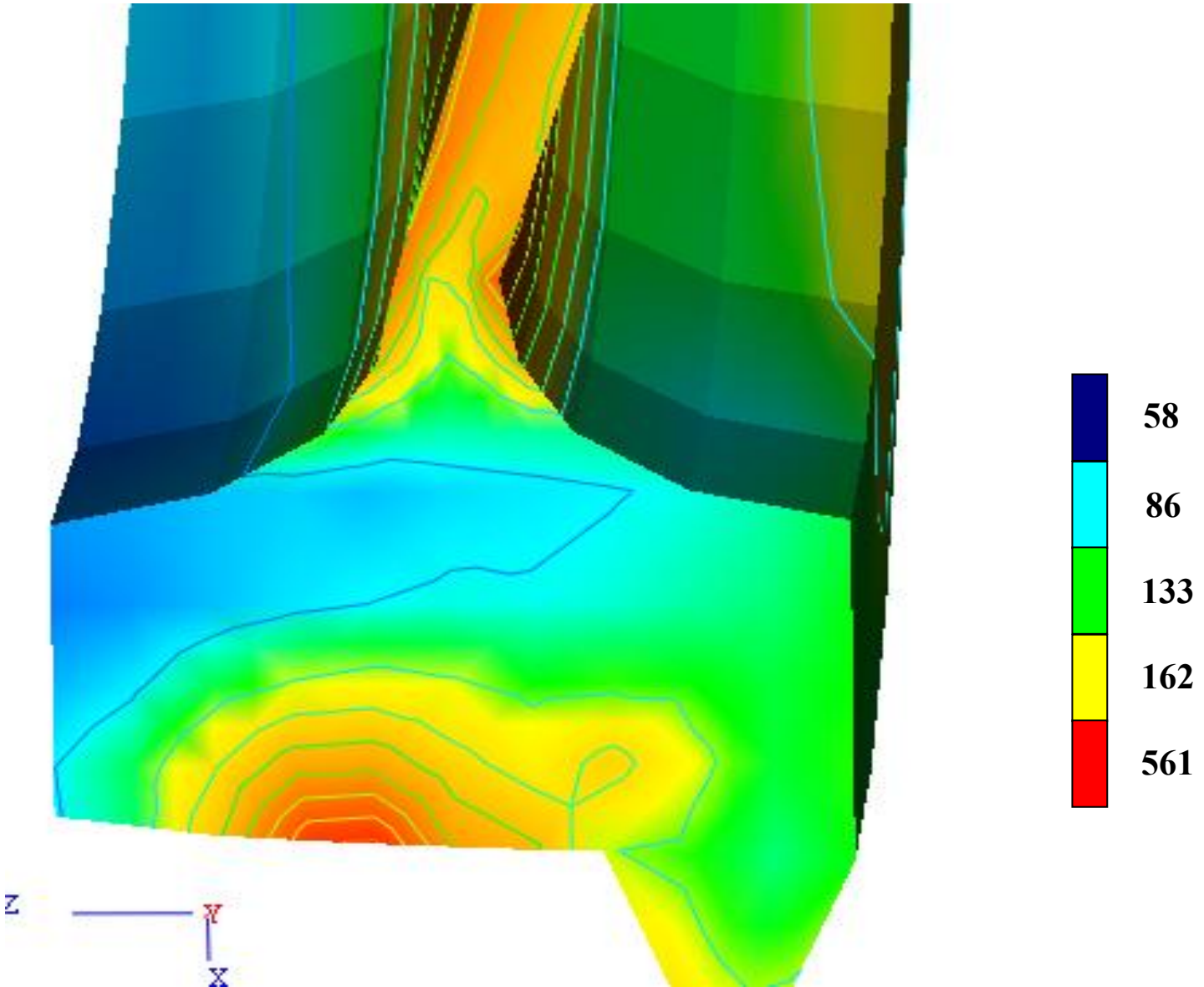
STRESS-DEFORMED STATE
VERTICAL LOAD 210 kN HORIZONTAL LOAD 60 kN



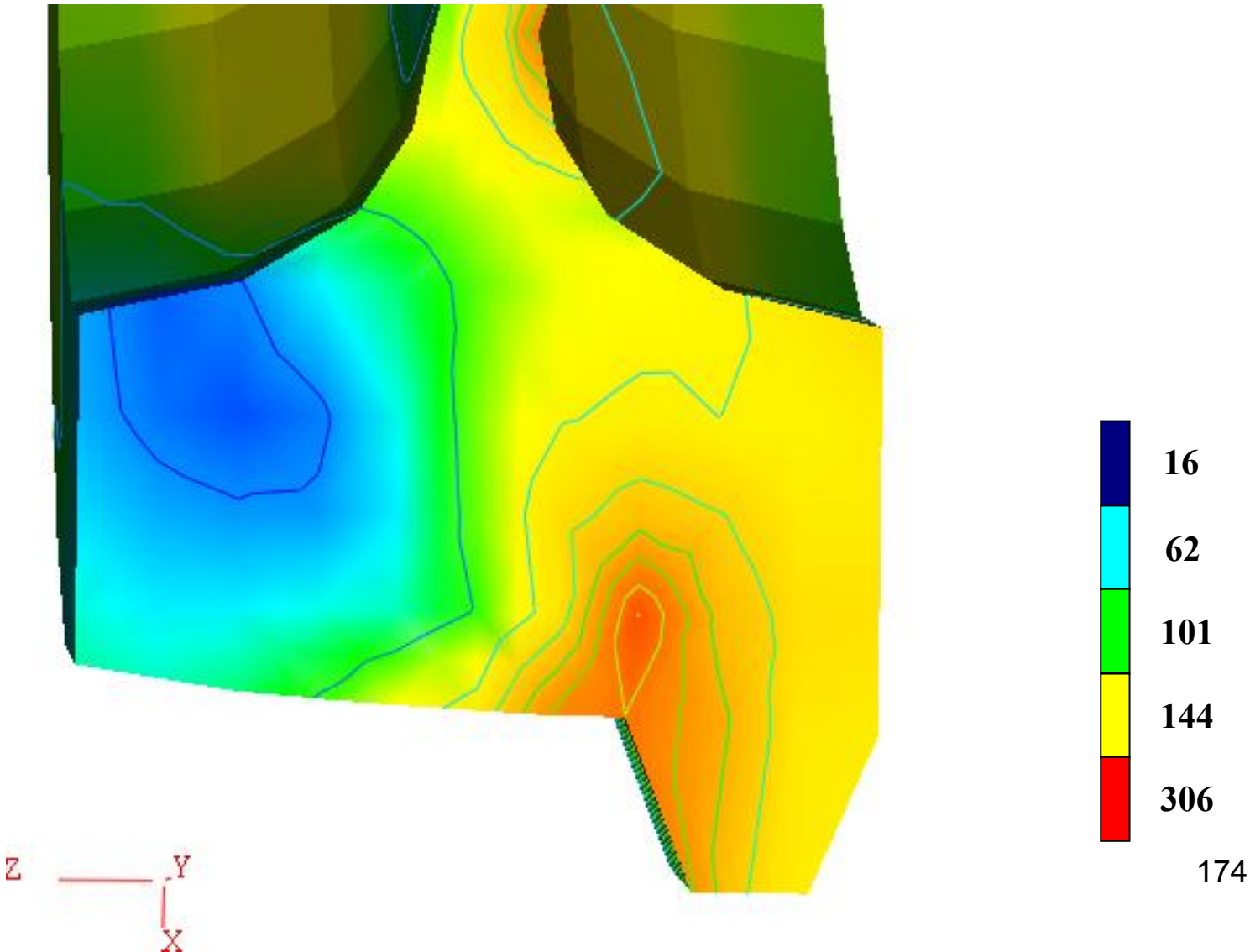
LEVELS OF ADJUSTABLE PARAMETERS

Vertical load on an axis (VERT)	**216 кN**		**245 кN**
Horizontal load on a wheel (POPER)	**60 кN**		**120 кN**
The twisting moment (MOKR)	**0**		**1710 кN·sm**
Mode of braking (TORM)	**0**	**1**	**2**
Eccentricity of a touched point to a rail (EXCENT)	**2,8 sm**		**7,5 sm**
Thickness of a wheel rim (TOLOBOD)	**7 sm**		**2,2 sm**

