REPORT
OF
IMPLEMENTATION DESIGN SURVEY TEAM
FOR
THE TECHNICAL COOPERATION PROJECT
OF
THE FORESTRY DEVELOPMENT
IN THE ARAKAN RANGE IN BURMA

JUNE, 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The Japan International Cooperation Agency dispatched, as part of technical co-operation of the Japanese Government to the Burmese Government, a survey team to Burma, headed by Heizaburo Tezuka, a senior technical staff member of the Japan Overseas Forestry Consultants Association, in November 1978, to prepare a detailed design for the Technical Cooperation Project for the Forest Development of the Arakan Range. The present report is based on the result of this survey.

Various designs for the facilities necessary for the construction of Model Operation Forest, which will be the site of education and training for the above-mentioned project, were made in this survey. Based on the present survey, necessary preparatory work for the on-the-job training is expected to be carried out speedily. I hope this report will serve as a useful technical guide for this preparatory work.

I wish to express my sincere appreciation to the officials concerned of the Timber Corporation and of the Ministry of Agriculture and Forests in the Socialist Republic of the Union of Burma for their close cooperation extended to our survey team.

June, 1979

Shinsaku Hogen
President
Japan International Cooperation Agency

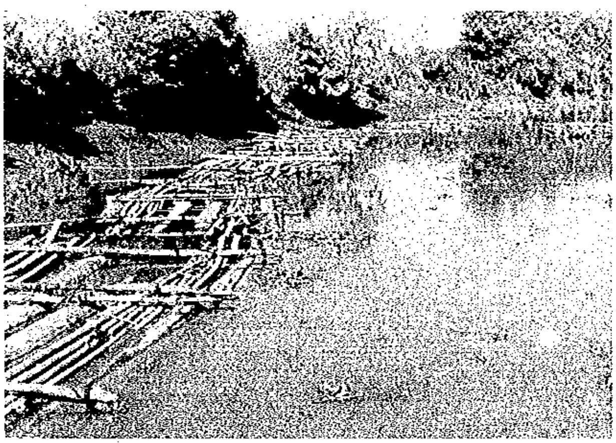
Ceremony of the Presentation of Machinary and Equipment,
Japanese Ambassador to Burma, Mr. Komuro (left)
Managing Director of Timber Corporation U Kyaw Saint (right)

Opening Ceremony for the Project

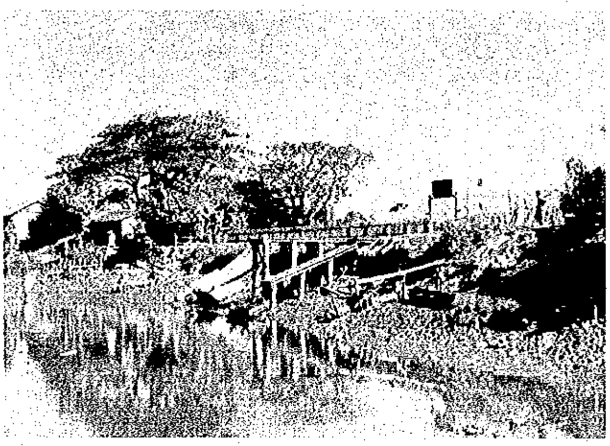
Compound of Shawbyar Pilot Training Center

Beginning Point of Forest Road

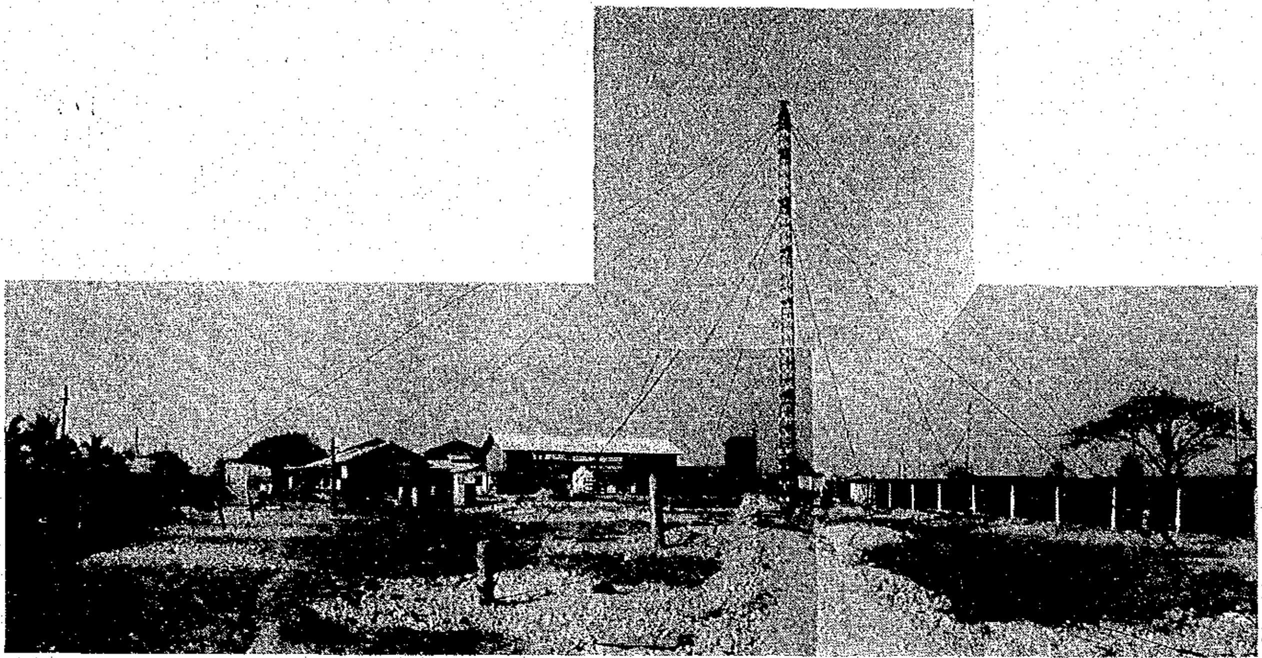
Logging by Elephant



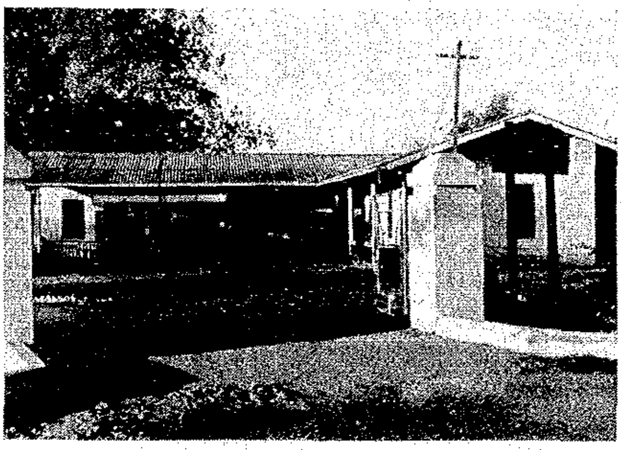
Log Transportation by Raft from Showbyar



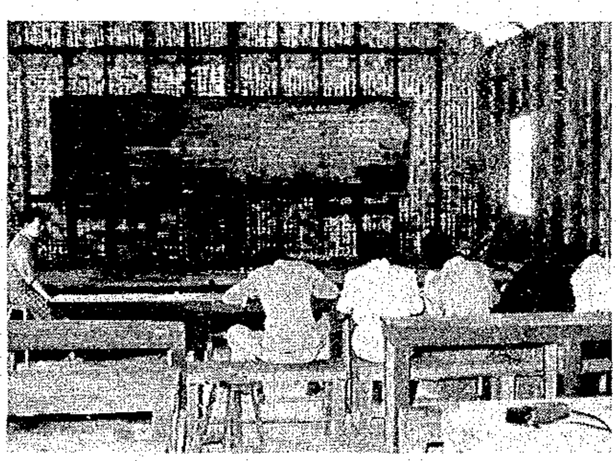
Ferry Port at Showbyar



Okkyin Central Training Center



Experts Bungalow at Bassein



Indoor Training at Shawbyar

CONTENTS

1. Purpose and Outline of the Survey

1-1 Background

1-1-1 Until RD Signing

As the result of the cyclone which hit the south-west of Burma in the rainy season of 1974, the tropical rain forest of the southern half of the Arakan Range which is under direct management of the Government as a classified forest was damaged. The damaged trees amounting to 4.61 mill. ton (8.3 mill. m^3 in Japanese log measuring system) were found in an area covering one million acre (400,000 ha).

Since removal of these damaged trees did not make progress as expected, there was a move of requesting cooperation with the Japanese Government in August 1976, and after several negotiations through diplomatic channels, the pre-survey team headed by Heizaburo Tezuka (the then chairman of the board of directors of the Forestry Credit Fund) was dispatched in December 1976 and, as a result, it was recognized that the implementation of the technical cooperation project with the State Timber Corporation concerning a mechanical logging system (mainly cable logging system) at the Arakan Range, was worth-while.

Since May 1977 two staff were sent to make a survey. The preparatory survey of the cooperation project was undertaken and soon the Implementation Planning Survey Team headed by Jiro Namura (the then Chief of Forestry Development Department of JICA (Japan International Cooperation Agency) was sent in June to examine various conditions.

With the cooperation and assistance of Mr. Arita, the Japanese Ambassador to Burma and Mr. Hara, the secretary of the Embassy, the project was included in the implementation budget of the Economic 4 Year Plan of Burma (the second term plan of the 20 year plan) from 1978 and the general agreement was reached on acceptance of the technical cooperation of Japan and on the draft of Record of Discussion-RD as per attached paper and in August, the Burmese Government decided at the cabinet meeting to go ahead with the project.

In November, the Implementation Arrangement Team headed by Heizaburo Tezuka was sent and with some revisions, the draft of RD was signed between Timber Corporation and Japanese side on 2 December. At this point, the forestry technical cooperation project of the Arakan Ranges of Burma was started.

Details of the above are shown in "Report of Implementation Planning Survey Team on the Technical Cooperation Project for the Forest Development in the Arakan Range, Burma" of 1978.

1-1-2 After Signing of RD

Based on RD, JICA budgeted the machines needed to aid the cooperation project in fiscal years of 1977 and 1978 and purchased and forwarded the machine and at the same time, dispatched experts on a long term basis and accepted technical trainees from Burma.

Experts on the long term basis are as follows:

Experts of Forestry Technical Cooperation Project

As of January 1979

Name	Duty	Duration	Office in Japan
Hitoshi Kato	Chief Advisor	16 April 1978 - 15 April 1980	Director, Operation Division, Tokyo Regional Forestry Office
Susumu Sakamoto	Liaison Officer	16 April 1978 - 15 April 1980	Chief, Overseas Forest Resources Survey Section, Planning Division, Forestry Agency
Osamu Takada	Logging	18 June 1978 - 17 June 1980	Director, Planning & Cordinating Division, Nagoya Regional Forestry Office
Hisaharu Hayashi	Extraction Planning	25 July 1978 - 24 July 1980	Senior Forestry Officer, Planning Division, Forestry Agency
Fumio Asaka	Cable Logging	25 July 1978 - 24 July 1980	Kikonai District, Hakodate Regional Forestry Office
Norimi Saijo	Cable Logging	24 August 1978 - 23 August 1980	Akan District Office, Obihiro Regional Forestry Office
Takeo Oda	Workshop Mechanics	1 December 1978 - 14 March 1979	Overseas Development Division, C. ITOH Forestry Co., Ltd.

On the Burmese side, U Hla Pe, General Manager, Extraction Department, Timber Corporation was appointed as Project Director and members of a Joint Committee which is composed jointly of Japanese experts as well as counter-parts have been chosen. The Timber Corporation has set up the central office for the project in its head office and lodgings for the Japanese experts, work shop in Bassein City, lodgings for Burmese trainees, class room for in-service training at the Shawbya timber yard were built by local cost in the end of October 1978.

In April 1978, U Hla Pe, U Aung Nyaing, and U Zaw Weik as the first group and in September, U Win Kyi (Manager, Irrawaddy Division, Timber Corporation), U Bo Lay and U Win Myint as the scond group, visited Japan for observation and training.

1-2 Purpose of the Survey

Based on the above, the implementation design survey team headed by Heizaburo Tezuka was dispatched on 10 November 1978 to make a survey of the preparation of training and the model operation forest on the spot and design the followings which are required for preparation of the training curriculum.

(1) **On the Job Training Program at Model Operation Forest**

-1- Decision of the area of model operation forest and grasp of stand condition
The location of the stand covering about 1,000 ha. which is set up in Chaungtha forest as model operation forest, is clarified by using the basic map which the Timber Corporation owns or an equivalent map, and important points are verified on the spot. With past data and reconnaissance, the forest condition of the model operation forest (the area by compartment, growing stock by species and cut volume) can be grasped.

-2- On the job yearly training program
With past data etc., the following yearly on the job training program provided with the following items is prepared.

a. Felling block map
b. Cut volume and cut area
c. Production by each operation process from felling to completion of yarding
d. Number of workers and man-days by each operation process from felling to completion of yarding
e. Other necessary matters

-3- Model operation forest plan
For the initial year of the yearly plan of -2- of (1) a more detailed model operation plan including following items is prepared.

a. Map which clarifies log hauling system including cut area, location of cable and main feeder roads.
b. Design of cabling and statement of estimate
c. Other necessary matters

(2) **Plan of Facilities for Model Operation Forest**

-1- Construction plan of yearly feeder road
Main feeder roads which are necessary for implementation of on the job training of -2- of (1) are examined by map and reconnaissance and the plan including following items is prepared.

a. Map of temporary forest road
b. Labor force and expenditure

Design of main feeder roads
For the initial year of yearly plan of -1- of (2), a main feeder roads is designed. The design will include:

a. Cross sectional view and profile of route
b. Earth work

c. Design of important structures and work arrangements
d. Labor force and expenditure
e. Other necessary matters

-3- Plan of facilities as buildings
Arrangement of facilities as buildings (garage, material warehouse and wireless etc.) which are needed for implementation of on the job training plan of 1 are examined and the plan is prepared.

(3) Plan of Technical Coöperation Center

-1- Plan of exercise area for simulation cable yarding
Design for installation of small type yarder in the exercise area for simulation cable yarding is made.

-2- Plan of training facilities
Arrangements of various facilities such as lecture room, laboratory, materials yard and teaching materials warehouse are examined and its plan is prepared.

(4) Yearly Plan of Aided Machines and Materials

In relation to every plan of (1) ~ (3), aided machines and materials after 1979 are examined and the annual aid program of machines and materials is prepared.

1-3 Activities of the Team

Days	Date	Day of Week	Itinerary
1	1 Nov.	Wed.	Tokyo - Bangkok
2	2 Nov.	Thus.	Bangkok - Rangoon, Courtesy call on Ambassador
3	3 Nov.	Fri.	Courtesy call on U Thein Myint, Director General, FERD, Ministry of Planning and Finance: Dr. Bo Lay, Deputy Minister, Ministry of Agriculture and Forests, and U Kyaw Saint, Managing Director, Timber Corporation
4	4 Nov.	Sat.	Survey on facilities of Okkyin Training Center, Rangoon. Invited by Managing Director of Timber Corporation.
5	5 Nov.	Sun.	Arranged with Japanese Experts. Rangoon - Bassein by ship.
6	6 Nov.	Mon.	In Bassein City, survey on Lodging for Japanese experts, mechanical work shop and Burmese trainees' lodging.

