GEOTECHNICAL STUDY AND DIMENSIONING FOR THE STRUCTURE OF THE AGRICULTURAL ROAD 122, FROM GODINEŞTI COMMUNE, GORJ COUNTY

Diana MARCHIŞ[1], C. NISTOR[1]
[1]University of Petrosani, Faculty of Mining
E-mail: marchisdiana@yahoo.com

***Abstract**: In the context of the need to modernize and develop the agricultural sector, the development of access roads for agricultural exploitation has become a goal without which progress cannot be achieved. With the start of the National Rural Development Program, it was necessary to find solutions for the dimensioning the road structures for certain agricultural areas of Romania, so in this paper we carried out a punctual research for an agricultural road situated in the commune of Godinesti, Gorj County. The road sector covered by this paper originates in P1 (km 0 + 000) at the junction with the county road DJ 672 and the destination in P 23 (km 1 + 100). The length of the agricultural road sector is of 1.100,00 m. In which regards the existing situation of the analyzed road sector, following the visual inspection and geotechnical investigations, it is noted that the agricultural road sector does not correspond to the actual requirements imposed for the category of use. Based on topographical, geological, hydrogeological and seismological studies conducted over the years in the area, the were carried out the necessary calculations for the sizing of an elastic road construction (with asphaltic structure) that can be used by agricultural machinery of up to 7.5 t, and the project for its implementation was completed.*

***Keywords**: agricultural road, rural development, asphaltic structure*

INTRODUCTION

The Oltenia Region is located in the south - west of Romania and consists of five counties: Dolj, Gorj, Mehedinti, Olt and Valcea. The region occupies an area of 29,212 km^2, representing 12.25% of the total area of Romania. [„Enciclopedia Geografica a Romaniei"]

The studied road sector is located on the administrative territory of Godineşti Commune, a locality in the West area of Gorj county on the county road DJ 672 and has as neighbors:

- la North – City Tismana
- la South – West – Commune Glogova
- la South – Commune Ciuperceni
- la East – Commune Câlnic
- la North – East – Commune Peştişani

The agricultural road 122 ensures the connection of the county road DJ 672 with the national road DN 67D. The road section between km 0 + 000 - 1 + 100, which is the subject of the present documentation, is located within the village of Arjoci belonging to Godineşti Commune and provides access of the villagers from Chiliu, Rătez and Arjoci to the county road DJ 672, to national road DN 67D and implicitly towards areas of social - cultural importance.

MATERIAL AND METHODS

Topography and geomorphology of the region

From a morphological point of view, there are two major units in the region: the mountainous area to the north and a depression to the south.

The mountainous area includes heights that often exceed 2000 m. The main massifs that form the peaks of the Vulcan Mountains, to the west and the Parang to the East, are separated from the Jiu water course that has deeply built the mountain chain. The two massifs send their extensions to the south in the form of parallel peaks, perpendicular to the direction of the main peak, separated by deep valleys generally oriented to N-S, valleys that are tributary to Jiu. [FAUR, 2009]

To the west of Jiu, on the southern edge of the mountain range, the relief changes, and from sharp peaks with steep slopes, a plateau is reached in the shape of a plateau with an altitude of 400 m. These plateaus are sprinkled with numerous valleys. The karstic phenomena in this part are very common, the limestone having a wide development (FAUR, 2009; MUTIHAC, 1964).

The mountainous area ends almost suddenly southward to a hilly area overlapping the getic depression. At the contact between mountain and depression, the valleys, especially the drainage waters, left important quantities of material.

Relief of the commune has a common evolution with the other territorial administrative units around it and consists mainly of hills covered mostly by the forests and meadows created by the waters passing its territory.

From a physical point of view, the territory of the commune is made up of the Oltenian subcarpathian depression, which is part of the great relief unit of the Getic Piedmont, a relief known as the Getic Plateau or the Getic Platform. The notion of a plateau explains the almost equal height of the hillocks, which is situated between 300 and 500 m subunit of the great geographic unit, the "Getic Subcarpathian Area", a geologically common part of the submountain depression system from Horezu to Godineşti. (MUTIHAC, 1964)

Climate and natural phenomena specific to the area

The climate of the researched perimeter is temperate - continental, having the following parameters:

• Annual average temperature .... +8.7 - 9.9 ° C;
• absolute minimum temperature .... -31.0 ° C;
• absolute maximum temperature .... + 40.6 ° C .