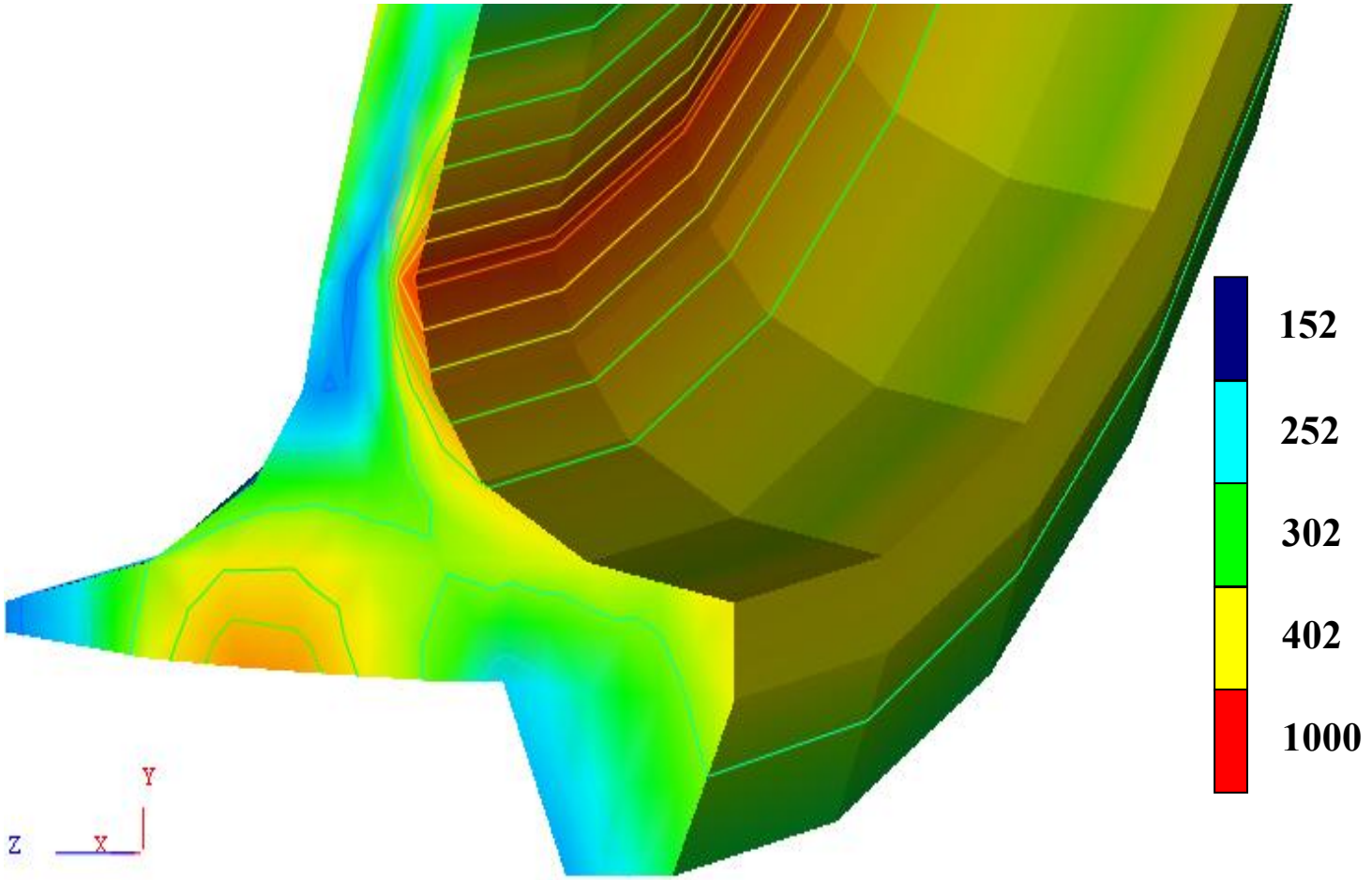
STRESS – DEFORMED STATE AFTER EXTREME BRAKING



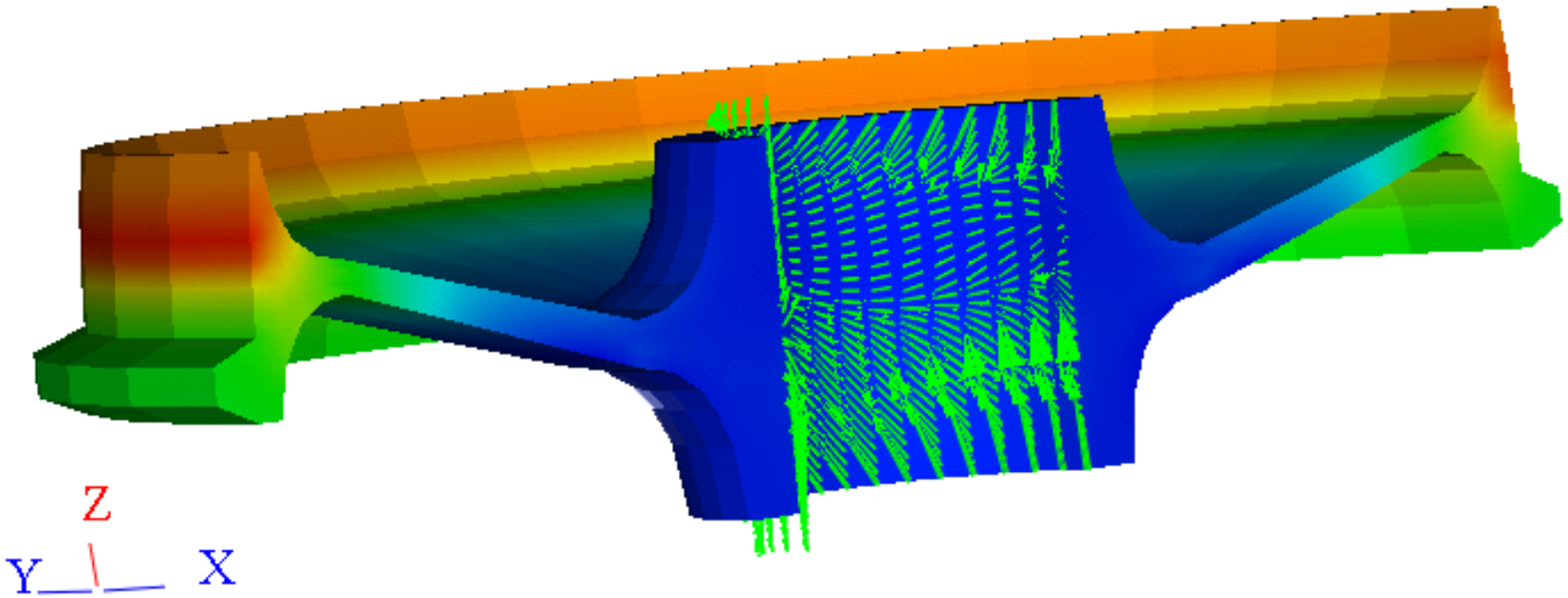
STRESS – DEFORMED STATE
