CHAPTER 7 COAL PREPARATION

7-1 Coal Quality

7-1-1 Raw Coal Quality

Coal quality of each seam in the investigated area was described in detail in the geological report in April, 1980. Therefore, the coal quality data in the whole investigated area are omitted from this report. And the data for a design of the preparation plant and the power plant are taken from the quality data in the mining area.

The mining area is divided into three, namely west open pit, east open pit and underground mine. There are four mineable seams for the west open pit area, the Nos. 5, 3, 2 and 1 in descending order, and three for the east open pit area, the Nos. 3, 2 and 1, and one for the underground area, the No. 1 seam and some partial production from the No. 3 seam.

Proximate analysis, total sulphur and calorific value of each seam in the mining areas are shown in Table 7-1, and ultimate analysis and other coal quality are shown in Table 7-2. All data in Table 7-1 are indicated on air dried basis.

Summarizing the above analytical data, proximate analysis, ultimate analysis and calorific value (d.a.f.), the Lakhra coal is classified into lignite with low coalfication and is evaluated for steaming coal as follows.

The Lakhra coal contains approximately 10 % of inherent moisture on air dried basis. Usually, this type of coal has 1 to 2 % higher moisture than this value on equilibrium moisture basis. Total moisture will be 25 to 30 % on as received basis, assuming from the PMDC geological report, 1976.

Assuming that the minimum desirable calorific value is 3,500 kcal/kg on air dried basis, the ash content of the coal fluctuates widely from about 10 to 40 %. The reason is considered that the volume of high specific gravity or high ash material varies widely in each raw coal sample, reviewing the results of the float and sink test. The fluctuation of the ash content or the calorific value will come into question for boiler use at the power station. Therefore, it will be necessary to uniform and reduce the ash content by blending or washing.

The total sulphur content is fairly high value of around 7 %. A ratio of the inorganic to the organic sulphur is 65 to 35 and the former is much more than the latter. About a half of the inorganic sulphur will be removed, but only about 30 % of the total sulphur content will be decreased from the raw coal by washing. This means about 5 % of the sulphur still remains in the clean coal. Therefore, a desulphurization process will be necessary at the power station.

Hardgrove grindability index is around 70, and nitrogen is 1.1 to 1.2 % of low content. The both figures are favourable for boiler use.

The ash fusion temperature is more than 1,300°C and the temperature is quite suitable for boiler use. But this temperature is a little lower than other common coal, because the Lakhra coal contains small amount of acid composition such as SiO_2 and Al_2O_3 and large amount of alkaline composition such as Fe_2O_3, CaO and MgO.

The electric resistance of ash is slightly high at 130°C, and it is a little over the maximum limit of 1×10^{13} Ohm-cm for the design of a electric dust collector.

7-1-2 Size Distribution

The drilling core samples from the investigated area were used for only quality analysis, and were not available for a screen analysis because of small amount of samples.

Since the size distribution of the Lakhra raw coal is necessary for the plant design, a bulk sample was taken from the National Mine No. 5 near the investigated area, and then the screen analysis, the float and sink test and the proximate analysis were carried out in Japan. (refer to attached annex). The above screen analysis data will be useful for the Lakhra coal in the mining area. The result of the screen analysis is as below:

Screen analysis

Size (mm)	Wt. (%)	Cum. Wt. (%)
+50	3.6	3.6
50 x 38	4.0	7.6
38 x 25	10.3	17.9
25 x 15	16.1	34.0
15 x 12	12.7	46.7
12 x 9	6.1	52.8
9 x 6	18.2	71.0
6 x 3	13.0	84.0
3 x 1	9.4	93.4
1 x 0.5	2.8	96.2
- 0.5	3.8	100.0

The top size of the actual plant feed coal, so called run-of-mine coal, will be 300 mm, and it is anticipated that the plant feed coal will have coarser fractions than the above size distribution.

For this reason, the hand picking and crushing system must have some allowance in capacity for the raw lump coal over 50 mm due to the size variation.

Therefore the size distribution to be applied to the plant design is estimated as follows:

Proposed size distribution

Size (mm)	Wt. (%)	Cum. Wt. (%)
300 x 50	10	10
50 x 12	40	50
12 x 0	50	100
Total	100	

The grain diagram to be applied to the Lakhra coal is shown in Fig. 7-1.

7-1-3 Float and Sink Test

In order to study the washability of the raw coal, 10 typical samples were taken from the investigated area, and the float and sink tests were carried out. The test results were described in the geological report. The samples were crushed into under 10 mm in size due to small amount of samples. Therefore, these washabilities are questionable in representing for the plant feed.

The ash content of the raw coal for the washability tests fluctuates widely. The reason is that the high specific gravity fractions, such as over 1.6, vary widely from 7 to 50 % in each raw coal smaple. The composite washability data of 10 samples is shown in Table 7-3 and its curves is in Fig. 7-2.

The raw coal is evaluated from the washability data: the coal contains relatively a small amount of good quality coal at the gravity fractions of less than 1.3, and it contains relatively a large amount of intermediate coal at the gravity fractions of 1.3 to 1.6.

Therefore when washing at a low specific gravity of less than 1.6, the washability is not so good, but while washing at 1.8, the near gravity material is improved to 7.5 % which makes a separation simple by a jig washing system.

Generally the Lakhra coal has high sulphur content, especially pyrite content is more than 50 % in the total sulphur.

According to the results of the separation test at 1.8 in specific gravity for the 7 typical raw coal samples, about 38 % of sulphur in average was removed from the raw coal.

However it is considered that the sulphur would be fairly removed from the coals, because these samples were crushed to less than 10 mm.

In the actual operation, the clean coal is supplied to the power plant at 50 x 0 mm in size in the feasibility report. Moreover according to the attached National Mine No. 5 analytical report, the rate of removal of sulphur content for the Lakhra coal ranges from 20 to 30 % at the specific gravity of 1.8, using the results of float and sink tests for the sulphur separation. Therefore desulphurization is not much anticipated by washing.

7-1-4 Relation Between Ash Content and Specific Gravity or Calorific Value

In general, there is close correlation between ash content and specific gravity, and the correlation for the Lakhra coal is shown in the following formula and is drawn in Fig. 7-3.

$$Y = 1.2506 + 0.01263\,X$$

Y: Specific gravity
X: Ash content %

However, at the specific gravity fractions of less than 1.4 for the Lakhra coal, the difference in ash content between fractions becomes very small and each fraction resembles very much, using the float and sink test.

There is also close correlation between ash content and calorific value. In the case of the Lakhra coal, the two kinds of correlation are separately shown in the following formulas and in Fig. 7-4.

