NO. 04

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR ESTABLISHING
THE METALLURGICAL LABORATORY FOR LATERITE
IN
THE REPUBLIC OF INDONESIA

JULY, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Republic of Indonesia, the Government of Japan has decided to conduct a basic design study on the Project for Establishing the Metallurgical Laboratory for Laterite and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Indonesia a study team headed by Dr. Kenji Tomita, Special Technical Advisor, JICA, from February 16 to March 7, 1987.

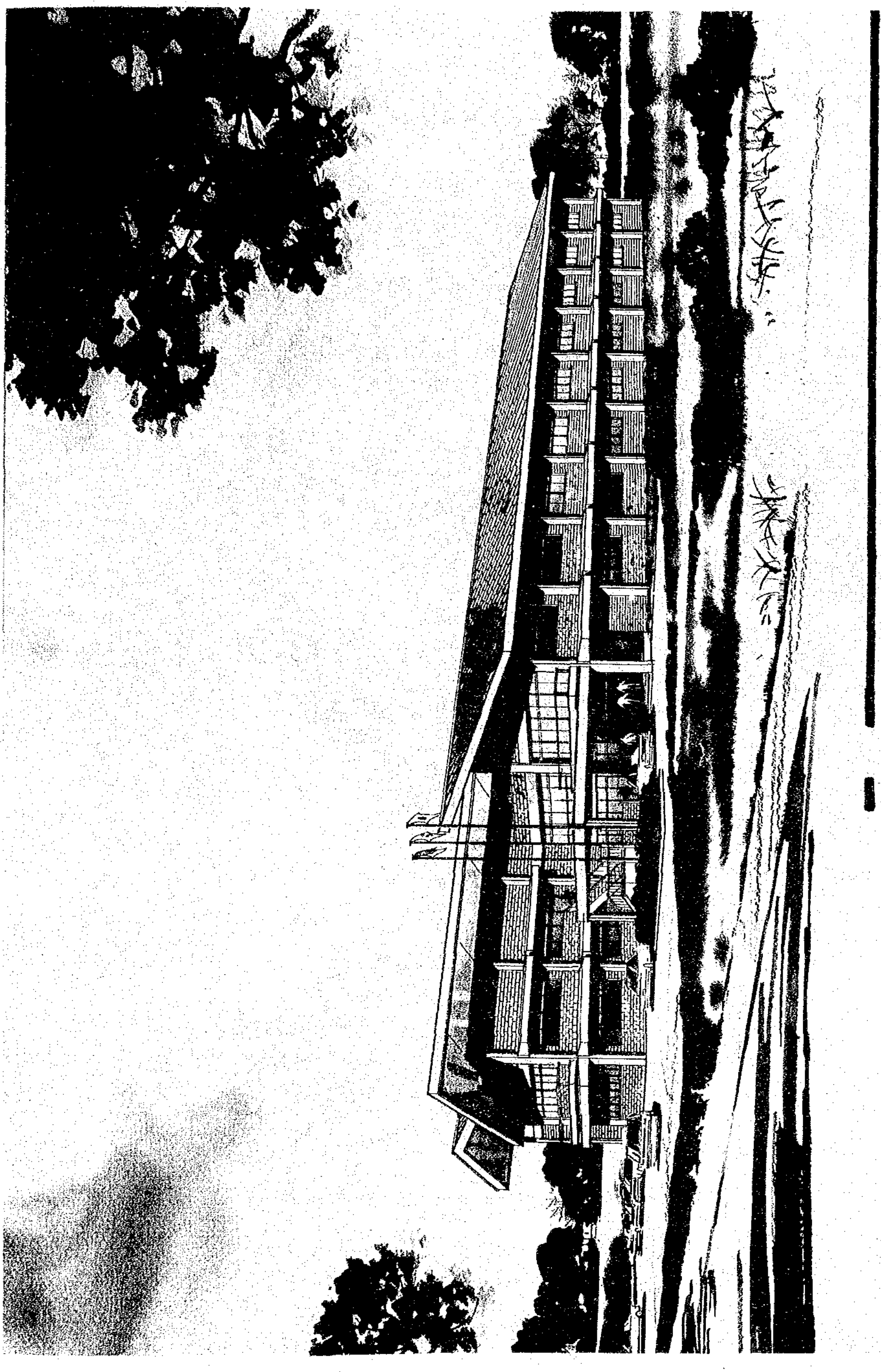
The team had discussions on the Project with the officials concerned of the Government of Indonesia and conducted a field survey in the Bandung and other areas. After the team returned to Japan, further studies were made, a draft report was prepared and a mission to explain and discuss it was dispatched to Indonesia. As a result, the present report has been prepared.

I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

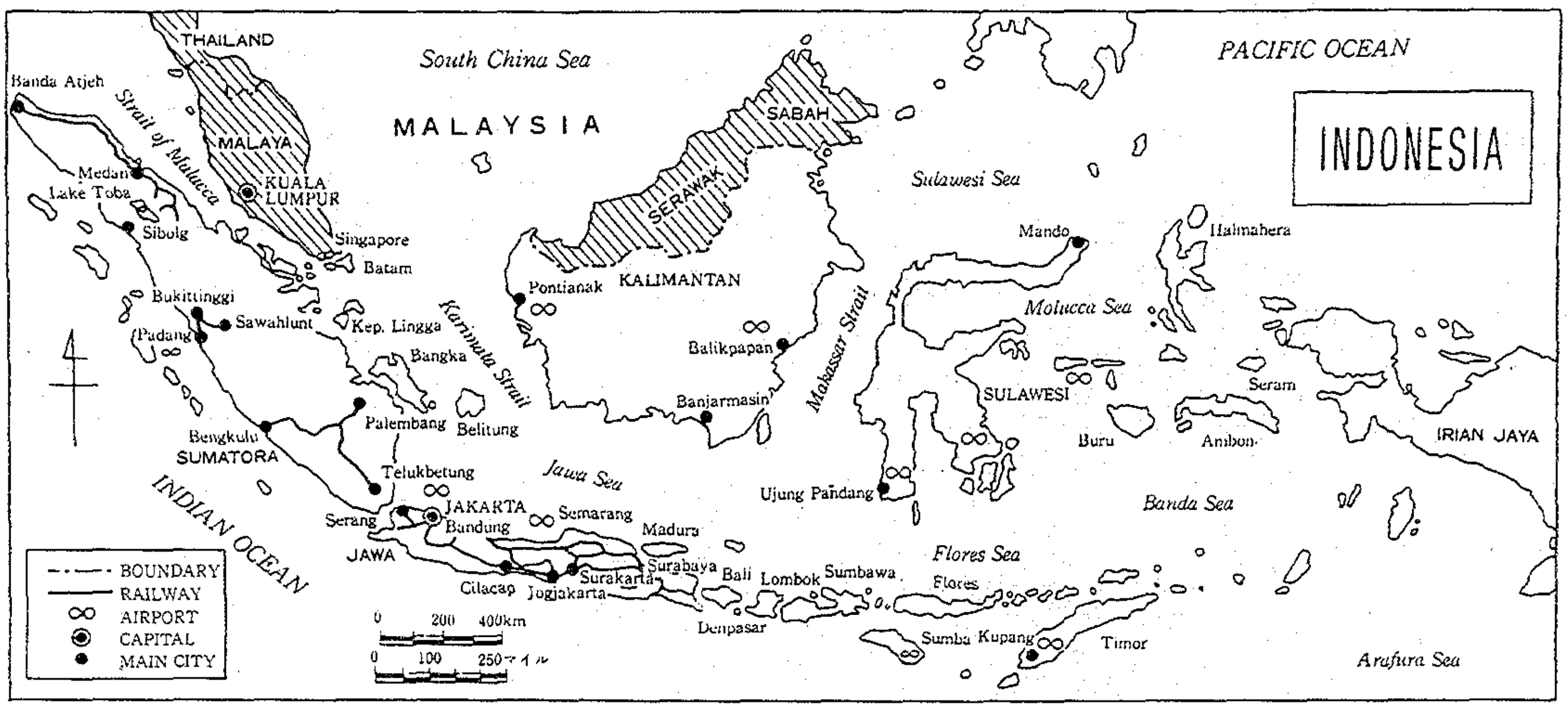
I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

July, 1987

Keisuke Arita
President
Japan International Cooperation Agency



INDONESIA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MALAYSIA
THAILAND
MALAYA
KUALA LUMPUR
Singapore
Batam
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SERAWAK
KALIMANTAN
Pontianak
Balikpapan
Banjarmasin
Strait of Malacca
Karimata Strait
Makassar Strait
Banda Atjeh
Medan
Lake Toba
Sibolg
Bukittinggi
Sawahlunt
Padang
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Bengkulu
SUMATORA
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JAKARTA
Serang
Bandung
Semarang
JAWA
Cilacap
Jogjakarta
Surakarta
Surabaya
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Bali
Denpasar
Lombok
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Timor
Sulawesi Sea
Mando
Molucca Sea
SULAWESI
Ujung Pandang
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Seram
Ambon
Banda Sea
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AIRPORT
CAPITAL
MAIN CITY
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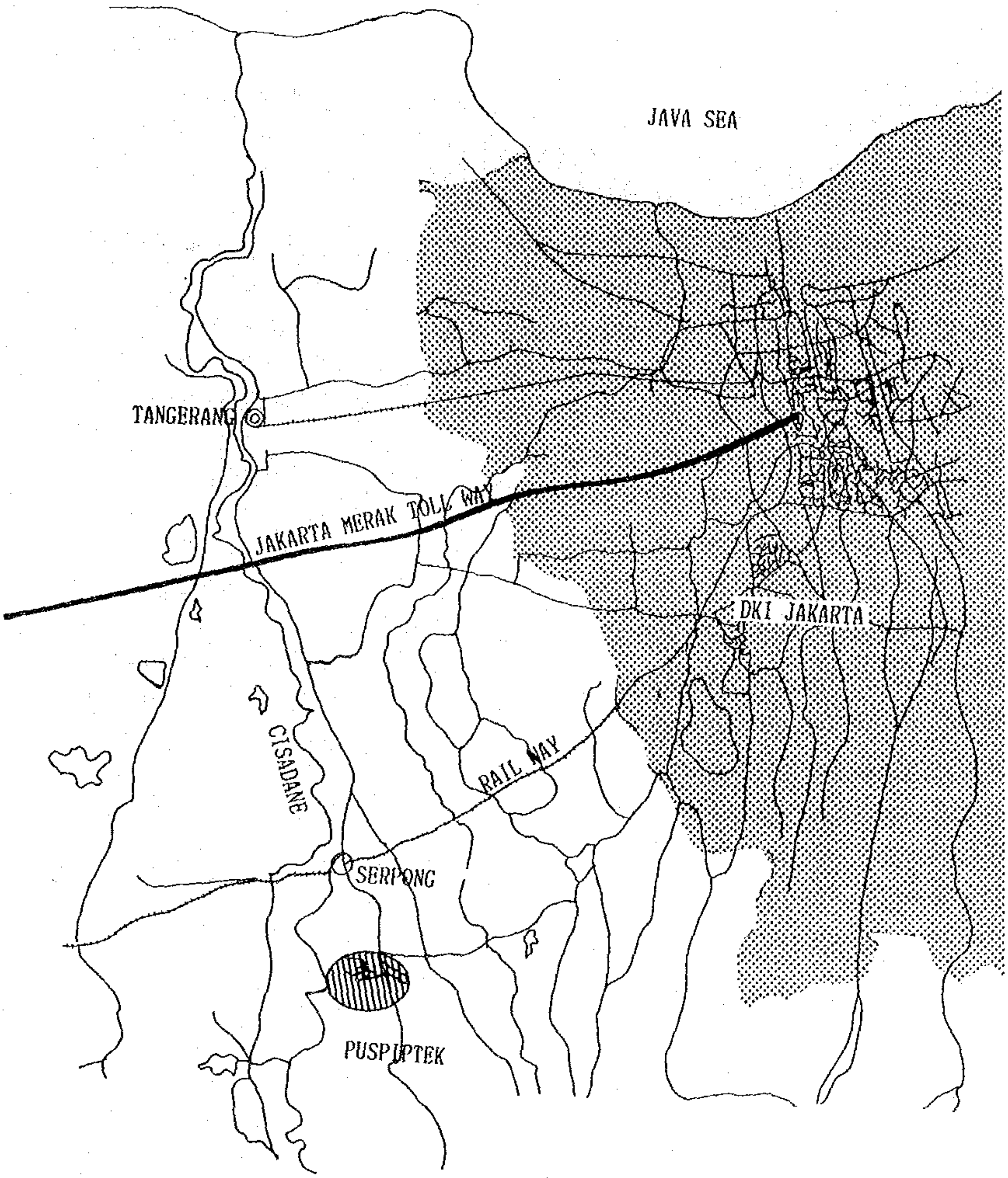
Project Site



SUMMARY

The Republic of Indonesia is the largest island nation in the world, and extends from the Indian Ocean to the Pacific Ocean. The country has a land area approximately 5.5 times as large as Japan, and consists of as many as 13,700 islands including the major ones, Sumatra, Java, Kalimantan, Irian-Jaya and Sulawesi. The population was 165 million as of 1985, fifth largest in the world. The Republic of Indonesia occupies a leading position in Asia as regards natural resources, and is blessed with rich underground reserves of petroleum and gas, the largest in Asia.

Indonesia increased its production of fiber, cement, fertilizer, iron & steel, aluminum and plywood through the 3rd 5-year National Development Plan (fiscal 1979 to 1983; April to March of the following year being the Indonesian fiscal year), and also increased its development of social capital, such as telephones, electric power, roads and bridges, and nearly established self-sufficiency in rice production. Such a development of the Indonesian economy owes much to the export of petroleum and gas; for example, the export ratio of these two items to total exports in 1984 reached 73.2%.

In order to improve this dependency of the economy on petroleum and gas, and establish a well-balanced economic structure, in the 4th 5-year National Development Plan (fiscal 1984 to 1988), the Indonesian Government is striving for the promotion of non-petroleum and non-gas industries, especially the promotion of export industries.

In light of this governmental policy, the non-petroleum and non-gas mining departments are investigating new mineral resources and also ways of increasing production of the existing minerals. Furthermore, they are making efforts to develop the new mining technology related thereto.

The major non-ferrous metal minerals found in Indonesia include tin, copper, nickel and bauxite, etc. Among these minerals however, tin and nickel are the most important mineral resources to economic strategy, along with petroleum, cobalt and uranium, etc. The nickel ore in Indonesia accounts for more than 11% of total world reserves, and its production accounts for 6.3%.

Nickel ore is normally classified into sulfide and oxide ores. The oxide ore is called "Nickel laterite ore". It is said that nickel laterite ore accounts for 80% of the reserves of all nickel ores. However, 60% of the nickel produced is from sulfide ore. The reason for this is that the sulfide ore is more conductive to nickel concentration by existing mineral dressing technology, and energy consumption is small in its leaching. As a result however, the sulfide ore, with only small quantities of remaining reserves, may possibly be exhausted. Consequently, it is considered that the nickel laterite ore will increase in importance in the future as nickel ore replacement for sulfide ore.

The nickel ore reserved in Indonesia is exclusively nickel laterite ore. From this deposit, a high grade nickel laterite ore with 2% or more nickel content is used for export, while the lower grade nickel laterite ore remains unused at present. On the other hand, Indonesia imports nickel metal as a product from foreign countries in order to satisfy the domestic demand for nickel, and the amount of its import is increasing year by year. In order to cope with an expected increase in domestic demand, and to promote the conversion of the nickel production from sulfide ore to oxide ore in the worldwide view, the development of technology of processing the low grade nickel laterite ores, left unused at present, and producing nickel metal is an important national task.

To achieve this, the Indonesian Government has requested the technical cooperation of the Japanese Government in the study on the mineralogical and the metallurgical studies, regarding the processing of low grade nickel laterite ore. In response to this request, the Japanese Government has dispatched experts since 1982 to the Research and Development Centre for Metallurgy (RDCM) which belongs to the Indonesian Institute of Sciences (LIPI), and a fundamental research stage is now being completed at the laboratory level.

In order to achieve further results, the Indonesian Government asked the Japanese Government for project-type technical cooperation to carry out a pilot plant testing for obtaining engineering data for the possible future industrialization , and grant aid for the construction of research facilities including the grant of experimental and research equipment and a pilot plant necessary for the study.

The Research and Development Centre for Metallurgy (RDCM) has an administration division and four research divisions. The Extraction Metallurgy Division, one of the divisions, is responsible for this project. This project is generally controlled by the Deputy Chairman for Technical Sciences of LIPI, and the Head of RDCM is responsible for the execution of this project as project coordinator. The Head of the Extraction Metallurgy Division as a project leader, directs and supervises 17 researchers, 17 technicians and 8 management office clerks. All Extraction Metallurgy Division members will be practically engaged in this project.

RDCM is located now in Bandung City, but it is scheduled to be moved to the National Centre for Research, Science and Technology (PUSPIPTEK) in Serpong in the western suburbs of Jakarta. PUSPIPTEK is directed to concentrate various governmental research agencies dispersed in districts of Indonesia in order to accomplish more efficient research. In 1976, PUSPIPTEK was established by presidential decree. At present, five laboratories have been completed on the 350 hectare site, and 3 more laboratories are now under construction.

The RDCM site is allocated to the northwestern part of this PUSPIPTEK complex. The PUSPIPTEK authorities are scheduled to execute the construction of roads, water supply, electricity, and telephone cabling works up to the site.

The proposed technology to be transfered by this project-type technical cooperation is called the Japanese type modified Nicaro-process. The hydrometallurgical ammonia leaching process for low grade nickel laterite ore includes a basic process which has been put into pratical use for the first time in Cuba, called the Nicaro process. There is also a Japanese type modified Nicaro process (SMM Process) which has improved the entire process to the demerit of the original Nicaro process. This method is characterized by low energy costs in processing, separate recovery of nickel and cobalt and recovery of various types of nickel compounds.

The outline of the facility and equipment included in this Project is as follows:

(1) Buildings:

Laboratory Building
Pilot Plant Building
Energy Centre Building
Ore Storage Building
Dangerous Material Storage Building

(2) Pilot-Plant Facilities:

Ore Preparation Facility
Reduction Furnace Facility
Ammonia Leaching Facility
Basic Nickel Carbonate Recovery Facility
Solvent Extraction Facility
Nickel and Cobalt Electrowinning Facility
Pollution Control Facility

(3) Analytical and Laboratory Equipment:

Analytical Equipment
Laboratory Equipment

The project costs to be borne by the Indonesian side are estimated at approximately 360 million rupiah.

Through the execution of this project, if further industrialization is accomplished, by developing the technology of recovering nickel metal economically from the low grade nickel laterite ores which have not yet been utilized, along with the recovering of metallic cobalt as a secondary product, the present situation in which Indonesia relies on imported nickel metal will not only be improved, but it will also contribute to the acquisition of foreign currency. It will, instead of exhausting the sulfide ore reserves, be significant in raising the worldwide economic valuation of Indonesia's rich reserves of nickel laterite ore.

CONTENTS

CHAPTER 1 INTRODUCTION

The Republic of Indonesia, aiming at improving its economic dependency upon petroleum and gas, is striving to promote export industries such as non-petroleum and non-gas industries in the 4th 5-year National Development Plan, starting from 1984. In response to this governmental policy, non-ferrous mining departments are scanning for unknown minerals, while looking for the development of new industrial technology.

Nickel is a non-ferrous metal, and when mixed with iron it gives better hardness and strength and is used to manufacture special steels such as stainless steel which has the quality of heat resistance, anti-corrosion and antifriction. Nickel ore, as a raw material of nickel, is classified into sulfide ore and nickel laterite ore (oxide ore). Sulfide ore, having not much problem when nickel leaching is carried out, is mainly used at present as a primary ore of nickel leaching. However, it is feared that sulfide ore will be exhausted, because of its small reserves. On the other hand, high grade nickel laterite ores of which the content is more than 2%, are mainly being used, while low-grade ores of which the content is less than 2%, are used for leaching in only 4 countries in the world, since the energy cost required for leaching is expensive.

Indonesian nickel ores are all nickel laterite ores; even in Indonesia, only high grade ores can be exported, while low grade ores are left unused. In consideration of this situation in Indonesia, instead of sulfide ore, the development of the technology for processing the low grade nickel laterite ores, presently left unused, is being taken up as a national task, taking into account the anxious situation of exhaustion of sulfide ores which are now mainly used for nickel leaching worldwide.

In order to achieve this task, the Indonesian Government has called on the Japanese Government for technical cooperation. In response to this request, the Japanese Government, since 1982, has dispatched experts to the Research and Development Centre for Metallurgy (RDCM) which belongs to the Indonesian Institute of Sciences (LIPI), and the technical cooperation has been performed. This technical cooperation has obtained the fruitful result for the fundamental study related to the low grade nickel laterite ore leaching, on the basis of laboratory scale and will be completed.

In general, when industrialization is to be conducted by developing a new technology, first, the study starts at the stage of the laboratory scale. Then, engineering data is collected for the industrialization, by performing a demonstration test at the pilot plant scale. Finally, a large size and full scale industrialized plant will proceed from the small size industrialized plant.

As a result of this study on the basis of laboratory scale mentioned above, the Indonesian Government decided to start its study on the basis of pilot plant scale as the following stage for industrializing the leaching of the low grade nickel laterite ore, and requested the project-type technical cooperation of the Japanese Government. In reply to this request, the Japanese Government dispatched the preliminary survey team in March, 1986.

