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Comparingthe expenses of forest road cut and fill operations with standard rules (Study Area: Northern Forests of Iran)

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ABSTRACT

Forest roads are one of the important feasible ways to forest areas in order to utilization, afforestation, forestry planning and recreation. Road development in forest has some negative and positive effects on environment. Thus, it is necessary for standardize of theirs geometric and technical characteristics. This research carried out for investigation and assessment of created forest road, considering to role of performed edaphic operations in forest roads on making expenses and optimum using of site potential in Neka - Zalemrrod catchment's. These watersheds located in between Neka and Behshahr cities in Mazandaran province (North of Iran) and included high diversity considering slope, aspect and earth structure. In this study, edaphic operations volume of a forest road section, viewpoint with and without standardized were surveyed. Also, excess expenses due to volume increasing of edaphic operations were calculated. An important result is significant differences between cut and fill volume and finally, total of expenses collection. According to the difference between calculated cut and fill volume in standard condition (10645.44 and 4153.88 m^3) and volume of performed operations (12511.59 and 4284.75 m^3) are considerable and followed an expenses increasing equal to 16967000 Rials, thus it is not acceptable economic consideration.

Key words: Forest road, Expense, Cut and fill operations

INTRODUCTION

Forest roads are one of the important feasible ways to forest areas in order to utilization, afforestation, forestry planning and recreation. Road development in forest has some negative and positive effects on environment[15]. Road constructions follow negative environmental effects such as area reduction of forest sites, natural drainage degradation, soil disturbance and rivers sediment production[14, 3]. Therefore, forest roads should be planned considering the existing technical standards to decrease cut and fill operations, to prevent way broaden, to avoid designing two-way road in steep slopes area. Also, in forest road construction total cost reduction should be considered[12].According to essential role of road network in forestry projects, design and construction is very important. Therefore, precise considerations of geomorphologic features, geologic aspects and soil mechanic of the study area can be proper for selecting technical construction operations of road. Soil type and drainage system are the most important effective factors for designing cut and fill slopes. Based on road width profile, it is very important to prepare culverts with suitable distance of each other. Cutting operation in unstable soils should be based on slope stability analysis except for conditions which adequate local experience exists [15].Usually, slopes are considered 1 to 2 for this kind of cut operations. Cut operations with more than 4.5m height should be constructed based on laboratory results and cut-slope concerns. Totally, deeper cut operation is needed to reduce average slope of road to achieve stability. The stability of clay cut and fill slopes can be increased with reducing tensions of soil by stair and drainage structures. Soil destruction can be avoided when human intervention is based on accurate scientific principles. Unlike, performing wrong cut and fill operations causesshort-term irreparable damages which can degrade soil in long-term [16]. According to existence of various high-risk conditions in mountainous regions for instance slope and topography, it is necessary to allocate longer time for designing forest roads. Due to vital role of forest road networks for optimum conservation of natural ecosystems, forest management, sustainable development, afforestation, ecotourism as well as added costs maximization, it is crucial to standardize geometric and technical considerations of forest roads[11].This issue is very important especially any mistake can cause high expenditures and hazardous destructive consequences[12]. This research was carried out to investigate some inhibits which can be obtained by considering the principles and operating based on standards.

MATERIALS AND METHODS

Study area: Study area was located in Sofly region of watershed number 74 (Mehraban Rood) with North latitude of 36°36' and East longitude of 53°26'. The distance of center of the region was 15 Km from Neka city, North of Iran. Geographical position of the study area is shown in Figure 1 [1].The average slope of watershed was approximately 45percentandin some areas reached to 60–70percent. The Altitude was recorded 80m.a.s.l. in compartment number 268 and 877m.a.s.l. in compartment number 130. Annual rainfall was measured 850mm [1]. The studied road was included 1800m length in most north parts of the forest project which is shown in Figure 2.