Annual average precipitation values are 750 - 800 mm and represent the average of values recorded over 10 years.

Separation of rainfall over seasons can be as follows:

- winter .... 150 - 180 mm
- spring .... 180 - 220 mm
- summer ....200 - 230 mm
- Autumn .... 170 - 200 mm

Are considered "precipitated" all days when water falls in the form of rain, snow, hail, snow, etc. totaling more than 0.1 mm.

Another important factor of the climate is the determination of the magnitude and direction of the winds. Thus, we can conclude that the predominant wind direction is the Nordic (14%) and the North-East (6.8%). Calm records the percentage value of 53.2% and the average wind intensity on the Beaufort scale is 1.6 ÷ 3.2 m / s.

Geology, seismicity

The Târgu-Jiu sheet is located in the SW part of Romania, covering a large part of northern Oltenia. The territory on the map contains the southern part of the Southern Carpathians, in which the crystallophilic formations with their granite and granitoid massifs spread, as well as the Paleozoic and Mesozoic sedimentary plateaus of the Danubian native. The tertiary formations of the Dacian basin are developing to the south. („Enciclopedia Geografica a Romaniei", 1982)

From a geological point of view, the two morphological units: the Getic Depression and the Southern Carpathians, represent sectors with a very special geological structure. The Getic Depression, which occupies the southern part of the map, consists of Neogene deposits with a relatively simple structure. To the north, the mountainous area has a very complicated geological structure. For the most part, this area comprises the formations of the Danubian lens, made up of crystalline shale (Dragan series, Lainici - Păiuş series) crossed by granite and granitoid massifs. This crystal supports the series of Tulisa (Paleozoic metamorphose) over which deposits of Permian and Mesozoic age deposits. (MUTIHAC, 1964; RĂDULESCU, ATANASIU, 1985)

In the eastern part of the map, as well as in the north-west corner, is represented also the unit of the getic (Getic cloth), made up of rocks with advanced metamorphism. In the form of an isolated coating, there are the crystalline valleys from the Vlaars, which belong to the getic field.

A third unit represented in the Târgu Jiu sheet is the Severin cloth, made up of Sinaia strata, which appears on the eastern edge of the map, in the Polovragi region. The hydrographic network of the studied territory is formed primarily by the river Tismana with its tributaries Orlea and Sângeriş.

The Tismana River has a surface area of 910 km² and has a length of 42 km, over 1/5 of which is located on the territory of Godineşti commune.

It is noteworthy the complex of hydro-energetic works that modified the natural flows of the Tismana River through underground adductions from the Cerna River and the Motru River as well as the creation of two accumulations for the complex use from which the Tismana downstream also has other uses (the regulation of the flood flows, the water supply localities, etc.).

According to the technical regulation "Design of seismic code - Part 1 - Design provisions for buildings" indicative P 100-1 / 2013, zoning of the ground acceleration for design, studied area for seismic events with the average recurrence interval IMR = 225 years (20% probability of overtaking in 50 years) has the value of ag = 0.15 g. (NISTOR, 2014)

The control period Tc of the response spectrum represents the boundary between the maximum acceleration spectrum range and the maximum range in the relative speed spectrum. Tc is expressed in seconds. For the studied area, the corner time is Tc = 0.7 sec.

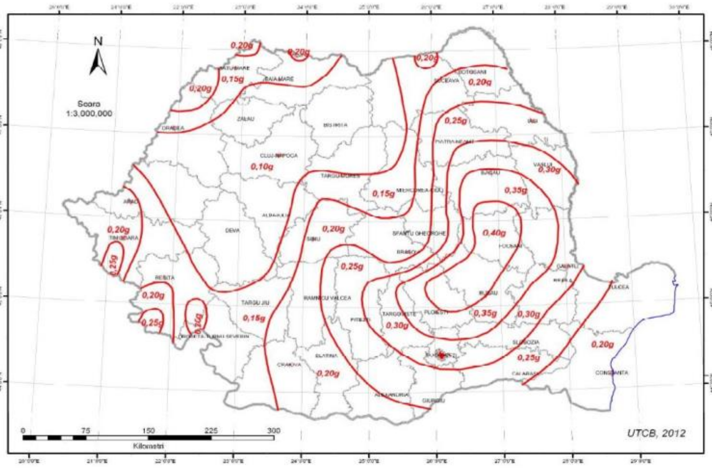

Figure 1. Zoning of peak acceleration values for a_g with IMR = 225 years and 20% probability of overtaking in 50 years

