CHAPTER V WAREHOUSE LOCATION AND ITS CAPACITY

CHPATER V WAREHOUSE LOCATION AND ITS CAPACITY

5-1 The Selection of Warehouse Location

The selection of warehouse locations has been determined in coordination with the production volume and marketing system of rice as background. The locations were analyzed and studied carefully to decide whether or not it would enable PWO to carry out, functionally and economically, receiving, storing and selling products nationwide, and to achieve their goals.

(1) Warehouse Locations for Regional Warehouses

Regional warehouses are to be built at the key marketing centers of agricultural products in the regions by dividing Thailand into 5 regions: the Central region, the Lower-Northern region, the Upper-Northern region, the Northeastern region and the Southern region. At present, PWO does not have any specified regional offices or warehouses, and all regional services have been provided through the central operation in Bangkok. If regional services are required locally, a responsible staff member is dispatched to each region. Since PWO has never had detailed information about the regions and efficient local activities, it has always been at a disadvantage. PWO, with this project as a turning point, is eager to establish a functional warehouse network system that connects major marketing centers in the regions of the country.

The main reason for dividing the country into 5 regions is not only on the basis of agricultural product type or production volume, but places an emphasis on strengthening PWO's regional activities. If it was decided to divide the country by placing an emphasis on production volume, it would be ideal to subdivide the Central region into an Eastern sub-region, Central sub-region and Western sub-region. When PWO's activities become more active, and the need for subdivided regions becomes greater, this plan could be put into effect according to the enhancement plan of PWO.

The location of the building sites for the regional warehouses are selected to be the following, which will be the key marketing centers of agricultural products in each region.

Central region	Nonthaburi
Lower-Northern region	Nakhon Sawan
Upper-Northern region	Lampang
Northeastern region	Nakhon Ratchasima
Southern region	Surat Thani

a. Nonthaburi in the Central Region

The proposed warehouse location is in Bankasor district in Nonthaburi Province; about 20 km north from the center of the city of Bangkok, and is situated on the east side of the Chao Phraya river. This site is near the interchange which connects Highway No. 1 (Central highway), No. 2 (North-East highway), No. 3 (South-East highway), and No. 4 (Southern highway), all of which are used to deliver agricultural products into Bangkok metropolitan area. In addition, this site has the advantage of avoiding the usual traffic jams in the city of Bangkok. Since this location is facing the Chao Phraya river, it is expected to be an excellent river port in the future.

The region is covering the central plain and the highest rice producing area in Thailand. The rice supplies about one third of the export rice from Thailand and is estimated to supply between 2 - 2.5 million tons annually of milled rice. At present, rice produced in the dry season is also increasing remarkably.

b. Nakhon Sawan in the Lower-Northern Region

The proposed warehouse location is about 10 km south from the center of the city of Nakhon Sawan, and is situated along the railway road at the site of Nakhon Sawan station. This site is an important traffic location because it is accessible to Highway No. 1 (Central highway). It is to be an marketing

center of agricultural products in the future and in addition, is in the district which is being planned by the "Municipal Authorities" as an industry development site.

The annual production volume of rice is about 3 million tons of paddy. This region is famous for its good quality, and the products are estimated to be about half the production volume and exceeds about one million tons of milled rice.

This town is a traditional agricultural product marketing center, and is surrounded by famous production districts of corn, sorghum, green beans and peanuts. This town is also expected to become a larger regional market if the river port is improved.

c. Lampang Warehouse in the Upper-Northern Region

The proposed warehouse location is situated about 10 km south from downtown Lampang where Highway No. 1 from Chiang Rai and Highway No. 11 from Chiang Mai interchange. This location is acknowledged as an important traffic center in the Upper-Northern region. That is, since this building site is near both Chiang Rai, where rice is produced in the Upper-Northern region, and Chiang Mai, where commercial products such as beans, tobacco, sorghum and peanuts are produced, the location is situated as a market base where these products are resold to Bangkok. About a half million tons of milled rice are supplied annually outside this region, but the volume is not to be despised if other agricultural products are added to the rice. This region is far away from the central (Bangkok) market. This places sales of agricultural products at a disadvantage. Thus, it would be beneficial for farmers if public warehouses were built by PWO.

d. Nakhon Ratchasima in the Northeastern Region

The proposed warehouse location is about 15 km west from the center of the city of Nakhon Ratchasima. It faces Highway No. 2 which links both Bangkok and the Northeastern region. The

production volume of rice in the Northeastern region is almost the same as the volume of the Central region but only about 450 thousand tons of milled rice are estimated to be supplied outside this region because of the large population. Traditionally, a large quantity of glutinous rice is produced, consumed and distributed in this region. Since there is no international market for glutinous rice, except the Chinese market in neighboring countries, i.e., Laos, Cambodia, Hong Kong and Singapore, the Government is strongly promoting to farmers in this region that they produce nonglutinous rice instead.

Inhabitants in this region are facing severe natural impairments of the soil and water supply which reduces productivity. Their income is low compared with other regions. This fact is becoming a social and economical problem in Thailand. PWO will help solve this problem by providing warehouses and marketing system in this region and increasing farmers' income and enhancing their welfare conditions.

e. Surat Thani in the Southern Region

The proposed warehouse location is near the site of a railway station which is about 10 km west from downtown Surat Thani and connected to Highway No. 41 by a 10 km road.

The Southern region is short of rice in term of production but produces tin as a mineral product, fish as a marine product, coconut and gum as agricultural products. Warehouses as a function of the distribution center in this region will promote the welfare of the regional population. They will be able to obtain good rice fairly. PWO is scheduled to receive rice delivered from the Central region and to store the rice in the proposed warehouses. PWO will then sell the rice to the inhabitants at stable prices after grading and packing.

(2) Warehouses Location for Provincial Warehousing

According to the Agro-Economic Zone in Thailand, guided by the Ministry of Agriculture and Agricultural Cooperatives, Thailand is divided into 19 regions based on the surrounding agricultural production volume and actual economic status.

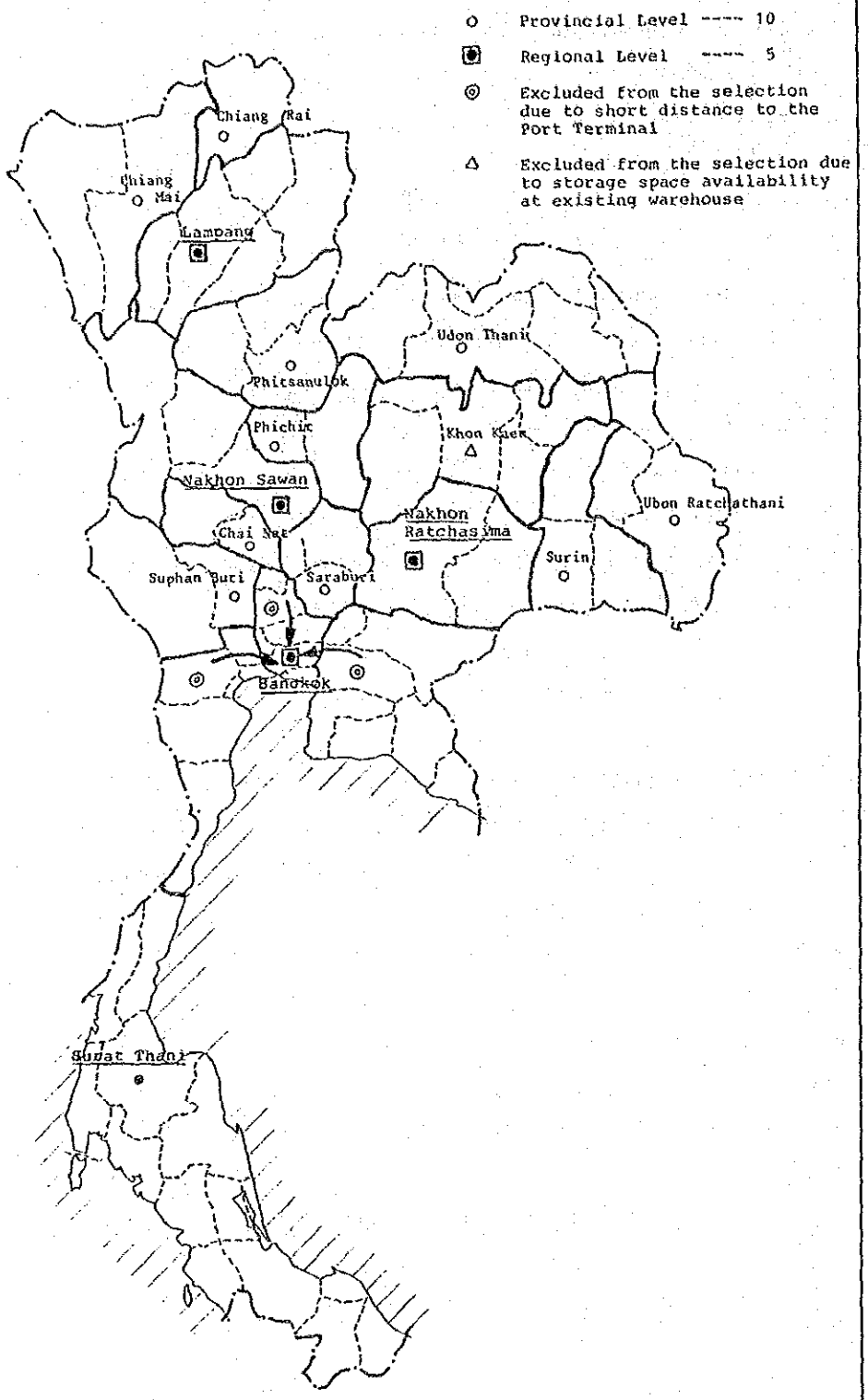
Fig. 5-1 represents a similar Agro-Economic Zone prepared by elements of food crop production volume like rice and its marketing system.

In this project, the provincial warehouse is planned to be built at the biggest marketing base in each division corresponding to the food crop production and its marketing system. The reasons are as follows:

1) If the provincial warehouses were built in principal provinces producing the main food crops like rice, the number of locations would be over 40. If all warehouses could be actually constructed, it would not be economical considering PWO's current operating capability.

2) PWO has to provide one warehouse at the agricultural product marketing center in each division and it is more practical for PWO to perform their services to the neighboring provinces in the same division.

Fig. 5-1 SELECTION OF LOCATIONS OF WAREHOUSES BY DIVISION



3) In the Central region, it is not practical from an economical viewpoint to build warehouses in each province because of short transportation to the Bangkok markets. Warehouses built in this area shall be limited to production areas of double-cropping or provinces producing many other commercial crops. On the other hand, equipment and systems must be prepared for locations having problems with procurement and storage.

4) Warehouse spaces at PWO's existing warehouses in the Khon Kaen district, Bangkok district, or other regional warehouses planned to be built newly in some regions in this project, must not be duplicated.

After carefully considering the above mentioned, the location for warehouses at the provincial level have been selected to be the following 10 sites:

Central region	Suphan Buri
	Chai Nat
	Saraburi
Lower-North region	Phitsanulok
	Phichit
Upper-North region	Chiang Mai
	Chiang Rai
Northeastern region ...	Udon Thani
	Surin
	Ubon Ratchathani

a. Suphan Buri

This province produces the highest volume of rice in the Central region. Since canal irrigation is especially advanced, the production volume of rice during the dry season as well as the rainy season is far higher compared with other provinces. This province is close to Bangkok and is a traditional rice-producing area, therefore no remarkable problems are present in the field of rice marekting. However, recently there have been problems concerning paddy harvested during the rainy season.

Most farmers do not have proper drier and release wet paddy at low prices. If the problems could be resolved, rice harvested during the rainy season in this province would be expected to increase dramatically.

b. Chai Nat

The Chai Nat dam is located in this province. A large quantity of rice is produced during both the rainy and dry seasons. This province has the potential of enabling farmers to produce a larger volume of other valuable agricultural products such as peanuts or beans by using irrigated water. Chai Nat city is the agricultural product collecting and distributing center in the Central region, which, because it is the farthest from Bangkok, has had a growing need for building the storage facilities around this city.

c. Saraburi

Saraburi city is famous for its regional agricultural product collecting and distributing center for corn, green beans, soybeans, sorghum as well as rice. Large rice mills are located here and a large quantity of export rice is delivered to Bangkok. As shipping facilities at the Tarua port nearby have been expanded, collecting corn is not as active now, but Saraburi city is still the central location for collecting green beans, sorghum, etc. Due to the large rice mills located around this city and the convenient traffic conditions, this city is expected to remain the central location of the regional market.

d. Phichit

This province produces the second largest volume of rice to Nakhon Sawan in the Upper-Northern region. Larger volumes of rice, corn and sorghum are collected here than in Kamphaeng Phet because it is close to the east and the crops are shipped to Bangkok.

e. Phitsanulok

This province produces a large quantity of rice of a superior quality and has been famous for its agricultural product collecting and distributing location since olden times. In addition, collecting new crops such as sorghum, soybeans and peanuts has been very active recently. This province is also an important traffic location because it is accessible to the Upper-Northern region and North-eastern region. All types of agricultural products are purchased and sold at the market which reminds us of an old trading location.

f. Chiang Mai

Due to the dense population, the marketing volume outside this province is not high in spite of the large quantity of rice production. This province is also well known for its production district of tobacco of a superior quality, and soybeans. PWO has recently been trying to enter the market to stabilize farm prices for dried garlic and onion.

g. Chiang Rai

Chiang Rai is a biggest rice production province in the Northern region. In the past, glutinous rice was produced in higher quantities than nonglutinous rice in this area. However, nonglutinous rice is recently being produced more than previously, thus improving the ratio. Under the existing price mechanism farmers receive comparatively lower prices for agricultural products than farmers from other districts due to transportation costs to the Central market. In addition, the unit price of fertilizer and agricultural supplements is high. These combined facts put pressure on the farmers' income. By building appropriate warehouses in this district, PWO will benefit farmers and increase their activities.

h. Udon Thani

Udon Thani was a deficit area in the Northeastern region for producing rice, since olden times. However, now this region has become self-sufficient in rice with the guidance of the Government.

By providing warehouses in this area and stabilizing the price of rice by actively buying rice produced in this region at Government support prices, the benefit would mainly go to the lower income inhabitants of this district.

i. Surin

This province produces the largest quantity of rice in the Northeastern region. If the neighboring districts of Buri Ram and Sisa Ket are included, a large volume of rice is distributed outside this district. This district produces more nonglutinous rice than glutinous rice as compared with other districts in the Northeastern region.

j. Ubon Ratchathani

This district, situated along the Mekong, is a traditional glutinous rice producing area in this region. Many milled rice mills are operated. However, the rice marketing volume outside of this district is relatively low due to the large population. This district is close to the national border between Thailand and Cambodia, therefore, public peace and order problems are present. From this standpoint, this district is important in maintaining economic stability.

(3) Warehouse Location for Port Warehouses

In this project, loading rice onto vessels is planned to be operated at both a river port, and a seaport. The reasons for this are as follows:

1) Even if rice shipping facilities around Bangkok are not modernized, these locations may still remain the current center of rice shipping in Thailand. Normally, when loading rice to the mother ship, the loading is done at the river port (Bangkok), within the limit of the mother ship's draft. The remaining loading is done by loading using a lighter after the mother ship moves to off Koh Si Chang. This loading practice method has been employed for about a century around the Bangkok port. Interrelationships among water transportation, land transportation and port facilities have been established during the past 100 years, and each has performed its duties functionally.

However, an aspect of international trade of Thai rice, which has changed dramatically, is the switch to long distance sea transport, bulk contract or large ship's assignment as compared with the past when rice was transported to Hong Kong or Singapore by using small vessels. Because of the change, the Bangkok port must modernize and increase its functions. However, limitations are present at the river port and improvement is not easy because of the large number of privately owned obsolete piers and facilities present in the port area.

2) The Thai Government is now actively tackling the construction of the "Eastern seaport" in order to attract heavy and light industries, and the farm product processing industry, to distribute the dense population in Bangkok, and to develop the Eastern and Northeastern districts. It has been clarified through the survey implemented by the Study Team that; for example, when shipping farm products from the Laem Chabang port, if the products are limited to those produced in the Northeastern region and Eastern district of the Central region, the shipment is very economical. However, for products from other regions, the usual shipment from Bangkok port and off Ko Si Chang is rather economical. This is because land transportation, especially truck fuel costs, are high and water transportation costs with lighter are currently cheaper.

For milled rice export, the shipping limitation volume from the Laem Chabang port is assumed to total 1.2 - 1.5 million tons, by adding about 0.5 - 0.6 million tons from the Northeastern region to 0.7 - 0.9 million tons gathered from other districts. These other districts are considered to be more economical districts when products are transported from the eastern side of central region to the Laem Chabang port, rather than Bangkok.

In the future, Laem Chabang port may take over the Bangkok port by improving the current economic disadvantages of the above land transportation. If this take over occurs, it will be necessary to establish a new system to transport export milled rice directly, with very low transportation costs, from the milled rice mill at the production site to the port. This may be done by enhancing water transportation capability after improving canal and river transportation in the central plain.