Days	Date	Day of Week	Itinerary
7.	7 Nov.	Tue.	Survey on training facilities and lodging in Shawbya log yard and Chaungtha model operation forest.
8	8 Nov.	Wed.	Chief and 2 Japanese experts: Bassein - Rangoon by ship. Members: surveyed on work materials at Bassein Branch Construction Corporation.
9	9 Nov.	Thus.	Chief: Rangoon - Taunggyi, surveyed Heho timber yard Members: surveyed wage, timber price and others
10	10 Nov.	Fri.	Chief: Field survey on pine logging in hilly land of Shan state. Members: surveyed on geographical environment near model operation forest and quarry near Seikkyi.
11	11 Nov.	Sat.	Chief: Taung-gyi - Rangoon Members: Shinohara and Fujiwara Bassein-Rangoon and joined Chief. Ikeuchi, Mitani, Sugawara, Dobashi and Kudo surveyed the field of 22 compartments near model operation forest.
12	12 Nov.	Sun.	Chief and 2 members: arranged with dispatched experts on the work. Members: surveyed on highway near model operation forest and 22, 23 and 24 compartments.
13	13 Nov.	Mon.	Chief and 2 members: arranged with Embassy and Timber Corporation. Courtesy call on U Maung Galay, Director General, Forest Department, Ministry of Agriculture and Forests. Invited Deputy Minister and others by Head. Members: reconnaissance of projected line of forest road to 24 compartment of model operation forest and survey on stand of 26 and 27 compartments.
14	14 Nov.	Tue.	Chief and 2 members: Rangoon - Bangkok Members: Ikeuchi, Dobashi, Kudo made field survey on 24 & 25 compartments. Mitani and Sugawara made field service of design of main forest road (plane surveying)
15	15 Nov.	Wed.	Chief and 2 members: Bangkok - Tokyo Members: field work of design of access road (plane surveying)
16	16 Nov.	Thus.	Design of main forest road (plane surveying)
17	17 Nov.	Fri.	Design of main forest road (plane surveying)

Days	Date	Day of Week	Itinerary
18	18 Nov.	Sat.	A.M. Design of main forest road (field work, plane surveying and profile levelling) P.M. Survey on near Chauntha of Bay of Bengal
19	19 Nov.	Sun.	Travel: Chaungtha - Shawbya
20	20 Nov.	Mon.	Ikeuchi, Mitani and Sugawara worked in the field on design of main forest road (plane surveying and profile levelling) Dobashi and Kudo worked in the field on survey of location of cable.
21	21 Nov.	Tue.	- Ditto -
22	22 Nov.	Wed.	- Ditto -
23	23 Nov.	Thus.	- Ditto -
24	24 Nov.	Fri.	2 Experts and Ikeuchi surveyed quarry near Seikkyi. Mitani and Sugawara worked in the field on design of main forest road and Dobashi and Kudo worked in the office on design of cabling.
25	25 Nov.	Sta.	Takata and Ikeuchi surveyed in the field on acquisition of quarry upper Showbya River Mitani and Sugawara designed access road (in office), Dobashi and Kudo designed cabling (in office).
26	26 Nov.	Sun.	Arranged materials. 8:00 p.m. Bassein - Rangoon by ship. 11:30 a.m. arrived in Rangoon. P.M. arranged business.
27	27 Nov.	Mon.	11:30 a.m. arrived in Rangoon. P.M. arranged business
28	28 Nov.	Tue.	Explained details of survey at Central Office of Project to experts. Field survey on training facilities at Okkyin.
29	29 Nov.	Wed.	Arranged materials.
30	30 Nov.	Thus.	Worked on plane survey of training facilities at Okkyin.
31	1 Dec.	Fri.	Ikeuchi, Dobashi and Kudo worked on plane survey of training facilities at Okkyin. Mitani and Sugawara worked on design of main forest road.
32	2 Dec.	Sat.	Arranged materials.

Days	Date	Day of Week	Itinerary
33	3 Dec.	Sun.	Arranged materials.
34	4 Dec.	Mon.	Explained the detail of survey and arranged with Burmese side at Okkyin Training Center.
35	5 Dec.	Tue.	Ikeuchi and Mitani: Trained local staff on main forest road work at Okkyin Training Center. Dobashi and Kudo: Designed cabling for training at Okkyin. Sugawara: Designed main forest road
36	6 Dec.	Wed.	- Ditto -
37	7 Dec.	Thus.	Ikeuchi: A.M. visited State Hume Pipe Plant and surveyed design data at Rangoon University Others: Arranged business. P.M. all members: Discussed on details of survey at the Central Office of Project.
38	8 Dec.	Fri.	Reported the detail of survey to the Timber Corporation and Japanese Embassy.
39	9 Dec.	Sta.	Rangoon - Bangkok
40	10 Dec.	Sun.	Bangkok - Tokyo

1-4 Composition of Japanese Members and Burmese Concerned with the Project

a. Head and Members

Name	Duty	Office in Japan
Heizaburo Tezuka	Chief (General)	Standing Expert of Japan, Overseas Forestry Corporation Association
Yasuyuki Shinohara	Planning of Cooperation	Asst. Chief, Planning Div., Forestry Agency
Takashi Fujiwara	Coordinator	Forestry Development Div., JICA
Iwao Ikeuchi	Planning of Forest Road	Special Engineer, Japan Overseas Forestry Consultants Association
Katsumi Mitani	Design of Forest Road	- Ditto -

Name	Duty	Office in Japan
Kenzo Sugawara	Planning of Facilities	Japan Forestry Civil Engineering Consultants
Masao Dobashi	Planning of Logging	Special Engineer, Japan Overseas Forestry Consultants Association
Daisaku Kudo	Planning of Logging Facilities	Japan Federation of Log Producers Cooperative

b. Burmese Concerned with the Project

Ministry of Agriculture and Forests

Dr. Bo Lay	Deputy Minister
U Khin Maung Latt	Director General, Planning and Statistics Dept.,
U Hla Moe	Director, Planning and Statistics Dept.,

Timber Corporation

U Kyaw Saint	Managing Director
U Hla Pe	General Manager, Extruction Dept. (Project Director)
U Khin Maung Gyi	General Manager, Planning Dept.
Major Kyaw Shein	General Manager, Marketing and Milling Dept.
U Soe Lin	General Manager, Engineering Dept.,
U Aung Htoon	Deputy General Manager, Accounts Dept.
U Saw Richard	Deputy General Manager, Extraction Dept.
U Win Kyi	Manager, Irrawaddy Div. (Deputy Project Director)
U Oak Soe	Manager (H.Q)
U Kyaw Nyein	Manager (Planning)
U Thein Shwe	Manager, Henzada Agency

U Aung Naing	Deputy Manager (Counterpart)
U Nay Win	Deputy Manager (Liaison Officer)
U Zaw Weik	Deputy Manager (Counterpart)
U Bo Lay	Deputy Manager (Counterpart)
U Win Myint	Deputy Manager (Counterpart)
U Than Tun	Deputy Manager
U Thein Zaw	Deputy Manager

Forest Department

U Maung Gale	Director General
U Tin Hla	Divisional Forest Officer, Bassein

Construction Corporation

U Aun Zan	Div. Chief Engineer, Bassein
U Khinmg Gyi	Deputy Chief Engineer, Bassein

1-5 Outline of Result of Survey

1-5-1 Survey of Facilities by Local Cost on the Burmese Side

a. Central Office of the Project
The room is rather narrow but it is inevitable for the time being.

b. Technical Cooperation Center at Okkyin
The building seems to suit its objective. The choice of the locality of the area for the exercise of simulation cable yarding was, at first, the former rubber farm 15 km suburb of Rangoon as surveyed by the Implementation Arrangement Team in November 1977 but because of the fact that the land is owned by a Bureau other than the Timber Corporation, the transportation of personnel is necessary and the store of teaching materials is needed, the proposed site was considered inefficient for implementation by the joint committee and eventually it was to be established adjacent to the training center of Okkyin.

c. Lodging for Japanese Experts in Bassein

Compared to the government guest house, these facilities seem to be more adequate.

d. Building of work shop and lodging for trainees in Bassein. They are now under construction but they seem to suit their objective.

e. Pilot Extraction Center and Lodging in Showbya Base
Considerations are paid to the field environment and the facilities seem quite adequate to suit their objective.

1-5-2 Survey on Model Operation Forest

Based on the detailed data presented by Forest Department of the Burmese Government on the model operation forest in the Chaungtha district which was chosen at the implementation planning survey, we made reconnaissance on area, growing stock, stand type, soil and topography.

a. Location and boundary
As shown in the map.

b. Area
2838 acres (1135 ha.)

c. Growing stock
22400 ton (40400 m^3)
Harvestable volume: over 6 feet G.B.H. (58 cm D.B.H.)
Mean growing stock per acre 7.9 ton (35.6 m^3 per ha.)
By species, 28% of Girgin (Dipterocarpus alatas), 34% of Taungthayet (Swintonia floribunda) and 38% of others.

d. Stand type
The stand type is the typical tropical rain forest composed of various evergreen species as Diptercarpaceae and Anacardiaceae and others. Several deciduous broad-leaves species are mixed and they shed their leaves in the dry season.
Although it is 4 years since the last wind damage, fallen trees are seldom found and many damaged trees lost crown and there is a sign of slight recovery. No infestation by pest has been recognized. The tree species are mainly Girgin and Taungthayet and there is no Pincado.
Other miscellaneous species are directed to the local market.

e. Soils
The soil is lithosol red clay and the topsoil is dark reddish and the lower layer is yellowish. There is no rock and gravel and as a whole the soil is clayey. Decomposition of humus and leaching of topsoil are significant and humus layer and A Horizon are thin. As usually seen in tropical trees, the root system is shallow and spreading like a disk. Considering such soil structure, unless forest road and feeder road are improved, they will be extremely muddy in the rainy season.

f. Topography

In general, the topography consists of mild slopes and hilly zones and small ravines are intricate and some slopes along ravines are 20° - 30°. The elevation is from 10 m to 120 m and construction of forest road and feeder road are not difficult but special consideration should be paid to their maintenance during the rainy season.

1-5-3 Planning of Forest Road Network and Design of Forest Road

Main forest road network for logging was planned and of this, 2.4 miles (3.9 km) was designed.

The main forest road network is needed to be an all season type suitable in the rainy season for training but since the Timber Corporation has no such experience, it is considered proper that the road network which was designed is implemented by the Japanese side as a model infra-structure. (See detail 3.)

1-5-4 Setting Up of Logging Plan (on the job training plan)

Based on topography and stand type, we make it a course of technical cooperation combining cable yarding and tractor yarding, in order to collect the felled and bucked logs efficiently along the main forest road. At the same time, we will secure an overall system of handling and repairing of forestry machinery and transportation machinery and maintenance and control of forest road and temporary forest road. Based on the above, we set up a logging operation plan by compartment from November 1979 to March 1983. The proposed extraction is about 40,000 ton (76,000 m^3) (See detail 2-2).

2. On the Job Training Plan for Model Operation Forest

2-1 Outline of Model Operation Forest

2-1-1 Location of the Model Operation Forest and Principle of Setting Up

According to R.D. (concluded 2 December 1977) which is the guiding principle for the implementation of the project, the model operation forest is to be set up in Chaungtha district located in the Arakan Range covering 1,000 ha.

As the exercise in the model operation forest is accompanied by felling operation, it is desirable to set up the model operation forest in such area that the forest involves matured stands or semi-matured stands and it is not dispersed. It must have much topographical variation and should be located near the existing road.

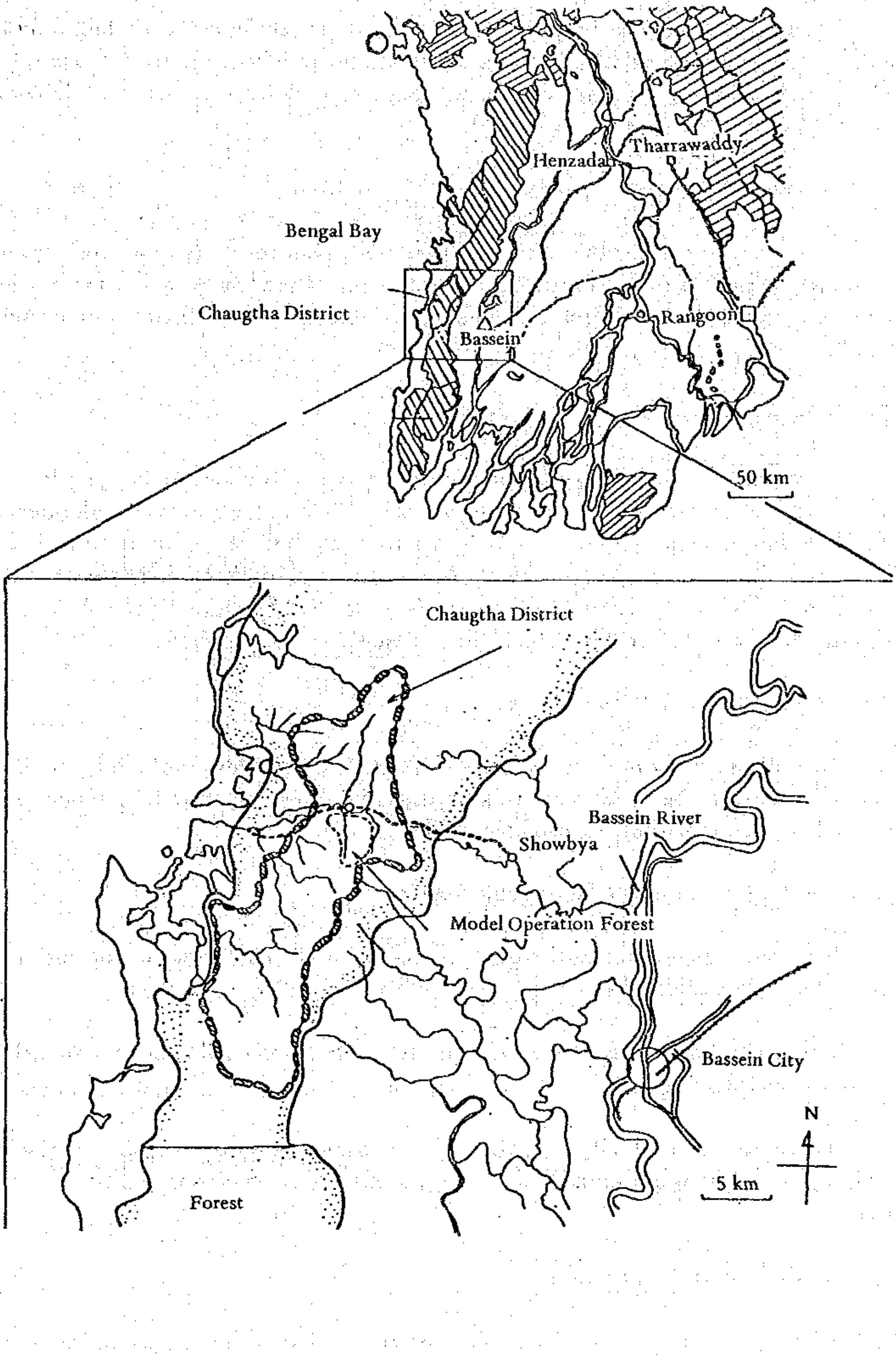
Based on such an idea, we negotiated with the Burmese side and considered future plan for the road network, the forest includes part of once extracted area (about 70 ha).

The location of the model operation forest is shown in Fig. 2-(1).