One is for the coal portion of less than 40 % ash, the other is for the reject of more than 40 % ash.

A: $Y = 7353.8 - 86.42\ X$ (−40 % ash)
B: $Y = 6167.8 - 67.81\ X$ (+40 % ash)

Y: Calorific value kcal/kg
X: Ash content %

Since the Lakhra coal has much inherent moisture and changes widely, the above formulas are shown on dry basis.

7-2 Out of Seam Dilution

There is a slight difference in coal quality between the plant feed coal for actual operation and the drilling core sample, due to some amount of out-of-seam dilution by roof or floor rock during the mining operation. Therefore the rock dilution must be added to the raw coal to estimate the ash content and the washability for the design of the preparation plant.

An estimate of the rock dilution is 5% in the raw coal for the multi seams in the open pits, and 4% for the single seam in the underground mine. The ash content of the roof and floor rock, and the specific gravity of them are estimated to be 75 % and 2.2.

7-3 Basic Design

7-3-1 Ash Content of Plant Feed Coal

Adding the above mentioned rock dilution from roofs and floors – 5% from the open pits and 4 % from the underground mine – to the average ash content of raw coal from each mining area, the ash content of the plant feed coal becomes as follows;

	Open pit		
	West	East	Underground mine
Raw coal ash (%)	25.1	21.1	22.3 (without dilution)
Plant feed ash (%)	27.6	23.8	24.4 (with dilution)

7-3-2 Selection of Washing System

The unwashed Lakhra coal is available enough to the power station by simple treatment of it, but by washing only coarse coal (+12 mm), the ash content and calorific value of it may be fairly improved and stabilized. And this washing will contribute to save the expenses for transporting coal from the mine site to the power station as well as the expenses for disposal of ash from boiler and further may be able to reduce somewhat sulphur content.

However, the washing system regularly has many weak points such as high capital and operation costs, difficult to supply water and an increase of total moisture of the product, etc. At this mine, two preparation systems can be considered as follows;

(1) Unwashing System

Raw coal is screened at 50 mm in size, and wastes in oversize raw coal are removed by hand picking. Over 50 mm coal is crushed and sent to the power station together with under 50 mm coal.

(2) Washing System

Raw coal over 50 mm is processed in the same method as above. Then over 12 mm raw coal is washed by jig washer. Thus washed clean coal is used at the power station together with under 12 mm unwashed raw coal.

Taking the failing conditions into consideration, the unwashing system is adopted for this mine in our plan.

As for the washing system, it is outlined in the attached annex.

7-3-3 Quality of Unwashed Coal

Assuming that the amount of waste with 75 % ash content, which can be removed by hand picking, is 4 % of the total raw coal, the quality of unwashed products from each mining area is supposed to be as follows respectively.

(1) West open pit

		Air dried	As recieved
Moisture	(%)	8.2	25.0
Ash	(%)	25.6	20.9
Volatile matter	(%)	34.6	28.3
Total sulphur	(%)	7.5	6.1
Calorific value	(kcal/kg)	4,550	3,720
Yield	(%)	96.0	96.0

(2) East open pit

		Air dried	As received
Moisture	(%)	11.4	25.0
Ash	(%)	21.7	18.4
Volatile matter	(%)	34.5	29.2
Total sulphur	(%)	6.3	5.3
Calorific value	(kcal/kg)	4,740	4,010
Yield	(%)	96.0	96.0

(3) Underground mine

		Air dried	As received
Moisture	(%)	9.1	25.0
Ash	(%)	22.3	18.4
Volatile matter	(%)	35.0	28.9
Total sulphur	(%)	7.6	6.3
Calorific value	(kcal/kg)	4,730	3,900
Yield	(%)	96.0	96.0

(4) Whole areas

		Air dried	As received
Moisture	(%)	9.3	25.0
Ash	(%)	23.8	19.7
Volatile matter	(%)	34.7	28.7
Total sulphur	(%)	7.2	5.9
Calorific value	(kcal/kg)	4,640	3,840
Yield	(%)	96.0	96.0

Notes: The coal quality from the whole areas is composed of at the following production ratio.

	Production ratio (%)
West open pit	50
East open pit	30
Underground mine	20
Total	100

7-4 Design Criteria

7-4-1 Annual Production Scale

Raw coal production

West open pit	525,000 TPY (air dried)
East open pit	315,000 TPY (")
Underground mine	210,000 TPY (")
Total	1,050,000 TPY (")
Clean coal production	1,000,000 TPY (")
Clean coal production	1,200,000 TPY (as received)

7-4-2 Plant Operating Schedule

Operating days per year is 300 days, based on following schedule:

2 shifts/day, 6 days/week

Plant availability	80 %
Plant yield	96 %

7-4-3 Plant Capacity

$$\text{Hourly raw coal feed rate} = \frac{1{,}050{,}000}{300 \times 16 \times 0.8}$$
$$= 273.4 \text{ t/h (air dried)}$$

Assuming 20 % peak load raw coal production and 20 % moisture factor as received basis (T.M. 25 %)

Plant capacity = 273.4 x 1.2 x 1.2
= 400 t/h (as received)
Max. raw coal capacity = 400 x 16 x 0.8 x 300
= 1,536,000 t/year (as received)

7-5 Flowsheet Criteria

A 300 mm grizzly is set on the raw coal dump hopper to restrict the maximum grain size of coal to be fed to the preparation plant within 300 mm. Lump coal in oversize materials is crushed by a hammer with electric hoist and other big wastes are taken out by a grab bucket.

The plant feed coal is screened at 50 mm in size and wastes in 50 mm oversize raw coal are removed by hand packing. It is estimated that the amount of hand picking raw coal is 10 % of the total plant feed raw coal and the amount of removed wastes is 40 % of the hand picking raw coal. The remained 60 % of the lump coal is crushed under 50 mm in size and used at the power plant together with under 50 mm screened coal.

Hand picking capacity	400 t/h x 0.1 = 40 t/h
Waste removed by hand picking	40 t/h x 0.4 = 16 t/h
Clean coal crushing capacity	40 t/h x 0.6 = 24 t/h

Assuming that 5 tonnes per man per shift of wastes can be removed by hand picking:

Required hand pickers	$\frac{16 \times 8 \times 0.8}{5} = 20$ men/shift
Unwashed clean coal	400 t/h x 0.96 = 384 t/h

7-6 Flowsheet

Fig. 7-5 is a flowsheet of the unwashing system. 80 % of raw coal to be fed to the preparation plant comes from the open pits and is discharged into a 100 tonne hopper. A 300 mm opening grizzly is set on the dump hopper. Oversize coal is crushed and wastes are removed. Raw coal in the hopper is drawn out from the bottom of the hopper by a vibrating feeder at a rate of 400 t/h and stored in a raw coal bin through a raw coal belt conveyor.