3) In order to enhance its shipping capability in river port, PWO must improve and expand the existing warehouses in Rajburana and the central regional warehouse, which is newly planned under the project in Nonthaburi must be used for export purposes. This permits efficient milled rice shipment because as a mother ship approaches the pier at Rajburana, the products can be loaded onto the vessel from both the Rajburana warehouse, land side, and Nonthaburi, river side by using barges. Next, PWO will construct a modernized warehouse and processing facilities in Laem Chabang in the seaport area. The plan here is to implement prompt and functional handling to an approaching large sized ocean-going vessel.

5-2 Determination of Warehouse Capacity

The warehouse capacity must be economical and appropriate to PWO's Inventory Management. Basically, the capacity of the provincial warehouse, regional warehouse and port warehouse must be determined after considering various elements such as the capacity of existing warehouses, storage period, warehouse space turnover to operate, and purchase and selling schedule.

A detailed study has already been completed at Phase I regarding the regional handling volume of milled rice by PWO. The Report ("Purchase volume for each month when PWO intervenes in 10 percent of the rice market" Table 10-1) has been issued.

A practical study has been performed as a result of this report and the contents have been referred to the basic data, for determination of the warehouse capacity.

According to the Phase I Study, the annual handling volume for each region in which PWO is involved is as follows:

Central region	225,000 tons
Lower-Northern region	115,000
Upper-Northern region	52,500
Northeastern region	57,500
Southern region	(10,000)*
Total	450,000 tons

* Rice operation in the Southern region is included in the handling volume in the Central region.

The attached Tables 5-1, 2, 3, 4, 5 indicates the details of PWO's annual inventory operations for each month. This table indicates PWO's maximum inventory volume in each region. The warehouse capacity required in each region is as follows:

Table 5-1 ANNUAL MILLED RICE HANDLING SCHEDULE IN CENTRAL REGION

Unit: ton

Month	%, monthly procurement schedule	beginning year			2nd and successive years			%, occupation of warehouse capacity
		milled rice in to warehouses	milled rice out from warehouses	stock balance	milled rice in to warehouses	milled rice out from warehouses	stock balance	
October	-	-	-	-	-	-	90,000	66.7
November	-	-	-	-	-	18,000	72,000	53.3
December	-	-	-	-	-	18,000	54,000	40.0
January	25	56,250	-	56,250	56,250	18,000	92,250	68.2
February	20	45,000	-	101,250	45,000	18,000	119,250	88.2
March	15	33,750	-	135,000(1)	33,750	18,000	135,000	100.0
April	-	-	-	135,000	-	-	135,000	100.0
May	-	-	27,000	108,000	-	27,000	108,000	80.0
June	-	-	27,000	81,000	-	27,000	81,000	60.0
July	20	45,000	27,000	99,000	45,000	27,000	99,000	73.3
August	15	33,750	27,000	105,750	33,750	27,000	105,750	78.5
September	5	11,250	27,000	90,000	11,250	27,000	90,000(5)	66.7
	100%	225,000 t.			225,000 t.	18,750 t. ave.(4)	98,400 t. ave.(3)	72.9% ave.(2)

Remarks: (1) Maximum requirement of storage capacity.
(2) Average rate of storage occupation.
(3) Average monthly stock balance.
(4) Average monthly shipping tonnage.
(5) Stock balance at end of yearly rice movement schedule.
(6) Average period of rice stock in warehouses:
98,400 t. ÷ 18,750 t. = 5.25 month
(7) Warehouses for milled rice handled in Central Region, including South Region:
a. Existing warehouses,
Rajburana ..... 50,000 ton
Bukkalo 45,000
b. Warehouses to be provided under the Project,
Nonthaburi ..... 20,000 ton
Suphan Buri 5,000
Chai Nat 5,000
Saraburi 5,000
c. Warehouse in South Region, rice to be dispatched from Central Region,
Surat Thani 5,000

Total Warehouse Capacity in Central Region:
135,000 ton

Table 5-2 ANNUAL MILLED RICE HANDLING SCHEDULE IN LOWER NORTH REGION

Unit: ton

Month	%, monthly procurement schedule	beginning year			2nd and successive years			%, occupation of warehouse capacity
		milled rice in to warehouses	milled rice out from warehouses	stock balance	milled rice in to warehouses	milled rice out from warehouses	stock balance	
October	-	-	-	-	-	-	46,000	65.7
November	-	-	-	-	-	9,200	36,800	52.6
December	-	-	-	-	-	9,200	27,600	39.4
January	25	28,750	-	28,750	28,750	9,200	47,150	67.4
February	20	23,000	-	51,750	23,000	9,200	60,950	87.1
March	15	17,250	-	69,000	17,250	9,200	69,000	98.6
April	-	-	-	69,000(1)	-	-	69,000	98.6
May	-	-	13,800	55,200	-	13,800	55,200	78.9
June	-	-	13,800	41,400	-	13,800	41,400	59.1
July	20	23,000	13,800	50,600	23,000	13,800	50,600	72.3
August	15	17,250	13,800	54,050	17,250	13,800	54,050	77.2
September	5	5,750	13,800	46,000	5,750	13,800	46,000(5)	65.7
	100%	115,000 t.			115,000 t.	9,600 t. ave. (4)	50,300 t. ave.(3)	72% ave.(2)

Remarks: (1) Maximum requirement of storage capacity in the Region.
(2) Average rate of storage occupation.
(3) Average monthly stock balance.
(4) Average monthly shipping tonnage.
(5) Stock balance at end of yearly rice movement schedule.
(6) Average period of rice stock,
50,300 ÷ 9,600 = 5.2 month

(7) Proposed warehouses in the Region:
a. Warehouse proposed,
Nakhon Sawan ..... 30,000 ton
Phisanulok 5,000
Phichit 5,000
b. Warehouse space moved to Laem Chabang
Laem Chabang 30,000
Total warehouse capacity proposed for the Region, 70,000 ton

Table 5-3 ANNUAL MILLED RICE HANDLING SCHEDULE IN UPPER NORTH REGION

Unit: ton

Month	%, monthly procurement schedule	beginning year			2nd and successive years			%, occupation of warehouse capacity
		milled rice in to warehouses	milled rice out from warehouses	stock balance	milled rice in to warehouses	milled rice out from warehouses	stock balance	
October	-	-	-	-	-	-	21,000	60.0
November	-	-	-	-	-	4,200	16,800	48.0
December	-	-	-	-	-	4,200	12,600	36.0
January	25	13,125	-	13,125	13,125	4,200	21,525	61.5
February	20	10,500	-	23,625	10,500	4,200	27,825	79.5
March	15	7,875	-	31,500(1)	7,875	4,200	31,500	90.0
April	-	-	-	31,500	-	-	31,500	90.0
May	-	-	6,300	25,200	-	6,300	25,200	72.0
June	-	-	6,300	18,900	-	6,300	18,900	54.0
July	20	10,500	6,300	23,100	10,500	6,300	23,100	66.0
August	15	7,875	6,300	24,675	7,875	6,300	24,675	70.5
September	5	2,625	6,300	21,000	2,625	6,300	21,000	60.0
	100%	52,500 t.			52,500 t.	4,400 t. ave.(4)	23,000 t. ave.(3)	65.6% ave.(2)

Remarks: (1) Maximum requirement of storage capacity in the Region.
(2) Average rate of storage occupation.
(3) Average monthly stock balance.
(4) Average monthly shipping tonnage.
(5) Stock balance at end of yearly rice movement schedule.
(6) Average period of rice stock,
23,000 t. ÷ 4,400 t. = 5.2 month

(7) Proposed warehouses in the Region:
a. Warehouse proposed,
Lampang ..... 20,000 ton
Chiang Mai 5,000
Chiang Rai 5,000
b. Warehouse space moved to Laem Chabang
Laem Chabang..... 5,000
Total warehouse capacity proposed for the Region, 35,000 ton

Table 5-4 ANNUAL MILLED RICE HANDLING SCHEDULE IN NORTHEAST REGION

Unit: ton

Month	%, monthly procurement schedule	beginning year			2nd and successive years			%, occupation of warehouse capacity
		milled rice in to warehouses	milled rice out from warehouses	stock balance	milled rice in to warehouses	milled rice out from warehouses	stock balance	
October	-	-	-	-	-	-	23,000	65.7
November	-	-	-	-	-	4,600	18,400	52.7
December	-	-	-	-	-	4,600	13,800	39.4
January	25	14,375	-	14,375	14,375	4,600	23,575	67.4
February	20	11,500	-	25,875	11,500	4,600	30,475	87.1
March	15	8,625	-	34,500(1)	8,625	4,600	34,500	98.6
April	-	-	-	34,500	-	-	34,500	98.6
May	-	-	6,900	27,600	-	6,900	27,600	78.9
June	-	-	6,900	20,700	-	6,900	20,700	59.1
July	20	11,500	6,900	25,300	11,500	6,900	25,300	72.3
August	15	8,625	6,900	27,025	8,625	6,900	27,025	77.2
September	5	2,875	6,900	23,000	2,875	6,900	23,000(5)	65.7
	100%	57,500 t.			57,500 t.	4,800 t. ave.(4)	25,160 t. ave.(3)	72% ave.(2)

Remarks: (1) Maximum requirement of storage capacity in the Region.
(2) Average rate of storage occupation.
(3) Average monthly stock balance.
(4) Average monthly shipping tonnage.
(5) Stock balance at end of yearly rice movement schedule.
(6) Average period of rice stock,
25,160 t. ÷ 4,800 t. = 5.2 month

(7) Proposed warehouses in the Region:
Warehouse proposed,
Nakhon Ratchastma 20,000
U. Thani 5,000
Surin 5,000
U. Ratchathani 5,000

Total warehouse capacity proposed for the Region, 35,000 ton

Table 5-5 ANNUAL PLAN OF RICE HANDLING OPERATIONS BY PROVINCIAL, REGIONAL AND PORT TERMINAL, WAREHOUSES INCLUDING IMPLEMENTATION PHASES

Unit: ton

Region	Warehouse Location & its Capacity		RAJBURANA 50,000 2/	NONTHABURI (20,000) 1/	BUKKALO 45,000	SURAT THANI (5,000)	TOTAL	LAEM CHABANG 4/ (70,000)	HANDLING TONNAGE FOR A WHOLE PROJECT
CENTRAL	NONTHABURI 3/	(20,000) 1/	-	40,000	-	-	40,000	-	40,000
	Suphan Buri	(5,000)	7,500	-	-	-	7,500	-	7,500
	Chai Nat	(5,000)	7,500	-	-	-	7,500	-	7,500
	Saraburi	(5,000)	7,500	-	-	-	7,500	-	7,500
	Rajburana	50,000 2/	40,000	-	-	-	40,000	-	40,000
	Bukkalo	45,000	-	-	40,000	-	40,000	-	40,000
	Direct delivery 6/		-	-	-	10,000	10,000	72,500	82,500
									225,000
UPPER NORTH	LAMPANG	(20,000)	10,000	-	20,000	-	30,000	10,000	40,000
	Chiang Mai	(5,000)	5,000	-	-	-	5,000	-	5,000
	Chiang Rai	(5,000)	7,500	-	-	-	7,500	-	7,500
									52,500
LOWER NORTH	N. SAWAN	(30,000)	10,000	-	30,000	-	40,000	20,000	60,000
	Phitsanulok	(5,000)	7,500	-	-	-	7,500	-	7,500
	Phichit	(5,000)	7,500	-	-	-	7,500	-	7,500
	Direct Delivery 6/		-	-	-	-	-	40,000	40,000
									115,000
NORTHEAST	N. RATCHASIMA	(20,000)	-	-	-	-	-	40,000	40,000
	U. Thani	(5,000)	-	-	-	-	-	5,000	5,000
	Surin	(5,000)	-	-	-	-	-	7,500	7,500
	U. Ratchathani	(5,000)	-	-	-	-	-	5,000	5,000
									57,500
TOTAL			110,000 5/	40,000	90,000	10,000	250,000	200,000	450,000
			150,000 export shipment		100,000 domestic sale				Grand Total

Remarks: 1. A figure in bracket shows a storage capacity to be newly provided under the Project.
2. A figure under line shows a storage capacity of each existing warehouse.
3. Warehouse locations with a line indicate locations of Regional Centers.
4. A capacity of Shipping Complex, 70,000 tons consists of 35,000 tons with regional warehouse functions and another 35,000 tons for shipping functions.
5. Warehouse spaces would be used with the following rates of "Turn-Over",
Provincial Warehouses -- 1.0 to 1.5, Regional Warehouses -- 2.0, Port Turminal Warehouses -- 2.0 to 2.85
6. Rice procured by PWO is directly delivered to Port Terminal Warehouses without storing at regional warehouses.

Central region	135,000 tons
Lower-Northern region	70,000
Upper-Northern region	35,000
Northeastern region	35,000
Southern region	5,000
Total	280,000 tons

(1) Capacity of a Provincial Warehouse

In this project, the warehouse capacity of ten provincial level warehouses being planned is determined to be 5,000 tons each. This is due to the following:

a) When considering provincial activities, a warehouse capacity of 5,000 tons is the most appropriate size.

b) When operating a warehouse, personnel expenses for office workers, superintendents or guards, and business and maintenance expenses are incurred. If the warehouse capacity is less than 5,000 tons, the burden on management is increased.

c) When PWO operates a warehouse, it can be managed by the standardization of a 5,000 ton unit system.

d) When constructing a warehouse, this capacity is convenient and economical for a unit structure and materials.

(2) Capacity of Regional Warehouses

1) Central Region

The required capacity in this region is a total of 135,000 tons. However, because three provincial warehouses with a capacity of 5,000 tons each have already been planned in Suphan Buri, Chai Nat and Saraburi, and two existing warehouses with a capacity of 95,000 tons (50,000 tons for Rajburana and 45,000 tons for Bukkalo) already exist, the required capacity for the warehouse to be constructed in Nonthaburi is 25,000 tons. However, 10,000 tons of milled rice procured in

this region would be transferred to the Southern region, and warehouse needed in this project is 20,000 tons.

2) Lower-Northern Region

The required capacity in this region is a total of 70,000 tons. Two provincial warehouses with a capacity of 5,000 tons each will be constructed in both Phichit and Phitsanulok. Therefore, a warehouse with a capacity of 60,000 tons will be required in Nakhon Sawan and will function as a regional warehouse.

3) Upper-Northern Region

The required capacity in this region is a total of 35,000 tons. Two provincial warehouses with a capacity of 5,000 tons each will be provided in both Chiang Mai and Chiang Rai. Therefore, a warehouse with a capacity of 25,000 tons will be required in Lampang and will function as a regional warehouse.

4) Northeastern Region

The required capacity in this region is a total of 35,000 tons. Three provincial warehouses with a capacity of 5,000 tons each are scheduled to be built in U. Thani, U. Ratchathani and Surin. Therefore, a warehouse with a capacity of 20,000 tons will be required in Nakhon Ratchasima and will function as a regional warehouse.

5) Southern Region

PWO's annual handling volume in this region approaches 10,000 tons. Therefore, a warehouse with a capacity of 5,000 tons will be required in Surat Thani and will function as a regional warehouse, based on the assumption that the rate of storage space turnover is two times.

Warehouse spaces of 30,000 tons and 5,000 tons, have been transferred from Nakhon Sawan and Lampang regional warehouses respectively to the Laem Chabang port because of the following:

1. Almost all of the milled rice collected by PWO in each region is to be transferred to a terminal warehouse or PWO's warehouse in Bangkok for export rice or consumption in Bangkok. It is more economical to directly transfer the milled rice bought by PWO in the regions to a port warehouse for storage.

2. When PWO is in charge of the export of milled rice, most shipments are handled by the government-to-government (G/G) trade system. Normally, this trade system handles a large quantity of products as compared with private foreign trade, and planning for the trade system seems to be difficult. In order to cope with this problem, PWO must reduce the stock in local level warehouses and make use of port warehouses whenever possible.

3. This means that milled rice procured by PWO is transferred to directly and stored in the port warehouses without storing in regional and provincial level warehouses.

(3) Capacity of the Port Warehouse (Laem Chabang)

The warehouse to be constructed in Laem Chabang in the seaport area is designed to ship milled rice for export. This is accomplished by implementing processing quality rice after collecting milled rice from each local level warehouse, and storing it for a short time. The Study Phase I has suggested the necessary capacity of the port level warehouse to be 35,000 tons. However, if a large vessel of over 20,000 tons is assigned and products are loaded into this ship, a warehouse capacity of 35,000 tons may be insufficient, as export rice includes many types. Thus, the efficient use of space is further necessary.

As planned in the "Capacity of a Regional Warehouse" mentioned above, a total of 35,000 tons of space (30,000 tons from Nakhon Sawan, 5,000 tons from Lampang) have already been transferred to the seaport warehouse in Laem Chabang. Therefore, the warehouse capacity planned for this port is a total of 70,000 tons. Such a large warehouse enables PWO to store various types of rice and cope with large vessels, big quantity contracts with G/G base and continuous ship loading.