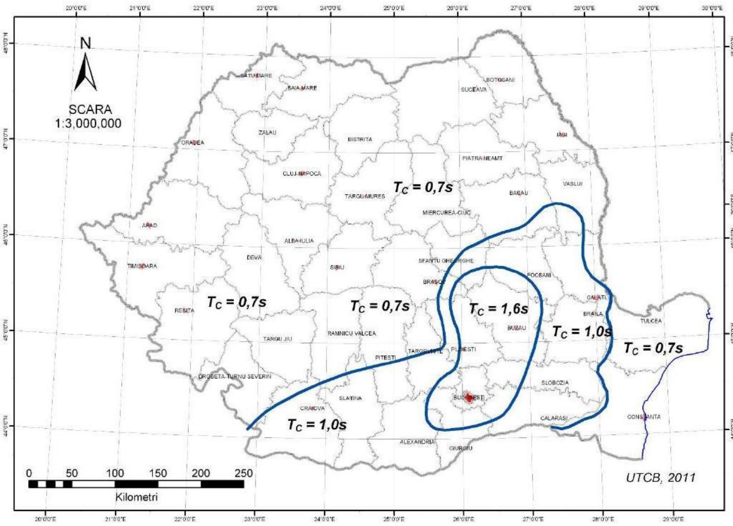

Figure 2. Zoning the territory of Romania in terms of Tc control period of the response spectrum

RESULTS AND DISCUSSIONS

Dimensioning of the road structure

The dimensioning of the road structure was based on the "Normative for dimensioning the slender and semi rigid road systems (analytical method)", indicative PD 177-2001.

The following steps have been taken into account in this dimensioning:

•Establishing the calculation of traffic

•Establishment of load-bearing capacity at the bed level

•Choosing the components of the road structure

•Analysis of the road structure at the action of the standard 115 kN axle

•Verification of the structure from the point of view of the specific admissible deformation at the base of the bituminous layers

•Verification of the structure from the point of view of the permissible vertical deformations at the foundation ground level

•Verification of structure in terms of resistance to frost-thaw phenomenon, according to STAS 1709/1, 2-1990. (NISTOR, 2014; RĂCĂNEL, 1992)

Establishing the calculation of traffic

The calculation of traffic (Nc) was based on the data provided by the beneficiary through the design theme.

Thus, the calculated traffic for the dimensioning of the road structure to be adopted on the projected sector is: Nc = 0.036 m.s.a. (million standard axles).
It results in a mild calculation, ranging from Nc = 0.03 ... 0.10 m.s.a, as indicated by CD 155-2001.

Establishment of load-bearing capacity at the bed level

According to the investigations carried out, the characteristics underlying the determination of the bearing capacity of the foundation ground are as follows:

-earth type: P5 (sandy yellow-brown clay, consistent plastic);

-hydrological regime: 2b (adverse hydrological conditions);

-Climate regime II (sub-Carpathian region).

According to the provisions of PD 177-2001, the deformability characteristics of the foundation ground are as follows:

- the calculation value of the dynamic elastic modulus of the foundation ground for the projected sector: Ep = 70 MPa. It follows that there is no need to provide a layer of shape;
- Poisson's coefficient of calculation: μ = 0,42, for P5 soil.

Choosing the components of the road structure

According to the conducted investigations and taking into account the current dangers of the projected road sector and the prevailing local materials in the area of the road site, the proposed resistance structure for modernization consists of the following road layers:

-30 cm thick existing layer of ballast (according to geotechnical survey):

-20 cm thick broken stone foundation layer;

- 6 cm thick asphalt cement mortar.

The calculation characteristics of the road layers that make up the structure of the design resistance are as shown (according to PD 177-2001) in table 1. (MANOLE, NISTOR, MARCHIȘ, 2015; NISTOR, 2014; RĂCĂNEL, 1992)

Table 1

The characteristics of the road layers

No.	Type of road layer	Dynamic elasticity modulus	Poisson coefficient
1	Foundation layer of ballast, h3 = 30 cm	E_3 = 182 MPa	μ_2 = 0,27
2	Stuffed crushed stone layer, h_2 = 20 cm	E_2 = 400 MPa	μ_1 = 0,27
3	Wearing layer of B.A.16, h_1=6 cm	E_1 = 3600 MPa	μ_1 = 0,35

The calculation of the dynamic elasticity modulus was made using the following equation:

$$E_4 = 0{,}20 \times h_4^{0{,}45} \times E_p = 182 \qquad \text{[MPa]}$$

Where E_4, h_4 and E_p have the same meaning as above.