Raw coal from the underground mine is hauled by mine cars through the inclined shaft and discharged with a tippler and then stored in the above mentioned raw coal bin through another raw coal belt conveyor. Those raw coal belt conveyors have a belt scale respectively to measure the quantity of raw coal output from each mining area. The capacity of raw coal bin is 1,500 tonnes equivalent to above 4 hour raw coal output.

Raw coal drawn out from the bottom of raw coal bin by vibrating feeders is fed to the raw coal screen through the plant feed conveyor to be screened at 50 mm in size. In order to reclaim tramp iron, magnet catcher is set at the top of the plant feed conveyor. The hand picking plant is designed to process 400 tonnes of raw coal per hour.

Over 50 mm raw coal is conveyed onto the hand picking belt conveyor and over 50 mm waste is picked out there by about 20 workers per shift. Thus picked out waste is sent to a 60 tonne rock bin through No. 1 and No. 2 rock belt conveyors and finally dumped out to a waste yard by a dump truck.

Over 50 mm coal on the hand picking belt conveyor is crushed to under 50 mm by a single roll crusher and stored in 2 clean coal silos together with coal under the 50 mm raw coal screen. The capacity of those silos is 4,000 tonnes equivalent to the clean coal output of 2 shifts per day.

A 20,000 tonnes outside stockpile is prepared to store about 5 days clean coal output for emergency use.

Clean coal from silos is loaded into freight cars through a loading hopper and is transported to the power plant after measuring by a track scale.

7-7 Plant Facilities

The proposed plant will produce one million tonnes per year on air dried basis of unwashed clean coal which will be used at Lakhra power station. The plant will operate two shifts per day, 300 days per year, with a nominal 400 tonnes per hour as received. The scope of the coal preparation facilities is from raw coal receiving dump hopper to clean coal loading hopper and the main process is a simple system with removing over 50 mm reject by the use of hand picking. Since the specification of the main equipment is indicated in the attached specification table, only outline of the equipment will be described.

7-7-1 Site Work

The clearing of all vegetation from necessary areas in general plant site and general excavation, backfilling and drainage of the plant site will be provided. Plant roads to provide access to various structures and haulage roads to truck dump for raw coal and reject transportation will be constructed. A proper soil investigation including classifications and allowable bearing values will be made for the purpose of foundation design. A survey of the plant site establishing buildings, conveyor center-lines, and service and haulage roads will be provided.

7-7-2 Raw Coal Receiving and Storage

These equipment mainly consist of a 100 tonne dump hopper and a 1,500 tonne raw coal bin, and over 300 mm lump coal and rock will be treated in this section. A ventilation system and leakage water treatment with pumping will be provided under the dump hopper.

7-7-3 Raw Coal Treatment

This section mainly consists of a raw coal screen, picking belt conveyor, crusher and reject bin.

An electro-magnet with a trolley operating by timer for the removal of tramp iron will be provided on the top of plant feed conveyor.

7-7-4 Clean Coal Storage and Loading

These equipment consist of two 2,000 tonne clean coal silos, a 20,000 tonne emergency stockpile, reclaiming equipment of coal, a 110 tonne loading hopper and a railway track scale system. A ventilation system and leakage water treatment with pumping will be provided in the tunnel of the clean coal reclaiming equipment.

7-7-5 Service Hoists

Two 3 tonne, 15 m lift, electric trolley hoists will be provided in the suitable places for repair and maintenance of equipment.

7-7-6 Weighers

The following weighers which will be capable of measuring and recording remotely at the control room will be provided in the plant.

(1) Belt scale

	Q'ty.
Raw coal conveyor	1
Plant feed conveyor	1
Clean coal conveyor	1
Clean coal loading conveyor	1
Reject conveyor	1

(2) Railway track scale 1

7-7-7 Foundations

A soil investigation for foundation design will be carried out. For estimating purposes the allowable soil bearing pressure of 25,000 kg/m^2 was used. A 150 mm layer of well-compacted crushed stone will be placed under all slabs. Foundations will be designed using concrete with a minimum compressive strength of 210 kg/cm^2 at 28 days. Proper amount of Portland cement and water to give 5 to 18 cm slump will be used. All reinforced concrete structures will be designed in accordance with the design criteria of Japan Society of Civil Engineers. Deformed bars conforming the Standard 34 to 35 will be used.

7-7-8 Structure

(1) Reinforced concrete structure

Raw coal dump hopper, raw coal bin, clean coal silos

(2) Steel structure

Reject bin, clean coal loading hopper

(3) Housing

Raw coal receiving, picking room including screen and crusher, electrical room, track scale

(4) Specification of housing

a) Structure: Steel structure
b) Exterior: Slate
c) Interior: Flexible board
d) Doors and windows: Steel

7-7-9 Electrical Equipment

Power will be supplied with 3 kV, 3 phase and 50 Hz to the coal preparation plant from the mine substation and the following complete set of electrical equipment will be provided at the plant.

(1) Motors — Enclosed, forced cooling type induction motor
Total motor horse power: 461.45 kW

(2) Power supply equipment

	Q'ty.
a) Incoming switchgear	1
b) Control desk	1
c) Transformer secondary switchgear	1
d) H/T volt switchgears	1 lot
e) Voltage system	
Motor	3 kV x 50 Hz x 3ϕ for over 55 kW
	400 V x 50 Hz x 3ϕ up to 54 kW
Control	240 V x 50 Hz x 1ϕ
Lighting	240 V x 50 Hz x 1ϕ
Instrumentation	100 V x 50 Hz x 1ϕ

(3) Control equipment

	Q'ty.
a) Control centre	1
b) Control desk	1
c) Illuminated mimic panel	1
d) Control relay cubicle	1
e) Site operating switches	1 lot

(4) Instrumentation

a) Coal bin sounding devices	1 lot
b) Belt scales	1 lot
c) Track scale	1

(5) Lighting equipment

a)	Mercury-arc lamps	1 lot
b)	Fluorescent lamps	1 lot
c)	Lighting switch boards	1 lot
d)	Others	1 lot

(6) Comminication equipment

a)	Amplifier set	1
b)	Handy sets	1 lot
c)	Loud speeker sets	1 lot

(7) Wiring materials

a)	Power & control cables	1 lot
b)	Steel materials & conduits	1 lot
c)	Insulating & splicing meterials	1 lot
d)	Other materials	1 lot

7-7-10 Mobile Equipment

A 24 tonne dump truck and a 12 tonne bulldozer will be provided for reject dump and outside coal storage.