Regarding warehouses in the river port area, in this project, the existing warehouse in Rajburana and the regional warehouse to be constructed in Nonthaburi under this project are to improve these areas' facilities for export shipment. According to this implementation plan, PWO's export facilities in the river port area will receive overall improvements.

The following table is a summary of the capacity of the provincial warehouses, regional warehouses and the port level warehouse classified by region:

Name of Region	Regional Warehouse Location & its Capacity		Provincial Warehouse Location and its Capacity	
Central region	Nonthaburi	20,000 tons	Suphan Buri	5,000 tons
			Chai Nat	5,000
			Saraburi	5,000
Lower-Northern	Nakhon Sawan	30,000	Phitsanulok	5,000
			Phichit	5,000
Upper-Northern	Lampang	20,000	Chiang Mai	5,000
			Chiang Rai	5,000
Northeastern	Nakhon Ratchasima	20,000	Udon Thani	5,000
			Surin	5,000
			Ubon Ratchathani	5,000
Southern	Surat Thani	5,000	-	-
	Total	95,000 tons	Total	50,000 tons
Warehouse in producing areas		Subtotal	145,000 tons	
Port warehouse at Laem Chabang			70,000 tons	
		Total	215,000 tons	

CHAPTER VI WAREHOUSE CONSTRUCTION

CHAPTER VI WAREHOUSE CONSTRUCTION

6-1 Survey of Planned Construction Sites

The survey was conducted in and around Bangkok, south eastern region, north eastern, northern region, central region and southern region. The number of survey sites totaled 35. A presurvey had been conducted by PWO in each of the regions except central and southern regions.

1) Several warehouses are currently used by PWO at Nonthaburi, Bukkalo, Rajburana in and around Bangkok. The survey was made on these existing warehouses as well as the planned construction sites in Nonthaburi and Bukkalo.

a. Nonthaburi

A 20,000 ton warehouse is planned to be built in Nonthaburi along with packing facilities for domestic rice, processing facilities for export rice and shipping facilities. A storage Technology Improvement and Training Center is proposed to build in this area along with several testing warehouses. The site has a total area of 77,408 m^2. This includes a pond with an area of 8,690 m^2, a jute factory with an area of 15,468 m^2 (built with ferro concrete for the main structure and brick for the walls), 10 warehouses with an area of 7,910 m^2, currently being used by PWO (built with ferro concrete for the main structure and brick for the walls), a power generating room with an area of 412 m^2 (built with ferro concrete for the main structure and unknown for the other parts), water tanks and other buildings. It is necessary to demolish the existing buildings.

The site faces the Chao Phraya river to the west, a road with a width of 6 m to the east, a carbide factory to the south, and to the north there are private houses on both side of a small stream with a width of 4 to 6 m.

The site is located at the northern tip of Bangkok, near the Chao Phraya river. Compared with other sites of PWO's warehouses,

it is convenient to load rice onto barges, but the presence of seven bridges crossing the river makes it difficult for larger boats to go down the river.

b. Bukkalo

Facilities for the domestic supply of rice are planned to be built in Bukkalo. There are four existing warehouses at the site. Three of them have an area of 2,400 m^2 each, and an office is attached to one of them. The last warehouse is shaped in such a way as to conform with the outline of the site and has an area of 7,450 m^2. The total area of the warehouses is 14,650 m^2. The eaves of the warehouses allow operations to be performed in all types of weather. In addition, two quays for barges are available along the east side of the Chao Phraya river. For about 150 m, there is an entry path adjacent to the road west of the site. There is a vacant lot with an area of 5,000 m^2 between the entry path and the gate. It would be possible to install processing facilities for the domestic supply of rice with an area of 1,000 m^2 on the vacant lot.

c. Rajburana

The most modern warehouse of PWO exists in Rajburana. There is a quay to the west side of the site with an extension of 57 m and a total length of 140 m. An ocean-going vessel may use this quay. The warehouse has an area of 16,700 m^2 with fire-extinguishing.

The survey was conducted to see if the facilities for processing of exported rice may be added to the existing warehouse; as well as to identify the load and other factors of the structure of the building which are required.

2) The site survey in the south eastern region covered LAEM CHABANG and MAP TA PHUT, which are the planned ports; and SATTAHIP PORT, which is the existing port.

3) The site survey in northeastern, northern, central and southern region was conducted between October 29 and December 4. A total of 32 possible construction sites were visited, and the local factors

such as the price of commodities, the capability of procurement, the legal regulation of planned urban zones and the natural conditions concerning earthquakes, etc. were collected from each provincial office (See Appendix F-1).

6-2 Survey

6-2-1 Traditional Warehouses

The survey covered both traditional wooden warehouses and recently built warehouses.

The traditional wooden warehouses are characterized by a high level floor, which is between 1.0 m to 1.5 m above ground. The floor plates are piled, each with a length of 30 mm to 36 mm. The high level floor serves the purpose of preventing leakage of the stored paddy and prevents moisture rising from the ground. The pillars of the high level floor were either filled ground to column or fixed to a cornerstone. No mousetraps were spotted around the floor.

There are two doors to the entrance; one is a sliding door facing the outside, and the other is a dropping door with concave grooves facing the inside. These grooves may be increased or decreased depending upon the volume of paddy. There is a space of about 1 m between the exterior sliding door and the interior dropping door. The space serves as a step for taking in and out paddy, and protects the paddy from rain.

The outer wall is boarded inside as firmly as the floor plate. The structure of the wall may be observed from the outside. The window is above 1.5 m from waist level and opens from both sides. It may be used for lighting. In Thailand wooden doors are designed to open both ways and to bring wind inside. Such doors are also adopted in local government offices. This allows one to feel cool if one steps inside a room.

Simple shingle roofing is considered a prototype of roofs in Thailand. Currently there are a number of corrugated asbestos slates. Bateen, with a thickness of between 20 to 24 mm, is stuffed under shingle roofing as substitutes for bricks. A roof has a steep slope. A monitor roof is laid to allow ventilation from the window to the roof top.

Another feature of the warehouse is larger eaves around the roof, which jut out about 1.5 to 3.0 m. They protect the surface of the walls as well as keep the surface of the ground dry. The eaves give the impression of stability to the high floor level building.

6-2-2 Recently Built Warehouses

The structure of larger warehouses is built with ferro concrete instead of wood or steel-frame. The survey was conducted on private warehouses in Nonthaburi, Bukkalo, Rajburana, Ban Pai and Ubon Rachathani. Each of the warehouses have a span of 30 m to 40 m and is as high as 8 m to 10 m from ground level to the eaves. Their floor level is rather low.

Other warehouses were also spotted during the car drive, but none of the rice milling warehouses had a high floor level. Probably the floor level is made low to make the ground level-to-eaves level higher, and to obtain a higher efficiency of operation by allowing trucks to come inside the warehouse. There were a couple of cement warehouses which kept in moisture. The floor level of these is approximately 900 mm above ground. No structural cracks were observed in the floor and wall surfaces. Structurally sophisticated methods were adopted for large-span roofs. However, a number of leaks were observed, probably as a result of installing several valley flashings inside the warehouse. Entrances were often seen on the eaves side, and none were noticed on the gable side.

Regarding ventilation, wire meshe with a height of 1 m is installed at the top of the eaves side, or monitor roofs are installed. Where operations were conducted with entrances open, it was more cool inside the warehouse than outside.

As well as for ventilation, wire meshe at the entrance is also designed to keep away birds, insects and rats. Some meshes are as large as 50 mm, through which birds can fly freely. No mousetraps were observed in any of the warehouses. Sheet fumigation was adopted to exterminate insects, which is the only viable method in view of the openness of the warehouses.

There were drainage systems within the site, but several places of the road were observed to have sunk, possibly due to rain water.

There were also truck scales, elevated tanks, offices and permeation tanks, but no lightning rods.

The fence was as high as 2 m to keep away burglars, but there were no other precautionary measures. There were a variety of fences, usually in four lower blind blocks and four upper perforated blocks.

6-2-3 Natural Conditions

A burnt tree was observed in a forest during the trip of the site survey. It was probably caused by lightning. According to the meteorological data from the past 30 years, lightning occurs for about 90 days per year on the average; this breaks down to 103.1 days/year for Chieng Rai, 86.1 days/year for Chiang Mai, 82.8 days/year for Lain Pang, 89.6 days/year for Phisanulok, 84.8 days/year for Udon Thani, 95.6 days/year for Khon Ken, 84.5 days/year for Ubon Ratchatani, 90.9 days/year for Surin and 83.3 days/year for Nakhon Ratchasima. However, no lightning rods were observed in any of the the rice mills or cassava factories on the plain.

6-3 Construction Costs

Data on price of materials, labor expenses, losses and expenses were collected with the cooperation of the Senior Architect of the Public Works Dept. in Bangkok. The regional unit prices of coarse aggregates, cement, gasoline and petroleum were collected from each provincial office (See Appendix F-2).

Coarse aggregates include earth, pebble, gravel and sand. The price of coarse aggregates differs from region to region; higher in a producing region and lower in other regions, as indicated by the Table 6-1. On the other hand, the prices of cement, gasoline and petroleum become higher in proportion to the distance from the central region.

The survey also covered the volume of materials available. Earth is the most difficult to procure. The price of earth in Bangkok is four

times as high as in local places. It is rather easy to procure earth in the mountainous regions, but there is no alternative but to dig in the plain regions. A traveler in Thailand may observe that both sides of a road look like rivers. This is because the roads are dug in such a way that piles earth upon the road. It is the same with both sides of a railraod. The unit prices were obtained with the cooperation of the Public Works Dept., and they were further enforced by other survey's on actual prices.

Table 6-1 Cost of Materials

(Unit: Bahts)

Location	Distance (km)	Soil (/M^3)	Boulder Stone (/M^3)	Ballast (/M^3)	Sand (/M^3)	Cement (/50 kg)	Diesel (/ℓ)	Petrol (/ℓ)
Bangkok	0	110	120	190	185	80	6.7	11.7
Sura Buri	85	40	150	160	200	81	6.79	11.79
Suphan Buri	120	70	200	200	180	85	6.91	11.91
Chai Nat	155	50	150	150	120	82	6.91	11.91
N. Sawan	205	40	180	150	90	82	6.9	11.9
N. Ratchasima	225	60	240	180	150	76	6.9	11.9
Phichit	339	50	210	200	150	80	7.0	12.0
Phitsanulok	355	30	180	200	120	80	7.0	12.0
Surin	385	50	190	210	85	82	-	-
Khon Kaen	392	40	240	180	40	85	7.0	12.0
U. Thani	482	30	200	240	180	85	7.2	12.2
Lampang	555	50	150	220	70	85	7.0	12.0
U. Ratchathani	592	50	190	212	86	82	7.0	12.0
Chiang Mai	665	40	220	180	60	87	7.1	12.1
Surat Thani	675	25	160	220	50	83	7.1	12.15
Chiang Rai	775	40	200	180	60	93	7.2	12.2

6-4 Basic Design

6-4-1 Site Planning

A building should be designed conforming to the profile of site. Based on meteorological data obtained, consideration should be given how to utilize wind direction. It is important for the building to be exposed to a minimum of sunshine; therefore, the building should preferably be designed to stand east to west so that it would absorb sunshine from north and south. The warehouse should be able to be accessed from both sides. Depending upon its scope, each warehouse would

have facilities such as a truck scale, guard room, office, overhead tank, well, permeation tank, drainage system, entrance for water flow, earthen pipe and a lightning rod.

6-4-2 Plans of Architectual Design

1) Provincial Warehouse

a. A local warehouse for rice collection is built on the assumption that 5,000 tons of milled rice would be stored for a couple of months.

b. Pillars are minimized in a warehouse, and products may be taken in and out from both sides of the building. Such a setup would enhance efficiency of handling and other processes of the operation, as well as ensure a smooth cargo load up.

c. Shutters are installed on the doors of the entrance, and mousetraps are installed underneath the floor. A steel side door is designed for each building as an emergency escape.

d. Based on a pallet of 2 m x 1.6 m, the plane of a building is computed from piling up 27 bags in height (See Chart).

e. The opening for ventilation is made larger, and monitor roofs are installed at the top of the roof. This would help lower the temperature within the warehouse.

2) Regional Warehouse

a. As there are more than two buildings, the eaves of them are protruded so that operations may be conducted even in rainy weather.

b. Manual labor is mostly conducted in regional warehouses. The width of a building is 25.5 m and the calculation of area is based on length.

c. As a model case, forklifts are used for handling in Nonthaburi. The calculation of area should take into consideration the operation by pallets for forklifts (See Appendix).

d. Eaves of a regional warehouse are made larger than those of a provincial warehouse in order to minimize rain and water. Ventilation is installed in more rooms and lower temperatures are obtained by the installation of monitor roofs.

3) Port Warehouse

a. 70,000 tons of rice may be stored in an aggregate shipping warehouse for exports. Processing facilities for export rice with an area of 18,000 m^2 are also to be built.

b. A compulsory ventilation system is required for two-storied warehouses.

c. Asphalt water-proof roofs should be adopted for a building which has a large plane. They should also be adopted for the processing facilities for export rice.

6-4-3 Design of Machine Facility Building

a. Buildings are designed mainly by steel frame which can reduce the pillars to match the machines installed.

b. As rice processing facilities need many pits, floor level is designed 500 mm - 1,000 mm above the ground level to avoid inundating the underground water.

c. Natural ventilation system with louver on the wall is adopted to the buildings. In case of one storied building, the air is exhausted from the monitor roof.

6-4-4 Calculation of Area and Space of a Warehouse

(1) Provincial Warehouses

The maximum storage of a provincial warehouse is designed to be 5,000 tons. A pallet of 2.0 m x 1.6 m is used as the plane unit. The calculation of the piling amount is based on a 27-deck piling, which is currently adopted in Thailand.

Five 100-kg bags are placed on a pallet.

Calculation of area

Number of pallets : 6(11 + 13 + 11) + 5(11 + 13 + 11) = 385 pallets

Amount in a deck : 385 sheets x 5(5 bags) = 1,925 bags

Amount in 27 decks: 1,925 bags x 27 decks = 51,975 bags
51,975 bags x 0.1 ton = 5,197.5 tons

Height

Height of a pallet: H 180 mm Height of a milled rice bag: 217 mm
180 + (217 x 27) = 6,039

Space for piling : 1,700
1,700 + 6,039 = 7,739

Space under the roof: ∴ 7,750 mm

The functions for taking in and out products and the local method of bag fumigation are taken into consideration for the arrangement of pallets.

(2) Regional Warehouses

The area of regional warehouses and other warehouses, except in Nonthaburi, is calculated as twice the area of a provincial warehouse. The amount of pallets in the three intermediate places in larger. Therefore, a space of 1 m is provided in between to reduce the proportion of block for fumigation, etc.

(3) Port Warehouse (Nonthaburi...river port, Laem Chabang...seaport)

As forklifts are used for the warehouse, hallways are designed to be larger than in other warehouses. The amount of piling of milled rice is based on 3.5 m, the maximum loading amount of a forklift, and 18 bags. 5 100-kg bags are placed on a pallet.