The technology, as a subject of this technical cooperation, is called the Japanese type modified Nicaro-process in which the leaching technology of low grade nickel laterite ore, turned to practical use for the first time in Cuba as a Nicaro process, was improved all over the process to decrease the energy consumption. Only a few countries in the world including Japan have an experience in application of this technology at the laboratory plant level. For this reason, the Indonesian Government requested the grant aid of the Japanese Government in August 1986 for the construction of buildings and pilot plant facilities, as well as supplies of analytical and laboratory equipment necessary for the experiment and research by means of this project type technical cooperation.

In answer to this request, the Japanese Government decided to conduct a basic design study for the purpose of determining the validity of the grant aid, and fundamental framework of this project. Between February 16 and March 7, 1987, the Japan International Cooperation Agency (hereinafter referred to as JICA) dispatched to the Republic of Indonesia a basic design study team, headed by Dr. Kenji Tomita, a JICA Special Technical Advisor. This study team was also accompanied by long-term study staff related to project-type technical cooperation. The study team consulted with the Indonesian Parties concerned such as LIPI and RDCM, made an on-site inspection of the relevant facilities including the facility of RDCM and the National Centre for Research, Sciences and Technology (PUSPIPTEK) where this project site is to be located, and collected the necessary data for this project. The outline of the discussions with the Indonesian side is as follows:

1) Background of the request for this project
2) Present situation of RDCM
3) Present situation and future view of nickel laterite research in RDCM
4) Confirmation of the request contents
5) Budgetary plan and personnel planning related to this project on the Indonesian side
6) Confirmation related to the preparation of infrastructure

The basic agreement reached through a series of discussions with the Indonesian side was summarized as Minutes of Discussions, which were duly signed by representatives of both parties on February 25, 1987.

This report was analyzed in Japan, based upon the study result mentioned above and was summarized as a "Basic Design Study Report on the Project for Establishing the Metallurgical laboratory for Laterite in the Republic of Indonesia".

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1 Present Situation of the Non-Ferrous Mining Industry in Indonesia

According to the Regulation (No. 27 year 1980) of Indonesia, mining materials are divided into three groups. The main agencies for the development of each group are defined below.

(Group A) Minerals Indispensable for the National Economy

Main development agencies: state companies or foreign enterprises.

Minerals: oil, liquid bitumen, paraffin, natural gas, solid bitumen, asphalt, anthracite coal, lignite, peat, uranium, thorium, other radioactive materials, nickel, cobalt, tin.

(Group B) Minerals Required for Improving the Standard of Living

Main development agencies: private enterprises and individuals.

Minerals: iron, manganese, titanium, bauxite, copper, lead, zinc, platinum, silver, etc.

(Group C) Minerals which are not Internationally Marketable

Main development agencies: private enterprises and individuals.

Minerals: halite, asbestos, alum, bentonite, marble, limestone, dolomite, granite, clay, etc.

The development of minerals belonging to Group A depends heavily on technology and capital. Development is to be implemented by state companies or foreign enterprises which are engaged in mining activities as contractors. These minerals are defined as strategic ones for sustaining the economic basis of the nation. Of the non-ferrous metals belonging to Group A, nickel, cobalt and tin are specified as strategic minerals. Accordingly it has been determined that Indonesia's national policy concerning non-ferrous metals will be developed with the greatest emphasis on nickel, cobalt and tin.

To illustrate the present situation of mineral production in Indonesia, the list of mineral products, excluding oil and natural gas, which was released by the National Bureau of Statistics (Biro Pusat Statistik) for the 1982/83 fiscal year, is presented in Table 2-1.1.

Table 2-1.1 Mineral Production in Indonesia (in 1,000 Rp) (From Indonesia's Mineral Statistics 1982/83, Biro Pusat Statistik)

Mining Commodities	Value of gross output	
1. Coal	12,949,709	
2. Asphalt	3,925,593	
3. Granite	25,001,032	
4. Manganese	1,314,365	
5. Iron Sand Concentrate	1,369,599	
6. Copper Concentrate	73,861,333	
7. Phosphate	5,106	
8. Nickel Ore	23,682,879	TOTAL 83,816,521
9. Nickel Matte	60,133,642	
10. Gold & Silver	3,099,862	
11. Bauxite	5,277,647	
12. Salt	7,074,458	
13. Tin Concentrate	263,854,869	
TOTAL	481,550,094	

The three non-ferrous metals with the largest production, according to the table, are tin, nickel and copper in that order. (The amount of "nickel" is the sum of nickel ore and nickel matte.) Among non-ferrous minerals bauxite, gold and silver follow the three, but their production is far below them. The production of tin, nickel and copper which contribute a great deal to the Indonesian economy by earning foreign currency through their high production, are briefly described.

1) Tin

Indonesia possesses part of the world's largest veins of tin which extend through Burma, Thailand and Malaysia. This makes Indonesia the third largest tin producing country in the world, next only to Malaysia and Thailand. (Indonesia's tin production in 1983 was 12.4% of the world's total, the third highest in the world.) Tin production is being implemented by an Indonesian state company and three enterprises based on foreign capital, which are engaged in comprehensive exploration, development and refining. The following corporations are involved:

P.T. Timah:	The state company producing 3/4 of Indonesia's total tin production.
P.T. Broken Hill:	An affiliate of the Broken Hill Corporation of Australia.
P.T. Koba Tin:	25% equity, P.T. Timah. 75% equity, Kujuara Mining, Australia.
P.T. Riau:	10% equity, P.T. Timah. 90% equity, Broken Hill International.

Most of the tin ore produced is smelted and refined in Indonesia and the metal is exported. Therefore the tin mining industry of Indonesia is regarded as a mature industry which makes full use of the abundant domestic natural resources.

2) Nickel

World nickel ore resources can be broadly classified into sulfide ore and oxide ore (nickel laterite ore), and it is presumed that the oxide ore accounts for 80% of the total. Of world nickel production, 60% comes from sulfide ore, and the remaining 40% from oxide ore. In Indonesia, there is no sulfide ore, and only oxide ore exists. As the nickel content of the sulfide ore can be enriched by ore-dressing technology, the sulfide ore is considered to be the more economical resource of nickel in general, because it is less energy intensive. However, depletion of sulfide ore is anticipated owing to the smaller reserves and greater consumption. Consequently, nickel laterite ore, which has larger reserves, will without fail become more important in future.

Nickel laterite ore is generally classified into high-grade ore with a nickel content of 2.0% or more, and low-grade ore with nickel content of less than 2.0%. The geological compositions of the different types of nickel ores are described later in 2-2-1.

The world nickel laterite ore reserves are illustrated in Table 2-1.2.

The reserves of nickel laterite ore in Indonesia accounts for more than 11% of the world's total, as indicated in the table. It is obvious that Indonesia stands highly at advantage in nickel resources.

Nickel laterite ore contains a small amount (1/10 to 1/40 of the nickel content) of cobalt. Cobalt is an important mineral resource, and is designated as a strategic metal in Group A.

Nickel production in Indonesia is being implemented by P.T. Aneka Tambang, an Indonesian state company, and P.T. International Nickel Indonesia, which is 98% owned by Inco, Ltd. of Canada, called P.T. Inco.

P.T. Aneka Tambang used to mine nickel ore in the Pomalaa area of Sulawesi and exported high quality ore to Japan. In 1976, however, it constructed a ferro-nickel smelting plant in that area and started exporting ferro-nickel. Later, the company developed a nickel mine on Gebe Island in the northern Moluccas, and moved its main operation of nickel ore for export to Gebe Island in 1979.

Table 2-1.2 The World Nickel Laterite Ore Reserves (1984)

(From Nickel Economy, 1984, Roskill Information)

Country	Company	Grade (%Ni)	Ore (mill.t)	Nickel contained (000t)
Australia	Queensland Nickel	1.3	22	294
	Others	1.3	29	371
Brazil	...	1.5	275	4,164
Burma	...	3.1	16	50
Burundi		1.5	455	6,825
Colombia	Cerro Matoso	2.7	21	567
	Others	...	40	...
Cuba	Cubaniquel	1.3	240	3,100
Dominican Republic	Falcondo	1.8	44	244
Greece		1.2	347	4,164
Guatemala		1.8	44	792
India		1.0	100	981
Indonesia	P.T. Inco	1.2	65	780
	Aneka Tambang	2.5	200	5,000
				5,780
New Caledonia		2.5	360	9,000
		1.5	400	6,000
				15,000
Papua New Guinea		1.1	82	913
Philippines		1.6	350	5,600
USA	Hanna	1.5	17	225
	California	0.8	62	500
Yugoslavia	Macedonia	1.0	110	1,100
		Total listed		50,670

P.T. Aneka Tambang conducts the following operations:

(1) Nickel mining and smelting at Pomalaa
(2) Nickel mining at Gebe Island
(3) Bauxite mining at Kijang
(4) Gold mining at Cikotok
(5) Processing and Refining of precious metals in Jakarta
(6) Iron sand mining at Cilacap

Approximately 70% of the total sales of this corporation are achieved by nickel mining and smelting of items 1) and 2) above. The total number of employees is 5,900.

P.T. Inco started mining nickel ore and producing nickel matte in the Soroako area of Sulawesi in 1977, with all of the nickel matte exported to Japan. Nickel production in Indonesia is illustrated in Figure 2-1.3. The production of nickel in 1983, as indicated in the table, corresponds to 6.3% of the world's total.

3) Copper

The deposits of copper in Indonesia are smaller in their scale, than those of tin and nickel and could scarcely be the target of exploitation. The only example of development has been the Eltzberg Copper Mine in Irian Jaya, operated by Freeport Indonesia Inc.; 81% of its equity is owned by Freeport McMoran, Inc. of U.S.A., 8.5% by the Government of Indonesia, 3.5% by Norddeutsche Affinerie of West Germany, and 7% by South Pacific Copper of the Netherlands. There is no copper refinery, and all the copper concentrate is exported to Japan and other countries.

Table 2-1.3 Nickel Production in Indonesia

(From a brochure of P.T. Aneka Tambang and the annual report of P.T. Inco.)

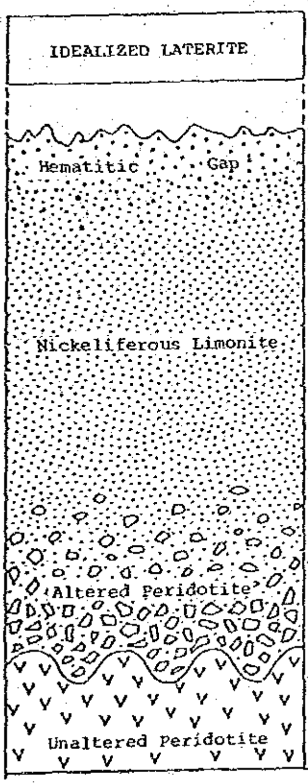
	P.T. Aneka Tambang		P.T. Inco
	Nickel Ore Export	Ferro-Nickel Production	Nickel Matte Production
	(in dry tons)	(in ton-nickel)	(in ton-nickel)
1973	727,904	-	-
1974	748,192	-	-
1975	849,648	-	-
1976	877,025	3,403	-
1977	831,964	4,996	1,620
1978	864,369	4,435	4,500
1979	1,114,469	3,990	8,589
1980	1,287,434	3,851	20,302
1981	1,184,938	5,117	19,940
1982	1,054,891	4,336	13,748
1983	737,036	5,722	18,228

2-2 Present Situation of Nickel Laterite Research in Indonesia

2-2-1 Urgent Need for Technology to Process Low-Grade Nickel Laterite

A conceptual picture of nickel laterite deposits and the corresponding processing method are illustrated in Figure 2-2.1.

Figure 2-2.1 Conceptual Picture of Nickel Laterite Deposits and the Corresponding Refining Method
(From International Laterite Symposium, 1979)



	APPROXIMATE ANALYSIS-% (%)					EXTRACTIVE PROCEDURE
	Ni	Co	Fe	Cr_2O_3	MgO	
(A)	<0.8	<0.1	>50	>1	<0.5	—
(B)	0.8 to 1.5	0.1 to 0.2	40 to 50	2 to 5	0.5 to 5	Hydrometallurgy
(C)	1.5 to 1.8	0.02 to	25 to 40	1 to	5 to 15	Hydrometallurgy or Pydrometallurgy
(D)	1.8 to 3	0.1	10 to 25	2	15 to 35	Pyrometallurgy
(E)	0.25	0.01 to 0.02	5	0.2 to 1	35 to 45	—

The part marked "D" in the figure is the high-quality deposit, which can be processed by pyrometallurgy, mainly using the electric furnace. This method is used in many smelters throughout the world, including Pomalaa and Soroako in Indonesia. Low-grade nickel laterite is located in parts marked "B" and "C", and production by hydrometallurgy is more economical than by pyrometallurgy. Application of hydrometallurgy, however, is found only at Nicaro and Moa Bay in Cuba, Greenvale in Australia, Nonoc in the Philippines and Tocantins in Brazil. Nickel laterite plants throughout the world and the processing methods are presented in Table 2-2.1.

There is only a limited amount of high-grade nickel laterite ore, as indicated in Table 2-1.2, which is found in Indonesia, New Caledonia and Colombia. As a large number of smelters consume the high-grade ore with their pyrometallurgical methods, there is a world-wide tendency toward degradation of the nickel content in laterite ore. In mining the high-grade ore, the parts indicated as "A" and "B" in Figure 2-2.1 must be removed first, and part "B", which is called the low-grade ore, is not utilized after mining but left at the mine site.

Considering the world-wide trend toward degradation of nickel laterite, as well as the anticipated depletion of the sulfide nickel ore, it is very important to establish a method for processing low-grade nickel laterite, which is inevitably the nickel resource of the future. As nickel is specified as the most important strategic metal in Indonesia, the development of low-grade nickel laterite is vital for Indonesia's economy in the future.

Table 2-2.1 Nickel Laterite Processing Plants throughout the World (From Nickel Economy, 1984, Roskill Information)

Country	Company	Process	Production Capacity (Ni t/y)
Greece	Larco	Pyro	30,000
Yugoslavia	State owned	Pyro	12,000
USSR	Youjouralnickel	Pyro	-
Brazil	Morro de Niquel	Pyro	3,000
	Codemin	Pyro	8,000
	Tocantins	Hydro (NH_3 leach)	10,000
Cuba	Cubaniquel	Hydro (NH_3 leach)	34,000
	Cubaniquel	Hydro (acid leach)	24,000
Dominica	Falcondo	Pyro	30,000
USA	Hanna	Pyro	11,000
Indonesia	P.T. Aneka Tambang	Pyro	5,000
	P.T. Inco	Pyro	36,000
Japan	Nippon Mining	Pyro	9,000
	Nippon Yakin	Pyro	12,000
	Pacific Metals	Pyro	24,000
	Sumitomo	Pyro	18,000
Philippines	Nonoc	Hydro (NH_3 leach)	31,000
Australia	Greenvale	Hydro (NH_3 leach)	21,000
New Caledonia	SLN	Pyro	75,000

2-2-2 Present Situation of Nickel Research and Development and the Research and Development Centre for Metallurgy (RDCM)

In Indonesia, research on nickel processing is being carried out only in the Research and Development Centre for Metallurgy (RDCM). Presently the Institute of Technology in Bandung, which is the only university boasting a field of extraction metallurgy in Indonesia, and the state company Aneka Tambang, which runs nickel mines and a smelting plant, are not carrying out research in this field. The present status of activities in RDCM is described below.

RDCM is a research institution under the Indonesian Institute of Sciences (LIPI), and is located in Bandung City. The organization charts of LIPI and RDCM are shown in Figure 2-2.2.

A number of research institutions under LIPI, including RDCM, are located on the premises of LIPI in Bandung City.

The total number of staff in LIPI in Bandung is 518, and 173 of them belong to RDCM. A number of the researchers have studied abroad and 16 of RDCM researchers are now studying abroad.

The major research activities in RDCM are presented below.

Figure 2-2.2 Organizational Chart of the Indonesian Institute of Sciences and the Research and Development Centre for Metallurgy

(From Research and Development of Low Grade Indonesia Nickel Laterite, Research and Development Centre for Metallurgy, 1987)

Indonesian Institute of Sciences (LIPI)

Chairman
Vice Chairman

- Deputy for Social Sciences & Humanities
- Deputy for Natural Sciences
- Deputy for Technical Sciences
  1. RDC for Applied Physics
  2. RDC for Applied Chemistry
  3. RDC for Telecomunication, Strategic Electronics, Component & Materials
  4. RDC for Informatic & Computer Science
  5. RDC for Electric Power & "Mecatronic"
  6. RDC for Metallurgy
- Deputy for Scientific Infra-structure
- Deputy for General Affair

Research and Development Centre for Metallurgy (RDCM)

RDC for Metallurgy

- Administration Division
  1. General Affair
  2. Finance
  3. Personnel
  4. Logistic
- Extraction Metallurgy Div.
  - Laboratories
    1. Ore Concentration
    2. Hydro Metallurgy
    3. Pyro Metallurgy
    4. Electro Metallurgy
    5. Process Development
- Metals Technology Div.
  - Laboratories
    1. Casting & Alloy
    2. Metals Forming
    3. Heat Treatment
    4. Welding
    5. Finishing
- Corrosion Div.
  - Laboratories
    1. Basic Corrosion
    2. High Temp. Corrosion
    3. Stress Corrosion
    4. Industry & Process Cor.
    5. Atmosferic Corrosion
- Science & Technology Service Division
  - Laboratories & Section
    1. Chemical Analysis
    2. Metallography
    3. Testing
    4. Engineering
    5. Workshop
    6. Documentation & Information

1 Research and development.

2 Studies.

3 Dissemination of information.

4 Technical and consultancy services

: Contract research

: education and training

: consulting

: technical services

: information services

: others

The following research and development themes are presently being studied.

1 Processing of low-grade nickel laterite ore.

2 Bauxite upgrading.

3 Lead and zinc refining.

4 Recovery of rare earth metals from tin tailings.

5 Processing of industrial wastes.

6 Production of coke from non-coking coal.

7 Utilization of manganese ore.

8 Utilization of jarosite.

Research on low-grade nickel laterite processing started in 1982, with the assistance of Japanese experts dispatched by the Japan International Cooperation Agency (JICA), and now that laboratory scale processing method has been established, further development of the process is needed in the pilot plant testing.

The following studies have been executed in RDCM in Bandung in the past five years.

1 Mineralogical Studies

: Analysis of constituent minerals of low-grade and high-grade Pomalaa ore.

: Research on decomposition and recrystallization temperatures of constituent minerals.

2 Research on Reduction Roasting and Leaching

: Research on the process of iron powder addition reduction roast acid leaching.

: Research on the process of iron powder addition steam reduction roast acid leaching.

: Research on the process of calcium chloride addition reduction roast ammonia leaching.

: Research on coal added pellet reduction roast ammonia leaching.

: Research on the process of coal, calcium chloride and sulfur added pellets reduction roast ammonia leaching.

3 Research on Purification of NH_3 Leach Liquor

: Research on elimination of magnesium by phosphate.

4 Research on Solvent Extraction

: Research on NH_3 stripping and cobalt oxidation methods.

: Research on treatment by alkyl-phosphoric, alkyl-phosphonic and carbonic acids.

: Research on a multi-stage method for separation of cobalt from nickel.

The researches from 1 through 4 above, are the hydrometallurgical methods for nickel laterite ore. The research described in 2 , which has been conducted in the laboratory, is a comparative study of the adaptability of various hydrometallurgical methods to Pomalaa ore. The results of the study indicated that the process of coal added pellet reduction roasting ammonia leaching is the most suitable for Pomalaa ore.

The pilot plant testing of low-grade nickel laterite will be a future top-priority item in the Extraction Metallurgy Division of RDCM.

In order to make research on nickel laterite successful in Indonesia, where nickel is designated as a strategic metal, it is necessary for researchers and engineers to become learned with extensive knowledge about practical applications, as well as basic aspects of related technologies, through the pilot test plant which is one step nearer to industrialization.

2-3 The National Centre for Research, Science and Technology (PUSPIPTEK) and Transfer Planning of the Research and Development Centre for Metallurgy (RDCM)

In October, 1976, the Indonesian Government established the National Centre for Research, Science and Technology (PUSPIPTEK), under the control of the Minister of State for Research and Technology, to concentrate in one place the various national research agencies for science and technology which are dispersed locally at present.

The purpose is to:

- provide conditions for efficient research by allowing continuous contact and involvement between research organizations;
- share the common facilities necessary for research;
- train persons in research, science and technological fields;
- grasp international developments in research, science and technology, so as to coordinate them with Indonesian developments; and
- support research and its application in private research agencies, various industries and various fields.

The PUSPIPTEK complex includes a 350 hectares site in Serpong in the western suburbs of Jakarta. This will later be expanded to 500 hectares. The complex extending to the east and west is divided by the Tangerang-Bogor road leading to the south and north. In the 120 hectares residential zone on the east side, there are approximately 600 flat-type houses including those under construction, a mosque, elementary and junior high schools, clinics, guest houses, parks and sports facilities. The research zone of 230 hectares is on the west side, where 5 laboratories have already been completed for research on material dynamics, energy, metrology, applied physics and applied chemistry. Also now under construction are aerodynamics, electronics laboratories and a nuclear reactor for multipurpose research.