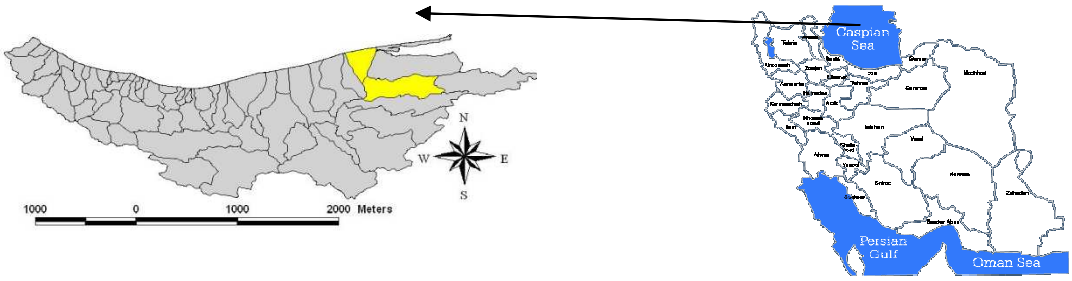

Figure 1- The map of study area

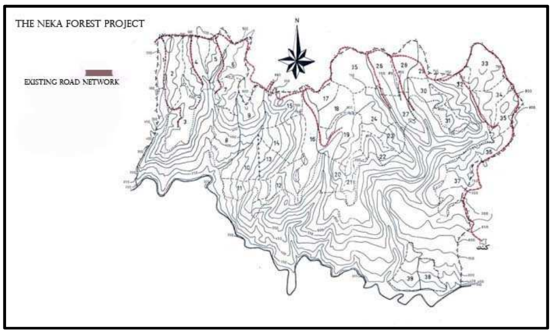

Figure 2- Existing road network in the study area

The standards of Cut and Fill slopes: The acceptable slope for cut slopes in steep areas with considering soil texture characteristics is proposed in table 1[13]. Also the slope infill-slope areas is investigated and the most optimum slope of these high-risk areas is presented in figures 3 and 4.

Table 1- Suitable slope for excavate gable roof in forest roads for different soils

Row	Soil type	Slope (The ratio of slope height to corner)
1	Fine sand	1:2 to 1:1.7
2	Large sand with silt	1:1.7 to 1:1.4
3	Dense sand	1:1.25 to 1:1
4	Dry silt and clay	1:1.5 to 1:1
5	Gravel	1:1.25 to 1:1
6	Rock	1:0.5 to 1:0.1

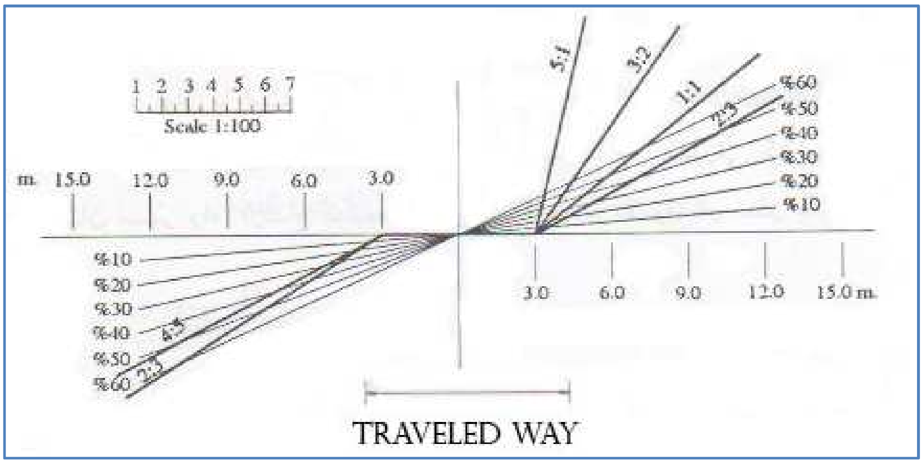

Figure 3- Determination of slope in the one-side ways

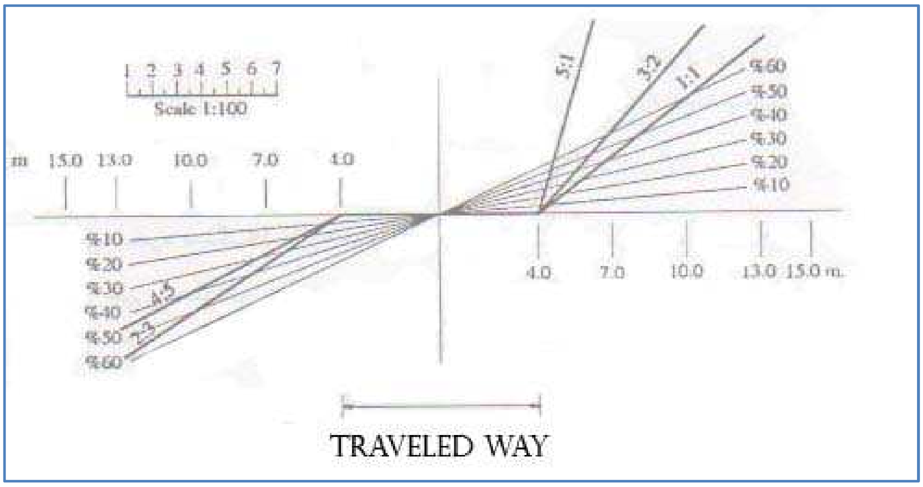

Figure 4- Determination of slope in the two-side ways

Road cross section profile features based on the Stair Method (Dumpy Leveling): This is a subtle method for drawing cross profile of road. In this method, at first, one horizontal and one vertical dumpy level in gare measured a long every 2 meter from edge point of road side. For this purpose, the first leveling is located in vertically and balanced, and then second leveling is placed horizontally to the first one. The differences of dumpy levels height is recorded in the first two meter. This process is done in first 8 meters of cut slope and primary 7 meter of fill slope[5].