Calculation of area

Number of pallets : 8(15 + 18 + 22 + 15) x 2 = 1,120 pallets

Amount in a deck : 1,120 sheets x 5 bags = 5,600 bags

Amount in 18 decks: 5,600 x 18 = 100,800 bags
100,800 x 0.1 ton = 10,080 tons

Height

Height of a pallet: H 180 mm Height of a milled rice bag: 217 mm

Height of pallet piling: 180 + (6 x 217) = 1,482 mm

Piling of 3 decks : 1,482 x 3 = 4,446 mm

Space for piling : 1,700 mm

1,700 + 4,446 = 6,146 mm

According to the above-mentioned calculations, the space under the roof is 6,150 mm, which is the same as that of a provincial warehouse considering the amount of the space needed for operation under the eaves, in Thailand. Pallets are designed to be on one side of the plane with 360 pallets in 8 x 15 x 3 decks as a unit block, and pallets on both sides of the plane are below 15 of that of a one side plane. (See Fig. 6-1, 2, 3, 4)

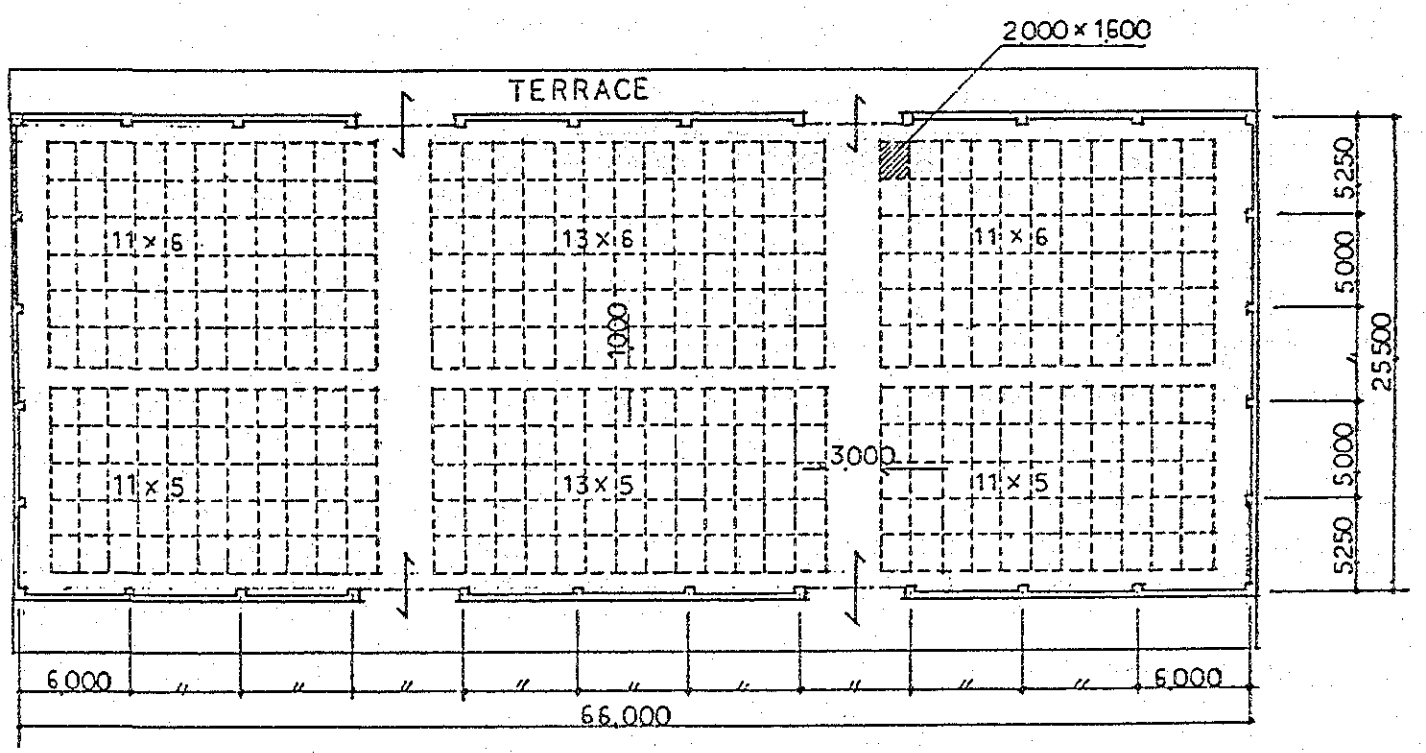
6-5 Design of Architectural Structure

Foundation: Some sites require pilings and others do not. Independent footing is adopted beneath the pillars. Beams are arranged underground in order to bear the perpendicular load of the walls.

Floor: A method for receiving loads of a warehouse by floor plates, whether there are pilings or not, is adopted.

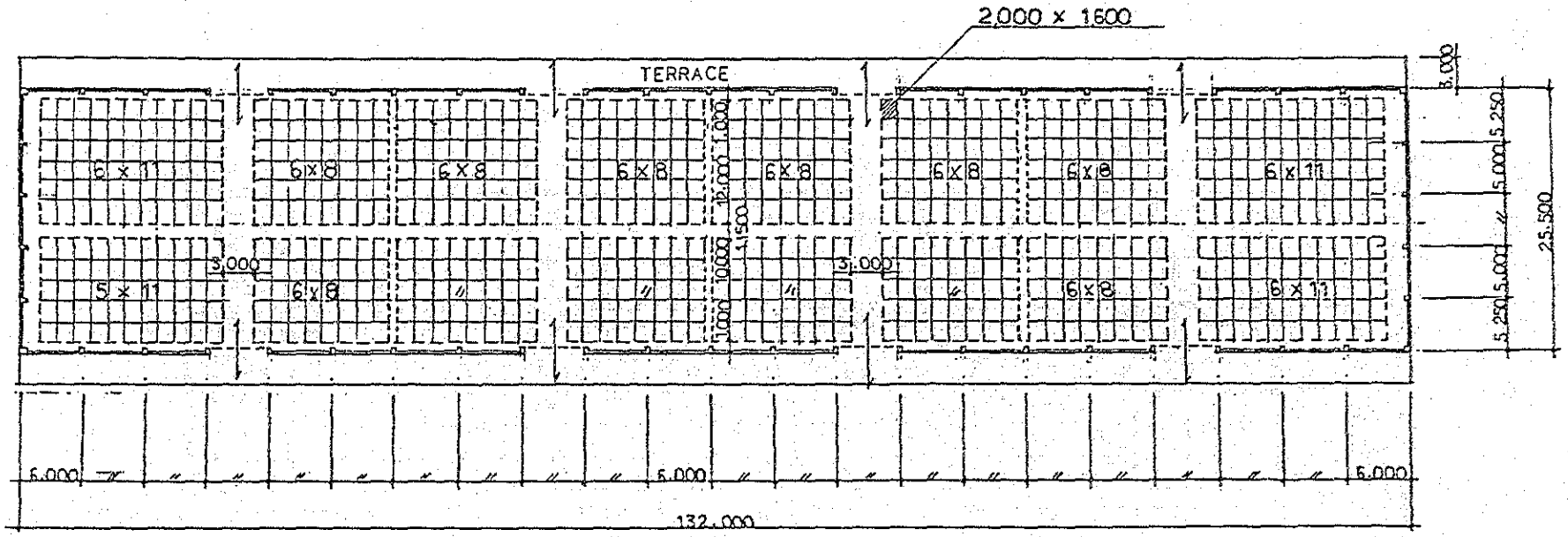
Wall: Light blocks are piled to make walls. A ring beam is set at a height of 4 m from the floor surface, which may be used as a connection between the heads of blocks.

Roof: Corrugated asbestos slates are used as materials for the roof, and light iron trusses are used as part of the roof structure. The structure of truss is adopted to prevent loads of the roof from opening laterally. The eaves are extended for about 3 m for a provincial warehouse and for 5 m for other warehouses. This helps avoid sunshine. This arrangement is also applied to the gable side.



5000 TON WARE HOUSE S=1:400

Fig. 6-1 Rice Stacks Arrangement Plan (1)



10.000 TON WARE HOUSE

Fig. 6-2 Rice Stacks Arrangement Plan (2)

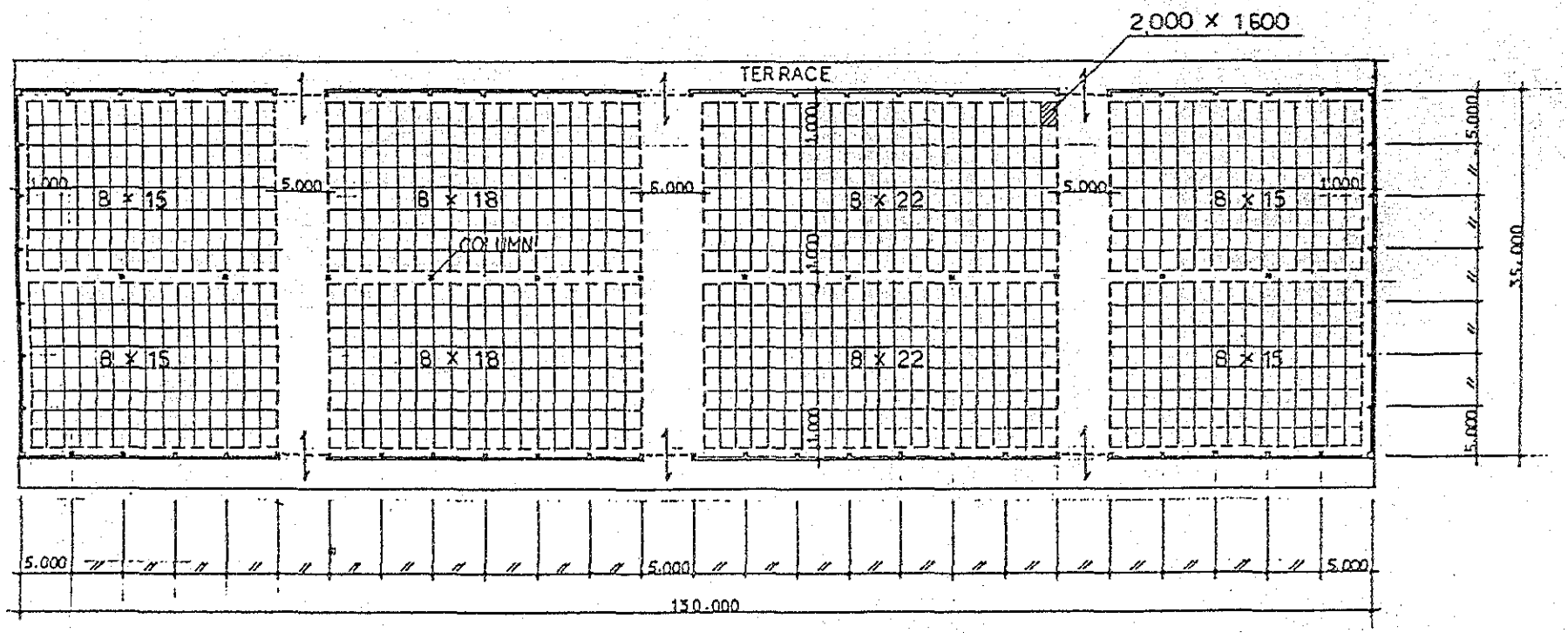


Fig. 6-3 Rice Stacks Arrangement Plan (3)

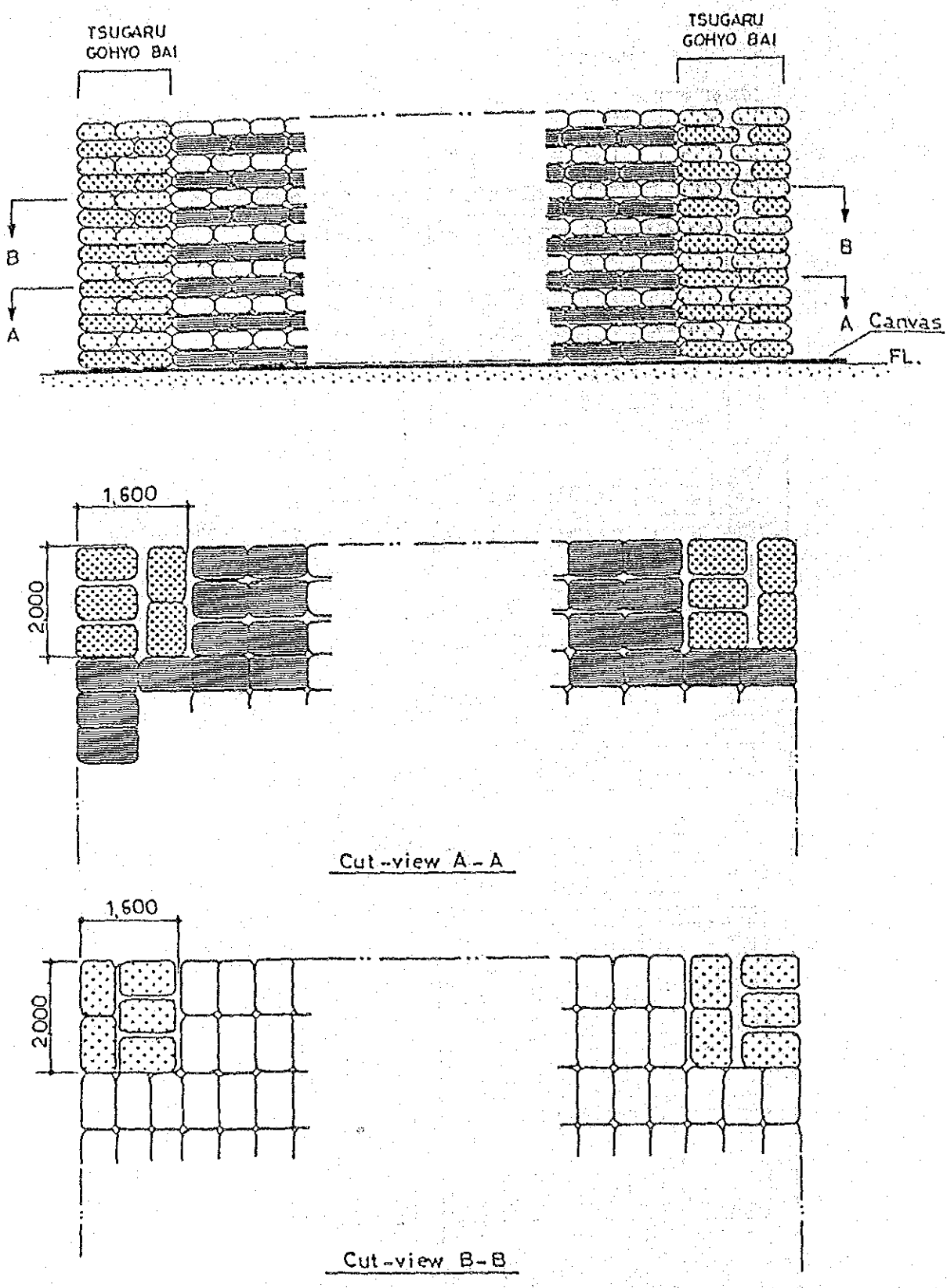


Fig. 6-4 Rice Bags Stacking Method

6-6 Design of the Facility

a. A simple water supply such as a digged well at provincial warehouse and an elevated water tank at regional warehouse is provided at each site of warehouse.

b. Sanitary drainage systems are installed. Drained water flows into a permeation tank. Each site has a permeation tank.

c. Initial fire extinguishers are installed in provincial warehouses, whereas two fire hydrant facilities are installed in regional warehouses.

d. An illumination of 200 lx is provided in a warehouse. Transmission for each site is also considered part of the construction costs.

e. Lightning rods are installed in each warehouse.

6-7 Calculation of Construction Costs

1) Calculation of construction costs was based on the unit price of materials, labor expenses and processing expenses, which were obtained with the cooperation of the Public Works Dept.

2) The currency of Thailand was devalued by 17% during the survey, but the calculation was based on the value before devaluation.

3) Estimates were made in bahts.

4) Detailed estimates were made on the construction costs of a warehouse of 5,000 tons. The total amount was divided by 1,683 m^2 (avarage floor area of 5,000 tons warehouse) to obtain the unit price per m^2 of the construction works. The value was applied to a warehouse of 10,000 tons. Costs of facilities were estimated separately.

Table 6-2 Construction Costs of a 5,000-ton Warehouse

(Unit: Bahts)

Item	Construction costs without piling	Construction costs including piling
Temporary works	185,640.-	185,640.-
Piling works	-	94,248.-
Soil works	38,095.-	38,095.-
Framing works	279,202.-	279,202.-
Ferro concrete works	935,040.-	1,025,922.-
Concrete works	1,188,855.-	1,188,855.-
Block works	143,260.-	143,260.-
Steel frame works	537,590.-	537,590.-
Roofing works	512,882.-	512,882.-
Ironware works	149,400.-	149,400.-
Plaster works	418,440.-	418,440.-
Piping works	313,400.-	313,400.-
Painting works	398,000.-	398,000.-
Carpentry works	286,000.-	286,000.-
Miscellaneous works	30,000.-	30,000.-
Total	5,415,804.-	5,600,934.-

CHAPTER VII FOUNDATION AND CIVIL ENGINEERING

CHAPTER VII FOUNDATION AND CIVIL ENGINEERING

7-1 Soil Condition

7-1-1 Outline of Soil Condition

The soil condition of the survey site is divided into three types. The first type is the delta deposit of the Chao Phraya River, the second is recent river deposits like the Mun River, and the third is stiff soil like Laterite.

The locations and survey sites of these types are shown in Table 7-1 and Figure 7-1.

Table 7-1 Survey Site and Soil Condition

	Location	Survey Site	Soil Condition
(a)	Central & Lower North Area	Nonthaburi Suphan Buri Nakhon Sawan Phichit Phisnulok	Delta deposits of the Chao Phraya River are widely distributed. The depth is approximately 10 - 30 m below the surface.
(b)	Northeast, Upper North & South Area	N-Ratchasima Ubon Ratchathani Chiang-Mai Lampang	Recent river deposits. Alluvial deposit not deep.
(c)	Northeast, Upper North Area & Part of Central Area	Chai Nat Saraburi Udon Thani Surin Chiang Rai Surat Thani	Gently sloping, hilly land & mountains. Laterite is widely distributed.