Table 2-1 Forest Condition of the Model Operation Forest

Compartment	Girth (feet inch)	Area	Glowing Stock				Proposal Felling Area	Proposal Felling Volume			
			Girgin	Taungthayet	Others	Total		Girgin	Taungthayet	Others	Total
		acre	ton	ton	ton	ton	acre	ton	ton	ton	ton
24	4'6"		2,080	2,397	3,069	7,546					
	5'0"		1,952	2,349	2,641	6,942					
	6'0"		1,476	1,891	1,781	5,148		1,476	1,891	1,781	5,148
	Total	610	5,508	6,637	7,491	19,636	610	1,476	1,891	1,781	5,148
25	4'6"		2,431	2,802	3,587	8,820					
	5'0"		2,282	2,745	3,087	8,114					
	6'0"		1,725	2,210	2,083	6,018		1,725	2,210	2,083	6,018
	Total	713	6,438	7,757	8,757	22,952	713	1,725	2,210	2,083	6,018
26	4'6"		1,572	1,812	2,319	5,703					
	5'0"		1,475	1,775	1,996	5,246					
	6'0"		1,116	1,429	1,346	3,891		893	1,143	1,077	3,113
	Total	461	4,163	5,016	5,661	14,840	369	893	1,143	1,077	3,113
27	4'6"		1,463	1,686	2,158	5,307					
	5'0"		1,373	1,652	1,857	4,882					
	6'0"		1,038	1,330	1,253	3,621		830	1,064	1,002	2,896
	Total	429	3,874	4,668	5,268	13,810	343	830	1,064	1,002	2,896
28	4'6"		2,131	2,456	3,145	7,732					
	5'0"		2,000	2,406	2,707	7,113					
	6'0"		1,512	1,938	1,825	5,275		1,512	1,938	1,825	5,275
	Total	625	5,643	6,800	7,677	20,120	625	1,512	1,938	1,825	5,275
Grand Total		2,838	25,626	30,878	34,854	91,358	2,660	6,436	8,246	7,768	22,450

Fig. 2-1 Location of the Model Operation Forest



2-2 On the Job Training Plan

2-2-1 Point of the Training Plan

At the technical cooperation center for the development of hill forest to be established in Rangoon and related facilities to be established in the Bassein district, required technical training under the guidance of Japanese experts is undertaken for the following field. (See Table 4-1)

(1) Logging Management Course

This course involves the setting up of a work plan for extraction work appropriate to the field, safety control of the operation, improvement of the logging operation, the grasping and clarification of the technical problem of felling work, and the systematization of individual technology.

(2) Logging Course

This course for the purpose of transfering the technology of logging is to enrich overall knowledge of forestry machine to educate mainly the cabling engineer, the operator of the yarder and the maintenance engineer and also to carry out basic education and technical training to foster the capacity of application. At Okkyin, technical training as basic training by the above basic education and simulation training facilities will be carried out and the graduates will work as applied trainees in cable logging in the model operation forest.

(3) Maintenance and Repair Course

In order to carry out the technical cooperation smoothly, the training for the satisfactory maintenance of the machinery will be done in terms of structure, function of the machinery and finding, repairing of a machine trouble.

2-2-2 On the Job Training Plan of Cable Logging

The most important techniques of education in cable logging operation is the technique of the skyline-cabling.

Cabling technology is a new field introduced in Burma and education in technology seems to require considerable time.

Therefore, first of all, regardless of the logging volume per cable, if the cabling operation is repeated, one could soon learn the most adaptable cable system and the cable logging techniques.

(1) Setting Up of the Location

In implementing the cable logging operation, first of all, we should consider the

Table 2-2 Estimate of Extraction Volume through Training

Year	Items		Yarder	Wheel Tractor	Total
1st year 1979/Apr. - 1980/Mar.	Imput of machines (number)		1	1	-
	Cutting area (ha)				
	Extractive volume (m^3)				
	Req. labour	Felling (men)			
		Yarding (men)			
2nd year 1980/Apr. - 1981/Mar.	Imput of machines (number)		2	4	-
	Cutting area (ha)		21	145	166
	Extractive volume (m^3)		800	5,500	6,300
	Req. labour	Felling (men)	115	785	900
		Yarding (men)	267	1,295	1,562
3rd year 1981/Apr. - 1982/Mar.	Imput of machines (number)		3	7	-
	Cutting area (ha)		63	297	360
	Extractive volume (m^3)		2,400	11,300	13,700
	Req. labour	Felling (men)	343	1,615	1,958
		Yarding (men)	800	2,659	3,459
4th year 1982/Apr. - 1983/Mar.	Imput of machines (number)		4	10	-
	Cutting area (ha)		84	454	538
	Extractive volume (m^3)		3,200	17,200	20,400
	Req. labour	Felling (men)	458	2,457	2,915
		Yarding (men)	1,067	4,047	5,114
Total	Imput of machines (number)		4	10	-
	Cutting area (ha)		168	896	1,064
	Extractive volume (m^3)		6,400	34,000	40,400
	Req. labour	Felling (men)	916	4,857	5,773
		Yarding (men)	2,134	8,001	10,135

1) As the training is mainly for cabling in the first year, extraction is not estimated.

2) A set of operators for logging by yarder consists of 1 driver and 2 helpers, totaling 3.

3) A set of wheel tractor for yarding consists of 2 drivers and 2 helpers, totaling 4.

location of the landing and installation of the yarder. It is most desirable to secure some area where the timber collected can be stored along the forest road or near the forest road. If the landing is near the forest road, it will be convenient to carry in various machines for cabling.

(2) Cable System

The cutting method in the model operation forest is the Burmese selective cutting system which is to cut over 6 ft of breast height girth (over 58 cm of D.B.H.).

Because the model operation forest has gentle slope, the cable to be installed here is for the logging operation with little difference in elevation. As the yarder to be used here is endless and a 2 drum type, based on experience in Japan, we will adopt the Endless Tyler system which is used frequently and efficient for selective cutting. (See Fig. 2-2).

(3) The Logging System

We have two logging systems: one is a ordinary logging (logging for bucked logs) and the other is a full stem logging (logging for limbed trees) but the trees in the model operation forest have 3.3 ton per tree (about 6 m^3) and most trees are of large diameters, 6,000 kg in weight and because of selective cutting, considering the capacity of yarder and work efficiency, the ordinary timber system is considered appropriate. Based on the above, we have set up the training plan.

(4) Trainees (Staff Members and Workers)

The staff members learn overall knowledge and skill of cable through training and after the training, they will perform the operation as the leader of field operators. For this purpose, they should not only understand and memorize the skill but learn from experience.

Therefore, even if they will not directly work by themselves in the future, they should be learned as a expeirence. The training should be based on this principle. However, as the days of training are limited and some operations are important and some not so important for the staff, efforts are to be made that from the above point of view, the arrangement and schedule of exercise have been prepared.

(5) Arrangement and Schedule of Exercise

(a) The arrangement of cable logging operation is as Table 2-3.4.5. In this table, ◎ mark in the column of staff indicates the training to be done by the staff only or that to be done by the staff mainly. ◎ mark is the training that the staff learns from experience but the operation itself is chiefly done by workers.

(b) The schedule of exercise is shown in Table 2-6.

The staff is shown by a solid line and the workers by a dotted line and mandays is shown by ( ).

(6) Important Matters for Training

In many cases, careless cable logging leads to serious disasters. Especially, begineers have few knowledge of wire-rope which is the cause of accident. Therefore, it is necessary that safety education such as sign of dangerous area, refuge and signaline be given to operators and others concerned.

(7) Cut Area and Extraction Volume

The cut area from April 1979 to March 1980 is the area shown by an oblique line in Fig. 2-3 and No. 1 cable is the area of 5.8 ac. and has an extraction volume of 48 ton and No. 2 cable the area of 8.3 ac. and has an extraction volume of 69 ton.

(8) Labour Volume and Cost Required for the Exercise

The labor volume and cost required for the cable logging exercise in the above period is shown in Table 2-7.

(9) Design of Model Cable Logging

Skyline load locus curve diagram is shown in Fig. 2-4 and Fig. 2-5 and statement of accounts on cable design is shown Table 2-8 and Table 2-9.

The method of calculation is referred to calculation method for the skyline design. (See the reference I).

Fig. 2-2 Endless Tyler Logging System

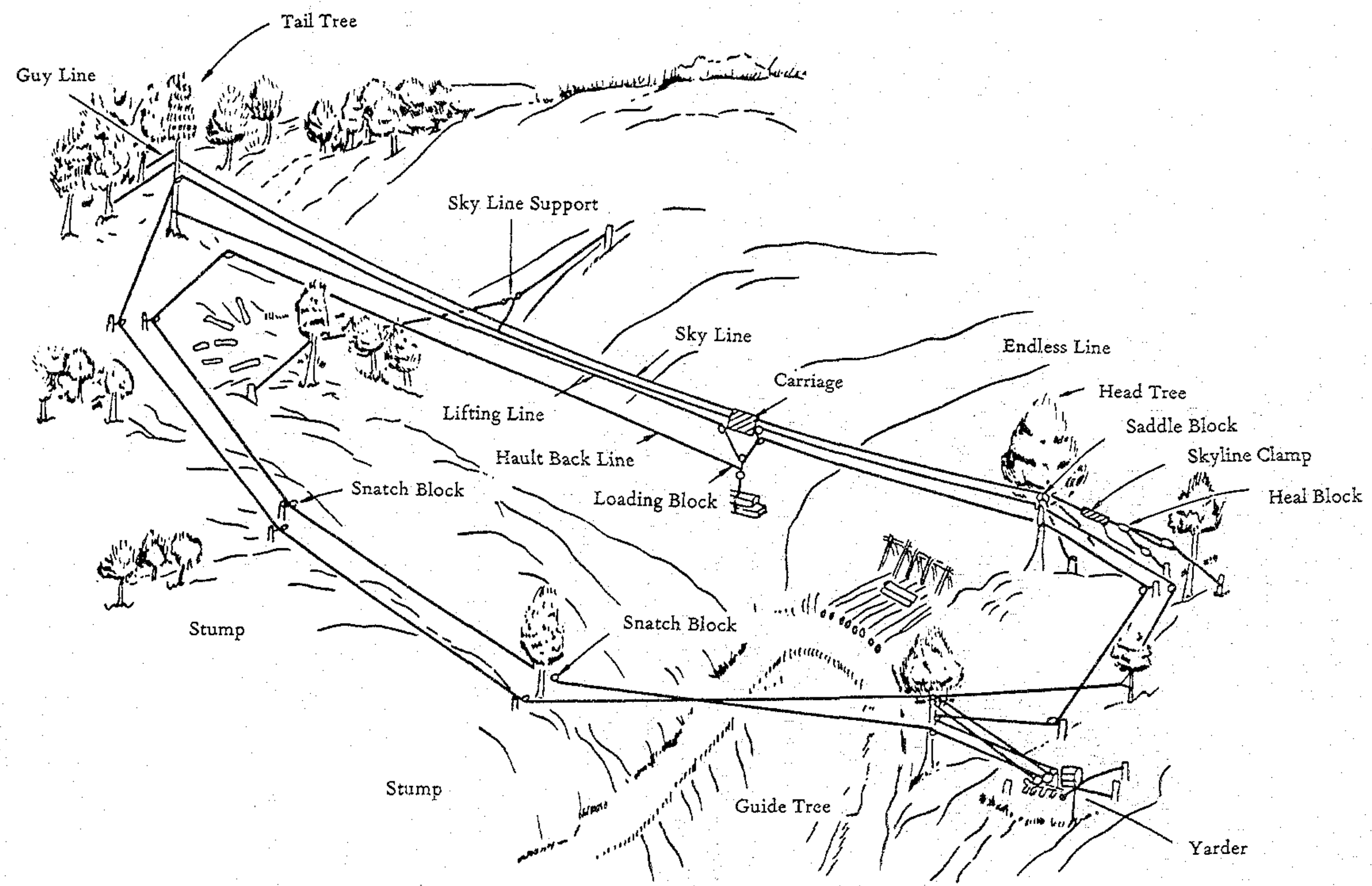


Table 2-3 Arrangement of Exercise of Cable Logging

No.	Item	Details	Operation	Trainees		Remarks
				Staff	Worker	
1	Reconnaissance	Reconnaisance on proposed site of logging	Make reconnaissance on site and forest conditions of proposed logging and examine and decide landing site and installation site of yarder, selection of head tree, tail tree, guide tree and anchor, and arrangement of operating line. These trees are painted or marked by tape	◎	o	Workers do subsidiary works as clearing of footpath and painting
2	Survey	Survey on site of installation of skyline	Survey from head tree to tail tree. Attention to the position of anchor.	◎	o	Workers do clearing of survey line and construction of survey pile.
3	Design	Cabling design	Based on the result of survey, decide cabling system, design and calculation of skyline and operating line. Also mapping of load locus.	◎		
4	Inspection & oiling of tools and machines	(1) Inspection and oiling of yarder	Inspect transmission and operation systems of yarder and inspect, oiling and adjust fuel oil, lubricating oil, electricity, and tools.	◎	o	
		(2) Inspection & oiling of attached tools	(a) Inspection of abrasion, deformation, corrosion of wire rope and breakage of kink wire. If seriously damaged, it is cut down. (b) Inspection of carriage, pulley & bearing and shackle, clip and other attachments. Oiling is to be done.			
		(3) Confirmation of q'ty of attached implements	According to attached details of cabling instruments, quantity of needed attachments and tools is confirmed.			

No.	Item	Details	Operation	Trainees		Remarks
				Staff	Worker	
5	Construction of footpath		Passing way to head tree and tail tree is constructed.		◎	
6	Preparation of protective wood	Preparation of material for protective wood	Protective wood and rubber band of head tree, tail tree and guide tree are prepared	o	◎	Trainees learn how to prepare protective wood
7	Felling operation	(1) Cutting of obstacle trees under line (2) Felling	Obstacle trees under skyline are extracted 10 m wide and trees for felling should be cut in a volume to be hauled during they are fresh.		◎	
8	Installation of yarder	(1) Moving a yarder (2) Construct a machine table and fix (3) Building of shed	Move the yarder using the drum of yarder or ... Construct a table and fix a yarder Yarder is set in horizontal position Four poles are erected at four corners and simple roof is provided. Attention is given not to disturb field of vision.	◎	o	Laborers work on land preparation of installation site and building of shed
9	Furnishing of telephone line		Furnishing telephone line from yarder to proposed logging site	◎	o	
10	Transport and arrangement of attachments	(1) Transport of attachments for head tree (2) Transport of heel block (3) Stump (attach) (4) Transport of carriage (5) Transport of attachments for tail tree (6) Transport of nylon rope	Protective wood, guy line, rope, heel block heel cramp, cramp iron, saddle block, guide block, tree climbing tool, carriage, loading block, clip and shackle needed for construction of towers are carried to proposed site of towers.	◎	o	The operation is mainly done by trainees and laborers only help them.

No.	Item	Detail	Operations	Trainees		Remarks
				Staff	Workers	
11	Construction of towers	(1) Construction of head tree (2) Construction of tail tree (3) Construction of guide tree (4) Construction of tower to attach operating line	In case of tree poles, limbing work, attaching of loading block, rope with protective wood, saddle block, guy line & guide block In case of man-made tower, assembly & removal of man-made tower, attaching of guy line, tension, construction of burying anchor are needed.	◎	o	The operation is mainly done by trainees and laborers only help them.
12	Cabling operation (Endless Tyler system)	(1) Haul-back line cabling	(a) At first, pull lead rope and join end of haul back line (b) Then, replace lead rope by haulback line	◎	o	
		(2) Pulling round of skyline and fixing of tail tree	Connect and pull around haul-back line and skyline clamp is tentatively fastened and then skyline is completely fixed. (in this case, SKL is fastened with stump over 2 turns and over 5 clips are used).			
		(3) Pulling round of lifting line	(a) Connection and pulling round of haul back line and lifting line. (b) Arrange nylon rope			
		(4) Setting up of carriage (Including replacement of HBL and ELL)	(a) Attach carriage to skyline (b) Attach guide block, loading block and weight with carriage (c) Replace haul back line by endless line. Haul back line is taken out from the first drum and wind up endless drum and through guide block of guide tree and guide block of head tree, attach to carraige. Release connection of HBL and LFL and HBL is attached to carriage.			