VERTICAL LOAD 245 kN HORIZONTAL LOAD 120 kN



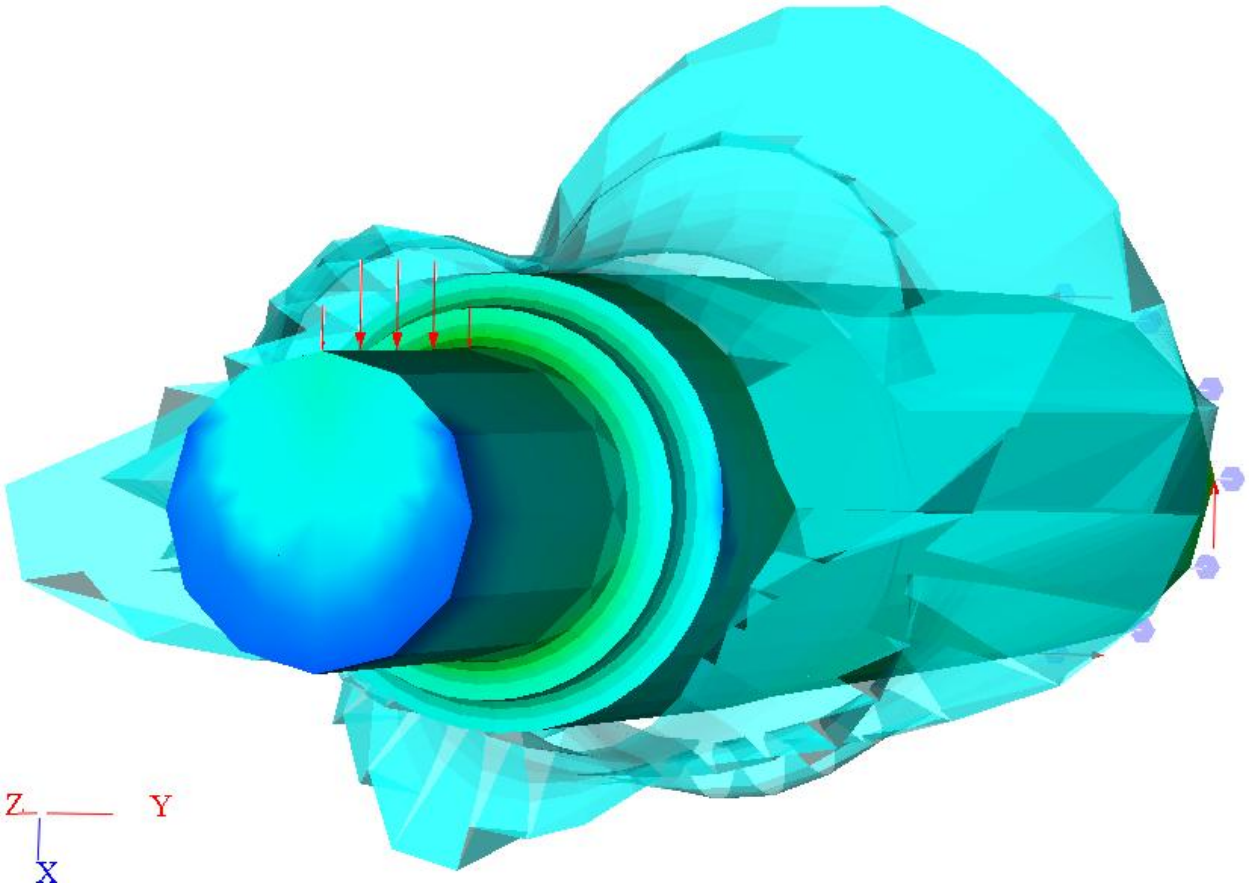
STRESS – DEFORMED STATE
VERTICAL LOAD 245 kN HORIZONTAL LOAD 120 kN
WORK BRAKING



