2-2. Industrialization level (Basic metal and machine industries around proposed sites)

A substantial plant maintenance system is indispensable for stable and efficient operations of a steel works after completion. Maintenance jobs of sophisticated and diverse facilities include:

1) Manufacture and repairing of equipment;
2) Civil engineering, electrical wiring, piping and other maintenance works; and
3) Procurement and spares control of electrical and mechanical parts.

If the steel works intends to carry out, by itself, all maintenance jobs other than procurement of mechanical and electrical equipment and parts supplied by special manufacturers, the scale of maintenance would be huge in personnel as well as in required equipment. If there are adequate and sufficient supporting industries as shown in Table 6-2-9 in the periphery of the steel works, it may ease the maintenance system that the steel works must involve.

In the following, based on the result of Step II study, present conditions of

- basic metals and machine industries (incl. shipbuilding and automobiles)
- supporting industry
- facilities maintenance system

in the West Jawa area (incl. D.K.I. Jakarta Province and Jawa Barat Province) and the North Sumatera area (incl. D.I. Aceh Province and Sumatera Utara Province) are summarized.

2-2-1. Basic metals & machine industries and supporting industry

(1) North Sumatera area

Table 6-2-9 Supporting Industry for Steel Works

Division	Sector of Industry
Apparatus and equipment supplier	◦ Refractory ◦ Electrical module and parts Electric motor Hydraulic parts Fan, blower, pump General machine parts Plumbing parts Parts for vehicles and cranes Lubrication oil/grease and hydraulic oil
Subcontractor's job inside steel works	Steel member working (including finishing) Plumbing Electrical conduit fitting Brick laying Computer operation
Subcontractor's job outside steel works	Machining (including gear cutting) Build-up welding and metal coating Casting and forging Repair and maintenance of instrumental and electrical apparatuses

1) Basic metals/machine industries

D.I. Aceh has neither large and medium-scale basic metal industry nor machine industry, whereas, there are 61 enterprises of such industries in Sumatera Utara.

Table 6-2-10 represents major basic metals/machine enterprises in Sumatera Utara, many of which are located in Medan.

Medan has 12 steel producers, 14 heavy machine manufacturers, a manufacturer of small capacity motor and a distribution transformer manufacturer. Medan is thus equipped with heavy industries in types and it would be demanded to expand the production scale in the future.

While Sumatera Utara is not on a high level of industrialization as a whole, Medan is called the highly industrialized district next to Jakarta and Surabaya.

Table 6-2-10 Major Basic Metal and Machine Industries in Sumatera Utara

Sector	Type of product	Enter-prises	Annual production capacity		Actual production
			Licensed	Installed	
Steel	Bars & sections	3	74,200 tons	91,000 tons	32,000 tons (1984)
	Wire rods	1	72,000 tons	46,400 tons	6,000 tons (1984)
	Galvanized sheets	3	67,000 tons	91,000 tons	43,500 tons (1984)
	Steel wires	4	33,600 tons		24,000 tons (1984)
	ERW pipes	3	22,200 tons	25,200 tons	
Metal prod.	Nails	7	13,400 tons		
Shipbuilding		17	16,250 DWT		
Electr.	Motor (up to 15 HP)	1	3,000 units		
	Generators		3,000 units		
	Transformers (50~1600 KVA)	1	1,000 units	3,000 units	
Heavy machine	Steel structure (Equipment for palm oil, sugar & rubber industries)	10			1,080 tons (1985. Jan.-Mar.)
	Machinery	5			4,450 units (1985. Jan.-Mar.)
Non-ferrous (Al)	Aluminium ingot	1	225,000 tons	225,000 tons	181,100 tons (1984)
	Aluminium extrusion	3	2,200 tons		

Source: Year Book of North Sumatera 1984.
Production Report on Machine Industry Term I. 1984 (M.O.I.)
Report on Basic Metal Industry 1985. (M.O.I.)

2) Supporting industry

Plant maintenance system presently carried out at the four enterprises visited (three steel producers and P.T. Inalum) is basically self-maintenance, and there seem to be only a few cases of ordering machine repairing and construction works to outside subcontractors except for in P.T. Inalum.

For example, the three enterprises except one, which motors are repaired at a very low frequency, repair their motors within their own plants. An enterprise among them has sufficient skill to repair AC 100 kw squirrel-cage motors. An electric furnace steel maker even manufactures mechanical parts for the rolling mill using a small-capacity cupola.

The machine repairing shop of P.T. Inalum has 15 up-to-date machines for plate working and machining including large-capacity lathes, a 200-ton forming press and a double-housing planning machine.

The self-maintenance is thus the usual practice except a few special cases (high-grade electrical works and large-scale works), which is partly due to the low availability of supporting industries which can meet such jobs.

According to a galvanized sheet manufacturer's infomation many of spares are procurable in surrounding areas of Medan.

P.T. Inalum (smelter) utilizing external contractors widely as compared with the other three enterprises sometimes orders some parts of maintenance jobs to three contractors working with P.T. Inalum since the beginning of plant construction, but their designing ability is said to be still insufficient and to need supply of drawings and guidance.

In MEDAN, a transformer maker is quality conscious and a machine builder (boilers, blowers) has high level of welding skill, and it seems that they are gradually accumulating technology.

It has been planned to construct Medan Industrial Estate of about 80 ha in the middle between Medan and Belawan, but we could find no trace of concrete progress and they seemed to be looking for applicant enterprises to become tenants.

(2) West Jawa area

1) Basic metals/machine industries

Indonesian basic metals and machine industries are concentrated in West Jawa area. Particularly, steel, shipbuilding, automobile, machinery and electrical sectors show a very high degree of cocentration: in terms of production capacity and number of enterprises, all above sectors in this area exhibit a share of at least 30%, and usually over 50%, and automotive and electrical sectors have a share of 80 to 90% (Table 6-2-11).

The annual production amount of heavy industries per capita of population is about 154,000 Rp for D.K.I. Jakarta, about 16,600 Rp for Jawa Barat, and about 42,600 Rp for West Jawa area as a whole.

As compared with the other areas, the index factor surpasses the national average of 13,700 Rp only in West Jawa area, with a figure more than three times as high as the average. It may be concluded from this fact that only West Jawa area has been heavy-industrialized over the other areas.

Table 6-2-11 Metal Products/Machine Industries in West Jawa

Sector	Type of Product	Item	West Jawa	Indonesia	West Jawa share
Iron and steel	Hot coil	Prod. (1984)	389,000 Tons	389,000 Tons	100%
	Rods	Prod. (1984)	104,000 Tons	207,000 Tons	50%
	Bars and sections	Prod. (1984)	478,000 Tons	641,000 Tons	75%
		Enterp.(1984)	17	30	57%
	Steel wire	Prod. (1984)	45,000 Tons	103,000 Tons	44%
	Steel pipes	Prod. (1984)	195,000 Tons	287,000 Tons	68%
		Enterp.(1984)	10	22	45%
	Galvanized sheets	Prod. (1984)	54,000 Tons	194,000 Tons	28%
		Enterp.(1984)	4	15	27%
	Iron and steel enterprises		41	85	48%
Ship-building	Major shipyards		14	33	42%
Auto-mobile	Components	Enterp.	25	35	71%
		Annual prod. capa.	368,500Units	427,000Units	86%
	Assembly	Enterp.	15	17	88%
Machi-nes	Machinery	Prod. (1985) Jan.-Mar.	15,600Units	23,300Units	67%
	Steel Structure	Prod. (1985) Jan.-Mar.	8,770 Tons	16,920 Tons	52%
	Major heavy machine enterp.		43	82	52%
Elect-rical	Cable	Annual prod. cap.	68,200 Tons	73,000 Tons	93%
	Household elec. appliances	Major enterp.	45	54	83%
	Generator	Annual prod. cap.	$110x10^3$Units	$118x10^3$Units	93%
	Motor	Annual prod. cap.	86,000Units	89,000Units	97%
	Transformer	Annual prod. cap.	22,300Units	26,300Units	85%
	Electrical machines and parts	Major enterp.	40	49	82%
		Employees	3,890	4,650	84%
Electro-nics	Micro computer	Annual prod. cap.	2,800Units	2,800Units	100%

Source: Based on Data from M.O.I., Jakarta

2) Supporting industry

In West Jawa area, nine of the steel enterprises have their steelmaking shops, among them, we visited P.T. Krakatau Steel and two open-hearth/electric furnace steel makers in Jakarta. All the three companies are basically in the self maintenance system, but unlike the other areas, considerable works are ordered to external contractors. The open-hearth and electric furnace steel makers in Jakarta order large-scale plate working, machine repairing, motor repairing and electric wiring works to external sources, and P.T. Krakatau Steel entrusts 15 contractors in total with piping works, plate working, installation of large machines, electric wiring works, furnace repairing, machining, buildup welding, casting and forging and electric appliance repairing. This means an high degree of development of supporting industry in this area as compared with the others.

Most of consumable parts can be procured from areas surrounding Jakarta, and they hold spares inventory of corresponding to about one-month consumption as a rule.

Even this area of West Jawa on a high level of industrialization with developed supporting industry does not have the supply capacity of sophisticated machines, electrical and instrumentation appliances. For the steel industry, rolls, motors and refractories which cannot be locally procured are almost imported.

We paid a visit to a transformer maker and a motor manufacturer. For power transformers, there is no problem concerning of the product capacity of 2-60 MVA at present. For motors, in contrast, the local industry is at present on the level of manufacture of small-capacity AC squirrel-cage motors up to 10kw, therefore, manufacture of larger-capacity motors and DC ones will be demanded in the future.

West Jawa area has a plan of constructing industrial estates each at Cilegon and Pulogadung. Some plants are under construction at Cilegon estate, and plants are already in production at Pulogadung estate where expansion is underway.

2-2-2. Plant maintenance

The present status of plant maintenance at 14 enterprises among those to which we paid a visit is as summarized in Table 6-2-12. These 14 enterprises consist of ten iron & steel makers, and each one timber, fertilizer, non-ferrous metal and oil refining companies. Although these enterprises cannot be compared on the same level because of the large differences in production scale and facilities among them, the information in this table gives an outline of the present plant maintenance practices in Indonesian manufacturing enterprises.

The following factors can be derived from Table 6-2-12.

1) Ratio of maintenance personnel to all employees (11 companies):
   - 15-20%: 5 companies
   - 10-15%: 3 companies
   - 5-10% : 3 companies
2) Scope of self-maintenance (14 companies):
   - Plant maintenance mainly by outside contractors: None
   - Only routine small-scale repairing jobs carried out within plant, and remaining jobs are externally ordered: None
   - Most of jobs other than large-scale works are disposed of within the plant: 12 companies
   - Almost all maintenance jobs except very sophisticated ones are conducted within plant itself: 2 companies
3) Ratio of local procurement of consumable parts:
   - Very high (about 8%): 3 companies
   - About 50% : 4 companies
   - About 20-40% : 2 companies

Table 6-2-12 Plant Maintenance in Indonesia

Enterprises (Location)	Type of industry/ product	Maintenance personnel (ratio of personnel to all employees, %)	Policy of plant maintenance				Features on daily maintenance		On-site facilities in machine repairing shop	Outside contractors (maintenance works, manufacture, repairing)		Procurement of materials and parts				Spares ledger	Spares control Inventory	
			I	II	III	IV	Machine	Motor repairing		Degree of utilization of contractors	Designing ability	Ratio of local procurement of consumable parts	Important items for steel industry Roll	Motor	Refractory		Consumable parts	Vital parts
A (Cilegon)	Integrated steel works	1,600			O		o Crane assembling o Small cast products o Large machine repairing	ACmax200kW, DC motor repairing being possible	Having 6 repair shops of a considerable scale; Small-capacity casting and forging facilities; 140 machines in total	o Installation of large cranes o Piping o Utilized as required (about 15 companies)	o Domestic and foreign major makers having sufficient capabilities	30 ~ 40%	All imported	All large-capacity motors of 100 kW and over imported	Domestic products used for low duty range	Existent	One-month stock	Stock of 3 ~ 4 month imports
B (Jakarta)	Open-hearth furnace steel works	50 ~ 100 (8 ~ 17%) no specific sections			O		o Electric construction (panel, wiring)	By external contractors	Having repairing shops of vehicles, cranes and forklifts	Large-capacity machines (plate working), electrical appliances: 3 companies		Very high (guide wire) for domestic companies	All imported (from Japan)		Use ratio of domestic products: 80%; mainly runner bricks			
C (Bekasi)	Electric furnace steel works	90 (18%)			O		o Preparing maintenance o check sheet, (monthly)	By external contractors	Small-scale machine repairing shop with two lathes and welding machine	Electrical machines: two companies		Very high			Almost all imported	Existent	One-month stock (hose, valve, cabtyre cord)	3 ~ 4 month stock (mostly imported)
D (Medan)	Electric furnace steel works	—			O		o Preservation for oxygen plant	Motor repairing	25 machines	Very low degree of utilization					Imported			
E (Medan)	Electric furnace steel works	40 ~ 50				O	o Making parts for rolling mill (casting materials)	ACmax200kW, DC motor repairing being possible	13 machines in total including 6 lathes, having a small-capacity cupola	– ditto –								
F (Surabaya)	Plates and bars	40 (13%)			O			By external contractors	5 machines in roll shop	Frequently used (P.T. Barata, etc.)		About 90%	Imported (from Japan)				Flanges and bolts	Large gear, metal bearings (imported)
G (Surabaya)	Electric welded tube	—				O	o Forklift repairing o Making small parts	Not necessary		Rarely used: only high-grade electrical works externally ordered (to Jakarta)		About 80%		Motors up to AC 10kW procurable in Surabaya			Roller belts, paint, gears, pulleys	Zinc Kiln, rollers (imported from Japan)
H (Medan)	Galvanized sheets	28 (14%)				O		– ditto –	5 machines in total including lathes and shaper	– ditto –		Procurable to a large extent in Medan		Motors up to 15 HP procurable in Medan				Zinc kiln (imported from (Japan)
I (U.Pandang)	Galvanized sheets	17 (9%)			O		o Forklift repairing	– ditto –	5 machines in total including 2 lathes and one shaper	Buildup welding and machining ordered to about two companies		Welding electrodes, bearings, cables widely procurable						Zinc kiln (imported from (Japan)
J (U.Pandang)	Reinforcing bars	18 (11%)			O			– ditto –	7 machines in total including large-capacity lathe and roll lathes	Spindles and shafts ordered to Surabaya			All imported (from Japan)			Existent	Belts, rollers guides, cutting tools)	Bearings (imported from Japan)
K (Samarinda)	Plywood	11 (2%)			O		o Making parts for ships and cars	– ditto –	4 machines including lathes and shapers			(Tape, paste, hoop)						One-year stock of imported, saws (from Japan)
L (Palembang)	Fertilizer (urea)	500 (9%)			O		o Large machine repairing	—	5 large-scale repairing shops: about 30 machines for plate working and piping in 2 shops	o New works ordered to foreign makers o No order to makers in South Sumatera								
M (Balikpapan)	Oil refining	1,000 (25%) incl. transport and material			O			—		New and large works ordered to foreign makers		20 ~ 40%		Imported				
N (Kuala Tanjung)	Non-ferrous metal (aluminum)	340 (15%)			O			ACmax125kW type motor repairing	Most modern repairing shop with 15 large-sized machines in total	3 local electrical and machine works companies	Insufficient designing ability; guidance required	10 ~ 20%						About one-year stock of imports

Notes: Scope of plant maintenance I: Mainly by external contractors II: Only routine small repairing jobs carried out within plant III: All maintenance jobs except periodical and large-scale works conducted within plant IV: Almost all within plant.

Because of the low level of development of supporting industry in the surrounding areas around the plants, all these enterprises adopt the maintenance policy of not depending upon outside contractors but conducting self-maintenance. Large-scale enterprises located in various provinces have their own perfected maintenance equipment, and the dependence on outside contractors for maintenance jobs is very low in the large-scale enterprises located in islands other than Jawa.

The general policy in the Indonesian industry for plant maintenance is "to emphasize preventive maintenance, without relying upon outside contractors, to conduct self-maintenance as to equipment repair, manufacture of small parts, repair of electrical appliances and wiring, piping and installation works, and to order only high-degree large-scale works to capable domestic or foreign makers." It will not make much difference in the maintenance system whether the steel works for the second generation is to be constructed at Arun or Cilegon.

2-3. Local administration

Local administration system is specified by "law concerning the basics of local administration", 1974, and the law as revised in 1980.

Firstly, there are 27 provinces and D.I.'s as the first class self-governing body, under which there are prefectures and cities as the second class self-governing body. Further under the second class self-governing body, there are organizations such as counties, communities and villages. Governors of provinces and D.I.'s are appointed by the President of Indonesia and the heads of prefectures, cities and counties are appointed by the Governors. The office term is 5 years; though they can be reappointed, they cannot serve three consecutive terms.

27 provinces and D.I.'s are as follows:

	Province	Capital
*	1. DAERAH ISTIMEWA ACEH	BANDA ACEH
	2. SUMATERA UTARA	MEDAN
	3. SUMATERA BARAT	PADANG
	4. RIAU	PEKAN BARU
	5. JAMBI	JAMBI
	6. SUMATERA SELATAN	PALEMBANG
	7. BENGKULU	BENGKULU
	8. LAMPUNG	TANJUNG KARANG
*	9. DKI. JAKARTA	JAKARTA
	10. JAWA BARAT	BANDUNG
	11. JAWA TENGAH	SEMARANG
*	12. DAERAH ISTIMEWA YUGYAKARTA	YOGYAKARTA
	13. JAWA TIMUR	SURABAYA
	14. BALI	DENPASAR
	15. NUSA TENGGARA BARAT	MATARAM
	16. NUSA TENGGARA TIMUR	KUPANG
	17. TIMOR TIMUR	DILLI
	18. KALIMANTAN BARAT	PONTIANAK
	19. KALIMANTAN TENGAH	PALANGKARAYA

20.	KALIMANTAN SELATAN	BANJARMASIN
21.	KALIMANTAN TIMUR	SAMARINDA
22.	SULAWESI UTARA	MANADO
23.	SULAWESI TENGAH	PALU
24.	SULAWESI SELATAN	UJUNG PANDANG
25.	SULAWESI TENGGARA	KENDARI
26.	MALUKU	AMBON
27.	IRIAN JAYA	JAYAPURA

* Daerah Istimewa

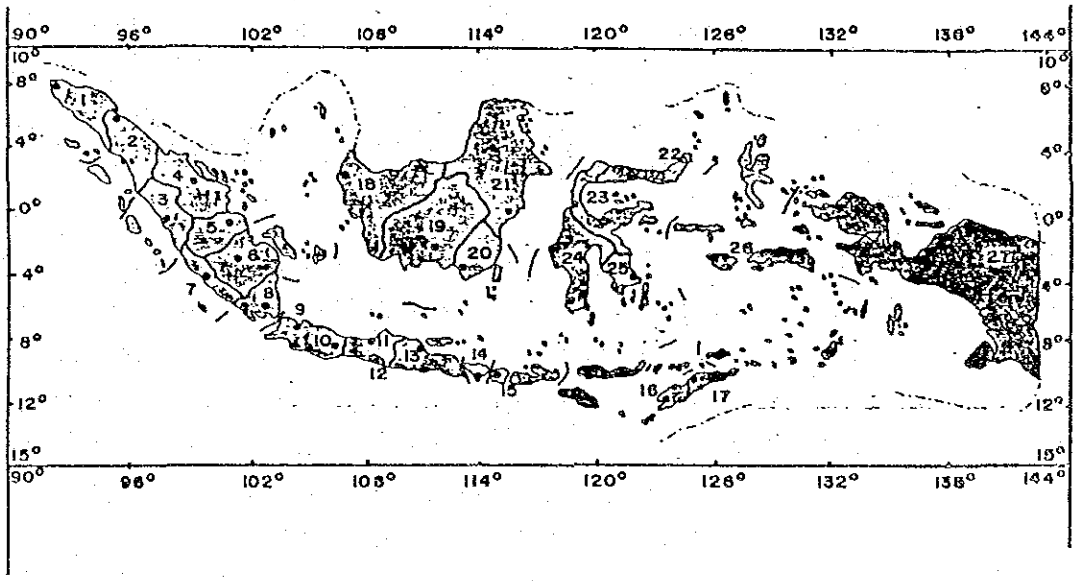


Fig. 6-2-1 Map of Indonesia

3. Availability of Natural Gas

3-1. Outline

Natural gas consumed for reduction and fuel at the new steel works for the second generation is estimated to be about 1.72 million Nm^3/D.

Table 6-3-1 Gas Consumption in the New Steel Works

(Unit: Million Nm^3/D)

Plant	Natural Gas Consumption
Direct reduction plant	1.39
Medium section mill	0.08
Bar mill	0.12
Wire rod mill	0.12
Central maintenance shop	0.01
Total	1.72

On the other hand, at the West Jawa area with Cilegon in the center, the reserves of natural gas is small and in addition the old gas field is being exhausted steadily. As a result, natural gas production in the area is decreasing from year to year and it is expected that the gas will be in short supply within ten years from now.

Therefore, the construction of the new steel works in the West Jawa area will be accompanied by a considerable difficulty in this respect, but the area is the most industrialized area in Indonesia and has advantages such as

1) closeness to steel consuming centers,
2) abundant manpower,
3) good availability of machinery and consumables, and
4) well developed infrastructure.

It is desirable to make a substantial adjustment including renovation of existing plants for the purpose of ensuring better demand and supply balance of natural gas and enabling construction of the new steel works.

Table 6-3-2 Natural Gas Deposit in Indonesia

(Unit: 10^9 Nm^3)

Area	Natural Gas Deposit
NORTH SUMATERA	475
CENTRAL SUMATERA	34
SOUTH SUMATERA	164
EAST KALIMANTAN	323
WEST JAWA	93
EAST JAWA	13
SOUTH SULAWESI	13
Total	1,115

On the other hand, in the North Sumatera area with Arun in the center, the reserves of natural gas is large, more than 5 times of that in West Jawa area, and as the area is not advanced in industrialization, the major part of the gas produced is processed to liquefied natural gas. Therefore, though it is necessary to expand capacity of gas pipeline, there should be no problem in gas supply for the construction of the new steel works.

3-2. West Jawa area

According to the data concerning natural gas balance prepared by Ministry of Mines and Energy of Indonesia, the forecast of supply capacity is assumed constant from 1992 and that of demand is assumed constant from 1989. Therefore this pre-F/S which places the target in 1995 and after also follows it.

3-2-1. Forecast of supply capacity

Table 6-3-3 is the data prepared by Ministry of Mines and Energy in January 1985 and shows gas production potential in West Jawa area including Cilegon. Gas production in 1985 is 8.33 million Nm^3/D, but as the old gas field is exhausted, the production will decrease by about 13% to 7.25 million Nm^3/D in 1992 and thereafter. The production in 1992 includes

gas production of 1.07 million Nm^3/D from IIAPCO gas field under development off Cilegon, which indicates poor natural gas condition in West Jawa area.

Table 6-3-3 Gas Production Potential in West Jawa

(Unit: 10^6 Nm^3/D)

	1985	1986	1987	1988	1989	1990	1991	1992
Old gas fields:								
1. PERTAMINA (ASS & NON ASS GAS)	1.02	0.88	0.80	0.72	0.62	0.54	0.51	0.48
2. EX LPG	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
3. LAPANGAN PERIGI	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48
4. ARCO TAIL GAS	1.61	1.10	0.83	0.62	0.43	0.27	0.11	0
Sub-total	6.99	6.34	5.99	5.70	5.41	5.17	4.98	4.84
New gas fields:								
1. PERTAMINA (LAP. PERIGI)	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
2. IIAPCO (OFFSHORE PABELOKAN)	-	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Sub-total	1.34	2.41	2.41	2.41	2.41	2.41	2.41	2.41
Total	8.33	8.75	8.40	8.11	7.82	7.58	7.39	7.25

3-2-2. Forecast of demand

Major changes in the forecast of natural gas demand in the West Jawa area shown in Table 6-3-4 are

1) production of DRI at P.T. Krakatau Steel is increased to 2 million t/y by 1987, and
2) fuel at cement plants is changed from natural gas to powdered coal by 1987.

The demand is expected to increase basically because while the capacity of DR plant is 2 million t/y, production of DRI in the 1985 and 1986 fiscal year was 1.1 million t/y and 1.3 million t/y, respectively, but the production is to increase to full capacity as soon as possible.

The total demand in 1989 and after is expected to be 8.24 million Nm^3/D, of which about 76% is accounted for by consumption at DR plant and in-house power station of P.T. Krakatau Steel, and it is necessary to review gas consumption at those plants.

