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## CONSTRUCTION LINK BETWEEN AGRICULTURAL AND FORESTRY ROAD NETWORKS

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**Abstract:** *The proper management and exploitation of forest areas are inextricably linked to the existence of a well-developed road network. One of the features of logging in forestry is that it is dominated by transport operations related to the transport of timber both on forest and on the field roads. The state and density of the road network are one of the main factors for increasing labor productivity in timber harvesting. On the basis of the conducted study it was found that as concerning the technical and constructive parameters the Polish roads have higher criteria. The drawback is that the sizing of Polish roads was carried out in the distant 1987 and it is necessary to update it.*

*It is necessary to create uniform Guidelines for the design of a forest - field road network*

### **Introduction**

The terrestrial road network can generally be defined as a strip reconstructed as a complex engineering facility intended for the movement of vehicles and pedestrians [1,3].

Modern roads are intended for the movement of various vehicles that form rolling stock. They must allow movement quickly, conveniently, safely and at low cost, regardless of type and composition [3].

The type of road determines its construction value, and taking into account its operational condition - the performance of the rolling stock and between repair periods. Roads are characterized by transport and operational qualities. There are a set of characteristics (strength, load-bearing capacity, speed) for the condition of the road as a transport facility, ensuring the safe and economical movement of the vehicles. The performance and efficiency of the vehicles depend on the characteristics. The main transport and performance indicators can be mentioned - the speed of traffic, the design load, the throughout and the traffic capacity and the patency of the road.

The road network is distinguished by dependent and functional use of the roads in a place, region, farm. Depending on the legal and administrative criteria, the roads are divided into state, regional, municipal, private, agricultural (Polish) and others. (Fig. 1). According to the purpose and place they are: long-distance roads and roads in populated areas. According

to the transport and technical characteristics the roads are divided into: servicing, collecting, cars only, one-way, two-way with dividing line, etc. [3]. On the basis of these criteria and the legal basis on the topic in the country a unified classification of roads in the Republic of Bulgaria was created. According to the classification, forest and agricultural roads fall into the group of specialized roads and are an integral part of the country's road network [1].



**Фиг. 1 Agricultural road**



**Фиг. 2 Forest road**

Logging is a natural production process. One of the characteristic features of forestry is that transport operations related to the transportation, export and transportation of timber from forest areas to consumer centers predominate. Most forest areas are located in remote, hilly or mountainous terrains with a poorly developed system of road transport communications. In most of Bulgaria the forest territories are bordered by arable land. The transport of timber from forest areas (temporary warehouses) to consumers is 100% mechanized. Timber transport is characterized by high volume and high mass (4). During the transportation of the wood, the vehicles are moving along a forest - road network, built for the needs and adapted to the specifics of the process. In some cases, heavy vehicles are required to deliver the timber to cargo stations or directly to consumers on agricultural (field) roads that are not constructed and tailored to such a load. This leads to damage to the field roads and impedes the movement of agricultural machinery and efficient management of fertile agricultural territories of our country. In many cases, the restoration of the damaged arable roads remains at the expense of the farmers and in some cases at the expense of the owners.

From the above, one can also determine the purpose of the study, namely, to consider the rules for the construction of agricultural (field) and forest roads and, if possible, to create uniform technical standards.

### **Methodology**

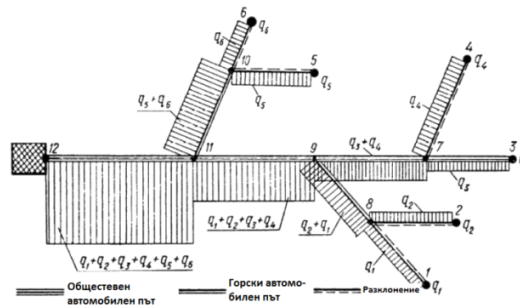
By analyzing the current regulatory framework and the available technical specification, the standards for construction and operation of field and forest roads will be determined. On the basis of the analysis, a technical specification for design standards will be created for the construction of the road network serving forest and field territories.

### **Object of research**

#### *Forest roads*

Forest roads are durable engineering facilities with a production purpose, whose main task is to serve the forestry and forestry industry in the performance of their functions - logging, afforestation, management, protection of special uses, etc. The construction, design and construction is coordinated with the Ministry of Agriculture, Food and Forests and the Forestry Executive Agency and is regulated by the Law on Forests and the normative acts that apply to it. The established system of forest roads form a forest road network [2].

The forest road network is characterized by the collective nature of the transported timber from the cuts to the consumer centers. Therefore, the quantity of timber transported along a part of the forest transport line (the so-called turnover-q) increases significantly (Fig. 3).



