作業道の林業的評価に関する研究(3)

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Studies on the Evaluation of Strip Roads for Logging and Management in Forestry (III)
—— Some of considerations on strip roads under the differences in terrain ——

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SUMMARY

At steep area both strip road and forest road had a wide distribution in small radius of curvature, and inreversely at low area in bigger radius.

Building a strip road at steep area was very advantageous in constructing cost. On the contrary there were few merits building a strip road at low area. Its building cost increased in drainage and ballasting at low area.

We can draw from these findings it is very significant that strip roads are widely developed at steep slope area as a road substituting for expensive forest road. On the other hand, it is desirable to develop forest roads with higher function rather than strip roads at low area.

1 Introduction

The following facts were found from the previous research on lots of strip roads built at steep and mountainous area, Tenryu districts : The first is a great difference in building cost at steep areas between forest road and strip one, that is, the strip road was very cheap. The second is the fact that any strip road joined any top of forest roads was unexpectedly tough as to natural disaster. The third is the point that a goal for building forest roads may be reached only by the strip road joined those forest road.

On the basis of these findings, the authors will mainly consider strip roads built at low slope area in comparison with forest roads.

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2 Research materials

For the purpose of this research we picked up next two districts : Tenryu districts and Fuji ones located at the foot of Mt. Fuji. The Tenryu districts belong to steep slope areas and consist of five municipalities in which we can find the beautiful sight on man-made forest, Japanese sugi because of famous sugi's forest zone. On the other hand, Fuji districts with mainly low slope areas belonging to a part of national forest and some of municipalities. Among some of forestry districts in Shizuoka prefecture, we can say that there are a great number of forest roads and strip ones in Tenryu district as seen in Table 1. This is how the authors were trying to pick up above two districts for this research.

In this paper the Tenryu districts are named

Table 1. Distributions of forest strip road belonged to Shizuoka prefecture 1985

Items / Districts	Number of roads	Total length (m)
Izu	12	8,155
Tobu	23	22,356
Fuji	21	12,358
Tchubu	22	30,526
Shidahaira	16	18,367
Chuen	48	80,082
Tenryu	101	150,903
Seibu	14	21,856
Total	269	366,378

as A zone and also the Fuji districts B zone. The following things were particularly gathered as researching materials: general plans, planes and profile for earth work, building cost and actual records as to road maintenances.

In order to make sure a lot of matrials gathered, we often surveyed related roads at the spot. Prices correction to building cost was done on the basical prices index in 1980.

3 Actual findings of the strip road researched

Table 2 shows actual circumstances on the strip roads researched at A and B zone. Comparing with any strip road at the Tenryu-shi, A zone, we can find there are fewer strip roads at B zone. On the other hand, there are 18 strip roads at Fujinomiya-shi of which 17 strip roads have been located at steep area even in B zone. In terrain there are both steep area and low area as seen in Table 3 and 4. Therefore, it is seen that there are fewer strip roads at low slope area. This reason will be discussed in next chapter.

Ohjiro national forest is well known as a district of high road density, 50 to 60 m/ha, in Japan. These roads net work had been kept 12 years ago, so most of researcing materials were not getting reserved any more.

4 Results and considerations

4-1 Terrain's distributions of researched districts

Table 3 shows terrain's characteristics by means of terrain index at both A and B zone. Of course, the terrain index is in average respectively.

According to this terrain analysis it is seen that B zone is divided into two areas from terrain index. The result is given as in Table 4.

The steep areas in Fuji-shi and Fujinomiya-shi have the same terrain index as the Tenryu-shi has. While considering the actual yarding system, some of cable systems have been used for A zone. On the other hand, a tractor skidding system for B zone. Therefore, it is considered that these actual skidding systems agree with the result of terrain index.

Table 2. Strip roads belonged to each district and their actual circumstances

Items / Districts	Strip road length belonged to district	Lines	Average length
Fuji-shi	2,281 m	3	760 m
Fujinomiya-shi	10,247	18	569
Fuji national forest	17,143	31	553
Ohjiro	22,052	15	1,470
Tenryu-shi	48,464	46	1,054

Table 3. Average terrain index at districts researched

Factors / Districts	Average slope Ii (%)	Undulation R	Valley number V number/km²	Terrain index I
Fuji-shi	34.4	196.2	10.0	36
Fujinomiya-shi	34.0	216.1	7.6	38
Fuji national forest	21.2	148.7	7.5	22
Tenryu-shi	51.3	301	4.6	50

Note : $Ir = R(0.1+0.01 \cdot V)$. $I = (3I_t+I_r)/4$

Table 4. Evaluation by means of terrain index and two zones classified by it

Factors / Districts	Average slope Ii (%)	Undulation R	Valley number V number/km²	Terrain index I
Fuji-shi, A zone	50	279.9	11.1	52
Fuji-shi, B zone	16.9	102.8	8.6	18
Fujinomiya-shi, A zone	50.2	308.2	7.4	51
Fujinomiya-shi, B zone	15.4	110.0	7.8	17
Fuji national forest	21.2	148.7	7.5	22
Ohjiro national forest	63.1	277.0	13.8	64
Tenryu-shi	51.3	301.0	4.6	50
Haruno-cho	65.3	432	4.7	65

Note : Both Fuji-shi and Fujinomiya-shi were classified into A and B zone from the result of terrain index.