No.	Item	Details	Operations	Trainees Staff	Trainees Workers	Remarks
			(d) LFL is attached to tail tree side and to loading block with reserve.			
		(5) Attaching of heel line	(a) Attach skyline with skyline cramp (b) Attach skyline cramp with heel block (c) Pulling round heel line and attach to heel block (d) Prevent twisting of heel line			
		(6) Tension of skyline	(a) End of heel line is wound round drum (b) Skyline is tensioned by yarder (c) Inspect and adjust tension			
		(7) Fixing of heel-line	Skyline is fixed and returned gradually and with equal power fixed with heel line.			
		(8) Fixing of lifting line	Carriage is sent to tail tree side and LFL attached to loading block is fastened up on stump at the backside of tail tree.			
		(9) Pulling round of haul back line	Carriage is pulled near tail tree and lead rope is attached to loading block or lead rope and HBL are attached to loading block and transported to tail tree and haul back line is pulled round			
13	Inspection of cable	(1) Inspection of tension of skyline (2) Inspection of operating line (3) Inspection of block and carriage (4) Inspection of each tree (5) Inspection of each stump (6) Inspection of connection	Whether rope touches rock or tree Whether block is hanging by itself Whether attaching or fixing of rope is done as prescribed. Whether clip and shackle are used as needed	◎		

No.	Item	Details	Operations	Trainees		Remarks
				Staff	Worker	
14	Load test	Inspection & adjustment	From no-load running, the line is gradually loaded. Skyline is fixed and more clips are applied and tension measurement of skyline at design load is performed.	◎	o	
15	Construction of landing	(1) Land preparation tion (2) Construction of landing	Landing is constructed if necessary. Refer to "Operation landing".	o	◎	

Table 2-4 Arrangement of Exercise of Withdrawal of Logging Cable

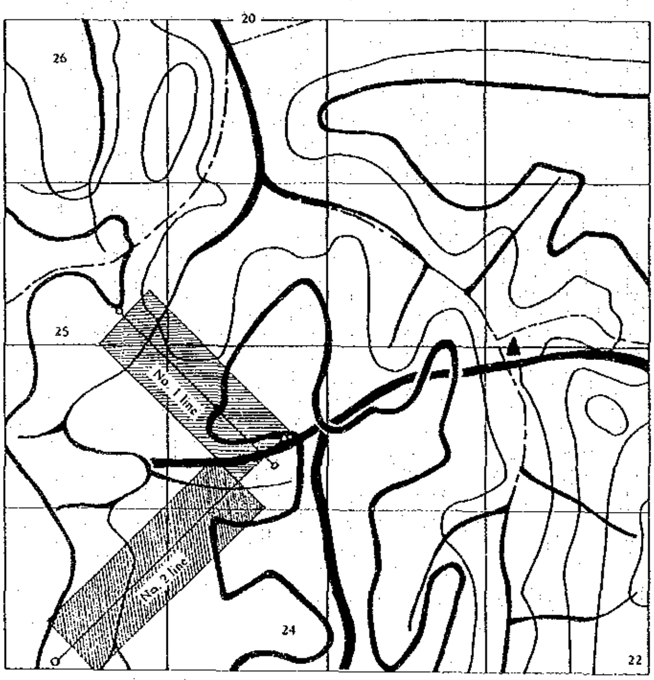
No.	Item	Details	Operations	Trainees Staff	Trainees Worker	Remarks
1	Slacken skyline	(1) Skyline is slackened.	(a) Carriage is removed to near landing. (b) Haul back line or lifting line is taken out from drum and heel line is fixed and wound up. (c) Heel line is gradually slackened and skyline is brought down to ground. (In this case, tension of endless line is slackened.)	◎	o	Help to transport implements
		(2) Dismantle of heel	(a) Skyline clamp and heel are dismantled			
2	Withdrawal of ropes	(1) Withdrawal of heel line	(a) Heel line is wound up to the drum and it is taken out from drum and arranged. (b) Haul back line is attached to No. 1 drum.	◎	o	Help to transport implements
		(2) Withdrawal of endless line	(a) Endless line is taken out from carriage (b) Endless line of head tree is arranged. (c) Making use of endless drum, endless line of tail tree is wound and arranged.			
			(a) Withdrawal of carraige, loading & weight (b) Untie fixing of skyline of tail tree (c) Take out fixing of lifting line (d) Connect lifting line and haul back line (e) Attach vise to skyline and making use of lifting line and haul back line, skyline is drawn near and wound up.			

No.	Item	Details	Operations	Trainees		Remarks
				Staff	Worker	
3	Withdrawal of	(1) Withdrawal of Head tree	Dismantle and transport of guy line, saddle block, snatch block, & protective wood	◎	○	
		(2) Withdrawal of guide tree	Dismantle and transport of guy line, snatch block, protective wood & ropes			
		(3) Withdrawal of tail tree	Dismantle and transport of guy line snatch block, protective wood, saddle block & ropes			
		(4) Withdrawal of telephone line etc.	Dismantle and transport of telephone line and snatch block etc.			
4	Withdrawal of yarder & facilities	(1) Dismantle, withdrawal & loading of shed	Withdrawal of galvanized iron sheet and dismantle and transport of fix-rope of yarder	◎	○	
		(2) Withdrawal & loading of yarder				
5	Inspection of equipments		Inspect and confirm quantity & condition of damages of withdraw equipments and arrange and store	◎	○	

Table 2-5 Procedure of Exercise of Logging Operation

	Operations
1	When a load comes near landing, the driver whistles a warning and speed is reduced.
2	Before the landing, carriage is stopped and load is lowered down.
3	The operation leader orders all members on landing to take refuge.
4	The operation leader, after confirmed the refuge of all members, gives a sign of OK and leads unloading.
5	The driver is subject to leading of the operation leader and draw a log (or logs) from the edge of the landing dragging on it and puts on a instructed position.
6	The operation leader, while all members await the order at shelter, takes off sling by himself and returns to signal spot and gives a sign of lifting.
7	After confirmed that carriage passes on the landing and there is no danger of any fall, he orders all members to start the operation again.

Fig. 2-3 24 Compartment, Logging Operation Exercise



No. 1 Cable

Span	300m
Cut area	5.7 acre (2.3 ha)
Extraction	87 m^3

No. 2 Cable

Span	436m
Cut area	8.2 acre (3.3 ha)
Extraction	125 m^3

N

M.N

S = 1 : 5000

1°45°W

Magnetic North

Table 2-6 Schedule of Cabling Exercise

Item / Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Reconnaissance	(4)																													
2. Survey		(8)																												
3. Design																														
4. Inspection & oiling						(2)																								
5. Construction of footpath					(6)																									
6. Preparation of tension wood						(4)																								
7. Transfer & installation of yarder							(6)																							
8. Cutting of hindering tree									(11)																					
9. Installation of telephone line								(2)																						
10. Construction of head tree									(6)																					
11. Construction of guide tree										(3)																				
12. Construction of tail tree											(6)																			
13. Construction of stump												(4)																		
14. Cabling operation														(3)																
15. Inspection of cable															(1)															
16. Load test																														
17. Logging operation																					(22)									
18. Withdrawal operation																													(6)	

Operation by staff ———
Operation by worker – – – –
(   ) indicates man days

Table 2-7 Detailed Account of Expenses for Cable Logging Operation Exercise

Curriculum	Items	Members		Category	Cost			Base of Calculation
		Trainee	Laborer		Quantity	Price	Amount	
Cabling exercise	1. Reconnaissance	◎	o	Man power	4	8.7 ks	34.8 ks	1' Clearing 3.0men Painting 1.0man
	2. Survey	◎	o	Man power	8	8.7	69.6	2' Clearing of course of traverse
	3. Inspection and oiling	o	◎	Man power	2	8.7	17.4	3' 1 day 20 men x 1 day = 20 men
	4. Construction of footpath		o	Man power	6	8.7	52.2	4' 1 day 30 men x 2 days = 60 men
	5. Preparation of tension wood	o	◎	Man power	4	8.7	34.8	5' 1 day 20 men x 2 days = 40 men
	6. Installation of yarder	◎	o	Man power	6	8.7	52.2	6' 1 day 30 men x 2 days = 60 men
	7. Cutting of hindering tree and felling		◎	Man power	11 11	9.5 8.7	104.5 95.7	7' 2 men 1 day 8 m^3 x 11 days = 88 m^3
	8. Cabling operation	◎	o	Man power	25	8.7	217.5	8' Installation of telephone line 2.0 Construction of head tree 6.0 guide tree 3.0 tail tree 6.0 stump 4.0 cabling operation 3.0 inspection 1.0
	9. Logging operation	◎	o	Man power	22	8.7	191.4	9' 1 day 2.0 men x 11 days = 22.0 men
	10. Withdrawal operation	◎	o	Man power	6	8.7	52.2	10' 1 day 20 men x 3 days = 60 men
	11. Fuel for yarder			Light oil	240 ℓ	3.0	720.0	11' Installation, logging & withdrawal 20 days x 1 day 12 ℓ = 240 ℓ
	12. Lubricating oil			Mobile oil	20 ℓ	21.3	426.0	
				Grease	5 kg	6.2	31.0	
				Other oil			40.0	
	13. Other supplies						100.0	13' Shed material, tube for protective wood, wire
	Total						2,239.3	

Table 2-8 Design Sheet of Skyline for Yarding

I Fondamental Terms (Type of Wiring System. Endless Tyler System)

Span

(1) Horizontal distance	(2) Inclination angle	(3) Oblique distance (lo/cos α)	(4) Height difference (lo.tan α)	(5) Original sag-span ratio
ℓo = 300 m	α = 5°	ℓ = 301 m	n = 15 m	So = 0.03

Wire Rope

Uses	Kind of construction	Rope diameter	(6) Guranteed breaking strength	(7) Weight of rope per meter	(8) weight [(7) x (3)]
Main cable	T6 x 7 A	28 mm	B = 63,300 kg	P = 3.27 kg/m	W = 984 kg
Lifting line	6 x 19% B	14 mm	B'_1 = 11,500 kg	P'_1 = 0.713 kg/m	W'_1 = 215 kg
Haul back line,	6 x 19% B	12 mm	B'_2 = 8,430 kg	P'_2 = 0.524 kg/m	W'_2 = 158 kg
Endless line					

Load

(9) Weight of load Po	Weight of empty carriage PC	Impact load coefficient I	Weight of operating line $W_1 + W_2$	(10) Weight of carriage load (designed) P
(2,100 kg + 425 kg) x (	+	) + 186 kg = 2,711 kg		

(11) Displacement of supporting point Δℓ = ( ) m (12) Displacement ratio of supporting point Δd = Δℓ/ℓ = ( )

II Calculation of the Safety Factor of Skyline

(13)	Total load	(8) (10) (W + P)		= 3,695 kg
(14)	Load ratio	n	(10)(8) = P / W	= 2.76
(15)	Equivalent coefficient of sag-span ratio	Z_1	[(n)]	= 0.6633

(16)	Corrected sag-span ratio	S	(5) (21) = So x E	Correction =
(17)	Equivalent sag-span ratio	S_1	(15) (5) (15) (16) = Z_1 x So or Z_1 x S = 0.0199	Correction =
(18)	Coefficient of max tension	φ_1	(2)(17) [α S_1)] 6.34	Correction =
(19)	Maximum tention	T_1	(13) (18) = (W + P) · φ_1 = 23,426 kg	Correction = kg
(20)	Safty factor	N	(6) (19) = B / T_1 = 2.7	Correction = ≧ 2.7

(21) Caculation of the correcting coefficient.
The coefficient is a result of (1) – (10) and (13) – (20).
The calculation will be done in case of N = < 2.7.

Wire tension of no load	Coefficient of max. tension	φ_0	(2)(15) [(a · So)]
	Maximum tension	T_0	(8) = W x φ_0
Tension with load (non-correction)	Equivalent sag-span ratio	S_1	(15) (5) = Z_1 + S_0
	Coefficient of max. tension	φ_1	(2)(17) [(a S_1) 13 table] P64
	Maximum tension	T_1	(13) = (W + P) · φ_1
	Tension difference	Td	= T_1 - T_0
Elastic elongation ratio	Tension per 1 ton	λ	[Rope diameter]
	Elastic elongation ratio	Δe	λ x Td
Coefficient of correction	For elastic elongation	E^c	(2)(5) [(α.So· Δ^e)]
	For displacement of supporting point	E^d	(2)(5) [α · So · $Δ^d$]
	Over all	E	= E^c x E^d

(10) List of items: Weight of carriage load P.

Item		Maker's standard	No.	Unit (weight)	Weight	Summary
Carriage	PC		1		215	
Guide black	PC		2	15	30	
Loading black	PC	{	1		75	
Loading hook	PC					
Ballast	PC		1		100	
Sling & others	PC		1		5	PC
Lifting line	W'_1	14 mm, ℓ/2	150	0.713	107	Total 425
Haul line	W'_2					
Haul back line	W'_2					
Endless line	W'_2	12 mm, ℓ/2	150	0.524	79	W'_1 W'_2
Weight of load	Po				2,100	186
Total P					2,711	

III Calculation of the Safety Factor of Operating Lines

(a) Lifting line (Hosting line, Haul back line of Falling Block system)

(22)	Maximum lifting stroke	n_1		22 m
(23)	Load on loading block	Pℓ	Total weight of logs, loading block & ballast	2,280 kg

* If the loading block is attached to the haul back line, the value is a resultant force of the total weight and the tension of the haul back line.
In that case, the calculation of the tension (haul back line) (b) should be done ahead.

(24)	No. of lifting line No.		2
(25)	Maximum tension Ti	(23)(7)(22) = Pl/not Pin'	1,151 kg
(26)	Safty factor N	(6) = B'_1/T'_1	9.9 ≧ 6.0

(b) Haul back line or Endless line

(i) Load pulling force. TP
Coefficient of load pulling force (sin β)
(In case of the sin α, extea coefficient should be used (30)')

(27)		SB	(16) = 0.8 S	0.024
(27)'		SB	(14) (15) = (1 + 2n) x So	

(Use (27)' if the carriage is able to reach the point within 10% of the span length near the upper supporting point.)