All these buildings are constructed by the Indonesian Government, while foreign cooperation is given in areas such as technical cooperation and grant of equipment. The Japanese Government started a survey related to the effective utilization of Banko coal in 1984 in the 5-year plan. At present, tests are being carried out with a pilot plant constructed within the Energy Laboratory.

The PUSPIPTEK complex presently has research agencies which belong to the Indonesian Institute of Sciences (LIPI), the National Atomic Energy Agency (BATAN), and the Agency for the Assessment and Application of Technology (BPPT). The Research and Development Centre for Metallurgy (RDCM) which belongs to LIPI, plans to transfer all its facilities from Bandung to the PUSPIPTEK complex as shown in Table 2-3.1. The entire transfer is to be completed in fiscal 1994.

The Metallurgical Laboratory for Laterite to be constructed in the PUSPIPTEK complex will belong to the Extraction Metallurgy Division of RDCM. However as the Extraction Metallurgy Division intends to be devoted to the research of nickel laterite ore from now on, the entire Extraction Metallurgy Division will move to Serpong following the construction of the new laboratory.

For the residence of transferred staff, 3 to 4 houses presently under construction in the above residence zone are allocated. 10 houses and 15 apartment houses are planned to be assigned to staff of RDCM by the time the facilities in this project are completed.

Table 2-3.1 Transfer Schedule of RDCM to PUSPIPTEK

Fiscal Year / Division	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	Floor space m^2
Administration					2500				2500
Science & Technology Service				1500			1500		3000
Corrosion			2250						2250
Metals Technology				1800			2000		3800
Extraction Metallurgy	2100					2000			4100

Table 2-4.2 National Center for Research, Science and Technology (PUSPIPTEK)

as of Feb., 1987

	Facility			Actual Cond. of Constr.					Actual Cond. of Internat. Coop.						
No.	Laboratory Name	Abbrv. Name	Upper Org.	Surv.	Schem. Desn.	Work Prepr.	Und Const.	Compl.	Equip.		Trainee Accep		Experts Envo.		Coop. Cont. Unclr.
									loan	grnt.	loan	grnt.	loan	grnt.	
1	Laboratory for Strength of Materials	LUK	BPPT					O	West Germany			West Germany		West Germany	
2	Laboratory for Energy (Banko Coal)	LSDE	BPPT					O	West Germany U.S.A.	Japan		West Germany U.S.A Japan		West Germany U.S.A Japan	
3	Laboratory for Aerodynamics	LAGG	BPPT				O		Holland			Holland		Holland	West Germany
4	Laboratory for Thermodynamics	LTMP	BPPT		O										France
5	Laboratory for Process Engineering	LTP	BPPT	O					France			France		France	U.S.A
6	Laboratory for Meteorological Disaster	LMBA	BPPT	O											
7	Laboratory for Metrology (Flow Meter)	LKIM	LIPI					O	West Germany	Japan		West Germany		West Germany	
8	Laboratory for Applied Physics	LFN	LIPI					O							
9	Laboratory for Applied Chemistry	LKN	LIPI					O							
10	Laboratory for Electronics	LET	LIPI				O								France
11	Laboratory for Metallurgy	LMN	LIPI	O											
12	Nuclear Reactor for Multi-purpose Research	RSG-LP	BATAN				O		West Germany			West Germany		West Germany	U.S.A France Italy Canada

(Source: PUSPIPTEK)

2-4 Contents and Progress of the Request

For the Government of Indonesia, research and development of the effective utilization of low-grade nickel laterite ore plays an important role in the acquisition of foreign currencies, thereby improving the economic conditions of the country. It was because of this, that in 1981 the Government of Indonesia requested the Government of Japan to provide technical cooperation to carry out a research program in the Research and Development Centre for Metallurgy (RDCM). The Government of Japan responded to this request by dispatching experts to RDCM, and research has since been conducted in RDCM under the guidance of Japanese experts. The basic research in the laboratory, conducted for approximately 5 years, was very successful. The next step is a program to establish technology for processing low-grade nickel laterite ore, on the basis of the successful result obtained; that is, a demonstration test program at a pilot-plant scale.

Development of low-grade nickel laterite ore processing technology, however, requires a very high level of technology, as exemplified by the fact that this topic is being studied by top metallurgists throughout the world. In addition, the financial constraints faced by the Government make it difficult for Indonesia to implement such a developmental program by itself.

For this reason, the Government of Indonesia requested funding in the form of grant aid, in addition to the project type technical cooperation, from the Government of Japan in May, 1986, in order to establish a pilot-plant and related research facilities.

The outline of the request is presented below.

1) Project Site

PUSPIPTEK Complex (Serpong City).

2) Implementation Body

The Research and Development Centre for Metallurgy under the Indonesian Institute of Sciences

3) Facilities and Equipment of the Requested Grand Aid

a. Pilot-Plant Facilities

1 1 set - Ore preparation facility.
2 1 set - Reduction furnace facility.
3 1 set - Ammonia leaching facility.
4 1 set - Basic nickel carbonate recovery facility.
5 1 set - Solvent extraction facility.
6 1 set - Nickel and cobalt electrowinning facility.
7 1 set - Pollution control facility.
8 1 set - Electrical and instrumentational facility.
9 1 set - Maintenance shop facility.

b. Analytical and Laboratory Equipment

1 1 set - Analytical equipment.
2 1 set - Laboratory equipment.

c. Buildings

1 1 - Analytical and laboratory building.
2 1 - Pilot-plant building.
3 1 - Ore storage.
4 1 - Dangerous materials warehouse.
5 Other buildings.

CHAPTER 3 CONTENTS OF THE PROJECT

3-1 Purpose of the Project

The purpose of the research to be carried out in this planned facility is to establish the technology for processing low-grade nickel laterite ore, which is found in abundance in Indonesia through the pilot plant testing, and thereby to help the economic progress of the country by commercializing this technology in future. Therefore, the construction of a pilot plant and related facilities is an important step towards the final goal.

The purpose of this project is summarized below.

1 To construct a pilot plant for processing nickel laterite ore and recovering nickel and cobalt metals, and to strengthen the research and development structure.

2 To establish the optimal processing method that is the most efficient and economical, and the plant operating conditions for the process, by operating the pilot plant and collecting and analyzing the data. And to collect the engineering data required for the construction of a commercial plant.

3 To install analytical and laboratory equipment related to the pilot plant.

4 To enhance the potential of researchers.

3-2 Studies on the Project Scheme

In this section, each item included in the request is studied based on an understanding of the status and role of the Research and Development Centre for Metallurgy in Indonesia.

(1) Pilot plant

It is well known that when newly developed technology is to be applied to an industrial operation, the results from laboratory experiments are first verified in a pilot plant demonstration, then in a small-scale commercial plant, and finally a large-scale commercial plant is constructed. This project verifies the new technology, based on laboratory tests conducted over the past 5 years at RDCM on the research and development of nickel laterite processing, by conducting tests with the pilot plant. This is an indispensable step in establishing new technology.

The ammonia leaching process being considered for this project is called the Japanese type Nicaro process (named the SMM-process), which is a fully improved version of the Nicaro process put into practical application for the first time in Cuba. Energy saving and high nickel recovery is expected from the SMM-process.

Each facility used in the pilot plant must be coordinated as part of the complete set of facilities which constitutes a comprehensive process.

The facilities listed in the request include all the necessary facilities, from laterite ore preparation to what is required for recovery of the final products, or nickel metal and cobalt metal. These facilities are considered to well cover the scope and the content needed for the research on the process which comprises the fundamentals of the laterite processing technology, and are considered to well meet the basic objectives of the project.

(2) Analytical and Laboratory Equipment

As this laterite processing research facility is to be established for research and development on the processing of low-grade laterite ore, samples to be treated, such as raw ore, leach liquor, intermediate salts and electrolytic nickel etc., will vary in their characteristics and have a wide range of forms.

The results of basic tests conducted in the laboratories will be subjected to verification in the pilot-plant test. The results of the pilot-plant test will be evaluated and analyzed in corresponding laboratories, and will then be taken into consideration in the next pilot-plant test. Consequently, analysis and research must be managed so that they are closely related to the pilot plant test.

However, equipment presently possessed by RDCM is not sufficient, and necessary equipment should be newly installed in order to implement the pilot plant test.

In particular, high-precision analyzing instruments such as ICP spectrometer, X-ray fluorescence spectrometer and electron probe micro-analyzer, etc., are indispensable for modern metallurgical research and play an important role in the smooth operation of the pilot plant.

(3) Buildings

The contents of the request for buildings are as follows.

o Number of buildings:	7 buildings including the analytical and laboratory building and pilot plant building
o Floor area:	2,100 m^2 in total
o Building equipment:	Water supply, drainage, sanitary, ventilation, air-conditioning, electricity and others.

When the contents of the respective buildings are studied, it is found that some buildings should be preferably rearranged and integrated. For example, it will be more effective functionally if the work shop building is integrated into the pilot plant building and the canteen building into part of the laboratory building respectively. In addition, the energy center building which supplies electric power to these buildings is newly required.

It seems that the request for the building equipment is nearly reasonable, however, as to air-conditioning equipment, taking into consideration the future maintenance and running costs, it is desirable that the objective floor area should be minimized where applicable. For example, the requested plan for laboratory building is of the middle corridor type. This type makes natural ventilation difficult to achieve, therefore, the air conditioning system would be required for the entire building. Consequently, the laboratory building should be of the side corridor type which may facilitate natural ventilation.

3-3 Outline of the Project

3-3-1 Execution agency and management system

(1) Execution agency

The execution agency for this Project is the Research and Development Centre for Metallurgy (RDCM), which belongs to the Indonesian Institute of Sciences (LIPI). The division which is actually engaged in research is the Extraction Metallurgy Division in RDCM.

(2) Management system

In LIPI, as shown in Fig. 2-2.2, 5 Deputies are appointed under the control of a Chairman, and RDCM belongs to the Deputy Chairman for Technical Sciences.

RDCM has an administration division and 4 research divisions including the Extraction Metallurgy Division under the control of the Head.

The Extraction Metallurgy Division has 5 laboratories under the Head.

The study related to the extraction metallurgy of nickel laterite ore belongs to the Extraction Metallurgy Division, which intends to be devoted to this study from 1987. When this Research Facility for Laterite is completed, the entire Extraction Metallurgy Division will move to the PUSPIPTEK complex at Serpong, and the Head of the Extraction Metallurgy Division will be directly responsible for the operation as Head of this facility. The Head of the Extraction Metallurgy Division is directed by the Head of RDCM at Bandung, who is controlled in turn, by the Deputy Chairman for Technical Sciences of LIPI.

3-3-2 Activities

The activities of this research institute, after the completion of the construction of facilities of the project, are presented below.

The design of this pilot plant is based on the SMM process, according to which research activities will be conducted. The following major subjects will be investigated in line with the SMM process.

1 Survey and analysis of the mineralogy of the raw ores.
2 Studies of drying and crushing conditions for ores.
3 Studies of pelletizing characteristics of materials and identification of operating conditions for producing high-quality pellets.
4 Studies of conditions for realizing high reduction rates and analysis of basic parameters for an optimal reduction furnace.
5 Studies of conditions in the ammonia leaching process which affects the nickel-leaching rate.
6 Establishment of a suitable purification method of leach liquor (removal of iron, manganese, copper, zinc, etc.).
7 Studies of crystallization characteristics of basic nickel carbonate (BNC).
8 Studies of parameters of the ammonia-recovery facility which minimize the loss of ammonia.
9 Studies of solvent extraction conditions for efficiently separating nickel and cobalt.

10 Studies of electrowinning.

11 Studies of methods for producing nickel oxide and nickel powder from BNC.

12 Analysis of heat, gas and water balance for all processes.

Each analytical and research laboratory promptly analyzes the large amount of data obtained during the pilot-plant operation, to provide guide lines for the following pilot plant operation.

By conducting laboratory scale tests and research at the same time, pilot-plant operation data will be verified.

The summary of the process of the pilot plant is given below. (See Figure 3-3-1, Basic Flow Sheet for Pilot Plant)

a) Ore Preparation

As laterite ore contains a large amount of moisture (25% to 30%, based on wet ore), it has to be dried. The coarse ore is crushed to an appropriate size and fed to the dryer. Coal and sulfur are added to the crushed ore, and, after grinding, pellets with a diameter of 10-15 mm are produced.

b) Reduction Roasting

The pellet is reduced and roasted in a vertical annular kiln, which has a reduction atmosphere of 700°C-850°C. Nickel and cobalt in the ore are selectively reduced to form metallic nickel and cobalt.

c) Ammonia Leaching

The roasted ore discharged from the reduction furnace is conveyed to the divider, where 2/3 of the total amount is rejected. The remaining 1/3 is sent to the subsequent ammonia leaching process.

The reduced ore is wet ground in ammonia solution from which nickel and cobalt is leached in 2-stage counter-current leaching system. The ammonia is distilled and separated from the solution after impurities have been removed, and the purified solution is fed to the basic nickel carbonate (BNC) recovery process. The residue after leaching goes to the 3-stage counter-current washing system, where the residual nickel and cobalt are recovered. The solution is then filtered after the ammonia has been stripped, and the tailings are disposed of.

d) BNC Recovery

The BNC precipitated from the solution after ammonia stripping is recovered as BNC cake by filtering. The BNC cake is actually a mixture of nickel carbonate and nickel hydroxide.

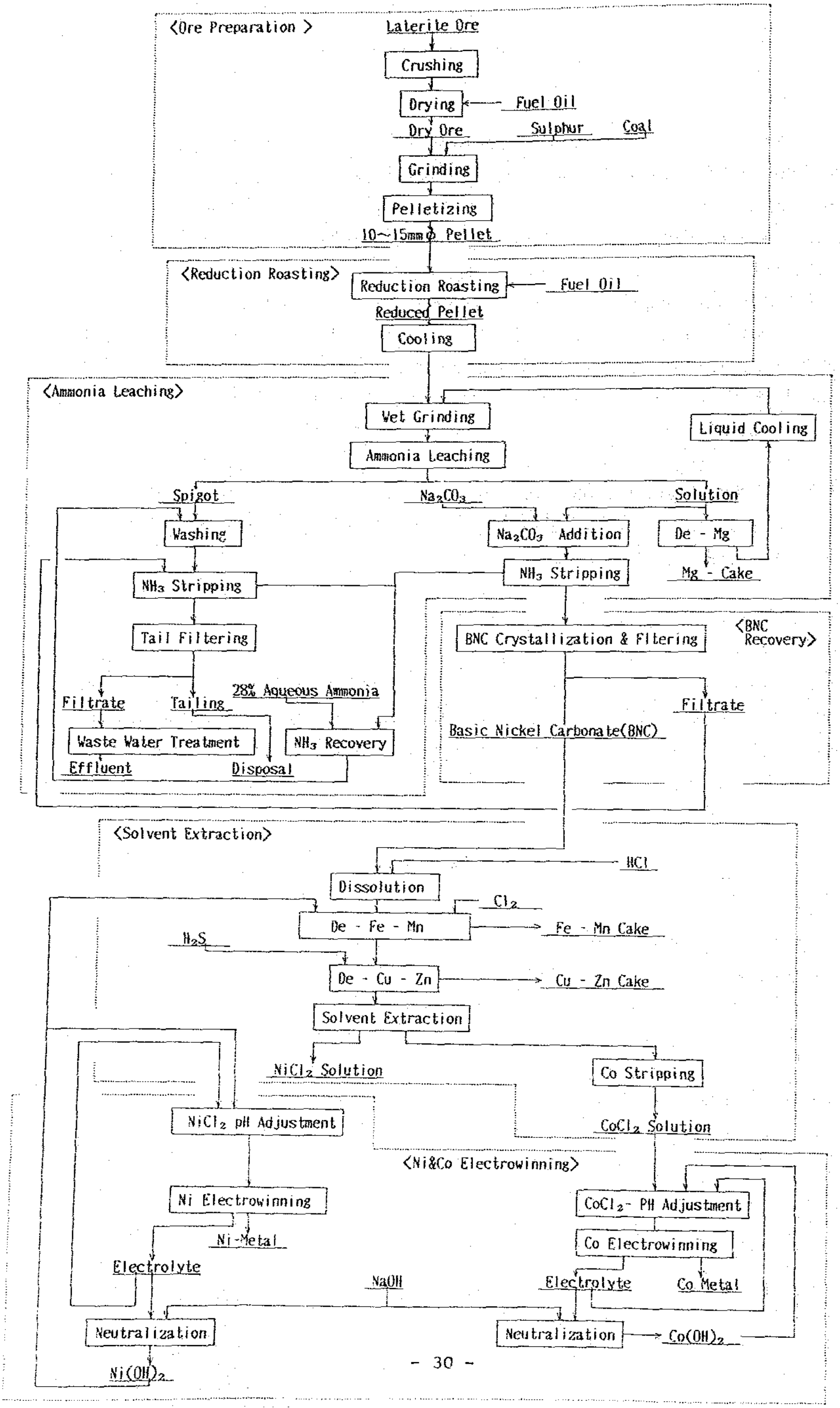
e) Solvent Extraction

The BNC cake is dissolved again in hydrochloric acid solution, after iron, manganese, copper, zinc, etc. are removed. The solution is then fed to the solvent extraction system. The mixer-settler is used in the solvent extraction system, where nickel chloride and cobalt chloride are separated with a suitable solvent.

f) Electrowinning

The nickel chloride solution and cobalt chloride solution, thus obtained by solvent extraction, after PH adjustment, are separately fed to the separate electrowinning cells, where metallic nickel and metallic cobalt are electrodeposited on the cathodes, using insoluble anodes.

Fig. 3-3. 1 BASIC FLOWSHEET OF PILOT PLANT



3-3-3 Location and situation of Project Site

(1) Location

The project site is located within the National Centre for Research, Science and Technology (PUSPIPTEK) complex in Serpong City, West Java Province. This site is situated in the suburbs 27 km southwest on a straight line from Jakarta. This area is in a farm village zone in whose vicinity rubber plantations are located along with paddy fields and upland fields. The PUSPIPTEK complex was built by clearing the hill areas near the Cisadane River, the largest in this district.

This Serpong district has become the object of a new urban plan, under the Jakarta Wide-range Metropolitan Cooperation Bureau (BKSP JABOTABEK) as a candidate for a dormitory town of Jakarta. Some housing estates are dispersedly found which are now under development along the Tangerang-Bogor road connecting Tangerang in the North and Bogor in the South. The population density in this district was 1,035 persons/km^2 as of 1984, and is projected to be 5,000 persons/km^2 in 2005. Incidentally, the planned population density in Jakarta is 18,000 persons/km^2.

(2) Traffic

The distance between the National Centre for Research, Science and Technology and the center of Jakarta City is approximately 40 km. The main route leading to this center enters the Jakarta-Merak toll highway connected to the Jakarta outer loop highway, and gets out of the Tangerang Interchange, passing the aforementioned Tangerang-Bogor road southward, and passing through Serpong City. At present, buses shuttle between Tangerang and Bogor, but this shuttle bus service is very limited. There is no direct public transport connecting PUSPIPTEK and Jakarta.

The national railway (PJKA) line connecting Jakarta and Merak on the west coast passes through Serpong. This railway is now a single line, but a double line between Tanah Bang in Jakarta and Serpong is being planned, and in the early 1990's it is expected to be a commuter line.

Within a 40 km radius, 7 air strips including Jakarta International Airport are located, and a heliport is set up within the PUSPIPTEK complex.

(3) Project Site

The project site is situated on hilly ground at the northwestern corner of the PUSPIPTEK complex facing down towards the Cisadane River. This area is designated formally by PUSPIPTEK as land required for the transfer of RDCM. The slope covered with shrubs leads down to the Cisadane River on the west side. It has a moderate slope in the southwest and heads down towards the existing loop road which surrounds the existing facilities of PUSPIPTEK. The straight distance between the site and the existing road is approximately 400m.

The north side of the site is partitioned with a net fence showing the boundary of the Complex with shrubs and bamboo at the far end, and is interrupted by the region's public cemetery partially protruding into the project site. This cemetery is scheduled to be moved to another place by PUSPIPTEK in the future.

(4) Infrastructure

1) Roads

The roads shown by the solid lines in Fig. 3-3.2 are all existing. The sub loop shown by the broken lines is a planned road for the project site which is spread to the northwest of the existing loop road around the applied chemistry, applied physics and metrology laboratories. This planned road has a structure as shown below, and is to be constructed by PUSPIPTEK.

