REHABILITATION OF FOREST ROADS – A BASIC COMPONENT OF SUSTAINABLE FOREST MANAGEMENT

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***Abstract**: Forests have always been a fundamental component in the evolution of human society through the products and services they provide. In recent centuries, as a result of growing demand for forest products, forests have undergone major changes in terms of both area, with a reduction in forest cover, and structure, with a reduction in species diversity and a loss of the natural complexity of ecosystems. Thus, for the sustainable management and rational use of the main and secondary products offered by forests, it is necessary to create a network of forest roads that meets all the technical requirements of forestry activities.*

***Keywords:** forest road, forest, sustainable management, rehabilitation*

1. Introduction

The evolution and progress of society cannot be achieved without transport routes. In space and time, life cannot be conceived as static. People, material goods, technical and cultural progress, life itself means movement, evolution. "The road is life," said the Romans. They had almost 100,000 km of highways, traces of which can still be seen today.

Transportation routes enable the development of all sectors of work, facilitating the transport of goods and people, the rational exploitation of national resources, the harmonious industrialization of all regions of the country, the exchange of goods, and ensuring the material and spiritual well-being of the people.

Forest roads were created due to technical and economic factors necessary to meet requirements such as: [1, 2, 3]

- accessibility in the forest;
- complex and varied use of forest products;
- reducing wood consumption and production costs in logging operations;
- carrying out forest management work;
- developing tourism.

According to the Forest Code forest roads are technological transport routes for private use, used for: forest management, hunting and sport fishing activities, interventions in case of damage, calamities or disasters, being closed to public traffic, as well as for owners' access to their own land. [4]

2. Materials and Methods

The general principles underlying the provision of roads in forests are as follows: [5]

- a comprehensive study of transport facilities, by production unit group, in order to achieve a unified approach to the provision and distribution of roads across the entire forest area, so that harvesting and transport operations can be carried out as economically and efficiently as possible;
- the design, construction, and modernization of forest roads shall take into account their function in the transport of forest products, as well as the prospective traffic structure, the rational use of forest land, and the need for safe traffic conditions;
- forest roads shall be designed only on the basis of economic efficiency studies, in compliance with the rules for their construction.

The rehabilitation of forest roads includes all the work involved in transforming existing roads so that they meet the new traffic requirements. [6, 7]

Modernization includes two categories of work: [8, 9]

- systematization of the geometric elements of the road, corresponding to the design speed and traffic intensity;
- construction of road systems appropriate to the traffic.

In the modernization, development, or construction of new forest roads, both physical-geographical and forestry factors are taken into account. [10]

Physical and geographical factors represent all the natural conditions existing in the area where the forest road is to be built, namely: [11, 12]

- the relief of the region, which determines the natural directions of timber flow and sometimes limits the layout and development of the network;
- the geological and hydrological structure of the land, which influences the location and construction of roads;
- the climate and hydrological characteristics of the region in terms of winds, snow, and floods.

Forestry factors refer to:

- the shape and size of the forest area served;
- the volume of timber to be harvested;
- annual road traffic;
- harvesting technology and how it connects to forest roads.

At the same time, forest roads indirectly influence sustainable forest management through: [13, 14, 15]

- reducing the distance for collecting wood, thereby helping to reduce damage to the soil;
- creating opportunities for regeneration felling and forest management;
- ensuring conditions for the continuous operation of forestry activities;
- ensuring conditions for harvesting secondary forest products: berries, mushrooms;
- developing the hunting economy;
- expanding the application of phytosanitary treatments;
- exploiting the hydroelectric and hydro-improvement potential of mountain areas;
- ensuring road connections between isolated settlements and administrative centers;
- developing tourism in forest areas;
- ensuring accessibility in difficult terrain conditions;
- facilitating operational interventions in the event of disasters: windfalls, insect attacks, fires.