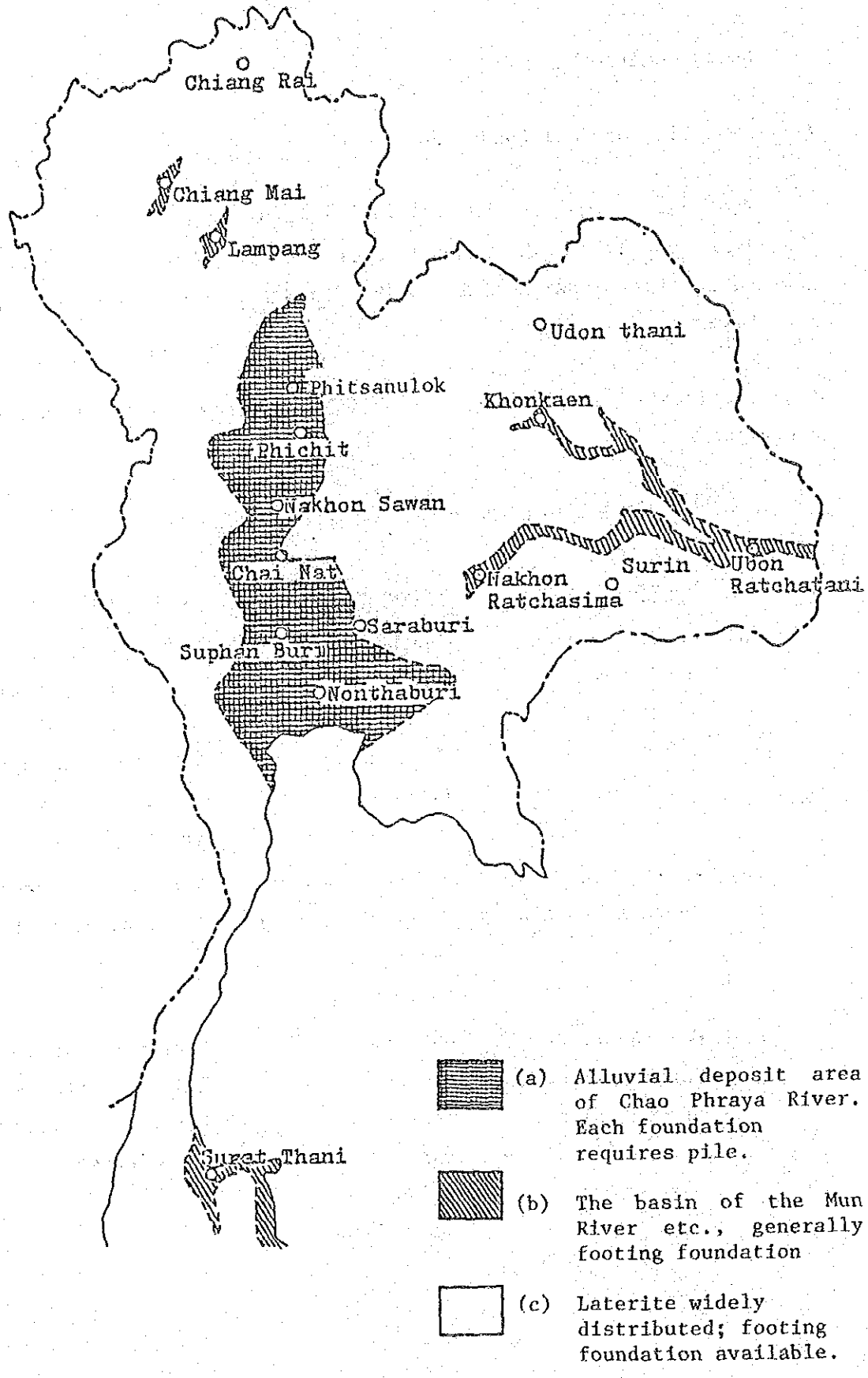


Fig. 7-1 Map of Survey Sites and Soil Types

7-1-2 Detailed Soil Condition of Three Types

The detailed soil condition of the three types is provided in the following articles from the data which was obtained in the field survey.

(1) Central and Lower North Area

Main boring data which was obtained in the field survey is shown in the Appendix G-1, Soil Test data (1), Figure 1 Nonthaburi, Figure 2 Ayuttaya, Figure 3 Phisnulok.
This data is categorized as follows:

(a) Nonthaburi

Upper part is high water content (i.e. high compressibility). Clay with a thickness of 22 meters.
Tips of pile should be situated into fine to medium sand under 22 meters.

(b) Ayuttaya

The layer above 8.5 meters is partly Natural Water Content > Liquid Limit. It indicates that the layer has an insufficient bearing capacity for spread foundations. Therefore, pile foundations are required.

The bearing layer is clay that is situated 8.5 to 14.5 meters below the surface, or sand deeper than 14.5 meters.

(c) Phitsanulok

Soft clay is deposited above 3.5 meters, and pile foundations are required.
The bearing layer is near 8.0 meters in fine sand, or dense sand deeper than 13.5 meters.

On the basis of the above data, every site in this area requires a pile foundation.

The study and calculation of pile bearing capacities are carried out by regional distribution as follows:

a) Nonthaburi data ... Nonthaburi
b) Ayuttaya data ..... Suphanburi
c) Phisnulok data .... Nakhon Sawan
Phichit
Phisnulok

(2) Northeast, Upper North & South Area

Appendix G-2, Soil Test Data (2), Figure 4 shows boring data in Chieng Mai. This data indicates that the minimum S.P.T-N of the layer under top soil is 25. Therefore, in Appendix G-2, Figure 4, the allowable bearing capacity of the spread foundation is approximately 25 to 30 t/m^2.

According to plate bearing test data in Ubon Ratchatani, the ultimate bearing capacity Ru and Settlement S in the test are as follows:

$Ru = 30.0\ t/m^2$, $S = 0.32$ inch $\fallingdotseq 0.8$ cm
$Ru = 20.9\ t/m^2$, $S = 0.39$ inch $\fallingdotseq 1.0$ cm

Allowable bearing capacity Ra in $Ru = 20.9\ t/m^2$, is as follows:

$Ra = Ru/Fs = 20.9/2.5 \fallingdotseq 8.4\ t/m^2$, $(Fs = 2.5)$

This value indicates that spread foundations are available at the testing site.

As a result of this data, spread foundations are available in this area. But foundation style should be decided by the allowable bearing capacity of each site.

(3) Northeast, Upper North Area & Part of Central Area

Appendix G-2, Soil Test Data (2), Figure 5 Plate Bearing Test shows the soil condition in Chieng Rai and Udonthani. Then ultimate bearing capacity Ru and Settlement S in Chiang Rai are as follows:

$Ru = 34\ t/m^2$ $S = 20$ mm: presumed value

And Ru & S in Udonthani,

$$Ru = 17.8\ t/m^2 \qquad S = 0.05 \text{ inch to } 0.085 \text{ inch} \fallingdotseq 1 \text{ mm to } 2 \text{ mm}$$

Ru & S of this data are presumed too small because the load level is low and the settlement is also too small.

This data indicates that the load could not obtain the ultimate condition in this test.

Therefore, calculation of Ra uses the former,

$$Ra = 34/2.5 = 13.6\ t/m^2$$

In this area, individual footings are available.

7-2 Seismology

According to the seismological report of Thailand, seismic activities compiled by the Network Headquarters Studies and Research Division of the Meteorological Department during 1975 to 1983, earthquakes in Thailand were distributed from the northern center with a magnitude in the 3 to 5 range.

The probabilities of seismic occurrences in Thailand by zone are shown in Appendix G-3, Figure 6. Each zone shows the approximate destructive intensity of earthquakes. The greater part is included in zone 0. Zone 0 means no damage. The northern part is include in zone 1. This means minor damage.

Appendix G-4, Figure 7 shows the distribution of earthquake epicenters in Northern Thailand. The majority of earhquakes occur in neighboring countries. Earthquake epicenters are mostly distributed in the following places:

(1) Burma from the South to the North
(2) Along the border between Burma, Laos and Thailand
(3) Andaman Sea

The seismic force of the foundation design is considered in each of the Department of Public Work's branches in the northern area. As a result of the hearing in this area, earthquake damages pose no threat to warehouse foundations.

7-3 Civil Engineering

7-3-1 Survey

A survey of each site was carried out during an investigation trip. The survey plans are shown in Appendix G-5, Figure 7, Survey Note. Of course, a plane table survey should be carried out in each selected site in detailed design.

7-3-2 Foundation

As mentioned in Article 2, the soil condition of the site is divided into three types. As a result of the study of these types, the foundation style has been divided into two types; pile foundation and spread foundation.

(1) Pile Foundation

(a) Method of Computation

Ultimate Bearing Capacity Ru and Allowable Bearing Capacity Ra of piles were calculated by data on Appendix G-1, Figures 1, 2 and 3, following Meyerhoff's equation.

Pile tip is situated in sand layer

$$Ru = 40\bar{N}Ap + \left(\frac{\overline{Ns}}{5} Ls + CuLc\right)\phi$$

Pile tip is situated in cohesive layer

$$Ru = 8CpAp + \left(\frac{\overline{Ns}}{5} Ls + CuLc\right)\phi$$

$$Ra = Ru/Fs \qquad Fs = 2.5$$

where Ru: Ultimate Bearing Capacity of single piles, (tons)

Ra: Allowable Bearing Capacity of single piles, (tons)

Ap: True sectional area of pile tip, (m^2)

$\bar{N}$: N average of the layer of pile tip (average of N between below and 4d above from pile tip. d = pile diameter)

$\overline{Ns}$: Average of S.P.T-N of sand layer, (blow/ft)

Cp: Cohesion of pile tip soil (t/m^2)

$c = 1/2qu$, $qu = N/8$, $\therefore c = N/16$ (kg/cm^2)

$= 10/16N$ (t/m^2)

Ls: Pile length of sand bed (m)

Cu: Cohesion of soil, (t/m^2)

Lc: Pile length of cohesion soil layer, (m)

: Length of pile perimeter, (m)

(b) Computation of Pile

Nonthaburi Area

The load of the facilities being planned is as follows:

1	Warehouse	4.5 t/m^2	A = 35 x 130 x 2 houses = 4,550 m^2 x 2 W = 20,500 tons x 2 houses
2	Packing Facility	5.0 t/m^2	A = 25 x 20 = 500 m^2 W = 2,500 tons
3	Export Processing F.	4.5 t/m^2	A = 25 x 75 = 1,875 m^2 W = 8,840 tons
4	Conditioned W.H.	4.5 t/m^2	A = 15 x 20 = 300 m^2 W = 1,350 tons
5	Fumigation F.	4.5 t/m^2	A = 10 x 20 = 200 m^2 W = 900 tons
6	Controlled A.W.H.	4.5 t/m^2	A = 10 x 20 = 200, 5 x 5 = 25 m^2 W = 900 tons, 113 tons
7	Training Center	3.0 t/m^2	A = 35 x 50 = 1,750 m^2 W = 5,250 tons

Pile is RC and its length is 24 meters.

Allowable Bearing Capacity Ra in each diameter is as follows:

Pile diameter (mm)	N	Ru (t)	Ra (t)
300	20	56	23
350	20	77	31
400	20	100	40

Suphan Buri, Chai Nat Area

The load of facilities is as follows:

Suphan Buri

1	Warehouse	4.5 t/m^2	A = 25.5 x 66 = 1,683 m^2 W = 7,574 tons

Chai Nat

1	Warehouse		A = 1,683 m^2, W = 7,574 m^2t
2	Paddy storage	5.0 t/m^2	A = 20 x 46 = 920 m^2 W = 4,600 tons
3	Drying F.	5.0 t/m^2	A = 16 x 40 = 640 m^2 W = 3,200 tons
4	Silo	Silo	20 tons/1 bin x 18 = 360 tons
		Foundation	1,330 tons
		Contact pressure	4 tons/m^2

When pile driving is to 10.5 meters, the Allowable Bearing Capacity Ra is as follows:

Pile Diameter (mm)	N	Cp (t/m^2)	Ru (t)	Ra (t)
300	20	12.5	7.1	2.8
350	20	12.5	9.6	3.8
400	20	12.5	12.6	5.0

Therefore, when pile driving is to 10.5 meters, the Allowable Bearing Capacity Ra is insufficient.

When pile driving is to 16.5 meters, the Allowable Bearing Capacity is as follows:

Pile Diameter (mm)	N	Ru (t)	Ra (t)
250	40	78.5	31
300	40	113	45
350	40	154	62

Nakhon Sawan Phichit, Phisnulok Area

The load of facilities is as follows:

Nakhon Sawan

1	Warehouse	4.5 t/m^2	A = 35 x 130 x 2 hours = 4,550 m^2 x 2 W = 20,500 tons
2	Packing Facility	5.0 t/m^2	A = 500 m^2, W = 2,500 tons
3	Grading Facility	5.0 t/m^2	A = 500 m^2, W = 2,500 tons

Phichit

1	Warehouse	4.5 t/m^2	A = 25.5 x 66 = 1,683 m^2 W = 7,574 tons

Phisnulok

1	Warehouse	4.5 t/m^2	A = 25.5 x 66 = 1,683 m^2 W = 7,574 tons

When pile driving is to 8.0 meters, the Allowable Bearing Capacity Ra is as follows:

Pile Diameter (mm)	N	Ru (t)	Ra (t)
300	10	28	11
350	10	38	15
400	10	50	20

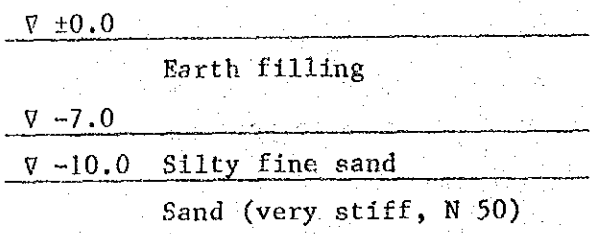
That is, when 400 mm, one pile requires 4.0 m^2. This is not possible, therefore, pile driving to 8.0 meters is not available.

When pile driving is to 15.5 meters, the Allowable Bearing Capacity Ra is as follows:

Pile Diameter (mm)	N	Ru (t)	Ra (t)
250	50	98	39
300	50	141	56
350	50	192	77

Laem Chabang

The soil condition of the filled ground is as follows:



The load of the facility is as follows:

1	Warehouse	1F	4.5 t/m^2	A = 35 x 130 = 4,550 m^2 W = 20,500 tons
2	Warehouse	1F	4.5 t/m^2	A = 35 x 130 = 4,550 m^2 W = 20,500 tons
3	Warehouse	2F	9.0 t/m^2	A = 35 x 130 = 4,550 m^2 W = 41,000 tons
4	Warehouse	2F	9.0 t/m^2	A = 35 x 130 = 4,550 m^2 W = 41,000 tons
5	Warehouse	2F	9.0 t/m^2	A = 35 x 70 = 2,450 m^2 W = 22,050 tons
6	Warehouse	2F	9.0 t/m^2	A = 35 x 70 = 2,450 m^2 W = 22,050 tons
7	Export Processing Facility		5.0 t/m^2	A = 35 x 80 = 2,800 m^2 W = 14,000 tons
8	Silo	Silo		45 tons/1 bin x 8 = 360 tons
		Foundation		= 1,092 tons
		Contact pressure		= 11 t/m^2

Silo (ϕ = 6.0 m, h = 20.0 m
R.C.t = 0.3 m)

Foundation concrete
(t = 1.2 m)

When pile driving is to 12.0 meters, the Allowable Bearing Capacity Ra is as follows:

Pile Diameter (mm)	N	Ru (t)	Ra (t)
250	50	98	39
300	50	141	56
350	50	192	76
400	50	251	100

(c) Pile Arrangement

When 4.5 t/m^2, the pile number for each area is shown in Table 7-2.

Table 7-2 Summary of Pile Number by Area
(When 4.5 t/m^2)

Pile Diameter (mm)	Ra (t)	Load ($t/100\ m^2$)	Pile Number (pieces/100 m^2)
Nonthaburi Area			
300	23	450	20
350	31	450	15
400	40	450	12
Suphanburi, Chai Nat Area			
250	31	450	15
300	45	450	10
350	62	450	8
Nakhon Sawan, Phichit, Phisnulok Area			
250	39	450	12
300	56	450	8
350	77	450	6

According to Table 2, the Allowable Bearing Capacity of piles is in the range of 30 to 60 tons. And in the case of continuous footing, the maximum area that two piles arranged on a cross part of the footing can support is as follows:

Load supportable area of two piles

$2 \times (30 \text{ to } 60) \div 4.5 = 13 \text{ m}^2 \text{ to } 27 \text{ m}^2$

Then the footing space is as follows:

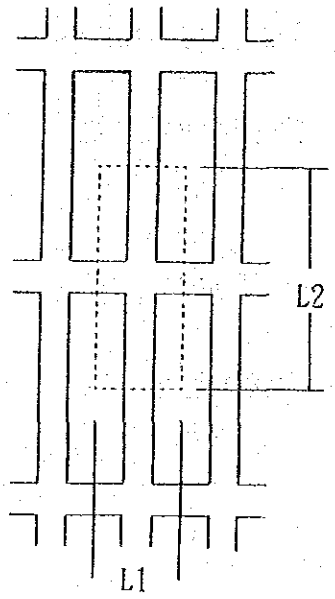
(2.5 m x 5.0 m) to (4.0 m x 8.0 m)

Appendix G-6, Figure 8 Standard Pile Foundation shows a standard pile arrangement plan.

(2) Spread Foundation

The foundation style of the rest of the area is spread footing. When the foundation beam space is (2.5 m x 5.0 m) to (4.0 m x 8.0 m), the relation between the Allowable Soil Pressure qa and the width of the footing Bf is as follows:

qa (t/m^2)	Bf (m)
8	1.0 to 1.5
15	0.55 to 0.85
30	0.27 to 0.42



That is, qa 15 t/m^2 Bf 1.0 m to 1.5 m Continuous footing

qa 15 t/m^2 Af 2.0 m to 5.0 m Individual footing

(Af: width of individual footing)

Appendix Figure 9 shows the standard continuous footing plan, and Figure 10, the standard individual footing plan.