Table 5. Distribution of radius of curvature under differences in terrain

		Range / Districts	8 to 20 (m)	20 to 40 (m)	40 to 60 (m)	60 to 80 (m)	80 to 100 (m)
			(%)	(%)	(%)	(%)	(%)
Steep area, A zone	Strip road	Tenryu-shi	58	34	5	0	3
	Forest road	Tenryu-shi	33	33	12	5	17
		Fuji-shi	52	25	20	2	1
		Fujinomiya-shi	46	20	20	9	5
		Ohjiro national forest	75	14	9	0	2
Low area, B zone	Strip road	Fuji-shi, B zone	25	30	30	6	9
	Forest road	Fuji-shi, B zone	6	35	40	13	6
		Fujinomiya-shi	15	33	33	3	16
		Fuji national forest	18	56	14	2	10

Note : These results were given from planes of whole researched roads.

4-2 Road design under the differences in terrain

In this section it is discussed whether the usual road design, radius of curvature and profile grade, will change under the influences of different terrain or not.

Table 5 presents distributions of radius of curvature which are found in a lot of strip roads and forest ones built at A and B zone. We can realize a tendency for the distributions that there are lots of small radius at steep slope area. On the contrary, any radius at low slope area is bigger than those of steep area.

Table 6 shows the maximum and average grade of longitudinal slope adopted at these areas. The maximum profile grades of each strip road are in 14 to 17 percent which are larger than those of forest road. However, the average is in 10 percent which it is in the limit of forest road.

Therefore, we can say that Japanese strip road has been recently developed as a way substituting for the expensive forest road in productive forest area.

Table 6. Profile grade between strip road and forest road found in different terrains

		Factors / Districts	Average grade	Max. profile grade
			(%)	(%)
Steep area, A zone	Strip road	Tenryu-shi	6.0	14.0
		Harno-cho	10.0	15.6
	Forest road	Fuji-shi	7.1	13.6
		Fujinomiya-shi	5.0	13.7
		Tenryu-shi	6.0	14.0
Low area, B zone	Strip road	Fuji-shi	6.8	13.7
	Forest road	Fuji-shi	4.5	9.0
		Fujinomiya-shi	2.9	11.4
		Fuji national forest	2.3	14.0

Note : These results were given from profiles of whole researched roads.

4-3 Building cost under differences in terrain

Table 7 shows contents on building cost of strip road and forest road at A and B zone.

The following things were drawn from these results : Firstly the building cost of strip road at low slope area, B zone was expensive in Japanese yen per meter, and did not get considerably cheap in comparison with forest road. Secondly, at steep slope area there was a great difference in building cost between forest road and strip road. On the basis of these facts, it may be considered that there is a great merit in building strip road as a road substituting for expensive forest road at steep area.

Therefore, it will be pointed out that a development of strip road in forestry is particularly favorable at steep area, and on the contrary its benefit is little at low slope area.

Nextly, Table 8 presents differences on soil volume in m^3 per m under different terrains. According to this result, cutting soil volume is greatly depended on terrain's conditions. A part of expensive building cost at steep slope area is also due to this fact. On the other hand, the constructing cost increases at low slope area.

These reasons are described in detail in next section.

4-4 Why is comparatively expensive a strip road at low area ?

Table 7 was prepared for the purpose of this research as to districts in the same class on terrain index. This presents us that the cutting cost gets large at steep area, and reversely the constructing cost increases at low area as described. Furthermore, this tendency was also the same to forest road.

The authors think that such an increase of constructing cost included in total building cost is probably a characteristic at low slope area. What

Table 7. Difference of building cost between two terrains

Road		Districts \ Contents	Building cost, per m (yen/m)			
			Cutting	Banking	Constructing equipment	Others
Steep area, A zone	Strip road	Tenryu-shi	982 (31.1)	476 (15.1)	1374 (43.5)	326 (10.6)
	Forest road	Fuji-shi	6044 (26.0)	1219 (5.0)	7360 (31.0)	9108 (32.0)
		Fujinomiya-shi	6490 (27.0)	447 (2.0)	7773 (32.0)	9229 (39.0)
		Tenryu-shi	11747 (26.0)	984 (2.0)	28464 (63.0)	4066 (9.0)
Low area, B zone	Strip road	Fuji-shi	1443 (14.9)	380 (3.9)	4606 (47.6)	3256 (33.6)
	Forest road	Fuji-shi	2282 (7.0)	1015 (3.2)	16722 (52.1)	12101 (37.7)
		Fujinomiya-shi	1014 (•5.0)	1084 (5.0)	11441 (52.0)	8348 (38.0)

Note : (1) The next things are included in constructing equipments ; sidedith, drainage, retaining wall, fence etc. as to forest road. On the other hand these equipments, as a rule, usedn't to be constructed in strip road.