The starting point for road construction is forest management. Forest management provides information on: [16, 17, 18]

- the division of the forest into production units and plots;

- the amount of wood that can be harvested and the period in which various interventions are carried out;
- the functional zoning of the forest: ecological or exploitation function;
- the road network necessary for forestry work;
- restricted areas and protected areas.

Drainage plays a very important role in the construction of forest roads. Effective drainage will protect the road from deterioration, so ditches must have the appropriate slope, cross-section, and depth, and culverts must be placed at the correct distances and with a sufficient diameter to carry water to collection areas.

Another important aspect is maintenance, so the construction of forest roads must include a plan for ongoing and periodic maintenance by carrying out desilting, culvert unblocking, vegetation clearing, or filling potholes on the road surface.

To create or extend a forest road, the following works are necessary:

- cutting a strip of trees;
- excavating slopes;
- building embankments, ditches, or bridges.

3. Results and Discussion

In order to discuss practical solutions for the development of the forest road network, the case study "Rehabilitation of the Bâsca Mare forest road" was chosen. [19]

The area under study is located in the administrative territory of Comandău commune in Covasna county, on the Bâsca Mare forest road between km 0+000 and km 5+000. According to the 2010 Forest Management Plan, the Bâsca Mare forest road, with a total length of 5.00 km, is part of the network of transport facilities within U.P.VI. Ghiurca, belonging to the Comandău Forest District, the road administrator. The section of the Bâsca Mare forest road that is the subject of this case study runs between the built-up area of Comandău and the reinforced concrete bridge (km 5+000) over the Ghiurca Mare stream, a left tributary of the Băsca Mare river.

The land occupied by the 5 km Bâsca Mare forest road is entirely owned by the Romanian state, with the road being managed by the National Forest Administration, through the Covasna Forestry Directorate, Comandău Forest District.

From a hydrographic point of view, the site is located in the Siret River basin, in the 1st order sub-basin, parallel to the Bâsca Mare watercourse, with cadastral code XII.-1.082.15.00.00.00.

Main characteristics of the planned forest road: [20]

- the planned road has a category of importance "D";
- the total area served by the forest road is 6894.87 ha, of which:
  - 4,619.15 ha of forest land owned by the state;
  - 2,275.72 ha of forest land owned by other entities;
- the total length of the road is 5.00 km and follows the course of the Bâsca Mare river to the bridge over the Ghiurca Mare river, near the confluence of the two rivers;
- the forest road does not run through national or natural parks;
- the design speed is 25 km/h, according to the classification of the forest road – main forest road, mountain region;

During the rehabilitation of the road, it was decided to build a road structure with simple two-layer gravel, with a carriageway width of 4.00 m + widening on bends, and shoulders 0.50 m wide. Water is directed to the culverts through unprotected ditches, or protected in justified

cases. Most of the culverts do not have a sufficient cross-section, so they will be replaced with new pipes, and the rest of the culverts will be unclogged and repaired.

