Bulletin of the *Transilvania* University of Braşov
Series II: Forestry • Wood Industry • Agricultural Food Engineering • Vol. 5 (54) No. 1 - 2012

DETERMINATIONS REGARDING DEFLEXION VALUES GENERATED BY ROAD TIMBER TRANSPORTATION

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Abstract: *This paper analyses the road complex bearing capacity for a gritted forest road. For this purpose, on the Pravăţ forest road, five homogeneous measuring sectors were sampled, where the elastic deflections were determined, in accordance with the current normative, by using a Benkelmann deflectometer. The obtained results indicated an insufficient and non uniform bearing capacity across the road, and as remediation, supplementary consolidation of the actual road structure by adding one more road layer was suggested.*

Key words: *elastic deflexion, deflect meter, roadway, bearing capacity.*

1. Introduction

Timber transport represents the hauling process of harvested timber, form the landing sites where it had been previously skidded or yarded to final consumers or beneficiaries. At nowadays' technical level, it is realized, mainly, on forest roads and partially on public transportation network.

The vehicles used in forest road transportation belong to several transport means categories such as forest truck-trains, truck platforms, trucks, tractors equipped with trailers etc. Generally, the mentioned means are permanently improving, the general trend being that of tonnage increment.

The most representative are forest truck-trains, composed of a tractor truck and a semi-trailer which transports stems, having usually a net load of 20…25 tones and a total mass of 35…40 tones; this can include in certain cases the crane for timber loading-unloading.

Transportation infrastructure is represented by different forest roads which constitute the permanent transport network, and which are connected to public transport network by forest linking roads [3].

If public roads can be either county or communal, rarely national, and can be endowed with different modern cover layers, forest roads are mostly gritted roads and only on short distances, in the proximity of public network connection, they can be endowed with superior cover layers.

From the above presented ideas, it results that the actual timber transport is performed mostly on gritted forest roads, forest truck-trains of increased tonnage are used as means of transportation [1].

The forest roadway is exposed, under traffic activity, to some efforts which are manifested at road-tire contact surface, and which, corroborated with the climatic factors' action, determines the appearance of some degradations, which, cumulated in

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time, can lead to a technical state of the road which does not permit the vehicle circulation any longer.

The extension of degradations depends, to a large extent, on the relation between the values of wearing provoked by vehicles and the bearing capacity of the roadway, this relation being critical for road behavior under traffic. Climatic factors can sometimes have a decisive role, but only in case of calamity. As a consequence, the road behavior under traffic is tributary to vehicle-roadway relation, or more specifically, to the tire-road relation.

In case of normal pressure tires, the vehicle action on the road is manifested through vertical and tangential stresses, being more aggressive as the tonnage is greater. The bearing capacity of the roadway depends on the bearing capacity of both roadbed and road system, and on the overall road complex quality [2].

For a safe circulation deployment, without brutal degradations of the roadway it is necessary that, between the two elements which influence the circulation process, to exist an adequate technical and economic equilibrium.

The measurable element which is offered by the current state of road technique is represented by deflection. This represents the movement on vertical axis of the roadway under external pressures, which, after the pressure removal, is manifested by a partial elastic recovery of the road complex. Consequently, by deflection we understand the elastic deformation of the road complex which occurs on the stress applying moment.

The smaller the deflection, the greater and better the road complex's bearing capacity. The bearing capacity of a non-rigid or semi-rigid road complex can be appreciated by means of deflection values [2].

In this context, the conducted research followed the qualification by considering the minimum relative bearing capacity of some gritted road sectors through characteristic elastic deformation.

2. Research Location and Methodology

2.1. Research location

Research was conducted on the forest roads network from Cotmeana Forest District, Piteşti Forest Administration, which presents a total of 101.9 km of roads, from which 91.9 km are main roads, and 10 km secondary roads. From these, there were considered the secondary roads, which, by their consolidation, corresponded better to the simple gritted forest roads concept (the forecasted consolidation for forest roads in the area).

For deflection measurements, the Pravăț gritted forest road (Figure 2) was selected, having a total length of 2.5 km, and a yearly traffic of 11,000 tones. Despite the fact that the forecasted transport quantity is greater than the normal limit for secondary roads (5,000 tones), by its geometrical elements and roadway consolidation the mentioned forest road can be considered a secondary road, following that wood transportation be made in a concentrated time period in favorable climatic conditions.