7-7-11 Laboratory Equipment

The following basic equipment will be provided in the coal laboratory together with the required auxiliary equipment:

		Q'ty
(1)	Modified acme dryer, type 1	1
(2)	Muffle furnace	1
(3)	Total sulphur measurement device	1
(4)	New Model Nenken type adiabatic calorimeter	1
(5)	Riffle sampler	1
(6)	Jaw crusher, No. 1023-4	1
(7)	Horizontal Type Brown crusher	1
(8)	Standard testing sieve shaker	1
(9)	Standard sieves, stainless steel	15
(10)	Digital balance, NL-200 TP	1

7-7-12 Miscellaneous

The required spare parts for 5 years will be provided for the plant operation. Several fireplugs and drinking water will be arranged at suitable places in the plant site. These cost estimate are included in the section of the surface facilities.

7-7-13 Equipment Maintenance

The maintenance of the mechanical, electrical and mobile equipment will be entrusted to the each repair shop at the surface. The maintenance costs for both of spare parts and repair are included in the operating cost of the coal preparation plant, and an estimate of the yearly repair cost is 2 % of the capital cost for the mechanical and electrical equipment, and 6 % for the mobile equipment.

7-8 Construction Schedule (see figure on next page)

7-9 Consideration for Spontaneous Combustion

7-9-1 Introduction

Coal stockpiled absorbs generally some oxygen in the atmosphere, and the temperature inside the stockpile rises due to the generated heat during oxidation, and the rate of oxidation of coal is gradually accelerated and spontaneous combustion occurs finally.

The generating factors of the spontaneous combustion can be divided mainly into the following two classes. One is physical factors regarding the environment and another is chemical factors based on the coal quality.

Physical factors:

- Existence of required air
- Condition of particle size of coal at stockpile
- Condition of moisture
- Period, volume and shape of storage
- Ambient atmospheric temperature
- Weather condition

Chemical factors:

- Composition of coal (proximate analysis and ultimate analysis, etc.)
- Characteristics of coal (oxygen absorption capacity, relative ignition temperature, rate of temperature rise and thermal conductivity, etc.)
- Content of vitrinite, exinite and pyrite.

Spontaneous combustion may actually occur by combination of above-mentioned both factors. In general, low rank coal of coalification such as lignite is much liable to spontaneous combustion, especially at the coal quality point of view.

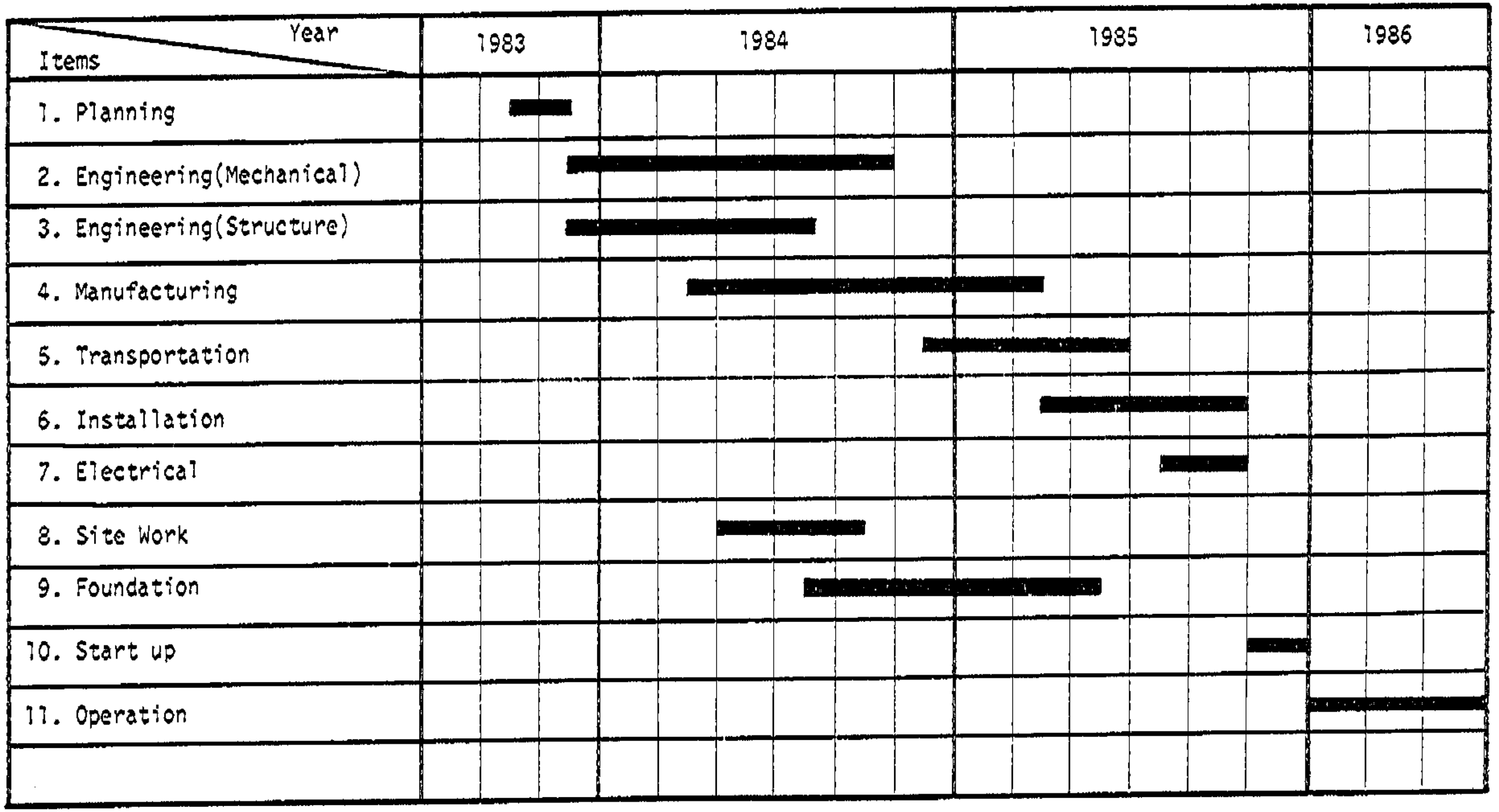
Therefore necessary countermeasures for the spontaneous combustion should be taken on each aspect of mining, handling, storage and transportation systems respectively.