(28)	Coefficient of load pulling force	sin β	(2)(27) or (27)' [(a · SB)]	= 0.18
(29)	Load	P	(10)	= 2,711 kg
(30)	Load pulling force	TP	= P x (sin β)	= 488 kg
(30)'	Substitute sin α	TP	= P x (sin α x 1.4)	=

(ii) Original tension of endless

(31)	Original sag-span ratio	S'	(16) = S x (1.2 – 1.3)	= 0.039
(32)	Coefficient of max. tension	φ_0	(2) [(a · S') 13 table] P64	= 3.30
(32)	Coefficient of max. tension		(8)	
(33)	Original tension	T'_0	= W'_2 x φ'_0	= 521 kg

(iii) Maximum tension

(34)	Tyler system	T'_2	(30) = TP x 1.4	= kg
	Endless tyler system	T'_2	(30) (33) = TP + T'_0	= 1,009 kg
	Falling block system	T'_2	(30) (25) = TP + T'_1	= kg
	Endless system	T'_2	(30) (26) = TP + T'_1	= kg
	Safety factor	N	(6) = B'_2/T'_1	8.35 ≧ 4.0
	Endless line of Endless system			≧ 6.0

Table 2-9 Design Sheet of Skyline for Yarding

I Foundamental Terms (Type of Wiring System. Endless Tyler System)

Span

(1) Horizontal distance	(2) Inclination angle	(3) Oblique distance (ℓo/cos α)	(4) Height difference (ℓo·tan α)	(5) Original sag-span ratio
ℓo = 436 m	α = 5°	ℓ = 438 m	n = 14 m	So = 0.03

Wire rope

Uses	Kind of construction	Rope diameter	(6) Guranteed breaking strength	(7) Weight of rope per meter	(8) Weight [(7) x (3)]
Main cable	T6 x 7 A	28 mm	B = 63,300 kg	P = 3.27 kg/m	W = 1,432 kg
Lifting line	6 x 19% B	14 mm	B'₁ = 11,500 kg	P'₁ = 0.713 kg/m	W'₁ = 312 kg
Haul back line, Endless line	6 x 19% B	12 mm	B'₂ = 8,430 kg	P'₂ = 0.524 kg/m	W'₂ = 230 kg

Load

(9) Weight of load Po	Weight of empty carriage PC	Impact load coefficient I	Weight of operating line $W_1 + W_2$	(10) Weight of carriage load (designed) P
(2,100 kg + 425 kg) x (1 + 0.2) + 271 kg = 3,301 kg				

(11) Displacement of supporting point Δℓ = (   ) m (12) Displacement of supporting point Δd = Δℓ/ℓ = (   )

II Calculation of the Safety Factor of Skyline

(13)	Total load		(8) (10) (W + P)	= 4,733 kg
(14)	Load ratio	n	(10)(8) = P / W	= 2.31
(15)	Equivalent coefficient of sag-span ratio	Z_1	[(n)]	= 0.6765

(16)	Corrected sag-span ratio	S	(5) (21) = So x E		Correction = 0.046
(17)	Equivalent sag-span ratio	S_1	(15) (5) (15) (16) = Z_1 x So or Z_1 x S	= 0.0203	Correction = 0.0311
(18)	Coefficient of max. tension	φ_1	(2) (17) [α S_1)]	= 6.34	Correction = 4.12
(19)	Maximum tention	T_1	(13) (18) = (W + P) · φ_1	= 30,007 kg	Correction = 19,500 kg
(20)	Safty factor	N	(6) (19) = B / T_1	= 2.1	Correction = 3.2 ≧ 2.7

(21) Caculation of the correcting coefficient.
The coefficient is a result of (1) – (10) and (13) – (20).
The calculation will be done in case of N = < 2.7.

Wire tension of no load	Coefficient of max. tension	φ_0	(2) (15) [(α · S_0)]	= 4.26
	Maximum tension	T_0	(8) = W x φ_0	= 6,100 kg
Tension with load (non-correction)	Equivalent sag-span ratio	S_1	(15) (5) = Z_1 + S_0	= 0.0203
	Coefficient of max. tension	φ_1	(2)(17) [(a S_1) 13 table] P64	= 6.34
	Maximum tension	T_1	(13) = (W + P) · φ_1	= 30,007 kg
	Tension difference	Td	= T_1 - T_0	= 23,907 kg
Elastic elongation ratio	Tension per 1 ton	λ	[Rope diameter]	= 0.0032/t
	Elastic elongation ratio	Δ^e	λ x T^d	= 0.0076
Coefficient of correction	For elastic elongation	E^e	(2)(5) [(α · S_0 · Δ^e)	= 1.53
	For displacement of supporting point	E^d	(2)(5) [α · S_0 · Δ^d)	
	Over all	E	= E^e x E^d	= (1.53)→(16)

(10) List of items: Weight of carriage load P.

Item		Maker's standard	No.	Unit (weight)	Weight	Summary
Carriage	PC		1		215	
Guide block	PC		2	15	30	
Loading block	PC	}	1		75	
Loading hook	PC					
Ballast	PC		1		100	
Sling & others	PC		1		5	PC
Lifting line	W'₁	14 mm, ℓ/2	219	0.713	156	Total 425
Haul line	W'₂					
Haul back line	W'₂					
Endless line	W'₂	12 mm, ℓ/2	219	0.524	115	W'₁ W'₂
Weight of load	Po				2,100	271
Total P					2,796	

III Calculation of the Safety Factor of Operating Lines

(a) Lifting line(Hoisting line, Haul back line of Falling Block System)

(22)	Maximum lifting stroke	n_1		15 m
(23)	Load on loading block	Pℓ	Total weight of logs, loading block & ballast	2,280 kg

* If the loading block is attached to the haul back line, the value is a resultant force of the total weight and the tension of the haul back line.
In that case, the calculation of the tension (haul back line) (b) should be done ahead.

(24)	No. of lifting line No.		2
(25)	Maximum tension Ti	(23)(7)(22) = Pℓ/not Pin'	1,151 kg
(26)	Safty factor N	(6) = B'₁/T'₁	10.0 ≧ 6.0

(b) Haul back line or Endless line

(i) Load pulling force. TP
Coefficient of load pulling force (sin β)
(In case of the sin α, extea coefficient should be used (30)')

(27)		SB	(16) = 0.8 S	0.037
(27)'		SB	(14) = (1 + 2n) x So	

(Use (27)' if the carriage is able to reach the point within 10% of the span length near the upper supporting point.)

(28)	Coefficient of load pulling force	sin β	(2)(27) or (27)' [(a · SB)]	= 0.23
(29)	Load	P	(10)	= 3,301 kg
(30)	Load pulling force	TP	= P x (sin β)	= 759 kg
(30)'	Substitute sin α	TP	= P x (sin α x 1.4)	=

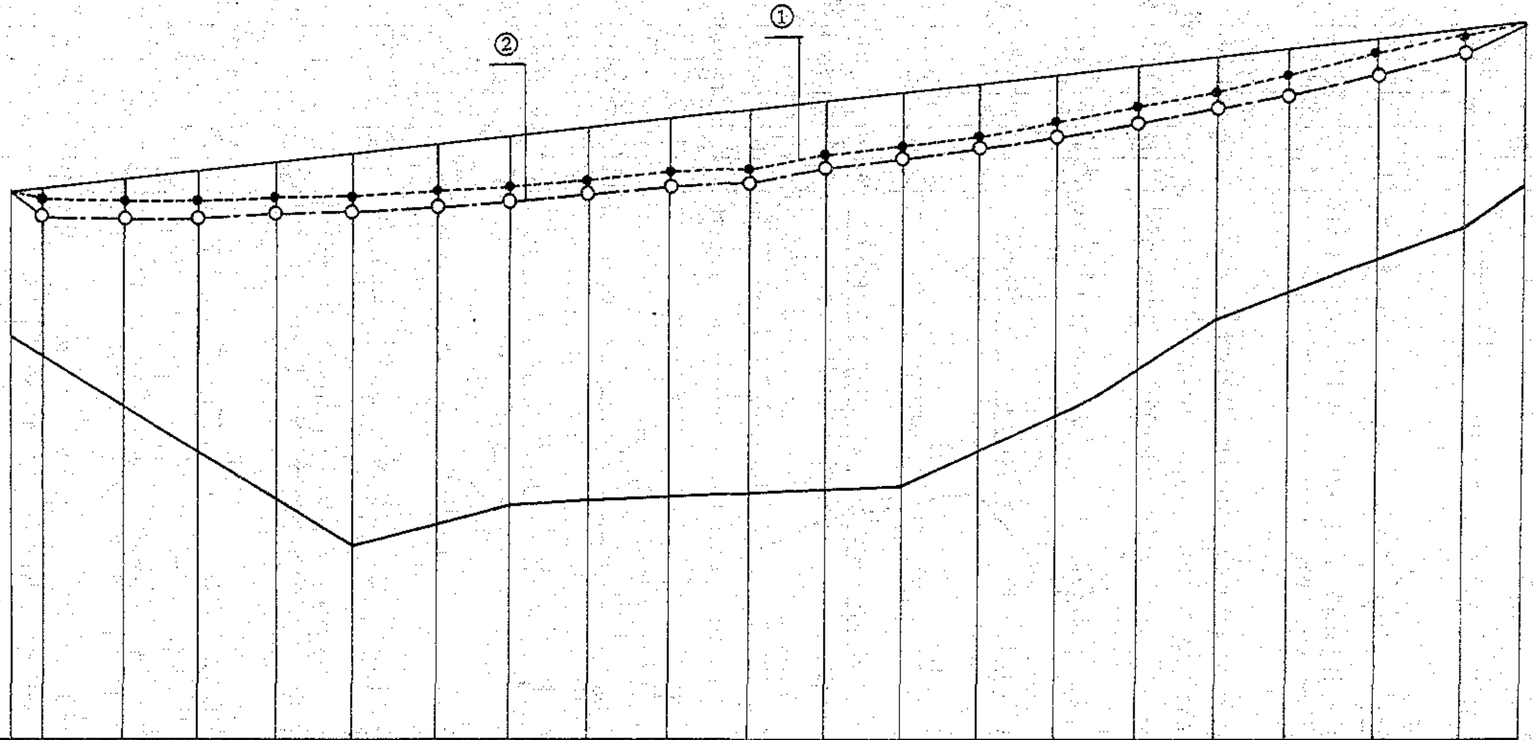
(ii) Original tension of endless

(31)	Original sag-span ratio	S'	(16) = S x (1.2 – 1.3)	= 0.060
(32)	Coefficient of max. tension	φ_0	(2) [(a · S') 13 table] P64	= 2.23
(33)	Original tension	To'	(8) = W'₂ x φ'₀	= 513 kg

(iii) Maximum tension

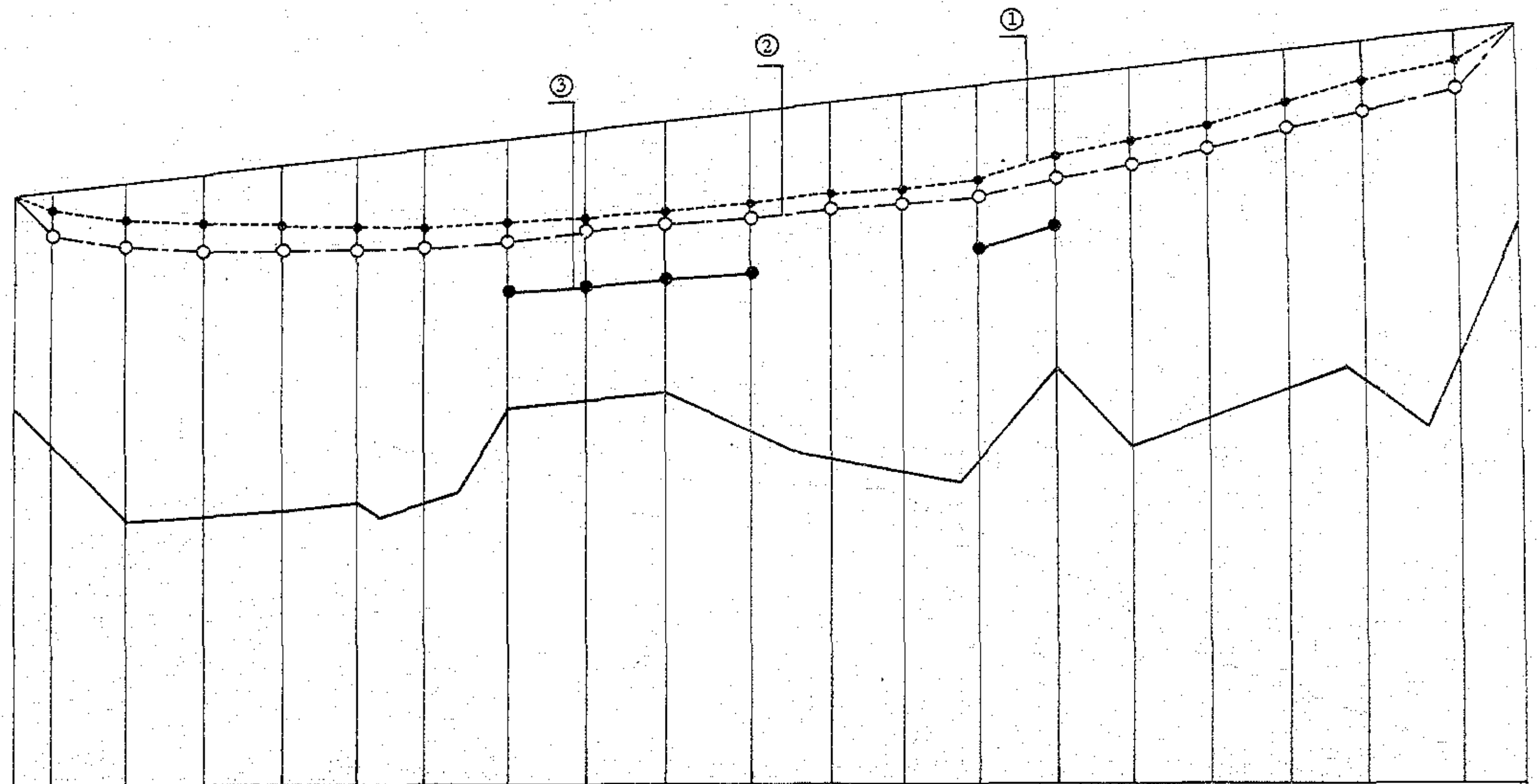
(34)	Tyler system	T'₂	(30) = TP x 1.4	= kg
	Endless tyler system	T'₂	(30) (33) = TP + T'₀	= 1,272 kg
	Falling black system	T'₂	(30) (25) = TP + Ti	= kg
	Endless system	T'₂	(30) (26) = TP + T'₁	= kg
	Safety factor	N	(6) = B'₂/T'₁	6.6 ≧ 4.0
	Endless line of Endless system			≧ 6.0

Fig. 2-4 Drawing of Load Locus Curve (No. I. Line)



Distance coefficient: K	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
Horizontal distance: X	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0	165.0	180.0	195.0	210.0	225.0	240.0	255.0	270.0	285.0	300.0
Form coefficient: m	0.19	0.36	0.51	0.64	0.75	0.84	0.91	0.96	0.99	1.00	0.99	0.96	0.91	0.84	0.75	0.64	0.51	0.36	0.19	
① Original form: fx	1.7	3.2	4.6	5.8	6.8	7.6	8.2	8.6	8.9	9.0	8.9	8.6	8.2	7.6	6.8	5.8	4.6	3.2	1.7	
Sag increase coefficient: r	2.47	1.86	1.59	1.42	1.32	1.25	1.20	1.17	1.16	1.15	1.16	1.17	1.20	1.25	1.32	1.42	1.59	1.86	2.47	
② Load locus curve: fr	4.2	6.0	7.3	8.2	9.0	9.5	9.8	10.1	10.3	10.4	10.3	10.1	9.8	9.5	9.0	8.2	7.3	6.0	4.2	
Correction coefficient: E																				
③ Corrected form: fD																				
Span: ℓo	← 300.0 m α = 5° →																			

Fig. 2-5 Drawing of Load Locus Curve (No. II. Line)



Distance coefficient: K	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
Horizontal distance: X	21.8	43.6	65.4	87.2	109.0	130.8	152.6	174.4	196.2	218.0	239.8	261.6	283.4	305.2	327.0	348.9	370.7	392.5	414.3	436.1
Form coefficient: m	0.19	0.36	0.51	0.64	0.75	0.84	0.91	0.96	0.99	1.00	0.99	0.96	0.91	0.84	0.75	0.64	0.51	0.36	0.19	
① Original form: fx	2.5	4.7	6.7	8.4	9.8	11.0	11.9	12.6	13.0	13.1	13.0	12.6	11.9	11.0	9.8	8.4	6.7	4.7	2.5	
Sag increase coefficient: r	2.43	1.85	1.58	1.42	1.32	1.25	1.20	1.17	1.15	1.15	1.15	1.17	1.20	1.25	1.32	1.42	1.58	1.85	2.43	
② Load locus curve: fr	6.1	8.7	10.6	11.9	12.9	13.8	14.3	14.7	15.0	15.1	15.0	14.7	14.3	13.8	12.9	11.9	10.6	8.7	6.1	
Correction coefficient: E							1.53	1.53	1.53	1.53			1.53	1.53						
③ Corrected form: fD							21.9	22.5	23.0	23.1			21.9	21.1						
Span: ℓo	← 436.1 m $\alpha = 5°$ →																			

(For reference I.)