Table 6-3-4 Natural Gas Demand in West Jawa

(Unit: 10^6 Nm^3/D)

	1985	1986	1987	1988	1989	1990	1991	1992
P.T. Krakatau Steel:								
1. DR plant	2.04	2.74	3.66	3.66	3.66	3.66	3.66	3.66
2. EAF - RM	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
3. Power station	1.22	1.57	2.10	2.36	2.58	2.58	2.58	2.58
Sub-total	3.40	4.45	5.90	6.16	6.38	6.38	6.38	6.38
City gas	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Fertilizer plants	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
Cement plants	0.94	0.94	-	-	-	-	-	-
Total	6.20	7.25	7.76	8.02	8.24	8.24	8.24	8.24

3-2-3. Demand and supply balance of natural gas

As mentioned above, the natural gas balance around 1995 will show the demand exceeding the production by about one million Nm^3/D, and if the facilities of P.T. Krakatau Steel are left as it is, it will be impossible to attain full-capacity operation of P.T. Krakatau Steel, not to mention the construction of the second steel works.

3-2-4. Demand and supply adjustment of natural gas

If it is possible to discover and exploit new gas fields in the West Jawa area with Cilegon in the center, it may be easy to improve natural gas supply condition, but such discovery of new natural gas deposits in the area is difficult and the following measures are to be taken.

(1) Renovation of DR plant of P.T. Krakatau Steel

At present, there are 4 units of HYL I type DR furnace in DR plant of P.T. Krakatau Steel. Base consumption unit of natural gas in HYL I type furnace is 5.8 Gcal per ton of DRI, which is very high as compared to 2.6 Gcal of the most modern furnace and is one of causes for poor supply condition of natural gas.

Therefore all the existing DR furnaces are to be replaced by Midrex process or HYL III type process. This will reduce natural gas consumption from 5.8 Gcal/T to 2.6 Gcal and save about 2 million Nm^3/D of the gas.

(2) Change of oil:gas ratio of fuel for in-plant power plant of P.T. Krakatau Steel

In the forecast of natural gas demand/supply balance, the oil:gas ratio of fuel for in-plant power plant is assumed to be 20:80. But recently efforts are being made to decrease the percentage of gas and the gas ratio was lowered to 60% as of March 1987. By decreasing the gas ratio further to 50:50, about 1.1 million Nm^3/D of the gas is to be saved.

With the above two measures, natural gas demand in 1992 and after will be 5.14 million Nm^3/D, leaving for the first time surplus of 2.11 million Nm^3/D which can fill the demand of 1.72 million Nm^3/D of natural gas required for the second steel works.

3-3. North Sumatera area

3-3-1. Forecast of supply capacity

As shown in Table 6-3-5, gas production potential in the North Sumatera area is 45 - 55 million Nm^3/D, or 5 - 8 times that of the West Jawa area, reflecting the scale of natural gas fields in the area.

Table 6-3-5 Gas Production Potential in North Sumatera

(Unit: 10^6 Nm^3/D)

	1982	1983	1985	1990	1995	2000	2003
North Sumatera	35.96	38.83	43.23	46.61	50.28	54.02	56.22

3-3-2. Forecast of demand

As shown in Table 6-3-6, L.N.G. production accounts for about 95% of the entire natural gas demand in North Sumatera area. Though start-up of an ethylene complex and a paper mill and others is planned around 1990, the percentage of L.N.G. is still as high as 80%.

Table 6-3-6 Natural Gas Demand in North Sumatera

(Unit: 10^6 Nm^3/D)

	1984	1988	1993	1998	2003
Power - Gas turbines		0.22	0.22	0.26	0.37
- Steam plants		0.51	0.51	1.47	3.16
Fertilizer-Existing	0.73	2.06	2.06	2.06	2.06
-Extensions			0.95	1.91	2.86
City gas		0.04	0.05	0.07	0.11
Light industry		0.01	0.06	0.12	0.20
Medium industry		0.02	0.07	0.15	0.26
Paper mill			0.29	0.29	0.29
Ethylene complex			1.69	1.69	1.69
L.N.G. plant	33.76	42.86	42.86	42.86	42.86
Total	34.49	45.72	48.76	50.88	53.86

3-3-3. Demand/supply balance of natural gas

As mentioned above, almost all of natural gas produced in the North Sumatera area with Arun in the center are used for production of L.N.G. and the condition is expected to continue for some years to come.

Considering the natural gas production in the area is as big as 5 - 8 times that in the West Jawa area, it should be easy to provide about 2 million Nm^3/D of natural gas required for the second steel works though it seems there is little room according to Fig. 6-3-1.

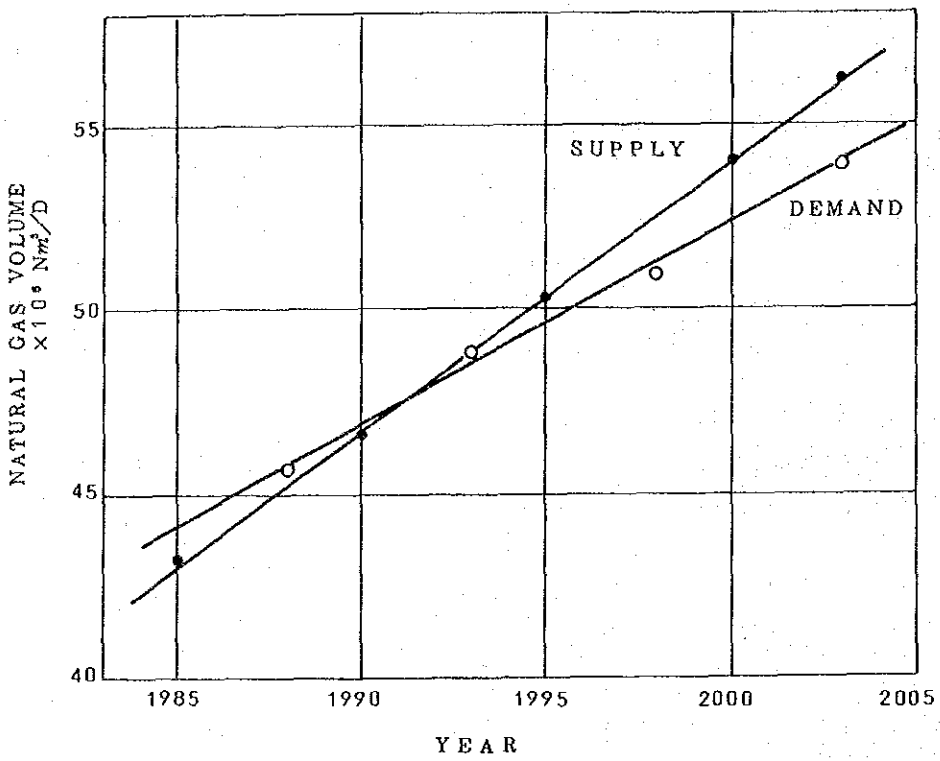


Fig. 6-3-1 Natural Gas Demand and Supply Balance in North Sumatera

4. Utilities and Infrastructure

4-1. Consumption of utilities

Utilities consumed at the second steel works include power, water, fuel, argon, nitrogen and oxygen gas, and compressed air, etc. Estimated consumption of those utilities are shown in Table 6-4-1. Characteristics of the new steel works in this regard are as follows:

1) As EAFs are used as main facilities in steelmaking process, power consumption is as high as 1210 kWh/ton of steel, which is twice that in BF-BOF process.
2) As ladle furnaces are used in steelmaking process, consumption of argon gas is as high as 0.24 m^3N/ton of steel.
3) Natural gas is used in DR furnaces.

4-2. Electric power

4-2-1. Power demand

EAFs account for more than 70% of power consumed in the entire steel works. As EAFs are in batch operation, there is sharp fluctuation in power demand. An example of expected fluctuation of power demand in the second steel works is shown in Fig. 6-4-1.

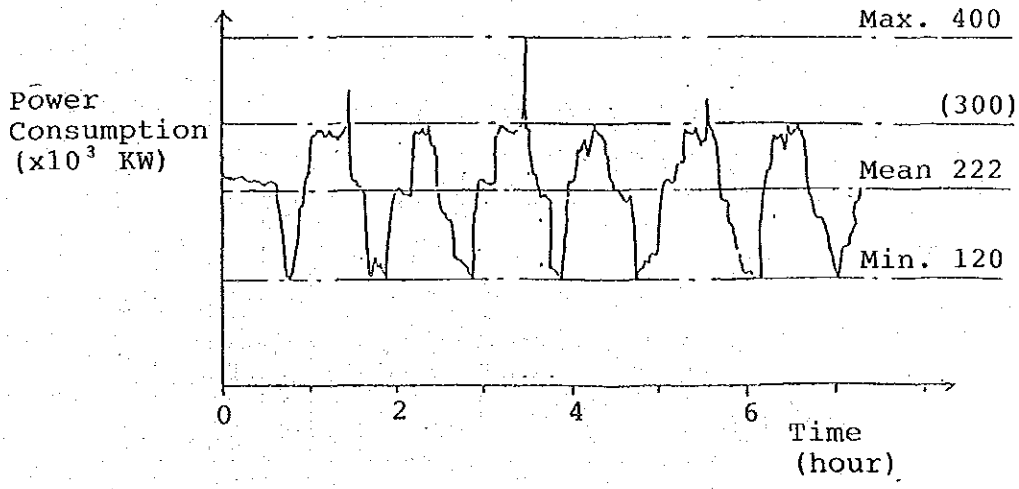


Fig. 6-4-1 Power Consumption

Table 6-4-1 Utilities Consumption

Plant	Production	Electricity	Argon	Nitrogen	Oxygen	Natural Gas (9165 Kcal/m^3N)	Oil (10200 Kcal/Kg)	Compressed Air	Industrial Water	Sea Water
	$x10^3$ t/y	$x10^3$ kwh/y	$x10^3$ m^3N/y	$x10^3$ m^3N/y	$x10^3$ m^3N/y	$x10^3$ m^3N/y	$x10^3$ t/y	$x10^3$ m^3N/y	$x10^3$ m^3/y	$x10^3$ m^3/y
Direct Reduction	1,367	164,040	0	684	0	387,801	0	tr.	2,051	0
Electric Arc Furnace	1,604	1,394,452	222	25	6,420	7,438	0	56,160	1,825	0
Continuous Caster	1,548	30,960	155	0	620	tr.	0	0	3,560	0
Section Mill	250	20,000	tr.	tr.	0	9,547	0	15,000	190	0
Bar Mill	650	65,000	0	tr.	0	21,277	0	32,500	230	0
Wire Rod Mill	600	90,000	0	tr.	0	19,640	0	24,000	420	0
Raw Material Yard		4,400	0	0	0	0	0	tr.	4	0
Transportation		2,057	0	0	0	0	0	tr.	tr.	0
Power Plant		148,920	0	0	0	0	401,382	tr.	438	262,113
Oxgen Plant		18,037	0	0	0	0	0	tr.	215	0
Water Supply		1,612	0	0	0	0	0	tr.	(*) ——	0
Maintenance Shop		2,100	0	0	50	104	0	tr.	24	0
Total		1,941,578	377	709	7,090	445,807	401,382	127,660	8,957	262,113

* Exclusive of potable water of 1752 x 10^3 m^3/y

4-2-2. Requirement in power supply

(1) As the sharp fluctuation of power demand of EAFs reaches about 180,000 kW, operation of power plant becomes very difficult. Therefore some measures have to be taken to cope with the condition. For example, the power line of the steel works is connected with outside transmission line and the capacity of power sources and also power demand on such transmission line are to be increased. Namely, the power line of the works is connected with transmission line of an area where power demand is high, or the power demand in the vicinity of the steel works is to be increased more than the power demand of the works itself through regional development, improvement and expansion of infrastructure, and induction of related industries or other industries which consume power in the area.

(2) The power line of the steel works is to be connected with large power plants of P.L.N., thereby ensuring back up power from the power plants and stability.

(3) To reduce flicker occurring at EAFs, compensator is to be installed to the power line of the steel works.

(4) Because sine wave of electricity is deformed to rectangular wave by operation of EAFs, there sometimes occur trouble called torque ripple in various machines which are motor-driven. To reduce the trouble, it is necessary to install harmonic-wave-filter to the power line of the works.

(5) By strengthening follow-up control of generator of the power plant of the works, severe frequency fluctuation in the power line due to operation of EAFs and rolling mills can be reduced. Namely, speed control function of turbines driving the generator, or sensitivity of governor, is to be increased.

(6) Voltage fluctuation in the power line due to operation of EAFs and rolling mills is to be reduced by increasing the sensitivity of automatic voltage regulator of generator in the power plant of the works.

(7) In order to prevent sudden change in load of electric power, certain limit is given to the operation of EAFs. For example, current limiter is installed to EAFs, but this inevitably lowers productivity of EAFs.

4-2-3. Fundamental plan of power plant

(1) Capacity of power plant

As shown in Fig. 6-4-1, power consumption of the new steel works is generally less than 300,000 kW, but there will be a peak close to 400,000 kW in some rare cases. When plural number of EAFs and ladle furnaces are operated lappingly, power demand of the works would be about 300,000 kW. Power demand is assumed to be about 400,000 kW only when the peak of power for rolling at rolling mills occurs at the time. Therefore, power demand of the works is expected to be less than 300,000 kW most of the time.

Even if a power plant for exclusive use of the works is constructed, it is prerequisite for the works to receive always power supply in some quantity from outside sources such as P.L.N. as mentioned in 4-2-2. Since power demand exceeding 300,000 kW is not frequent, the capacity of the power plant at the time of normal operation can be made 300,000 kW or less and any power demand exceeding it may be obtained from outside power sources.

Utilization factor is used for evaluation of the rate of utilization of capacity of power plant and it is generally said desirable that the factor is 60% or higher.

$$\text{Utilization factor} = \frac{\text{Mean output}}{\text{Licensed output}} \times 100$$

Let us calculate the utilization factor in the instance as given below. For an actual power plant, shutdown period of 2 to 5 weeks a year is provided to each unit for periodical inspection and maintenance and repair. The capacity of a power plant necessary for the second steel works is calculated as follows:

Condition: Max. power demand to be satisfied 300,000 kW
Output per unit 100,000 kW
The above max. power demand to be satisfied even if one unit is shut down for periodical inspection and maintenance.

Calculation:

"n" to be the number of units required,

$100,000 \times (n-1) = 300,000$

$n = 4$

Namely, if capacity per unit is 100,000 kW, then a power plant with 4 units, or 400,000 kW capacity, is necessary.

In the above instance, if annual average output is assumed to be about 222,000 kW and 3 units in constant use, the utilization factor is calculated to be 74%.

$$\text{Utilization factor} = \frac{222,000 \times 100}{100,000 \times 3} = 74(\%)$$

From macro-viewpoint of power demand and supply, a power plant with the total output of 400,000 kW with four 100,000-kW units is given as basic model.

In fact, even in the above instance, power equivalent to about 10% of power demand of the steel works will be purchased from P.L.N. The reason is that, as described later, it will be difficult for the power plant to follow demand fluctuation

of EAFs and the power plant will have to be operated in power balance which requires back up power from P.L.N. In such case, annual average output of the power plant will be revised to about 200,000 kW and its utilization factor is estimated to be 67% with 3 units in constant operation.

$$\text{Average output} = 222{,}000 \times 0.9 = 200{,}000 \text{ kW}$$

$$\text{Utilization factor} = \frac{200{,}000 \times 100}{100{,}000 \times 3} = 67\%$$

If the utilization factor during operation is 60% or more, decrease of thermal efficiency of the power plant is about 2%. Relation between utilization factor during operation and drop in thermal efficiency of thermoelectric power plant is shown in Fig. 6-4-2.

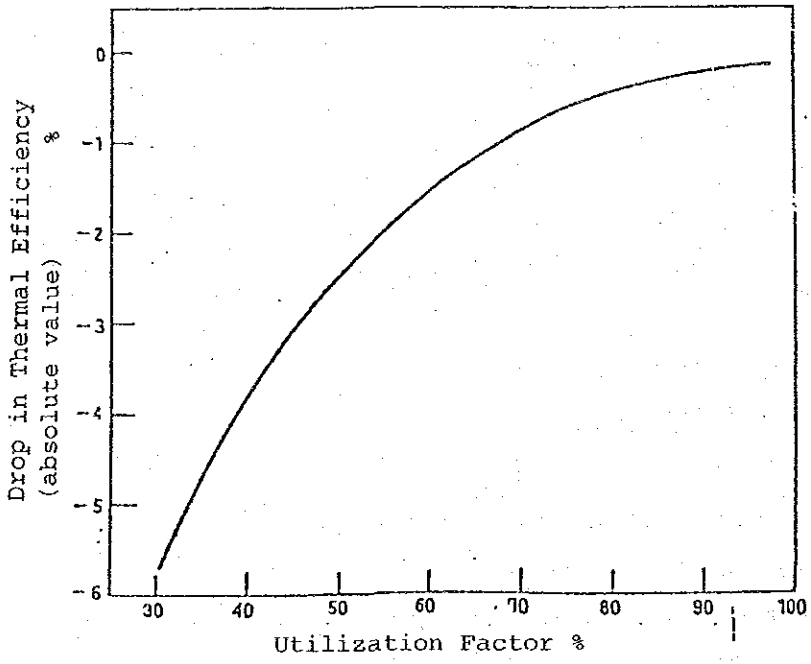


Fig. 6-4-2 Relation between Utilization Factor and Drop in Thermal Efficiency during Operation of Thermoelectric Power Plant

(2) Selection of power plant type

As already mentioned in VI - 3, there is little prospect that natural gas can be used as fuel for a power plant in the Cilegon area. In Arun area, though natural gas production is considerable, it is unlikely that there is surplus capacity to satisfy the requirements of 1.3 million m^3N/D of natural gas for the power plant. Consequently, main fuel for the power plant will possibly be oil, in particular heavy oil, and coal in Cilegon area while it will be oil or coal and partially N.G. in Arun. Oil is mainly produced in Kalimantan. Although there are abundant reserves of oil in the area, the capacity of refineries is limited and besides it is uncertain whether the oil can be made available in quantity for domestic use as it is an important export commodity. Coal, on the other hand, is supplied in quantity from South Sumatera to West Jawa and is being used especially at the Suralaya power station of P.L.N. But large consumption of coal involves disadvantages of increase of direct investment expenditures in transportation facilities including ports, railways and others. With respect to fuel cost, in August 1985, price of oil was Rp.25.6/1000 kcal and price of coal Rp.7.6/1000 kcal, about one third of the oil price. As regards oil and natural gas, the export policy has a considerable effect on their prices. From the above, it can be said that coal is better in fuel cost and oil and natural gas are better in direct investment expenditures though natural gas poses a problem in supply.

Power plant may be roughly classified into two types; boiler & turbine based on reheat cycle and gas turbine based on gas turbine combined cycle. The latter is compact and highly efficient, but basically it uses only natural gas and so in this study its adoption can be considered only when a smaller-scale power plant is contemplated in Arun area. In case of the former, it is easy to convert it from oil firing to coal firing and vice versa, and also to natural gas firing.

In addition, in this boiler and turbine system, it is easy to use combination firing of oil, coal and natural gas. It can safely be said that this reheat cycle boiler and turbine sytem is best suited to cope flexibly with unstable fuel condition.

Next, there remains the problem which is used as main fuel, oil or coal. Except for high fuel cost, oil firing is advantageous in that its direct investment is lower than coal firing and its speed of response to load fluctuation is faster. Coal firing generates ash, which in 15 years needs ash deposit area as broad as the site of the power plant itself, and besides requires expansion of port facilities and construction of coal storage yard. Therefore, this pre-F/S study will be made based on the oil firing plant.

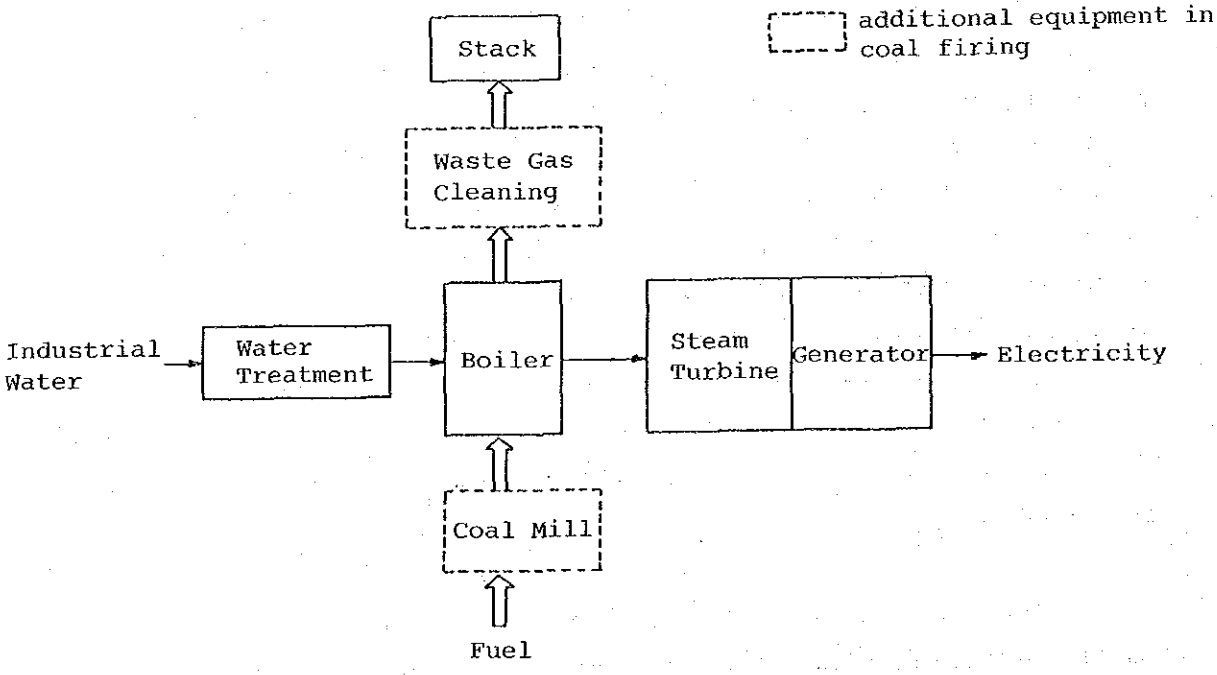


Fig. 6-4-3 Block Diagram of Power Plant

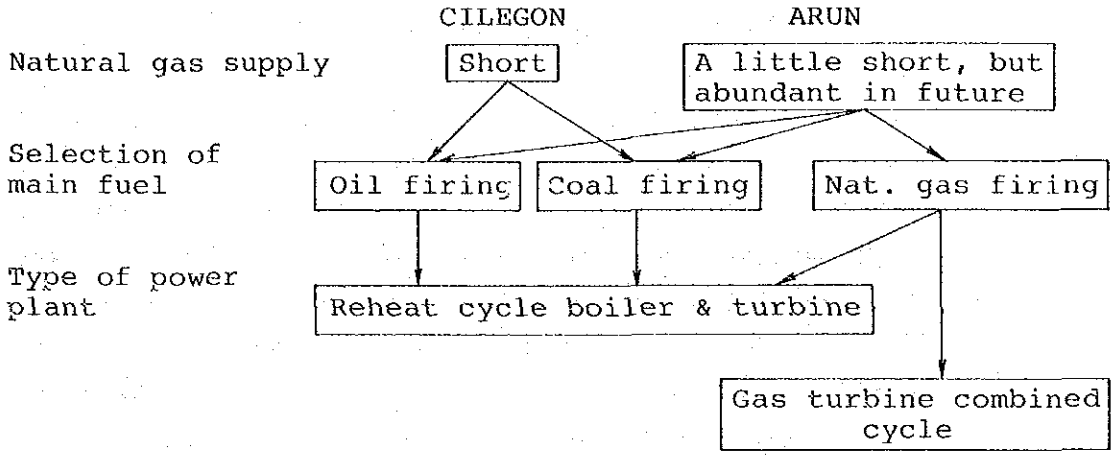


Fig. 6-4-4 Concept of Selection of Power Plant

Table 6-4-2 Comparison among Oil-firing, Coal-firing & Natural Gas-firing

	Oil-firing	Coal-firing	Natural gas-firing
Direct investment cost (excl. port)	100 (Base)	130	80 (Gas turbine combined cycle)
Fuel cost (Aug. 1985)	Rp.25.6/ 1000 kcal	Rp.7.6/ 1000 kcal	Rp.18.9/ 1000 kcal
Reheat cycle boiler & turbine	Combined firing possible	Same as left	Same as left
Gas turbine combined cycle	Suited	Unsuited	Suited
Ash deposit area	Not required	Required	Not required
Response to load fluc-tuation	Fast	Slow	Fast
Notes		1	

Notes: 1. Broad land required for ash deposit and storage yard; fuel cost low

4-2-4. Electricity in Cilegon area

According to the data of P.L.N., there is 2,770,000 kW of installed capacity of power plants in Jawa Island and 150 kV and 500 kV superhigh voltage integrated power lines connecting those power plants as of 1983. In addition, at Suralaya in the vicinity of Cilegon, there is P.L.N.'s coal power plant with two 400,000 kW units as of 1985. They said that the capacity of Suralaya power plant would be expanded to 3,200,000 kW in future.