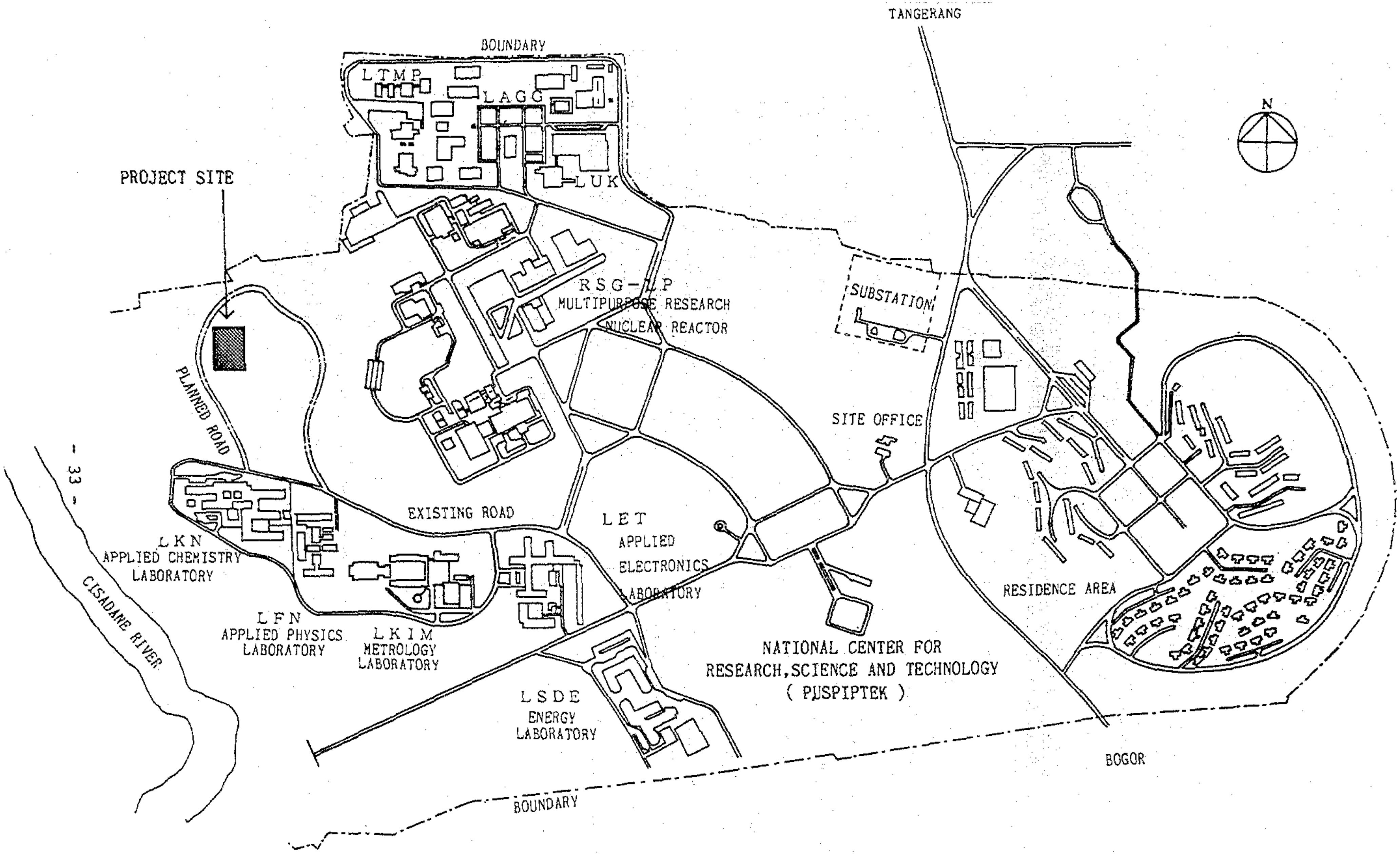
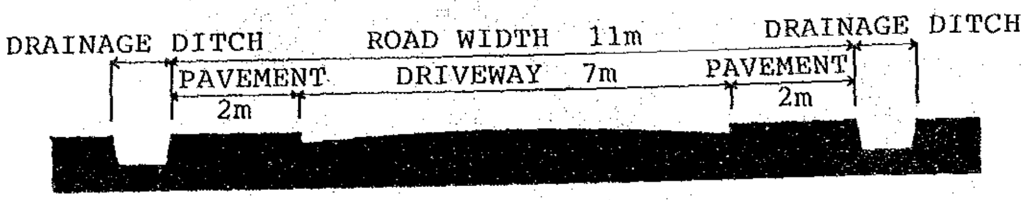


Fig. 3-3.2 Layout Plan for Project Site



ROAD CROSS SECTION

2) Water supply

The river water in the Cisadane River flowing through the west side of the PUSPIPTEK complex from the south to the north is used as raw water. After treatment (processing capacity 100 ℓ/sec), the water is pumped up to the water tower (storage capacity 600 m^3 and approximately 40 m in height) which is located in the center of the complex.

The water quality comforms to the WHO (World Health Organization) Drinking Water Standard and can be utilized as drinking water.

The main piping (200 mm dia.) forms a loop from the water tower as illustrated in Fig. 3-3.3, which supplies water stably to the respective facilities.

This main piping network is also used for fire fighting, and fire hydrants are provided at regular intervals.

3) Drainage

Public sewage treatment facilities are not fully arranged within the PUSPIPTEK complex. Waste water from experiments is discharged into the PUSPIPTEK drainage system (road side ditch) after being treated, so that the water quality standard for the Cisadane River into which it will discharge is satisfied.

4) Gas

LPG is normally used within the PUSPIPTEK complex. Town gas is planned in the future, but will not be realized soon.

5) Refuse disposal

Paper, cloth and garbage are disposed of using the incinerator inside the complex. Non-flammables are disposed by burying..

6) Electric power

As shown in Fig. 3-3.4, electric power is distributed to the respective facilities using underground cables from the substation provided by the National Electric Power Company (Perusahaan Umum Listrik Negara, P.L.N.) within the PUSPIPTEK complex. The required power can be led sufficiently into the planned facilities by extending the existing power distribution line.

The power distribution system includes a 3-phase 3-wire 20 kV/50 Hz loop system of 2 circuits.

For reference, the P.L.N. substation is outlined as follows.

. Transformer capacity	:	60,000 kVA x 2 sets 120,000 kVA total
. Primary voltage	:	500 kV
. Secondary voltage	:	20 kV

7) Telephones

A large capacity telephone exchanger is provided within the telephone center in the PUSPIPTEK complex. Consequently the extensions are connected to the respective facilities using underground cables. The number of extension lines arranged for the planned facilities is 10. After 1990, the line can be expanded upon request.

For reference, the capacity of the telephone exchanger is as follows.

- No. of incoming lines : 360 Max.
- No. of extensions : 3,500 Max.

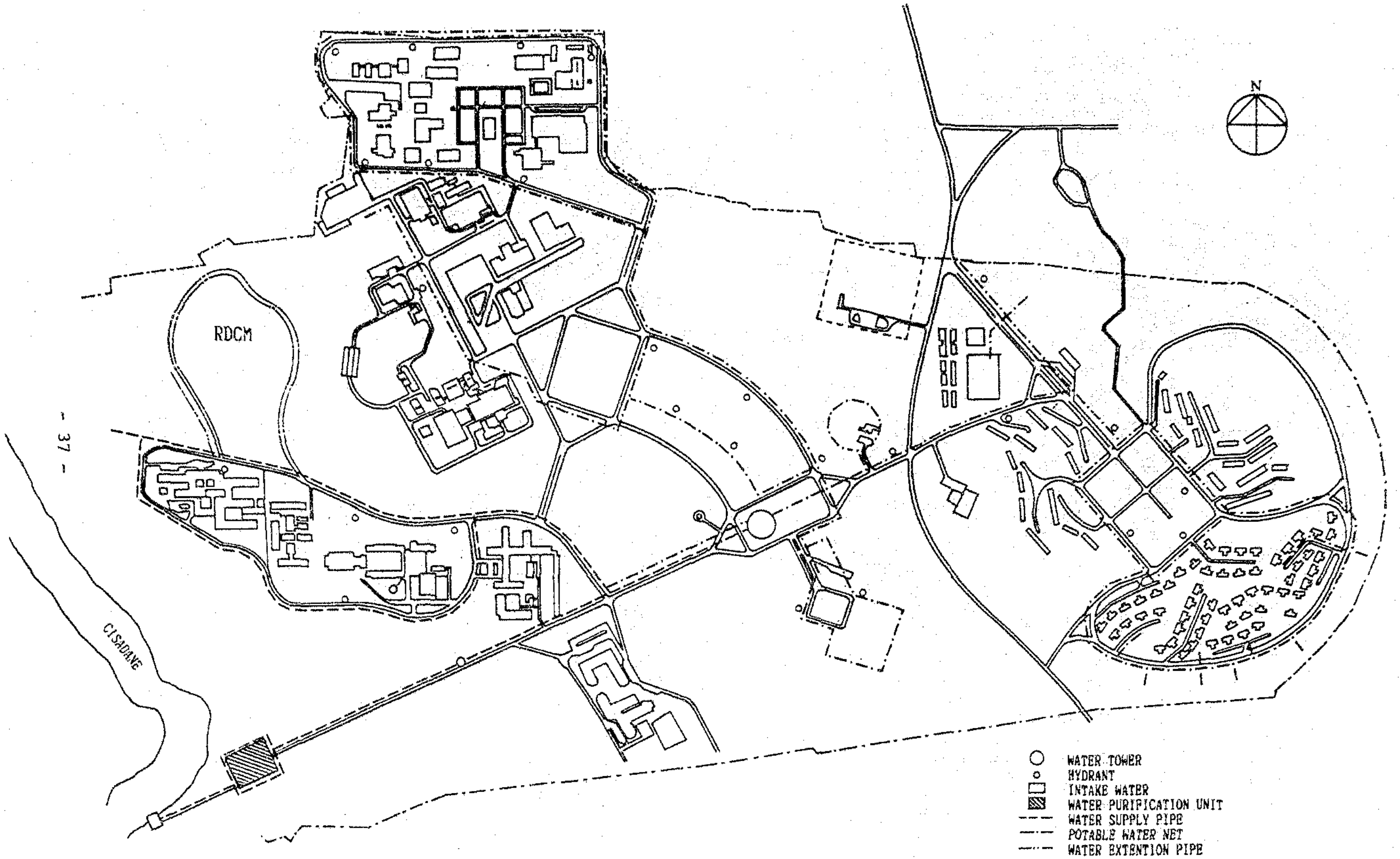


Fig. 3-3.3 Pipe Line of Water Supply

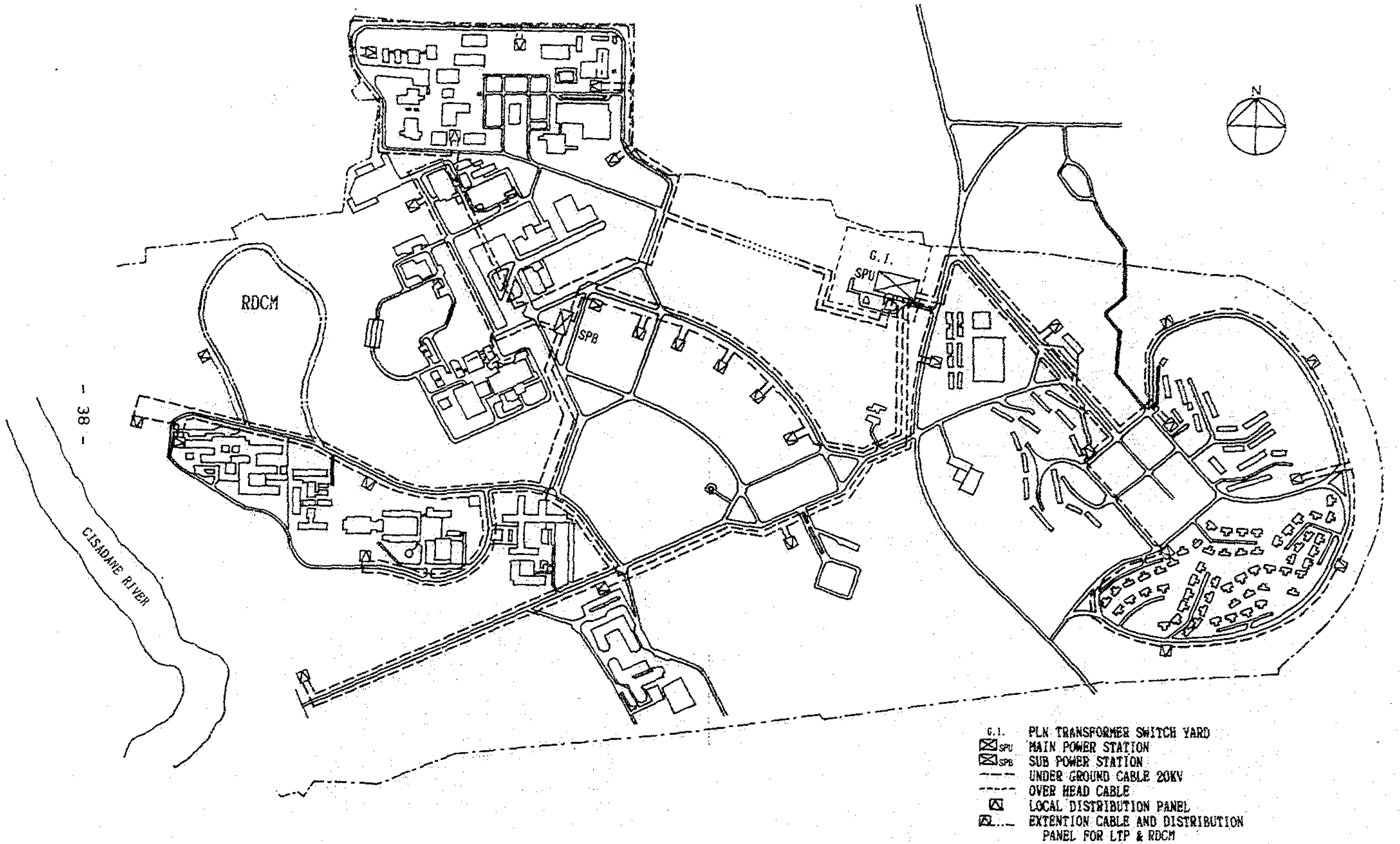


Fig. 3-3.4 Trunk Line of Electric Power

3-3-4 Outline of buildings, facilities and equipment

The Metallurgical Laboratory for Laterite in this project will be founded to establish the processing technology of low grade nickel laterite ore. As mentioned, the pilot plant satisfies the main requirements such as the acquisition of engineering data by smooth operation, and labor saving for the transportation and manipulation of materials and equipment, and anti-pollution measures. The analytical and laboratory equipment consists of a series of equipment necessary for the analysis of various operational data of the pilot plant and for the examination of the operational conditions. Furthermore, the buildings to accommodate these should be utilizable in the functional research activities and be suitable for the climate and natural features at the site.

The outline of each facility and its building equipment is as follows.

(1) Outline of buildings

Outline of buildings is as follows;

a) Laboratory building

- Sample preparation room
- Mineral dressing room
- Pyrometallurgy room
- Hydrometallurgy room
- Mineralogical room
- Chemical analysis room
- Instrumental analysis room
- Others

b) Pilot plant building

- Pilot plant room
- Work shop room
- Operation room
- Others

c) Energy centre building

d) Ore storage building

e) Dangerous material storage building

f) Guard house

g) Connecting corridor

h) Others

(2) General outline of pilot plant facilities

1) Ore preparation facility 1 set

For drying laterite ore with a high moisture content and producing pellet with a diameter of 10-15 mm, after grinding.

1 Jaw crusher
2 Dryer
3 Auxiliary material hopper
4 Grinding mill
5 Pelletizing equipment
6 Platform scale

2) Reduction furnace facility 1 set

For roasting the pellet at a high temperature in a reduction furnace after weighing, and recycling a part of the exhaust gas from the furnace, after treatment.

1 Pellet bin and conveyor
2 Reduction furnace

3) Ammonia leaching facility 1 set

For leaching nickel in ammonia solution, after grinding the reduced pellet, and then separating the tailings after leaching.

1 Grinding and quenching equipment
2 Leaching equipment
3 Washing equipment
4 Purification equipment
5 Soda ash (Na_2CO_3) addition equipment
6 Ammonia recovery equipment
7 Tailing still equipment
8 Tailing filtration equipment
9 Ammonia receiving equipment
10 Steam generator

4) Basic nickel carbonate recovery facility 1 set

For separating BNC as filter cake after leaching and crystallizing.

1 Buffer tank equipment
2 BNC filtration equipment

5) Solvent extraction facility 1 set

For dissolving BNC and separating nickel and cobalt with a suitable solvent after removing impurities.

1 BNC dissolving equipment
2 De-Fe Mn equipment
3 De-Cu Zn equipment
4 Solvent extraction equipment
5 Stripping equipment

6) Ni & Co electrowinning facility 1 set

For recovering nickel metal and cobalt metal from the electrolyte in their respective electrolytic cells.

1 $NiCl_2$ and $CoCl_2$ pH-adjustment equipment
2 Ni and Co electrolytic equipment
3 $Ni(OH)_2$ and $Co(OH)_2$ filtration equipment

7) Pollution control facility 1 set

For effectively collecting and treating dust, exhaust gas and waste water generated during processing.

1 Bag filter
2 Gas scrubbing equipment
3 Waste water pH adjustment equipment

8) Electrical and instrumentational facility 1 set

For plant operation and control.

9) Auxiliary facility 1 set

1 Compressor
2 Oil receiving tank

10) Workshop facility 1 set

For maintenance and repairing minor problems quickly.

1 Lathe
2 Electric welder
3 Drilling machine
4 Sawing machine
5 Grinder
6 General tools

11) Vehicles and handling equipment 1 set

For handing ore and operating material.

1 Shovel loader
2 Small truck and van
3 Pallet lift

(3) Analytical and laboratory equipment

1) Analytical equipment

Analytical equipment is broadly divided into equipment for instrumental analysis and equipment for general analysis. Typical equipment in each category is as follows.

1 Equipment for instrumental analysis

: EPMA

: ICP

: X-ray fluorescence spectrometer

: X-ray diffractometer

: Carbon-sulfur analyzer

2 General analysis

: Spectrophotometer

: pH meter

: Balance

: Drying oven

: Stirrer

: Heater

2) Laboratory equipment

The following equipment is used for a specific research purpose.

1 Sample preparation equipment

: Crusher

: Mixer

: Drying oven

: Balance

: Screening set

2 Mineral dressing equipment

: Flotation tester

: Magnetic separator

: Grinding mill

: Dryer

: Balance

3 Mineralogical equipment

: Microscope

: Sample mounting apparatus

: Film processor

4 Pyrometallurgical equipment

: Muffle furnace

: Crucible furnace

: Induction furnace

5 Hydrometallurgical equipment

: Mixer-settler

: Electrolytic cell

: Stirrer

: Filter

: Autoclave

: Balance

3) Auxiliary equipment

The following auxiliary equipment is for use with analytical and laboratory equipment.

: Pure water making system

: Air compressor

: Scrubber

: Various dust and exhaust gas hoods

: Microcomputer for data processing

: Table

: Wares and tools

: Pit pump for waste water

3-3-5 Management plan and personnel plan

(1) Management plan

RDCM is composed of the administration division and four research divisions as shown in Fig. 2-2.2. The division which is engaged in research on the extraction metallurgy of nickel laterite ore is the Extraction Metallurgy Division. Accordingly, the Head of the Extraction Metallurgy Division, serving concurrently as the Head of this Metallurgical Laboratory for Laterite, assumes control of the research teams consisting of 40 people in total. The research teams are classified into the pilot plant group and the laboratory research group as shown in Fig. 3-3.5. Each group is controlled under the Coordinator.

The Head of RDCM is in charge of the general management for the execution of this Project, as a Project Coordinator, who is controlled under the Deputy Chairman for technical sciences of LIPI.

RDCM is forming a budget plan of development related to the nickel laterite research indicated in Table 3-3.1, considering fiscal 1987 to 1988 as the preparation period, fiscal 1989 to 1991 as the operation period, and fiscal 1992 as the evaluation period for this Project.