7-9-2 Several Factors for Spontaneous Combustion

(1) Moisture

The true effect of moisture for the dried coal is obscured, while many reports have been published. A temperature rise of various coals due to the heat of wetting of coal is the more,

CONSTRUCTION SCHEDULE



the lower the rank coal of coalification. It has been recognized that around 10 % moisture content in coal is highly liable to oxygen absorption and is dangerous for spontaneous combustion.

The high inherent moisture content in coal is liable to oxidation, while the high surface moisture content in coal is not liable to oxidation. On the other hand, the high inherent moisture content in coal generates the distortion between surface and inside of coal by a change of humidity to pulverize and collapse.

(2) Rank of Coalification

Lignite in general is highly susceptible to spontaneous combustion, sub-bituminous next, bituminous according to the rank of coalification, and it may hardly occur in case of anthracite. It has been recognized that there is a strong relation between spontaneous combustion and coalification or oxygen content, the spontaneous combustibility is high for the low rank coal of coalification and the high oxygen content coal.

(3) Oxygen Absorption Capacity

Winmill suggested that the oxygen absorption capacity of a coal could be related to its relative liability to spontaneous combustion. In general, a coal absorbs 5 – 10 times oxygen of its volume under a normal temperature. The oxygen absorption capacity is so much for the low rank coal of coalification and for example it is reported that a lignite absorbs 10 – 15 cc oxygen per 1 gram coal and a bituminous coal absorbs 7 – 8 cc per 1 gram coal.

In general, the calorific value to be generated by the oxygen absorption is 2.1 – 3.3 calories per 1 cc oxygen (O_2). For example, if the coal of 1 gram absorbs the oxygen of 10 cc under a normal temperature, the heating value becomes 21 – 33 calories.

If this heat is accumulated inside the coal without any radiation to the outside and a specific heat of a coal is 0.25, the temperature of coal rises by following figures.

$$(21 - 23\ \text{cal}) / 0.25 = 84 - 132°\text{C}$$

Accordingly, the oxidation of coal is highly accelerated due to this temperature rise, and then a spontaneous combustion will occur finally.

(4) Particle Size

The size of coal particles as well as temperature is one of main factor which influences largely to the oxidation reaction of the coal. The oxidation rate of coal increases as an osculating plane or specific surface area become larger.

Accordingly, the coal which is easily degraded has a strong tendency of the spontaneous combustion.

(5) Ferrous Sulphide

Ferrous sulphide is classified into pyrite and marcasite, and both molecular formular are the same as FeS_2, and the later is liable to the oxidation. The oxidation for ferrous sulfide required some water and the reaction formula is as follows;

$$2\ FeS_2 + 7\ O_2 + 2\ H_2O = 2\ H_2SO_4 + 2\ FeSO_4$$

In this case, the generated heat is 4.3 calories per 1 cc of absorbed oxygen and it is equivalent to two times of the oxygen absorption rate of coal. Therefore, in case a large amount of the ferrous sulphide is contained in the coal, possibility for the spontaneous combustion will be quite high.

(6) Relative Ignition Temperature

The relative ignition temperature is commonly measured as the testing method for the oxidation or spontaneous combustion of coal. There is a considerable correlation between the relative ignition temperature and carbon or oxygen content, that is, its temperature is low for the low rank coal of coalification.

7-9-3 Spontaneous Combustibility Tests for Lakhra Coal

(1) Sample Preparation

In order to test the spontaneous combustibility of Lakhra coal, the core sample was prepared by blending 10 samples which has been used to the float and sink test.

The sample for the spontaneous combustion test with exception of proximate and ultimate analysis sample, was pulverized less than 0.5 mm in size. The test temperature of sample is set up at 60°C for both oxygen absorption capacity and vacuum flask tests, and at 30°C fot the thermal conductivity test.

(2) Test and Analysis Items

Proximate analysis	
Ultimate analysis	
Measurement of heating value	(Fig. 7-6)
Measurement of relative ignition temperature	(Fig. 7-7)
Measurement of oxygen absorption capacity	(Fig. 7-8)
Measurement of thermal conductivity	(Fig. 7-9)
Temperature rise test using vacuum flask	(Fig. 7-10)

(3) Test Results

Proximate analysis (air dried)	
Inherent moisture	9.4 %
Ash content	19.9 %
Volatile matter	36.1 %
Fixed carbon	34.6 %
Calorific value	4,900 kcal/kg (air dried)
" "	6,930 kcal/kg (d.a.f.)
Total sulphur	6.98 %

Ultimate analysis (d.a.f.)

C	68.0 %
H	5.5 %
O	16.1 %
N	1.2 %
S	9.2 %

The test results of spontaneous combustion

No.	Sample	Size (mm)	Moisture (%)	O_2 Absorption (K value)	CO_2 (%)	Temperature rise (°C)
1.	Lakhra coal (Pakistan)	−0.5	9.2	1.210	1.34	14.6
2.	K coal (Indonesia)	−0.5	7.4	0.930	1.33	8.6
3.	W coal (Australia)	−0.5	8.0	1.015	1.08	8.0

No.	Sample	Temperature (°C)		Heater		Thermal conductivity (kcal/m.h.°C)	Relative ignition temp. (°C)
		T_1	T_2	Volt (V)	Amp (A)		
1.	Lakhra	39.5	30.1	4.67	0.182	0.1310	172.3
2.	K coal	53.0	33.4	4.90	0.201	0.0725	195
3.	W coal	41.8	32.0	4.90	0.180	0.1300	–

(4) Consideration for Test Results

Proximate analysis of the sample shows inherent moisture 9.4 %, volatile matter 36.1 % and calorific value 6,930 kcal/kg on dry basis, and also ultimate analysis indicates carbon 68 %, oxygen 16.1 % and total sulphur 6.98 % on dry ash free basis. On the basis of above analytical data, the Lakhra coal is classified into lignite with low coalification. Therefore this coal is easily oxidized and liable to spontaneous combustion based on the said quality. Besides, the pyrite in total sulphur is high ranging in content from 50 – 60 % described in the geological report, and its presence activates the spontaneous combustion.

As a result of the oxygen absorption test it has been determined that the K value, the absorption speed of this coal is 1.21 (O_2 generation 0.208 cc/gram/h). The K value is much higher than that of general sub-bituminous coals and it is considered that this coal is combustible spontaneously. The coal also gives 0.039 cc/gram/h CO_2 (1.34 %), but it is difficult to estimate the possibility of the spontaneous combustibility by the amount of CO_2 only.