Large back up power of 200,000 kW or more can be easily obtained by connecting the integrated power line through Jawa Island and the power line of the steel works. The back up power should facilitate reduction of voltage fluctuation due to EAF operation and stabilization of power source. If the Suralaya power plant has surplus power supply capacity, it is possible to purchase more electricity. The more electric power available from P.L.N., the less the scale of the power plant to be installed at the steel works and so the investment required. The distance from Suralaya power plant to the site proposed for the works is short, about 10 km.

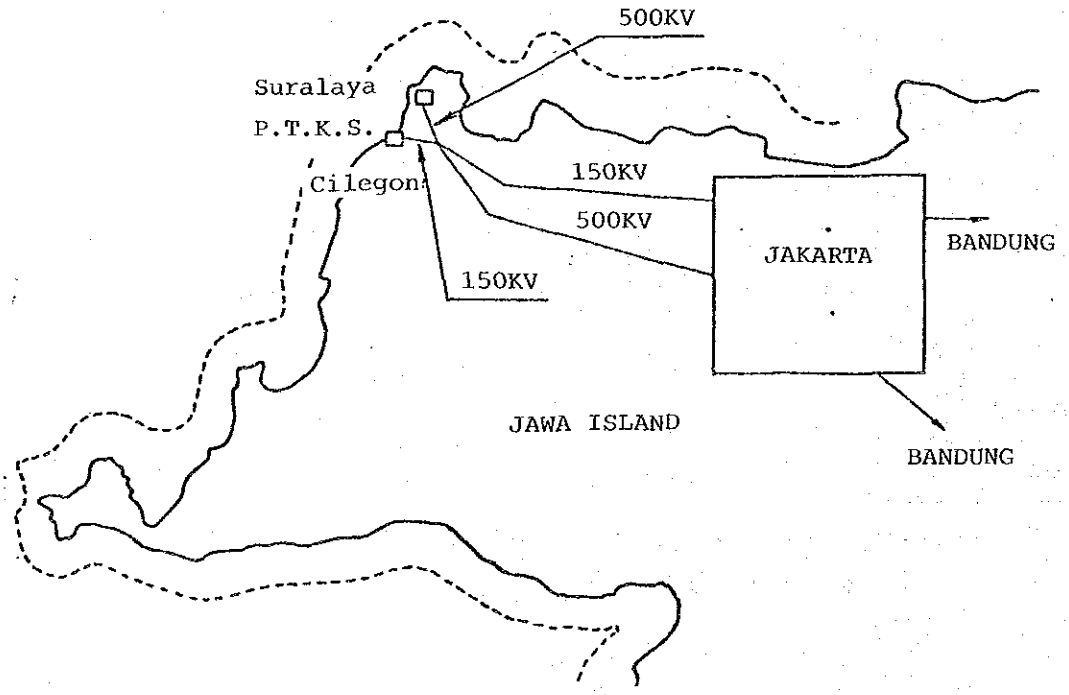


Fig. 6-4-5 Conceptional Diagram of Transmission Line in West Jawa

4-2-5. Electricity in Arun area

As of 1985, power source around Arun and Lhokseumawe is not sufficient. According to the data of P.L.N., as of 1983, the capacity of power plants in Aceh province totalled only 29,000 kW, which equals to only 15% of average power consumption of the steel works. However, according to the data concerning future development, "Perencanaan Tata Ruang Wilayah Industri Aceh Utara/Tim Pengendalian Dan Pembangunan Wilayah Industri Aceh Utara 1984", future capacity of power sources around Arun and Lhokseumawe is expected to reach 181,000 kW.

Table 6-4-3 Future Power Demand around Arun

Big Industry:	143,000 kW
LNG (P.T. ARUN)	20,000
P.T. ASEAN ACEH FERTILIZER	15,000
P.T. PUPUK ISKANDAR MUDA	15,000
CENTRA OLEFIN	10,000
SUBENTRA	83,000
Linkage Industry	28,000
House Keeping	10,000
Total	181,000 kW

In Lhokseumawe, located close to and to the east of Arun, P.L.N. has a plan to construct a gas turbine power plant with two 200,000-kW units. It is said also that a hydropower plant will be constructed at Langsa located 150 km to the southeast of Arun.

As power source around Arun is not sufficient until 1985, it is essential to increase future power demand through industrialization and regional development of the area. In general, construction of a power plant takes more years than that of a steel works and so it is necessary to push a plan to construct a power plant before the project to construct a steel works. In North Sumatera there is a big hydropower plant at Lake Toba, and power plants will be built at Langsa

and Lhokseumawe in future. Therefore improvement of power transmission line connecting those power plants will help alleviate the power problem of the steel works. High voltage (50 kV or higher) transmission line connecting Arun area and Medan area is desirable.

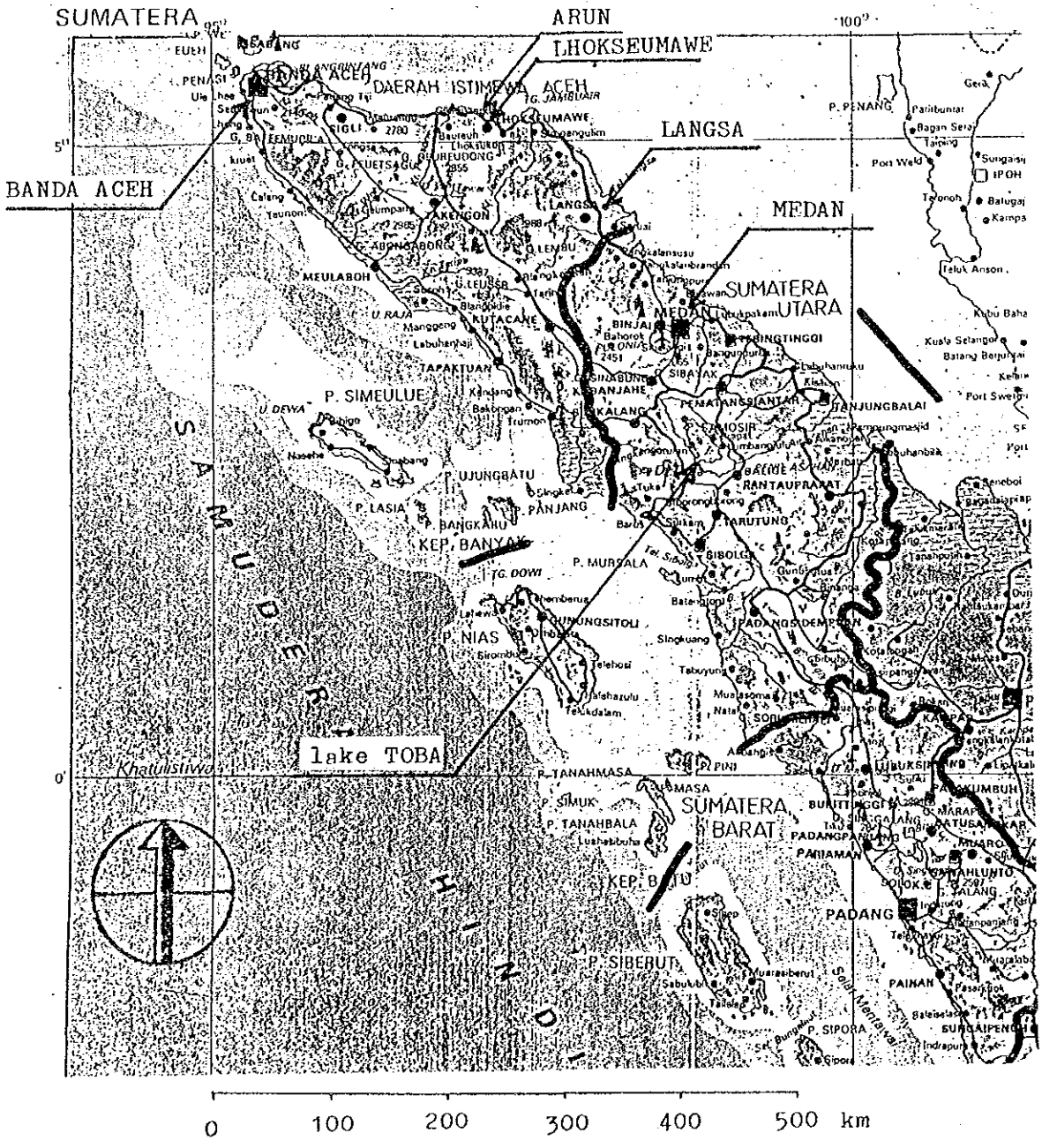


Fig. 6-4-6 Power Sources in North Aceh

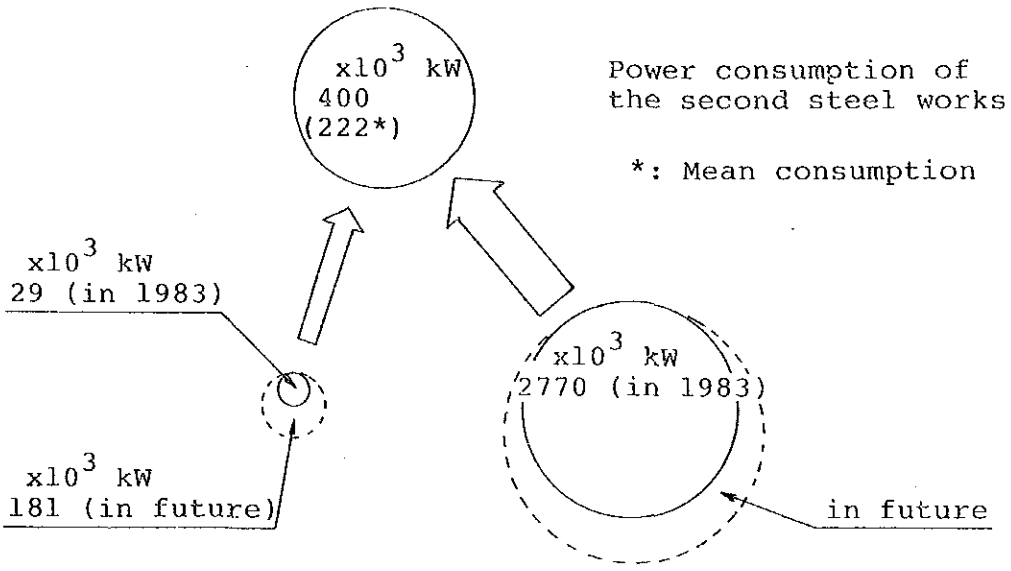


Fig. 6-4-7 Power Consumption of the Steel Works and Capacity of Power Plants

4-3. Water

4-3-1. Water requirements

Water required in the steel works includes both fresh and sea water. Fresh water is used as cooling water in iron and steel making process and potable water while sea water is used as cooling water in condenser of steam turbine in the power plant. Quantity of water used in the steel works is roughly as follows:

Fresh water	approximately 1,200 m^3/h	(inclusive of potable water of 200 m^3/h)
Sea water	approximately 60,000 m^3/h	(equivalent to output of 400,000 kW)

The above does not include supply of water to the neighborhood of the steel works.

Since main use of water in the steel works is cooling water, the two points of adequate supply and quality of water are important.

4-3-2. Conditions in supply of water

In case of sea water, water depth at intake point must be 4 m or more, and the sea condition determines the degree of difficulty of civil engineering work. As regards quality, any sea water will do unless its ammonium and sulfur contents and its chemical oxygen demand are exceptionally high. As both Cilegon and Arun faces the open sea and their population is small, there should be no particular problem.

In case of fresh water, however, it was pointed out at the time of site survey in 1985 that short supply of fresh water would be a problem in Cilegon area, but fresh water is abundant in Arun area and so no problem in the latter area. As regards quality, the 1985 site survey revealed no special problem in the water in both Cilegon and Arun. The present source of fresh water in Cilegon area does not have adequate

water for the steel works and the mention of its quality is only for reference.

Table 6-4-4 Comparison of Quality of Fresh Water

	Standard quality (Note 1)	Cilegon (Note 2)	Arun (Note 3)
Turbidity	20 ppm	65-155	Excellent
Specific conductance	-	70-245	210 μs/cm
pH	6.5-8.0	6.4-7.5	8.0
M alkalinity	75 $CaCO_3$ ppm	14- 70	87
Total hardness	120 $CaCO_3$ ppm	26- 55	80
Chloride ion	80 ppm	2- 29	13
Iron	0.3 ppm	1.5-6.7	0.67
Manganese	0.2 ppm	0.8	n.a.
Ammonium	-	0.6	0
Sulfate	-	0	11
Natrium	-	6- 39	17
B.O.D.	-	8.7	7
C.O.D.	-	60	9

(Note 1) "Handbook of Water & Waste Water", H. Shimizu et al. Maruzen Publishing Co.

(Note 2) Water quality data on Cidanah River provided by P.T. Krakatau Steel

(Note 3) Analysis of two samples taken from Krueng Peusangan River on July 30, 1985, during the site survey

4-3-3. Basic plan for water supply

As the steel works faces the sea, it is easy to install sea water intake facilities.

There are abundant fresh water available in Arun area and it is possible to supply fresh water through water pipe line. But in Cilegon area, shortage of fresh water is expected in 1995 and after, and the requirements of fresh water of the steel works will have to be satisfied by either plan, transportation of fresh water from alternative sources, more than 50 km distant, or sea water desalination.

4-3-4. Cilegon

According to P.T. Krakatau Steel, it is said that the Cidanah River, fresh water source in Cilegon area, alone can not satisfy the requirements in 1995 and after. The main reason is the expansion plan of P.T. Krakatau Steel. There is a plan to receive the water from Karian multipurpose dam which is being considered at Rangkasbitung, about 50 km to the east of Cilegon. The dam will be hereinafter called the alternative water source.

Table 6-4-5 Future Fresh Water Balance in Cilegon Area

(Unit: lit/sec)

	1985	1990	1995	2000
- Raw water supply from the Cidanah	2,500	2,500	2,500	2,500
- Raw water demand				
P.T. Krakatau Steel Works	594	1,340	1,709	2,530
Anyer-Merak area	8	9	9	10
Suralaya power station	35	46	46	58
Cilegon industrial estate	122	190	580	831
Others	27	55	82	123
Total	786	1,640	2,426	3,522
- Balance	+1,714	+860	+74	-1,052

Source: P.T. Krakatau Steel

In the meantime, cost of sea water desalination showed a considerable decrease recently, and it is necessary to give full consideration to the both plans of construction of canal or a pipeline as long as 50 km or so, and of sea water desalination. The matter of water source in Cilegon area should be decided under an overall regional development policy. One of criteria in the economic comparison between the desalination plan and the plan to transport fresh water from the alternative water source is that unit price of fresh water produced by desalination is forecasted, in 1987, to be ¥100-150/m^3 on the basis of 20-year depreciation, or Rp.1,000 - 1,500/m^3. However, as the alternative water source project itself is a big project, a broader study is necessary for the comparison with the desalination plan. The focus is on the regional development and the expansion plan of P.T. Krakatau Steel rather than on the second steel works.

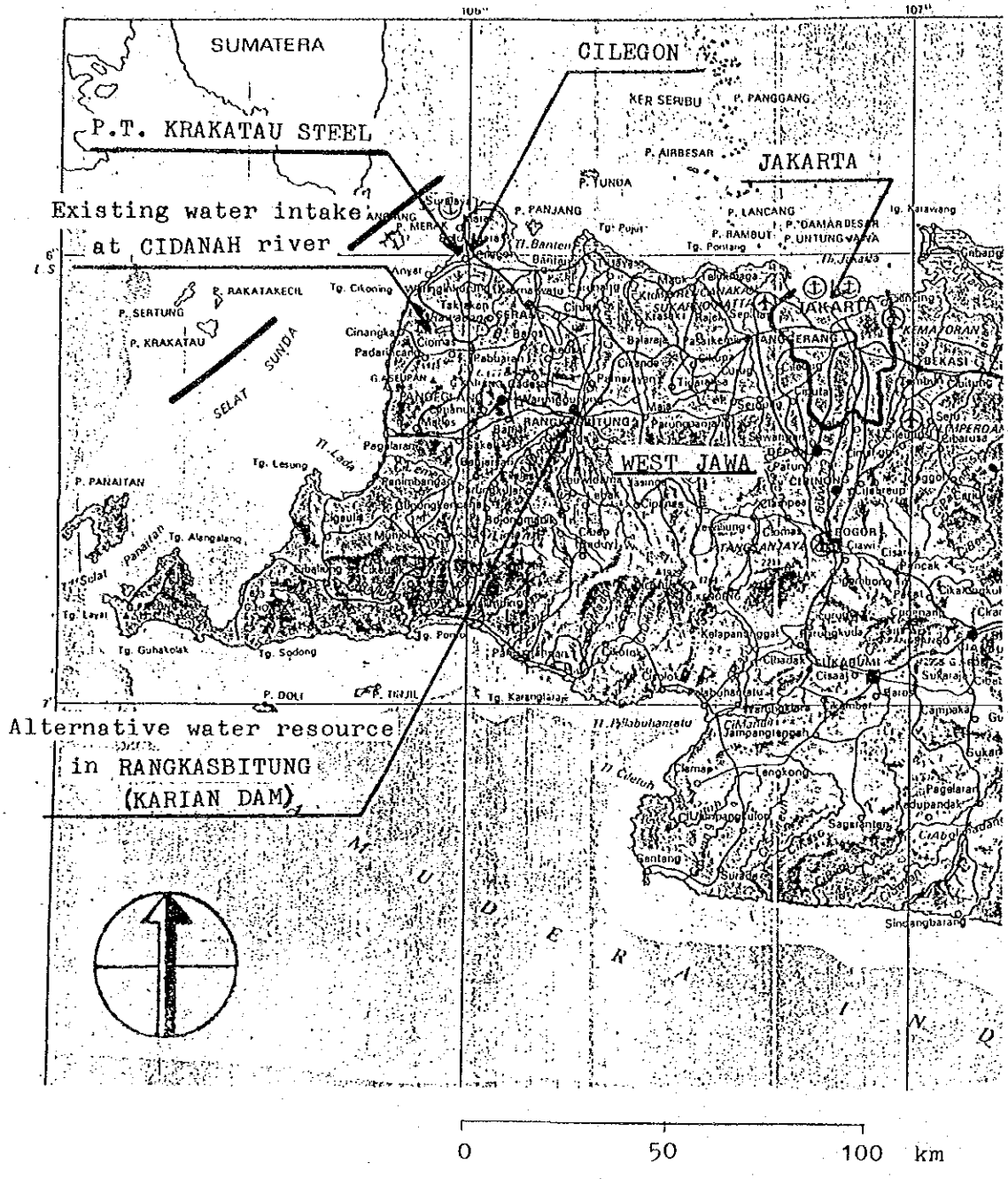


Fig. 6-4-8 Water Sources in West Jawa

Table 6-4-6 Analysis of Sea Water in Cilegon Area

Substances	Samples		
	I	II	III
Total Solids (mg/ℓ)	34,226.0	36,110.0	39,232.0
Salt Content (mg/ℓ)	34,186.0	35,841.0	35,874.0
Sediment Content (mg/ℓ)	40.0	269.0	3,358.0
Conductivity (mho/cm)	49,200.0	49,300.0	49,300.0
Turbindity (mg/ℓ. SiO_2)	1.2	96.2	11,550.0
Colour (scale PtCo)	12.5	15.0	turbid.
pH	8.2	8.2	8.1
Organic matter (mg/ℓ. $KMnO_4$)	35.4	32.9	107.4
Hardness (dh)	349.9	352.5	355.0
Ca (mg/ℓ)	387.8	319.2	327.8
Mg (mg/ℓ)	1,331.5	1,323.3	1,328.9
Fe (mg/ℓ)	0.1	20.0	60.0
Mn (mg/ℓ)	0.0	0.0	0.0
NH_4 (mg/ℓ)	0.15	0.08	0.17
NO_2 (mg/ℓ)	0.0	0.0	0.0
HCO_3 (mg/ℓ)	79.3	79.3	90.3
CO_2 (mg/ℓ)	6.1	6.1	6.1
CO_2 aggressive (mg/ℓ)	2.0	2.0	22.0
Cℓ (mg/ℓ)	17,899.0	18,099.0	17,999.0
SO_4 (mg/ℓ)	2,550.0	2,650.0	2,700.0
Sulfide (mg/ℓ)	neg.	neg.	neg.
PO_4 (mg/ℓ)	0.05	0.05	0.08
SiO_2 (mg/ℓ)	2.5	2.5	3.5
K (mg/ℓ)	568.8	655.5	631.3
Na (mg/ℓ)	9,687.5	9,750.0	9,700.0

Notes: Samples were taken on Wednesday May 1, 1974

(I) : Depth 6.2m
(II) : Depth 7.3m
(III): Depth 8.5m

Source: P.T. Krakatau Steel

4-3-5. Arun

According to the data on industrial development in North Aceh, "Perencanaan Tata Ruang Wilayah Industri Aceh Utara/ Tim Pengendalian Dan Pembangunan Wilayah Industri Aceh Utara," the water flow of Krueng Peusagan River flowing about 30 km west of Arun is as much as 28 m^3/sec, and the future water balance is said to be as given below. Since the water requirements of the second steel works is only about 0.3 m^3/sec and a fraction of the water flow and poses no problem.

Table 6-4-7 Future Water Balance around Arun Area

Big Industry	2.0 m^3/Sec
LNG (P.T. Arun)	0.14m^3/Sec
P.T. ASEAN Aceh Fertilizer	0.35m^3/Sec
P.T. Pupuk Iskandar Muda	0.35m^3/Sec
Centra Olefin	0.57m^3/Sec
Aceh Kraft	0.55m^3/Sec
Linkage Industry	0.2 m^3/Sec
House Keeping	0.1 m^3/Sec
Irrigation	25.7 m^3/Sec
Total	28.0 m^3/Sec

Table 6-4-8 Agricultural Water around Arun Area

Item	Water Sources	Area of Rice Field (ha)	Water Requirement (m^3/sec)
1	Krueng Peusangan River	8,000	11.0
2	Krueng Mane River	2,600	2.6
3	Krueng Geukuh River	950	1.0
4	Krueng Puse River	7,200	7.2
Total		18,750	21.8

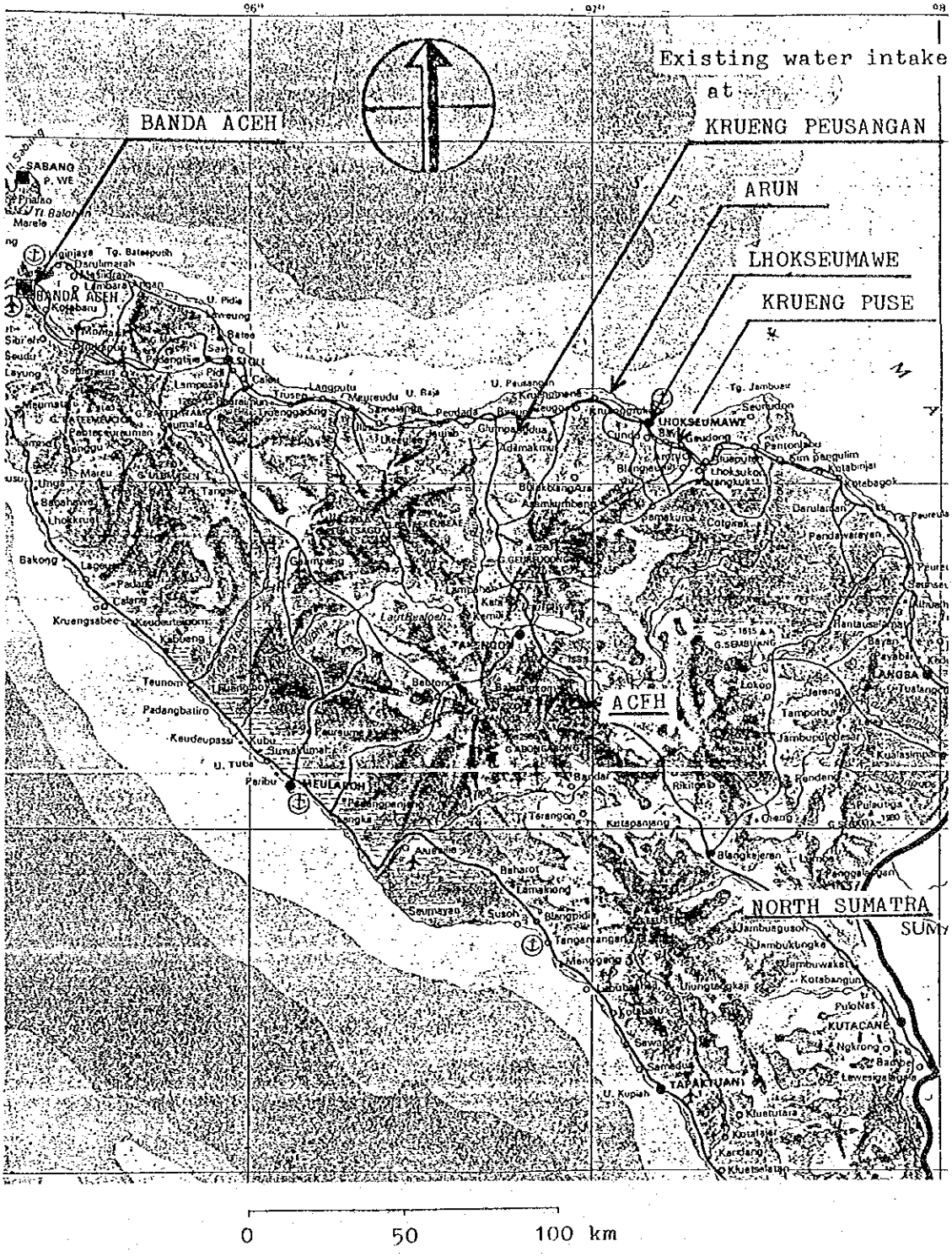


Fig. 6-4-9 Water Sources around Arun Area

4-4. Argon, nitrogen, oxygen and compressed air

Characteristic is that argon is used in quantity. The plant is given emphasis on its function to separate argon rather than oxygen. As it is easy to produce surplus oxygen in future, production and sale of oxygen may be possible. At any rate, the plant will produce argon while bleeding part of oxygen produced.