Фиг. 3 Freight traffic on the forest network

The classification of the forest roads and the standards for the design, construction and putting into operation is regulated by REGULATION No. 5 OF 31 JULY 2014 ON CONSTRUCTION IN THE FORESTRY WITHOUT CHANGE OF THE PURPOSE OF THEM (Am. 2 and amended 19). March 2018). The creation of this regulation is the result of a number of proposals from the academic community with a view to updating it and reaching a high technical level [4]. According to REGULATION No. 5, forest roads are subdivided into the following categories [5,6]:

1. permanent forest roads - roads for connecting forest territories between them or with the national and local roads;
2. temporary forest roads - roads for maintenance of clearings and other forest sites and their connection with permanent forest roads.

Depending on the transport - operational and technical level, permanent forest roads are separated into four stages. Of these, the third and fourth degrees are the largest share of the total forest road network. They are connected either directly to the national road network or via Polish roads. These roads have a traffic intensity of up to 5 OA / day with a dimensioning axis of 10 tones and a road structure with asphalt, surface treatment, or crushed stone flooring, and in any case without pavement.

The design of road structures for forest roads is especially dependent on the category of traffic, the bearing capacity of the road base and the climatic zone of the country [6].

The use of wood is determined by the Forest Management Plans, which indicates the possible use of specific forest management units (departments and subdivisions).

On the basis of the developed forest road network and the intended use, it is possible to determine the turnover in the next 10 years and, under the circumstances, to improve the agricultural road network in order to increase the bearing capacity of the pavement.

#### *Agricultural roads*

The agricultural roads providing access to agricultural land in accordance with the Roads Act and the Regulations there and the classification drawn up refer to specialized roads. According to their purpose they are divided into [7]:

- main - intended for daily and year-round use and link farms, livestock complexes and farms, large crop rotation arrays, agricultural airports and pasture complexes with roads of the national road network, settlements or other major agricultural sites;
- secondary - they are of limited use and serve the production processes on the territory of the individual crop rotations and cultivated species;

- farm-roads - roads built in livestock and poultry complexes and farms and roads in farm yards

In terms of timber transport from the forest territories, the main and secondary agricultural roads are of paramount importance. According to the relief of the area in which the agricultural roads will be developed, three terrain categories are distinguished, the characteristics of which coincide with the prepared classification for forest roads.

As an engineering facility, agricultural roads must ensure maximum use of favorable terrain, engineering, geological and hydrogeological conditions, to protect the land in accordance with the applicable normative documents for the protection of land and the environment. They also have the necessary strength, durability and durability of facilities and road and optimum performance.

Agricultural roads are categorized according to the accepted traffic intensity, corresponding to the expected agricultural traffic, according to Table. 2.

**Table 2 Categories of agricultural roads [7]**

Traffic category	Intensity of traffic, truck /24 h	Number of courses per year, в course / truck	Estimated transport load of agricultural goods в kt/ truck
Medium	от 41 до 200	от 11,97 до 58,40	от 47,88 до 233,60
light	от 11 до 41	от 3,21 до 11,97	от 12,85 до 47,88
Very light	от 11	до 3,21	до 12,85

Unfortunately, this intensity was determined on the basis of the rolling stock at the time of preparation (1987), with a load capacity of it. It is therefore necessary to make new calculations, including the intensity of passing forestry machinery.

When designing agricultural roads that connect forest areas, therefore, it is expected that timber will be exported, and they need to be dimensioned as forest-road lines. Depending on the assortment structure of the plantations (large, medium and small timber), the rolling stock of forestry vehicles is also determined. The load capacity of these machines varies from 4 to 20 t, which makes it impossible to transport timber with heavy goods vehicles through field roads.

### **Results of the study**

According to the relief of the area where the field and forest roads are built, they are divided into three terrain categories:

**Table 3 Distribution of terrains**

Terrain type	Transverse slope	Longitudinal slope
Flat	15%	3%
hilly	15-30%	3-5%
mountainous	Над 30 %	Над 5 %

In view of the fact that the third and fourth category of forest roads are directly related to the main and secondary field roads, a comparison of the technical parameters is made in Table 4