7-3-3 Access Road

An access road between a main road and a planning site is constructed of soil and gravel from the region. As shown in Appendix G-6, Figure 11, the effective width is five meters.

Nonthaburi needs a bridge, and the plan is shown in Appendix G-7, Figure 12.

7-3-4 Siding

In general, sidings are constructed and operated by the State Railway of Thailand.

The sites where sidings can be constructed are as follows:

Chiang Mai, Nakhon Sawan, Nakhon Ratchasima, Surin, Udon Thani, Surat Thani

Standard profile of sidings is shown in Appendix G-7, Figure 11.

7-3-5 Banking

Most of the survey site is wet land and at a level lower than the road or surrounding land. So, most of the survey site requires soil banking. Soil from the region is used.

7-3-6 Drainage

Concrete pipe is used for drainage (ϕ = 400 mm), and drains rain and miscellaneous water from all of the land. Drainage basins are built every fifty meters.

A standard plan is shown in Appendix G-7, Figure 11.

7-3-7 Wharf

A wharf is being planned on the Chao Phraya River at the Nonthaburi site.

The design of the wharf was carried out by following the harbor structural standard code.

The Japan Harbor Association
Harbor Structural Standard Code

Appendix G-9, Figure 17 shows the plan and profile of the wharf.

(a) Calculation Data

Water Level at Nonthaburi

According to the data surveyed by the Harbor Department, the tidal difference at Bangkok Bar (38 km from the mouth of the Chao Phraya River) is 2.20 meters. This data was applied to the tidal difference at Nonthaburi.

The high water level at Nonthaburi was EL + 2.0 meters, as a result of the observation of the flood mark on the shore protection at Nonthaburi.

Therefore, the low water level at the site is EL -0.2 meters.

Water Depth

Data on the water depth, which was surveyed in November, 1984 is shown in Appendix G-2, Figure 5.

Size of Barge

The type and size of barges which have been used on the Chao Phraya River are shown in Appendix 10. According to this data compiled by the Harbor Department, the biggest barge is 1000 gross tons with most barges under 400 gross tons.

Therefore, the length of the wharf is adopted to 100 meters. This is the length to which two vessels of 400 gross tons can be moored at the same time.

Dimensions of the Wharf

According to the above mentioned standard code, when using a forklift, the width of the apron is 15 to 20 meters. In consideration of working efficiency, a 20 meter width is adopted. Other conditions are as follows:

Planning water depth	-5.2 meters
Dimension apron	20 m x 100 m
Dimensions of one apron block	20 m x 20 m
Height of upper bed	EL + 2.50 meters

Seismic Power

As shown in Appendix G-3, Figure 6, the Bangkok area is not threatened by earthquake damage. Therefore, the seismic power of this wharf is not taken into consideration.

Load Condition

(1)	Dead load	2.0 t/m^2
(2)	Live load	1.0 t/m^2
(3)	Crane load	50 tons
(4)	Impulsive load and tractive force	Both 30 t/one block

Therefore, the load of one block is as follows:

Vertical load	(1)	20 x 20 x 2.0 =	800 tons
	(2)	20 x 20 x 1.0 =	400 tons
	(3)		50 tons
		Total	1,250 tons
Horizontal load	(4)		30 tons

Soil Condition

The soil condition is as in Figure 7-2.

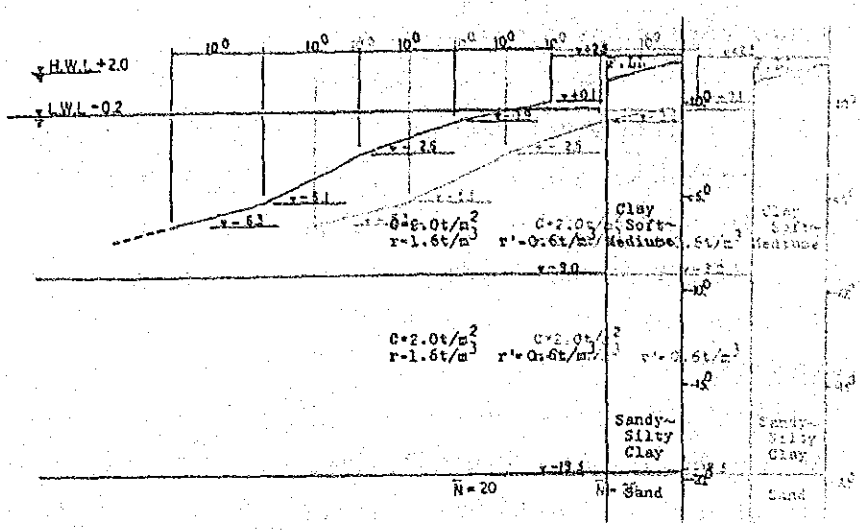


Fig. 7-2 Water Level, Water Depth and Depth and Soil Condition at Nonthaburi

(b) Apron Plan

Foundation Pile

Dimensions of pile: Steele Pile ϕ = 500 mm, t = 12.7 mm, l = 24.0 m
Space of pile: 5.50 meters, 16 pieces/one block

Detailed calculations are shown in Appendix G-11.
Pile arrangement is shown in Appendix G-8, Figure 15.

Dimensions of Slab

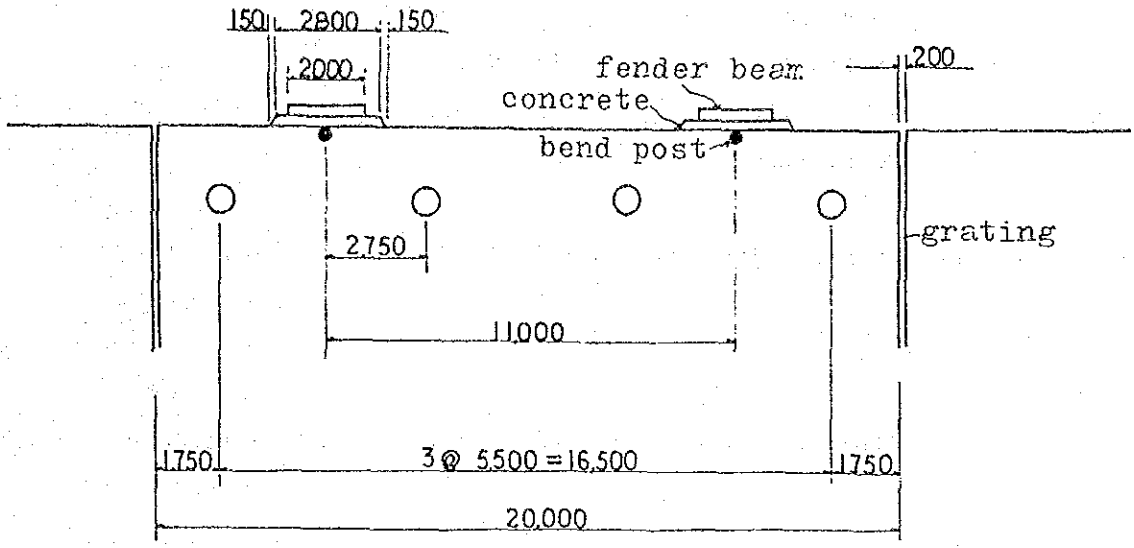
Pavement	Thickness: 10 cm	10 cm		
Slab	Thickness: 25 cm	25 cm		
Girder	Height: 100 cm	100 cm	Width: max. 100 cm	100 cm
			min. 60 cm	60 cm
Pile head	Height: 100 cm	100 cm		

Details are in Appendix G-8, Figure 13.

Other Facilities

Fender beam: V type, space of beam 11.0 meters
Bend post: Tractive force worked to bend post 15.0 tons
set same place with fender beam
Grating: Set between each block

These are arranged as in Figure 7-3.



(Unit: mm)

Fig. 7-3 Fender Beam, Bend Post and Grating

(c) Retaining Wall

This is constructed with concrete and cobblestone. Details of the calculations and profile are shown in Appendix G-11.

(d) Slope Stability

The stability slope gradient after dredging was calculated by the use of Taylor's figure. The result of the calculation is 1:2.0. Details of the calculation are shown in Appendix G-11.

(e) Total Plan

The wharf total plan is shown in Appendix G-9, Figure 17. The volume of each material is as follows.

Pavement	2,000 m^2
Concrete	1,610 m^3
Reinforced bar	150 tons
Fender beam	20 meters
Bend post	10 pieces
Grating	175 pieces
Steel pile	80 pieces
Cobblestone	1,275 m^3

7-4 Civil Engineering Cost Estimates

(1) Total Cost

The total costs were estimated in detail for three cases.

Case 1: Highest costs of warehouses + Shipping Facilities
Case 2: Lowest costs of warehouses + Shipping Facilities
Case 3: Comparison of Seaport and River Port

	Total Cost (฿'000)	Foreign Currency (฿'000)	Local Currency (฿'000)
Case 1:	64,236	33,889	30,347
Case 2:	57,790	32,859	24,931

Note: Details are given in Table 7-3, Table 7-4 and Appendix G-12.

Case 3: Location of Shipping Facilities	Total Cost (฿'000)
(1) Nonthaburi	50,429
(2) Nonthaburi + Laem Chabang	36,153

Note: Details are given in Appendix G-12, C-21, C-22 and C-23.

Table 7-3 Civil Engineering Cost of the Project

Case-1

Item No.	Location		Total Cost (฿'000)	Foreign Currency (฿'000)	Local Currency (฿'000)
C-2	Suphan Buri	No. 29	4,950	1,600	3,350
C-4	Saraburi	No. 32	999	289	710
C-5	Chai Nat		485	273	212
C-6	Lampang		1,633	401	1,232
C-7	Chiang Mai	No. 22	2,748	781	1,967
C-9	Chiang Rai		877	283	594
C-10	Nakhon Sawan		6,506	3,209	3,297
C-11	Phisnulok		2,240	736	1,504
C-12	Phichit		2,023	852	1,171
C-15	Nakhon Ratchasima	No. 12	2,272	769	1,503
C-16	Surin		1,306	393	913
C-17	Ubon Ratchathani		494	259	235
C-19	Udon Thani	No. 2	1,081	307	774
C-20	Surat Thani		469	250	219
C-21	River Port (Nonthaburi-1)		26,303	17,426	8,877
C-23	Seaport (Laem Chabang)		9,850	6,061	3,789
	Total		64,236	33,889	30,347

Table 7-4 Civil Engineering Cost of the Project

Case-2

Item No.	Location		Total Cost (฿'000)	Foreign Currency (฿'000)	Local Currency (฿'000)
C-1	Suphan Buri	No. 28	2,881	1,318	1,563
C-3	Saraburi	No. 31	577	328	249
C-5	Chai Nat		485	273	212
C-6	Lampang		1,633	401	1,232
C-8	Chiang Mai	No. 23	921	413	508
C-9	Chiang Rai		877	283	594
C-10	Nakhon Sawan		6,506	3,209	3,297
C-11	Phisnulok		2,240	736	1,504
C-12	Phichit		2,023	852	1,171
C-14	Nakhon Ratchasima	No. 11	753	403	350
C-16	Surin		1,306	393	913
C-17	Ubon Ratchathani		494	259	235
C-18	Udon Thani	No. 1	472	254	218
C-20	Surat Thani		469	250	219
C-21	River Port (Nonthaburi-1)		26,303	17,426	8,877
C-23	Seaport (Laem Chabang)		9,850	6,061	3,789
	Total		57,790	32,859	24,931

(2) Components of the Cost

The cost estimate of the project was made in the following manner:

(1) Access road:

Access road between the existing road and the gate of the land, to include the cost of an existing narrow road

(2) Banking:

Banking of the proposed land

(3) Drainage:

Main drainage of the proposed land

(4) Foundation:

Piles, excluding footing, beam and slab

(5) Siding:

As a rule, siding is constructed by the State Railway of Thailand.

(6) Pre-engineering works:

Pre-engineering works include the survey works for proposed lands and soil tests.

(7) Others:

The costs exclude preparation, contingency and overhead.

Detailed information on the cost estimate is shown in Appendix G-12.

(3) Unit Cost

The cost of civil engineering construction works was estimated on the basis of the prevailing unit costs offered by The Public Works Department, State Railway and others.

The components are as follows:

(a) Unit Cost

Labor unit prices (common with each site)

Description	Unit	Prices (฿)
Labor	day	80.0
Foreman	day	130.0
Driver	day	100.0
Operator	day	200.0
Carpenter	day	150.0
Steel Worker	day	150.0

Unit price of materials (common to each site)

Description	Unit	Prices (฿)	Remarks
Rail	bar	1,666.6	60 lbs/m, l = 8 m
Side Plate	2 pcs	73.0	
Bolt	set	5.1	
Fish Plate	pcs	17.5	
Spike	pcs	7.6	
Rail	pcs	4,200.0	60 lbs/m, l = 8 m
Sleepers	bar	290.0	
Turnpoint Sleepers	set	14,000.0	
Turnpoint	set	51,000.0	
Safety Peg	pcs	360.0	
Steel Pile ϕ500 mm			
l = 15 m	pcs	33,600.0	Bangkok,
l = 13 m	pcs	29,300.0	(include
l = 10 m	pcs	22,950.0	transportation)

Table 7-5 Unit Price of Materials

Description	Unit	Bangkok	Suphan Buri	Sara Buri	Chai Nat	Lam-pang	Chiang Mai	Chiang Rai	Nakhon Sawan	Phisnulok	Phichit	Nakhon Ratchasima	Surin	Ubon Ratchathani	Udon Thani	Surat Thani
Portland cement	50 kg	80.0	85.0	81.0		85.0	87.0	93.0	82.0	80.0	80.0	76.0	82.0	82.0	85.0	83
Reinforced steel bar	kg	9.0	9.6	9.1		9.6	9.8	10.5	9.2	9.0	9.0	8.6	9.2	9.2	9.6	9
Gasoline	l	11.7	11.9	11.8		12.0	12.1	12.2	11.9	12.0	12.0	11.9		12.0	12.2	12
Diesel oil	l	6.7	6.9	6.8		7.0	7.1	7.2	6.9	7.0	7.0	6.9		7.0	7.2	7
R.C. Pile																
ϕ = 0.25 cm	m	170.0	173.0	169.0	177.0	220.0			182.0	198.0	196.0					
= 0.30 cm	m	210.0	216.0	211.0	222.0	285.0			232.0	253.0	251.0					
= 0.40 cm	m	375.0	384.0	360.0	393.0	490.0			405.0	442.0	438.0					
= 0.50 cm	m	500.0	514.0	501.0	527.0	673.0			545.0	600.0	594.0					
= 0.60 cm	m	800.0	806.0	792.0	826.0	920.0			850.0	923.0	916.0					
Soil	m^3	110.0	70.0	40.0		50.0	40.0	40.0	40.0	30.0	50.0	60.0	50.0	50.0	30.0	25
Cobblestone	m^3	120.0	200.0	150.0		150.0	220.0	200.0	180.0	180.0	210.0	240.0	190.0	190.0	200.0	160
Ballast	m^3	190.0	200.0	160.0		220.0	180.0	180.0	150.0	200.0	200.0	180.0	210.0	212.0	240.0	220
Sand	m^3	185.0	180.0	200.0		70.0	60.0	60.0	90.0	120.0	150.0	150.0	85.0	86.0	180.0	50
Concrete pipe																
ϕ = 0.40 cm	pcs	5,245.0	5,573.0	5,310.0	5,310.0											
l = 4.0 cm																

(b) Proportion of Foreign and Local Currencies

Description	Percentage	
	F/C	L/C
Cement	60	40
Steel Bar	70	30
Steel Pile	100	0
R.C. Pile	60	40
Concrete Pipe	60	40
Fuel & Oil	80	20
Labor	0	100
Construction Equipment		
Depreciation Cost	100	0
Repair Cost	80	20
Administrative Cost	0	100

(c) Operation Cost of Construction Equipment

		Total	F/C	L/C
		(฿/hr)	(฿/hr)	(฿/hr)
Bulldozer	11.0 tons	329.4	225.9	103.5
Backhoe	0.4 m^3	266.5	175.6	90.9
Truck Crane	10.0 tons	313.4	210.4	103.0
Pile Driving Machine	D-40	685.4	498.8	186.6
Boring Machine	5.5 kW	191.0	135.7	55.3
Dump Truck	8.0 tons	259.6	190.8	68.8

7-5 Pre-Engineering

A survey and geological investigation of each site should be completed before beginning a detailed design. A description of required items is as follows:

(1) Survey

Plain table and cross sectional surveying at each site.