4-5. Other utilities

Supply of potable water for 10,000 employees and sewage treatment are necessary, but their construction won't pose any problem.

4-6. Transportation

The steel works is characterized, among other things, by carrying in and out a large quantity of heavy goods and corresponding facilities for their transportation are necessary.

(1) Sea transport

At both Cilegon and Arun areas, port facilities are to be constructed adjacent to the steel works for receiving raw materials and sub-materials and shipping products.

At Cilegon area, offshore jetty is built and berth which can accommodate large ships to receive raw materials is constructed. And berths are built on the shoreline to receive scrap, limestone and auxiliary materials and ship 25% of the products.

At Arun area, however, sea current necessitates a port completely protected by breakwater and therein built are berths for receiving raw materials and shipping 82% of the products.

(2) Land transport

1) Road transport

At Cilegon area, 45% of the products are shipped by road transport and materials and machinery used by the steel works also are received mainly by road transport. If a steel works of 1.5 million t/y class is constructed in addition to the existing P.T. Krakatau Steel, roads in Cilegon area are expected to be heavily congested.

A motor highway is being completed between Jakarta and Cilegon, and its completion is considered essential.

At Arun area, it is expected that 18% of the products will be consumed in Sumatera area. All those products are to be transported by truck. But road network there cannot be said adequate, and much expectation is placed on the regional development of Sumatera by Indonesian Government. At present, trans-Sumatera roads are being planned, and once those roads are completed, steel consumption of steel in Sumatera area is expected to show a fast increase.

2) Railway transport

Cilegon area is connected with a network of railways in Jawa area and it is possible to ship 30% of the products by rail. However, rails in Cilegon area are heavily damaged and require repair.

There is inadequate railway in Arun area, therefore rail transport is not considered. However, for the future, the steel works is to be constructed with a layout permitting future installation of railway.

5. Selection of Plant Site

5-1. History

In Step I and Step II of this study, sites proposed for the new steel works as agreed between the Japanese side and the Indonesian side were the following six.

1) Bontan Area
2) Cilegon Area
3) Lhokseumawe Area (Arun)
4) Pare Pare Area
5) Tanjung Enim Area
6) Yogyakarta Area

The above six proposed sites were studied by the Step II mission through detailed field survey during July-August 1985.

The points of the field survey were as follows:

1) Civil engineering condition at the site (topographic condition, soil condition, etc.)
2) Port (difficulty of port construction, oceanographic and meteorological conditions, etc.)
3) Transportation (difficulty of transportation of raw materials and products)
4) Natural gas (availability of natural gas)
5) Power (power consumption pattern in neighboring area and difficulty of plan to construct a private power plant)
6) Industrial water
7) Manpower
8) Supporing industries

As a result of the study of those sites, the Step II mission recommended that of the above six sites, the South Sulawesi (Pare Pare) area and the North Sumatera (Arun) area are the sites which are suited for construction of the new steel works from the viewpoint of steelmaking technology.

5-2. Planned sites in Step III

The study in this Step III took up the North Sumatera (Arun) area and the Cilegon Industrial Estate as the planned plant sites.

In the recommendation of the Step II mission, evaluation of the Cilegon Industrial Estate as plant site ranked low as question was raised about availability of industrial water and natural gas in the area.

However, in compliance with the request of the Ministry of Industry of Indonesia and in expectation that completion of a planned dam in future will ensure supply of industrial water in the quantity as required for operation of the new steel works in the Cilegon Industrial Estate and that as discussed in Sec. 3 of this Chapter, though it is difficult to expect demand and supply of natural gas to balance even in future, natural gas may be made available by cutting its consumption at P.T. Krakatau Steel and by changing to other fuels at P.T. Krakatau Steel and neighboring plants (cement factory, etc.), the site in Cilegon Industrial Estate was added as one of the planned site in the Step III.

5-3. Characteristics of the two planned sites

Location condition of the new steel works should be studied from the points enumerated in 5-1 above, and advantages and disadvantages of the two sites, Arun and Cilegon, when viewed again from the above points are as follows:

(1) Arun area

1) Advantages

a) Not much problem in ensuring necessary land
b) No problem in availability of industrial water and natural gas

2) Disadvantages

a) Large expenditures required for port construction
b) With no power consumption in neighboring areas at present, a great care called for construction plan of power stations
c) With no supporting industries in the area at present, difficulty expected in availability of materials and spares at the time of construction and start-up of the new steel works
d) Recruitment of manpower for construction as well as for operation of the works most likely a problem
e) Far from steel consuming centers in Indonesia

(2) Cilegon area

1) Advantages

a) Necessary infrastructure complete now serving P.T. Krakatau Steel mainly
b) Easy to recruit manpower
c) Close to steel consuming centers
d) No special problem as to land and sea transportation

2) Disadvantages (questionable points)

a) Necessity of further study on supply of industrial water
b) Necessity of detailed study on demand/supply balance of natural gas

Though the sites have advantages and disadvantages as above, it can reasonably be expected that part of those disadvantages may be solved in due course as there will be social and economic change in Indonesia by the time when the plan is implemented.

Therefore, in compliance with the request of the Ministry of Industry of Indonesia, the Step III mission was to make a study on the construction project of the new steel works for the second generation with respect to the both sites at Arun and Cilegon.

Chapter VII. CONCEPTIONAL DESIGN OF THE STEEL WORKS FOR THE SECOND GENERATION

Chapter VII. CONCEPTIONAL DESIGN OF THE STEEL WORKS FOR THE SECOND GENERATION

1. Product Mix and Production Scale

Product mix and production scale of the present project were agreed by Ministry of Industry of Indonesia and the Step III Mission based on the forecast of domestic demand in Indonesia as discussed in Chapter IV as follows:

1) Product mix --- Sections, bars and wire rods
2) Production --- 2,000,000 t/y or less (in crude steel)
3) Process --- DR (Gas based) - EAF - CC - Rolling

As a result of study of production scale most suited technically and economically as an integrated steel mill under the above premises, the Mission reached the following conclusion.

1-1. Conditions of production of the project

1) Production scale --- 1,500,000 t/y (in rolled steel)
2) Production and product size range by mill

Mill	Production (1,000 t/y)	Product Size Range (mm)
Sections	250	L50-120, I75-125 FB70-125, [75-125 T100-125
Bars	650	10-50 ø
Wire rods	600	5.5-16.0 ø

3) Scrap and scale generated in the works are to be recycled as much as possible in the works.
4) The ratio of lump ore:pellet at DR plant is to be as follows:

   Lump ore:Pellet = 30:70

5) DRI blending ratio at EAF is to be as follows:

   DRI:Scrap+Scale = 75:25

6) Billets produced at CC plant are to be all used in rolling mills of the steel works and no outside sale is planned.

1-2. Material balance

Fig. 7-1-1 shows the material balance of 1,500,000 t/y of products under the above production conditions.

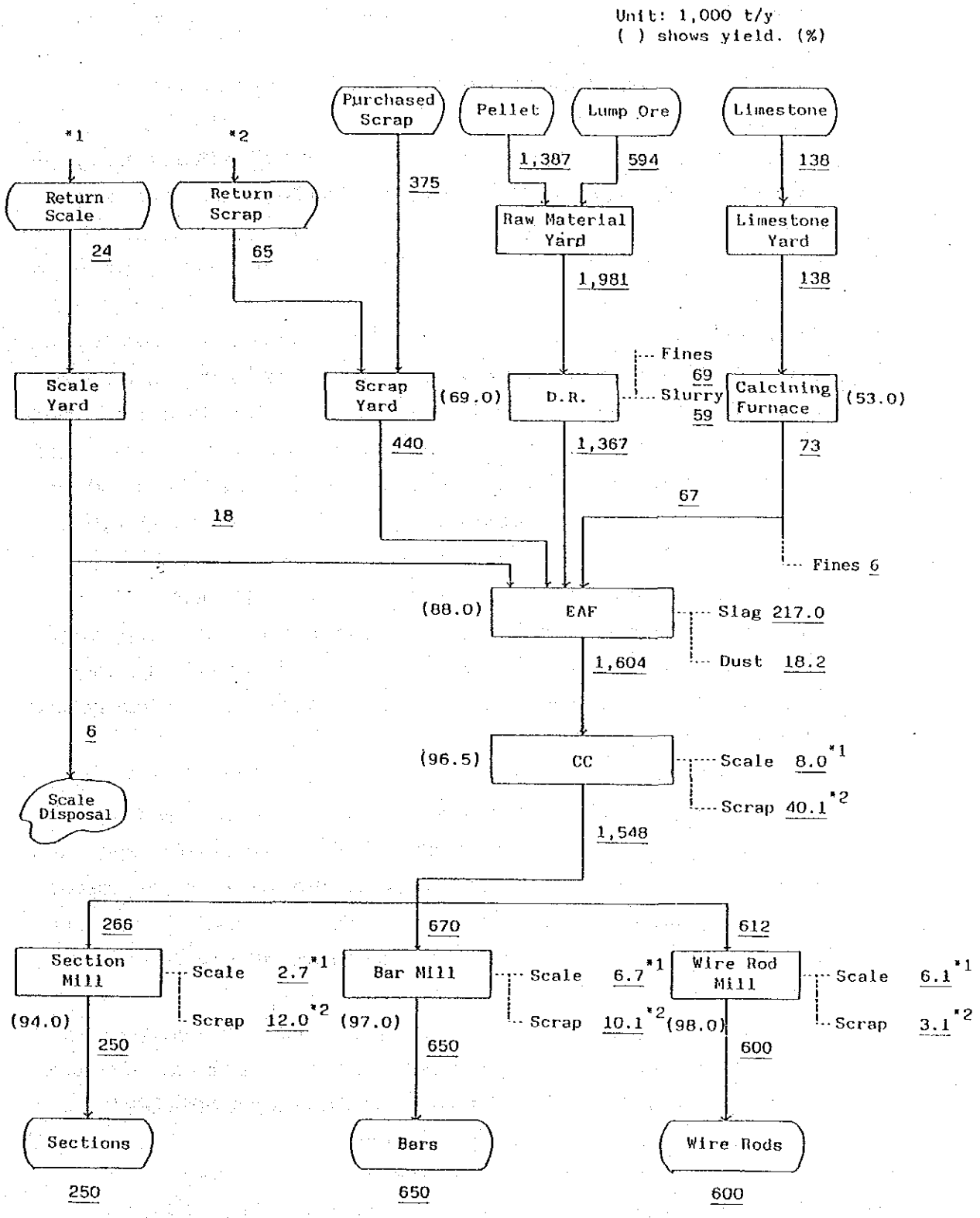


Fig. 7-1-1 Material Balance at Products 1,500,000 T/Y

2. Determination of Production Process

2-1. Main processes for iron and steel production

Iron and steel making processes adopted extensively in the world can be classified into the following 3 processes.

(1) Blast furnace (BF) - basic oxygen furnace (BOF) process

From the top of a vertical shaft furnace type blast furnace, lump iron ore, sintered ore and/or pellets are charged as main raw materials into the furnace, and similarly from the top, coke which is the product of carbonization of coal or charcoal which is the product of carbonization of wood is charged as reducing agent.

A blast of heated air is introduced through tuyeres at the bottom of the shaft to have the reducing agent react with iron ore and the reduced iron containing much carbon is taken out in molten state from the bottom of the blast furnace.

Molten pig iron, or hot metal, is then charged into a vessel called converter, or basic oxygen furnace, and blowing highly pure oxygen from above to the hot metal oxidizes and burns impurities in the hot metal and produces steel of specified chemical composition.

In order to make steel refining more effective, combined blowing, a process in which oxygen or inert gas is blown into the furnace from the bottom in addition to the top blowing, is now generally adopted.

(2) Electric arc furnace (EAF) process

This is a process to make steel by using scrap as main raw material and three-phase alternating current. In the EAF, direct-arc takes place between charged raw material and electrodes of the furnace and the generated heat heats and melts the charged raw material.

(3) Direct reduction (DR) process

In place of scrap in the EAF process, sponge iron which is produced by reducing iron ore in solid state is used as raw material.

There are several processes to produce sponge iron, or DRI, but the process based on natural gas is most popular throughout the world.

2-2. Points requiring attention in selecting production processes

The above three processes are all adopted worldwide as established iron and steel making technology, but the following points must be considered when deciding which process is to be adopted for the new steel works being planned.

(1) Production scale of the steel works

BF-BOF process requires a vast initial investment as it requires coke making facilities and sinter or pellet production facilities as up-stream facilities.

Therefore, if the scale of final production of the new steel works planned is not big (2 million t/y or less), the construction cost is said comparatively higher for BF-BOF process than the other processes.

(2) Availability of raw material and fuel

Where scrap is available cheaply and abundantly and low cost power is available stably, irrespective of production scale, adoption of EAF process can be said generally economical from the viewpoint of construction cost.

Where natural gas or oil resource is abundant and cheap and power is available at low cost, DR process is often adopted. However, in this case, the scale of the final production of the steel works does not exceed 2 million t/y generally.

Where solid reducing agent such as coal, charcoal, etc. is available cheaply and abundantly as reducing agent for iron ore, DR process based on such solid reducing agent (rotary kiln process such as SL/RN) or charcoal BF - small BOF process is also realistic.

2-3. Production process adopted in Step III study

From the above points, the gas based Direct Reduction Process using natural gas produced in quantity in Indonesia as reducing agent is a natural conclusion.

On the other hand, DR process based on solid reducing agent may be used only when there are coal mines developed in the vicinity of the steel works as mentioned in Sec. 6-3.

Also as a result of market research, the steel works is planned to have the fianl production scale not exceeding two million t/y.

As it is judged from the above that adoption of natural gas based DR process is most realistic as compared with the other processes, natural gas based DR process is to be adopted in the present pre-F/S.

3. General Layout of the Steel Works

3-1. Basic policy in planning the layout

1) Draft layout is to be prepared for the two sites of Cilegon and Arun areas.
2) Site conditions (land shape, soil condition, etc.) for the steel works in those two areas are to be set up on the basis of the study of Step II and Step III study missions.
3) The major part of raw materials and sub-raw materials are to be brought to the steel works by sea.
4) Shipping of products from the steel works in respective areas is to be made by the following methods:

	Sea Transport	Land Transport
a) Cilegon area	25%	75% (rail & truck)
b) Arun area	82%	18% (truck only)

5) Production scale of the steel works is to be 1.5 million t/y (in rolled steel), but the facilities are to be laid out so as to permit expansion of production scale by about 50% in the future.
6) Power plant, water reservoir and slag disposal area are to be installed in the compound of the steel works.
7) Green belt in width 50 m min. is to be created around the steel works.

3-2. General layout

1) In view of flow of goods such as flow between major processes, carrying in and out of raw materials and products, in-plant vehicle movement, etc., the flow of production process at both Cilegon and Arun areas is considered best if it is from berths to inland to berths.
2) Assuming that natural gas and raw water are brought to the steel works from inland area, the reservoir and raw water treating facilities are to be laid out, together with oxygen plant, at the inland side of the steel works and close to DRP and SMP which consume much water and oxygen.

Assuming its fuel oil is carried in by sea and in view of its facilities being cooled by sea water, the power plant and substation are to be laid out at the sea side of the steel works.

3) SMP and RMP are arranged so that hot charge can be made.
4) As central maintenance shop and central material warehouse are closely related each other, they are to be built close each other and also relatively close to SMP and RMP whose weight in maintenance jobs is high.
5) Facilities related to administration are to be built at the inland side of the steel works for the convenience of visitors and so laid out that the facilities are kept from effect of dust from raw materials and scrap yards, etc. as much as possible.

The above basic policy and general layout are reflected in Fig. 7-3-1 (Cilegon area) and Fig. 7-3-2 (Arun area).

CILEGON SITE

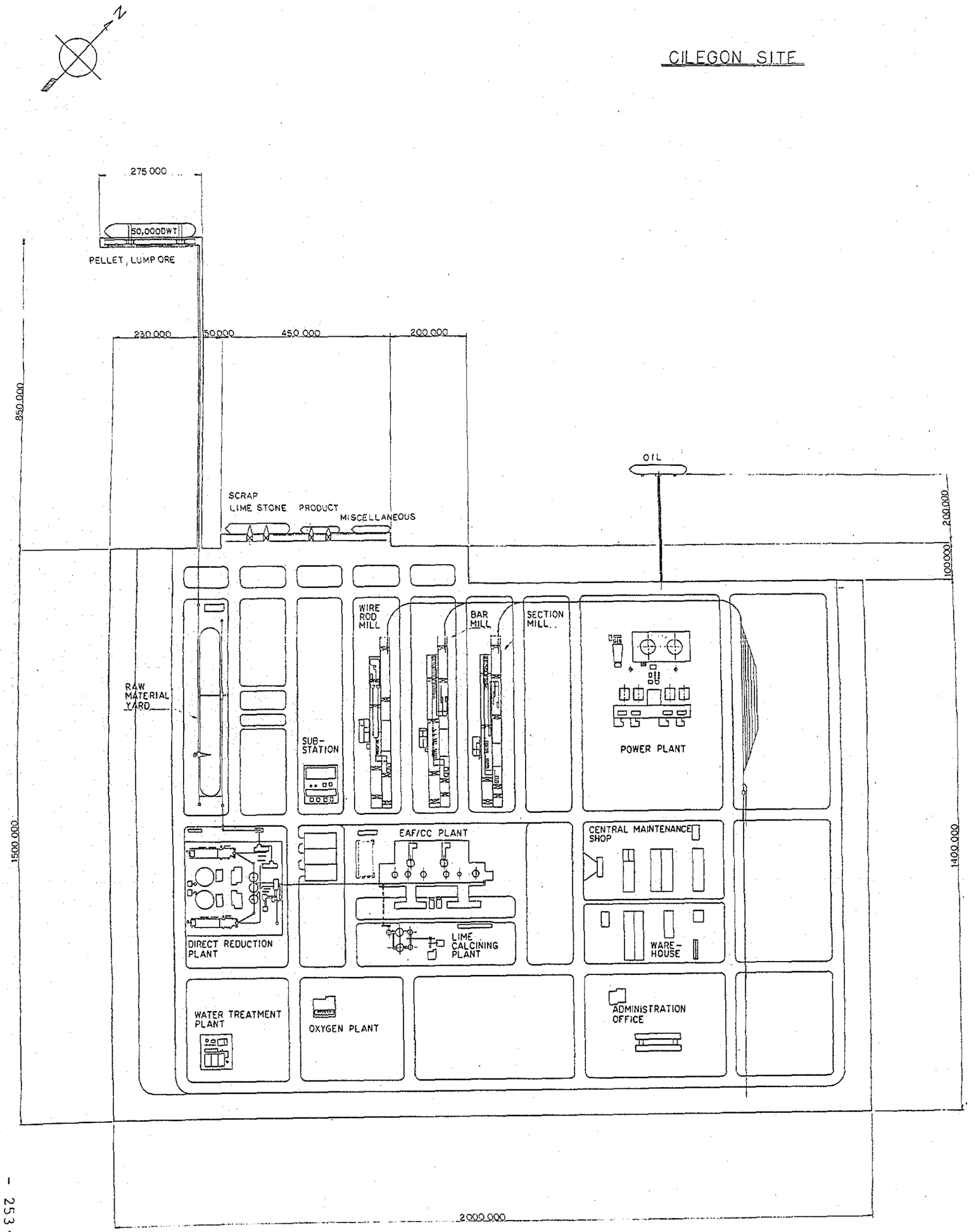


Fig. 7-3-1 (CILEGON Area)

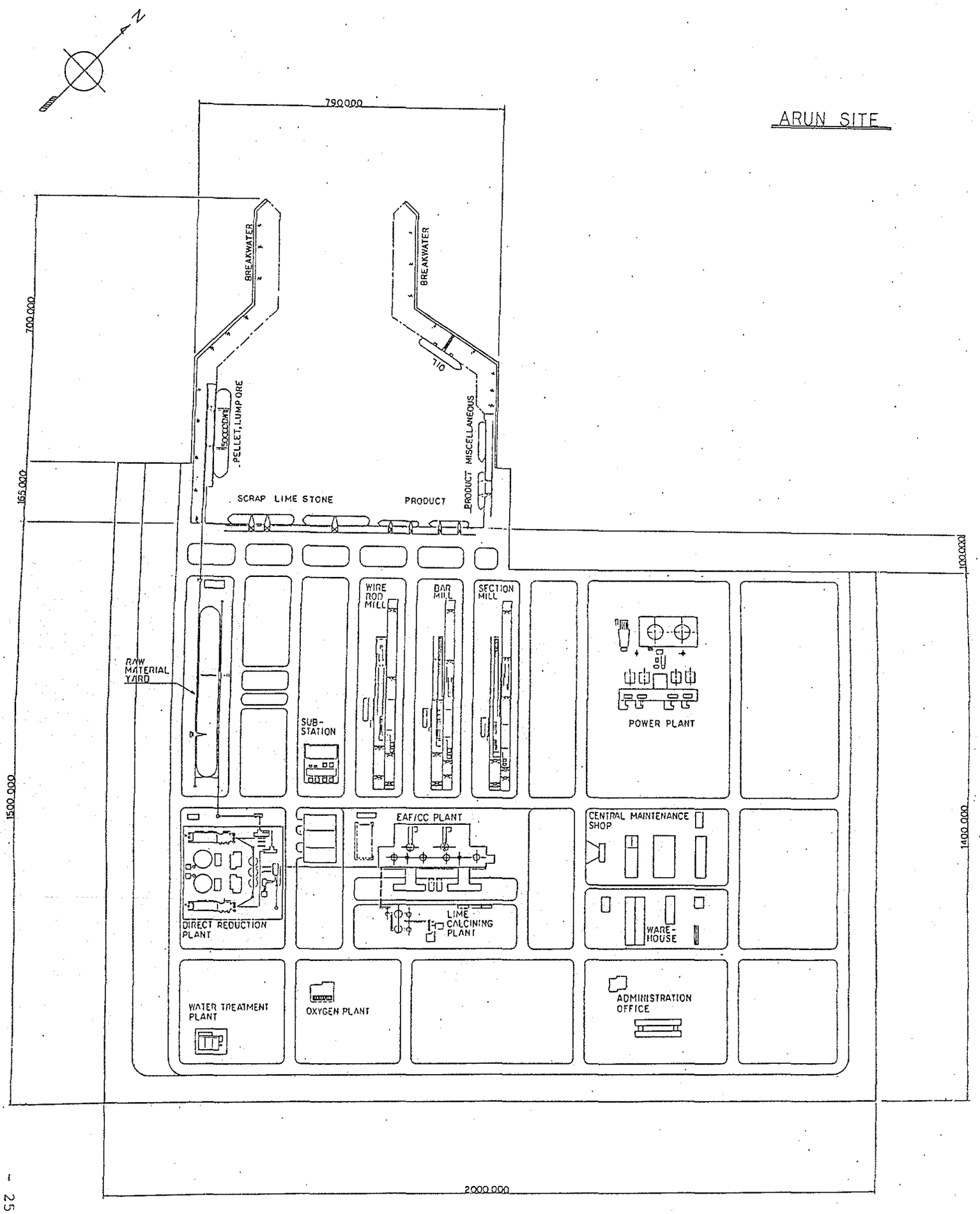


Fig. 7-3-2 (ARUN Area)

4. Overall Construction Schedule

Construction schedule of the entire steel works is influenced greatly by availability of manpower, construction machines and others for field work when the construction is actually under way.

In this study, the overall construction schedule is planned on the assumption that such field work condition may be attained relatively smoothly.