Table 3-3.1 Estimated Operational Cost Requirement for Nickel Laterite Research of RDCM (in thousands Rp)

	Preparation		Operation			Evaluation
Items \ Fiscal year	87/88	88/89	89/90	90/91	91/92	92/93
Additional Salary	19,500	30,000	60,000	60,000	40,000	20,000
Material	14,000	40,000	75,000	75,000	40,000	30,000
Travel	1,500	20,000	30,000	30,000	30,000	20,000
Utilities	-	20,000	75,000	75,000	45,000	25,000
Others	500	10,000	30,000	30,000	15,000	5,000
Total	35,500	120,000	270,000	270,000	170,000	100,000

(2) Personnel plan

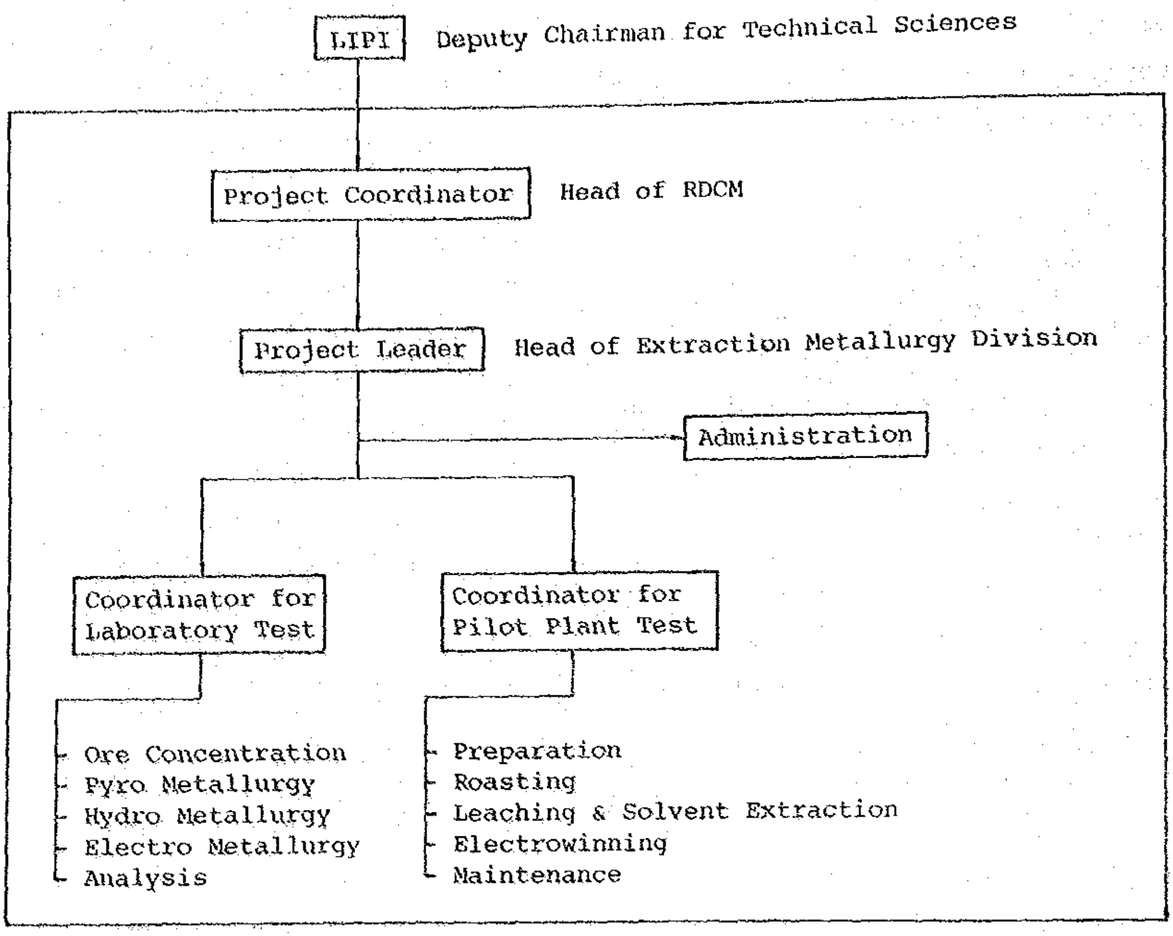
The total number of personnel in the RDCM Extraction Metallurgy Division is 37 at present. However the number of personnel who will be engaged in extraction metallurgical research for nickel laterite is possibly 48, as follows.

Head:	1
Laboratory chiefs:	5
Laboratory staff (university graduates):	11
Laboratory staff (engineering school graduates):	6
Technicians (high school graduates):	17
Management office clerks:	8
Total	48 persons

One of the laboratory staff will be supplied from the Metal Technology Division, 2 of them from the Science/Technology Service Division, and the management office clerk will be supplied from the administration division.

P.T. Aneka Tambang, which is a government owned mining company, is to supply personnel proficient in this type of plant operation, and the personnel required will be secured. However, techniques for maintaining stable operation of the plant and collecting data which complies with the purpose of research, owe much to the operational skill of those operators. Accordingly, after completion of pilot-plant facilities installation, sufficient time should be reserved for operational training and operating instructions to be given to each operator.

Fig. 3-3.5 Management System for Operation of the Pilot Plant



3-4 Technical Cooperation

Prior to this project, the Government of Japan has implemented the technical cooperation to the Research and Development Centre for Metallurgy in Indonesia for the purpose of the laboratory scale research on low grade nickel laterite ore processing. This cooperation has been executed in the form of dispatching long term experts from Japan. The outline of the technical cooperation which has been implemented during past five years are summarized as follows:

1) Counterpart organization

Research and Development Centre for Metallurgy (RDCM)

2) Dispatch of experts and acceptance of counterparts

a) Japanese experts for nickel laterite ore processing

Number of experts	One
Term	April 1982 - April 1987

b) Japanese experts for analysis

Number of experts	Two	
Term	September 1984-September 1985	
	one	
Term	April 1986- present	one

c) Acceptance of counterparts in Japan

Training at National Research Institute for Pollution and Resources	Three counterparts

3) Field and scope of technical cooperation

a) Research of Mineralogical characteristics on Indonesian nickel laterite ore.

b) Fundamental research and experiment of preferential reduction, with the addition of sulfide and chloride, of Indonesian nickel laterite ore.

c) Ammonia leaching test after preferential reduction.

d) Test of iron powder-steam roasting and leaching nickel and cobalt oxide with dilute sulfuric acid.

e) Leaching test of nickel and cobalt oxide under high temperature and high pressure with autoclave after iron powder-steam roasting.

f) Test of separation of nickel and cobalt with organic solvent and electrowinning of each metal.

4) The results of research

As for the above item 3), the Japanese experts and RDCM staff executed the study of laboratory scale and could aquire a large number of data.

Mainly Pomalaa nickel ore mined at Pomalaa area in Slawesi island was used for the study. It was confirmed that the leaching ratio of nickel was almost 90% through reduction and leaching. Regarding the solvent extraction test, nickel and cobalt were almost completely separated but the electrowinning test has not been finished yet.

The Government of Indonesia requested of Japan the technical cooperation for the project type technical cooperation to develop the results of the above mentioned project. In response to the request, the Government of Japan implemented a preliminary survey to confirm the contents of the request in March of 1986 and further a long term survey was implemented to discuss the outline of technical cooperation in February of 1987.

Although the concrete implementation plan will be prepared in detail through discussions between both parties, the outline of the project type technical cooperation agreed upon during the long-term survey is shown below.

1) Implementation organization :

Research and Development Centre for Metallurgy (RDCM)

2) Project site :

Phase 1 RDCM in Bandung

Phase 2 Metallurgical Research Laboratory for Laterite which is under planning for construction in Serpong city by the requested Grand Aid Program.

3) Scope of cooperation :

A) Preparatory experimental studies prior to completion of the laterite research facilities. (Phase 1)

A.1) Review of basic research over the previous five years

A.2) Preparatory research using existing research and analysis equipment at Bandung.

1 Detailed study of material ore

2 Basic study of reduction

3 Basic study of ammonia leaching

4 Basic study of solvent extraction and electrowinning

A.3) Preparation of research plans at the Metallurgical Laboratories for Laterite.

1 Preparation of standards of operation for analysis, laboratory facilities and pilot plant.

2 Preparation of standards of operation control.

3 Preparation of tests and study planning of pilot plant.

B) Test work after completion of the laterite research facilities (Phase 2)

B.1) Related to analytical and laboratory equipment

1 Basic research ahead of research with the pilot plant.

2 Back-up tests and analytical work during research with the pilot plant.

B.2) Related to pilot plant

1. No-load test of pilot plant equipment
2. Instruction of pilot plant operating procedure
3. Instructions for preparation of raw materials, auxiliary materials and chemicals for pilot plant tests
4. Research with the pilot plant
5. Preparation and analysis of research data obtained from the pilot plant testing
6. Preparation for engineering data
7. Reporting

C) Configuration and schedule of the experts to be dispatched in relation to the above

C.1) Before starting operation of the pilot plant

Chief advisor	1 person
Pyrometallurgical engineer	1 person
Hydrometallurgical engineer	1 person
Analytical engineer	1 person

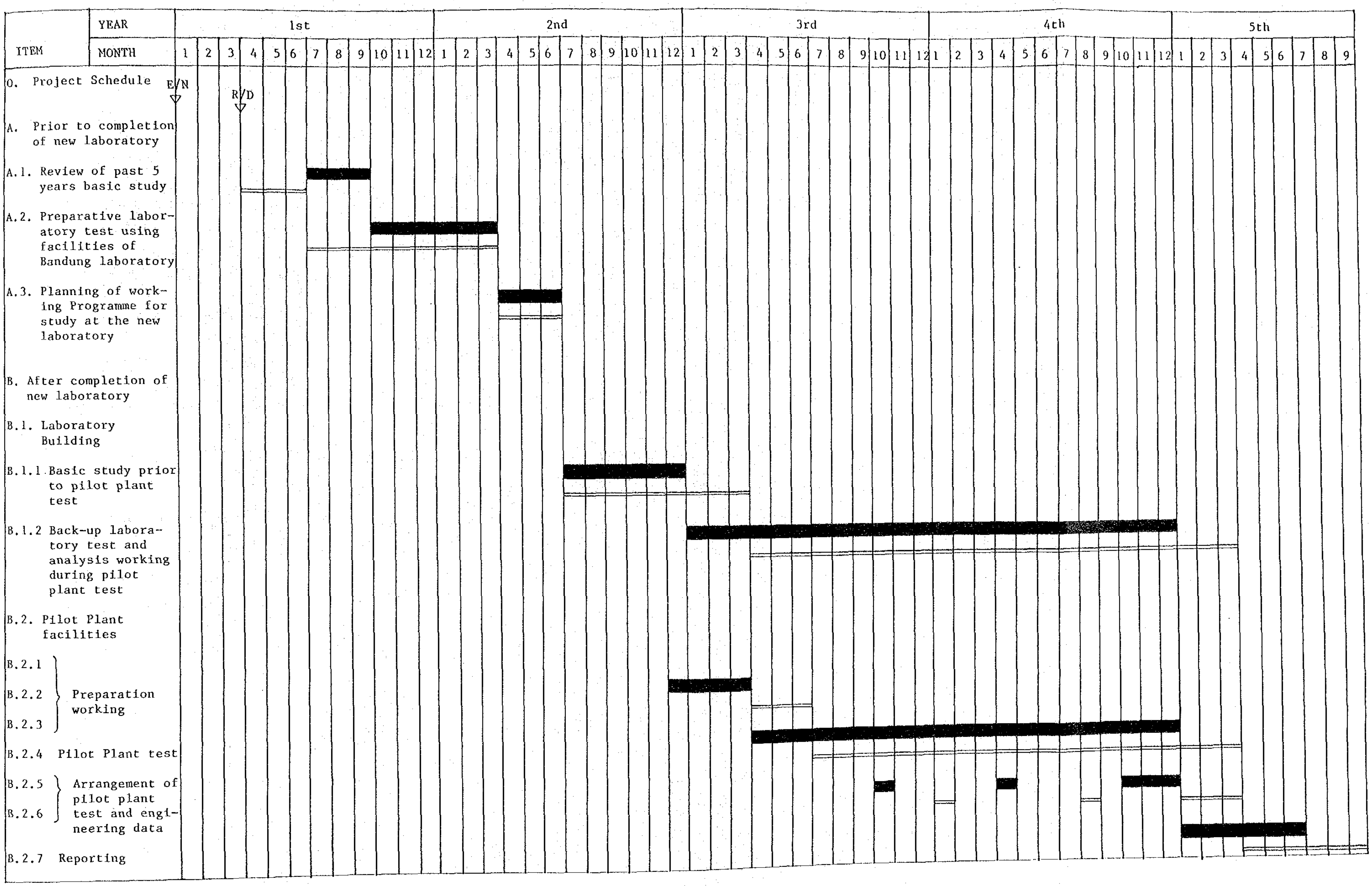
C.2) Until end of reporting after pilot plant commences operation

Chief advisor	1 person
Pyrometallurgical engineer	1 person
Hydrometallurgical engineer	1 person
Plant engineer	1 person
Analytical engineer	1 person

C.3) Technical Cooperation Schedule

See the Table 3-3.2

Table 3-3.2 Technical Cooperation Schedule



REMARKS : ▬ Proposal of the Team

═ Proposal of RDCM

CHAPTER 4 BASIC DESIGN

4-1 Basic Design Policy

The following items should be the basic design policy, based upon the contents of Chapters 2 and 3.

(1) Buildings and building equipment

1) Fulfillment of function

The facility to be established will have the specific and clear objective of carrying out metallurgical research on low grade nickel laterite ore. It is most important that the functions necessary to accomplish this objective are fulfilled. The most important buildings in this regard are the pilot plant building and laboratory building. The experimental results obtained in the pilot plant building will be analyzed in the laboratory building and influence later experimental planning. In this way these two buildings are closely related. However, in the pilot plant building, vibration, noise and dust occur as a result of experiments, while in the laboratory building these should not intrude because precision analyses are carried out there. The efficiency and quality of work obtainable from these facilities therefore relies on successfully integrating these different functions.

Furthermore in the construction of the buildings, since the building equipment has an important role in supplying adequate energy and assuring the proper functioning of all plant equipment and instruments, priority should be given to the coordination of both laboratory equipment planning and building equipment planning at the planning stage.

2) Reduction of running costs

Under the present severe economic situation in Indonesia, the running costs incurred after the completion of the facility should also be kept to a minimum.

Therefore, it is important to minimize the amount of energy consumption of the plant equipment at the planning stage. Further, air-conditioned areas should be decreased by means of natural ventilation.

3) Design compatible with the environment

The facilities should be of high habitability and suited to the climatic conditions of the site, where temperatures and humidity are considerably high throughout the year. Moreover, the building design should be compatible with the environmental design at the PUSPIPTEK complex where many facilities have already been completed or are under construction.

4) Basic design policy for building equipment planning

The primary object of the building equipment plan is to lower the running costs after completion of the facility. For the selection of systems and equipment, their reliability and ease of maintenance under the climatic conditions of the site, where temperatures and humidity are high, should be taken into consideration. The Law, Criteria and Standards of Indonesia should be observed. However, unless specified otherwise, Japanese domestic stipulations will be applied.

(2) Pilot plant facilities, and analytical and laboratory equipment

The following requirements shall be met as the basic policy in the design of the pilot plant facilities, and analytical and laboratory equipment.

1) To establish process flow corresponding to the Indonesian laterite ore, and to design facilities and equipment to be flexible in order to cope with changes in the ore.

2) To design equipment and machinery to be durable, easy to operate, with a high degree of reliability.

3) To establish a plan aiming at reducing running costs.

4) To select analytical and laboratory equipment to be capable of coping quickly and functionally with pilot plant operation and analyses.

5) To take environmental control into consideration by providing dust collection, gas processing and waste water treatment.

4-2 Examination of Design Conditions

Various design conditions were established to achieve its objective at the stage of the basic design study for this Project. They were the technological conditions in which the research activities on nickel laterite processing, as the subject, correspond with the Projects aim, the natural and physical conditions of the site, and procurement and construction conditions, as well as conditions related to cost factors.

The design conditions are as follows:

(1) Buildings and building equipment

1) Experiment and research rooms

Rooms related directly to experiments and research are as follows:

Room Name	Design Condition
Laboratory Building	
1. Sample Preparation Room	Room space is fixed according to the equipment arrangement
2. Mineral Dressing Room	"
3. Pyrometallurgy Room	"
4. Hydrometallurgy Room	"
5. Mineralogical room	"
6. Chemical Analysis Room	"
7. Instrumental Analysis Room	"
8. Research Room	Room space is fixed according to the number of researchers

Room Name	Design Condition
Pilot Plant Building	Roof height is fixed according to the height of the vertical kiln.
1. Pilot Plant Room	Room space is fixed according to the equipment arrangement
2. Work Shop Room	"
Ore Storage Building	Building space is fixed by the amount of storage ore
Dangerous Material Storage Building	Building area is fixed by the amount of storage materials

2) Maintenance

The facilities are to be readily accessible for inspection and repairs.

3) Reducing of running costs

Energy conservation measures should be considered. Particularly, air conditioned areas are to be limited.

4) Design

The surrounds of the PUSPIPTEK complex are enclosed with fencing, and guard houses are situated at important positions. Fencing will not be provided for each individual facility. The space between the proposed building and the road boundary will be more than ten (10) meters. In the design of the buildings in the PUSPIPTEK complex, structural frames such as columns and beams are to be of an exposed concrete finish with ornamental brick walls for the design uniformity.

5) Ground condition

The ground survey shows the soil to be red clay which is similar to Kanto loam in Japan, but is not as compact as the Kanto loam layer. The bearing capacity of this soil is under five (5) tons per square meter.

6) Climate at site

The yearly average temperature at the site is 26.9 degrees centigrade and humidity is eighty (80) per cent. Yearly rainfall is 1755 mm with a maximum rainfall per month of 335 mm in January. Incidentally, Tokyo averages a temperature of fifteen (15) degrees centigrade, sixty-nine (69) per cent humidity and 1503 mm in yearly rainfall. The month of the most frequent rainfall, October, records 203 mm.

7) Telephones

Due to the policy of PUSPIPTEK and the current telephone situation, a public telephone line will not be provided as far as the planned facilities are concerned. Only ten (10) extension lines to be connected with the telephone switchboard located in the PUSPIPTEK telephone center will be provided.

8) Emergency generator

At the PUSPIPTEK complex, approximately twenty (20) minutes power shut-off occurs at an average of once every two (2) months. Therefore, it is necessary to take measures to deal with power failure because it will not only interfere with the continuous operation of the pilot plant, but could also lead to disaster.

9) Waste water treatment facility

At the PUSPIPTEK complex, a centralized treatment facility is not provided as a whole, at the present stage. Therefore, an independent waste water treatment facility will have to be provided for the planned buildings.

(2) Pilot plant facilities and analytical and laboratory equipment

The following design conditions were established for the pilot plant facilities and analytical and laboratory equipment.

1) Design conditions relating to process flow

a) Provide flexibility to make it possible to cope with changes in raw ore or auxiliary materials.

b) Aim at establishment of a comprehensive laterite processing technology, from laterite ore handling to the metallic nickel production, in relation to laterite ore processing.

c) Leave room for the research on the production of other products (nickel oxide, nickel power etc.) than electrolytic nickel and cobalt.

d) Make continuous operation possible in the pilot plant.

2) Design conditions relating to equipment

a) Reduce manual handling of the operating materials, and establish safety measures for workers, while maintaining the stable operation of the pilot plant.

b) Put the greatest emphases on "easy to operate" and "easy to maintain in Indonesia".

c) Establish energy saving and low cost processes.

d) Make the facilities and equipment usable, even after the completion of the whole project, so that RDCM can use them for the future research and development.

3) Conditions relating to pollution control

a) Install dust collecting and gas processing systems relevant to the purpose.

b) Install an appropriate treatment system of waste water which is generated continuously or intermittently, and provide a storage pit to enable rechecking before discharge.

4-3 Basic Planning

The basic design planning for this Project is as follows:

4-3-1 Scale setting

(1) Buildings

The scale of the pilot plant, analytical and research rooms was established mainly according to the layout design of the machinery and equipment as shown below. The scales of the rooms other than those mentioned above were established according to the number of people to be accommodated. Incidentally, the column for Scale Setting Factor in the table shows the setting factors and computed areas, and the column for Setting Area indicates the real area in accordance with the basic design plan.

Table 4-3.1 Floor Area Scale Setting

	Room Name	Scale Setting Factor	Room Space
1)	Laboratory Building		
	Administration Room	8 persons x 4.5 m^2 = 36 m^2	32.25 m^2
	Manager's Room	1 person x 18 m^2 = 18 m^2	18 m^2
	Guest Room	1 room x 18 m^2 = 18 m^2	17.25 m^2
	Research Room (First and Second Floors)	22 persons x 7.2 m^2 = 158.4 m^2	162 m^2
	Storage	W x D x H	36 m^2
		Rack for Analytical and Laboratory Equipment Spare Parts (1.5m x 0.75m x 2.1m) 4	
		Rack for Consumables (") 4	
		Rack for Building Repair Materials (") 3	
		Rack for Office Supplies (") 2	
		Rack for Miscellaneous Goods (") 2	
	Rest Room	3 rooms x 9 m^2 + WC, Shower + Passage Way	48 m^2
	Locker Room	40 persons x 0.55 m^2 = 22 m^2	22 m^2
	Sample Preparation Room	Crusher, Mixer, Dryer, Screening Set, etc.	102 m^2
	Mineral Dressing Room	Flotation Cell, Magnetic Separator, Balance, etc.	54 m^2
	Mineralogical Room	Microscope, Polishing Apparatus, Sample Mounting Apparatus Photo Dark Room, etc.	54 m^2
	Pyrometallurgy Room	Tube Furnace, Muffle Furnace, Crucible Furnace, Induction Furnace, etc.	120 m^2
	Hydrometallurgy Room	Fume Hood, Experimental Table, Electrolytic Equipment, Autoclave, etc.	120 m^2
	Chemical Analysis Room	Pure Water Maker, Chemical Laboratory Table, Hume Hood, Spectrophotometer, etc.	118.5 m^2
	Instrumental Analysis Room	Infrared Spectrophotometer, Polarograph, X-ray Diffractometer, X-ray Fluorescence Spectrometer	126 m^2
	Advisor Room	10 persons x 7.2 m^2 = 72 m^2	70.5 m^2
	Library	12 persons x 1.5 m^2 + 3 Bookcases	36 m^2
	Conference Room	24 persons x 2 m^2 = 48 m^2	48 m^2
	Canteen and Meeting Room	48 persons x 2 m^2 + Kitchen + Food Storage + WC	120 m^2

Table 4-3.1 (cont'd)

	Room Name	Scale Setting Factor	Room Space
	Lavatory (First and Second Floors)	Ladies and Gentlemen + Hot-water Service Room + Entrance = 1 unit 36 m^2	72 m^2
	Corridor, Step, Hall (First and Second Floors)		606 m^2
	Piping Spare (First and Second Floors)		6.5 m^2
	Sub Total		1,992 m^2
2)	Pilot Plant Building		
	Pilot Plant Room	Ore Preparation Facility, Reduction Furnace Facility, Ammonia Leaching Facility, BNC Recovery Facility, etc.	480 m^2
	Work Shop	Lathe, Electric Welder, Drilling Machine, Working Table, etc.	48 m^2
	Operation Room	21 persons x 1.5 m^2 = 31.5 m^2	30 m^2
	Locker, Shower, WC	15 persons x 0.6 m^2 + Shower, WC	18 m^2
	Storage (Mezzanin Floor)	Rack for Plant Equipment Spare Parts (W x D x H) (3.0m x 0.9m x 1.8m) 8	48 m^2
	Sub Total		624 m^2
3)	Ore Storage Building	500t/Average Storage Height 2.5 m = 200 m^2	200 m^2
4)	Dangerous Material Storage Building		15 m^2
5)	Energy Centre Building	Switchgear Room, Transformer, Emergency Generator, etc.	108 m^2
6)	Connecting Corridor	Distance between Buildings 20 m x Width 2 m = 40 m^2	40 m^2
7)	Guard House	2 persons x 3 m^2 = 6 m^2	6 m^2
	GRAND TOTAL		2,985 m^2

(2) Pilot plant

1) Metallurgical process

Nickel processing methods using laterite ore as the raw material can be roughly divided into two types: pyro and hydro. This has already been explained in Section 2-2-1. In this plan hydrometallurgical method is employed, because the ore to be treated is low grade nickel laterite.