(2) Geological Investigation

Borehole Drilling

Suphan Buri	1 = 20 m	3 pcs
Saraburi	10 m	1 pc
Chai Nat	10 m	1 pc
Lampang	15 m	4 pcs
Chiang Mai	15 m	2 pcs
Chiang Rai	15 m	2 pcs
Nakhon Sawan	15 m	4 pcs
Phisnulok	20 m	2 pcs
Phichit	20 m	2 pcs
Nakhon Ratchasima	15 m	2 pcs
Surin	10 m	1 pc
Ubon Ratchathani	10 m	2 pcs
Udon Thani	10 m	2 pcs
Surat Thani	10 m	1 pc
Nonthaburi	40 m	9 pcs
Laem Chabang	20 m	2 pcs

Physical Test

By using samples of each borehole

Standard Penetration Test

Measuring the N value in each borehole

CHAPTER VIII MACHINERY AND EQUIPMENT

CHAPTER VIII MACHINERY AND EQUIPMENT

8-1 Basic Concept of Machinery and Equipment Designs

First, the basic designs for machinery and equipment are carried out, then the fundamental areas requiring detailed design are determined.

The principal work for the basic design involves the following:

(A) to design an outline that includes the integration process

(B) to formulate an alternative plan for comparison before the final selection of an optimum plan

(C) to survey the following items for the purpose of final evaluation:

- ° Socio-economic appropriateness
- ° Feasibility of the project in terms of technology, financing and profitability
- ° Operating an organization structure
- ° Adaptability of operating management

8-2 Machinery and Equipment for Regional and Provincial Warehouses

8-2-1 Approach to the Machinery and Equipment Program

The machinery and equipment to be selected must be adaptable to the rice distribution system in Thailand and must correspond to the current state of technical and economical conditions. From the technical standpoint, these facilities must be compatible with the rice distribution system and also must be expandable to the private sector as an incentive project from an economical point of view.

Concrete ideas for the approach include:

a. Machinery and equipment related to the warehouse are not only required to have individual machinery technology but must also be superior in combing each machinery function including good operability.

b. New Technology in Thailand is comparatively advanced but some problems are likely to be present in machine maintenance and management. Special consideration of functions such as maintenance free operation is therefore required.

c. Current manpower oriented loading works are to be mechanized step by step, while works requiring a limited amount of manpower are also to be mechanized.

d. A plan for the scale of machinery and equipment must be set on the basis of the lowest limit of a given condition (planned processing volume). An excess capacity must be avoided.

e. Quality control for rice stored in warehouses has been conducted using intuition or by measuring with the eye. In order to improve quality control, the scientific approach using machinery and tools must be employed.

f. It is important to keep things in good order both inside and outside a warehouse in order to maintain a good storage environment. Constant attention should be given to gears and tools for possible repair and renewal.

8-2-2 Fundamental Design for Machinery and Equipment for Regional Provincial Warehouses

The machinery required for the local warehouses is the standard type commonly used in handling agricultural products in general. It includes common machines such as the truck and platform scales, conveyor, stackers, bag-closing machines and inspection machines. However, warehouse machinery and equipment with the following different functions are required depending on the local climate of agricultural products where warehouses are to be built.

(a) Grain Cleaning and Grading Facilities:

Local warehouses are not used fully throughout the year. This empty space could be used more efficiently to improve marketability and stockability in the area of Nakhon Sawan and Lampang, where

secondary crops (beans and miscellaneous cereals) as well as rice crops are well produced. So facilities with functions for grain cleaning, grading and packing are to be proposed. These facilities provide an unhulled rice processing capability.

If broken grains of rice or cereal are intermixed with beans or miscellaneous cereal, a rich breeding ground for harmful insects is created. Insects do not breed easily in clean grain, but they breed easily in broken grains of rice or mold, so that grain cleaning is the most important process. The broken grains of rice must be removed, because even with humidity control, mold increases more quickly in broken grains than in whole.

(b) Small-sized Rice Cleaning and Packing Facilities

The facilities are designed to improve rice marketing in the main regional cities and becomes a so called "Rice Distribution Center". The facilities provide warehouses. Cleaned rice to be stored in warehouses is mixed with 2 - 3 different types of rice according to market needs, and packed into small plastic bags. PWO rice is supplied directly to domestic consumers by packing 100 kg-rice into jute bags without small plastic bag packing. Facilities are thus not required to provide the equipment with the full processing capability to cover the total expected sales volume. It is proposed that five regional warehouses be equipped with these facilities.

(c) Grain Processing Facilities

Grain processing facilities are to be proposed for the safe storage of agricultural products harvested in the rainy season for double-cropping. These facilities are to be designed to carry out pre-cleaning, drying and packing for high humidity grains.

Processed grains packed in bags are to be stored in a flat warehouse. It is proposed that these facilities be built at two regional warehouses in Nakhon Sawan and Nakhon Ratchasima, which are key locations in rice distribution.

8-2-3 Machinery and Equipment Designs for Regional and Provincial Warehouses

Measurement tools (truck scale, platform scale) conveyors, stackers, pallets, bag sewing machine and inspection instruments are arranged as in table 8-1-(1), (2), as machinery and tools for regional warehouses.

Each machinery tool and its use is described in the following:

(a) Truck Scale

This scale is used to provide facilities for the delivery of cargo by measuring truck, at the time of rice delivery at warehouses. A 6 or 10 ton (10-wheel truck) capacity truck is the most widely used truck in Thailand. Thus rice transportation also currently depends on these trucks.

There is the opinion that the 10-wheel truck should be changed to a trailer truck due to present road maintenance, but as no concrete plan for this opinion has been proposed, the truck scale for the 10-wheel truck is described in this proposal.

Since the truck scale requires a pit for its installation, a drainage area may be needed, depending on the installation site. However, the proposed local warehouses are not to be built in low lying areas, so that a drainage area is not required.

Weighing system	Mechanical lever
Display system	Manual poise slider
Printing system	Engraving
Weighing capacity	30 ton
Platform	3 x 6.5 - 7 m, steel plate
Pit drainage	Septic tank or drainage ditch

Table 8-1-(1) Proposed Machinery and Tools for Regional and Provincial Warehouses
(Only Common Machinery Tools)

Item \ Location (Capacity of Warehouse)	Nonthaburi (20,000ton)	Suphan Buri (5,000ton)	Chai Nat (5,00ton)	Saraburi (5,000ton)	Lampang (20,000ton)	Chiang Mai (5,000ton)	Chiang Rai (5,000ton)	Nakhon Sawan (30,000ton)
1. Truck scale	1	-	-	-	1	-	-	1
2. Platform scale	2	1	1	1	2	1	1	3
3. Chain conveyor	-	2	2	2	8	2	2	12
4. Stacker	-	1	1	1	4	1	1	6
5. Small bag sewing machine	1	1	1	1	1	1	1	1
6. Cleaning instruments one set	1	1	1	1	1	1	1	1
7. Inspection instruments	(including central shipping complex) 1	1	1	1	1	1	1	1
8. Pallets	(Same as above)	1,300	1,300	1,300	5,200	1,300	1,300	7,800

Table 8-1-(2)

Item No.	Phitsanuloke (5,000ton)	Phichit (5,000ton)	Nakhon Ratchasima (20,000ton)	Surin (5,000ton)	Ubon Ratchathani (5,000ton)	Udon Thani (5,000ton)	Surat Thani (5,000ton)	Total
1.	-	-	1	-	-	-	-	4
2.	1	1	2	1	1	1	1	20
3.	2	2	8	2	2	2	2	50
4.	1	1	4	1	1	1	1	25
5.	1	1	1	1	1	1	1	15
6.	1	1	1	1	1	1	1	15
7.	1	1	1	1	1	1	1	14
8.	1,300	1,300	5,200	1,300	1,300	1,300	1,300	32,500 *

* 20,000 tons of 32,500 tons are diverted from the existing central warehouse.

(b) Platform Scale

The platform scale is used as a sampling check to receive the packed rice. This scale is also used in the repacking process when a bag is broken. The weighing capacity is therefore covered up to 500 kg (approximately 5 bags).

Since the accuracy of the platform scale may be incorrect due to frequent movement, the number of scales to be installed is set at one set for each warehouse.

Weighing capacity	10 - 500 kg
Platform size	About 500 x 700 mm

(c) Conveyor and Stacker

The planned packing procedure for local warehouses is applied to the current method in Thailand. However, mechanical conveyor and stacker systems are employed to rationalize loading work in the warehouses.

The conveyor machinery and equipment are combined into two types; flat type and slope type. In this proposal, for the warehouse design, three conveyors satisfy the needs of every warehouse because each conveyor can be connected from every door with a maximum distance.

A set of three conveyors (2 conveyors for horizontal feeding, 1 conveyor for slope feeding) is arranged for a 5,000 ton capacity. Electric power is available at each site so that the conveyor is operated by a motor. Since the packed rice weighs 100 kg the conveyor must be able to manage this weight. The slat chain conveyor is suitable.

The slope type of conveyor requires the full length of elevation because the above mentioned packed rice bags are piled up to 27 bags (about 6 m in high).

Type	Chain moving type, flat or slope
Power type	Electric motor
Capability	600 - 1000 bag/hour (100 kg rice)
Length	6 - 8 m
Width	About 500 mm
Max. tilting height	7 m (slope type)

(d) Small Bag Sewing Machine

The small bag sewing machine is used when a small volume of repacking is required, as when bags are broken in a warehouse. This machine is used everywhere in the warehouse as it is needed. It must therefore be portable and the power source must be single-phase. The conventional jute bag (for 100 kg rice or 50 kg rice) and the chemical fiber cloth bag (for 50 kg rice) can be used with this machine. One sewing machine is allocated for each warehouse.

(e) Cleaning Tools for Warehouses

For warehouse operating management, it is very important to clean the inside and outside of the warehouse to maintain the quality control of the stock. A manual sieve is useful for cleaning grains scattered on the floor.

If a hand-cart is always provided for moving packed grain bags a short distance, it is very helpful for proper rearrangement works. For packed rice handling, an extended scupper and concave platform are also convenient.

(f) Inspection Instruments

One complete set of inspection instruments is provided for each warehouse to inspect incoming grain. Additional instruments are also necessary for grading paddy in a warehouse where it is handled. An inspection room in the provincial level (regional warehouse) should adjoin the truck scale display room and be located in the same building for optimum convenience.

The inspection instruments include: Grain moisture meter, Micro meter, Table balance, Karton (seed sample pan) chemical reagent, probe, divider, Dockage tester or sieve set, Grain identification board, Test rice husker, Test milling machine, Test dryer.

(g) Pallet

Palletization is not planned at the local warehouse level for operating a warehouse, so the pallet is designed to protect packed grain bags. Stock or wooden pallet is widely used for grain warehouses in Thailand. In this proposal, a pallet shown in Fig. 8-1, which is widely used in Thailand, is designed to meet the purpose.

Size: 1.0 x 1.0 m
Height: 0.11 m
Weight: About 24 kg

Hardened wood is used as lumber and anti-ant processing is also implemented.

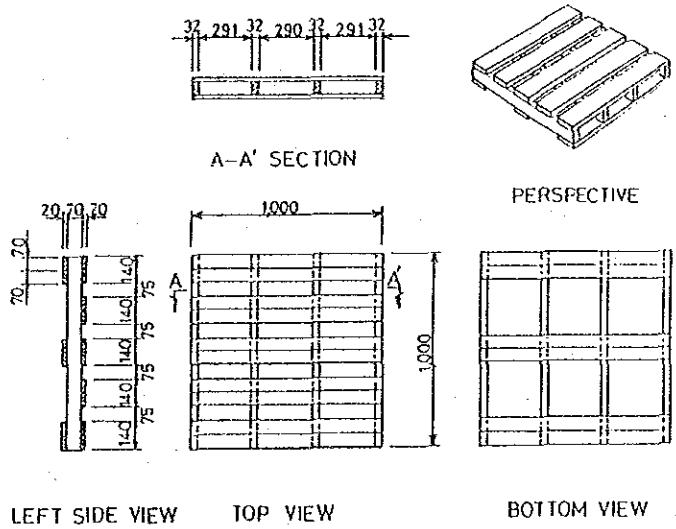


Fig. 8-1 Example of Existing Pallet

Machinery and equipment already mentioned in the above are arranged in Table 8-2, and described in the following:

Table 8-2 Planning for Machinery and Equipment for Warehouses

Name of Machinery and Equipment	Process	Processing Capability	Site
1. Grain cleaning facilities	Receiving, Cleaning, Grading, Bagging,	1 - 2 ton/hr.	Lampang Nakhon Sawan
2. Small-sized cleaning rice packing facilities	Cleaning, Re-milling, Mixing, Weighing, Packing	2 ton/hr.	Lampang Nakhon Sawan Nakhon Ratchasima Nonthaburi Surat Thani
3. Grain processing facilities	Cleaning, Drying, Weighing and Packing	200 tons/day for receiving products (140 tons/day for drying)	Nakhon Sawan Nakhon Ratchasima
4. Forklift	Delivery	2.5 tons/base	Same as 2. (one base for each site)

(h) Grain Cleaning Facilities

These facilities provide equipment with processes covering cleaning, grading and packing for green beans, soybeans and rice. The process chart is shown in Fig. 8-2. The processing capability must be established to conform to the planning volume of the collection of products, but the scale of facilities is to be set to the minimum for this type of plant. This is because the facilities are designed to use the warehouse efficiently, by using vacant spaces during the off season.

Given design conditions

Object grains: Paddy, green bean, soybean

Processing capability: 1,000 - 2,000 tons/year
(1 - 2 tons/hour)

Process: Receiving, Cleaning, Grading, Packing

Main components

Receiving hopper, Pre-cleaner, Rolling cleaner, Thickness, Width, Length graders, Stonner, Weighing and packing device

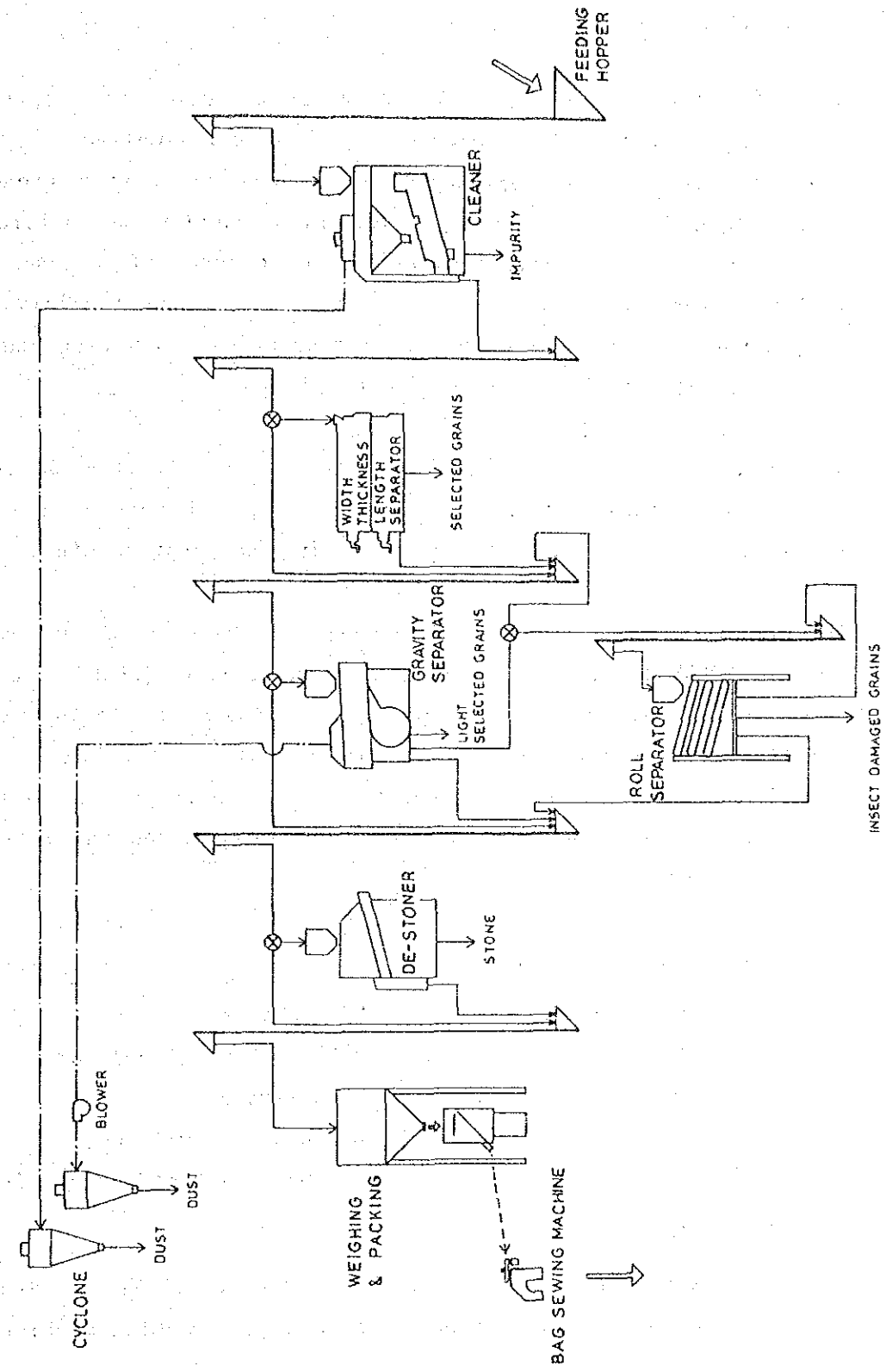


Fig. 8-2 Flow Chart of Grain Cleaning and Grading Facilities, Lampang and Nakhon Sawan

(i) Small-sized Rice Packing Facilities

There has been the tendency for conventional sales in retail mode weight for domestic rice consumption to change to small-sized packed rice of 5 kg, called prepackaged rice. Because of this trend, in this proposal, a small-sized pilot plant design is offered to improve not only the retail distribution in local cities, but also to handle the healthy cleaning of rice as food. The facility scale is planned to have a 2-ton per hour processing capability based on the capability of the small packing machine.