4-1. Premises for planning

1) It is assumed to take 20 months from the basic facility plan to their purchasing agreements. The breakdown is as follows:

Preparation of the basic facility plan	6 months
Preparation of specifications of equipment to be purchased	4 "
Estimation by bidders	4 "
Evaluation of bids and preparation for agreements	6 "

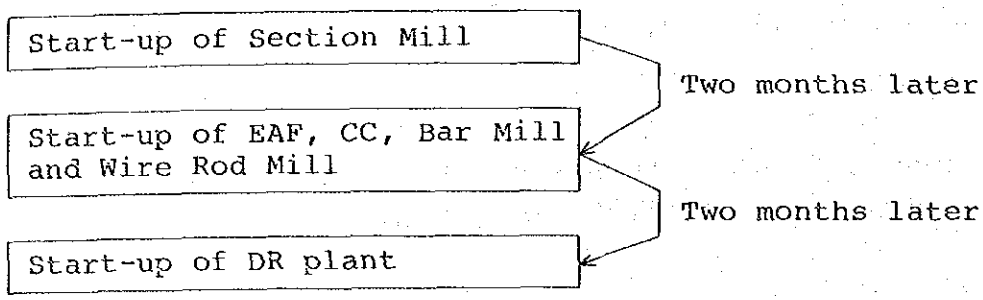
2) Start-up period of major production plants is set as follows:

DR plant	3 months
EAF plant	3 "
CC plant	6 "
Section Mill plant	12 "
Bar Mill plant	6 "
Wire Rod Mill plant	6 "

3) As regards site preparation which precedes construction of facilities and power plant whose construction period is extremely long, agreements are entered into prior to the purchasing agreements of facilities of the above production plants.

4-2. Idea about start-up period of each plant

1) Start-up timing among the major production plants is set as given below by considering availability of materials for each plant.



2) Start-up of port facilities is to take place concurrent with that of section mill.
3) Start-up of raw materials treating facilities is to be two months ahead of that of DR plant in view of time required for stocking raw materials.
4) In the beginning of operation, EAF plant is operated on 100% scrap and lime calcining plant is to be started up concurrent with DR plant.
5) Start-up of power plant is timed same as section mill plant. For this, purchasing agreements of power plant facilities are to be made 8 months ahead of the agreements of major production plants because the power plant requires longer construction period.
6) Substation facilities are to be started up concurrent with water supply and sewage treating facilities.
7) Start-up of oxygen plant is two months ahead of that of EAF and CC plants.
8) Start-up of water supply and sewage treating facilities is to be three months ahead of that of section mill.
9) Start-up of central maintenance shop is to be one month ahead of that of section mill plant. (For some of the facilities, earlier start-up is considered so as to cope with troubles in erection of equipment.)

4-3. Overall construction schedule table

The overall construction schedule based on the above is shown in Fig. 7-4-1.

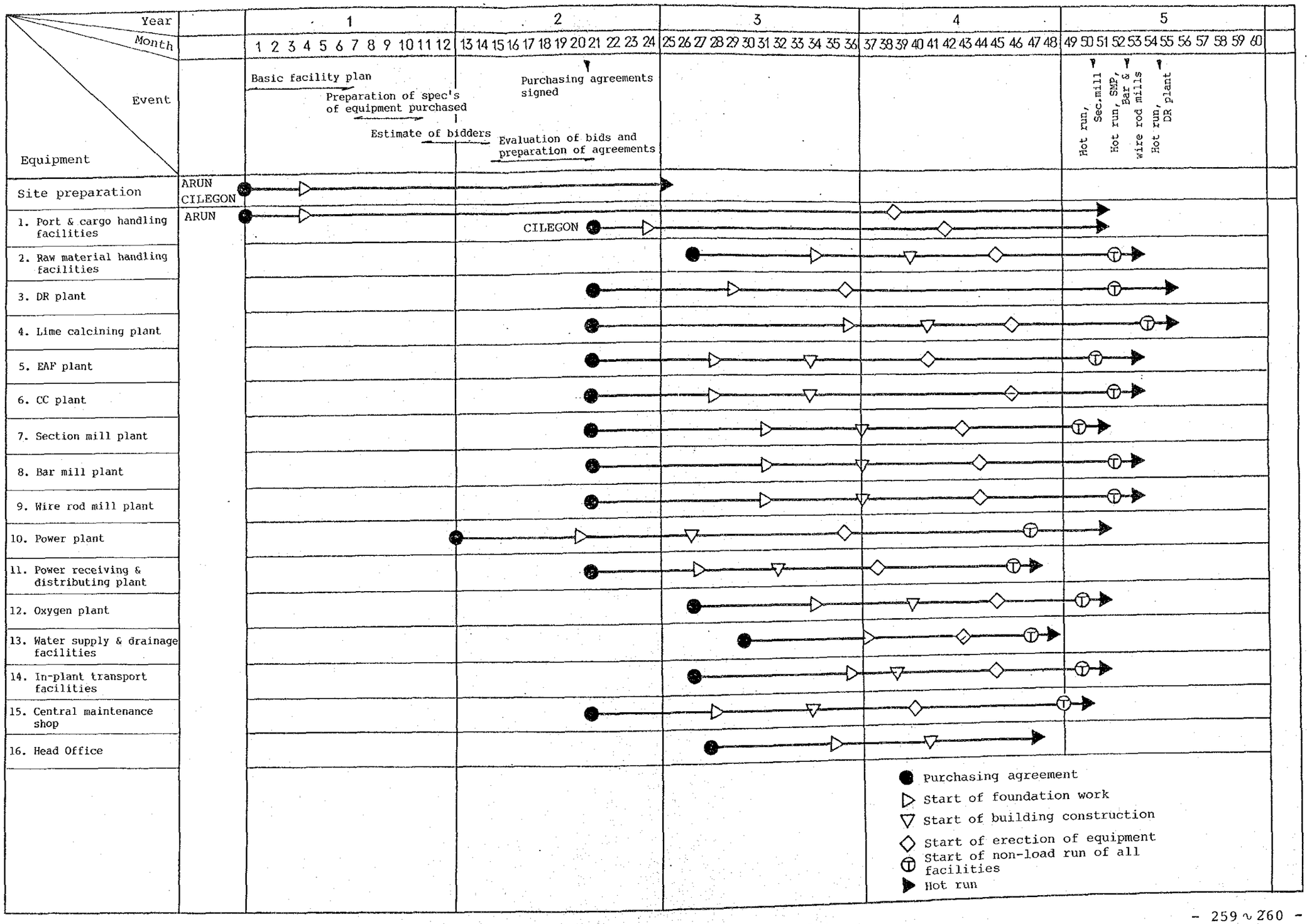


Fig. 7-4-1 Overall Construction Schedule

5. Preparation for Operation of the Steel Works and Personnel Plan

5-1. From the construction planning to the commencement of operation of the steel works

(1) Principal body for planning and promoting the project

Whether the project is a governmental project or private project, the matter to be decided first is to organize a body which materializes and pushes planning of this project.

(2) Role of the planning and promoting organization

Role of the principal body of this project includes the following.

1) Financing plan
2) Outlook of obtaining site land and main and auxil. raw materials and energy
3) Organization of a body to push the construction plan
4) Organization of a body to push operation preparation
5) Organization of a body as a corporate entity
6) Contact and negotiation with relevant governmental and public offices and local self-governing bodies
7) Sales plan (incl. transportation plan of raw materials and products)
8) Personnel plan
9) Relation with infrastructure
10) Analysis of profitability of the entire project

(3) Promotion of the construction plan

The planning and promoting body will push strongly the above items in conformity with the type of enterprise, but the points which need attention in pushing the construction plan of the body are considered as stated below.

1) Study of purchasing method for equipment and work in accordance with sources of fund

Whether the sources of fund is World Bank loan or bi-lateral loan, there are cases where equipment and work purchasing method is subjected to restriction according to respective loans.

It should be taken into consideration that there are cases where equipment purchasing is conditioned from the viewpoint of promotion of domestic industries.

Therefore it is necessary to study without delay purchasing method for each plant to be purchased---incl. unit of equipment purchasing agreements and whether the agreement is full turn key basis including work.

2) Site preparation

Firstly it is necessary to undertake site preparation based on the layout at the location determined. Matters of importance in this are ensuring routes for carrying in materials and machinery required for construction work, power and water for the work, measures related to construction workers, etc.

3) Preparation for purchasing equipment and work

Based on the decision of purchasing method, preparation has to be pushed for actual purchasing. Namely it will include a series of purchasing work from preparation of specifications of equipment and work of each plant to invitation of tenders, evaluation of bids, etc. In general, often professional consultants are employed for the work. From the aspect of economy in personnel of the body, employment of such consultants may be said desirable.

4) Management of construction work

Once purchasing of equipment and work is decided and contractors for the respective equipment and works are determined, how efficiently the construction work is carried out has some bearing on the construction period and the performance of equipment after constructed. At this point also, it is effective to employ professional consultants and have them conduct construction management.

(4) Promotion of operation preparation

In parallel with the progress of construction, preparation for commencement of operation of the steel works must be pushed on and will include the following.

1) Study of organizational setup for the operation of the steel works
2) Drawing up personnel plans for departments
3) Plan for recruitment of personnel
4) Study of matters related to employment of personnel (housing, transport means, welfare facilities, etc.)
5) Employment and training of personnel
6) Preparation of production plan and start-up production plans of plants
7) Study of production system by kind of product (manufacturing standards, operation standards, etc.)
8) Preparation of materials required for operation (refractories, lubricant, roll, etc.)

5-2. Operation plan

Rolled steels planned in this project include medium sections, bars and wire rods.

Operation plans for respective rolling mills are made with due consideration to the products which have big demand from market requirements and the products which are easy to make in view of skill and training of workers.

After the start of operation at each rolling mill, trial rolling of one or two new sizes of products should be made every month so as to gradually get used to production of planned sizes of the products.

Generally, in rolling non-flat products, it is not wise to change product sizes frequently because it lowers operating rate of rolling mills markedly. Therefore, operation plans should be made in such manner that permits the maximum production of the same size of product at one rolling chance.

5-3. Personnel plan

Only the personnel engaged in the operation of the steel works will be discussed. Needless to say, in a corporate entity, central administrative organ is necessary in addition to operation departments. Namely, besides executive office, financial and accounting dept., sales dept., purchasing dept., personnel and labour dept., public relations dept. and others are required and so are construction dept. and R&D dept. But the personnel required in those depts. are not included.

The reasons are:

1) Administration organization of the company should be decided by the type of the company and by its top management.
2) It should be studied also from capability of employees and local conditions.

3) As for construction dept., it should be considered in parallel with employment of consultants.
4) And therefore, the above belongs to the role played by the planning and promoting body mentioned in Sec.5-1(2).

Table 7-5-1 Personnel Plan

Facilities	Manager level	Staff level	Operator level	Total
Raw materials	2	2	38	118
DR plant		4	72	
Lime calcining plant	7	25	508	540
EAF plant				
CC plant				
Section mill plant	2	8	Cilegon 250 Arun 258	Cilegon 260 Arun 268
Bar mill plant	2	8	Cilegon 264 Arun 272	Cilegon 274 Arun 282
Wire rod mill plant	3	8	Cilegon 287 Arun 295	Cilegon 298 Arun 306
Power plant	3	11	356	370
Power rec. & distri.				
Oxygen plant				
Water supply & drainage				
Instrumentation maintenance	3	10	137	150
Transport (incl. port)	4	4	Cilegon 419 Arun 493	Cilegon 427 Arun 501
Test & analysis	3	6	56	65
Maintenance	21	16	877	914
Warehouse	4	2	76	82
Administration	52	248		300
Total	106	352	Cilegon 3,340 Arun 3,472	Cilegon 3,798 Arun 3,930

6. Detailed Plant Description

6-1. Port and unloading and loading facilities

6-1-1. Port (berth and bank protection)

(1) Basic idea

Harbor plan occupies an important position in the location of the steel works. As it is said that steel industry is transportation industry, a vast amount of raw materials are brought into the works and products in the works are carried out from it. The reason why the proposed sites in Cilegon and Lhokseumawe are on the seaside is that it is most economical to transport such great volume of goods by sea. Therefore the port facilities which accommodate ships employed for the sea transport are very important among various facilities in the steel works and their layout and structure must satisfy efficient distribution of goods and natural conditions and others.

In the new steel works, unloading berths for pellets, scrap, limestone, etc., product shipping berths and heavy oil unloading berth will be constructed.

As the Step III study was not based on detailed soil analysis, water depth measurement and sea current study, it is necessary to review the plan by adequate field survey before implementing it. In particular, should there be an extensive coral reef, the location of the port may have to be changed.

(2) Premises for facilities plan

1) Cilegon area

Location and scale of berths are selected on the following conditions.

a) Raw materials berth (pellet)

Pellet, raw material, is to be imported and a berth with planned water depth of 17 m is constructed for 50,000 DWT class full-load ore carrier and 120,000 DWT class half-load ore carrier.

b) Raw materials berth (scrap and limestone)

The ships carrying scrap and limestone are 35,000 DWT class, max. and a berth with planned water depth of 13 m is constructed.

c) Product berth

As the products are shipped out by sea, rail and truck in Cilegon area, two product berths are constructed, which can accommodate general cargo boats of 5,000 DWT class, max. Planned water depth is 8 m.

d) Oil berth

Unloading berth for heavy oil used as fuel for own power plant is located in front of heavy oil tank to shorten the distance of heavy oil transportation and the ship used is tankers of 10,000 DWT class, max. and the planned water depth is 9 m.

2) Arun area

Location and scale of approach channel, turning basin, and berths are studied on the following conditions.

a) Approach channel

Width and water depth of the approach channel are determined based on 120,000 DWT class half-load ore carriers, which are the largest vessels to use the port. The width of the approach channel is 300 m, the length of the vessel, and the water depth is 17 m.

b) Turning basin

The harbor has a layout with adequate space for the turning basin in the center, and the turning is done with the help of tugboats. The turning basin is of round form with diameter 1.5 times the length of the biggest ship employed.

c) Breakwater

Layout of breakwater should be decided according to the direction of swell and designed wave, but in this pre-F/S, the breadwater is extended to the point where water depth is 17 m.

d) Raw materials berth (pellet)

Same as Cilegon area

e) Raw materials berth (Scrap and limestone)

As scrap and limestone is all brought in by sea in Arun area, two berths with planned water depth of 13 m are constructed for accommodating cargo boats and ore carriers of 35,000 DWT class, max.

f) Product berth

Same as raw materials, the products are mostly taken out of the works by sea and so four berths of 8 m planned depth are constructed for general cargo boats of 5,000 DWT class, max.

g) Oil berth

At the northeast part of the harbor, one oil berth with 9 m planned depth is constructed in a distance from product berth and for unloading heavy oil from 10,000 DWT class tankers.

(3) Technical explanation

1) Cilegon area

a) Natural condition

Prevailing wind direction and velocity in Cilegon area are as shown in Table 7-6-1 and it can be seen that the winds are north wind with velocity of about 2 m/sec. throughout the year.

Table 7-6-1 Wind (Cilegon)

Period	Direction	Velocity
Mar. - Nov.	North	3.8 - 4.4 knots
Dec. - Feb.	West or North	4.1 - 4.3 knots

Waves are comparatively mild and wave height is 0.3-1.5 m throughout the year, with average wave height being 0.6 m. The tidal current runs along the shoreline and its direction is southwest and northeast. Velocity of the tidal current averages 0.7 knots and as small as 1.2 knots even at the maximum. As shown in Fig. 7-6-1, the range of tide also is comparatively small, 0.55 m, and the height of quay wall at the top of M.S.L. +4.0 m, same as the ground level, is adequate. In addition, installations outside the harbor such as breakwater are not required.

Layout and construction of port facilities should be decided after knowing the topographic features of sea bottom through detailed sounding measurement together with information on softness of ground, but the layout was decided based only on the topographical map shown in Fig. 7-6-2 at the present stage. Water depth is about 10 m at the distance of about 300 m from the present shoreline, about 20 m at the point about 1,200 m offshore, and shallower to the northern side. Coral reef is seen part of the shoreline and there is a possibility of an extensive coral reef existing.

According to soil test data on land area, it seems there exists sticky soil layer about 15 m thick under the present ground level and below the layer, supporting bed with N-value being 50 or more. Though construction of port facilities and length of piles should be decided based on detailed soil test, it was assumed that sea bottom soil consists of almost same layers as those on land along the sea bottom.

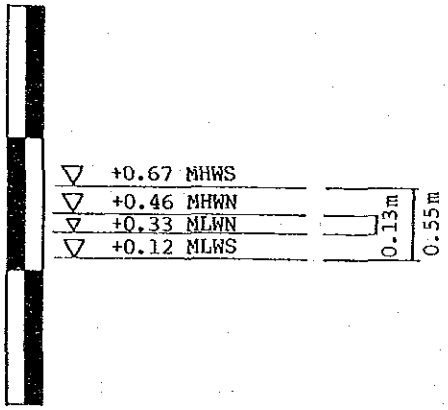


Fig. 7-6-1 Typical Tide Levels (Merak Port)

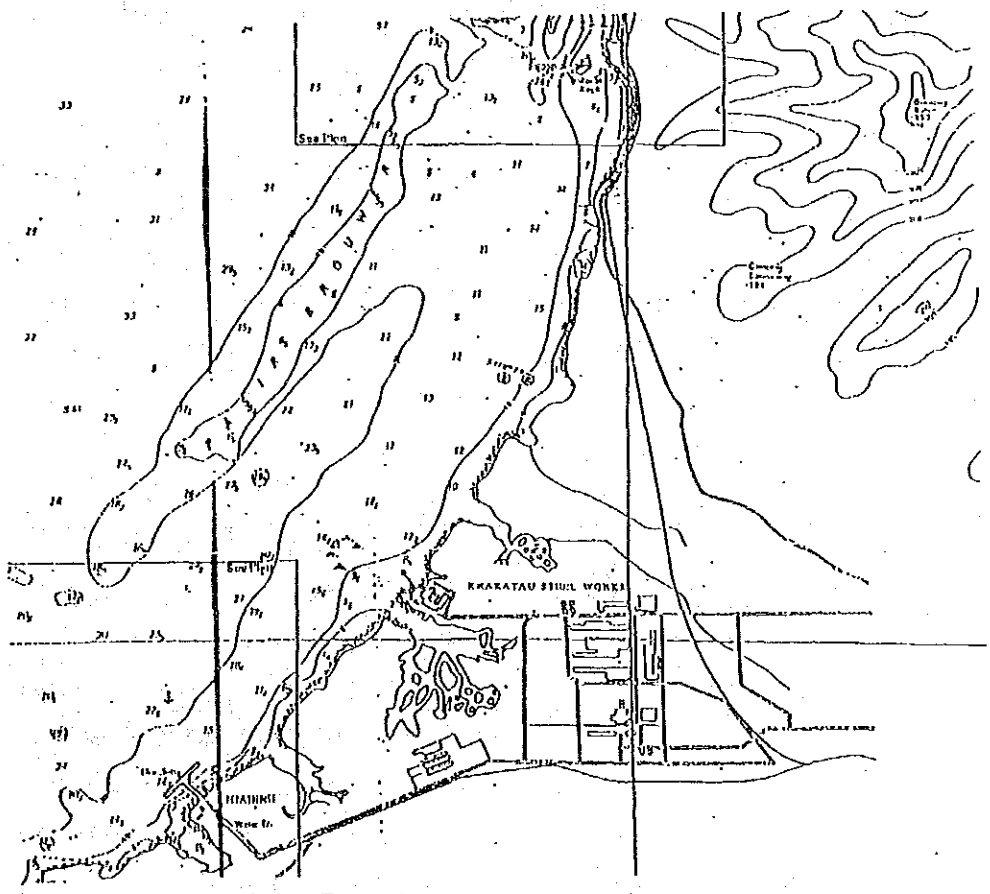


Fig. 7-6-2 Topographical Map

b) Design conditions

i) Design seismic coefficient

According to "Standard Design Criteria for Port in Indonesia", Cilegon is in Zone 3, with its design seismic coefficient being 0.05 at stiff soil and 0.07 at soft soil.

ii) Approaching velocity

In principle, a large ship is to approach the quay by the help of tugboats and design approaching velocity of 10-12 cm/sec. is used, but as the harbor has no breakwater, about 15 cm/sec. velocity should be considered. However, oil jetty is used for unloading dangerous article and so 20 cm/sec. is considered as approaching velocity and 6^{o} as approaching angle.

iii) Load conditions of cargo handling machines

Table 7-6-2 Raw Material (Pellet) Unloader

	Sea Side	Land Side	Load Condition
During operation	192 t/corner	150 t/corner	Long term

(6 wheels/corner x 4 corners)

Table 7-6-3 Scrap Unloader and Product Loader

	Sea Side	Land Side	Load Condition
During operation	110 t/corner	118 t/corner	Long term

(4 wheels/corner x 4 corners)

iv) Live load

Table 7-6-4 Live Load

(t/m^2)

	Quay	Bridge
Raw material (pellet) berth	3.0	1.0
Scrap and product berth	2.0	-
Oil jetty	1.0	0.5

Note: Live load in earthquake is to be a half.

2) Arun area

a) Natural condition

Prevailing wind direction and wind velocity in Arun area are as shown in Table 7-6-5, and winds are often southwest with velocity about 2 m/sec. throughout the year.

Table 7-6-5 Wind (Arun)

Period	Direction	Velocity
Dec. - Feb.	NE - SW	3.0 - 4.0 knots
Mar. - Nov.	SW	2.0 - 4.5 knots

Design waves at neighboring LNG port and AAF port are shown in Table 7-6-6.

Table 7-6-6 Wave Condition

Port	Specification	Wave Height	Term
LNG	100 years storm wave	$H_{1/3}$ = 4.27 m	11 sec.
	Operational wave	$H_{1/3}$ = 1.30 m	10 sec/
AAF	20 years cyclone wave	H_0 = 3.5 m	8 sec.
	20 years NE monsson wave	H_0 = 3.3 m	8 sec.
	50 years cyclone wave	H_0 = 3.9 m	9 sec.
	50 years NE monsoon wave	H_0 = 3.4 m	8 sec.

Oceanographic condition is fairly severe with swell coming from the Bay of Bengal, for example, and outer protective facilities such as breakwater is necessary and their height is to be M.S.L.+6.5 m. The range of tide is as shown in Fig. 7-6-3 and the height of quay at the top in the harbor surrounding by the breakwater is to be M.S.L.+4.5 m.

According to the topographical map shown in Fig.7-6-4, water depth is 5 m at about 300 m distance from shoreline, 10 m at about 500 m from shoreline and 20 m at about 800 m from shoreline. According to the data of F/S of AAF, it seems sticky soil with relatively high strength of N value being about 7 in the thickness of 18 m from the present ground level, and below it, sup-

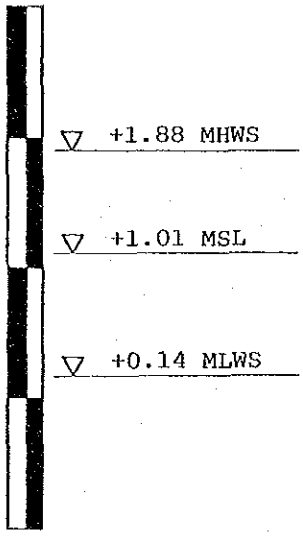


Fig. 7-6-3 Typical Tide Levels (Arun)

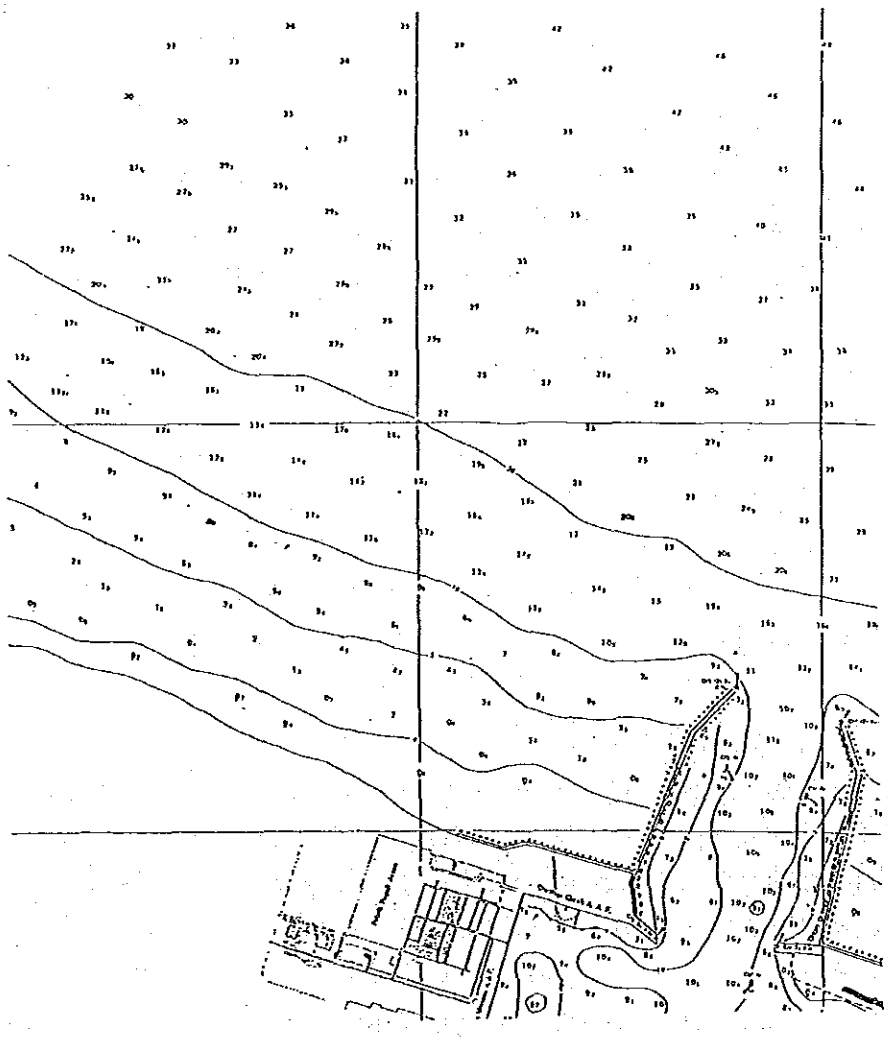


Fig. 7-6-4 Topographical Map (Arun)

porting bed with N value being 50 or more exist. Construction of facilities is studied on the assumption that soil in the sea bottom has almost the same profile, but detailed soil exploration is necessary when the project is implemented.