CALCULATION METHOD FOR THE SKYLINE DESIGN

In the case of cabling the most important thing to be kept in mind is that the wire rope must be strong enough to stand the load without cutting off during operation. In Japan the labor safety regulation provides coefficient of safety.

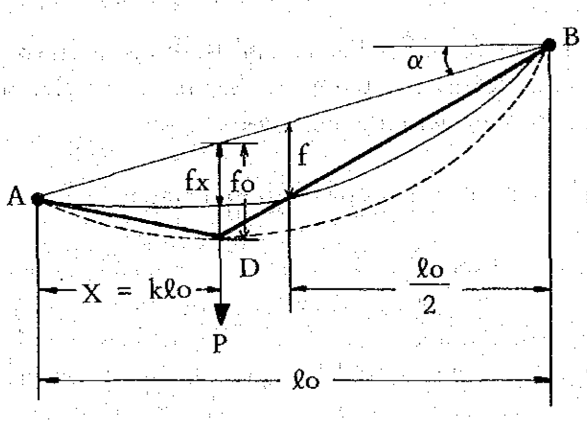
Purpose of wire rope	Coefficient of safety
SKL	2.7
HBL	4.0
LFL	6.0
GYL	4.0

In general, if cabling is too strong, the tension is too great and in order to keep a given coefficient of safety, there is no other alternative but to use a large rope or to reduce the load. On the contrary, if cabling is too weak, the sag of the rope is great and the load of the carriage hangs too much and it touches obstacles on the ground and the swinging of the rope during the operation is too great so the operation cannot be smooth.

The degree of cabling is expressed as central sag/span ratio (ratio of the sag of the rope and the center of span and the horizontal distance of span). Even if there are minor difference, they can have great influence on linear or tension so we should decide carefully. 0.02 - 0.06 is standard but if possible, 0.03 - 0.05 is more desirable. In this design, the sag ratio is 0.03. If the coefficient of safety is still low, we can raise up the coefficient of safety by increasing it to 0.04 - 0.045.

(a) Calculation of linear skyline

Fig. 2-6 Cable and Load Locus Curve



Central sag of cable curve is $f = s.\ell o$ and the sag of the arbitrary point (point on horizontal distance x from A) on curve AB is obtained from $fn = m.f.$ Provided m is cable linear coefficient and obtained from $m = 4\ (K\text{-}K^2)$. K is the horizontal distance coefficient measured from $X/\ell o$ point A. Generally, if ℓo is divided into 20 equal-length portions and the point is taken horizontally, K and m are as shown in the following table.

K	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.45	0.55	0.50
m	0.19	0.36	0.51	0.64	0.75	0.84	0.91	0.96	0.99	1.00

With above values, the cable linear curve figure can be prepared. Then, the locus curve when the carriage load moves with the load is calculated. If carriage is placed on an arbitrary point between A and B, as shown in Fig. 2-6 the cable sags to point D and in equilibrium. Horizontal distance from A to D is x and fn is the sag of the cable at the time of no-load and f_D is the sag when loaded,

$$f_D = rfx$$

Provided, r is loaded cable increased sag coefficient and calculated by following formula

$$r = \frac{1 + 2n}{\sqrt{1 + 12(n + n^2)(K - K^2)}}$$

K	=	$x/\ell o$	Load position coefficient
n	=	P/W	Load ratio
P	:		Carriage load
W	:		Dead load between supporting points

(b) Calculation of the correction factor

Because skyline is strongly stretched and both ends are fixed, the supporting point shifts sometimes and there are change in temperature and elastic elongation. For those reason we can obtain a more accurate value with the correction factor.

(1) Correction of the displacement of the supporting point

Because of some displacement toward the inside between the supporting points, the distance of span is reduced and the sag increases. This minor displacement between supporting point is $\Delta\ell$ and inclined distance of span of cable is ℓ, the displacement ratio is $\Delta d = \Delta\ell/\ell$. Now, assume there has been no displacement, and sag is f_D so when there was displacement, the sag is f_D'

$f_D' = Ed.f_D$

$$Ed = \sqrt{\frac{1 + \frac{3}{8s^2 \cos^4 \alpha} \Delta d}{1 - \Delta d}}$$

f_D : Sag (in case of no displacement)
f_D' : Sag (in case of displacement)
s : Central sag ratio of cable
a : Inclined angle of span

(2) Correction of the change in temperature

When skyline being constructed and when skyline is operating, temperature changes and because of the change in temperature, wire rope expands and contracts and the sag increases and decreases.

The elasticity ratio of the wire rope to temperature is $w = 11 \times 10^{-6}$ per 1°C and relatively minor value.

The initial sag of the arbitrary point of cable is fx and the sag after expansion and contraction is fx',

$$fx' = Et \cdot fx$$

Provided $Et = 1 \pm \frac{3}{16s^2 \cos^4 \alpha} wt^\circ$

Et : Correction factor of sag to change in temperature t°C.
Et remains as it is when weight is loaded.

That is, when there is no change in temperature, the sag at the loaded point is f_D and the sag after change in temperature is f_D'.

$f_D = r \cdot fx \quad f_D' = r \cdot Et \cdot fx$

$\therefore \quad f_D' = Et \cdot f_D$

+ means sag increases when the temperature rises.
– means sag decreases when the temperature goes down.

(3) Correction of the elastic elongation of wire rope

When wire rope is loaded, tension increases and as a result, elastic elongation is brought about and the sag increases. As the cable is stretched with considerable tension, elongation to the initial tension is considered to have disappeared.

If elastic elongation is ΔL, and cable length is L, elastic elongation ratio Δe is following formula.

$$\Delta e = \Delta L / L$$

Assuming that there is no elastic elongation, the sag is f_D and when there is elongation, the sag is $f_D' = Ee \cdot f_d$

Provided $$Ee = \frac{1}{2} [1 + \sqrt{1 + (1 + (1 + \frac{3}{8s^2 \cos^4 \alpha}) \Delta e} \,]$$

Ee : The sag correction coefficient to the elastic elongation of wire rope is attended by the increase of tension arising from load.

$$\Delta e = \lambda \cdot Td$$

Δe : Elongation ratio

$$\lambda = \frac{1}{A \ E}$$

$$Td = T max - To$$

A : Effective sectional area of wire rope
E : Elastic coefficient
Tmax : Non correction factor of maximum tension of loaded cable
To : Maximum tension of cable

(4) Overall correction

When the above displacement of the supporting point, change in temperature and elastic elongation are brought about simultaneously, the overall correction coefficient E is:

$$E = Ed \cdot Et \cdot Ee$$

Then, the overall correction weight f_D' is calculated by the following formula.

$$f_D' = E \cdot f_D = Ed \cdot Et \cdot Ee \cdot f_D$$

If the length of f_D' at the respective position of K, is lower than the straight line of AB and connectes at the respective point, the corrected locus curve is obtained and the safety against the obstacle on the ground can be checked.

(5) Examination of the skyline system design

From the above, when the basic design of the skyline system is prepared, and the operation is actually done with load of log, we should check it in order to prevent breakage of the wire rope and the interruption of the operation.

In designing of skyline system, it is a waste to use larger rope than required for safety and for the basic design, as a rule, the thinnest rope possible is used and we should check it with the safety factor (safety coefficient).

(a) Tension of the skyline and safety factor

Weight of carriage for the design of skyline includes the dead weight of carriage, live load and the weight of the operating rope on the carriage and the impact load. The impact load indicates impact coefficient I and the weight of the operating rope is weight W' of ½ of span. The weight of carriage is P.

$$P = [(Po + Pc) \times (1 + \text{Large } I)] + W'$$

Po : Weight of timber
Pc : Weight of empty carriage
I : Impact coefficient 0.2 – 0.3
W' : Weight of operating rope on carriage

If a cable strained with a given tension is loaded with a carriage (loaded cable), the tension of the cable naturally increases. The tension is changed not only by load but by the position of carriage. When carriage is at the center of span, the maximum tension is at the upper supporting point.

The maximum tension T_1 at upper supporting point is

$$T_1 = (W + P) \times \Phi$$

W = Skyline weight
P = Carriage load as calculated as above

Φ Maximum tension coefficient. Calculate from the following formula.

$$\Phi = \sqrt{\frac{1 + 4sl + \tan \alpha^2}{8sl}}$$

α : Inclined angle of span

$$S_1 = Z_1 \cdot s$$

s : Central sag ratio of cable

Z_1 : Sag ratio equivalent coefficient

$$Z_1 = \frac{1 + n}{\sqrt{1 + 3n + 3n^2}}$$

n : Load ratio $\frac{P}{W}$

Maximum tension T_1 is thus determined and the guaranteed breaking force is B.

Safety coefficient is $N = \frac{B}{T_1}$

As a result of these calculations if N is smaller than 2, it is dangerous and it should be $N > 2.7$.

In this case, the correction coefficient should be used.

(b) Tension of operating line and safety factor

Maximum tension T' of the lifting line of the Endless Tyler system is determined from the following formula.

$$T_1 = \frac{P\ell}{No} + P_1' \times h'$$

$P\ell$	:	Load of loading block
P'	:	Weight of per unit length of lifting line
h'	:	Maximum lift (Maximum distance from skyline to ground surface)
No	:	No. of ropes on loading block

This formula cannot only be applied to the lifting line of the Endless Tyler system but also to the Tyler system, and the lifting line of the Falling Block system.

From the above, the safety coefficient $N = \frac{B}{T_1'}$ is determined and confirmed that it is over 0.6.

Then, tension T_2' of the endless line is obtained from the following formula.

$$T_2' = T'o + Tp$$

T'o	:	Basic tension
Tp	:	Traction load

When empty carriage comes near the upper or lower supporting point, endless skyline is so strained that sag ratio S' (basic sag ratio) is 1.2 – 1.3 times of the sag ratio S (Skyline).

$T'o = (P_2' \times \ell) \times \Phi$

P_2'	:	Weight of unit length of endless line
ℓ	:	Inclined distance of span
Φ	:	Maximum tension coefficient

Traction load T_p is divided into T_{p1} when carriage does not come near the supporting point, and T_{p2} when carriage comes near the supporting point, and calculated.

$T_{p1} = p \times \sin \beta_1$

$T_{p2} = p \times \sin \beta_2$

p	:	Load of carriage
β_1	:	Inclined angle of carriage locus when carriage does not come near the supporting point.
β_2	:	Inclined angle of carriage locus when carriage comes near the supporting point.

Maximum tension of the endless line is T_1 when carriage does not come near the supporting point, and T_2 when carriage comes near the supporting point, we get following formula.

$T_1 = T'o + T_{p1}$

$T_2 = T'o + T_{p1}$

Then, the safety coefficient is determined from B/T_1 and B/T_2 and is over 4.0.

Note: •As to all coefficients stated in the above, the coefficient table is available and if you quote it, you need not calculate each one individually.

(For reference II)

OPERATION DECK

In Japan, with regard to cable logging and truck logging, generally a deck is constructed at the termination of a yarding site and logs are bucked into specified size on the deck and loaded on truck and carried to the timber yard.

In Burma, as loading is done by a log loader, it seems to be not necessary to construct a deck for the time being but for future reference, its construction is stated below.

A simple deck is to lay small logs in parallel on the ground. Some deck is to set up a scaffold or parallel crosses using logs, as a scraching deck, a bucking deck or a loading deck.

The scraching deck is to collide logs carried by the yarder and change the direction and drop them on the loading deck. This operation will avoid dangers on the deck.

The size of a deck depends on a length of a full stem. In general, in the case of 20 m of full stem, the frontage of the deck is 22 m and the depth is less than ½ of the frontage. Depending on the position of deck. If the depth equivalent to the length of full stem is impossible, full stems which are carried are unloaded to cut half stem in front of the deck and then, carried to the bucking deck and bucked.

The size of a loading deck depends upon a size of a logging truck but the spacing should be enough to lay down logs for one truck at least.

Generally, in full stem yarding, in order to minimize the removing of the log after bucking, the frontage should be wide but in ordinary yarding, the frontage is short, as the unloading site is fixed. If the depth is long, timber store is possible to some extent.

To calculate the manpower required for construction of a deck, we have followed an experimental formula.

(1) Structure of scaffold: $Z = 0.066x + 2.120y + 10.27$

(2) Structure of parallel crosses: $Z = 0.030x + 5.902y + 10.24$

Provided
- x : area of deck (m^2)
- y : maximum height of deck (m)
- z : man-days for construction of deck (man)

* Structure of scaffold means that the structure of the lower part of the lower part of the deck is to combine with the column and beam like a scaffold.

* Structure of parallel crosses means that logs are combined like a lattice-work.

The manpower required for the withdrawal of a deck is 30% of those required for construction. Timber volume and size required for construction of a deck are as follows.

(1) Scaffold structure: $y = 0.071 + 0.0064x$

(2) Parallel crosses structure: $y = 0.029 + 0.0111x$

Provided y = timber volume per 1 m^2 of deck (m^3)

x = diameter of log used (cm) (at the top)

On the Job Training Plan of Tractor Logging

In order to develop the technology for the tractor logging, the construction of feeder road, the establishment of a effective logging system from the viewpoint of the relationship between yarding distance and amount production and improvement in the techniques of repair and so on will be achieved.

(1) Proposed site

Many small ravines are streaming in the model operation forest but as this area is a gentle hilly zone, in general, we can exercise the tractor logging anywhere in the forest. Therefore, there need be no specified area.

(2) Logging system

Logging system is the ordinary yarding system which is currently the tractor logging system. If we expect higher productivity with small logs, we will exercise the half stem logging system or the full stem logging system in the training schedule. The tractor for this exercise is a wheel type and 6 ton dead weight.

(3) Training

Since the tractor logging system was introduced in the timber production in Burma, it seems that trainees have a basic knowledge and skill. In consequence, it is not necessary to set the training period on the spot. But, as the full members of the trainnees do not join in the working of the yarder operation during the training period, 3 trainees as a group will join in the construction of the tractor road and in the logging operation in shifts during the period.

(4) Staff and Worker

According to the concept of the operations the staff have to exercise main works and the worker will be engaged in other works.

(5) Arrangements and daily programme of exercise

The arrangements for the exercise of the tractor logging is in Table 2-10 and the daily programme of exercise of the tractor logging is in Table 2-11.

For details, refer to (Reference) "Method of tractor logging."

(6) Felling area and felling volume

With refence to the training period, it is scheduled that the felling area for April 1979 - March 1980 will be about 1.5 ha and felling volume will be about 60 ton (110 m^3).

(7) Manpower and the cost of training

The manpower and the cost required for the exercise of the above tractor logging are in Table 2-12.

(8) Other important matters for training

In case of the training before rainy season, it is necessary that the felling is counter-balanced with the progress of the yarding without any residuals arising from advanced felling.

Table 2-10 Arrangements of Training of Tractor Logging Operation

	Items	Details	Operations	Trainees		Remarks
				Staff	Worker	
1	Reconnaissance	Reconnaissance on proposed logging forest	(a) Decision of logging area (b) Decision of proposed log dump (c) Decision of main feeder road (Hindering trees are marked with tape.)	◎	○	
2	Cutting of hindering trees	(1) Cutting of hidering tree on main line of (2) Cutting of hidering trees in log dump	On main line of the feeder road hidering trees 5 m wide inside from the center are cut. When deck is constructed, hidering trees in log dump are used for deck construction. Timber length is informaed and ordinaly bucking is made.		◎	Inform workers the main feeder road and log dump site
3.	Construction of main feeder road		The main feeder road is 2.8-3.0 m wide. On flat land, vegetation is not removed as much as possible. With construction of main road, logging of logs for deck is performed.	◎		
4	Felling and limbing	Cutting of logged timber (full stem operation)	Proposed logging areas are divided into (1) and (2) and when cutting of (1) area completes, considering progress of logging operation, cutting of (2) area starts. In felling near the feeder road, safety operation is secured as to confirm any tractor, and to give signals.		◎	
5	Yarding & bucking	Full stem yarding & bucking operations	Trainees exercise loading, unloading and stacking operations, and learn by experience. If necessary, they alternate with workers. Bucking operation is done by workers.			
6	Construction of deck	Construction of operation deck	For bucking deck, small logs of 10-15 cm in diameter are laid in 30 cm interval. Height of loading deck is in proportion to height of loading platform of truck.			