Wood transport on this road will be realized with increased tonnage vehicles (SCANIA, MAN, MERCEDES), endowed with loading crane and having a net load greater than 25 tones. The mentioned vehicles belong to the two operating agents from the area.

The geometrical and constructive characteristics of the road, according to its design project and field measurements are:

- design speed: 15 km/hour;
- average platform width: 5.2 m;
- average roadway width: 3.5…4.1 m;
- shoulder width: 0.375 m;
- minimum radius: 20 m;
- maximum longitudinal rise:
    - on loaded transport: 9%;
    - on empty transport: 12%;

- visibility distance: 40 m;
- the confidence degree on torrential events: 3%;
- recommended road system: simple gravel with two ballast layers.

2.2. Research methodology

In order to determine the deflections, five experimental sectors were set on the road length at 500 meters distance in which five homogeneous sampling sectors were delimited.

In the conducted research, the Benkelmann deflectometer (Figure 1), also named Benkelmann beam was used; its utilization is enforced by the normative indicative CD31-2002 [4].

The measurements were effectuated on measuring lines, located at approximately 1 meter from the roadway edge. The measuring line represents the imaginary line which connects the measurement points situated under the same double-tire pair of the used vehicle rear axle.

The auxiliary vehicle used on measurements was R 10.215 with double-tired simple axle having the load on the rear axle P = 100 kN, as well as the tire pressure according to the normal pressure (6.25…6.75 atm). The tires presented the same pattern and no advanced depreciation.

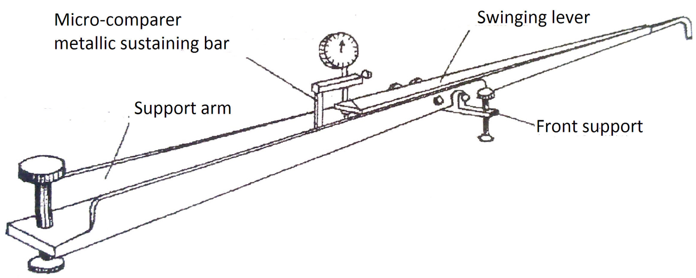

Fig. 1. *Benkelmann deflectometer*

For each measurement point, the deflections in millimeter hundredths were determined in the two stationing positions, respectively to 2.4 and 5.0 meter from the mathematic stationing point. The deflection readings were effectuated in the moment in which the double-tired axle was located in crossing at 2.4 meters, then at 5.0 meters, respectively, one minute after the vehicle's crossing over the measuring point (the vehicle movement was smoothly realized).

The recorded field data was centralized in Table 1. Supplementary calculations as well as office determinations regarding the corrected deflections according to the influence line and transformations according to the sample vehicle, respectively values for "d" and "d_i" are provided.

Fig. 2. *Pravăț forest road*

In columns 3 and 4, 7 and 8, the "d" and "d_i" deflections calculated by applying the following relations were inscribed:

$$d = 2\, d_{5.0} - d_{2.4} \text{ [mm hundredths]}, \quad (1)$$

$$d_i = 115\, d/P \text{ [mm hundredths]}, \quad (2)$$

Table 1

Inventory of recorded deflections measured on homogeneous sectors as well as calculated deflections for forest road PRAVĂȚ

Road sector no. and kilometric position	Degradation of roadway							
	Left [0.001 mm]				Right [0.001 mm]			
	$d_{2.4}$	$d_{5.0}$	d^{*}	d_i^{**}	$d_{2.4}$	$d_{5.0}$	d^{*}	d_i^{**}
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 Km 0+500	96	98	100	115	122	126	126	149
	140	148	156	179	254	272	290	333
	340	348	356	409	196	204	212	244
	166	174	182	209	140	146	152	175
	400	402	402	465	520	528	536	616
2 Km 1+000	340	372	404	558	420	450	480	662
	400	400	400	552	412	428	444	613
	740	786	832	1148	470	510	550	759
	360	376	392	541	320	334	348	480
	670	700	730	1007	340	360	380	524
	420	430	440	607	350	376	392	541
	1470	1500	1530	2111	880	894	908	1253
	720	770	820	1132	416	436	456	629
3 Km 1+500	350	355	360	497	250	268	286	395
	152	156	160	221	200	270	280	386
	380	392	404	558	170	176	182	251
	140	145	150	207	178	205	232	320
	120	126	132	182	85	87	87	20
	97	100	100	138	-	-	-	-
4 Km 2+000	450	496	542	726	240	280	320	429
	210	260	310	444	420	496	572	766
	230	264	294	394	416	448	480	643
	258	276	292	391	350	384	418	560
	370	374	374	501	266	280	294	394
	340	390	440	590	390	420	450	603
5 Km 2+500	258	260	260	343	160	160	160	211
	190	194	194	256	340	356	372	491
	290	296	302	399	220	234	248	327
	858	858	858	1133	-	-	-	-