The ammonia leaching process is one of the hydro methods, and is the most commonly used for laterite processing in the world. In the ammonia leaching method, nickel and cobalt contained in laterite ore are extracted by ammonia solution, after being sellectively reduced to the metallic state in the reducing atmosphere of the furnace. It is recovered as an enriched nickel internudiate. This is called the Nicaro process and various improvements have been proposed world-wide to lower production costs and increase the overall nickel recovery. Research was conducted in Japan to improve the whole process, and the improved technology was established at the pilot level. The Japanese type Nicaro process (called the SMM process) is highly acclaimed by metallurgical engineers throughout the world, and is the basis of the process, which RDCM will proceed to use.

This method has many features in adaptability to Indonesian laterite, low running costs when commercialized and a high nickel recovery rate. Therefore, it is considered to be the best process for this project. The process flow sheet is shown in Fig. 3-3-1.

2) Pilot plant capacity

The pilot plant consists of the pyro process including the reduction furnace, and the hydro process including ammonia leaching and solvent extraction. An Annular Vertical Kiln (A/V kiln) is used in this process to efficiently reduce less than 2% of nickel contained in laterite. Although the outer-shell diameter of the A/V kiln in commercial plants is 6-10 meters, a 1.5-meter diameter kiln is used for this test. A 1.5-meter A/V kiln is the smallest possible that can be manufactured, and yet is satisfactory equipment for obtaining engineering data; such as heat balance and material balance of the furnace, which is operated at a high temperature and with a strong reducing atmosphere. A planned processing capacity of three tons of dry ore per day is appropriate, considering the consumption of raw ore sent from a distant area and the difficulty of handling in the pilot plant.

One ton per day on dry basis, or 5 m^3 per day on a leach liquor basis, is a suitable capacity for the hydro process to cope with the leaching reaction procedure while maintaining a constant flow over the entire system. The pilot plant facilities are also so sized that engineering data to be obtained is well qualified for the future scaling-up. The two tons/day of redundant roasted ore generated between the pyro and hydro capacities are discarded through the divider.

(3) Analytical and laboratory equipment

The analytical and laboratory equipment play important roles in rapidly and accurately analyzing pilot plant operation results obtained during research, and in giving adequate instructions for the subsequent research. The objective and scope of activities in each laboratory is described, in determining the scale of the laboratories. The equipment installed in the instrumental analysis room should be capable of responding to all demands for analyses needed during research: tests on raw material such as ore and auxiliary materials such as coal and pyrite; quick element analysis (ICP, atomic absorption spectrometer, X-ray fluorescence spectrometer) of intermediate and finished products; crystalline structure analysis (X-ray diffractometer, infrared spectrometer) of ore and other products; element analysis of microscopic portions (electron beam microanalyzer); and configuration analysis (polarograph).

A chemical analysis room is necessary for the analysis of the samples which are difficult to analize with instrumental analyzers and also for the analysis of the samples for checking data from instrumental analyzers. The sample preparation equipment should have functions to provide the samples demanded for analysis in the appropriate procedure; crushing, pulverizing, screening, drying, mixing and sample reduction, of raw and auxiliary materials.

A mineralogical room shall be provided with the microscope and equipment for sample preparation and for developing and printing photos. A mineral dressing room should have equipment capable of conducting tests on all basic benefication methods such as floatation, magnetic separation and sorting.

A pyrometallurgical room shall be provided with the equipment for conducting a series of tests such as high temperature heating, pyro reduction and melting of metal in the various containers (boats, crucibles) under various conditions.

In a hydrometallurgical room, it should be possible to conduct basic hydrometallurgical tests such as pressure leaching, solvent extraction and electrowinning. It should also be possible to conduct related tests such as centrifugal separation and drying.

4-3-2 Block plan

The project site is situated at about 6° South latitude. The sun in the daytime is higher than 72.5° in southing and higher than 60.5° in northing. That is, since the sun is always overhead in the daytime throughout the year, direct sunlight can be prevented by overhanging sunshades or eaves attached to the buildings. On the other hand, since the height of the sun is low in the morning and evening, there are no effective measures to block the strong tropical sunlight during these hours. Therefore it is necessary to design the plot plan so that facilities are not easily affected by morning and evening sunlight.

According to the requested plot plan, the two main buildings, the laboratory building and pilot plant building, are located at right angles to each other. When one building is sited on an east-west axis, the other will be sited on south-north axis and the received quantity of heat coming from windows for natural lighting will be greater. This increases air conditioning loads and leads to increases in energy consumption.

In this preliminary plan, all the buildings including the laboratory building and pilot plant building will be located on an east-west axis, decreasing the east-west face, so that the received quantity of heat can be decreased in the morning and evening.

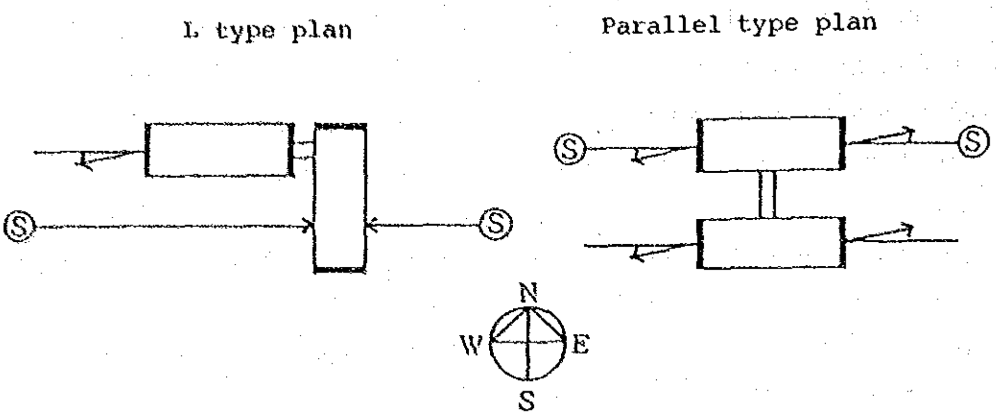


Fig. 4-3.1 Comparison between L Type Plan and Parallel Type Plan

The space between the laboratory building and pilot plant building will be 20 meters so as to prevent the vibration, noise and dust that originate at the pilot plant building from reaching the laboratory building. The laboratory building and pilot plant building will be located on the south and north sides in the site respectively. The dust from the pilot plant building will not reach the laboratory building as the primary wind direction is east-west. A connecting corridor will be provided between these two buildings.

The energy center will be located at the middle of the connecting corridor, thus the distance of power supply lines for both buildings will be reduced. The ore storage building will be sited facing the outside surrounding road, on the north side of the pilot plant, for convenience in carrying ore to the storage. The ore will be supplied from the ore storage building to the pilot plant by means of a belt conveyor. Thus, the principal buildings will be sited on the north and south in the parallel form with east and west as an axis.

The branching of the eleven (11) meter wide access road to the project site from the existing loop road will be determined by the PUSPIPTEK authority road plan, but it should be constructed in the location shown in Fig. 4-3.2. That is, first, coming up north reaching the cemetery as the west road shoulder which slopes down towards the Cisanade

River, then turning to the right and going eastward along the boundary of the Complex. The topographic survey shows that the project site has a gentle slope toward the southeast which becomes steeper as it goes. Since it is desirable to construct the buildings on top of cut soil, it is advantageous to move the whole facility to the northwest side as shown in Fig. 4-3.2, to lessen the amount of cut soil.

When future extensions are needed, it is possible to extend both the laboratory and energy buildings in an easterly direction, and both the pilot plant and ore storage buildings to the east and west respectively.

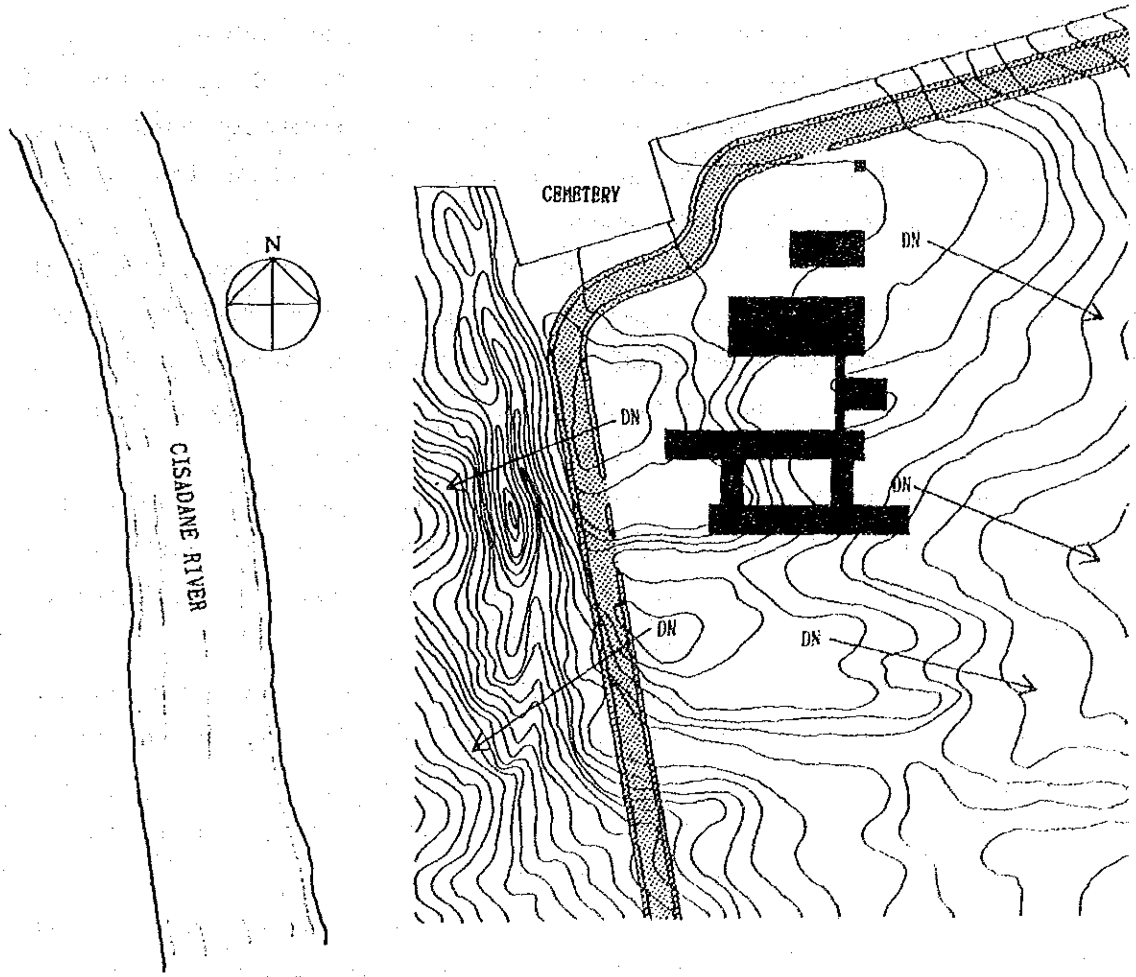


Fig. 4-3.2 Block Plan

4-3-3 Architectural Planning

(1) Floor planning

1) Laboratory building

By taking 75 cm as a general standard for experiment tables, equipment arrangement, and passageway width, waisted space may be minimized. This 75 cm will be called the basic module (M).

The Fig. 4-3.3 shows the space around the laboratory tables.

The standard unit size of laboratories will be 8M x 8M (6 meters x 6 meters) with 8M (6 meters) column space in the ridge direction, and a room depth of 8M (6 meters). Column space in the span direction is 8 meters after adding 2 meters of corridor width.

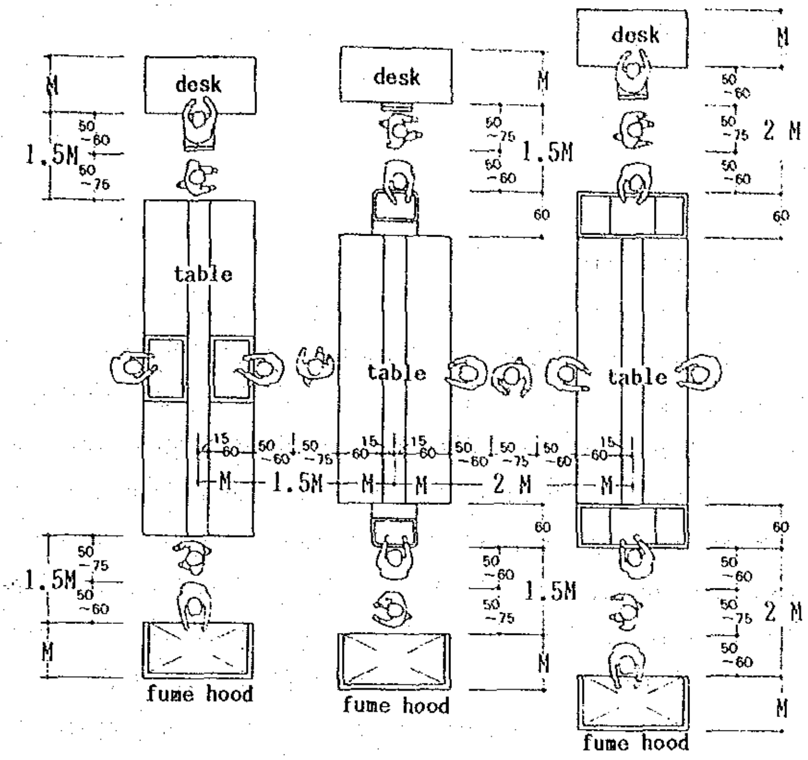
The two two-storied buildings with side corridors are connected with two corridors including steps, with a courtyard between them. The connecting corridors in this place will have a sufficient width for putting in benches etc., so as to create a place where researchers can exchange information and can make themselves confortable.

The total length of the corridor will be shortened with the provision of independent rooms, by projecting the end section of the building to accommodate comparatively large rooms such as, the pyrometallurgy, hydrometallurgy, sample preparation room and the canteen.

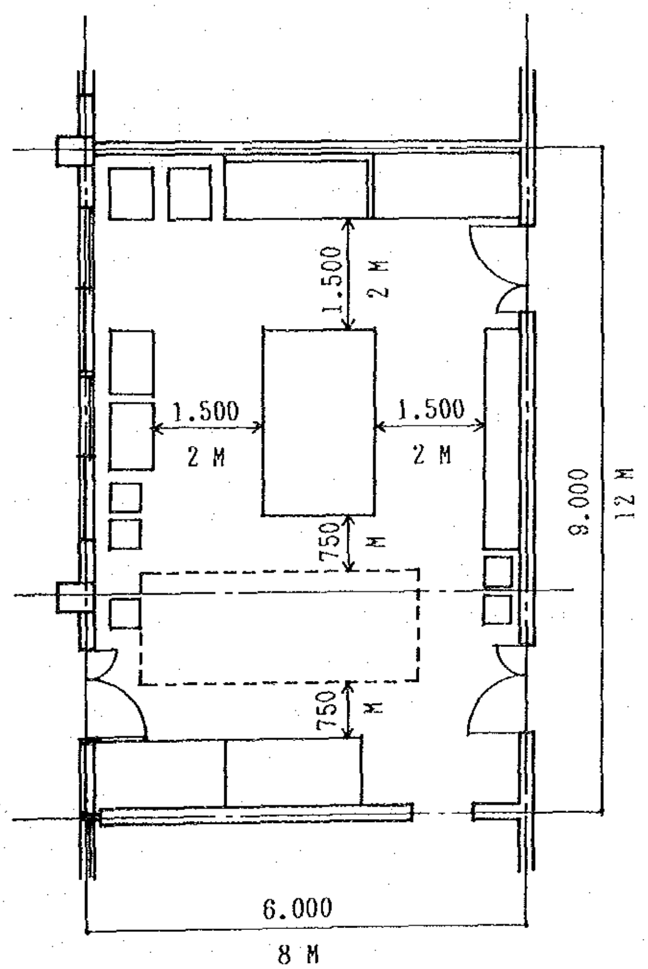
The rooms with heavy equipment and vibrating machinery, such as the pyrometallurgy and sample preparation rooms will be located on the first floor with special foundations.

The west end of the second floor, where the Cisanade River can be viewed, will be used for the canteen and meeting room.

The partitioning wall on the corridor side will be wooden with ventilation grills top and bottom to induce natural ventilation.



Space required around laboratory tables



Example: Mineral Dressing Room

Fig. 4-3.3 Equipment Layout by Module

2) Pilot plant building

One span on the east side of the pilot plant area will be allocated for a work shop, operation room with lavatory and locker room. The operation room will be used for training in plant operation, work briefing at the shift changes, instruction, discussion and resting. Storage will also be allocated for spare parts, consumables and tools by providing a mezzanine floor on the operation room. An overhead travelling crane will be installed to reach to the east end of this space for the convenience of carrying the heavy equipment to the work shop and storage.

In case of future extentions to the east side, this space will be moved to the east end of the newly extended section.

3) Energy center building

The switching gear room, transformer room and emergency generator room will be accommodated in this building.

(2) Sectional planning

1) Laboratory building

In order to reduce the foundation load in consideration of the poor bearing capacity of the ground, the weight of the whole structure will have to be reduced. Therefore the roof of the second floor should be locally produced tile roofing. Zinc corrugated steel sheet will be layed under the tile roofing to prevent any water leakage. The space of the second floor garret is available as a service space for ducts, having the role of insulating the heat from the roof surface. The lower face of the second floor concrete slab will be finished directly as the first floor ceiling and in principle, it will not be double ceiling. The pipe rack will be suspended underneath the corridor beam to provide piping and wiring for electricity, water and gas for each room. If the effective corridor height under the rack is kept within the limit of 2.5 meters, then the floor height will become approximately 3.6 meters. Thus, the eaves height of the building will be about 7.5 meters. Among the exhaust ducts provided for the laboratory equipment such as draft chambers, the special ones which can not be exhausted directly from the exterior wall will be let out through an exhaust fan or gas scrubbing tower that will be provided on the roof of the east and west connecting corridor, by horizontally leading to the second floor garret. Accordingly, a flat concrete roof slab is to be provided on these two connecting corridors. Precast concrete eaves will be provided on the upper part of outer windows for awning and flashing. No windows will be provided in the outer wall of the courtyard, exposing corridors to the open air.

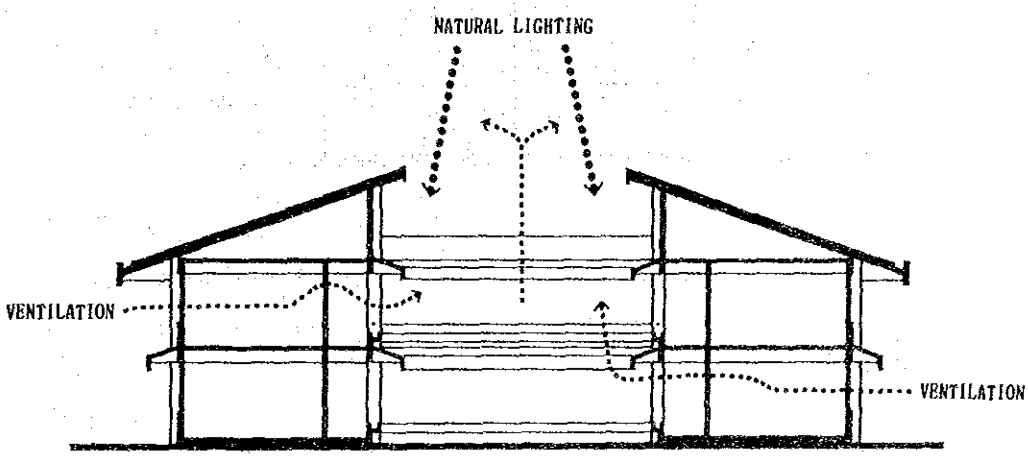


Fig. 4-3.4 Planned Section of Laboratory Building

2) Pilot plant building

Amongst the equipment of the pilot plant, the highest piece is the vertical kiln with a height of 7.5 meters. Therefore minimum height will have to be 8 meters under the end of the hoist hook which is attached to the overhead travelling crane. Thus, the eaves height may become approximately 10 meters. On the roof of the upper part of the vertical kiln, an exhaust tower will be installed.

