INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

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DETERMINATION OF THE MOST ALLOWABLE SLOPE OF STRIP ROAD FOR SKIDDER TIMBERJACK 450C

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ABSTRACT
In skidding using ground skidding machines some of factors are effective on skidding time such as slope, loading volume, skidding distance and etc. Slope factor is one of the effective factors on skidder activities in skidding operations. In order to determination of the most allowable slope in strip road with Timber Jack 450C in downward skidding, six different slopes classes (21-24%, 24-27%, 27-30%, 30-33%, 33-36% and 36-39%) determined in skid trails of parcel eleven (district two of Langa management plan forest, Kelardasht region in North of Iran). Then, time study was performed on loaded traveling and unloaded traveling in every of slope classes (with 3.80-6.00m^3 and 8.21-10.40m^3 volume classes in determined distances). The first, collection of data have noted in special form and then have converted to uniform unit of m/s. Analyses of data were performed for every component of loaded traveling and unloaded traveling, separately. In every of two components with fixing of the other factors, slope factor on loaded traveling, slope and loading volume on loaded traveling were analyzed. Descriptive statistics for each data set were calculated using the SPSS package. Tukey test was used for analysis of variance and means comparison of loaded traveling speed. Results showed the significant effectives on traveling speed in α = 5% probability level for unloaded traveling (in 36-39% slope classes) and loaded traveling (in 30-33% slope classes). Furthermore, loading volume has no effective on loaded traveling speed.

KEYWORDS: The most allowable slope, skidding, strip road, Langa (Kelardasht region), TimberJack 450C

INTRODUCTION

Almost, 1.9 million hectare areas of Iran forests are situated in southern of Caspian that have merchant value. This forest is known to hyrcanian forests and valuable of genetic viewpoint due to this forests are biotic fossil of European forests (Yakhkeshi, 2003). Primary transportation is one of the most sensitive, the most expensive and hard level of forest utilization (Sarikhani, 2001). Tractor machine have used for skidding and transportation of woods in uneven and long routs since 20 century (Zecic, et al. 2006).
Nowadays, skidders have high efficiency in sloped regions (Trzeniwski, 1978; Ewing, 2003). Primary transportation is performing by skidder and crawlers in Iran (Sarikhani, 2001). Loaded and unloaded traveling factors are relation to strip roads (Lotfalian, 2002). Slope factor of strip roads are one of the effective factors in designing of strip roads and skidding components. In downward skidding, skidding time is depended to number of logs, skidding distance, loading volume and strip road slope parameters (Naghdi, 2005). But, results of Lotfalian (2002) research showed that loading volume, number of logs and rout slope had no significant effects on loaded traveling time.

MATERIALS AND METHODS

Study area

Iran forests have divided to 103 catchments area. Study area is situated in 36 of Kazemrod catchments area, the second district of Langa management plan forest, and parcel 11. This district is located between 51˚ 1′ to 51˚ 6′ longitude and between 36˚ 30′, 36˚ 38′ latitude. The maximum elevation is 2500m and the mean elevation is 1650m. The dominant aspects are northeast and west. Bedrock is sandstone with silting and argillite, and lime stone. Permeable of soil is between mean and weak. Soil type is forest brown with low acidity; soil texture is heavy, relatively. The dominant forest type is Faguetum with mixed types of Alder and Maple. Forest management and silviculture methods are even aged high forest with shelter wood cutting (Anonymous, 2003). By these explanations, Langa region (parcel 11) was selected for this research. This research was performed in the summer of 2007.

The effective variables

For this research whole of effective variables on slope classes hypothesized as fixed. These variables includes: skidding machines (skidder timberjack 450C), deriver expertise (using fixed deriver), soil (whole strip roads were selected of one parcel with soil texture of average to heavy), downward skidding direction, without cross slope, soil moisture (data collection at sunny days with dry routs), without curvature and change of length slope (slope changes were ± 1.5% in every slope classes), primary and secondary speed (routs with monotonous slope), slope aspect (northeast and northwest), strip road cross (between 3.5 to 4m), bushes and stand density (number of 182.15 per hectare), composition of rout superficial (the amount and type of litter was alike), number of logs (number of 3 in every once of skidding; only in 36 – 39% slope class at two once of skidding, number of logs were 2), log

qualitative grade (whole were 1 and 2 grades), log length (between 5.6 to 11.20m), log type (whole of logs were beech; only, at once of skidding, one of logs was alder).