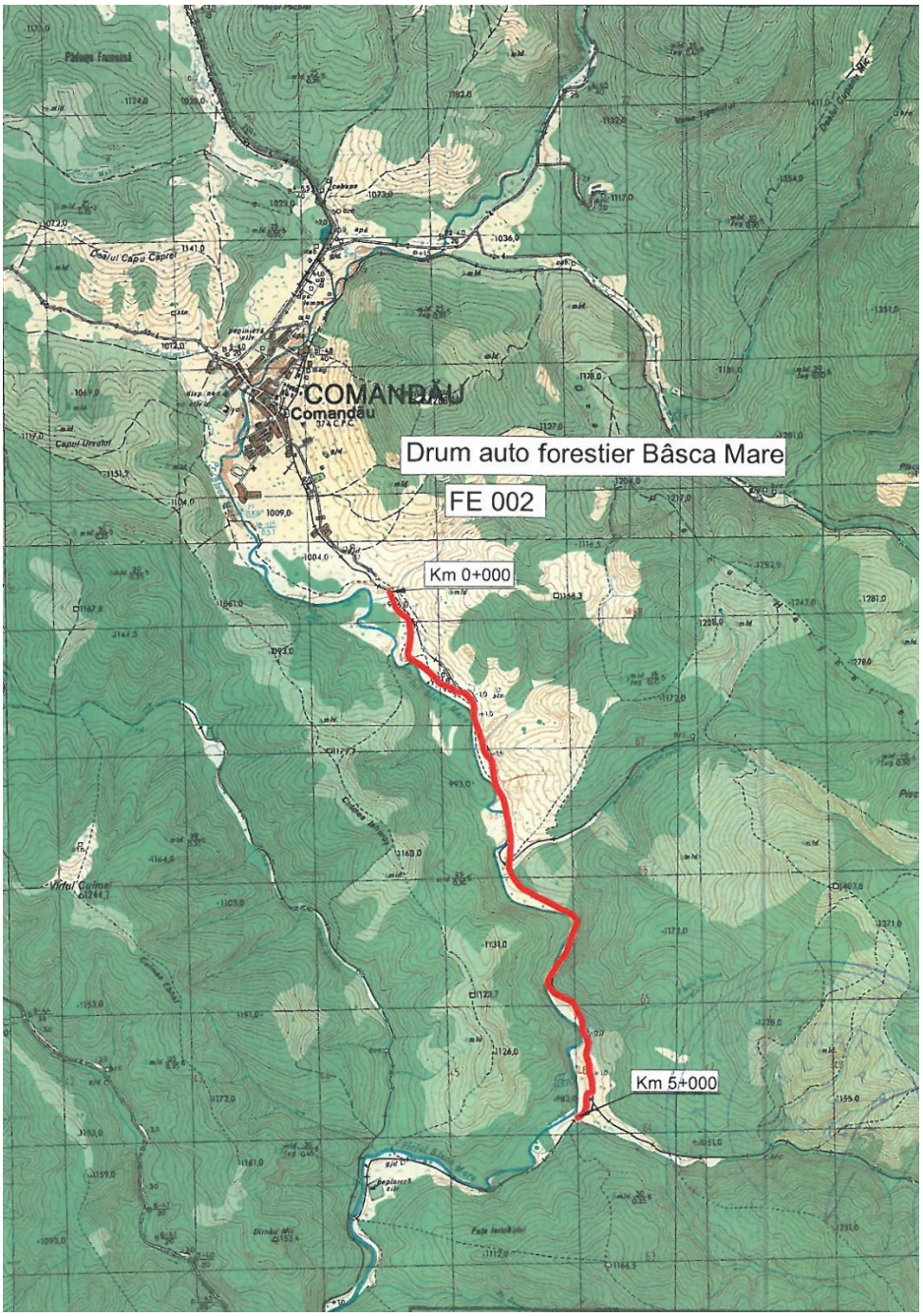

Fig.1 Zoning plan for the area - Forest road Bâsca Mare KM 0+000- KM 5+000 – Land Registry and Real Estate Advertising Office Covasna

The forest road in the plan

The following technical conditions are taken into account for the rehabilitation of the forest road: [20]

- the total length of the studied route is 5.00 km, consisting of a succession of alignments and curves. the connections are formed by circular arcs with radii between 10 m and 350 m;

- the plan follows the route of the existing road;
- all curves will be widened on the inside of the curve, or to avoid the construction of retaining walls and excavations in the rock and on the outside;
- the widening connects to alignments at distances of 10 m, in exceptional cases, to avoid difficult reinforcement works, at 5 m;
- the widening does not affect the width of the shoulders, which retain their current width in the alignment;
- the geometric elements in plan, including the spatial arrangement of curves (widenings, conversions, elevations), are established for a design speed of 25 km/h. these elements will be improved within the limits of the existing possibilities on the ground, without the need for major earthworks;
- to ensure the passage of vehicles traveling in opposite directions, crossing platforms are built, which are 2.70 m wide and 20 m long and are designed within the limits of visibility. they are preferably located on the side, in the upward direction, and, in the case of difficult terrain conditions, in the descending direction. the platform is connected to the roadway over a length of 10 m at the entrance and 10 m at the exit;
- in the case of crossing platforms located on a curve, the width of the alignment is increased by the width of the curve.