(2) Building cost is calculated from materials of both strip road and forest road built in 1980 to 1984. Prices correction was done on the basical prices index in 1980.

Table 8. Soil volume in earth work under different terrains

Road		Districts \ Items	Road Width (m)	Cutting and Banking Soil Volume in m^3/m	
				Cutting	Banking
Steep area, A zone	Strip road	Tenryu-shi	3.0	3.8	1.1
	Forest road	Tenryu-shi	3.0 to 3.6	10.7	2.0
		Fuji-shi	3.0 to 4.0	7.2	3.5
		Fujinomiya-shi	3.0	7.9	1.3
		Ohjiro national forest	3.6	8.4	0.9
Low area, B zone	Strip road	Fuji-shi	3.0 to 3.6	2.0	1.4
	Forest road	Fuji-shi	4.0	3.4	2.6
		Fujinomiya-shi	3.0 to 4.0	3.5	2.6
		Fuji national forest	3.6	2.4	1.3

Table 9. Contents involved in constructions of strip road and those percentage of building cost, at low area, Fuji-shi

Contents \ Road	S Road	T Road	M Road
Ballasting	44 %	75 %	62 %
Drainage	43	12	29
Slope protection	13	13	9

kinds of constructing equipment will get related to the cost increased at low area? In order to make clear this point, Table 9 is shown as an actual sample of strip roads built at low area. We can realize that both ballasting and drainage keep a lot of percentages in constructing cost. This fact was also the same to forest road.

Namely, according to a relation on forest road it is seen from Table 10 that there are both ballasting and drainage in high rate even in constructions of forest road at low area. The following reasons on these results are considerd: Firstly since the surface runoff moves slowly on low slope area, the moving water is apt to accumlate anywhere. Therefore, lots of drainages get necessary at such a place, in order to get free from the water accumlation. Secondly, the fact that a lot of constructing cost are due to ballasting and drainage, means the resisting capacity of ground soil is small. This situation has to be improved by drainage, ballasting, etc.

These are reasons why strip roads are comparatively expensive at low area. Through the above considerations, it will be drawn that any strip road at steep area brings us a large merit because of very cheap building cost. Such a strip road must well be evaluated as a road substituting for expensive forest road, and besides as a channel joined forest road.

However, this estimation does not directly agree with those of strip road at low. area. We can even say that it is desirable to develop forest road with higher functions rather than strip road at low area, because its building cost gets comparatively expensive comparing with those of forest road at low area.

This gives us an important suggestion as to a way of developing strip roads. That is to say, it is important to consider how topography and terrain the building area is located in.

Table 10. Contents of constructions of forest road and those percentage in building cost at Fuji districts

Contens \ Terrain	Steep area, A zone		Low slope area, B zone	
	Fuji-shi	Fujinomiya-shi	Fuji-shi	Fujinomiya-shi
Ballasting	25.9 %	1.6 %	27.1 %	30.3 %
Drainage	36.0	7.5	42.9	41.7
Slope protection	16.2	6.7	4.6	6.2
Block protection	21.6	29.1	21.6	17.9
Retaining wall	—	47.2		0.6
Pavement work	—	—	4.8	0.8
Guardrail, Fence	0.3	7.9		2.5

Note: Pavement rate of whole forest road in Japan is nowadays about 10 percent.

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作業道の林業的評価に関する研究（第３報）
地形の相違からみた作業道作設への２，３の考察

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摘　　要

この研究は，地形の相違（急斜地域と緩斜地域）によって，作業道の作設がその構造上，また作設コストの面で，さらに林道との間にどのような関係が成立するか，などについて調査，考察したものであり，凡そ次のようにまとめられる。

急斜地域に作設される作業道は，かなり小さいカーブを多く取り入れており，緩斜地域では大きいカーブを現実に多く取り込んでいく傾向にある。

急斜地域への作業道の導入は，林道に較べ作設コストの面で格段に有利である。しかし，このことは緩斜地域では，同じ意味に解することはできない。

緩斜地域に作設される作業道は，林道の場合と同様，土工量が減少する傾向がみられるが，一方で路面支持力を高めるための排水施設（排水溝，砂利・砕石の敷込み）による費用の増大が原因となり，作業道の割高感をまねいている。

急斜地域（山岳地域）の作業道は，同地域にみる高価な林道に十分代替しうる道路として，林業的評価を与えることができる。一方緩斜地域には，林道か作業道か，の問題にそれ程のポイントはなく，できれば機能的に上位の林道開設が得策だという考え方もできる。