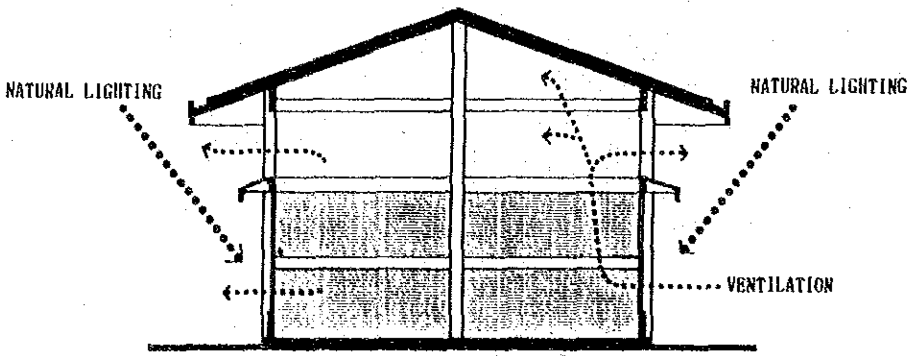


Fig. 4-3.5 Planned Section of Pilot Plant Building

3) Ore storage building

Average height of ore stack will be 2.5 meters therefore, eaves height will become approximately 5 meters.

4) Dangerous materials storage building

Taking into account the built-in shelves, eaves height will be approximately 3 meters.

(3) Structural planning

There are two points to be considered in the structural design, as follows;

1) According to the results of the soil investigation, the soil is silty and the mean bearing capacity is 5 tons. Therefore the structure should be light weight so as to reduce the foundation load. Furthermore the buildings should be constructed on the cut soil so as not to cause differential settlement.

2) The structure will have members of sufficient section and rigidity such that vibration will not cause any measurement error in the precision instruments in the laboratories.

(4) Building equipment planning

1) Plumbing system

a) Water supply system

Water supply by gravity from the PUSPIPTEK water tower will be branched from the pipeline network for water supply as shown in the Fig. 3-3.3 and will be supplied to these facilities through the water meter.

The water pressure at the service point of the site is approximately 3.5 kg/cm^2 and will be sufficient for the operation of the facilities.

Analytical data shows the quality of water to be satisfactory for drinking, therefore it is not necessary to provide a water treatment system within the facilities.

For piping material, vinyl chloride lined steel pipe or vinyl pipe may be considered for use.

The distribution diagram for water supply is shown in Fig. 4-3.6.

The water supply for the laboratories in the main building is branched from the main pipe of the corridor shown in Fig. 4-3.7.

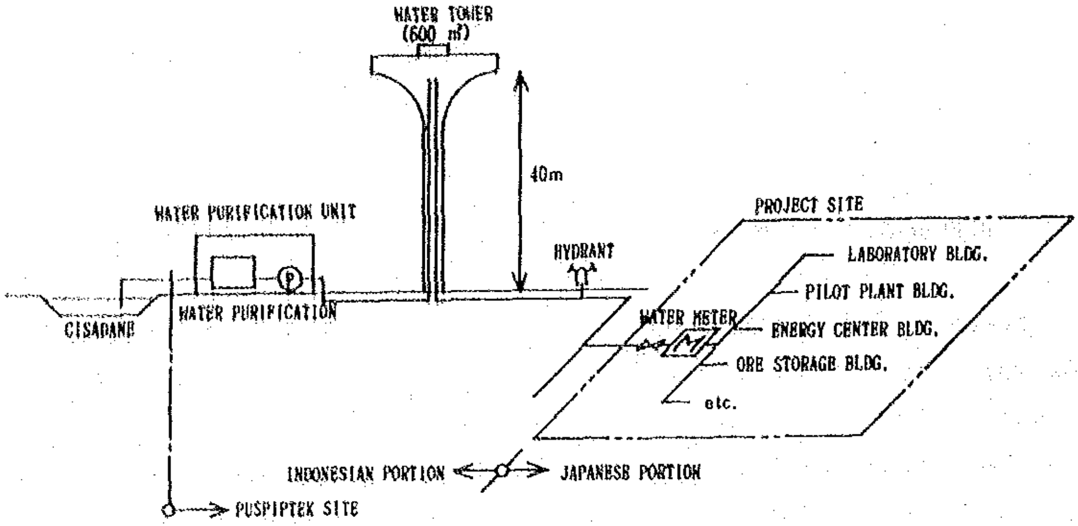


Fig. 4-3.6 Pipeline of Water Supply

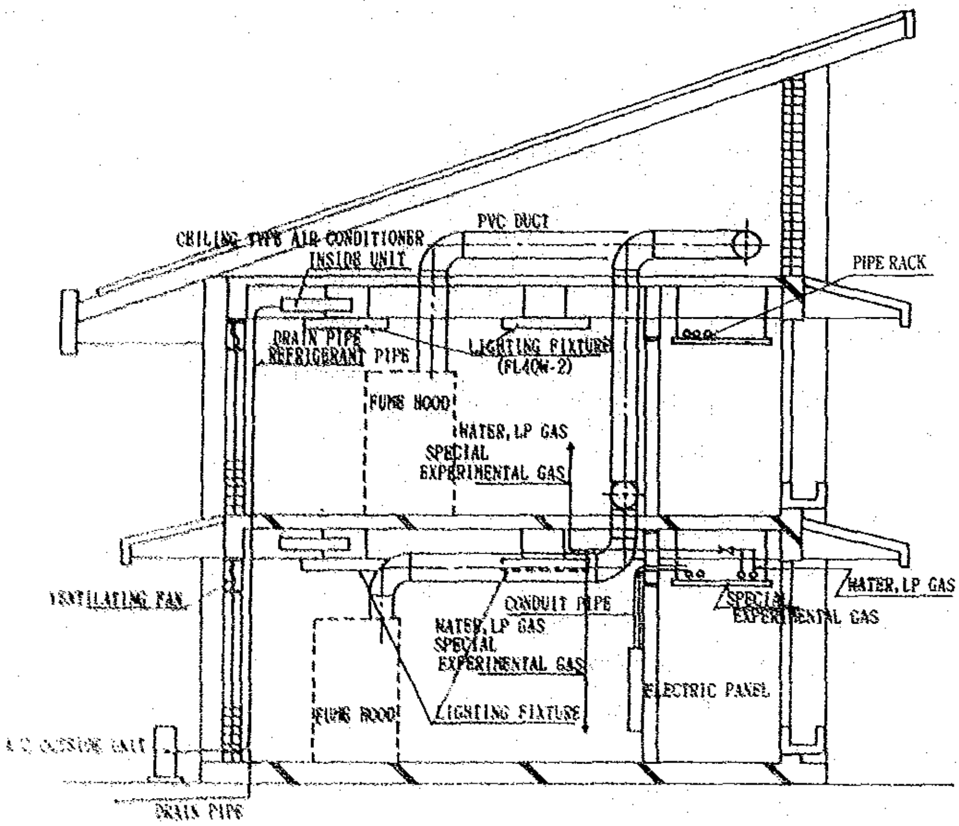


Fig. 4-3.7 Layout of Building Equipment for Laboratories

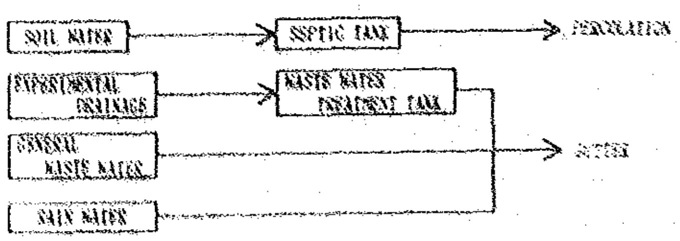


Fig. 4-3.8 Drainage Flow

b) Hot water supply system

Hot water will be supplied to the shower room and kitchen using gas or electricity as a heat source. For piping material, copper tubing will be used.

c) Sanitary Facilities

Fixtures such as western and Indonesian style toilets will be provided, taking into account the local situation. Further, fixtures which are available locally should be adopted as much as possible, assuming that breakages and trouble may occur after completion of the work.

d) Waste water treatment

The sedimentation septic system will be adopted for the septic tank, which is simple in maintenance. The tank is of concrete.

The waste water will be monitored at the laboratory waste water treatment tank and will be discharged after waste water quality standards are satisfied.

In case waste water quality standards are not satisfied, the water will be discharged after being chemically treated, or treated with a diluent. The tank will be concrete and the inside protected with resin lining so that the concrete will not be chemically corroded.

e) Drainage system

Sewage will be treated at the septic tank and discharged into the ground by the percolation system. The septic tank will be sited close to the toilets and the percolation area will be provided adjacent to the septic tank. The treated water will be filtrated underground through a waterway provided with bricks and crushed stone available at the site.

The waste water from the laboratories will be treated to meet the waste water quality standard at the laboratory waste water treatment tank installed within the site, and discharged into the gutter of PUSPIPTEK provided at the roadside. General waste water and rain water will be directly discharged into the gutters of PUSPIPTEK.

The drainage flow is shown in Fig. 4-3.8.

The piping materials to be used are as follows:

laboratory waste water; vinyl chloride pipe
other indoor waste water; vinyl chloride pipe
other outdoor waste water; concrete pipe or vinyl chloride pipe.

f) Gas service system

LPG gas will be supplied to the places requiring it from the LPG central device. Black steel pipe will be used for piping material. A gas leak detector will be installed wherever it is deemed necessary for safety.

g) Fire protection system

Outdoor fire hydrants will be installed around the buildings within distances of not over 40 meters in radius. The water source is connected to the water service lines of PUSPIPTEK and the fire hydrant sizes are 75 mmø (double nozzle). This is a system in which PUSPIPTEK's fire engines will extinguish fires by collecting water from the fire hydrants.

Small sized dry chemical extinguishers will be installed in accordance with the "Fire Prevention Law of Japan". A special type of fire extinguisher will be provided at places where it is considered necessary.

h) Kitchen

Kitchen equipment such as the sinks, dressers and shelves etc., will be provided. The heat sources to be used are gas and electricity.

i) Special gas equipment (for experiments)

Special types of gas used in large amounts and of wide range, will be centrally supplied from the terminal that is located close to the main laboratory building.

For the special type of gas used in small amounts and partially, a cylinder will be provided adjacent to the place where it is to be used.

2) Air-conditioning and ventilation

a) Air-conditioning system

Air conditioners provided will be the separate type air-cooled package unit that is generally used in Indonesia. Taking into account interchangeability when selecting the equipment, types and kinds of equipment should be minimized. In principle, considering the effective use of laboratory spaces, the ceiling type should be installed as shown in Fig. 4-3.7.

Conditions for the calculation of cooling loads for air conditioning are as follows;

Outdoor temperature 33°C DB, Humidity 80 to 90% RH

Indoor temperature 26°C DB, Humidity 60 to 70% RH

b) Ventilation system

In principle natural ventilation will be available, but the rooms in which odors, heat and harmful gases are generated (lavatories, kitchen, substation, pilot plant room and draft chambers etc.) will be ventilated by means of forced ventilation.

Vinyl chloride fans and vinyl chloride ducts will be employed in the exhaust systems for corrosive gases (acids and alkali etc.).

Exhaust from the draft chambers of the laboratories in the main building will be led through the garret, as shown in Fig. 4-3.7.

Ceiling fans will be provided for the improvement of dwelling conditions for rooms where no air conditioning is provided.

3) Electrical system

a) Incoming system

The power supply line will be branched from the existing switchgear house which is sited near the research center for applied physics in the PUSPIPTEK complex, and will be extended underground by PUSPIPTEK, to the switchgear room to be installed in this project site. The power distribution system will be 3-phase 3-wire 20 kV, 50 Hz, 2 circuits.

The wiring diagram of the substation system is shown in Fig. 4-3.9.

The telephone line will also be branched from the existing line and will be extended underground to the planned facilities by PUSPIPTEK.

b) Substation system

Power will be supplied to the necessary loads from the transformer installed in the substation of the planned facilities, after being transformed from 3-phase 3-wire 20 kV to 3-phase 4-wire 380V/220V. The standard of the voltage of power distribution will be 3-phase 380V for motors, and single phase 220V for lighting and receptacles, and also will supply 110V, single phase where required.

c) Emergency generator system

An emergency generator will be installed in the energy center to be used as an emergency electricity source in case of power failures. The load capacity to be supplied will have a minimum limit. The generator rating will be 3-phase 4-wire 380V/220V, 50 Hz, 1,500 RPM.

The power can be controlled at the respective places where the power is used. The total power failure signal will be sent to the administration office.

d) Lighting and receptacle system

Illuminance will conform to the "Japan Industrial Standards." The fluorescent light is most commonly used because of its high efficiency as a lighting fixture, but on occasion, mercury-vapor lights (outdoors or high ceilings) and other appropriate light sources will be provided. Lighting zones should be divided in detail, so as to reduce energy consumption. The location of receptacles should be determined by making close study of the power source type of the laboratory equipment to be used, and its connecting method. From the viewpoint of security, outdoor lights should be provided at appropriate places.

e) Lightning protection and earthing system

As the project site is in a thunderstorm region, lightning rods will have to be installed even if the height of the buildings is under 20 meters. As well, earthing will have to be provided as occasion demands for the laboratory equipment.

f) Communications system

MDF will be installed by connecting with the exchanger of the telephone center in the PUSPIPTEK complex, so that people within this facility and the PUSPIPTEK complex can communicate mutually and also with places outside the PUSPIPTEK complex as well. As the available number of extension lines will be limited to 10 up to 1989, telephone lines should be used effectively in the design.

g) Broadcasting system

Amplifiers and speakers will be provided so as to make possible information dissemination and emergency announcements within the building.

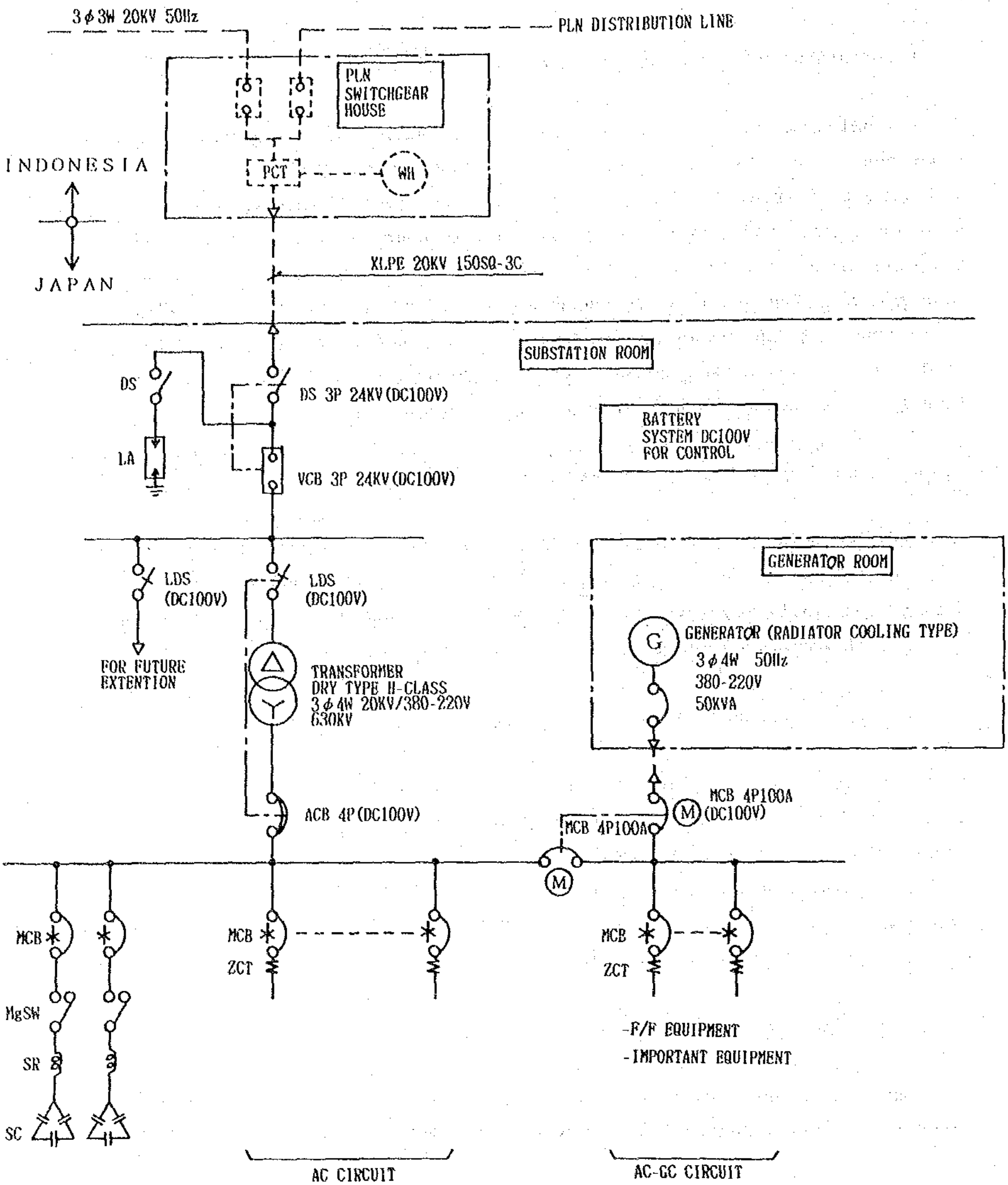


Fig. 4-3.9 Wiring Diagram of Substation System

h) Interphone system

An interphone will be installed at the following places.

For operation and management:	Guard house - administration office, etc.
For maintenance of equipment:	Substation - administration office, etc.

i) Automatic fire alarm system

Automatic fire alarms and detection systems will be provided to automatically detect fire at the earliest stage, and prevent magnification of disasters. The "Fire Department Code of Japan" will be applied as the installation criteria.

(5) Building material planning

In selecting building materials, the products of Indonesia will be used as much as possible. The following are the principal building materials to be used.

o Reinforcing steel
It is not much of a problem quality-wise if the material which is prescribed by the Industrial Standard of Indonesia (SII) is used.

o Cement
Same as for reinforcing steel above.

o Gravel (coarse aggregate)
Gravels are mainly composed of crushed stones which satisfy the requirement of the Japanese Architectural Standard Specification for Reinforced Concrete Work (JASS 5), but the grading distribution is slightly unfavorable.

o Sand (fine aggregate)

River sand is obtainable at the site and fully satisfies its requirements.

o Concrete mixing

There is a ready mixed concrete plant on the north of the PUSPIPTEK complex. In addition, with the sufficient project site space, a batcher plant can be considered.

o Steel

Most of the section steel available for building has a small section, and large H-section steel is now being imported. There are some steel fabricators having a fairly high-technical level, and welded joints are also available if they are not too complicated.

o Brick laying

Brick has generally been used as a construction material for walls, with mortar coating on both surfaces, but the selection of proper materials and skilled craftsmen will make it possible to have beautiful ornamental brick finishing as is seen in the traditional precise brick laying on Bali Island. The existing building located in the PUSPIPTEK complex shows this type of very fine ornamental brick masonry.

Table 4-3.2 List of Main Materials

Work	Material	Production on the Spot	Imported Material	Remarks
Reinforced Concrete Work	Cement	O		
	Reinforcing Bar	O		
Foundation Work	Cast-in-place Concrete Pile	O		
Form Work	Form	O		
Brick Work	Brick	O		
Waterproofing Work	Asphalt Waterproofing		O	Imported Material on the Spot
Stone Masonry Work	Marble	O		
	Terrazzo Block	O		
Ceramic Tile Work	Semi-Porcelain Tile	O		
	Porcelain Tile	O		
Carpenter's Work	Lumber	O		
	Laminated Lumber	O		
	Plywood	O		
Metal Work	Lightgage Steel Backing		O	Imported Material on the Spot
Door and Window Work	Aluminum Fittings			
	Steel Fittings	O		Imported Material on the Spot
	Wooden Fittings	O		
Plaster Work	Mortar Finish	O		
	Terrazzo Topping	O		
Glazing Work	Common Plate Glass	O		
Painter's Work	Interior Paint	O		
	Exterior Paint		O	According to the quality

Table 4-3.2 List of Main Materials (Cont'd)

Work	Material	Production on the Spot	Imported Material	Remarks
Interior Finish Work	Plaster Board		O	
	Rock Wool Acoustic Board		O	Imported Material on the Spot
	Plastic Tile		O	
Miscellaneous Work	Sink	O		
	Styrofoam		O	Imported Material on the Spot
Equipment Work	Cable, Wiring Accessories	O		
	Lighting Fixture	O		
	Transformer, Tables		O	Imported Material on the Spot
	Generator		O	According to the quality
	Package Type Air-conditioner		O	

4-3-4 Facility and equipment planning

The planned list of facilities and equipment, chosen according to the basic design principle and the basic design planning, is shown below.

(1) Pilot plant facility planning

The various equipment required for the pilot plant, based on the process flow sheet, are as follows.

1) Ore preparation

A series of equipment for drying the high moisture-content ore to be used for this test, for handling of necessary materials such as coal and sulfur and for making 10 - 15 mm diameter pellets after mixing and grinding.

