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Using the ROADENG system to design an optimum forest road variant aimed at the minimization of negative impacts on the natural environment

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ABSTRACT: The optimization study was carried out in the part of the Jeseníky Mts. region in order to find the optimum variant of a forest road route. The ROADENG system was used for determining the Jezerná forest road design with use of projection above the digital elevation model of terrain. Particular variants of the forest road route were calculated and analyzed on the basis of environmental approach. The final report recommended one of the variants for the final elaboration of project documentation and for construction.

Keywords: forest road design; ROADENG system; DMT (DEM) method; soil conservation; secondary drainage network

The Czech Republic takes up about 80,000 km^2 area of land. Forested area represents 33.4% of the total area, i.e. 2,632,000 ha. Average density of the Czech forest road network is 16.61 m/ha. The figure represents 40,400 km of forest roads. In addition, there are skidding roads whose number is about three times higher than that of forest roads (ca. 120,000 km) (Report on the State of Forests and Forestry in the Czech Republic, 1995). These two figures indicate that the secondary drainage network is enormously extensive. By evaluating and optimizing the amount of forest roads depending on management we can minimize negative impacts on the environment.

Forest road design is a very responsible act for designers. There are many steps that must be made before the actual design of a forest road. Designing the optimum variant of a forest road route is one of the most important ones. The designer usually has to follow the wish of a forest manager and the potential design made by the Institute for Forest Management (ÚHÚL) organization. This organization makes forest management plans. In order to find an optimum variant of the forest road, the designer can make modifications as follows:

1. Size of road body (aesthetic, soil conservation and hydrological functions of the forest);
2. Volumes of cuts and fills (economic evaluation of future development of forest road network).

Those two and other things the designer can do in the office if using the DMT method.

In these days, the forest manager has to decide where the potential future forest road should be designed. The detail optimization study has to be done for the best location of the forest road route. An output of this study is the design of the forest road route and hence the complementation of the forest road network in the affected area.

MATERIAL AND METHODS

In the first part of this study, it is very necessary to divide the area under study into similar parts (transport segments) where the wood potentially gravitates to one point. These segments usually correspond with small watersheds whose size is about 500 ha. In these segments, we have to calculate specific criteria for assessing the groups of accessibility. According to BENEŠ (1973), the most important criteria are the coefficient of terrain division, density of streams, coefficient of slope inclination, and coefficient of contour division. The necessary density of forest road network is appraised for different groups of accessibility (BENEŠ 1989).

$$Ct = (It/5 + Ds/10 + 2 \,.\, Ccd)/3 \quad (1)$$

where: Ct – coefficient of terrain division,
It – average slope of terrain (%),
Ds – density of streams (m/ha),
Ccd – coefficient of contour division.

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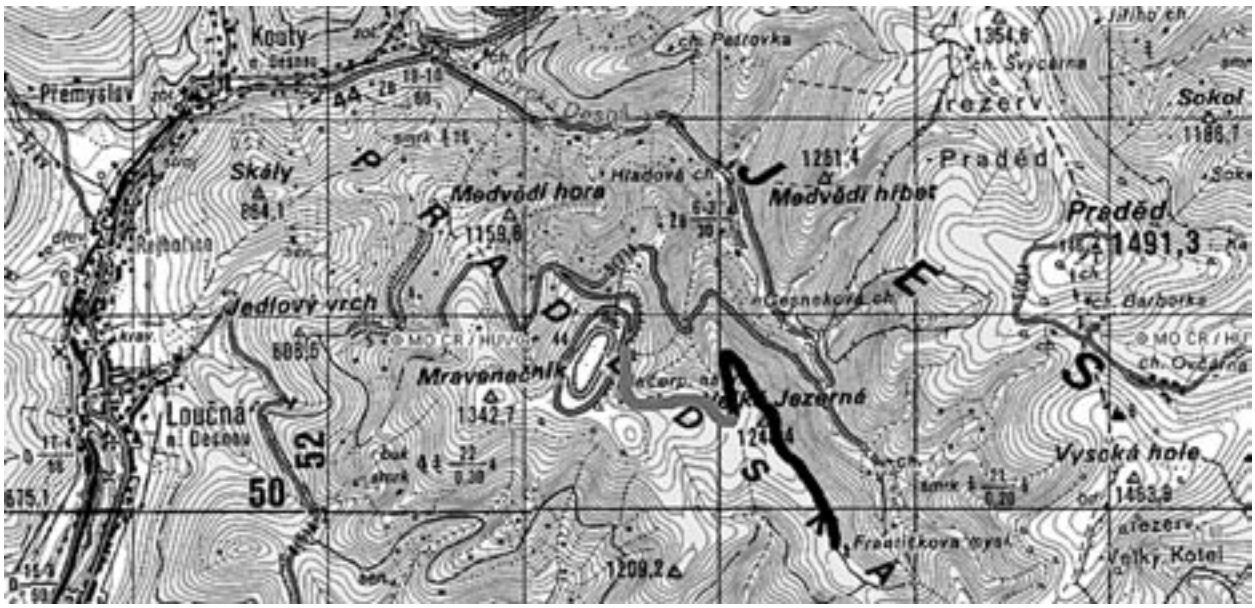