Analysis of the road structure at the action of the standard 115 kN axle

For roads without bituminous clothing, the above-mentioned road structure was considered, for which, following the running of the CALDEROM 2000 program, the following were concluded:

Road: 122 is a homogeneous sector: modernized and non-modernized and the parameters are:

- Load. 57.50 Kn
- Tire pressure 0.625 Mpa
- Circle radius 17.11 cm

Layer 1: Module 3600. MPa, Poisson Coefficient .350, Thickness 6.00 cm

Layer 2: Module 400. MPa, Poisson Coefficient .270, Thickness 20.00 cm

Layer 3: Module 182. MPa, Poisson Coefficient .270, Thickness 30.00 cm

Layer 4: Module 70. MPa, Poisson .420 Coefficient, and Semifinite

The results are presented in table 2.

Table 2

The results for the analysis of the road structure at the action of the standard 115 kN axle

R	Z	Radial tension	Relative radial deformation	Relative vertical deformation
cm	cm	MPa	microdef.	microdef.
.0	-6.00	.790E+01	.192E+03	-.296^{E}+03
.0	6.00	.834E-01	.192E+03	-.116^{E}+03
.0	-56,00	.429E-01	.225E+03	.323^{E}+03
.0	56.00	.133E-02	.225E+03	-.525E+03

Criterion of specific deformation at the base of the bituminous layers

The specific deformation criterion at the base of the bituminous layers is respected if the fatigue degradation rate (FDR) has a value less than or equal to the admissible FDR, which for streets has a max. value of 0.90.

RDO_{adm} = max. 0,90

$$RDO = \frac{N_c}{N_{adm}}$$

where:

N_c - is the calculation of traffic in 115 kN standard axles in m.s.a (Nc = 0.036 m.s.a.);

N_{ada} - the number of admissible loads, in m.s.a, which can be taken over by the bituminous layers corresponding to the deformation state at their base, calculated on the basis of the radial deformation determined by the CALDEROM program at the base of the bituminous layers, as follows:

$$N_{adm} = 4{,}27 \times 10^8 \times \varepsilon_r^{-3.97} \qquad [\text{m.s.a}] \qquad \text{for } N_c > 1 \text{ m.s.a.}$$

$$N_{adm} = 24{,}5 \times 10^8 \times \varepsilon_r^{-3.97} \qquad [\text{m.s.a.}] \qquad \text{for } N_c < 1 \text{ m.s.a}$$

where:

ε_r - is the radial deformation at the base of the bituminous layers (in microdeformations), according to the results table.

For ε_r = 192 results N_{adm} = 2,110 m.s.a $\Rightarrow$ R.D.O. = 0.017 <$R.D.O._{adm}$

The structure is checked for compliance with the specific deformation criterion at the bottom of the bituminous layers. (RĂCĂNEL, 1992)

Criterion of specific vertical deformations at ground foundation level

The criterion of permissible vertical deformation at the level of the foundation ground is met if the following condition is accomplished:

$$\varepsilon_z \leq \varepsilon_{z\,adm}$$

ε_z - is the specific vertical deformation at the level of the foundation ground, in microdeformations, according to the results table;

$\varepsilon_{z\,adm}$ - the permissible vertical deformation at ground level, in microforms, according to the relation:

$$\varepsilon_{z\,adm} = 329 \cdot N_c^{-0.27} \qquad [\text{microdef.}] \qquad \text{for } N_c > 1 \text{ m.s.a}$$

$$\varepsilon_{z\,adm} = 600 \cdot N_c^{-0.28} \qquad [\text{microdef.}] \qquad \text{for } N_c < 1 \text{ m.s.a.}$$

In this case:

$\varepsilon_{z\ adm} = 600 \times 0.036^{-0.28}$ = 1522 microdeformations

Taking into account that ε_z = 525 microdeformations ⇒ ε_z = 140< $\varepsilon_{z\ adm}$ = 1522 ⇒ the structure is checked for adherence to the admissible vertical deformation criterion at ground level.