If there is an extensive coral reef in the harbor, there is a possibility of locations of port facilities being forced to be altered.

b) Design conditions

i) Design seismic coefficient

According to "Standard Design Criteria for Port in Indonesia", Arun is in Zone 4 and its design seismic coefficient is 0.03 at stiff soil and 0.05 at soft soil.

ii) Approaching velocity

Same as Cilegon

iii) Load conditions of cargo handling machines

Same as Cilegon area and as shown in Tables 7-6-2 and 7-6-3.

iv) Live load

Same as Cilegon area and as shown in Table 7-6-4. On the breakwater it is 1.0 t/m^2.
Live load in the earthquake is studied as a half of the load.

(4) Equipment specifications

Specifications of equipment installed on raw materials berth (pellet), raw materials berth (scrap & limestone), product berth, oil jetty and breakwater are given in Table 7-6-7.

Table 7-6-7 Specifications of Port Facilities

Name	Structural Type	Water Depth	Applicable Vessel	Remarks	Reference Figure No.
Material (pellet) Berth	Steel pipe pile type quay	−17.0m	120,000DWT (half load) Ore Carrier	Rope Trolly Crane	Fig. 7−6−5
Material (scrap) Berth	Steel pipe pile type quay	−13.0m	35,000DWT Cargo Vessel	Level Luffing Crane (15t hoist)	Fig. 7−6−6
Product Berth	Steel pipe pile type quay	− 8.0m	5,000DWT Cargo Vessel	Level Luffing Crane (10t hoist)	Fig. 7−6−7
Oil Berth	Dolphin type quay	− 9.0m	10,000DWT Oil Tanker	Oil Loading Arm	Fig. 7−6−8
Revetment	Steel sheet pile type revetment	−3.0 ~ − 5.0m	−		Fig. 7−6−9
Breakwater	Interlocked steel pipe pile type	±0.0 ~ − 7.0m	−		Fig. 7−6−10
Breakwater	Double interlocked steel pipe pile wall	−7.0 ~ −17.0m	−		Fig. 7−6−11

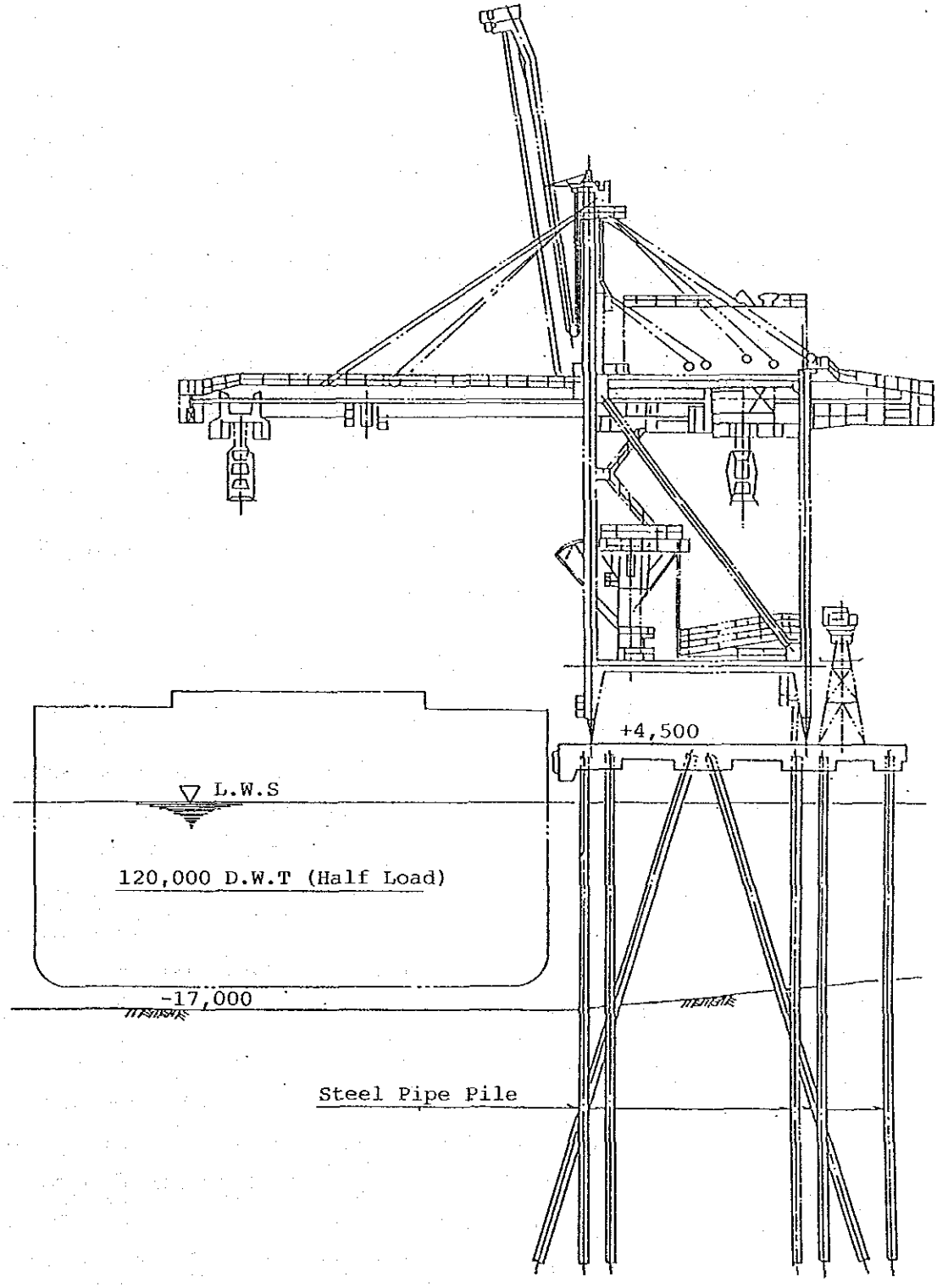


Fig. 7-6-5 Profile of Material (Pellet) Berth

1) Raw materials berth (pellet)

Raw materials berth for unloading pellet is for 120,000 DWT class half-load ore carrier. The ship length is 300 m and its draft at half-load is 15.5 m, and the berth is to be 275 m long and planned water depth 17 m. At the both ends of the berth, dolphins are constructed to moor a ship.

On the raw materials berth run 2 units of rope trolley type crane with grab-bucket capable of lifting the total weight of 550 t. The back of the crane permits mounting conveyor and the width of the berth is to be 28 m. The cross-section of the berth is shown in Fig. 7-6-5.

Construction of the berth is that of quay wall on piles type supported by steel pipe piles, 900 mm dia. and about 30 m long, and batter piles are arranged to cope with approaching force and horizontal force in the earthquake.

2) Raw materials berth (scrap and limestone)

Raw materials berth for unloading scrap and limestone is for general cargo boat of 35,000 DWT class. The ship length is 210 m and its draft at full load is 11.5 m, and planned water depth is to be 13 m. On the berth runs LLC with lifting capacity of 15 t and dead load of 350 t. The quay is 17 m wide and has cross-section as shown in Fig. 7-6-6.

Construction of the berth is that of quay wall on piles type supported by steel pipe piles, 660 mm dia. and about 25 m long, and steel sheet piles are arranged on the back of the berth to ensure front water depth. And batter piles are arranged to cope with back earth pressure, approaching force and horizontal force in the earthquake.

3) Product berth

Product berth for shipping rolled steels such as wire rods and sections is for general cargo boats of 5,000 DWT class. The ship length is 103 m and its draft at full load is 6.8 m and planned depth is to be 8 m. On the berth runs LLC with lifting capacity of 10 t and dead load of 350 t. The width of the berth is 17 m.

Construction of the berth is, same as the raw materials berth for scrap and limestone, of quay wall on piles type supported by steel pipe piles and steel sheet piles on the back and the cross-section is shown in Fig. 7-6-7.

4) Oil jetty

Oil jetty to unload heavy oil for the power plant is to accommodate 10,000 DWT class oil tankers. The ship length is 139 m and its full draft 8.1 m, and planned water depth is made 9 m.

The jetty has platform equipped with loading arm and other cargo handling equipment in the center and at the both ends, there are two units each of dolphin for approaching and mooring ships, and its cross-section is as shown in Fig. 7-6-8.

5) Bank protection

Bank protection in Cilegon area is to be constructed northeast of the product berth in the total length of about 1.3 km at the present water depth of about 3 m. Steel sheet piles are used as retaining wall and H pile are employed to support the wall from the inside. In order to ensure alleviation of earth pressure on the back, reduction of its change and stability, mound zone is formed on the back and front of sheet piles. The cross-section is as shown in Fig. 7-6-9.

Bank protection in Arun area is used in the SW and SE corners of the harbor and its construction is same as that in Cilegon area.

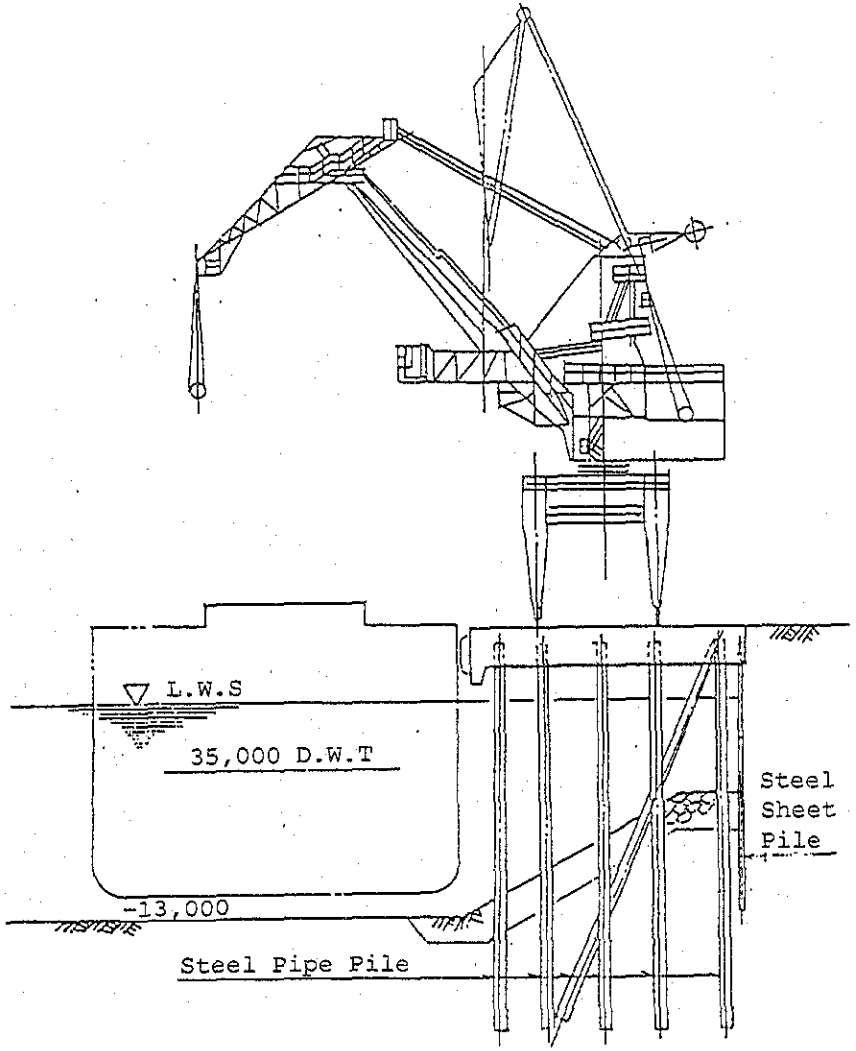


Fig. 7-6-6 Profile of Material (Scrap) Berth

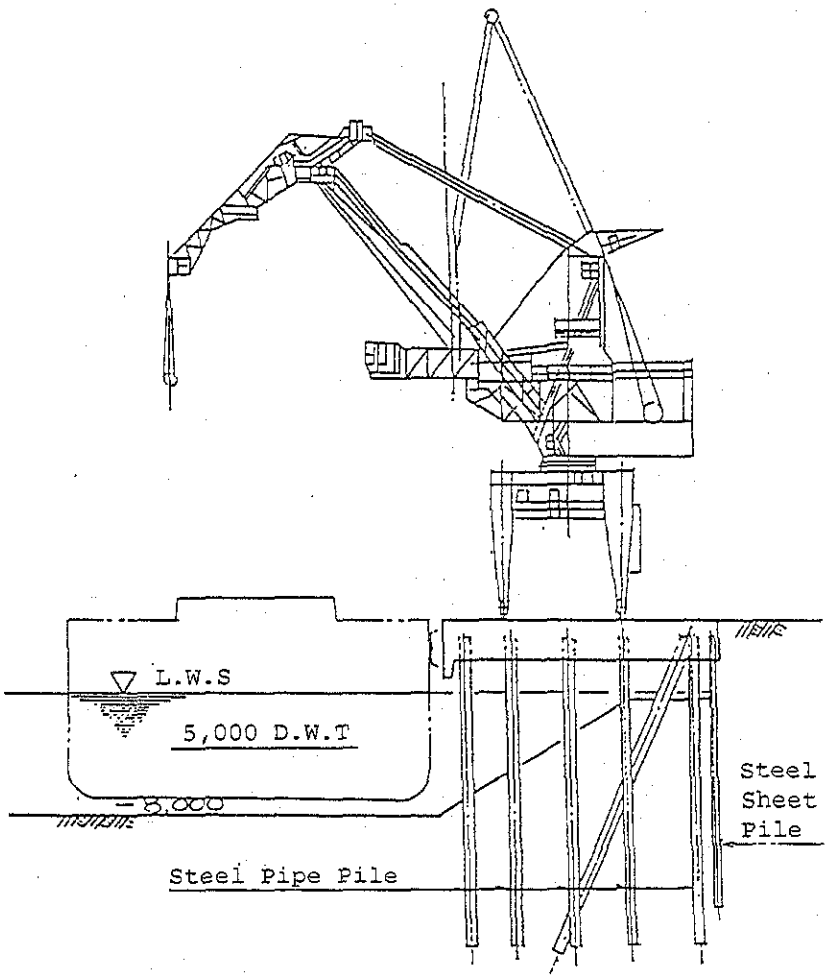


Fig. 7-6-7 Profile of Product Berth

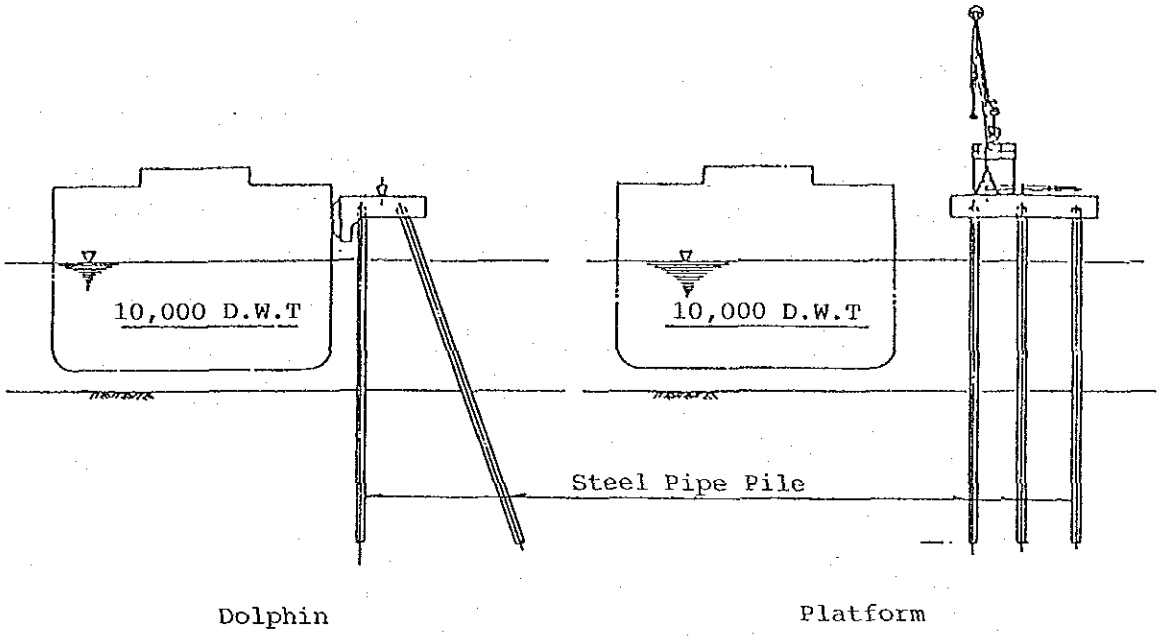


Fig. 7-6-8 Profile of Oil Jetty

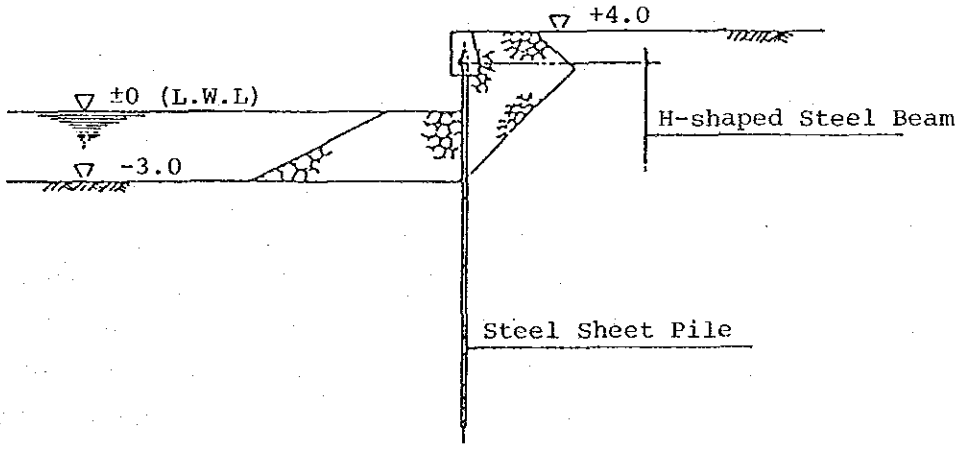


Fig. 7-6-9 Profile of Bulkhead

6) Breakwater

In Arun area, waves are big and swell can be expected to enter the harbor, and it is necessary to construct breakwater to keep wave height low in the harbor. The breakwater at places where the present water depth is 7 m or less is to have cross-section as shown in Fig. 7-6-10, and it has construction consisting of steel pipe piles and steel pipe batter piles. At places with the present water depth is 7 m or more, it is built with double-wall of steel pipe piles as shown in Fig. 7-6-11. The height of breakwater at the top is M.S.L. +6.5 m.

7) Crossing pier

Crossing pier to raw materials berths has road with effective width of 5 m and conveyor and is supported by steel pipe piles. The pier has road parts, one per 300 m, which are separable and have effective width of 10 m, and earthquake resistant columns are installed in the direction of extension, one per 100 m.

Crossing pier to the oil jetty is the same and is of contruction with road and pipe lines supported by steel pipe piles.

(5) Layout

1) Cilegon area

Raw materials berth (pellet) will be constructed about 850 m off the present shoreline to ensure the water depth. As water depth is small in NE part and large in SW part due to the topographic features of the sea bottom, the berth will extend to the south. The scrap berth will be built in front of scrap yard to shorten the distance of transport and also connected to product berth to save the amount of soil to be dredged. The oil jetty will be constructed in front of heavy oil tank for power plant and about 300 m offshore to ensure water depth.

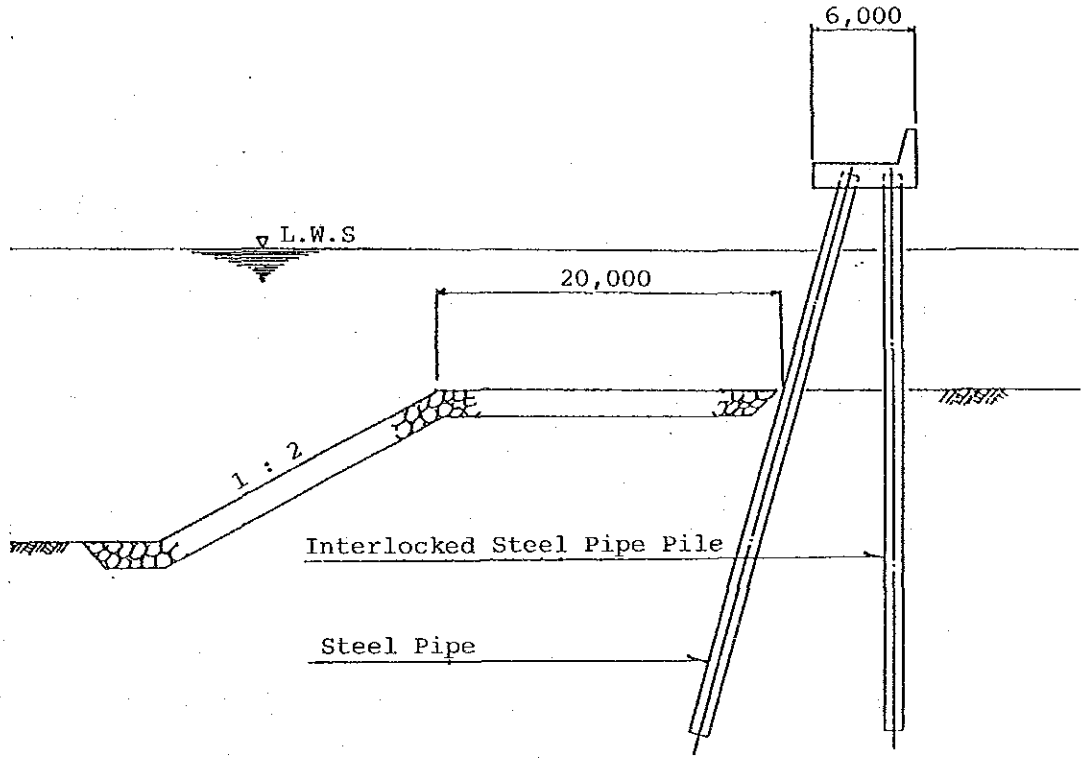


Fig. 7-6-10 Profile of Breakwater (±0∿-7.0m)

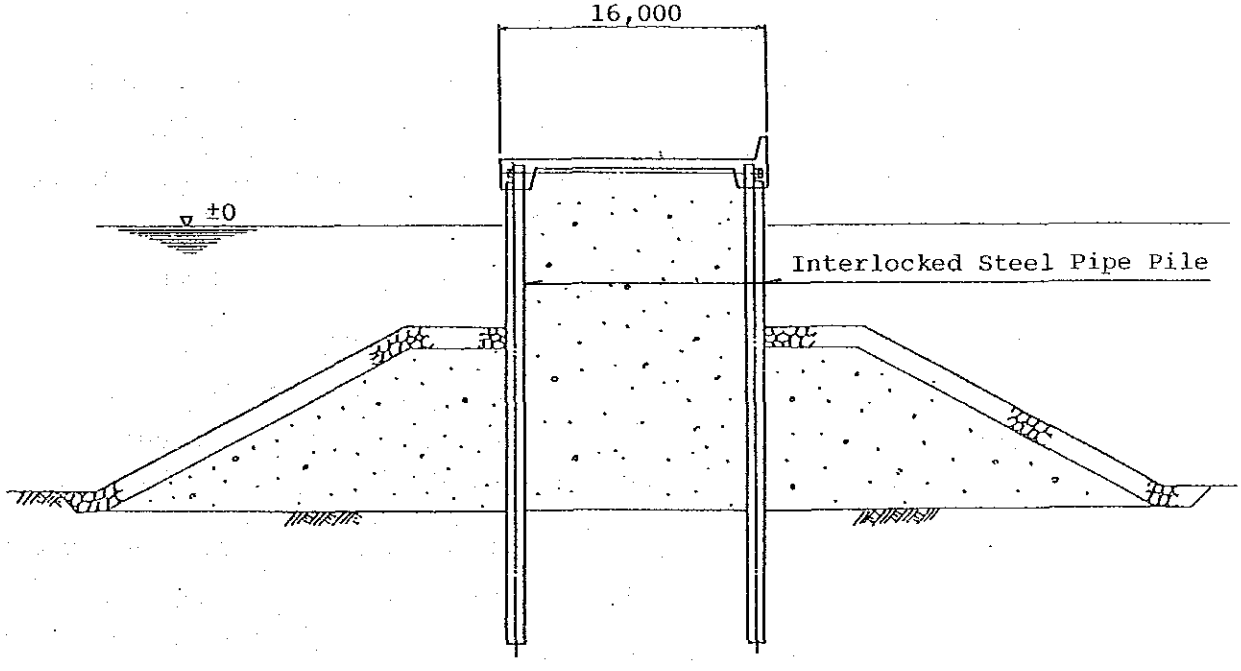


Fig. 7-6-11 Profile of Breakwater (-7.0∿-17.0m)

2) Arun area

Because of severe oceanographic condition in Arun area, breakwater will be built to keep the harbor from high waves. The breakwater has to be laid out considering prevailing direction of waves. The width of approach channel in the harbor is to be adequate for the length of the largest vessels entering the harbor and the turning basin to have an area of diameter being 1.5 times the length of such vessels.