As a result of vacuum flask test, it is noted that the temperature increased by 14.6°C at a condition of inherent moisture of 9.2 %. This shows higher temperature rise than other coals under the same condition, thus it has much possibility for spontaneous combustion. When inherent moisture is reduced from 9.2 % to 3 – 5 % by drying, the temperature of coal rises up to 25 – 30°C. Consequently the coal will be liable to combustion.

The thermal conductivity of the coal is 0.131 kcal/m.h.°C at 9.2 % of inherent moisture basis. It is generally considered that when coal has low thermal conductivity, the coal gives off only few heat from the latent heat and it becomes combustible finally. When the coal is dried to 3 – 5 % inherent moisture, its thermal conductivity decreases to more dangerous range of 0.07 – 0.09 kcal/m.h.°C.

The relative ignition temperature of this coal is low at 172.3°C. In general, there is a relation between relative ignition temperature and carbon or oxygen content, and the temperature is low for the coals low rank coal of coalification, but this can not be applied in all the cases, because it is sometimes impossible to judge the spontaneous combustibility only from the relative ignition temperature.

On the basis of above tests for spontaneous combustibility it has been proved that the Lakhra coal is liable to spontaneous combustion and therefore certain countermeasure which will be described later should be taken.

7-9-4 Progress for Spontaneous Combustion

Coal at a stockpile absorbs some oxygen under a normal temperature and then generates the heat. Although the heat is too small, the temperature of the coal rises when its heat is not radiated. The oxygen absorption of the coal activates due to the temperature rise, accordingly the temperature of the coal increases still more and then the spontaneous combustion occures finally. These progress can be classified into the following four stages.

(1) First stage: Normal temperature – 60°C

The action of oxidation progresses slowly and the temperature rises also slowly. Steam generation and perspiration phenomenon can be observed.

(2) Second stage: 70 – 200°C

The temperature rises rapidly and CO, CO_2 and some smell generate. The immediate measure and treatment for the coal are required.

(3) Third stage: 200 – 300°C

The temperature rises suddenly and the coal resolves a little and the rate of gas generation also increase.

(4) Fourth stage: 300 – 500°C

The coal catches fire and generates a large quantity of smoke and various gases.

7-9-5 Countermeasures for Spontaneous Combustion

It is not recommendable that a large amount of raw coal such as lignite are stored at the stockpile for a long period before treatment at a coal preparation plant. The followings are the main countermeasures for spontaneous combustion of the Lakhra lignite.

(1) Underground

Main entries and gate entries should be equipped with suitable fire doors to isolate from any section of the mine as and when required. The goaf area should be sealed completely with suitable materials to prevent air leakage and to isolate from the working area. It is also necessary that even a small amount of coal is not left in the goaf area.

Normally, the carbon monoxide produced due to ambient temperature oxidation of coal is steady at a particular level commonly known as standard for the mine. Thus by studying the changes in the level of carbon monoxide concentration, it will be possible to predict the onset of heating at an early stage. Recently in western countries and Japan, "Tube Bundle" system has been adopted in some underground mine to detect CO generation which is automatically and continuously recorded at the surface from several working areas.

It is also possible to detect remotely the coal temperature by using infra-red thermometer. The infra-red thermometer would be a powerful tool in early detection of heating, and the method will be invaluable for determining hidden oxidation or fire before it spreads extensively.

(2) Open Pit

Best countermeasure for spontaneous combustion at open pit is that the coal seam should not be disturbed when the overburden is stripped. In this condition, no air can enter into the coal seam and thus the oxidation could be avoided. However, coal could be supplied to a power station any time using coal excavating machines.

(3) Surface Storage

It is most important that a suitable method should be selected. Either by preventing the air passage or by keeping the piles lower in size, the heat accumulation can be protected.

Followings are recommendable for the Lakhra coal.

a) The period of coal storage may not be more than a week.

b) In case of natural storage, a suitable height for stockpile will be less than 1.5 meters.

c) In case of packed storage by bulldozer, the height of stockpile may be under 3 meters.

d) The temperature of the inside of storage should be measured at regular intervals.

e) If the temperature is over 60 to 70°C, the coal should be moved rapidly to another suitable place.

f) The stockpile should be selected carefully following problems such as ground condition, inclination, drainage, mixing of other materials, surrounding equipment and influence of weather, etc. are to be considered.

(4) Compacted Stockpilling Methods

A practical method for stockpilling of the Lakhra lignite is that the crushed coal is piled and compacted by a bulldozer or loaded truck to isolate the external air into the pile to prevent oxidation.

By introducing this method, large quantity of the Lakhra coal can be stocked for longer periods. Two practical methods can be recommended for compacting the coal. One is to compact the stockpile only by bulldozer, and the other is to compact with a combination of bulldozer and loaded truck. The former is more economical than the latter, but inferior to the latter in compacting efficiency, therefore the latter is better for a longer period of stockpile. In this method, a stockpile should be built by unloading the coal closely to the surface of the pile, and then the stockpile is stamped down and compacted by weight of truck or other suitable equipment to make the surface flat.

In order to build and keep a safe stockpile, the stockpile must be compacted at every layer of piles, and the height of each layer should be kept at 40 – 50 cm, especially during hot summer months or for stockpilling the coal of which quality is much liable to spontaneous combustion such as Lakhra coal. The 2nd layer onwards, the stockpile will be compacted by that the truck pass evenly around the surface of the stockpile. The truck weighs 12 tonnes which is the same as that of a bulldozer. Ramp roads for truck should be altered at every layer to extend compacting areas and to improve the efficiency. The slanting surface of stockpile will be compacted by descending empty truck if the height of stockpile becomes higher than 7 m. In some cases, the level portion will be compacted by truck while the slanting portion will be compacted by bulldozer, after selecting certain routes for trucking.

For the compacting efficiency, the bulk density of coal will be increased from 0.8 – 0.9 to 1.1 – 1.2 and the volume of coal will decreased by 25 to 40 % as compared with natural stockpile.

In Miike Colliery in Japan, several stockpiles of a 0.5 million tonne class stockpile were built at a height of 15 m several years ago, applying the above mentioned compacting methods, and more than 2 million tonnes had been stocked for several years without any problems

In case of the natural stockpile, the temperature of stockpile reached to the dangerous temperature of 60°C in about 6 months. Whereas, in case of the perfect compacted stockpile, no temperature had been noted even after two years, and kept 20 to 30 degrees centigrade which had been lower than the air temperature.