Cost analysis and output coefficient: The operations that machine have the main effects(e.g. machinery excavating operations) include many separated components that should be considered and be performed continuously. Failures or stops of every elements are effective on other sections output. In the cost analysis of this study at first, machine cost was calculated in every row based on mathematic calculations and independently according to output coefficient of machine type and structure, for achieving semi-actual cost average and then, the coefficient of groups and field works were considered based on experiential information and time condition [10].

Expense calculation so fare as with unstable soil: Table 2 shows calculating expenses of excavating operations in areas with unstable soil[10]. For this purpose, there is no need to machine for transporting materials. Due to using same bulldozer for excavating operations, it was possible to transport soil in short distances (less than 20m). The bulldozer which was mentioned in this cost analysis was based on the performance in cross section profiles with approximately 15m leveling. The efficiency of bulldozer with considering output coefficient relevant to work condition, machine type and average labor power was calculated $55m^3h^{-1}$. Proficiency of the bulldozer in trails with 10–15m width and 5–10m wid this reduced down to 5% and 10%, respectively[10].

Expense calculation so fare as with stable soil: Table 3 is used for calculating cut and fill operations performed in areas with stable soil. The efficiency of bulldozer in these types of soils with considering output coefficient is approximately $50m^3h^{-1}$. Excavating operation technician observes cut and fill operation and also loading stage[10].

Table 2- Cut and Fill operations in areas with unstable soil by distance of 20m from center

Labor power	day	
Excavating operations technician		0.0005
Labor (one man for 1000 m^2)		0.001
Topographer assist		0.0005
Topography worker		0.001
Labor (one man for 1000m^2)		0.001
Total wages for labor power		
Machines		
bulldozer with 150 hours power	hour	0.018
Total hire of machines		

Table3-Cut and Fill operations in areas with stable soil by distance of 20m from center

Labor power	day	
Unstable soils		
Machines		
bulldozer with 200 hours power	hour	0.02
Total hire of machines		

Expense calculations of materials transport: According to the costs list, loading and soil transport are paid based on cubic meter of cut and fill operations. These parameters are varied regarding to soil type, loading machine type, transport machine type, loading and depletion places condition, rout condition and place distances. Thus, cost analysis should be based on special condition in every component. Average condition is considerable in this cost analysis: loading machine, bulldozer with 150 hours power equal to 950 caterpillars, average soil type with inflation coefficient of 27%, transport machine, truck with 7m^3 power. The numerical value of these coefficients that are considerable is dependent to rout length and quality of transport rout. In this study, transport distance was calculated in two distances: first, the distance less than 500m, which was used for transport of soil surplus in transition verse, decking station and turning places. Second, in 32 Km distances to decking station this is including soil surplus which was not used in transition verse, decking station, and turning places. After calculation volume of excavation operations, the expenses should be calculated. Tables 4 and 5 are related to transport expenses in mentioned distances [10].

Table 4- The surplus cost for material transport in distance more than 100m

Machines	hour	
Comperesi machine with 7m3 capacity		0.0027
Total hire of machines		

Table 5- The surplus cost for material transport in distance more than 500m in no-asphalt ways

Machines	hour	
Comperesi machine with 7m3 capacity		0.016
Total hire of machines		

Research method: The studied road was classified into second grade based on standards. Furthermore, the characteristics of road shoulders, decking, turning places position, arch, arch length and arch radius were assessed considering the standard of cut and fill slope [10, 9, 13].Soil texture of study area was identified. Then, according to table 1 and figures 3 and 4 the standard slope for each point was calculated. To measure volume of excavation operations the cross section of road was drawn using Stair Method (Dumpy Leveling). The study area was divided in three slope classes (0–30%, 30–60% and 60<%). Totally, 102 soil profiles were recorded in 1800m length of studied road. 34,57 and 11 soil profiles were belonged in slope class of 30-60%, 30-60% and 60<%, respectively. For calculating soil operation volume, the Road software was[10].