Fig. 1. Location of the designed forest road route. The Jeseníky Mts., Šumperk district, Czech Republic. Black line is the designed road Jezerná, grey line an expected road for future development

Table 1. Comparing different variants of the Jezerná forest road

Variant	1	2	3
Length (km)	2.250	2.323	2.230
Non-productive area (ha)	2.220	1.720	1.980
Cuts (1,000 m^3)	4.853	3.054	3.806
Cuts per m (m^3)	2.160	1.310	1.710
Average cut depth (m)	1.280	0.960	1.120
Fills (1,000 m^3)	2.954	2.113	2.436
Fills per m (m^3)	1.310	0.910	1.090
Investment costs (mil. CZK)	4.212	2.612	2.953
Costs per 1 km (mil. CZK/km)	1.872	1.125	1.324

There are different values of road density recommended for different landscapes. Calculated coefficient specifies the road density necessary for the given locality. According to this study, the area in question is either insufficiently accessible or overaccessible. If we find an area with insufficient access, we can complete the forest road network by designing a new road or enlarging some current road. On the other hand, in the situation with superfluous access we can recover the old road and protect the surrounding area against negative impacts.

The design can be solved above the DMT (Digital Model of Terrain), in publications in English also known as the DEM (Digital Elevation Model). With use of DMT we can transfer the route of a forest road into the plan, longitudinal horizontal and vertical profiles, and economic calculations. We can solve this problem by using the ROADENG software prepared by the Canadian company SOFTREE (HERALT 1999).

Background required for ROADENG:

1. DMT defined by the triangular point network or by 3D digitized forest map, etc.
2. Current forest road network.
3. Planned direction and route of the forest road.

One of many studies was carried out by the Department of Forest Engineering and Reclamation, Mendel Univer-

Fig. 2. The stretch of the plan of the Jezerná forest road Variant 2 designed by ROADENG