1	Jaw crusher	1 set
2	Truck Hopper and Feeder	1 set
3	Belt conveyor	4 sets
4	Rotary Dryer	1 set
5	Hot Stove and Combustion Equipment for above	1 set
6	Bag Filter and Fan for above	1 set
7	Hopper and Feeder for Auxiliary Materials	4 sets
8	Coal Handling Pallet	1 set
9	Ball Mill	1 set
10	Pneumatic Conveyor	1 set
11	Fine Ore Bin and Feeder	1 set
12	Screw Conveyor	1 set
13	Pelletizer	1 set
14	Water Tank and Water Spray Unit	1 set
15	Pellet Conveyor	1 set

2) Reduction Furnace

A series of equipment for high-temperature reduction-roasting of green pellets, and for converting the nickel and cobalt in the ore to metallic nickel and cobalt by selective reduction.

1	Pellet Bin and Weighing Feeder	1 set
2	Lift Conveyor	1 set
3	Reduction Furnace	1 set
4	Hot Stove and Combustion Equipment for above	1 set
5	Scrubber Unit and Fan for above	1 set
6	Pellet Cooler	1 set
7	Divider	1 set
8	Reject Conveyor	1 set
9	Pallet	3 sets

3) Ammonia Leaching

A series of equipment for efficient leaching of nickel and cobalt from the reduced ore in ammonia solution, and for separating and removing tailings after leaching.

1	Wet Mill	1 set
2	Quench Tank and Pump	1 set
3	Leaching Tank and Pump	2 sets
4	Leaching Thickener and Spigot Pump	2 sets
5	Washing Tank	3 sets
6	Washing Thickener and Spigot Pump	3 sets
7	De-Mg Tank and Filter	1 set
8	Leaching Liquid Tank and Pump	1 set
9	De-Fe Mg Tank and Filter	1 set
10	De-Cu Zn Tank and Filter	1 set
11	Cartridge Filter	1 set
12	Soda Ash Additive Tank and Pump	1 set

13	Product Still and Kettle	1 set
14	Condenser	2 sets
15	Ammonia Gas Absorber	1 set
16	Ammonia Recovery Tank and Pump	1 set
17	Repulp Tank and Pump	1 set
18	Tailing Still	1 set
19	Tailing Tank and Pump	1 set
20	Tailing Filter	1 set
21	Waste Water Tank and Pump	1 set
22	NH_4OH Receiving Tank and Pump	1 set
23	Steam Generator	3 sets
24	Tailing Pallet	5 sets

4) Basic Nickel Carbonate Recovery

A series of equipment for crystallizing nickel in the solution as basic nickel carbonate (BNC) after leaching and ammonia stripping, and separating it by filtering.

1	Buffer Tank and Pump	1 set
2	BNC Filter	1 set
3	Filtrate and Pump	1 set
4	De-Co Tank and Filter Unit	1 set

5) Solvent Extraction

A series of equipment for removing impurities from the BNC after dissolving it in a hydrochloric acid solution, and extracting and separating nickel and cobalt by using a suitable solvent.

1	BNC Dissolving Tank and Pump	1 set
2	De-Fe Mg Tank, Pump and Filter	1 set
3	De-Cu Zn Tank, Pump and Filter	1 set
4	Buffer Tank and Pump	1 set
5	Solvent Extraction Mixer Settler	2 sets

6	Stripping Mixer Settler	2 sets
7	Circulation Tank and Pump	2 sets
8	Water Adding Tank and Pump	1 set

6) Ni and Co Electrowinning

A series of equipment for producing high purity nickel and cobalt metal by electrowinning from separate solutions containing nickel and cobalt after separation by solvent extraction.

1	$NiCl_2$ pH Adjustment Tank and Pump	1 set
2	Ni Electrowinning Unit	1 set
3	Ni Electrolyte Tank and Pump	2 sets
4	Ni Condensation Tank and Pump	1 set
5	$Ni(OH)_2$ Neutralization and Filter Unit	1 set
6	$CoCl_2$ pH Adjustment Tank and Pump	1 set
7	Co Electrolysis Unit	1 set
8	Co Electrolyte Tank and Pump	1 set
9	Co Fluid Concentration Tank and Pump	1 set
10	$Co(OH)_2$ Neutralization and Filter Unit	1 set

7) Pollution Control

A series of equipment to effectively remove dust and scrub gases after collecting the dust and gases generated in the pilot plant. Centralized treatment of waste water is to be conducted for pollution control.

1	Bag Filter and Fan	1 set
2	Gas Scrubbing Equipment	1 set
3	Waste Water pH Adjustment Equipment	1 set
4	Pit Pump	2 sets

8) Electrical and Instrumentational

1	Low Tension Motor Panel	3 sets
2	Switch Panel	5 sets
3	Instrumentational Panel	1 set
4	Distribution Panel for Workshop Equipment	1 set
5	Instrumentational Equipment	1 set
6	Wiring Material	1 set

9) Accessory

1	Compressor	1 set
2	Oil Receiving Tank and Pump	1 set
3	Cleaner	1 set
4	Duct and Piping Material for Plant	1 set

10) Workshop

1	Lathe	1 set
2	Electric Welder	2 sets
3	Drilling Machine	2 sets
4	Sawing Machine	2 sets
5	Grinder	2 sets
6	Tool Set	3 sets

11) Vehicle and Handling Cart

1	Shovel Loader	1 set
2	Small Truck	1 set
3	Van	1 set
4	Pallet Lift	2 sets

(2) Analytical and Laboratory Equipment Planning

The equipment to be used for analytical and laboratory studies consists of the following items which must achieve the functions and the purpose assigned to each room, as explained in the previous section.

1) Chemical analysis room

1	Ultrasonic cleaner	1 set
2	Water bath	1 set
3	Magnetic stirrer	2 sets
4	pH meter	1 set
5	Electro conductivity meter	1 set
6	Ion meter	1 set
7	Shaker	1 set
8	Vacuum dryer	1 set
9	Fusion table	1 set
10	Muffle furnace	1 set
11	Centrifugal separator	1 set
12	Draft chamber	1 set
13	Balance	2 sets
14	Spectrophotometer	1 set
15	Pure water making system	1 set

2) Instrumental analysis room (A)

1	I.C.P.	1 set
2	Atomic absorption spectrometer	1 set
3	Carbon-sulfur analyzer	1 set
4	Balance	1 set

3) Instrumental analysis room (B)

1	X-ray fluorescence spectrometer	1 set
2	X-ray diffractometer	1 set

3	EPMA	1 set
4	Sample preparation unit	1 set

4) Instrumental analysis room (C)

1	DTA-TG and DSC system	1 set
2	Automatic moisture balance	1 set
3	Coal analysis apparatus	1 set
4	Infrared spectrometer	1 set
5	Polarograph	1 set

5) Sample preparation room

1	Crusher	4 sets
2	Screening set	1 set
3	Air compressor	1 set
4	Dryer	4 sets
5	Balance	2 sets
6	Sample mixer	1 set
7	Sample divider	2 sets
8	Dust collector	1 set

6) Mineral dressing room

1	Flotation cell (Labo type)	2 sets
2	pH meter	2 sets
3	Ball & rod mill, driver	3 sets
4	Dryer	2 sets
5	Electrostatic separator	1 set
6	Vacuum filter	3 sets
7	Balance	2 sets
8	Magnetic separator	2 sets

7) Mineralogical room

1	Microscope	2 sets
2	Desiccator	2 sets
3	Diamond saw cutter	1 set
4	Sample mounting apparatus	1 set
5	Polishing apparatus	1 set
6	Film processor	1 set

8) Pyrometallurgical room

1	Tube furnace	3 sets
2	Muffle furnace	3 sets
3	Crucible furnace	2 sets
4	Induction furnace	1 set

9) Hydrometallurgical room

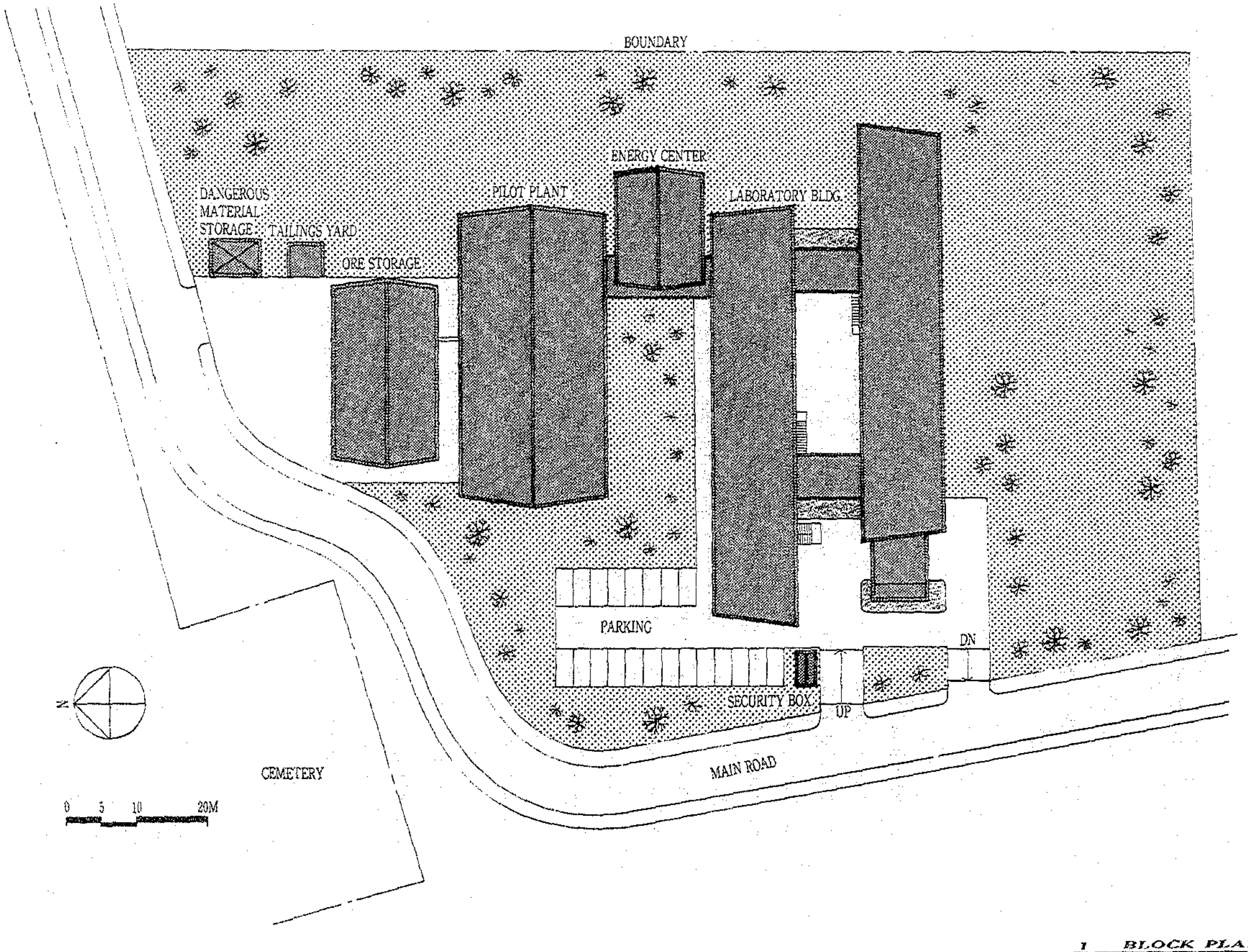
1	Auto still	1 set
2	Centrifugal filter	1 set
3	Centrifuge	1 set
4	Jar tester	1 set
5	Magnetic stirrer	5 sets
6	Ultrasonic cleaner	1 set
7	Muffle furnace	1 set
8	Autoclave	1 set
9	Electrolytic cell	1 set
10	pH meter	5 sets
11	Ion meter	1 set
12	Balance	2 sets
13	Mixer-settler	1 set
14	Shaker	1 set
15	Potentiostat	1 set

10) Other common equipment

1	Micro computer (Personal computer)	1 set
2	Scrubber	1 set
3	Pit pump	1 set

4-3-5 Basic Design Plan

1. Block Plan
2. First Floor Plan of Laboratory Building
3. Second Floor Plan of Laboratory Building
4. Elevations and Section of Laboratory Building
5. Floor Plan, Elevation and Section of Pilot Plant Building
6. Floor Plans, Elevations and Sections of Energy Center, Ore Storage Building and Dangerous Material Storage Building
7. Overall West Side Elevation
8. Plot Plan of Pilot-Plant Facilities
9. Equipment Plot Plan of Chemical Analysis Room, Instrumental Analysis Room (A)
10. Equipment Plot Plan of Instrumental Analysis Room (B), (C)
11. Equipment Plot Plan of Mineral Dressing Room, Mineralogical Room and Dark Room
12. Equipment Plot Plan of Sample Preparation Room
13. Equipment Plot Plan of Pyrometallurgy Room
14. Equipment Plot Plan of Hydrometallurgy Room


BOUNDARY
DANGEROUS MATERIAL STORAGE
TAILINGS YARD
ORE STORAGE
PILOT PLANT
ENERGY CENTER
LABORATORY BLDG.
PARKING
SECURITY BOX
DN
UP
MAIN ROAD
CEMETERY
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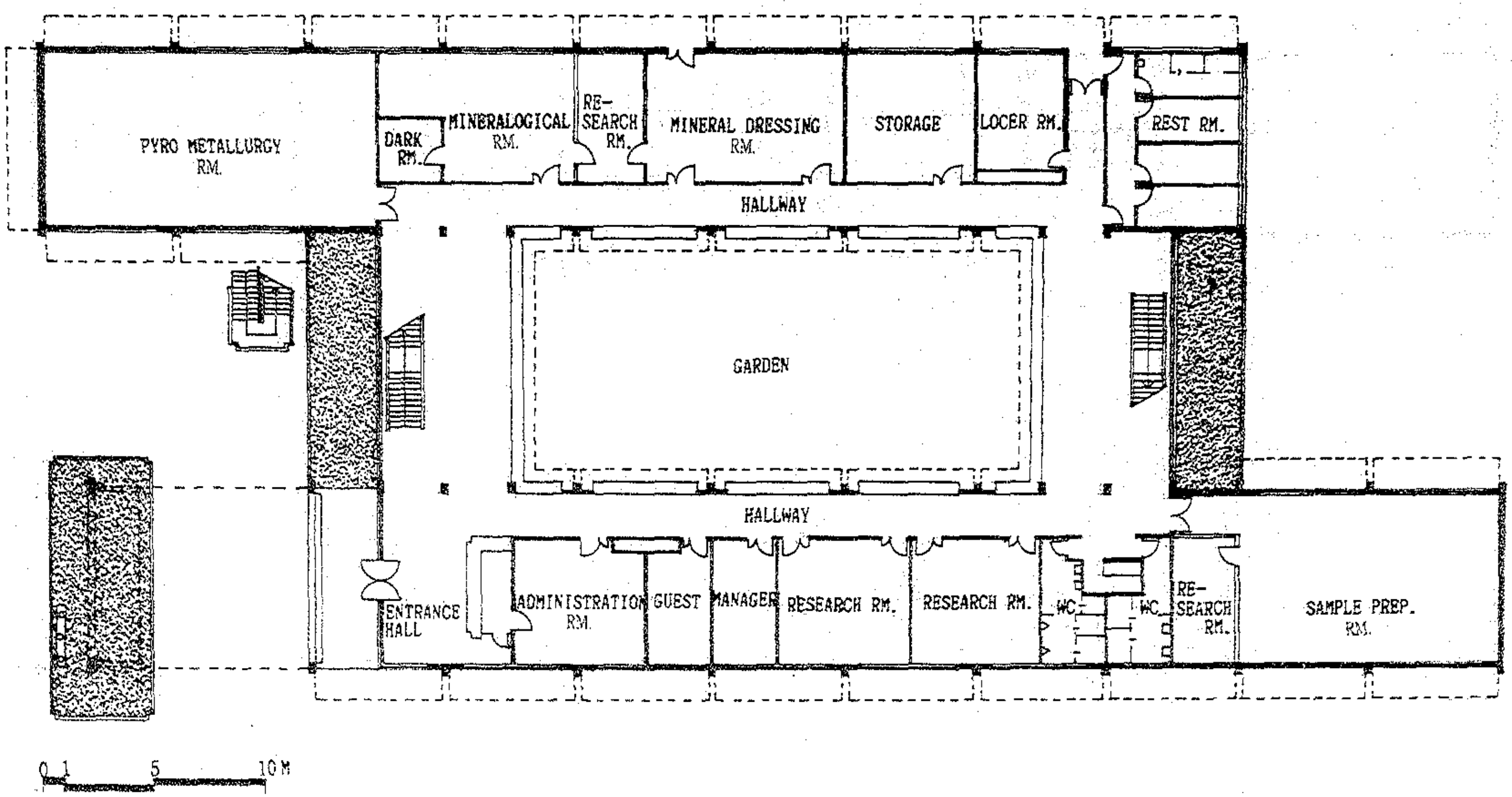
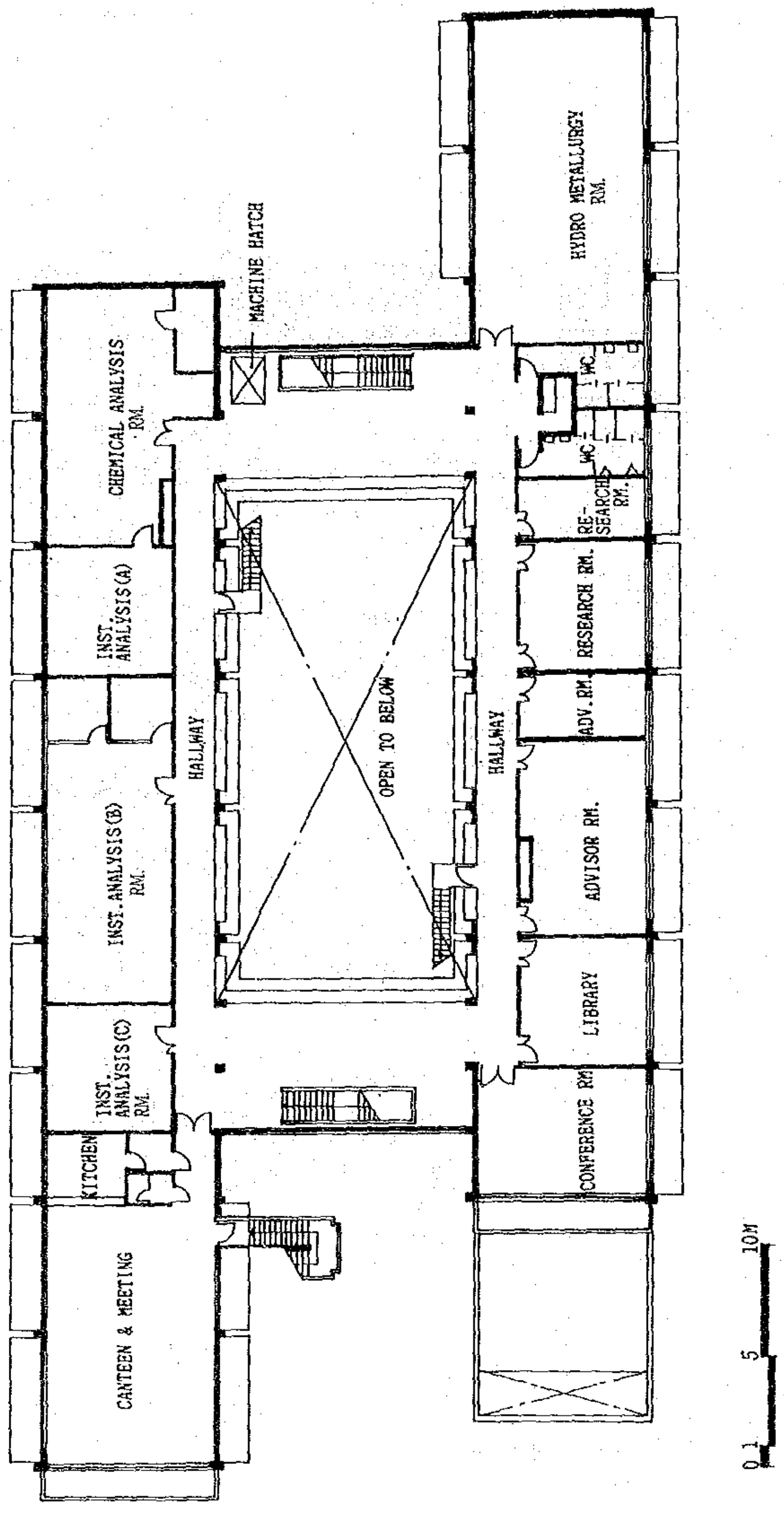
0 5 10 20M

1 BLOCK PLAN



2 FIRST FLOOR PLAN OF LABORATORY BUILDING


HYDRO METALLURGY RM.
MACHINE HATCH
CHEMICAL ANALYSIS RM.
INST. ANALYSIS (A)
INST. ANALYSIS (B) RM.
INST. ANALYSIS (C) RM.
KITCHEN
CANTEEN & MEETING
HALLWAY
OPEN TO BELOW
HALLWAY
WC
WC
RE-SEARCH RM.
RESEARCH RM.
ADV. RM.
ADVISOR RM.
LIBRARY
CONFERENCE RM
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