TABLE 1: Number of needed samples for slope classes

Strip road Slope (%)	Strip road length (m)	Mean of movement time (Second)	Standard deviation	Number of needed samples
21 – 24	139	99.02	9.88	19
24 – 27	51	38.32	2.25	7
27 – 30	73	57.63	6.49	25
30 – 33	62	51.31	3.51	9
33 – 36	83	74.91	7.75	21
36 – 39	51	65.01	6.05	17

Determination of the six strip roads

For this research, the 20 – 40% slope selected on basis of performed studied and experts opinions. Slope class of 5% was used in previous researches for assessment of machines and studies of forest utilization, but in this research, slope class of 3% was used for more precession thus 21 – 24%, 24 – 27%, 37 – 30%, 30 – 33%, 33 – 36%, 36 – 39% slope classes were classified. After selection of research location, whole strip roads of parcel 11 were determined in March 2007 then, routs length with monotonous slope (using suunto clinometers) and slopes (with 1% precession) were measured and recorded. For measuring length every slope class, the distance on strip roads were measured (with 0.1m precession) using strip meter of 20m. Extremely, the first and end distances every slope classes were determined by wood sticks, color and yellow strip.

Data collection

Data were collected in March 2007. In skidding season, loaded and unloaded traveling time were recorded using stop watch by interrupted time method in every classes. Length and logs average diameter measured in loaded location. The data that delay effects on theirs (except technical delay), logs type was different and or number of logs weren't 3, deleted for analysis. Logs volume calculated by Huber formula (Eq. 1) and loading volume was calculated with plus of logs volume in every skidding time.

$$V = gm.L \qquad [1]$$

Where V, log volume; gm, basal area of log medium; L, log length.

RESULTS & DISCUSSIONS

Results of this research divided to loaded and unloaded traveling sections. In unloaded traveling (with hypothesis this slope of strip road are effective on movement speed) using analysis of variance showed that mean of unloaded traveling speed in timberjack 450C aren't similar in every six slope classes, and have significant differences at level of $\alpha = 0.05$ (Table 2).

TABLE 2: Analysis of variance for unloaded traveling speed in slope classes

Variables	Sum of square	Degree freedom	Mean of square	F	P
Between groups	4.652	5	0.930	72.52	0.00
Within groups	1.232	96	0.013	-	-
Total	5.884	101	-	-	-

Grouping of slope classes using tukey test is showed in table 3 and fig. 1. Results showed that 21 – 24%, 24 – 27%, 27 – 30%, 30 -33%, 33 – 36% slope classes had no significant differences at level of $\alpha = 0.05$ in downward skidding by timberjack 450C, but 33 – 36% slope class had significant differences with the other classes. Also, linear curve adherence ($R^2 = 0.602$) was more than the other curves (Fig. 1) thus, this is mentionable that curve of unloaded traveling speed for timberjack 450C was reduced as linear with increasing slope of strip roads.

In loaded traveling by pre hypothesis this slope of strip roads and loading traveling are effective factors on movement speed, thus, these two variables were analyzed. Analysis of variance (Table 4) showed that means of loaded traveling speed in timberjack 450C for two classes of loaded traveling volume (3.80 – 6.00 and 8.21 – 10.40) had no significant differences at level of $\alpha = 0.05$.

Analysis of variance for slope parameter (Table 5) showed that means of loaded traveling speed by timberjack 450C in every six slope classes had significant differences at level of $\alpha = 0.05$.

TABLE 3: Grouping of slope classes using Tukey test in unloaded traveling

Slope (%)	Number	Grouping for α = 0.05	
		Group one (a)	Group two (b)
36 – 39	17	-	1.5706
33 – 36	21	2.0848	-
30 -33	10	2.0850	-
27 – 30	25	2.1396	-
24 – 27	10	2.1400	-
21 – 24	19	2.2016	-
Pr>F	-	0.062	1.000

TABLE 4: ANOVA for loading volume in downward skidding

Variables	SS	DF	MS	F	P
Between groups	0.37	1	0.374	0.74	0.39
Within groups	30.69	61	0.503	-	-
Total	31.07	62	-	-	-

TABLE 5: ANOVA for slope parameter in loaded traveling

Variables	SS	DF	MS	F	P
Between groups	45.49	5	9.100	79.69	0.000
Within groups	10.96	96	0.114	-	-
Total	56.46	101	-	-	-

Results showed that slope classes were classified in downward skidding with loaded traveling component by timberjack 450C as following: 21 – 24%, 24 – 27% and 27 – 30% slope classes were at one group (a), 30 – 33% slope class at two group (b), 33 – 36% slope class at three group (c), 33 – 36% slope class at four groups (d) (Table 6). Also, linear curve adherence ($R^2 = 0.847$) was more than the other curves, thus, it is resulted that with increasing of strip road slope, the curve of timberjack 450C movement speed is reduced as linear (Fig. 2).