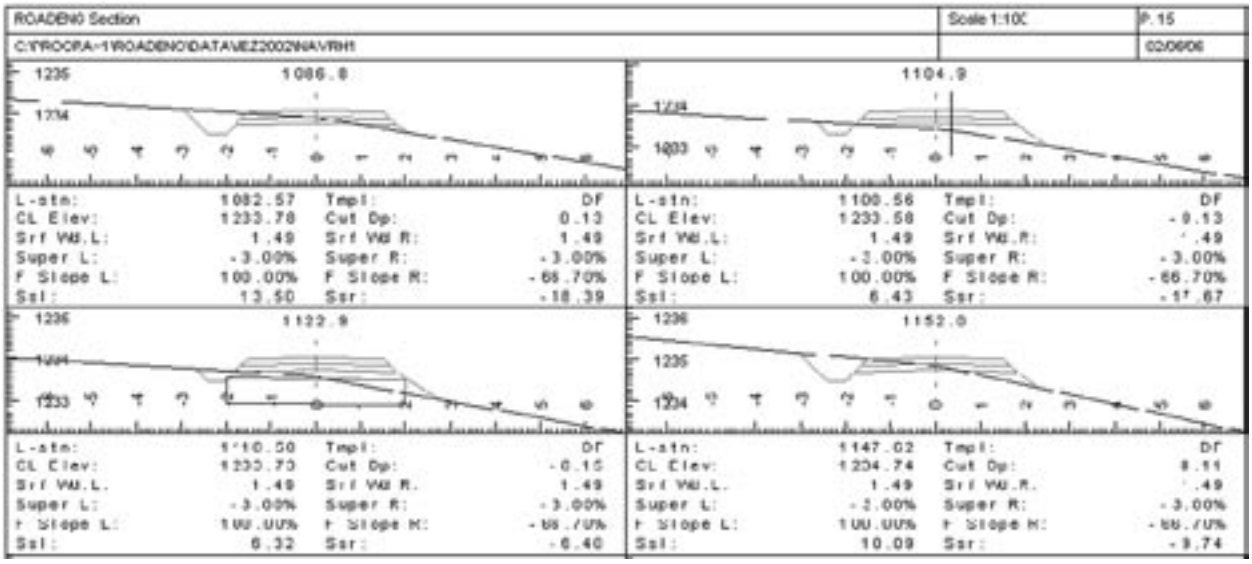

Fig. 3. An example of the sections of the Jezerná forest road Variant 2 designed by ROADENG

sity of Agriculture and Forestry in Brno. The new forest road route was designed with the help of the ROADENG system in the Jeseníky Mountains according to the advice of the forest manager in the given locality of Loučná.

RESULTS

The example of using the ROADENG for designing an optimum variant of the forest road Jezerná can be shown for visualization. With the use of the ROADENG three different variants of this road were designed. Summary of this example is presented in Table 1. Variant 1 was designed according to the forest manager of the area in question and according to his field round. The manager wished the route to be located on the terrain edge because of skyline yarding. Variants 2 and 3 were designed by using DMT in the ROADENG system. The road route was formed according to terrain features and consistently with forest road design standards. The total amount of cuts in the best variant is 3.054 thousand m^3. This figure represents 1.31 m^3 per m of road, which is less than the average in mountain locations. The values for Variant 1 (the forest manager's vision) correspond to mountain locations. The value of cuts per meter of road is 2.16 m^3 per m. It is so

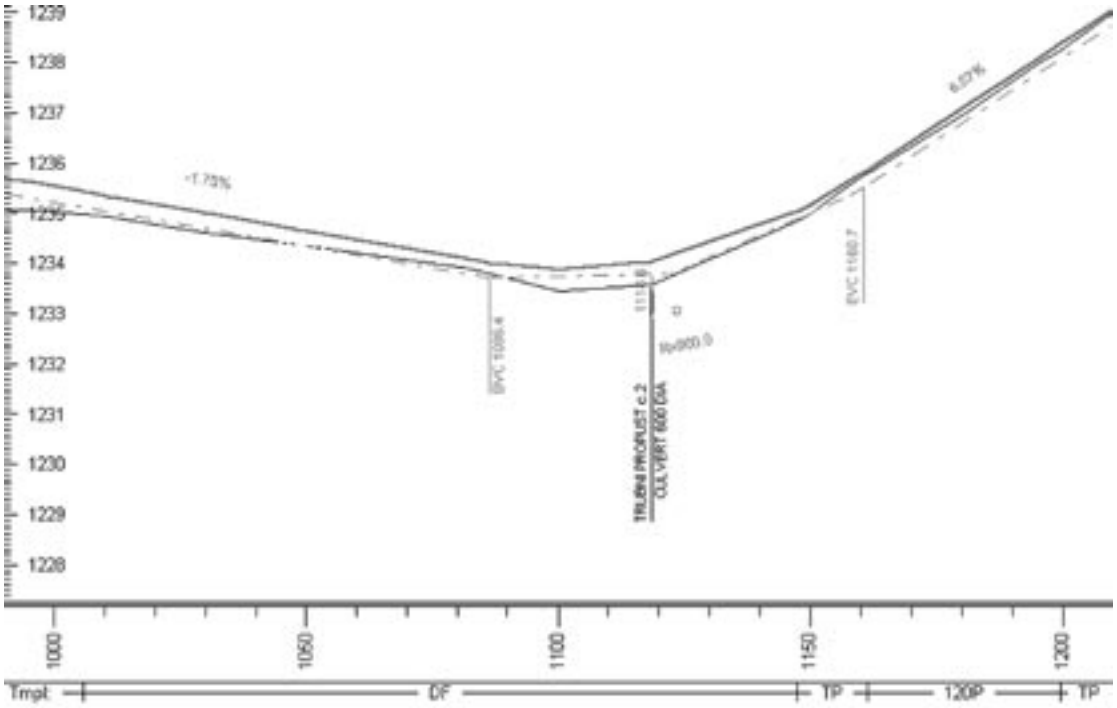

Fig. 4. The stretch of the profile of the forest road Jezerná Variant 2 designed by ROADENG