6-1-2. Product and raw materials loading/unloading facilities

(1) Basic idea

In this section, port facilities required for receiving by sea various raw materials necessary in the new steel works for the second generation and for shipping by sea products produced in the works are planned.

1) Raw materials unloading facilities

A raw materials berth which can receive imported pellet and lump ore by large 50,000 DWT carriers will be built and equipped with ship unloader which can handle cargos of half-load ships up to 120,000 DWT class ships.

For receiving scrap and limestone, level luffing crane with 15 ton loading capacity will be installed.

Of the raw materials received, pellet and lump ore are carried by belt conveyor to raw materials yard and scrap and limestone are carried by dump truck.

A berth for unloading by truck crane is planned for sub-materials such as ferro-alloys and fluorite.

2) Product loading facilities

Products are carried by trailers from product yard of each mill to product berth and directly loaded on ships

or loaded after temporarily stocked at the rear of the berth. As loader, a 10 t level luffing crane which can handle various kinds of products is arranged.

(2) Premises for the facilities plan

1) Quantities handled at raw materials berths and product berth

The quantity handled at each berth is shown in Table 7-6-8.

Table 7-6-8 Amount of Handling on the Berth

Type		Quantity (1,000 t/y)		Remarks (Type of Vessel)
		Cilegon	Arun	
Unloading	Pellet	1,387	1,387	Max. 50,000 DWT
	Lump Ore	594	594	or
	Sub total	1,981	1,981	Half load of 120,000 DWT
	Scrap	188	338	Max. 35,000 DWT
	Lime Stone	69	69	Max. 5,000 DWT
	Sub total	257	407	
	Miscellaneous (Ferro Alloy, Fluorite, etc.)	144	144	Max. 5,000 DWT
	Oil			Max. 10,000 DWT
Loading	Products			
	Medium Profile	63	206	
	Bar	163	536	Max. 5,000 DWT
	Wire Rod	150	495	
	Total	376	1,237	

Pellet & lump ore: All assumed to be imported

Scrap: According to the report of Step II study, steel consumption by area in Indonesia is

Jawa area	75%
Sumatera area	18%
Others	7%

and assuming that scrap generated by area is in proportion to the above percentages and giving allowance, it is planned that the steel works in Cilegon can receive 50% of the requirements by sea and that the works in Arun can receive 90% of the requirements by sea.

Limestone: It is planned that whether constructed in Cilegon or Arun, the works can receive 50% of the requirements by sea.

Miscellaneous: All auxiliary materials required by the steel works are planned to be received by sea.

Product: Based on the percentage of steel consumption by area in Indonesia as given in the report of Step II study mission, it is planned that the steel works if in Cilegon will ship 25% by sea and if in Arun 82% by sea.

2) Operation condition

a) Working hours In principle, 3-shift continuous work

b) Rate of occupation of berths

Table 7-6-9 Rate of Occupation of Berths

Berth	Rate of Occupation (%)	
	Cilegon	Arun
Pellet & lump ore berth	30	30
Scrap & limestone berth	40	47
Miscellaneous berth	55	55
Product berth	49	61

(3) Technical explanation

1) Raw materials berths

Pellet and lump ore are unloaded at the berth. All the pellet and lump ore are imported. Though they are assumed to be transported by 50,000 DWT class vessels, ship unloader is planned to be capable of handling the cargo of half-load large vessels of 120,000 DWT or less.

This ship unloader is of rope trolley type to reduce weight and equipped with grab bucket to unload pellet and lump ore. (Fig. 7-6-12) Those raw materials are fed into the hopper installed on the unloader and through feeder and conveyor on the unloader they are supplied to belt conveyor on the ground and transported continuously to the raw materials yards.

As the size of vessels increases, the part of the cargo to be plowed in the hold increases and the efficiency of crane decreases, and it's important to have a bulldozer in the hold to ensure efficient working.

On the other hand, as scrap is carried by 10,000-35,000 DWT class ships, a 15 t level luffing crane suited to this ship size is planned (Fig. 7-6-13) and the crane is equipped with Polyp-bucket or lifting magnet for unloading scrap.

Unloaded scrap is either directly loaded on dump trucks or loaded on trucks using the level luffing crane again after temporarily stocked on the berth and transported to scrap yard.

Limestone is transported by ships of 5,000 DWT or less. Same as scrap, limestone is unloaded by grab bucket installed to the level luffing crane and part of the unloaded limestone is directly loaded on dump truck and carried to limestone yard adjacent to lime calcining plant.

Limestone unloading capacity with the level luffing crane is as big as about 600 t/h which far exceeds transporting capacity of dump truck and so unloaded limestone has to be temporarily held in the rear of the crane. The rear area has capacity of more than 5,000 t, which is more than enough for one ship load. Limestone temporarily held is later transported by shovel loader and dump truck to limestone yard.

Sub-materials used in the steel works (ferro-alloys, fluorspar, carbon powder, etc.) and refractories are unloaded by truck crane at the miscellaneous berth. The largest ship used is planned to be 5,000 DWT. But when there is idle time for the above level luffing crane for scrap or the level luffing crane for products described later, it is desirable to use those cranes for unloading sub-materials and refractories from the aspects of working condition and unloading efficiency.

2) Product berth

A 10 t level luffing crane which can handle cargo for ships of 5,000 DWT class max. is planned for shipping products to domestic markets.

Products are all carried by trailer or truck from mills direct to the crane and loaded on ships. Though it is possible to hold products at a site in the rear of the crane temporarily to improve loading efficiency, it is more desirable to avoid cost increase by double handling whenever possible.

The crane is to be equipped with hoisting apparatus necessary for handling wire rods, bars and sections.

3) Oil jetty

At Cilegon and Arun area, natural gas as fuel for power plant in the steel works is not available sufficiently and oil is used instead. As facilities for receiving this oil, oil jetty facilities are planned.

The largest ships which can approach the jetty is to be 10,000 DWT, max.

(4) Specifications of major facilities

Main specifications of port facilities required for handling the above cargoes are shown in Table 7-6-10.

(5) Layout

Layout of port facilities at Cilegon and Arun is shown in Fig. 7-6-14 and Fig. 7-6-15, respectively.

SPECIFCATIONS

TYPE OF UNLOADER	ROPE TROLLEY UNLOADER WITH SHUTTLE TROLLEY	
HANDLING MATERIAL	PELLET & LUMP ORE	
GRAB BUCKET	LOAD	SELF WT.
PELLET	10 t	10 t
MAX. LIFT	37m	
ELECTRIC SOURCE	AC 3300 V, 60 Hz, 3 Ph.	

MOTION	SPEED		MOTOR		BRAKE
		m/min	kW	R.P.M	
CLOSING	HOIST	110	220	1000/1200	M.B
	LOWER	132			
HOLDING	HOIST	110	220	1000/1200	M.B
	LOWER	132			
TROLLEY TRAVEL		130	44	1300	M.B
BOOM HOIST	5 min Over load		44	1300	M.B, B.B
GANTRY TRAVEL		25	11 x 6	1200	M.B
NO.1 CONVEYOR		100	15	1200	M.B
NO.2 CONVEYOR		120	30	1200	M.B
CAB TRAVEL		30	1.5	1800	M.B

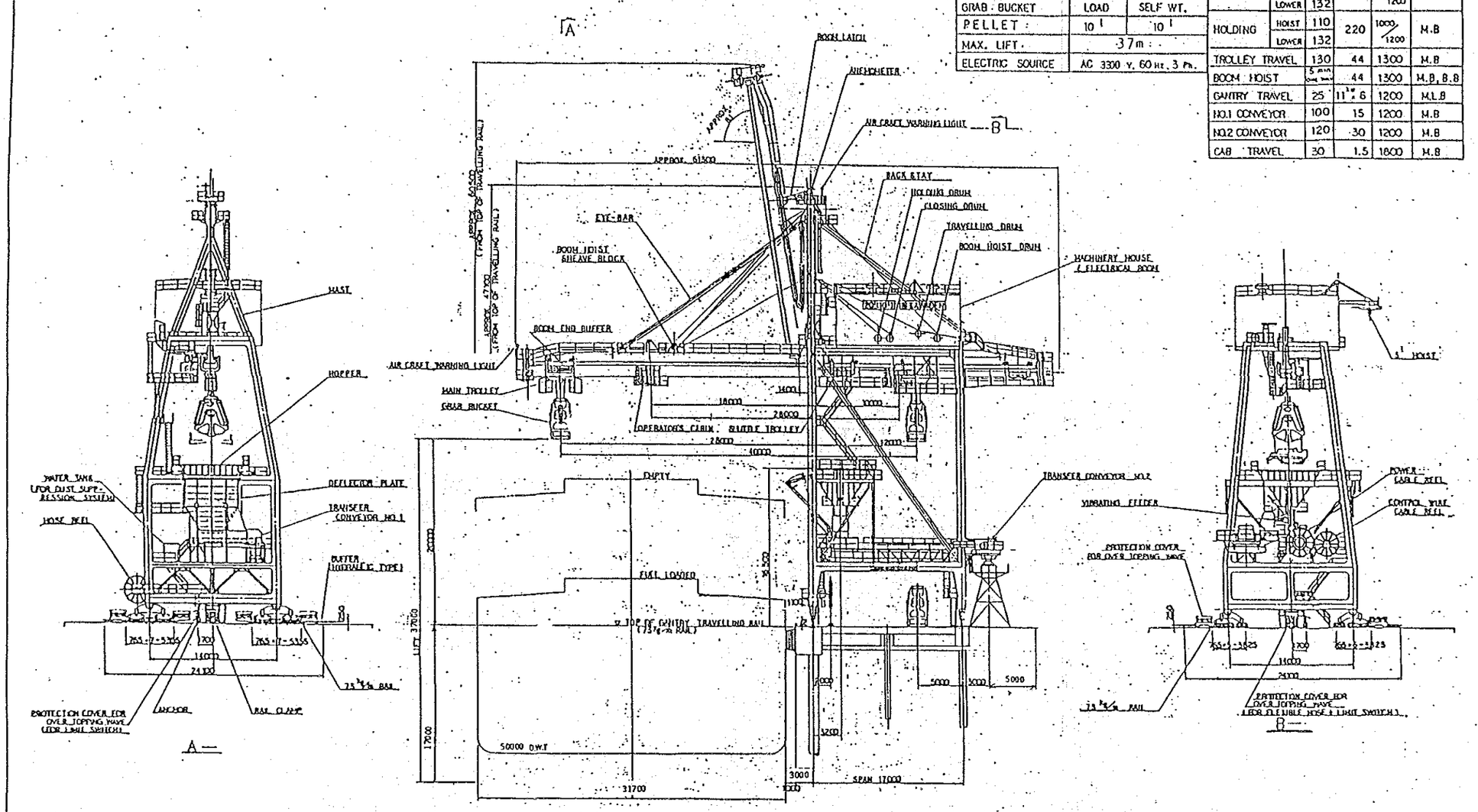


Fig. 7-6-12 800 t/h SHIP UNLOADER

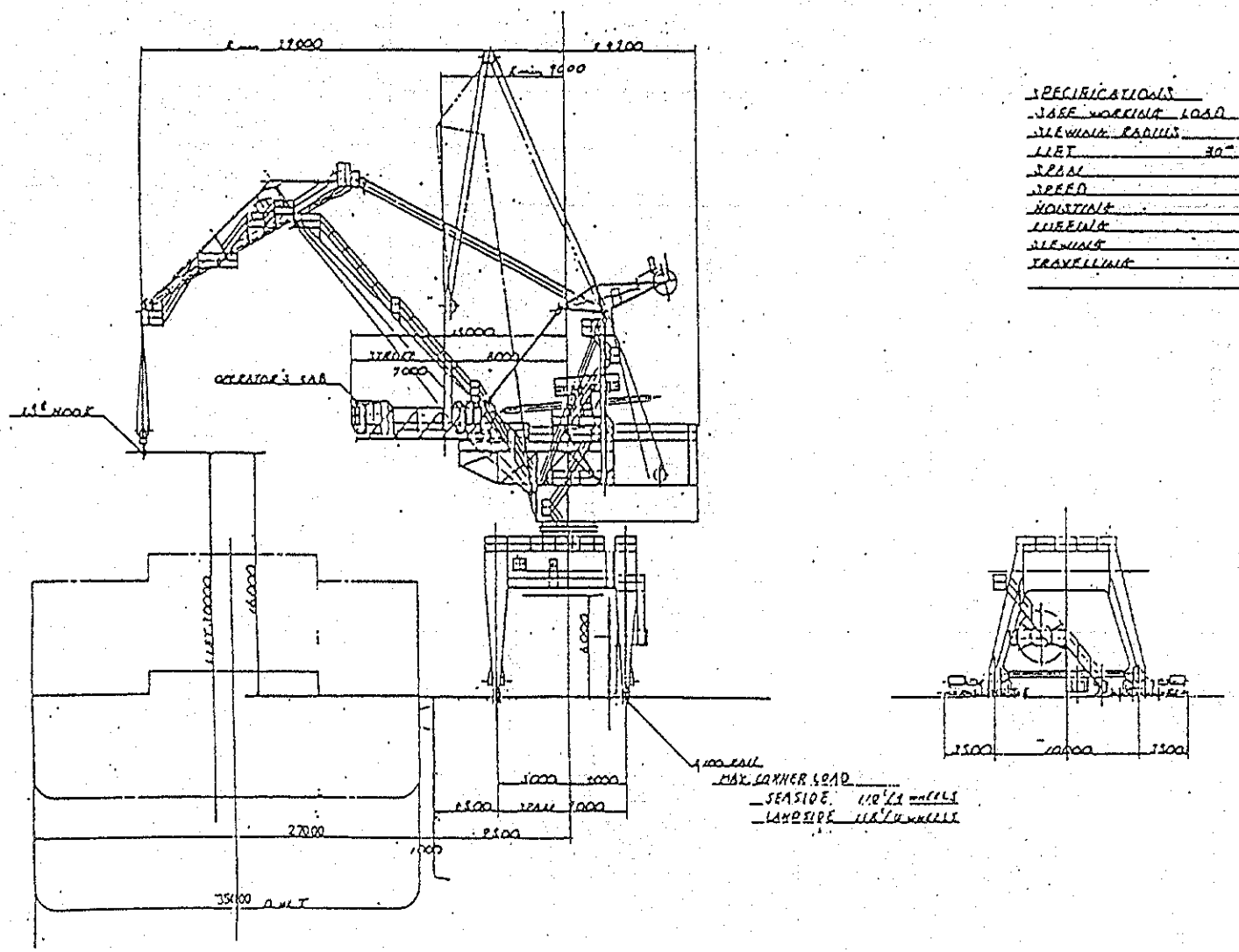


Fig. 7-6-13 15 TON LEVEL LUFFING CRANE

Table 7-6-10 Specification of Port Facilities

Item	Specification	Quantities	
		Cilegon	Arun
1. Raw material shipunloader	Capacity 800 t/h Type Rope trolley crane	2	2
2. Scrap & lime stone unloader	Lifting capacity 15 t Type Level luffing crane with lifting magnet or bucket	2	3
3. Product loader	Lifting capacity 10t Type Level luffing crane	2	6
4. Truck crane	Lifting capacity 40t Boom length 18.5m, Operation radius 14m ⇨ Lifting 7t	1	1
5. Conveyor for pellet & lump ore	Capacity 1,600 t/h Belt width 750 mm Belt speed 200 m/min.	1	1
6. Bulldozer	Engine power 105 HP	2	2
7. Building			
(1) Port control center	Office area 500 m²	1	1
(2) Sub-station	Office area 100 m²	1	0
(3) Electric power room	Room area 100 m²	1	1
8. Heavy oil unloading equipment	Pipe line size 10 inch	1	1

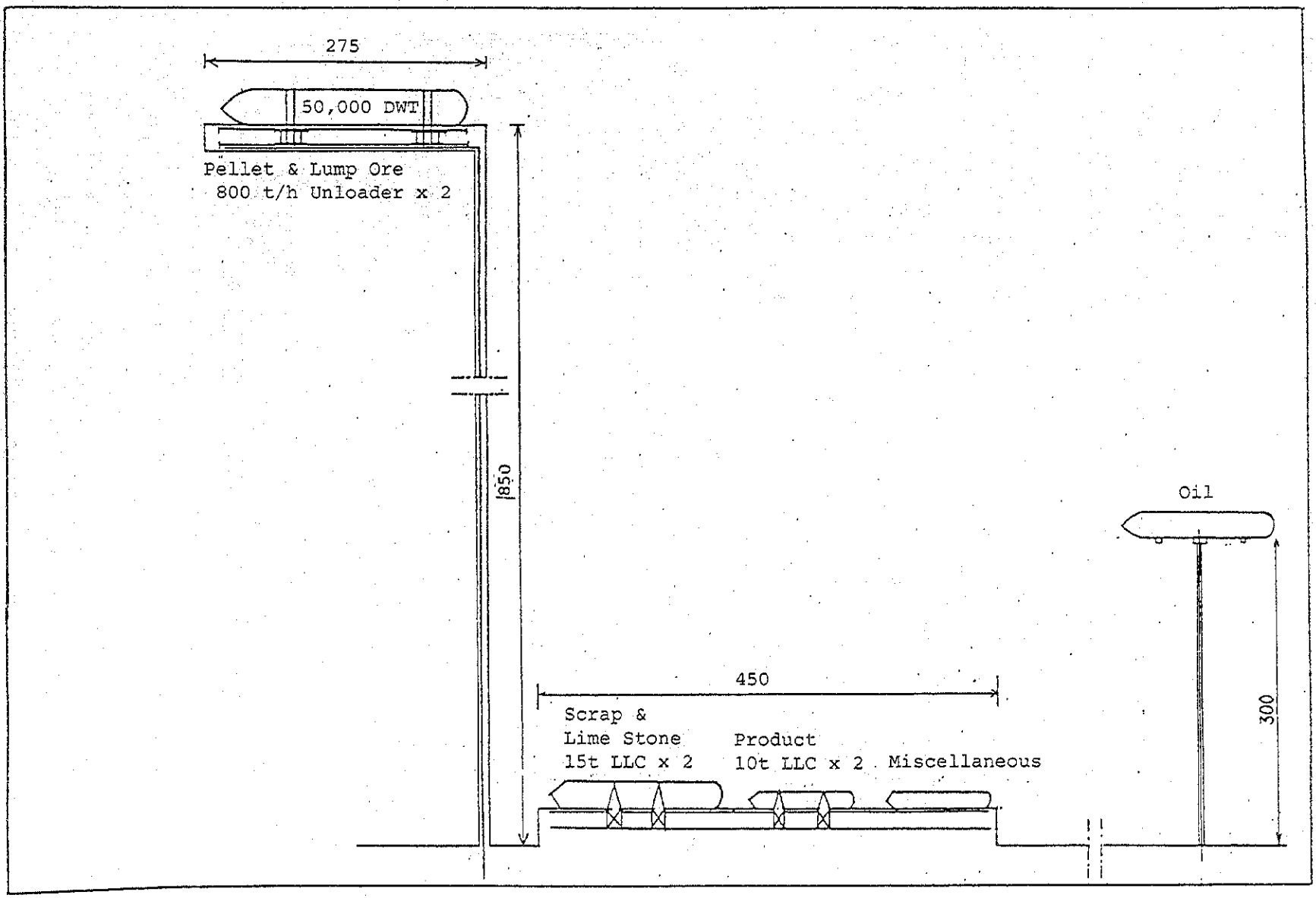


Fig. 7-6-14 CILEGON PORT

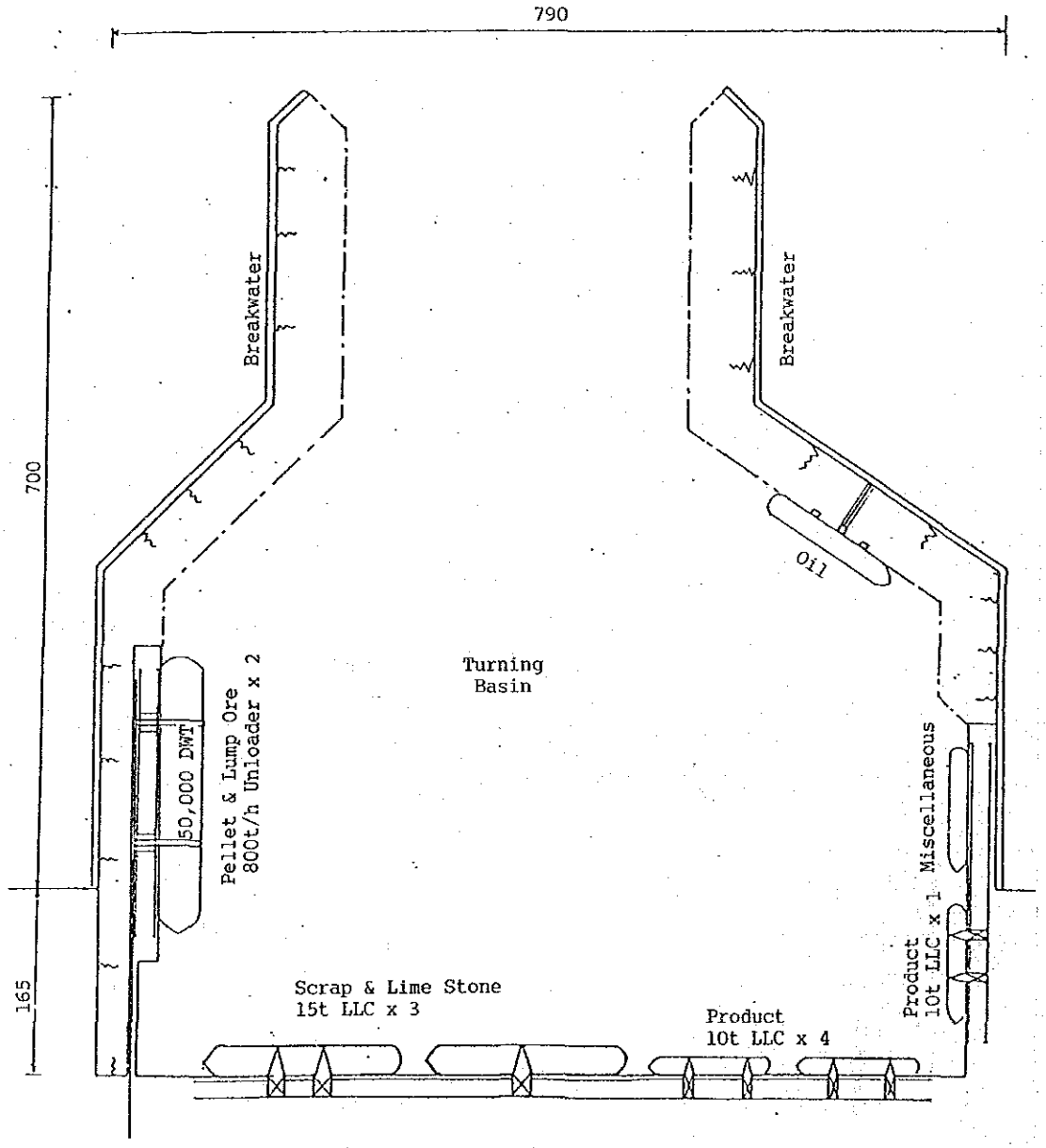


Fig. 7-6-15 ARUN PORT

6-2. Raw material handling facilities

6-2-1. Basic idea

Raw material handling facilities in this project have the function to receive 2 million tons a year of iron oxide, store and supply it to DR plant stably and continuously.