Table 2-11 Schedule Tractor Logging Exercise

Item \ Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Reconnaisance	(4)																													
2. Culting of hindering tree				(20)																										
3. Construction of tractor road								(10)																						
4. Construction of log yard													(2)																	
5. Felling operation										(16)																				
6. Logging operation																	(14)													

Operation by staff ————

Operation by worker – – – – – –

(   ) indicates man-days

Table 2-12 Details of Cost for Exercise of Tractor Logging Operations

Curriculum	Items	Trainees		Category	Cost			Base of calculation
		Staff	Worker		Quantity	Price	Amount	
Tractor logging	Reconnaissance	◎	o	Man power	4 p.	KS 8.7	KS 34.8	Clearing footpath
	Cutting of hindering trees on road and and log dump		o	Man power	10 10	9.5 8.7	95.0	1 day 4 men (100 m) x 5 days = 20 men
	Construction of logging road	◎	o	Man power	10	8.7	87.0	Clearing up branches and twigs on proposed line 1 day 1 man x 10 days = 10 men
	Construction of log dump	◎	o	Man power	2	8.7	17.4	1 day 2 men
	Felling and limbing		o	Man power	8 8	9.5 8.7	76.0 69.6	2 men one group (1 day 14 m^3) x 8days = 16 men
	Logging operation	◎	o	Man power	14	8.7	121.6	1 day unloading 1 man, loading 1 man total 2 men x 7 days = 14 men *see under
	Tractor fuel			Light oil	450 ℓ	3.0	1,350.0	1 day 25 ℓ x 18 days = 450 ℓ
	Grease & oils			Mobile	18	21.3	383.4	1 day 1 ℓ x 18 days = 18 ℓ SAE 90
				Other oil			40.0	
	Other supplies						10.0	rugs, etc.
	Total						2,371.8	
								* logging 110 m^2 1 day 16 m^2 = 7 days

(For reference III)

METHOD OF TRACTOR LOGGING

A. Location and Construction of the Log Dump and the Route of Feeder Road

In order to perform efficient tractor logging, we will pay special attention to the location of the log dump and the route of feeder road.

(1) The log dump

(a) Such a log dump is convenient for the transportation of logs by trucks.

(b) In case of the full tree or full stem yarding, the limbing site, the bucking site and the order of stacking are considered previously.

(c) In general, the log dumps, in case of tractor logging, is apt to lined up one way. And the entrance to the log dump is apt to be steep.
For this reason, where the road surface is weak, the road will become muddy and tractor traffic heavy. It is necessary to make some inclination or drainage ditches around the log dump to collect rain fall or water from the ravines. It is desirable to have some reserved log dump which can used when conditions are very wet and unfavorable. Near the log dump, the frequency of tractor traffic is high and as it is feared that operational efficiency on a muddy road will be decreased, so we should pay attention to selection, construction and maintenance of the log dump.

(2) Construction of feeder road

We may classify the feeder road as a main line and a branch line. When we examine logging plan, we should consider and decide where to locate and construct the road in the felling area. That is the main line. On the contrary, in performing the logging operation, we can construct and raod and if necessary, we can extend it. That is the branch raod. With reference to this definition, we will state how to construct the main line and the branch line.

(a) Main line serves as the skyline in the cable logging, so considering the range of the winch, it should be constructed at the most beneficial point.

(b) Since the main line will be used as a feeder road (car road) in the future, it is desirable to construct it along a contour line considering the slope etc.

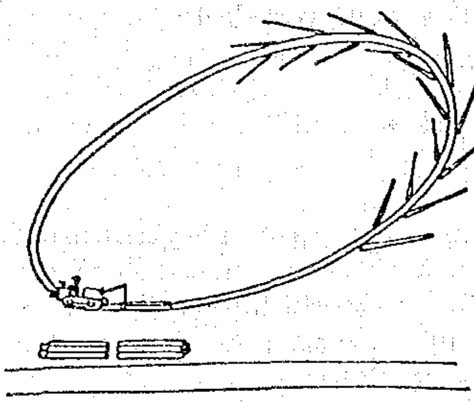
(c) When pre-yarding is done by the winch, if the log is lifted from a low site, the top of the log is rainsed up and it is easy to operate, it is hard to draw from a high site. If the road is constructed in the marshes along a ravine, the raod will be poorly drained and become muddy. Considering the above, it would be better to construct it in a dry and well drained area.

(d) It is desirable that the main line should be constructed without any dead-end, so that the tructor will not require and U turn change. (See Fig. 2-7)

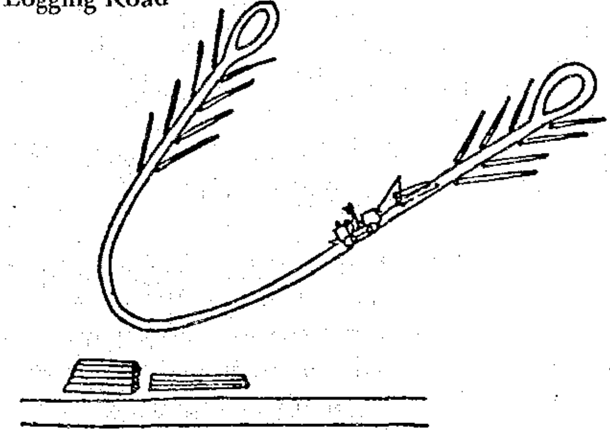
(e) The main line should be constructed before the felling starts. If construction starts after felling, not only efficiency decreases because of fallen trees and other obstacles but the felling direction can not be regulated and the logging operation is eventually hindered.

(f) The branch line is not constructed in advance as the main line but is constructed along with pogress of the logging operation. After the yarding within the range of the winch (generally more or less 30 m), the tractors will enter into the forest in order to collect felled trees outside the range. The branch line is constructed at this time. If the conditions of the ground surface are favorable, the tractor can proceed the yarding easily in this case. No earth-moving operation is required and the road will be naturally constructed.

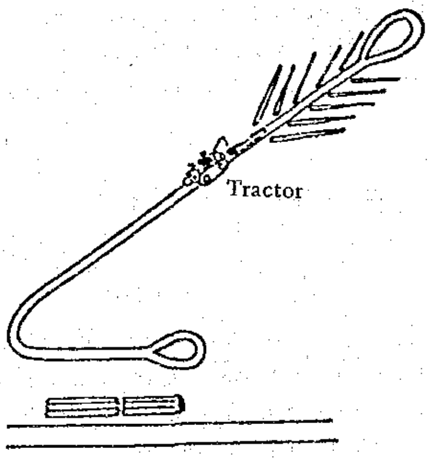
Fig. 2-7 Tractor Logging Road



(1) Loop line



(2) U type line



(3) L type line

The branch line is different from the main line as it supports a low frequency of tractor traffic. In short, it is enough that a tractor pulling felled trees should be able to pass.

(g) In constructing the feeder road, as a rule, only vegetation on the ground surface should be cut. The reason for this is that the roots of bamboo and other bushes can prevent the road.

(h) The width of the feeder road is over 1.2 times the width of tractor gauge and the curve is widened as required in proportion to the length of logs.

(i) The slope of the tractor logging road is constructed according to the following standards.

(i) The grade limit of the road is 25 degrees of earth way.

(ii) The slope of the road close to the grade limit for distances of over 50 m will not be constructed.

(iii) At the front and rear of the road close to the grade limit, a section of mild slope is constructed.

(iv) Any curve of small radius will not be allowed in the inclined roads close to the grade limit.

(j) As regards the density of the tractor logging road, the ideal logging range of the tractor is within 30 m and if its over 50 m, it will not be efficient. From this fact, considering the road density, assuming 30 m to be within the reach of the winch including main and branch lines, the density is 160 m/ha. But if we consider the length of felled trees, and assume 50 m or so, it is 100 m/ha.

(k) The slope of the climbing road of the tractor, depending upon the condition of the soil, is 14-15 degree wich is the limit for an ordinary earth road and if it is over, will not only slip and hard to climb at the time of rain or after rain but damage the road.

B. Felling and Bucking in Tractor Logging

(1) Direction of felling

Felling is better if done at 30-40 degrees to the feeder road. In general, as shown in (2) of Fig. 2, it is a rule to direct the bottom end to the feeder road but as in (3) of Fig. 2. There have been many cases where the top end is directed to the feeder road and felled to raise up logging efficiency. In case the of full stem logging, the latter is more beneficial for the following rasons.

(a) If we attach a sling to the log top, it is easy to load and it saves time.

(b) The drawing distance of the length of the tree height is reduced.

(c) When drawn by a winch, it is rare that a nose is lifted or that it touches an obstacle such as the stump. Sometimes, the tree top is broken but quality and volume are not influenced much.

(d) Much loading

(e) Little impact on the winch

(f) Damages to the tractor road are relatively few

(g) In ratio of load share of sulky and earth surface, sulky is less and troubles are few.

On the contrary, there are the following disadvantages.

(a) In felling, trees are felled in an adverse direction and wood is damaged.

(b) When the log is hanging, unless the top end diameter is of a moderate size, the sling rope falls out.

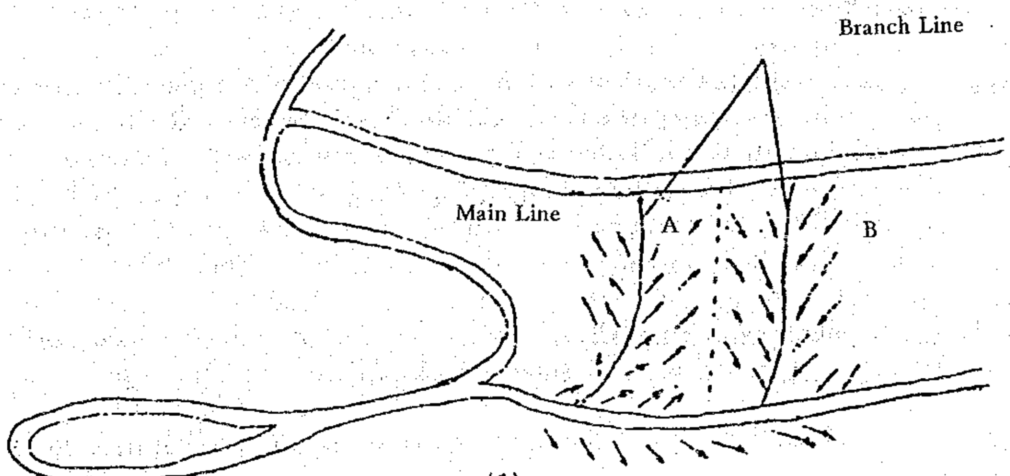
(c) While dragging the log, the top end is damaged and sometimes re-hanging is required.

(d) While dragging the log, resistance to ground dragging becomes great.

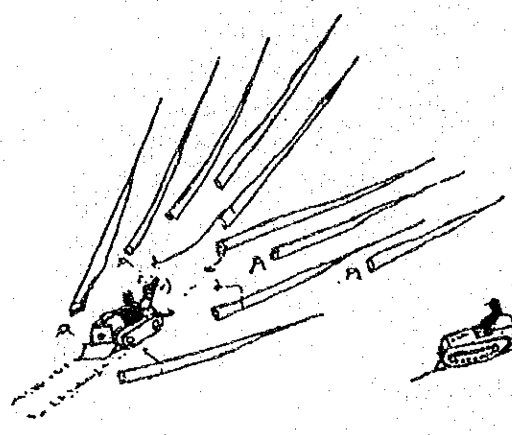
(2) Stump height

The stump height is as low as possible so the tractor can pass easily.

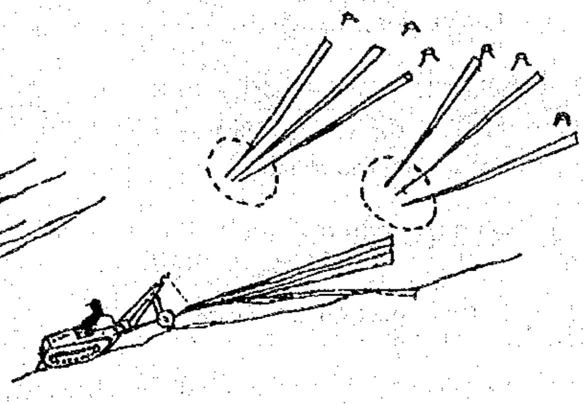
Fig. 2-8 Logging Road and Felling Direction



(1)



(2)



(3)

(3) Others

(a) As full tree logging involves dragging unnecessary twigs and branches, the number of trees per dragging is small and unprofitable, and the yarding close to the full stem yarding is has to be done to increase efficiency.

(b) In the ground yarding, if the log has a round-shaped end, the resistance is less and damage to the wood is also less.

(c) In dragging, if the road courves outward, logs sometimes fall down so that standing trees are left on the outside as a guide.

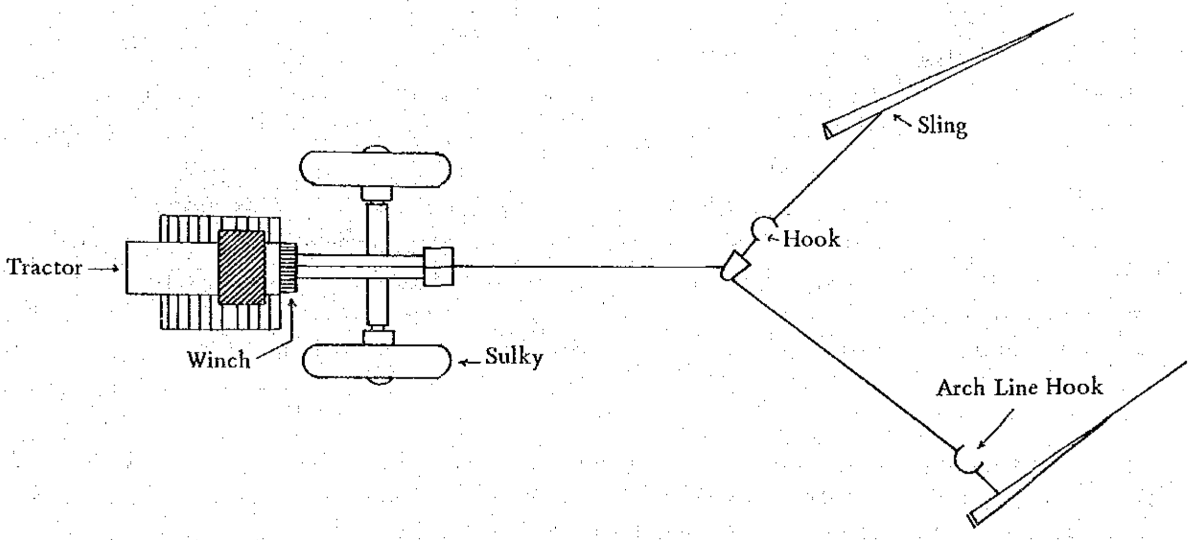
C. Some Important Matters for Yarding Operation

(1) Pre-yarding

(a) Pre-yarding distance by the winch has somthing to do with the difficulty and process. If the pre-yarding distance by the winch is too long, the lifting anlge of timber is small, logs can touch bushes and stumps and eventually the progress of the operation is reduced. Pre-yarding distance, depending on the winding capacity of winch, is within 40 m at the highest and within 20 m on average which is reasonable as regards work efficiency and safety.

(b) As the pulling capacity of the winch has a surplus, the process is almost the same in both upward prelogging and downward prelogging.