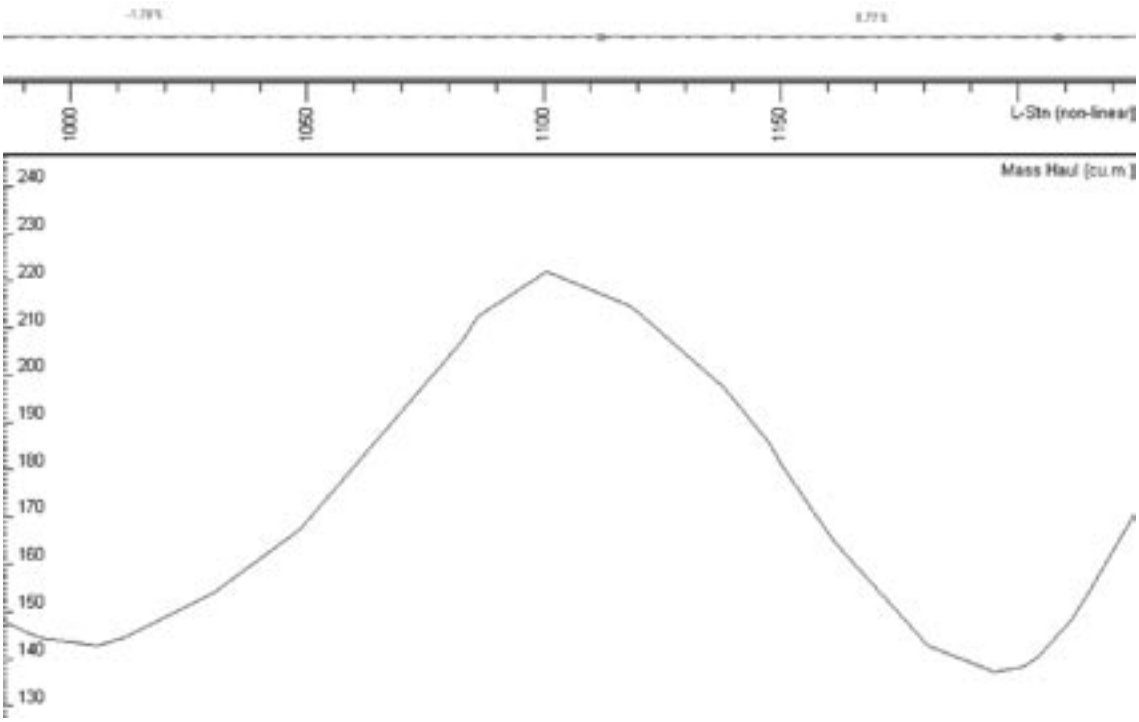

Fig. 5. The fraction of the Mass Haul of forest road Jezerná Variant 2 designed by ROADENG

because the centre line of the forest road route is too close to the terrain edge and the longitudinal profile of the route has to be lower than in Variants 2 and 3. There were more than only 3 variants of the road route made, but only these three were representative.

Based on the results we can suggest that Variant 2 is most acceptable because all data reflect minimum impact on the environment (hydrological, soil conservation, and aesthetic functions of the forest).

DISCUSSION

Design of forest roads is a very difficult task that depends on many factors. Not only the expenses for developing a new road are critical. Location of the route in the surrounding area and landscape pattern, hydrological and soil conservation functions of the forest play a very important role in the forest road designing.

The amount of cuts and fills describes the volume of earthworks. According to this factor the designer can suggest impacts on the environment (DVORŠČÁK 2001). The area, size, slope inclination, and the way of slope protection can contribute to the minimization of negative impacts, however this would be only a repressive measure (BENEŠ 1981).