TABLE 7-1 PROXIMATE ANALYSIS

Seam	West Open Pit No.5	No.3	No.2	No.1	Average
Thickness (m)	0.96	1.20	1.53	2.91	1.65
S.G.	1.546	1.544	1.543	1.572	1.566
I.M. (%)	8.8	8.2	8.6	7.9	8.2
Ash (%)	23.8	25.2	24.5	25.7	25.1
V.M. (%)	33.8	36.1	35.2	34.5	34.8
F.C. (%)	33.6	30.5	31.7	31.9	31.9
T.S. (%)	7.33	6.68	6.53	8.14	7.51
Cal. Val.(Kcal/kg)	4,713	4,561	4,566	4,579	4,592

Seam	East Open Pit No.3	No.2 & 1	Average
Thickness (m)	2.13	2.61	2.37
S.G.	1.447	1.526	1.491
I.M. (%)	12.3	10.7	11.4
Ash (%)	17.1	24.2	21.1
V.M. (%)	35.6	34.0	34.7
F.C. (%)	35.0	31.1	32.8
T.S. (%)	5.87	5.59	6.28
Cal. Val. (Kcal/kg)	5,090	4,565	4,794

Seam	Underground Mine No.3	No.1	Average
Thickness (m)	1.07	1.71	1.66
S.G.	1.435	1.538	1.530
I.M. (%)	10.0	9.0	9.1
Ash (%)	13.7	23.1	22.3
V.M. (%)	36.6	34.9	35.0
F.C. (%)	39.7	33.0	33.6
T.S. (%)	6.64	7.74	7.65
Cal. Val. (Kcal/kg)	5,217	4,688	4,730

TABLE 7-2 ULTIMATE ANALYSIS & OTHER QUALITY

		Open Pit		Underground	Whole Area
		West	East	No.1	(5 : 3 : 2)
Non-combus.	S %	0.61	0.47	0.47	0.54
Combustion	S %	7.21	5.17	6.93	6.54
Inorganic	S				
Sulfate	S %	1.25	0.62	0.81	0.97
Pyrite	S %	4.31	3.26	3.29	3.79
Organic	S %	2.16	2.39	3.31	2.46
H. G. I.		72	73	69	72
Ultimate Analysis					
C	%	63.5	68.0	65.3	65.2
H	%	5.1	5.3	5.4	5.2
O	%	18.9	16.7	17.8	18.0
N	%	1.1	1.2	1.1	1.1
S	%	11.4	8.8	10.4	10.5
Ash Fusion Temp.					
Deformation	°C	1315	1315	1300	1310
Hemisphere	°C	1380	1370	1390	1380
Flow	°C	1410	1400	1410	1410
Ash Composition					
SiO_2	%	31.40	33.79	34.31	32.70
Al_2O_3	%	18.52	22.48	20.89	20.18
Fe_2O_3	%	32.44	26.84	29.81	30.23
CaO	%	4.74	4.53	4.11	4.55
MgO	%	2.33	2.62	1.66	2.28
Na_2O	%	1.34	1.19	0.75	1.18
K_2O	%	0.63	0.61	0.59	0.62
SO_3	%	6.42	6.30	5.65	6.23
Ash Resistivity					
100°C	10^{13} ohm-cm	4.5	1.2	1.4	2.9
130°C	10^{13} ohm-cm	5	1.9	2.1	3.5
160°C	10^{13} ohm-cm	3.3	1.5	1.9	2.5
Specific Gravity		1.56	1.49	1.54	1.54