Iron oxide is in the form of pellet and lump ore, and as it is planned to be imported by sea, joint purchasing and transport with existing P.T. Krakatau Steel should be planned naturally and its effect on capacity of raw material handling facilities is of course more advantageous than there is only one integrated steel mill in Indonesia.

Considering the above, the important functions of the facilities are still requested; namely they could receive without delay iron oxide transported from unloading facilities at the berth which is built to serve large 60,000-100,000 DWT vessels; they could keep in stock proper quantity of iron oxide so as to ensure stable operation of subsequent processes of DR plant and EAF; and finally they can provide stable supply of iron oxide to DR plant.

To satisfy the above required functions, raw material handling facilities are planned to have

1) Receiving conveyor compatible with berth unloading facilities
2) Stacker used exclusively for receiving
3) Assuming two brands of pellet and one brand of lump ore, one ore yard with full capacity of 300,000 tons (which equals to 1.8 times the monthly consumption)
4) Conveyor and exclusive reclaimer for transporting iron oxide to DR plant
5) Iron oxide sampling facilities
6) Remote automatic controls for the above facilities

6-2-2. Premises for facilities plan

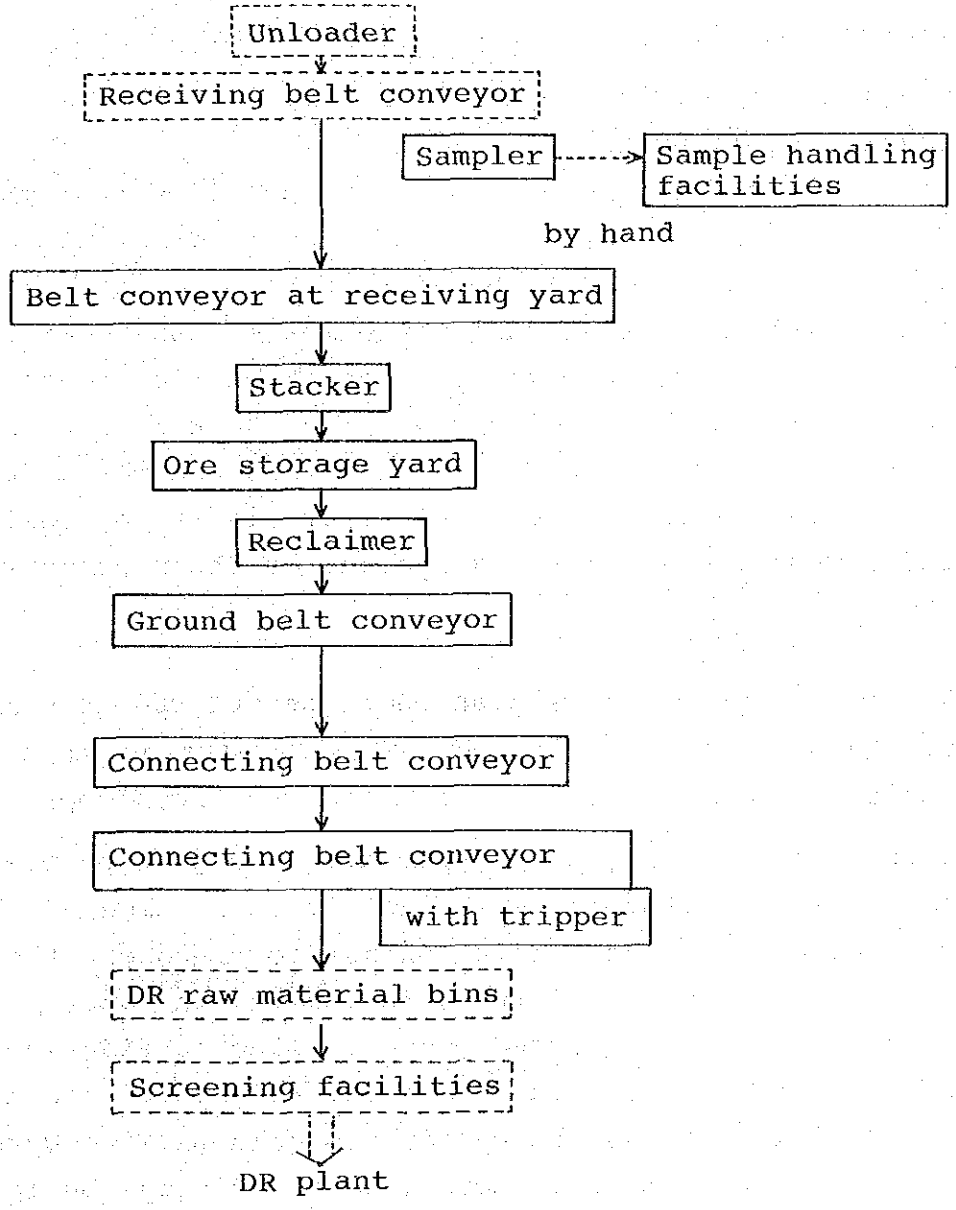
(1) Conditions as premises for the plan

1)	Annual consumption of iron oxide	1,981,000 tons
	Of which, pellet	1,387,000 tons
	lump ore	594,000 tons
2)	Expected brands of iron oxide	3 brands
	Of which, pellet	2 brands
	lump ore	1 brand
3)	Average monthly consumption of iron oxide	165,000 tons
	Of which, pellet	115,000 tons
	lump ore	50,000 tons
4)	Capacity of raw material receiving facilities	1,600 t/h
5)	Necessary max. ore storage capacity	300,000 tons for 3 brands
	(1.8 times the monthly consumption)	
6)	Specific gravity of iron oxide	2.3
7)	Rest angle of ore pile	30^{o} - 35^{o}
8)	Operation condition	Continuous operation (4-group, 3-shift)

6-2-3. Technical explanation

(1) Process flow

Process flow of raw material handling facilities are as shown below.



(2) Reasons for selecting those facilities

1) Belt conveyors

Belt conveyor method is adopted as it has been used widely for stable and continuous transportation of iron oxide in quantity and has proven reliable.

2) Stacker

An exclusive stacker is installed as yard stacker with capacity of 1,600 t/h.
Though alternative idea is stacker-reclaimer type which functions also as reclaimer mentioned in 4) below, an exclusive stacker should be adopted because of its reliability and operational performance, considering the quantity of iron oxide to reach 2 million tons a year carried by large carriers. The stacker is planned to run on the rails laid along the yard and has a function that permits stacking the materials at any desired place, thus facilitating management of the storage yard.

3) Ore storage yard

Capacity of the yard is planned to be 300,000 tons max. for three brands. The 300,000-ton storage capacity equals to about 1.8 times the monthly ore consumption.

Expected shippers of iron oxide are likely to be Brazil and Sweden in future as well, and it is considered that it takes about 40 days (1.3 months) to transport the material by large carriers to Indonesia, the above storage capacity is judged proper. Also considering possible joint purchasing and joint transporting with P.T. Krakatau Steel, the capacity should permit operation with less stock in normal time and stock-building when in emergency, enabling the management more flexible.

With a view of easy control and flexibility of the yard, the yard is planned to be open stocking pile type.

4) Reclaimer

Transport of raw materials to DR plant which may be considered the actual start of material flow in the steel works begins with reclaimer in the yard. Therefore, most widely used and reliable reclaimer of swing and bucket wheel type is selected.

The only disadvantage of this type is difficulty in automation as compared with bridge type reclaimer, but the function of the selected reclaimer to excavate stock pile of any brand on the storage yard should more than offset such disadvantage. Therefore, as it can flexibly meet the situation when any brand of iron oxide required by DR plant could be excavated and transported, therefore in future supply condition of the materials becomes tight, the selected reclaimer would be judged to be the most suited one.

5) Sampler

Automatic sampler interlocked with weighing scale on the belt conveyor is installed.

This performs sampling of the material periodically and automatically, enabling inspection and control of quality of the purchased raw materials.

6-2-4. Specifications and drawings of main raw material handling facilities

Specifications of main raw material handling facilities are shown in Table 7-6-11.

Table 7-6-11 List of main raw material handling facilities

Item	Description		
	Capacity	Spec.	Remark
Belt Conveyor for Yard (No.1)	1,600 t/h	750 mmW x 200 m/min	
Stacker	1,600 t/h		
Stock Yard	300,000 t	45 mW x 450 mL	
Reclaimer	600 t/h	Bucket wheel type	
Belt Conveyor for Yard (No.2)	600 t/h	600 mmW x 130 m/min	
Belt Conveyor (No.3)	600 t/h	600 mmW x 130 m/min	
Belt Conveyor (No.4)	600 t/h	600 mmW x 130 m/min	
Sampler		Automatic type	

Outside view drawings of stacker and reclaimer, the main raw material handling facilities, are shown below.

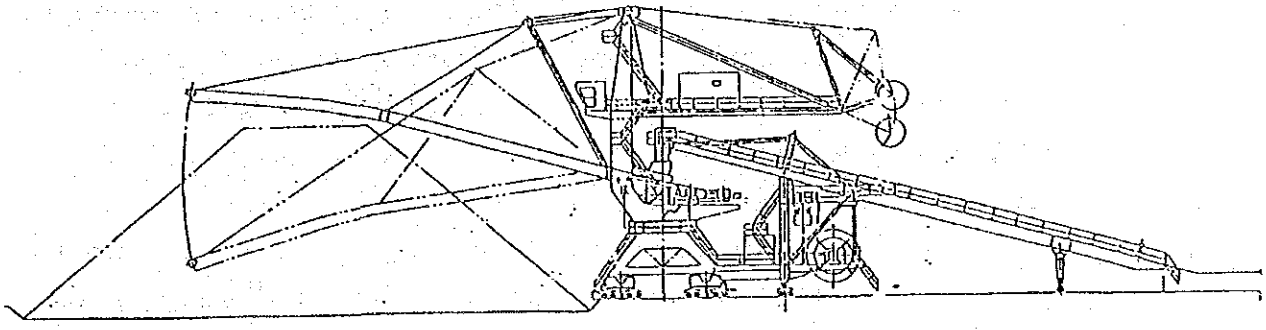


Fig. 7-6-16 Stacker

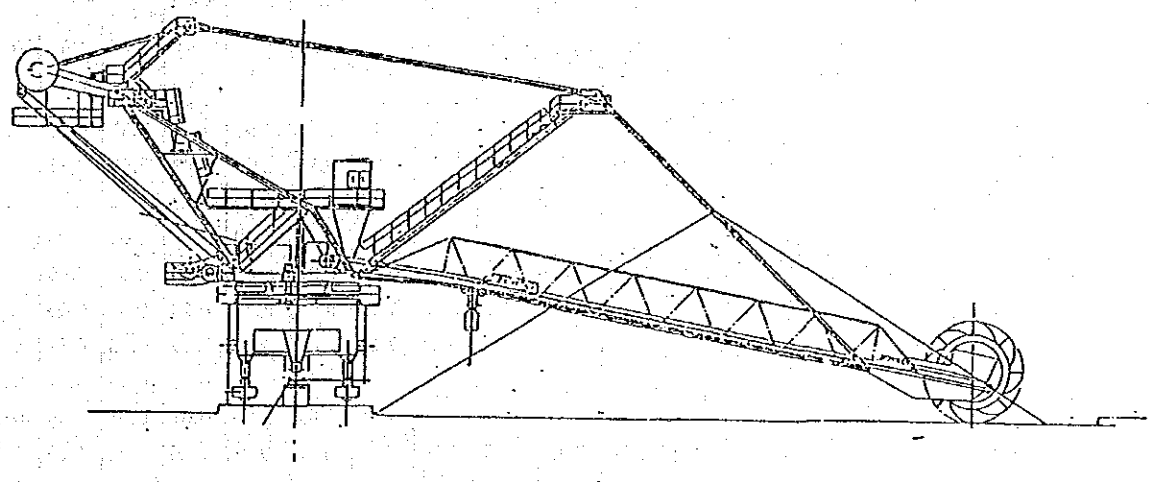


Fig. 7-6-17 Reclaimer

6-3. Gas based DR plant

6-3-1. Basic idea

In the world, many types of direct reduction process were invented and used in production of direct reduced iron (DRI) or sponge iron. But among them, the gas based shaft furnace type is most popular and produces more than 90% of DRI produced in the world.

In Indonesia also, the gas based shaft furnace type DR plant which is technically established and easy in operation and quality control is considered though there is a problem of deterioration of availability of natural gas in Cilegon area in particular of the two proposed sites in Cilegon and Arun.

Table 7-6-12 Direct Reduced Iron Production by Process

(Unit: Million tons)

Process \ Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Midrex	0.06	0.13	0.44	0.77	1.11	1.11	0.95	1.35	2.12	3.77	3.97	4.25	3.87	4.08	4.94
HYL I	0.62	0.67	0.78	0.75	1.03	1.09	1.35	1.66	1.96	2.12	2.33	2.48	2.52	2.71	2.86
HYL III											0.10	0.27	0.18	0.33	0.39
NSC								0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Purofer	0.03	0.03	0.03	0.04	0.06	0.06	0.07	0.10	0.23	0.02	0.00	0.00	0.00	0.00	0.00
Armco				0.13	0.23	0.20	0.17	0.10	0.12	0.21	0.21	0.24	0.07	0.00	0.00
Fior							0.02	0.08	0.12	0.20	0.22	0.23	0.23	0.32	0.33
Plasmared												0.01	0.03	0.02	0.02
K-M									0.01	0.01	0.00	0.01	0.01	0.00	0.01
SL/RN	0.02	0.03	0.05	0.07	0.10	0.15	0.19	0.14	0.14	0.08	0.23	0.26	0.27	0.25	0.45
DRC									0.01	0.01	0.01	0.01	0.00	0.03	0.08
Codir				0.03	0.06	0.07	0.09	0.00	0.08	0.01	0.02	0.12	0.10	0.05	0.08
Accar				0.01	0.01	0.01	0.06	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.05
Total	0.73	0.86	1.30	1.80	2.60	2.69	2.90	3.36	4.83	6.64	7.20	7.89	7.28	7.80	9.21
Cumulative	0.73	1.59	2.89	4.69	7.29	9.98	12.88	16.24	21.07	27.71	34.91	42.80	50.08	57.88	67.09
Gas Based	0.71	0.83	1.25	1.69	2.43	2.46	2.56	3.21	4.58	6.33	6.83	7.48	6.90	7.46	8.54
Coal Based	0.02	0.03	0.05	0.11	0.17	0.23	0.34	0.15	0.25	0.31	0.37	0.41	0.38	0.34	0.67

Besides, though there are several types of gas based shaft furnace type DR process, in the recent DRI production by process, Midrex process accounts for 54% and HYL I & III process 35%; namely about 90% of the total is accounted for by those processes as shown in Table 7-6-12.

Therefore, either of those process is to be selected for the new steel works for the second generation. The features of those processes may be given as follows:

1) Though it is said that HYL I and III type accounts for 35% of the total DRI production, 31% is accounted for by HYL I type. Recently because of its high unit consumption of natural gas and uneven product quality, the process began to be replaced by HYL III type which is an improvement of HYL I, and so HYL I type may be said an old process.

2) In the meantime, as shown in Table 7-6-13, since the first machine was installed in 1979, six units of HYL III type were built, but all are in Mexico and actual performance of the process is unknown in many points.

3) DR plants which began operation or are under construction since 1980 include 24 Midrex units, totalling 12 million t/y, and 11 HYL I units, totalling 6 million t/y, and 5 HYL III units, totalling 2.5 million t/y, and it seems Midrex process has the advantage.

As already mentioned, supply condition of natural gas in Indonesia, in Cilegon in particular, is not very favorable, and as one of measures, a plan began to replace existing 4 HYL I units of P.T. Krakatau Steel by other DR process.

Such being the case, it is unconceivable to adopt HYL I type in the new steel works and adoption of HYL III type with short history is risky in view of hard natural gas supply condition also.

Table 7-6-13 Direct Reduction Plants Producing Steelmaking-Grade DRI

(Installed or under construction as of June 1, 1985)

No.	START-UP	COMPANY	CITY	COUNTRY	PROCESS	UNITS	FUEL	CAPACITY (1,000 t/year)
1	1957	Hylsa	Monterrey	Mexico	HyL	1	Gas	95
2	1967	Tamsa	Vera Cruz	Mexico	HyL	1	Gas	235
3	1969	Hylsa	Puebla	Mexico	HyL	1	Gas	315
4	1970	NZS	Glenbrook	New Zealand	SL/RN	1	Coal	165
5	1971	HSW	Hamburg	W. Germany	Midrex	1	Gas	400
6	1971	GSC	Georgetown, SC	USA	Midrex	1	Gas	400
7	1973	Piratini	Charquedas	Brazil	SL/RN	1	Coal	65
8	1973	Dunswart	Benoni	S. Africa	Codir	1	Coal	150
9	1973	Sidbec	Contrecoeur	Canada	Midrex	1	Cas	400
10	1974	Usiba	Bahia	Brazil	HyL	1	Cas	250
11	1976	Sidor	Matanzas	Venezuela	HyL	1	Gas	360
12	1976	Siderca	Campana	Argentina	Midrex	1	Gas	330*
13	1976	Fior	Matanzas	Venezuela	Fior (HBI)	1	Gas	400
14	1977	NISCO	Ahwaz	Iran	Purofer	1	Gas	330
15	1977	Sidbec	Contrecoeur	Canada	Midrex	1	Gas	600
16	1977	Hylsa	Puebla	Mexico	HyL	1	Gas	630
17	1977	Sidor	Matanzas	Venezuela	Midrex	1	Gas	355
18	1978	Krakatau	Cilegon	Indonesia	HyL	1	Gas	575
19	1978	Acindar	Villa Const.	Argentina	Midrex	1	Gas	600
20	1978	Qasco	Umm Said	Qatar	Midrex	1	Gas	400
21	1979	BSC	Hunterston	UK	Midrex	2	Gas	800*
22	1979	Hylsa	Monterrey	Mexico	HyL III	1	Gas	250*
23	1979	Soidac	Khor Al-Zubair	Iraq	HyL	2	Gas	485*
24	1979	Sidor	Matanzas	Venezuela	Midrex	3	Gas	1275
25	1980	SIIL	Paloncha	India	SL/RN	1	Coal	30
26	1980	Siderperu	Chimbote	Peru	SL/RN	3	Coal	100
27	1980	Krakatau	Cilegon	Indonesia	HyL	1	Gas	575
28	1980	ISCOTT	Point Lisas	Trinidad	Midrex	1	Gas	420
29	1980	Sidor	Matanzas	Venezuela	HyL	2	Gas	1408
30	1981	Mining Corp.	Maymyo	Burma	K-M	1	Coal	20
31	1981	Nordferro	Emden	W. Germany	Midrex	2	Gas	880*
32	1981	Sidor	Matanzas	Venezuela	HyL	1	Gas	704
33	1982	Hadeed	Al Jubail	Saudi Arabia	Midrex	1	Gas	400
34	1982	Krakatau	Cilegon	Indonesia	HyL	2	Gas	1150
35	1982	DSC	Warri	Nigeria	Midrex	2	Gas	1020
36	1982	ISCOTT	Point Lisas	Trinidad	Midrex	1	Gas	420
37	1983	OEMK	Kursk	USSR	Midrex	1	Gas	417
38	1983	Scaw Metals	Germiston	S. Africa	DRC	1	Coal	75
39	1983	Hadeed	Al Jubail	Saudi Arabia	Midrex	1	Gas	400
40	1983	Hylsa	Monterrey	Mexico	HyL III	1	Gas	500
41	1983	OSIL	Keonjhar	India	Accar	1	Coal	150
42	1984	SGI	Labuan Island	Malaysia	Midrex (HBI)	1	Gas	650
43	1984	ISCOR	Vanderbijlpark	S. Africa	SL/RN	4	Coal	600
44	1984	Mining Corp.	Maymyo	Burma	K-M	1	Coal	20
45	1984	SIIL	Paloncha	India	SL/RN	1	Coal	30
46	1985	Sicartsa	Las Truchas	Mexico	HyL III	2	Gas	1000
47	1985	Perwaja	Chukai	Malaysia	NSC (HBI)	1	Gas	600
48	1985	Davsteel	Vanderbijlpark	S. Africa	Rot. Kiln	1	Coal	30
49	1985	NISCO	Ahwaz	Iran	Midrex	3	Gas	1200
50	1985	J&S Complex	Misurata	Libya	Midrex	2	Gas	1100
51	1985	OEMK	Kursk	USSR	Midrex	1	Gas	417
52	1985	USCO	Vereenging	S. Africa	Plasma	1	Coal Gas	250
53	1986	Sicartsa	Las Truchas	Mexico	HyL III	2	Gas	1000
54	1986	Ipitata	Joda	India	Tisco	1	Coal	90
55	1986	OEMK	Kursk	USSR	Midrex	1	Gas	417
56	1986	NISCO	Ahwaz	Iran	HyL	3	Gas	1000
57	1987	Soidac	Khor Al-Zubair	Iraq	HyL	2	Gas	1000
58	1987	NISCO	Mobarakeh	Iran	Midrex	2	Gas	1280
59	1987	ANSDK	El Dikheila	Egypt	Midrex	1	Gas	716
60	1987	OEMK	Kursk	USSR	Midrex	1	Gas	417
61	1988	NISCO	Mobarakeh	Iran	Midrex	3	Gas	1920

* Out of operation, (HBI)---Hot Briquetted Iron

Consequently, it was decided to consider Midrex process which is alreay technically established.

6-3-2. Premises for facilities plan

(1) DR furnace midrex 600 module 2 units

(2) Production 1,367,000 t/y

1) Production capacity 4,470 t/d
186 t/h

2) Working days 306 d/y
Working hours 7,344 h/y

3) Raw materials supplied
before screening 270 t/h
6,480 t/d
1,981,000 t/y

4) Fines under screen
(-3 mm) 69,000 t/y

5) Charges into DR
furnace 1,912,000 t/y

(3) Unit consumption of utilities

1) Electricity 120 kWh/t
2) Natural gas 2.6 Gcal/t
3) Industrial water 1.5 m^3/t
4) Nitrogen gas 0.5 Nm^3/t

(4) Raw materials

1) Blending ratio: Pellet 70% : Lump ore 30%

2) Composition

FeO	0.5%
Fe_2O_3	95.6%
Gangue	3.9%
Total Fe	67.25%

(5) DRI

1) Composition	Metallic Fe	84.9%
	FeO	8.3%
	Gangue	5.3%
	C	1.5%
2) Degree of metallization		93.0%
3) Total Fe		91.28%

6-3-3. Technical explanation

(1) Material flow (See Fig. 7-6-18 & Fig. 7-6-19)

Raw materials, namely pellet and sized lump ore, are to be transported by conveyor from the raw material yard to oxide day bins in DR plant. There are 6 bins with total capacity corresponding to about a day's consumption of raw material, ensuring stable supply of raw material to DR furnace.

Raw material discharged from the bins at specified blending ratio is screened to remove fines (-3 mm) and fed into the hopper at the top of shaft furnace. As DRI is continuously discharged from the furnace, the charge solids in the hopper descends by gravity and are fed into the furnace through vertical piping and heated and reduced by reaction with counterflowing high temperature reducing gas.

The vertical piping part is sealed by injection of high pressure inert gas to prevent escape of furnace gas to the atmosphere. This is applied also to the bottom of the furnace where DRI is discharged and as it is not mechanical seal, namely there is no movable part, the system is very simple.

Hot DRI reduced at the upper part, or reduction zone, of the furnace enters into the under part, or cooling zone, of the furnace where inert gas is circulated and cooled to near room temperature and discharged and sent to DRI storage bins.

The cooled DRI is stocked for about one week in the inert atmosphere, but during the time DRI is further cooled and aged to increase its resistance against re-oxidation, or to minimize any danger of spontaneous ignition during extended storage. DRI discharged from the storage bins is further screened and fed to EAF, and reduced fines are finally briquetted to make them a usable DRI product.

(2) Gas flow (See Fig. 7-6-20)

The top gas leaving DR furnace is cooled and scrubbed to remove dust particles and divided into that as fuel and process gas. About 70% of the gas is recompressed, enriched with natural gas, and preheated in the heat exchanger using sensible heat of waste gas and sent to the reformer. Blended gas of natural gas and process gas is reformed by catalytic reaction to reducing gas when it passes through tubes in the reformer.

The reforming in Midrex process is classified as CO_2 reforming and as it proceeds in a way close to stoichiometric reaction, concentration of reducing gas component ($CO+H_2$) is as high as 90-92% and the residual CO_2 and H_2O is low. Therefore, the gas after reforming can be fed as reducing gas into the shaft furnace with only slight temperature adjustment and removal of the residual H_2O as seen in H_2O reforming is unnecessary.

Reforming tubes are fixed to the roof of the reformer and any elongation of the tubes is absorbed downward through the bottom plate of the reformer, but expansion seals are installed between lower ends of individual tubes and the reformer to prevent infiltration of air.

As Midrex process is so designed that the major part of H_2 and CO in the top gas is recycled, the quantity of H_2 and CO generated by reforming is only a half of the requirements, which results in lower unit consumption