Longitudinal profile of the forest road

The following are taken into account in the longitudinal profile: [20]

- the road in the longitudinal profile has a minimum slope of 0.10% and a maximum slope of 5.00%. The connections provided for in the vertical plan are circular and vary between R=100m...10000m. The designed line follows the current line of the terrain, and the differences in the axis are positive and approximately equal to the thickness of the road system and the necessary corrections applied so that the design step provided for in STAS863/85 is respected.
- there are no exceptional slopes on the road studied; on the contrary, there are many areas with gradients below 0.50%, where it is very important to correctly construct the transverse slopes of the road (min. 3.5%) and the gradients of the ditches.

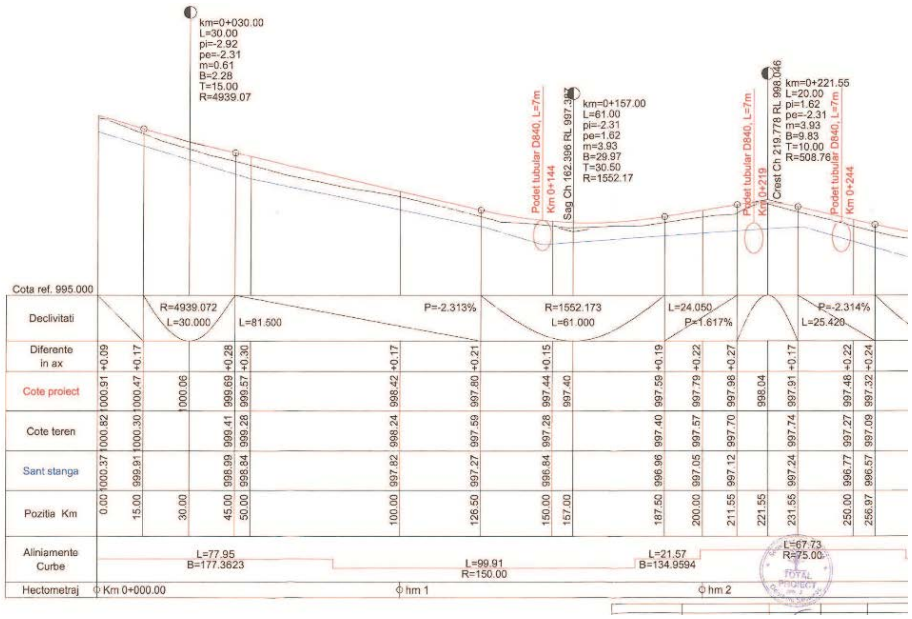

Fig. 2 Longitudinal profile of the forest road

Forest road in cross section

In cross-section, on the rehabilitated route, the width of the carriageway will be increased by the widening of the curves and will be as follows: [20]

- Bâsca Mare: from Km 0+000 to Km 5+000 - 4.0 m with 0.5 m shoulders;
- the cross slope will be roof-shaped, 3.5% towards the outside, towards the designed ditches and gutters;
- in curves, the carriageway will be widened and converted or raised, in accordance with STAS 863/85 and PD-003.