STRESS-DEFORMED STATE AFTER WORK BRAKING



TOTAL SHEAR STRESSES IN WHEEL-AXLE ASSEMBLY

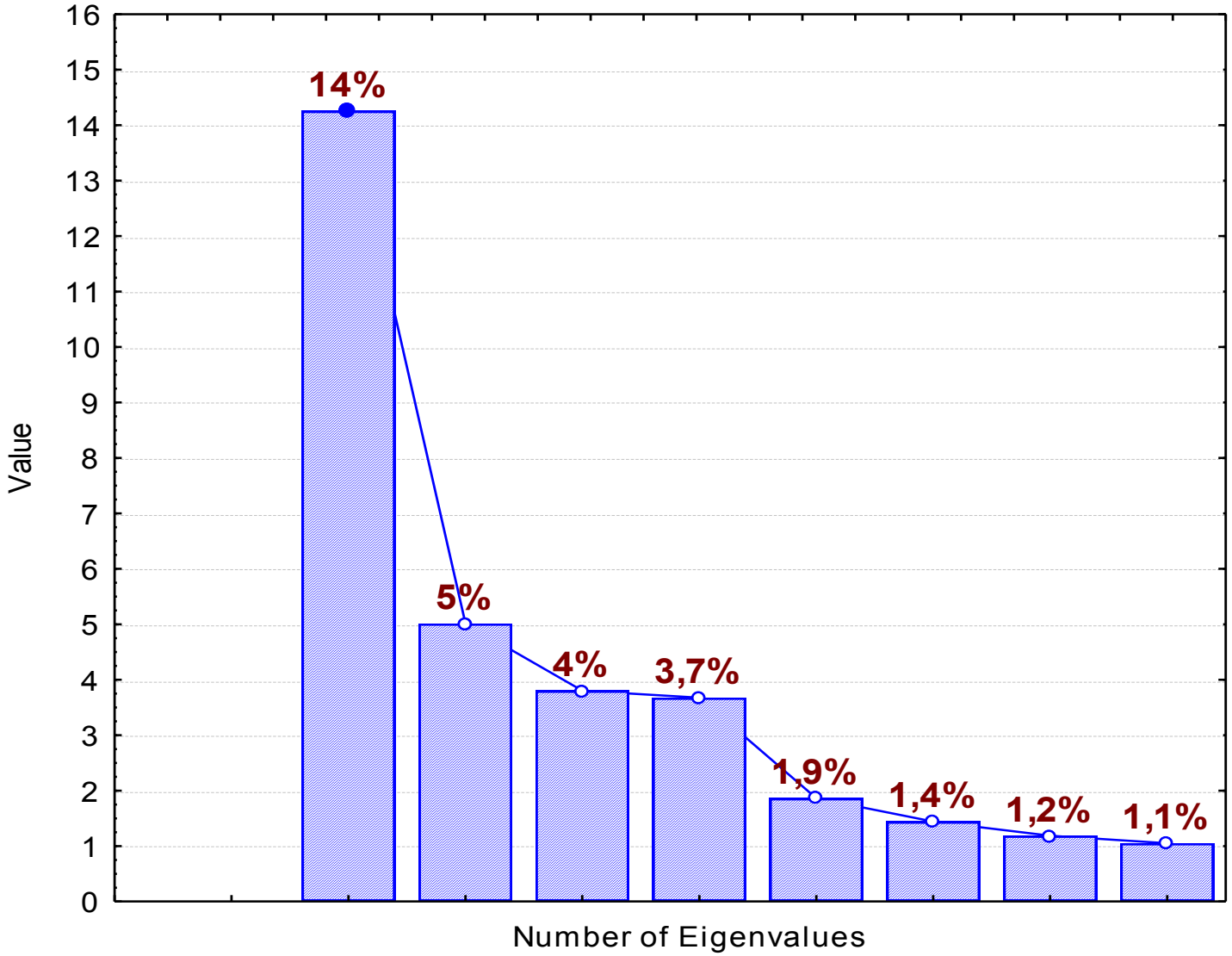


Variable	Factor Loadings (Varimax raw) Extraction: Principal components (Marked loadings are > ,400000) Fact 1	Fact 2	Fact 3	Fact 4	Fact 5	Fact 6	Fact 7	Fact 8
VERT	0.0	0.01	0.01	-0.02	0.01	-0.02	-0.01	0.95
POPER	-0.1	0.73	0.02	0.12	0.08	0.52	0.15	-0.02
MOKR	0.0	-0.14	0.02	0.96	-0.11	0.02	0.02	-0.01
TORM	0.3	0.04	-0.94	0.02	-0.02	0.05	-0.08	0.03
EXCENT	0.1	-0.47	0.01	-0.12	-0.02	0.74	-0.03	-0.08
TOLOBOD	-0.3	-0.10	-0.16	0.01	-0.08	-0.09	0.74	-0.01
SUMFORSE	-0.9	-0.07	-0.36	0.05	-0.03	0.08	-0.05	0.02
MAXPRESS	0.3	0.91	0.11	0.08	0.14	0.03	0.07	0.03
MAXROUND	0.5	0.12	0.40	0.19	0.03	0.10	0.29	0.06
MAXAXIS	0.1	0.94	0.02	0.09	-0.02	-0.03	-0.05	0.02
ZONESKOL	0.2	0.74	0.27	0.05	-0.05	-0.16	-0.13	0.12
NORMCONT	0.1	0.27	0.06	0.93	-0.05	0.03	0.00	0.00
TANGCONT	-0.1	0.10	0.06	0.40	-0.01	0.33	0.14	0.31
EQUMAX	0.9	0.18	-0.20	-0.01	0.02	0.06	-0.15	0.02
SX_MAX	1.0	0.10	-0.06	0.03	-0.00	0.00	0.02	-0.03
SY_MAX	1.0	0.13	-0.03	0.00	0.03	-0.02	0.00	-0.01
SZ_MAX	1.0	0.14	-0.07	0.01	0.03	-0.02	-0.00	-0.01
TXY_MAX	0.9	0.11	-0.30	0.02	0.01	0.01	-0.13	0.02
TXZ_MAX	0.8	0.14	0.29	0.20	0.21	-0.01	0.07	0.01
TYZ_MAX	0.7	0.12	0.20	0.11	0.19	-0.18	-0.02	0.16
EQU__STR	0.6	0.49	0.25	-0.10	0.42	0.23	0.27	0.03
SX	-0.3	-0.85	-0.13	0.02	-0.25	-0.14	-0.03	-0.03
SY	0.5	-0.03	0.26	-0.21	0.53	0.40	0.29	0.02