The planned forest road route is shown in Fig. 1. It starts from the Františkova myslivna gamekeeper's lodge and proceeds to the top of Velká Jezerná Mt. The entire mountain ridge from Velká Jezerná Mt. to Mravenečník Mt. is not accessible. There are only skidding roads that are in a very poor condition because of the peaty soil layer. Retention capacity of the cover on these enormously dam-

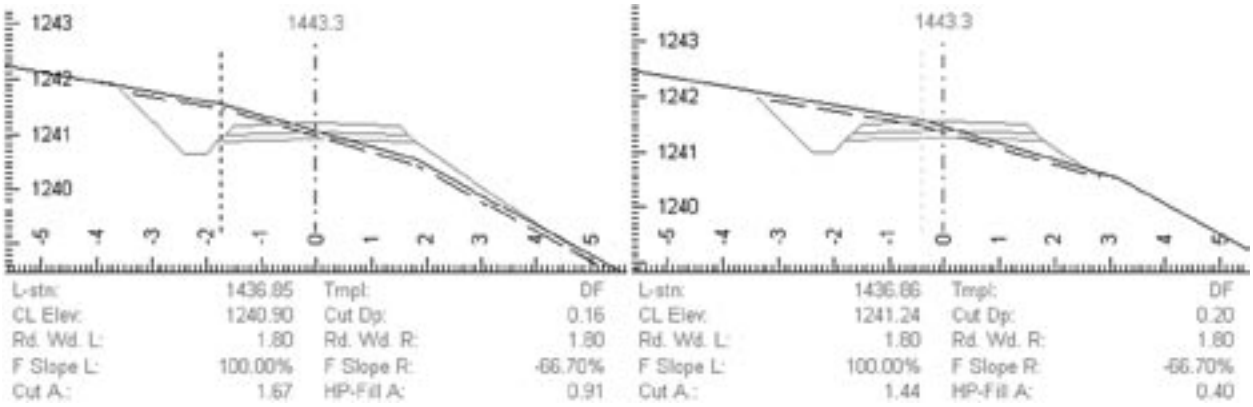

Fig. 6. An example of differences between the first and the second variant of the Jezerná forest road

aged skidding roads is very small, and in the locations like the Jeseníky Mountains with 1,200 mm of precipitation this could be a critical factor for the soil conservation function of surrounding forests.

CONCLUSION

The ROADENG software, although not constructed for finishing the optimization studies, is highly applicable for the activity. In addition, the data outputs serve the purpose of decision-making. The forest manager can certainly claim the variant of forest road to be optimized and therefore needed. Besides some benefits, any road and any route will also have some negative impacts on the environment. However, these can be minimized with the help of a powerful tool.

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Využití programového systému ROADENG pro navržení optimální varianty lesní cesty ve snaze o minimalizaci negativních dopadů na přírodní prostředí

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ABSTRAKT: Z důvodů nalezení optimální varianty trasy lesní cesty byla v jesenickém regionu zpracována optimalizační studie. Programový systém ROADENG byl použit pro zpracování návrhu trasy lesní cesty s využitím projekce nad digitálním modelem terénu. Jednotlivé varianty tras lesní cesty byly rozpočtovány a analyzovány na základě environmentálního přístupu. Závěrečná zpráva doporučila jednu z variant pro dopracování projektové dokumentace a pro výstavbu.

Klíčová slova: projekt lesní cesty; program ROADENG; metoda DMT; půdoochranná funkce; druhotná odvodňovací síť

Programový systém ROADENG, ačkoliv nebyl konstruovaný pro zpracování a dokončování optimalizačních studií, je pro tuto činnost velice vhodný. Navíc mohou výstupy z programu ROADENG lesnímu hospodáři, investorovi posloužit jako podklady pro územní řízení. Lesní hospodář může s jistotou prohlásit danou variantu trasy budoucí lesní cesty, a tím i zpřístupnění daného celku, za optimální a tedy potřebné. Způsob vedení dané lesní cesty je velice složitý problém, který závisí na mnoha faktorech. Nejen cena a délka budoucí cesty jsou rozhodující, ale také zakomponování trasy lesní cesty do rázu krajiny a v neposlední řadě důsledné dodržování těžebních technologií ovlivňují navržení budoucí stavby.

Hodnoty objemu výkopů a násypů spoluvytvářejí zemní práce, na základě kterých můžeme sledovat negativní dopady na prostředí. Velikost plochy, sklony svahů, ale také způsoby jejich sanace minimalizují tato negativa.

Návrh trasy lesní cesty je veden od Františkovy myslivny okolo vrcholu Velké Jezerné. Celý hřeben směřující od Velké Jezerné k Mravenečníku je nezpřístupněn. Doprava dříví se provádí pouze po přibližovacích cestách a vlivem rašelinného horizontu dochází k jejich velkým poškozením. Zadržovací schopnost je vlivem těchto devastovaných cest velmi oslabena, což v regionu se srážkami okolo 1 200 mm způsobuje vysoké riziko narušení půdoochranné funkce lesů.

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