**Table 4**

**Technical parameters for agricultural roads by terrain and category - Plain (P), Hilly (X) and Mountain (P) [5,7]**

Type of road	Forest Road						Agricultural road					
	Third			Fourth			Main Roads			Secondary roads		
The nature of the terrain	(P)	(X)	(II)	(P)	(X)	(II)	(P)	(X)	(II)	(P)	(X)	(II)
Design speed, km/h	40	30	20	30	25	10	40	30	25	25	20	17
Number of lanes	1	1	1	1	1	1	1	1	1	1	1	1
Lane width m	4	4	4	4	4	4	6	6	6	6	5.5	5
Banquet width, m	0.5	0.5	0.5	0.5	0.5	0.5	1.25	1.25	1.25	1.5	1.25	1
Width of bridges between railings, m	5	5	5	5	5	5	6	6	6	7	7	7
Width of bridges between borders, m	4	4	4	4	4	4	4.5	4.5	4.5	4.5	4.5	4
Visibility distance to the surface of the pavemen, m	35	25	20	25	20	15	35	25	20	20	20	20
Maximum longitudinal slope, %:	7	8	9	7	8	9	7	8	8	9	9	9
Maximum unilateral transverse slope in straight section %	2.5	2.5	2.5	2.5	2.5	2.5	2	2	2	2	2	2
Maximum one-sided cross slope in a curve, %	6	6	6	6	6	6	6	6	6	7	7	7
Minimum radius of convex vertical curves m	1000	1000	1000	1000	1000	1000	1500	1000	1000	400	300	200
Minimum radius of concave vertical curves, m	500	500	500	500	500	500	1000	599	500	400	300	300
Minimum radius of horizontal curves in coils m	-	20	15	-	20	15	-	30	20	-	15	15

From Table 4, it can be concluded that field roads have approximately 7% higher technical parameters compared to forest roads. Forests in the minimum vertical curves only prevail, which is related to the characteristics of the terrain in which they are built.

In terms of road construction, the Polish roads again prevail. The minimum thicknesses of the structural layers of roads are presented in Table 5.

**Minimum thickness of structural layers [1,7]**

**Table 5**

Type of material in the formation	Minimum thickness, cm	
	Forest Road	Agricultural road
Asphalt		
single layer	3	3
two-layer	7	7
Bituminous ballasters and crushed stone	5	5
Stabilized ballast and crushed stone	<b>10</b>	<b>15</b>

Stabilized soil	10	10
Crushed stone and crushed slag	10	10
Crushed stone and rubble slag	15	15
Ballast, sand, crusher	10	10

The choice of the appropriate type of road surface is made on the basis of determining the traffic and the category according to the turnover, as well as based on soil and hydrological conditions. Table 6 gives the dimensional modulus of elasticity for the materials of the structural layers.

As has been emphasized, the categorization of road traffic on the roads needs to be refined with regard to modern means of transport. Only then will we be able to make a correct comparison of the modulus of elasticity for the two types of roads.

**Table 6 Required modulus (En) of the pavement surface [1,7]**

Traffic category according to	Горски път		Полски път		Modulus of elasticity в МПа
	Intensity of traffic, OA/day	Annual volume of logging m <sup>3</sup>	Intensity of traffic, авт./24 h	Estimated transport load of agricultural goods в kt/truck	
average	21-100	над 18 000	от 41 до 200	от 47,88 до 233,60	200
Easy	011-20	8000-18000	от 11 до 41	от 12,85 до 47,88	155
light, medium light	06-100	2000-8000	от 11	до 12,85	120
Very light	до 5	до 200	-	-	120

The implementation of the various types of road construction activities for forestry and agricultural roads must be complied with the legal and regulatory framework in the field of occupational safety and good practices on the subject [8].

### Conclusions

After the analysis of the available regulatory and technical database related directly to the construction, operation and technical condition of the field roads, the following conclusions can be drawn:

- There is a discrepancy in the basic technical parameters for the construction of agricultural and forest roads
- The categorization of field roads on the basis of traffic intensity was adopted in 1987, with a carrying capacity of 4 t. It is necessary to create a new one according to the modern vehicles.
- The categorization of field roads on the basis of traffic intensity was adopted in 1987, with a carrying capacity of 4 t. It is necessary to create a new one according to the modern vehicles.
- Currently, the elasticity of the road structure is incomparable, since it is necessary to refine the classification of field roads.
- In view of the interconnection of forest and field road networks, it is necessary to develop uniform Guidelines for the design of a forest - field road network.

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## КОНСТРУКТИВНА ВРЪЗКА МЕЖДУ ЗЕМЕДЕЛСКИТЕ И ГОРСКИТЕ ПЪТНИ МРЕЖИ

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**Ключови думи:** полска и горска пътна мрежа, товарооборот, товароносимост, земеделска продукция, дърводобив, дървесина, норми

**Резюме:** Правилното стопанисване и експлоатация горските територии са неразривно свързани с наличието на добре развита пътна мрежа. Една от характерните особености на дърводобивната дейност в горското стопанство е това, че в нея преобладават транспортните операции свързани с превоза на дървесината както по горските така и по полски пътища. Състоянието и гъстотата на пътната мрежа е една от основните фактори за повишаване на производителността на труда при извоза на дървесина. На база проведеното проучване е установено, че при техническите и конструктивни параметри, полските пътища имат по високи критерии. Недостатък е че оразмеряването на полските пътища е извършено през далечната 1987 г. и е необходимо актуализиране.

Необходимо е създаване на единни Указания за проектиране на горско – полска пътна мрежа.