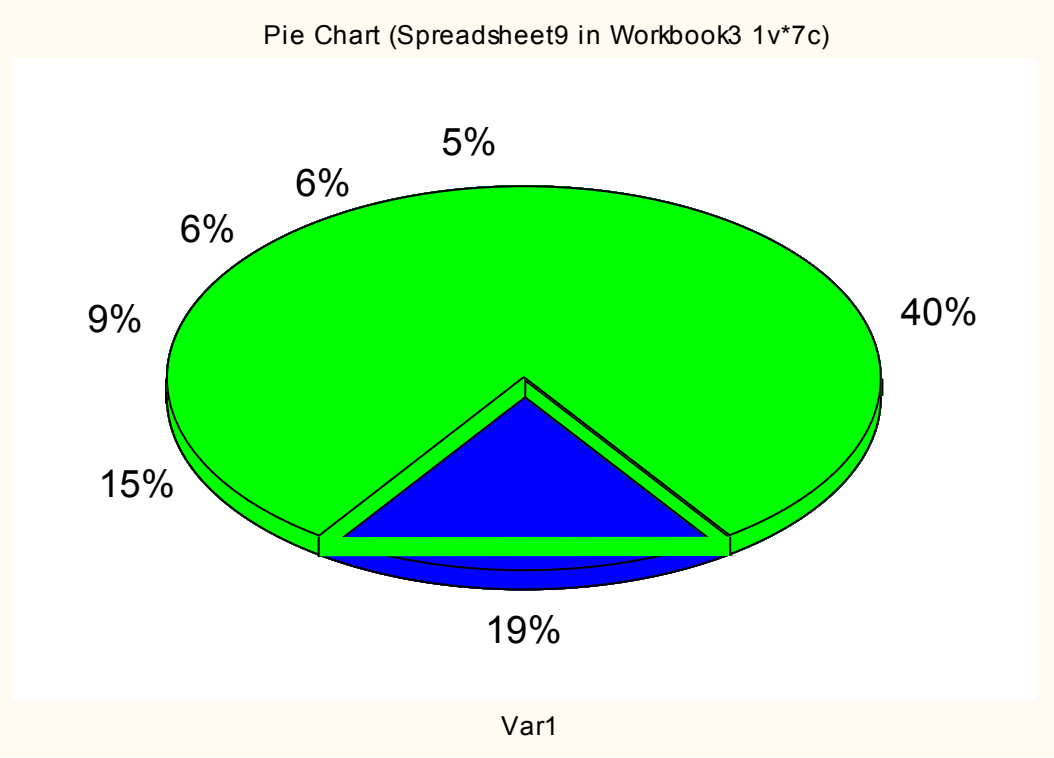
FACTORS WITH EIGENVALUES >1

Value	Eigenvalues Extraction: Principal components			
	Eigenvalue	% Total variance	Cumulative Eigenvalue	Cumulative %
1	14.25938	37.52468	14.25938	37.52468
2	5.01179	13.18893	19.27117	50.71360
3	3.80098	10.00257	23.07214	60.71617
4	3.67520	9.67157	26.74734	70.38774
5	1.86337	4.90359	28.61071	75.29133
6	1.44283	3.79693	30.05354	79.08826
7	1.18720	3.12420	31.24073	82.21246
8	1.05172	2.76769	32.29246	84.98015

EIGENVALUES BY FACTORS



DISPERSION EXPLAINED BY 7 FACTORS



DEFINE VARIABLE OR FACTOR

$$ZSK = -0,474 f_1 - 0,633 f_2 + 0,009 f_3 + 0,077 f_4 + 0,27 f_5 + 0,049 f_6 -$$
$$-0,013 f_7 + 0,095 f_8 + 0,138 f_9 - 0,203 f_{10}$$

$$F_1 = -0,028 V_1 - 0,265 V_2 - 0,059 V_3 - 0,074 V_4 + 0,077 V_5 + 0,356 V_6 +$$
$$+0,896 V_7 - 0,666 V_8 + 0,837 V_9 - 0,617 V_{10} - 0,439 V_{11} - 0,474 V_{12} -$$
$$-0,309 V_{13} - 0,032 V_{14} - 0,876 V_{15} + 0,608 V_{16} - 0,921 V_{17} + 0,577 V_{18} -$$
$$-0,921 V_{19} + 0,577 V_{20} - 0,913 V_{21} - 0,21 V_{22} - 0,804 V_{23} + 0,811 V_{24} -$$
$$-0,912 V_{25} + 0,785 V_{26} - 0,747 V_{27} + 0,744 V_{28} - 0,788 V_{29} + 0,67 V_{30} -$$
$$-0,575 V_{31} + 0,194 V_{32} - 0,095 V_{33} + 0,309 V_{34} +$$
$$+0,384 V_{35} + 0,824 V_{36} + 0,227 V_{37} - 0,833 V_{38}$$