Note: d^{*} - deflections corrected in function of the influence line; d_i^{**} - deflection corresponding to the rear axle of the etalon vehicle R10215.

where: d represents the corrected deflection in relation to the influence line; $d_{5.0}$ and $d_{2.4}$ - deflection readings of the instrument for 5.0, respectively 2.4 meters from the edge of the roadway; P - the load on the rear axle of vehicle R.10215 (P = 100 kN).

3. Results and Discussions

The results of the measurements were statistically analysed, by considering the following indicators:

- Average deflection:

$$d_{BM} = \sum_{i=1}^{n} \frac{d_i}{n} ; \quad (3)$$

- Standard deviation:

$$s_B = \sqrt{\frac{\sum d_i^2 - n d_{BM}^2}{n}} ; \quad (4)$$

- Variation coefficient:

$$C_v = 100 \frac{s_B}{d_{BM}} , \quad (5)$$

where: d_{BM} - is the arithmetic mean of the determined deflections values in hundredths of mm; d_i - the individual values of corresponding deflection for the sample vehicle, with the loads of 115 kN on the rear axle calculated with relation:

$$d_i = 115 \frac{s_B}{d_{BM}} , \quad (6)$$

where d is deflection corrected according to the influence line (Table 1); P - the load on the rear axle of the measurement vehicle (100 kN); n - number of individual values; s_B - standard deviation for the deflections measured by the Benkelmann deflectometer, in hundredths of mm; C_v - variation coefficient.

For all five homogeneous measurement sectors, the centralization of the resulted values is presented in Table 2, which also contains a final column representing the characteristic deflection values d_{CB}.

In order to appreciate the quality of the bearing capacity, in relation to the minimum relative bearing capacity, the characteristic deflections d_{CB} were calculated using the following relation:

$$d_{CB} = d_{BM} + t_\alpha s , \quad (7)$$

where: d_{BM} is the medium deflection measured by the Benkelmann deflectometer; s - standard deviation, hundredths of mm; t_α - a coefficient which depends on the probability of a greater value than the characteristic one for deflection occurrence, as well as on the technical class of the road and on the number of determinations (for forest roads included in the IV and V technical classes, the following values must be adopted: 2.09 for $n \geq 20$ determinations and 1.96 for $n < 20$ determinations).

Table 2

Statistical indicators of measured deflections and resulted characteristic deflections

Homogeneous sector no. and kilometric position	**Statistical indicators**			d_{CB} **[0.01 mm]**
	d_{BM} **[0.01 mm]**	s_B **[0.01 mm]**	C_v	
1 [0+500]	289.40	154.15	53.27	591.53
2 [1+000]	819.81	414.00	50.54	1631.25
3 [1+500]	288.64	152.74	52.92	588.01
4 [2+000]	536.75	126.13	23.50	783.96
5 [2+500]	451.43	290.83	64.42	1021.46

Note: all the investigated sectors present an insufficient bearing capacity, having values for $d_c < 300$ hundredths of mm.

4. Conclusions

The determination of characteristic elastic deflections using the Benkelmann deflectometer lead to values which permit the qualification of the bearing capacity for Pravăț forest road as being insufficient on all the five homogeneous sectors, sampled on the road length. The minimum prescribed value (current normative) is of

300 hundredths of mm in case of gravelled or gritted roads [4], a value which is exceeded in all the five sectors.

The execution uniformity is considered to be unsatisfactory because the values of the variation coefficients are greater than 40% in the case of all five sectors [4].

From a qualitative point of view, it is obvious that the bearing capacity is neither sufficient nor uniform on the road length.

Among the possible causes of this situation, the sub-dimensioned road system, as well as the utilization of some local rock materials in road construction, having non-verified mechanical quality and insufficient compaction can be mentioned.

Road rehabilitation supposes, as a general measure, the supplementary consolidation of the current road structure, by adding a supplementary road layer.

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