(c) When prelogging, if logged timbers are far away from the axis of tractor and pulled as they are, they are in danger of turning sideways. In such an instance, we can apply the guide block or the automatic switch block or as shown in Fig. 3, so besides the ordinary arch line attached to the end of rope, another hook is prepared which can move freely on the arch line and the logs on the right and left side of the axis of tractor are strapped to the balance and are attached to a respective hook and pulled simultaneously. Then, the direction of the resultant force of the log weight and the direction of the axis of the tractor almost agree and relatively smooth logging can be carried out.



When logs to be preyarded are not on the axis of the tractor, prelogging by double arch line hook can be carried out.

(d) In the pre-yarding by winch, sometimes, pulling can not be done because logs are touching bushes and stumps. In such a case, if winding continues with the power of the winch, logs can stand up and fall down in unexpected directions or the rope is cut and serious accidents can occur. Such a forced operation should not be carried out. It is important that after it has been confirmed that the rope has completely slack and the logs have been stabilized, then, the next work starts.

(2) Loading, travelling and unloading

(a) Usually loading is done by one man in sulky and integral arch logging. When the tractor is returning the loading laborers considers the topography and direction of felled trees and decides on the next logs to skid and procedure and attaches the sling. In this case, bushes and branches and twings which hinder logging are removed in advance.

(b) The logging volume of one operation depends on the size of the extracted timber but considering the site and conditions of the model operation forest, 2-4 m^3 seems reasonable.

(c) When the pulling operation can not be done because of a muddy logging road or a reversed slope, the logs are unloaded once and only the turck proceeds and where ther ground conditions are good, logs are drawn closer by the winch.

(d) In the loading and unloading operations, the laborers and the drivers cooperate closely and should confirm their signals and after safty has been confirmed, the next operation starts.

3. Plan for the Facilities of Model Operation Forest

3-1 Yearly Forest Road Construction Plan

3-1-1 Condition of Construction of Present Feeder Road and Idea of Construction in Model Operation Forest

While the State Construction Corporation undertakes construction, maintenance and control of highway for general traffic, construction and planning of the feeder road to transport timbers from the national forest is done by the Extraction Department of the State Timber Corporation (in the case of this forest district, the Bassein Division of the Department).

The highway of the Chaungtha district of the Bassein Division covers about 12 miles (20 km) from Shawbya to Seikkyi village to north-west along the Bengal Bay. The road surface is macadam road and suitable in rainy season, and this is only one road in this district.

At present, in Burma there is no regulation covering the standard and structure of forest roads and in timber hauling, feeder roads are always constructed by a bulldozer if the case demands it. The construction uses reconnaissance only and the design (accompanied by survey) is not carried out. Gravel is not used to built the feeder road and it is not provided with a side ditch. Drainage on the road surface is ignored and although the road surface is stabilized in the dry season, it is useless in the rainy season as a log-hauling road.

In order to carry out the felling through out a year and to raise up the productivity, it is necessary, to set up the overall plan of all season forest road which can be used even in the rainy season and the yearly plan of construction are implemented alongside the construction of the feeder road together with the progress of the felling operation. In the construction of an all season type forest road, surveying and location of structure are to meet the objective of use. The construction is done in the work period, and is to be based on the design map. We can reach the entrance of the model operation forest in 30 minutes by car.

3-1-2 Natural Conditions

(1) Location and Traffic

The model operation forest of the Chaungtha forest district is located to the south of the Arakan Range north-west of Bassein City and the route to this model operation forest is 9 miles up stream of the Bassein River in the north and 9 miles (15 km) from the tributary in the west to reach Shawbya village. (It takes 2.5 hours by tug boat and 30 minutes by car then to arrive at the proposed site of entrance of model operation forest 6 miles (10 km) away.)

There is a highway from here to Seikkyi village which is about 6 miles (10 km) from the Bengal Bay in West-North-West and there is a route from Seikkyi to Chaungtha on the Bengal Bay which takes 80 minutes by boat but at present, there are no harbour facilities for loading and unloading at Seikkyi and Chungtha and this route is not suitable for bringing in materials.

(2) Climate

In Bassein City, the highest annual mean temperature is 31°C and the lowest annual mean temperature is about 22°C. The lowest is from December to January in the dry season and the highest is from April to May just before rainy season.

The rainfall is heavy from the middle of May to the middle of October. The monthly rainfall is highest in June and there are 25 rainy days and the monthly rainfall is 32.3" (8020 mm).

Because of meteorological observation data being unavailable for Shawbya district, details of climate and temperature are unknown but as the district is in the mountains and in the Chaugtha forest district, some areas facing the Bengal Bay are hit by wet tongue directly from the sea, it seems that the district has more record-breaking rainfalls than the Bassein district.

For information, the record-breaking rainfalls in Japan are as follows:

Table 3-1 Record-breaking Rainfalls in Japan

Recorded hours of rainfalls	Rainfall	Location	Date
10 minutes	(1.93") 49 mm	Ashizuri, Kochi	Oct. 1946
	(1.57") 40 mm	Choshi, Chiba	Aug. 1947
60 minutes	(5.91") 150 mm	Ashizuri, Kochi	Oct. 1944
	(5.75") 146 mm	Mt. Hakone	Aug. 1938

(3) Specific Discharge and Designed Rainfall

From the water flow trace at the location of No. 1 bridge which is planned at the boundary of compartments No. 22 and No. 24, specific discharge is estiamted.

Date: (See Fig. 3-1)

Area of drainage basin	4.8 km^2
Section area of water flow	25.7 m^2
Hydraulic mean depth	R = 1.56 m
Grade	I = 0.005
Coefficient of roughness	n = 0.04
Chezy's coefficient	C

$$C = \frac{1/n + 23 + 0.00155/I}{1 + (23 + 0.00155/\pm\, n/\sqrt{R}}$$ (Ganguillet Kutter's formula)

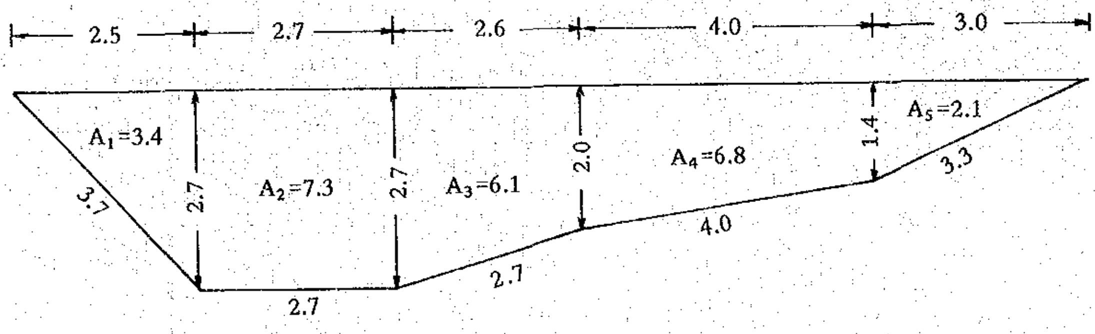
48.31/1.747 = 27.7

Velocity $V = C\sqrt{R.I} = 27.7 \quad \sqrt{1.56 \times 0.005} = 2.45$ m/sec.

Discharge $Q = V \times A = 2.45$ m/sec. x 25.7 m^2 = 63 m^3/sec.

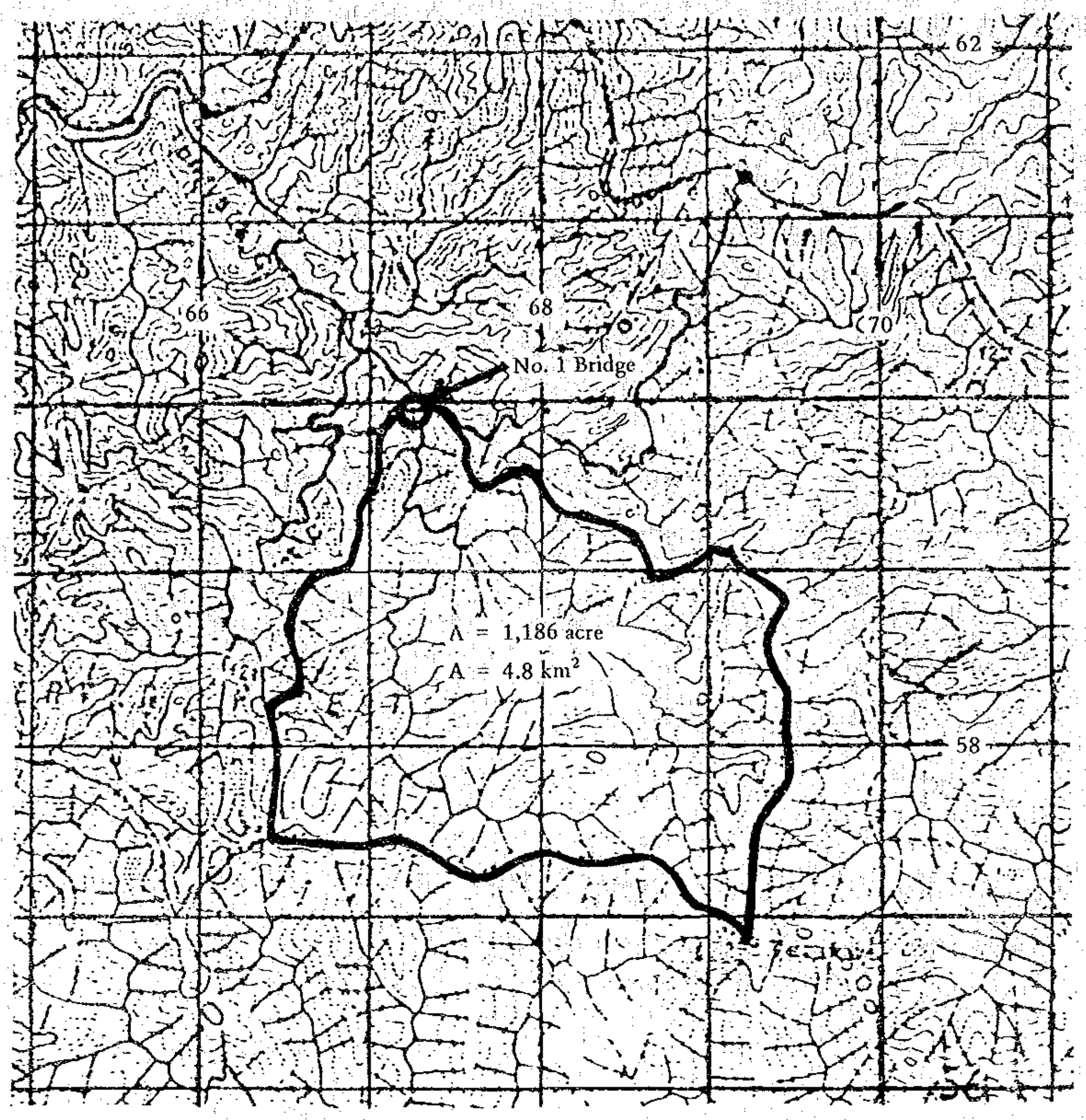
Specific Discharge = Q/Area of drainage basin = 63 m^3/sec./4.8 km^2
13 m^3/sec./km^2 = 186 ft^3/sec./100 acre

No. 1 Bridge – Section of Water Flow



Sectional area	$A = A_1 + \ldots\ldots. A_5 = 25.7$ m^2
Wetted perimeter	$P = 3.7 + 2.7 + 2.7 + 4.0 + 3.3 = 16.4$ m
Hydraulic mean depth	$R = A/P = 25.7$ m^2 / 16.4 m $= 1.56$ m

Fig. 3-1 Location of No. 1 Bridge



Specific discharge

$13 \ m^3/sec./km^2 = 186 \ ft^3/sec./100$ acre

Value of specific discharge

$186 \ ft^3/sec./100$ acre,

if coefficient of runoff is 1, is 17.7" (47 mm) in conversion of rainfall per 60 minutes

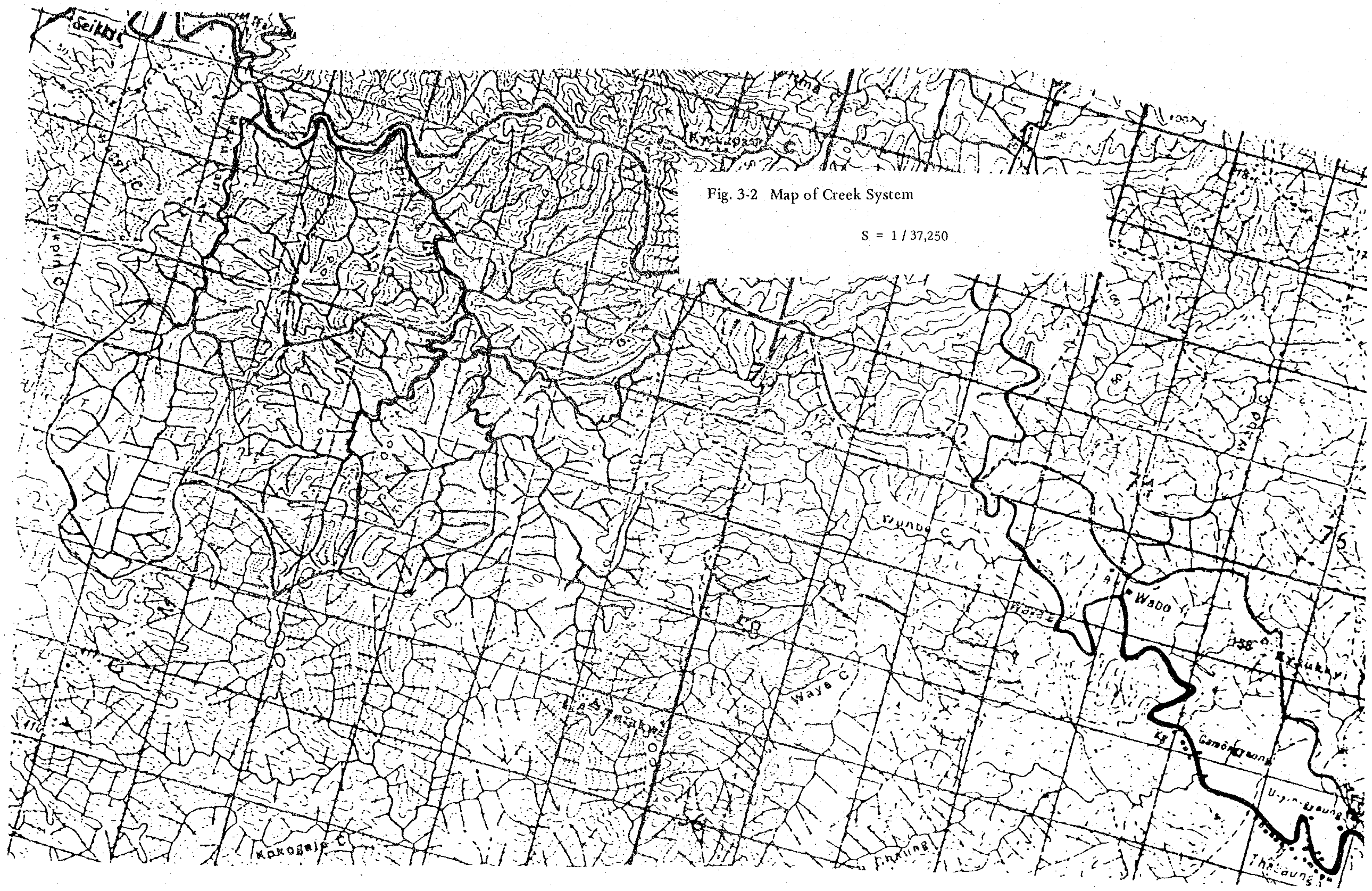


Fig. 3-2 Map of Creek System

S = 1 / 37,250