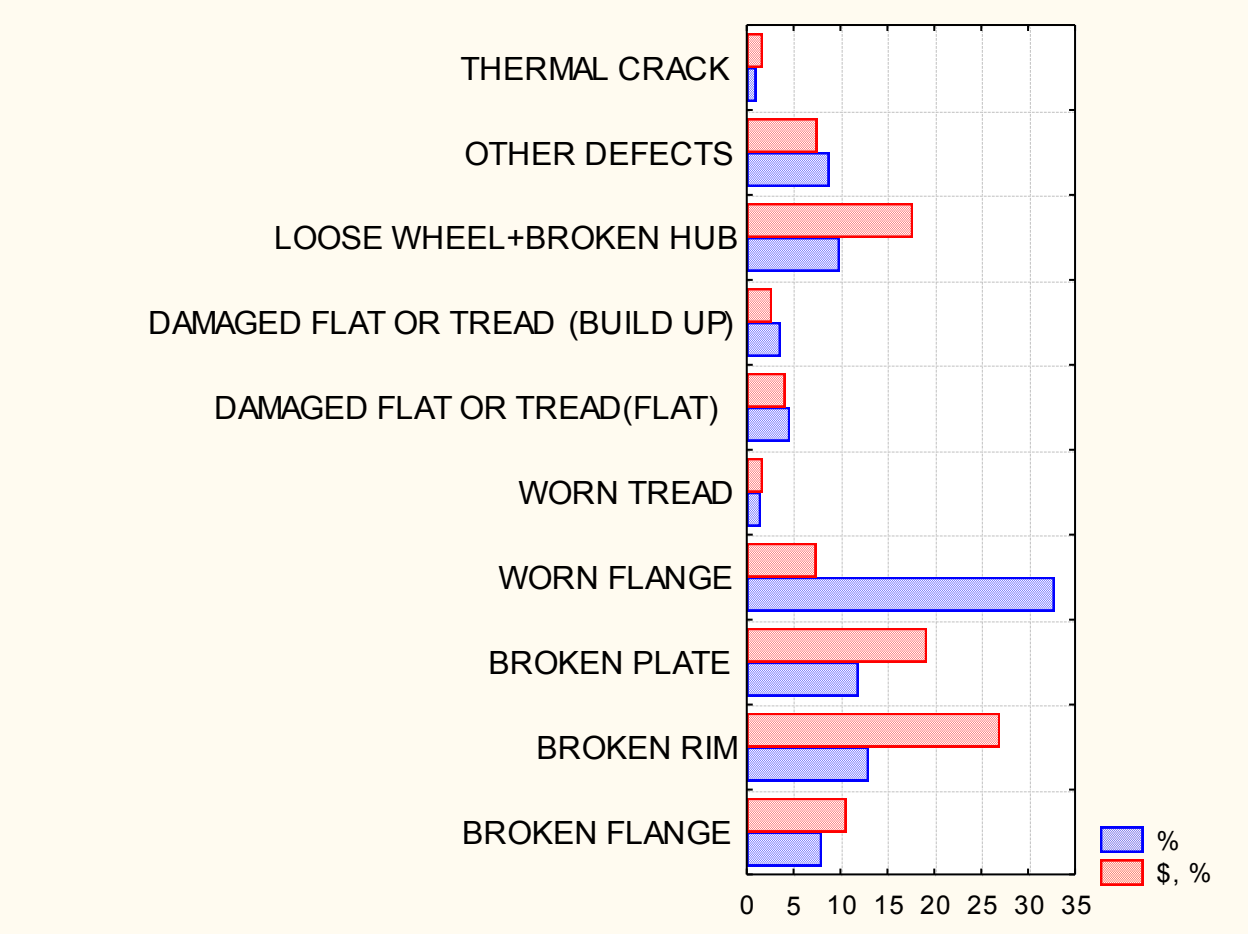
INTERPRETATION OF FACTORS

1. stress – deformed state of the wheelset
2. carrying capacity of the wheel-axle assembly
3. state of the wheelset during braking
4. effect of horizontal load on the wheelset
5. wheelset wear
6. vertical load on the axle wheelset

REPORTABLE DAMAGE (AVERAGE)

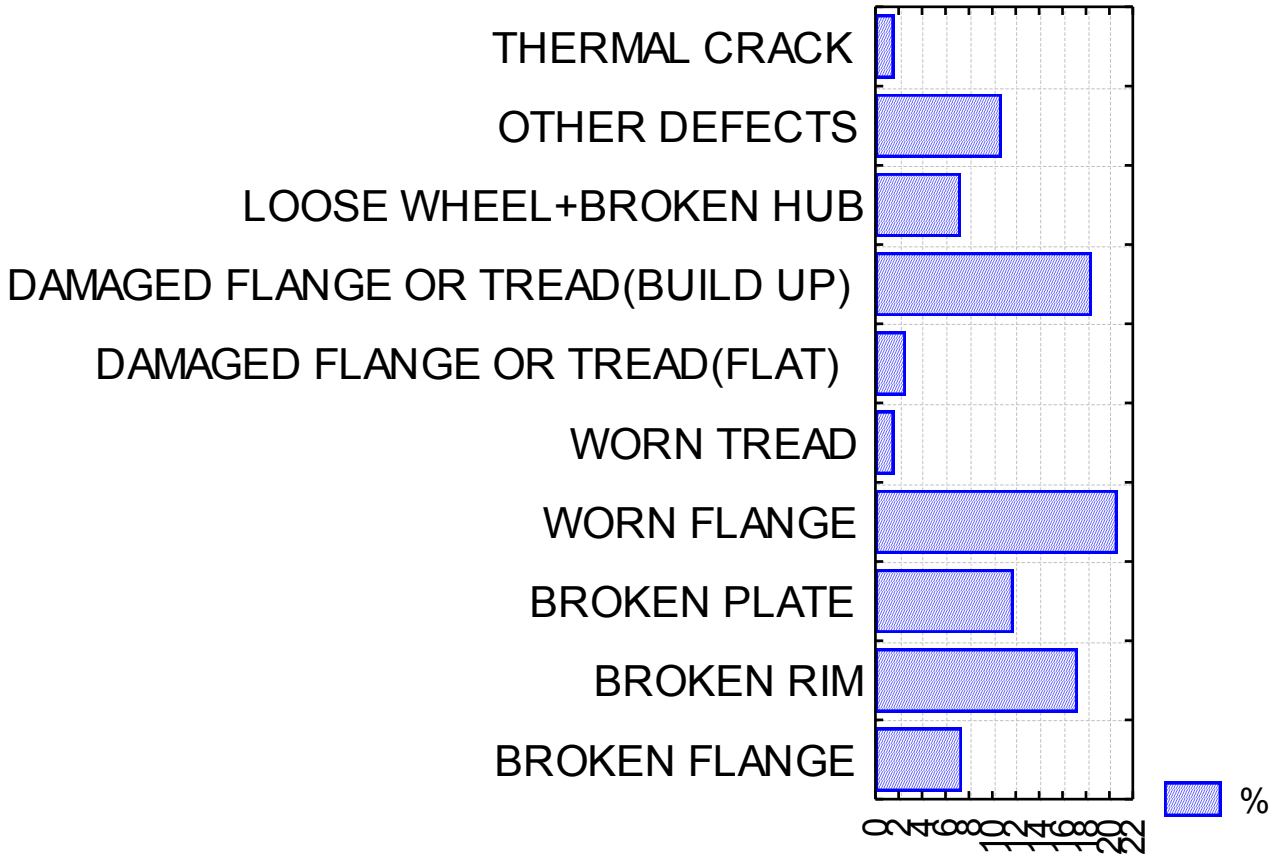
Specific causes:	$
Broken flange	113729
Broken rim	176638
Broken plate	137962
Worn flange	19198
Loose wheel	120348
Damaged flange or tread (flat)	76858
Damaged flange or tread (build up)	64477
Worn tread	100420
Thermal crack, flange or tread	143760