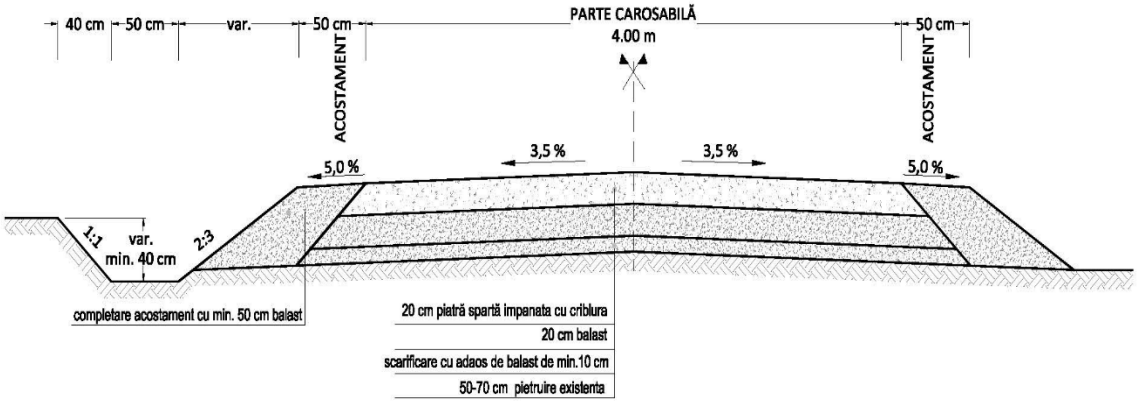

Fig. 3 Forest road in cross section

Water drainage

In order to achieve drainage for the analyzed road sector, the following are taken into account: [21, 22, 23]

- rainwater drainage will be ensured by longitudinal and transverse slopes, and collection will be ensured by gutters and ditches, drained through bridges;
- the rehabilitation of marginal ditches and gutters will be carried out on the site of the existing ones or, where necessary, in all embankment areas and in sectors where water accumulates and needs to be drained;
- the bottom of the ditches shall be located at least 0.2 m below the level of the rehabilitated roads;
- rainwater from the road platform shall be collected in the ditches designed at the edge of the carriageway and discharged through existing channels, existing or designed transverse bridges.

Defense and reinforcement works

For the analyzed road section, the following defense and consolidation works were considered: [21, 22, 23]

- bank protection works have been planned for sections where watercourses parallel to the road (the Bâsca Mare stream) have caused bank erosion to such an extent that the road platform is endangered.
- to secure the road platform, bank reinforcement and protection works are planned, involving hydrotechnical works using gabion boxes and mattresses, and concrete walls;
- the gabion boxes will be placed on gabion mattresses of varying heights;
- concrete retaining walls are planned to support the slopes, create clearance, and reinforce the slopes.

The planned works are intended to ensure the vertical and horizontal stability of the stream beds and do not alter the flow regime of surface water or groundwater, but they do alter the water level regime and increase the transit capacity of the stream bed. The planned works will only have beneficial effects on the socio-economic objectives in the area, allowing safe traffic on the Bâsca Mare forest road.