Verification of the structure in terms of resistance to frost-thaw phenomenon, according to STAS 1709/1, 2-1990

According to STAS 1709/1 and STAS 1709/2, the calculation steps are as follows:

- Calculate the depth of frost in the road complex. The depth of freezing in the foundation ground, according to STAS 1709/1 - 90, is Z = 65 cm.

- the depth of freezing in the roadside was calculated with the following relationship:

$Z_{cr} = Z + \Delta Z$ [cm]

in which: Z is the depth of freezing in the foundation ground;

ΔZ = Hst – He;

Hst - the thickness of the road structure;

He - the equivalent thickness of frost calculation of the road structure.

So:

Z = 65 cm (according to STAS 1709 / 1-90);

Hst = 30 cm existing dowry from gravel and crushed stone +20 cm layer of broken stone, designed + 6 cm bituminous clothing = 59 cm;

He = 6 x 0,50 + 20 x 0,75+30 x 0.9 = 45 cm (according to point 3 of STAS 1709-90);

ΔZ = Hst – He =56 – 45 =11 cm;

Zcr = Z + ΔZ = 65 + 11 = 76 cm ;

Given that:

Hst <Zcr <Naf (depth of groundwater level)

We find the situation in Table 3, STAS 1709/2, so verification is required.

Calculate the degree of frost penetration in the road complex (STAS 1709 / 2-90):

$$K = \frac{H_e}{Z_{cr}} = \frac{45}{76} = 0.592$$

A structure is considered to be freeze-thaw resistant if the frost penetration degree K has, according to Table 4, STAS 1709/2, col. 5, earth type P5 and climate type II, value min. 0.45.

Consequently, the road structure adopted is also checked against the freezing criterion (NISTOR,2014; RĂCĂNEL, 1992, 1987)

CONCLUSIONS

Regarding the existing situation of the analyzed road sector, following the visual inspection and geotechnical investigations, it can be noted that it can be grouped according to the degree of improvement of the existing road clothing, as follows:

- Sector without bituminous clothing (km 0 + 710 - 0 + 760):

Following the investigations, it was found that in the non- bituminous sector the state of viability is totally inadequate for running in normal conditions with failures of the running surface and of the frequent road surface and extended surfaces with a non-conforming road coat (with the technical condition of road clothing affected by climatic conditions, with the generation of dust and mud as a result of road traffic, etc.) and the infiltration of precipitation water into the road body (road clothing that allows infiltration of water into the road body, collecting and discharging surface water bodies that either lack or are in an inappropriate technical state, with water that can stagnate in the building area, etc.).

- Sectors with bituminous clothing (km 0 + 000 - km 0 + 710, km 0 + 760 - 1 + 100):

On the bituminous clothing sectors, it was found that the technical state of existing bituminous clothing is under-dimensioned for current and prospective traffic. The paved areas have a number of specific malfunctions such as pits, cracks, fusions, frost - thaw degradation, which make road traffic much more difficult.

The investigated sectors have been made for a long time, the duration of their exploitation is exceeded for many years, and for its prolongation the maintenance interventions were local and insignificant, which led to the current state of degradation.

Unfortunately, these road sectors have a very advanced degradation state almost all of their length.

Based on open surveys and drills executed on existing sectors and visual inspection, these sectors were found to be totally inadequate for circulation. This state of viability can also be explained by the lack of preventive and permanent maintenance work, but especially by not taking the necessary measures to ensure the collection and discharge of surface water in the area of the road and the existing culverts are clogged and in some cases they are missing.

From a geometric point of view, the sectors surveyed have the carriageway and the variable platform, and the water collecting and evacuation devices are in a totally inappropriate state, and on sectors of long length they are completely absent.

The route does not have a high complexity in the plan, and in the longitudinal profile the gradients are relatively low.

Although the analyzed road sector is of major importance both for the economic and social - cultural development of the locals in the area, due to the lack of necessary funds could not be brought to a higher degree of modernity.

It is appreciated that the modernization of the agricultural road section is of significant importance for the development of the commune from a socio-economic point of view, and the accomplishment of the work will considerably improve the technical condition of the road and, implicitly, the comfort and the safety of the traffic. Environmental conditions will also be considerably improved by reducing the dust and pollutants discharged into the atmosphere, reducing the noise caused by road traffic as well as the operating costs borne by the road users.

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