TRAIN ACCIDENTS BY CAUSE FROM FRA
ALL WHEEL ACCIDENTS, $ + %

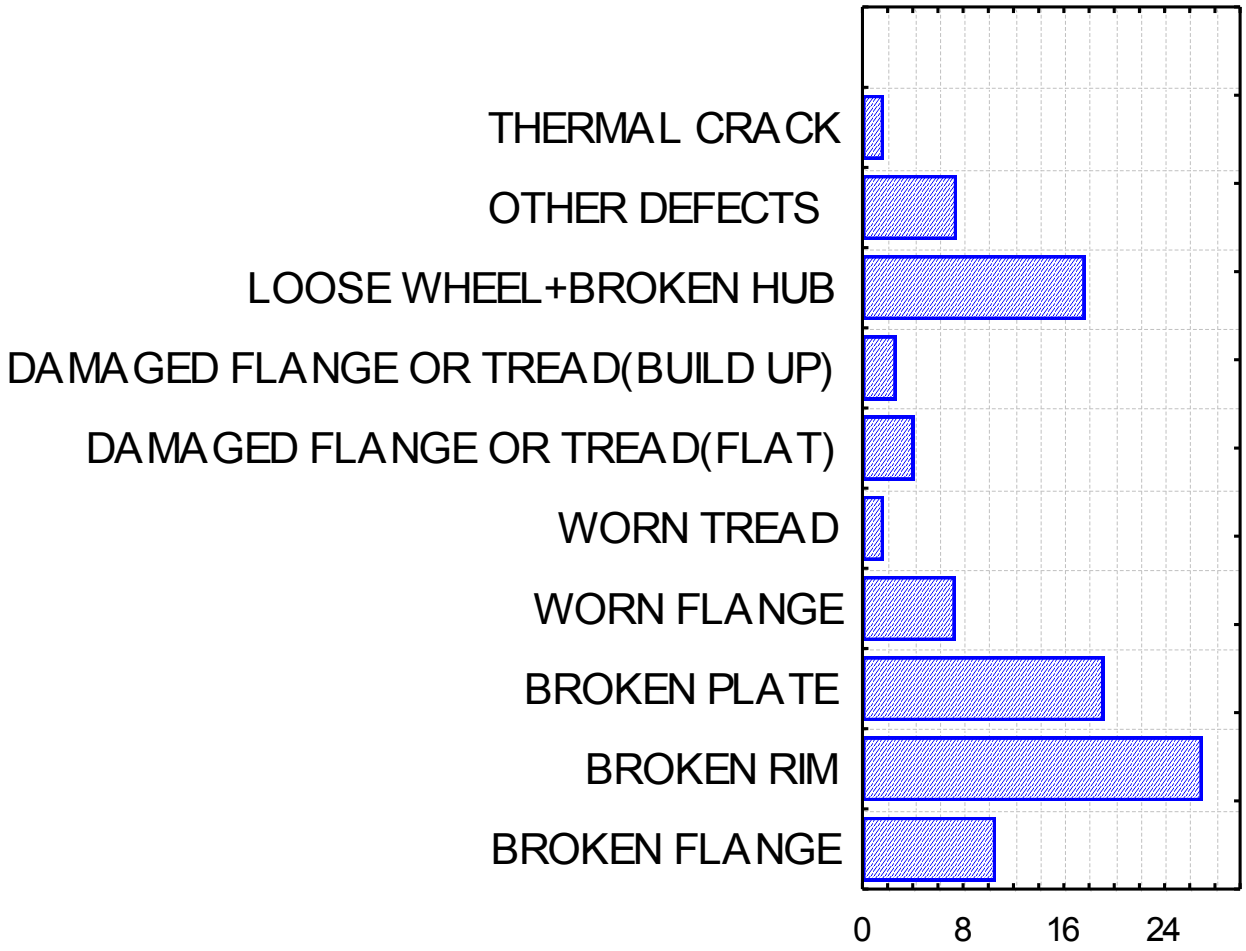


TRAIN ACCIDENTS BY CAUSE FROM FRA

ALL WHEEL ACCIDENTS, %



TRAIN ACCIDENTS BY CAUSE FROM FRA
ALL WHEEL ACCIDENTS, $ (%)



WHEEL ACCIDENTS (30 YEARS) OF ALL USA RAILROADS | %+$

Specific causes:	Total		Type of Accident			Reportable Damage		Casualty	
	Cnt	%	Coll	Der	Othr	Amount	%	Kld	Nonf
Broken flange	354	7.9	3	345	6	40,259,905	10.6	0	18
Broken rim	582	13.1	1	565	16	102,803,055	27.0	0	22
Broken plate	530	11.9	-	512	18	73,120,004	19.2	0	47
Broken hub	116	2.6	-	116	-	13,924,275	3.7	0	3
Broken hub (LOCO)	4	0.1	-	4	-	1,689,946	0.4	0	0
Worn Flange	1,460	32.8	18	1,427	15	28,029,167	7.4	0	22
Worn flange (LOCO)	99	2.2	-	99	-	5,820,886	1.5	0	7
Worn tread	67	1.5	1	64	2	6,728,130	1.8	0	1
Damaged flange or tread (flat)	204	4.6	1	200	3	15,679,079	4.1	0	11
Damaged flange or tread (build up)	161	3.6	-	159	2	10,380,824	2.7	0	0
Loose wheel	328	7.4	3	324	1	39,474,295	10.4	0	44
Other wheel defects (CAR)	392	8.8	14	363	15	28,602,483	7.5	18	67
Thermal crack, flange or tread	46	1.0	-	46	-	6,612,950	1.7	0	1
Thermal crack, flange or tread (LOCO)	2	0.0	-	2	-	304,838	0.1	0	0
-- Total	4,457	100	41	4,327	89	380,934,187	100.0	18	262