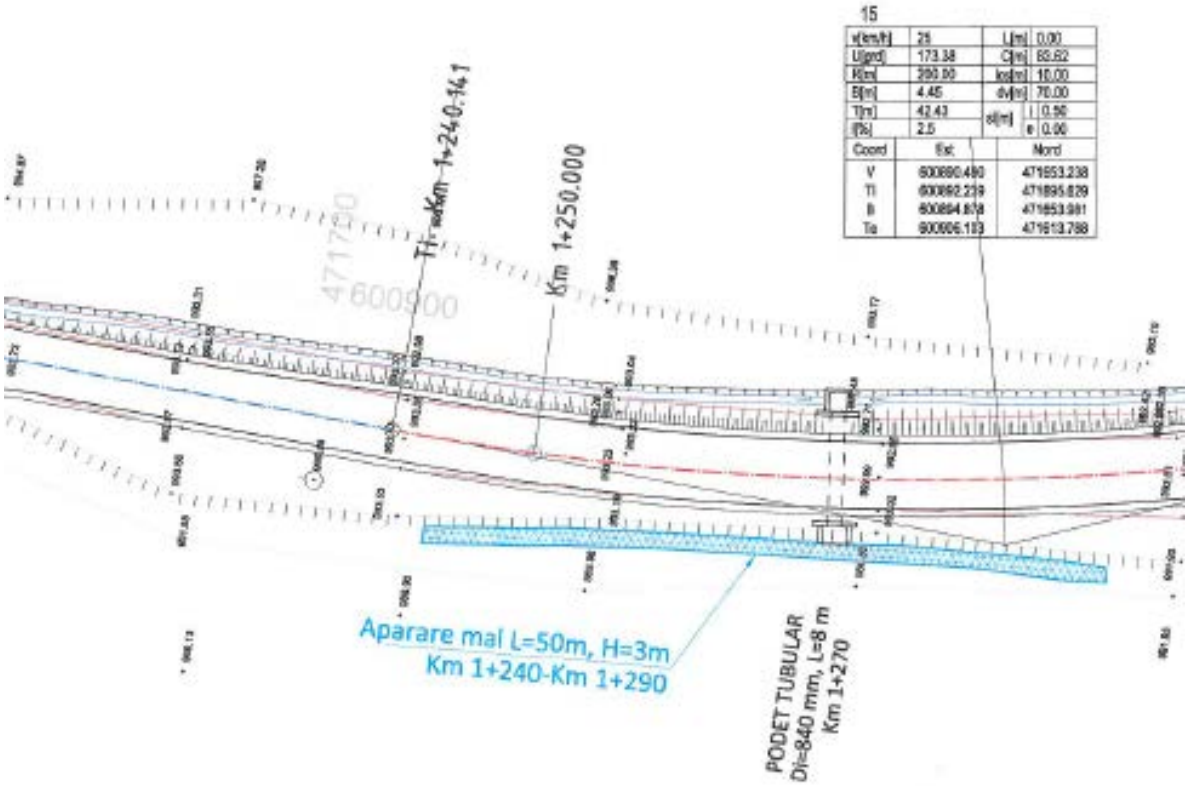

Fig. 4 Gabion bank protection

Torrent correction

In order for the forest road to function according to design parameters, a series of works are planned to correct the existing torrents in the vicinity of the road, including the clearing and arrangement of the torrent beds upstream and downstream of all bridges and footbridges. [21, 22, 23]

Most of the torrents are located near tubular or slab bridges, so the alluvium brought by the unimproved torrents clogs the bridges with stones, wood, or earth, causing the water to overflow onto the road. Their improvement consists of building a gabion weir of variable length and width. This threshold is composed of a 1.0 x 1.0 m gabion box and another one above it, but with variable dimensions (x1), depending on the size of the torrent being developed. In front of the boxes, a gabion mattress is built to dissipate the energy of the water. It will be the same width as the boxes and will be 20 cm thick, with the mattresses having a 1% slope towards the decks.