TABLE 6: Grouping of slope classes using tukey test in loaded traveling

Slope (%)	Number	Grouping for α = 0.05			
		a	b	c	d
36 – 39	17	-	-	-	1.65
33 – 36	21	-	-	2.53	-
30 – 33	10	-	2.99	-	-
27 – 30	25	3.38	-	-	-
24 – 27	10	3.45	-	-	-
21 – 24	19	3.50	-	-	-
Pr>F	-	0.93	1.0	1.0	1.0

The most consumed time for a time of skidding is belonging to loaded and unloaded traveling time. Furthermore, slope and distance parameters are the most effect factors on loaded and unloaded traveling. Pay attention to, the recorded data were converted to uniform units of m/s for analysis of skidding time in different slope classes, thus the effect of distance on skidding time was deleted in data analysis. Results of this research showed that in loaded traveling component, the slope of strip road had no significant effect to 33 – 36% slope class (almost 35%) in compare to the lower slope class and slope upper to 35% (36 – 39 slope class) had significant effect on skidding time (Table 2 and Fig. 1).

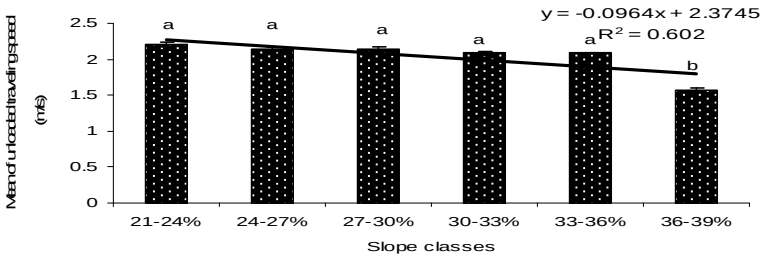

Fig. 1: Grouping of slope classes using tukey test for unloaded traveling

In unloaded traveling of downward skidding, the skidding time is increased with increasing of slope and its curve is as linear (Jorgholami, 2006). In this research with increase of slope classes, the speed of unloaded traveling was reduced but this reduction of speed wasn't significant to 33 – 36% slope class (almost 35%). Also, this research confirmed the linear relation of skidding time curve with increase of slope. In downward skidding, length of strip road is effective on skidder movement time and loading volume, number of logs in every time and strip road slope parameters are ineffective on movement time (Lotfalian, 2002). In loading traveling, skidding time will increase with increasing of slope (Mostafa Nejad, 2002; Zecic, et al. 2006; Lotfalian, et al. 2007). In this study, slope parameter had significant effect on skidding time of 30 – 33% slope class.

In the other word, loaded traveling speed of timberjack 450C had no significant differences at 21 – 24%, 24 – 27% and 27 – 30% slope classes one another (Table 6 and Fig. 2). Loading volume factor is ineffective on loading volume component (Lotfalian, 2002; Lotfalian, et al. 2007) that is visible in this research, also. With increasing of loading volume, the skidding time is increased and its curve is as linear (Mostafanejad, 2002; Egan and Baumgas, 2003; Akay, et al. 2004) that is visible in this research, but wasn't significant viewpoint statistical between two classes of loading volume. Also, linear curve of skidding time is confirmed in this study (Fig. 1 and 2).

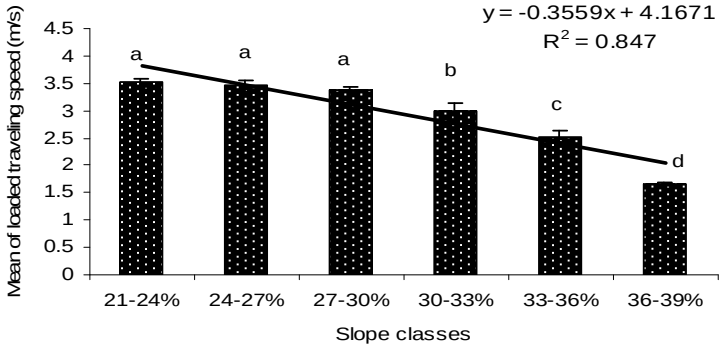

FIGURE 2: Grouping of slope classes using tukey test for loaded traveling

CONCLUSIONS

In this research the effect of skidding distance (conversion of skidding time to uniform unit of m/s) and number of logs (in whole time of skidding was 3 but in slope class of 33 – 36% by reason of not be of extractable industrial logs in every two time of skidding were number of 2) were deleted. Therefore, slope and loading volume parameters considered in this study. Skidder timberjack 450C was able to skidding at 36 – 39% slope class, although, movement speed in this class had significant differences with lower slope classes (Tables 2 and 5; Fig. 1 and 2). But, by reason no existence of slope classes' upper of 36 – 39%, the determination the most allowable slope for skidder Timberjack 450C was impossible considering results of this research.

ACKNOWLEDGEMENT

The authors wish to thank the Sari Agricultural Sciences and Natural Resources University.

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