RESULTS AND DISCUSSION

Soil operations volume in standard condition: Using Road software, all 102 existing cross section profile soft he road was calculated. The numerical cost of cut slope and fill slope was equal to 10645.44 m^3 and 4153.88 m^3, respectively. The difference of soil volume between cut and filling operations (6491.56 m^3) is used during project for transition instead, decking station and turning points creating.

Soil operations volume in present condition: The volume of existing soil operations was calculated exactly by means of field observations and incorporating data in Road software. The numerical values of the costs were calculated about 12511.59 m^3 for fill slopes. The cut slope surplus values was 822.84 m^3 that 1050 $m^3$was transported off in 32 Km distance far from study area and others were used for creating of transition, decking station and turning points creating.

Comparison volume of standard soil operations with performed operations: Based on obtained cost of soil operations volume with considering standard algorithm and existing condition, the volume of cut operations had increased in compare to standard conditions. In soil profiles of 3, 4, 11, 12, 13, 20, 21, 22, 23, 24, 25, 26, 27and 28, volume of filling operations was observed but in soil profiles of 5, 6, 7, 14, 19 and 34 this amount was decreased in compare to standard. This trend was continued consistently to soil profile of 57 but in soil profiles of 57, 58 and 64 the increase of volume in cut operations was considerable. In soil profiles of 59, 60, 61, 62, 63, 65, 66 and 67the volume of cut operations was declined. The volume of filling operations in soil profiles 57, 59, 60 and 63 was raisedbut in profiles 60 and 65 was decreased.

Comparison of soil operations expenses: the comparison of performed soil operations in standard and existing situation are mentioned as follow (table6,7,8 and 9).

Table 6- Expenses comparison in slope class less than 30%

Expenses (Rials)	Standard condition	Existing condition
Wages expense	1639600	5288700
Machine expense	12163600	20901200
Expenses collection	13803200	26189900
Expenses differences	12386700	

Table 7- Expenses comparison in slope class 30 – 60%

Expenses (Rials)	Standard condition	Existing condition
Wages expense	1333900	1570000
Machine expense	9149400	13812600
Expenses collection	10483300	15382600
Expenses differences	4899300	

Table 8- Expenses comparison in slope class more than 60%

Expenses (Rials)	Standard condition	Existing condition
Wages expense	523600	513400
Machine expense	3433000	3124200
Expenses collection	3956600	3637600
Expenses differences	-319000	

Table 9- Collected expenses comparison in standard and existent condition

Expenses (Rials)	Standard condition	Existing condition
Wages expense	3497100	7372100
Machine expense	24746000	37838000
Expenses collection	28243100	45210100
Expenses differences	16967000	

According to tables 6, 7, 8 and 9 surplus expense of cut and filling operations in present situationwas considerably different from calculated expense in proposed theory [13].

CONCLUSION

The obtained results are based on determined standards and official calculation. Perhaps, it is necessary for continues returns to field and environmental condition and works control by observation method. By reason of mentioned inflexible standard numerical in table 1 and figures 3 and 4 are not based on dynamic of nature. Also, soil characteristics and soil texture condition would not be good criteria for proposing of cut and fill slope. For example in slope class of more than 60%, because of local soil stability, cut slope can be created with slope more than 1 to 10. This issue will reduce cut operations expenses. Also, in slope class of 30–60%,it was considered that most of trees were juvenile and inclined to direct of low slope. This subject is a reason for existence of in stables oil and it is necessary to reduce the slope in cut and fill slopes areas. In a research in Finland, slope was introduced as the most important effective factor in road designing operations[15]. It was reported that roads planning are corrected with considering soil, ecosystem condition and using natural slope of region[4]. This research is confirmed previous research result and soil texture is introduced as the most important factor on cut and fill slope. In other studies, it was shown that nature degradation and sediment creation by forest road network depended on characteristics of road cross section, cut and fill slopes and side cross[2, 14]. One of the best ways for expenses reduction is to avoid selecting regions with sensitive soils for road designing[17].Also in another research, results showed that optimizing expenses it would be possible to reduce maintenance expenses of forest roads in long term[8].Considering environmental issues, one of the most important principles is forest roads network construction. It should be considered the least length and side cross of road for minimizing environmental degradation and expenses of road construction in forest management[18]. As mentioned before, the best method for planning and following project line of road are hector-metric method and rout sticking[7]. Furthermore, it is proposed that planning and performing of pilot rout and slope regulating in cut and fill slops depended on results of soil analysis, soil mechanic and field observations[6]. Presence and control of experience supervisor engineer during cut and filling operations can prevent increasing possible expenses and environmental damages. In areas with unstable soil and moderate slope, cut operations and degradation are more.

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