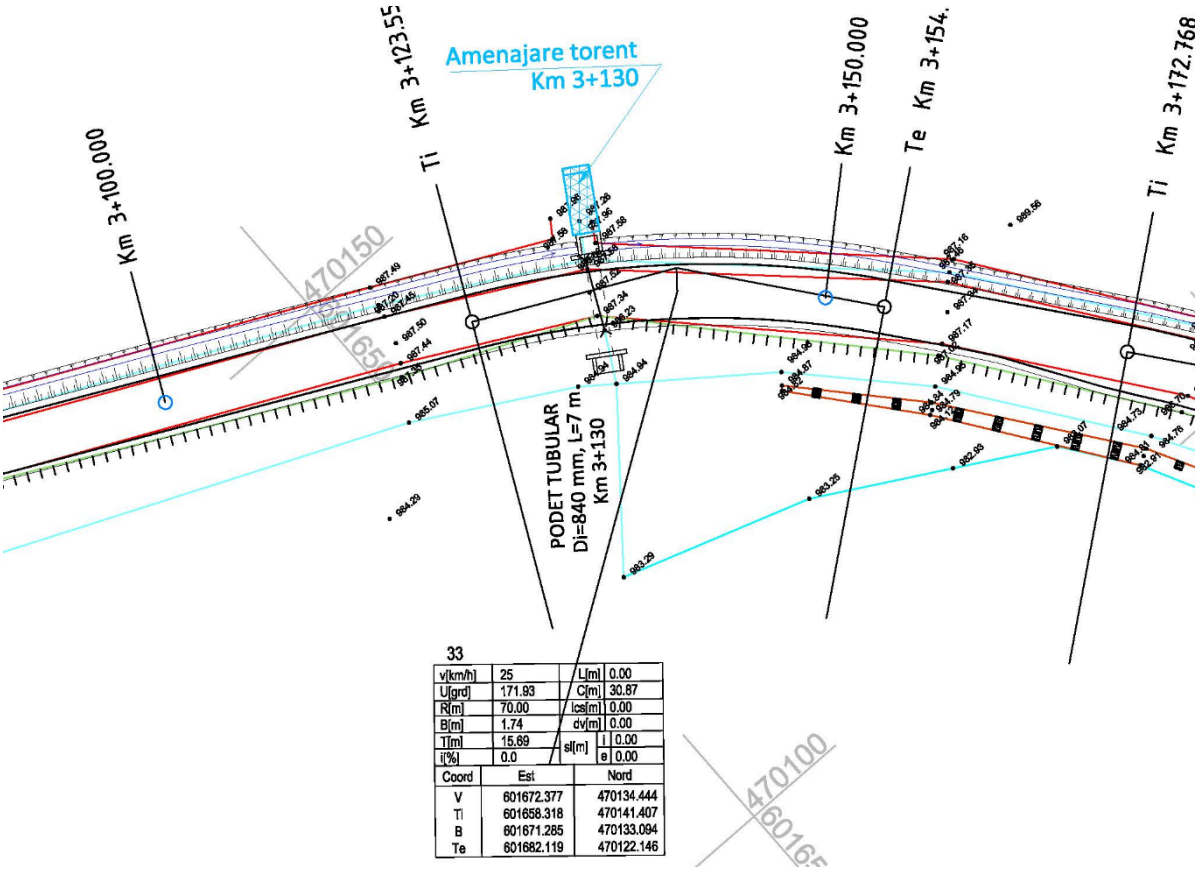

Fig.5 Torrent arrangement

4. Conclusions

The forest is nature's greatest treasure. Forests provide us with wood, mushrooms, berries, but also oases of peace, relaxation, and nature walks. Their invisible side protects our soil from erosion, regulates water in rivers and streams, cleans the air, and provides a home for many animals and plants.

In recent years, climate change has begun to complicate the situation dramatically. We are seeing shorter but very heavy rains and long periods of drought, followed by storms and heavy floods. These phenomena put pressure on ditches, footbridges, bridges, and embankments. For this reason, the design and construction of forest roads must take into account higher water flows and more frequent episodes of extreme weather, and the roads must be more resistant and better designed.

Many forest roads are used by locals and tourists. They provide access to sheepfolds, agricultural land, cabins, or viewpoints, which is why traffic safety, signage, and sometimes access restrictions are also taken into account in their design. In protected areas, some roads are closed to the public or have special regulations.

With regard to degraded forest roads, it should be noted, for each existing road, the sections of road that require routine maintenance of the infrastructure and engineering structures (retaining walls, ditches, bridges).

The designer, in collaboration with the forest fund administrator, analyzes the need to increase the accessibility of the forest fund and may propose, through forest management, the design and construction of new forest roads in inaccessible or poorly accessible areas.

Forest road development is a very important part of sustainable forest management. They must be designed to ensure sufficient access without destroying the environment. Good

network planning, correct technical design, quality execution, and ongoing maintenance are required so that forest roads can fulfill their economic, forestry, and protective roles without affecting the long-term health of the forest.

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