Normal facilities are expected to process 10 - 20 tons daily and 2,500 - 5,000 tons annually. The process includes cleaning, re-milling, mixing and weighing and packing as preprocessing.

Any grading process for domestic consumption rice is not necessary. However, PWO is selling a rice mixture called "orcha rice" as economical rice, so that rice mixture processing is indispensable. Re-milling capability is designed in a small scale, because only deteriorated rice and high quality rice are re-milled with the facilities. The flow chart is shown in Fig. 8-3 and the reference layout is shown in Fig. 8-4.

Given design conditions

Processing objects:	Milled rice
Total processing volume:	2,500 - 5,000 tons/year
Processing capability:	2 tons/hour
Process:	Cleaning, Re-milling, Mixing, Weighing and packing

Main components

Receiving hopper, Cleaner, Rotary shifter, Stonner, Polisher, Mixing device, Weighing and Packing machine

(j) Grain Processing Facilities

The facilities are to be planned for processing primarily high moisture paddy to be harvested in the rainy season. Paddy, which contains more than 17 - 18 percent moisture is difficult to store in a warehouse. The rice must be dried as soon as possible to be fit

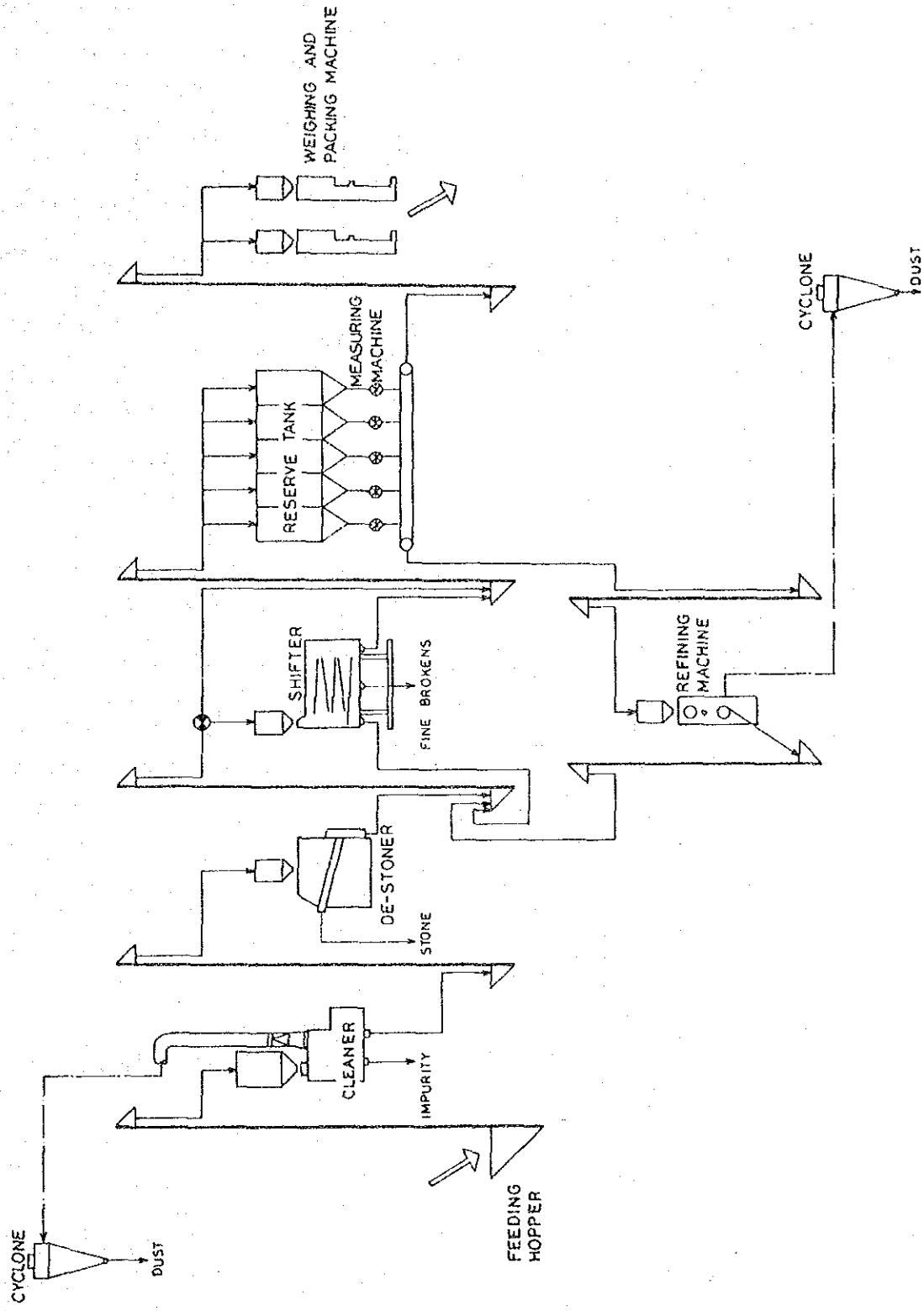


Fig. 8-3 Flow Chart of Rice Packing Facilities for Regional Warehouses

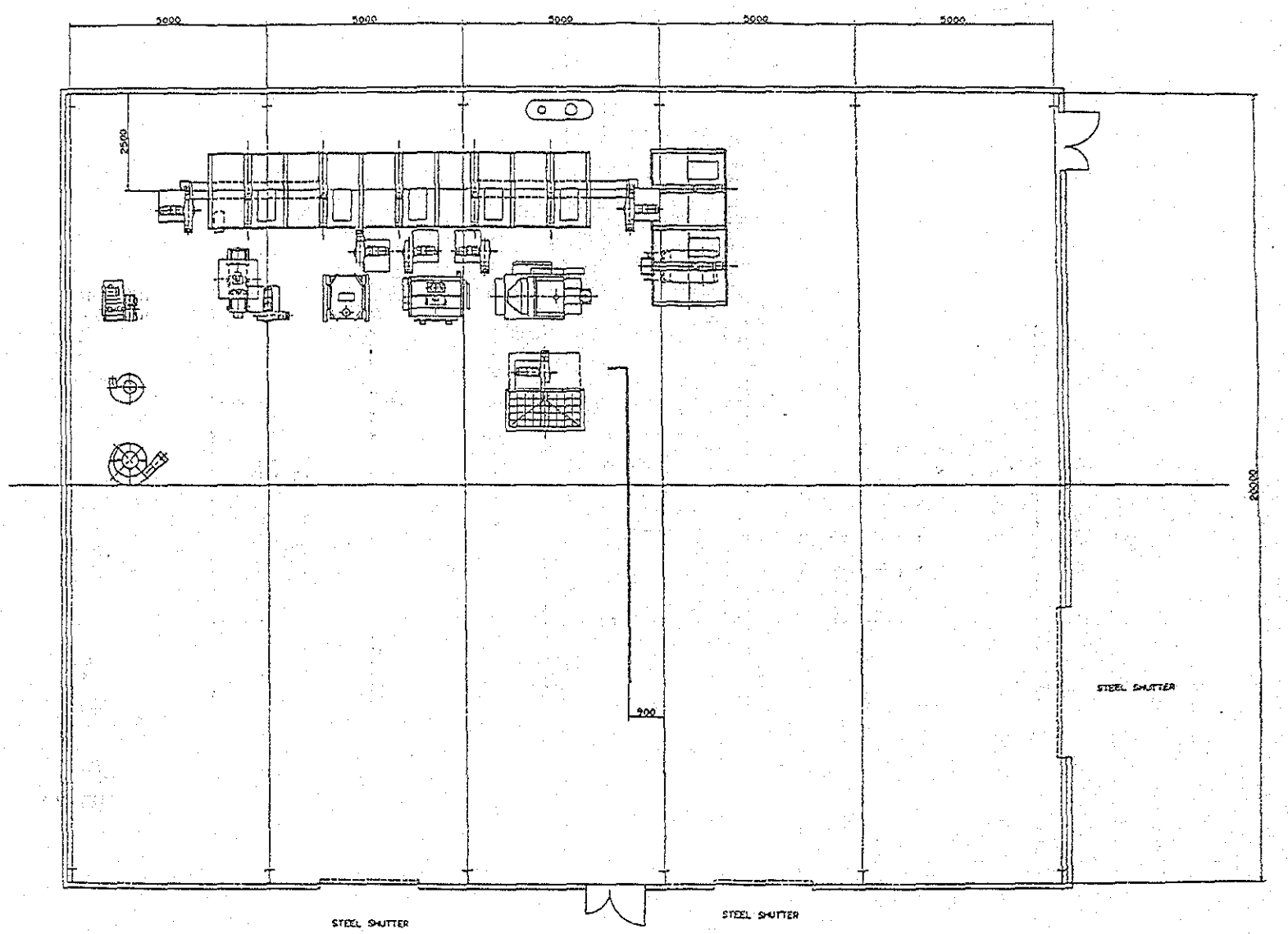


Fig. 8-4 Layout Plan of Rice Packing Facilities

for storage. However, not all paddy in a warehouse receives drying. Problems due to the high moisture content of paddy must be considered. The ratio is assumed to be 50 - 70 percent.

Recent threshing works in Thailand have employed the throwing type of thresher method, so that high moisture paddy has not been applied to the threshing works. The grain processing facilities are designed to cover this fact. Since drying rice straw is required as preprocessing for threshing work, chaff is dried to some extent. Limiting the moisture of paddy for the throwing type of thresher is expected to be 18 - 30 percent. In some paddy, the limitation value is 24 percent. Processing at the grain processing facilities includes cleaning, weighing, drying and bagging, as well as pre/post dry processing as stated above.

The facilities are basically designed as open-air type facilities, but working sites for receiving and packing are to be kept inside. In addition, since products are to be stored in a flat warehouse the packing site and location of the warehouse must be connected functionally because of independent weather works. In this proposal however, the packing site is to be apart from the warehouse to prevent fire.

The flow chart is shown in Fig. 8-5. The reference layout is shown in Fig. 8-6.

Given design conditions

Processing objects: Paddy and other grains
Total processing volume: 10,000 tons/year
Number of days to be received: 60 days

Maximum receiving volume: 200 tons/day
Volume subject to drying: Maximum receiving volume x 50 - 70%
Moisture reduction: Maximum 10% (from 24.5% to 14.5%)

Main components

Receiving hopper, Pre-cleaner, Sampling device,
Weigher, Receiving and tempering tank, Dryer,
Weighing and packing device

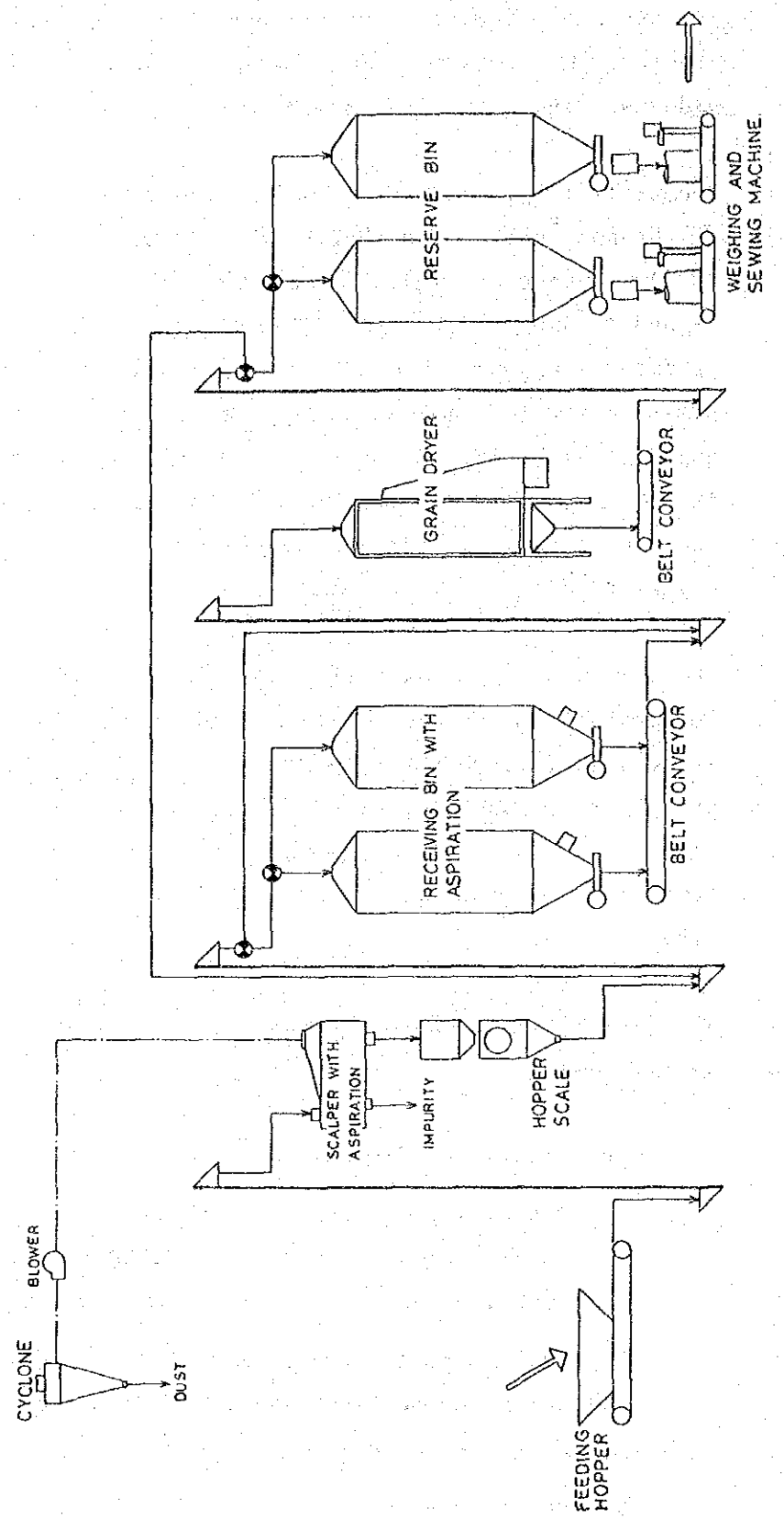


Fig. 8-5 Flow Chart of Grain Processing Facilities
Nakhon Sawan, Nakhon Ratchasima

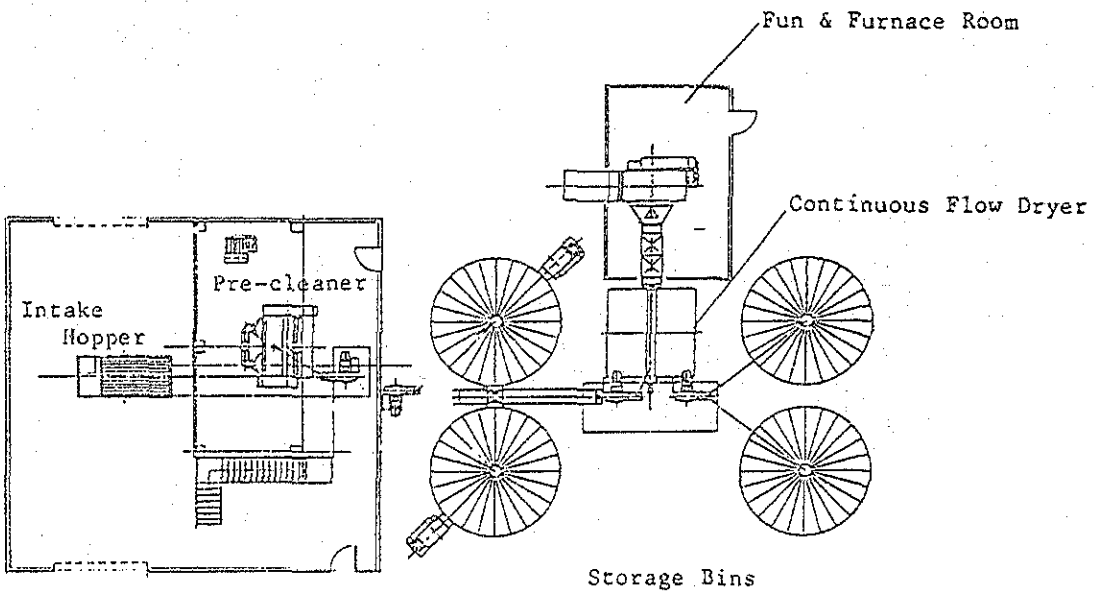


Fig. 8-6 Layout Plan of Grain Processing Facilities