RRB'S GRAIN DIAGRAM

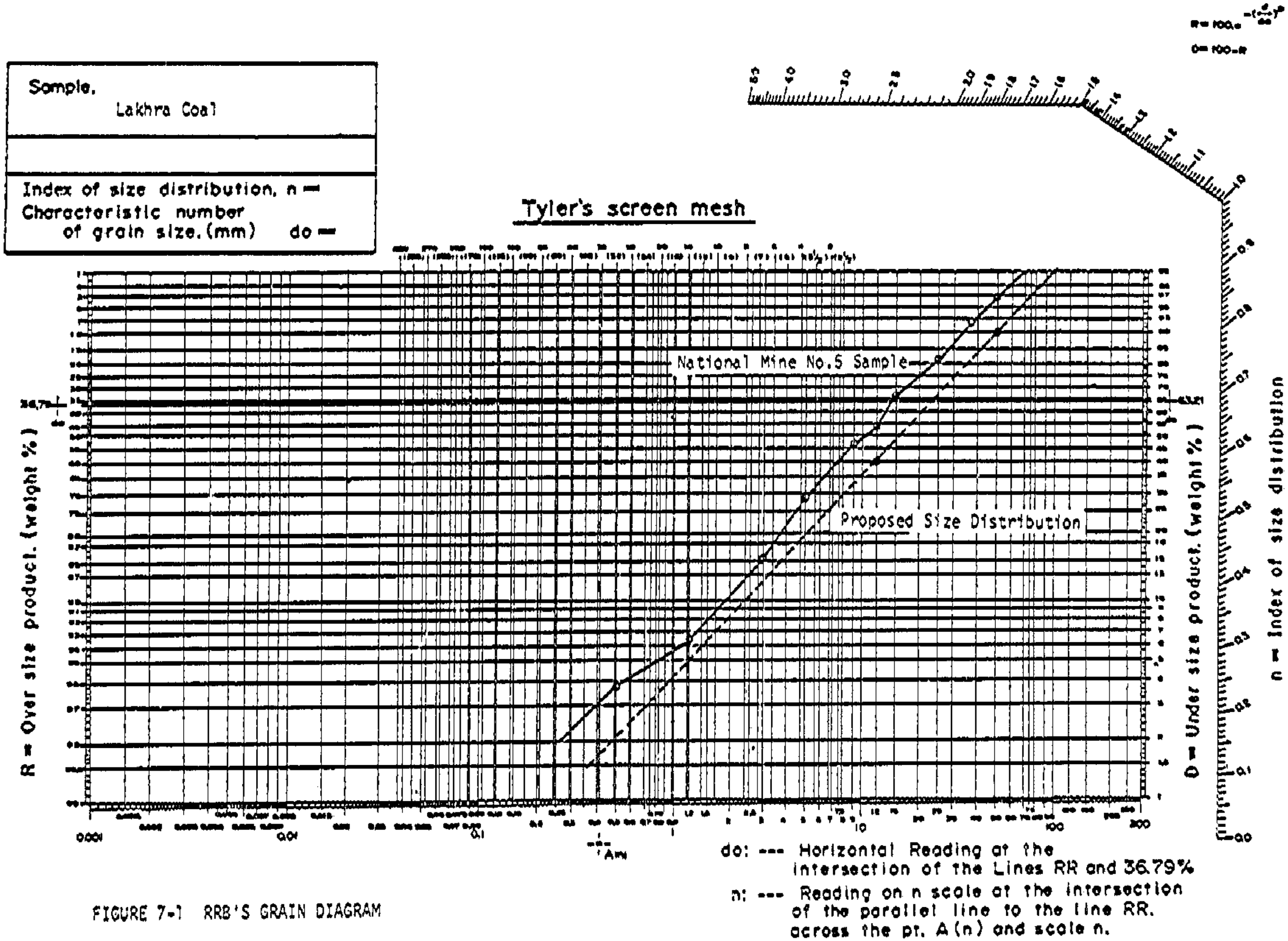


FIGURE 7-1 RRB'S GRAIN DIAGRAM

TABLE 7-3
FLOAT AND SINK TEST

SAMPLE: LAKHRA COAL EXPLORATION DRILL HOLE
10 HOLES COMPOSITE

DATE: 1979

SIZE: -10MM

Specific gravity	a		b	c	d	e	f	g	h	i	j
	Weight (%)	Ash (%)	$\Sigma W_{n-1} + \frac{W_n}{2}$	W·A	ΣW·A	ΣW	$\frac{\Sigma W \cdot A}{\Sigma W}$	Total W·A -ΣW·A	100 -ΣW·A	$\frac{g}{h}$	±0.1 SG
- 1.30	11.93	5.42	5.97	64.66	64.66	11.93	5.42	1.904.37	88.07	21.62	
1.30 ~ 1.35	9.09	5.77	16.47	52.45	117.11	21.02	5.57	1.851.92	78.98	23.45	
1.35 ~ 1.40	23.07	6.55	32.55	151.11	268.22	44.09	6.08	1.700.82	55.91	30.42	53.94
1.40 ~ 1.50	21.78	11.67	54.98	254.17	522.39	65.87	7.93	1.446.64	34.13	42.39	29.14
1.50 ~ 1.60	7.36	20.12	69.55	148.08	670.47	73.23	9.16	1.298.56	26.77	48.51	12.28
1.60 ~ 1.70	4.92	31.72	75.69	156.06	826.54	78.15	10.58	1.142.50	21.85	52.29	8.97
1.70 ~ 1.80	4.05	39.25	80.17	158.96	985.50	82.20	11.99	983.54	17.80	55.25	7.46
1.80 ~ 1.90	3.41	43.95	83.90	149.87	1.135.37	85.61	13.26	833.67	14.39	57.93	6.41
1.90 ~ 2.00	3.00	51.38	87.11	154.14	1.289.51	88.61	14.55	679.53	11.39	59.66	
2.00 ~ +	11.39	59.66	94.30	679.53	1.969.03	100.00	19.69	.00	.00	.00	
~											
~											
~											
-											

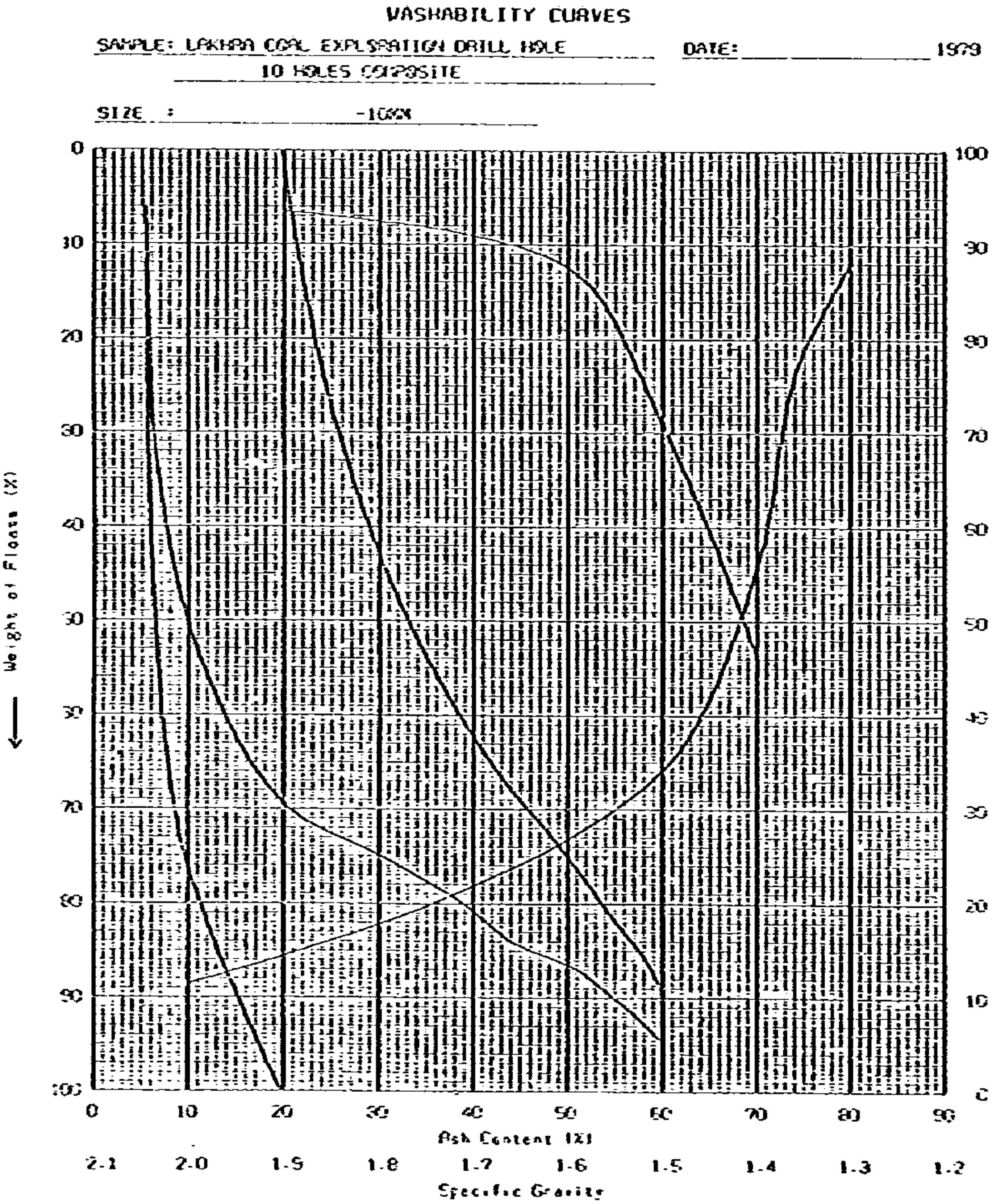


FIGURE 7-2 WASHABILITY CURVES

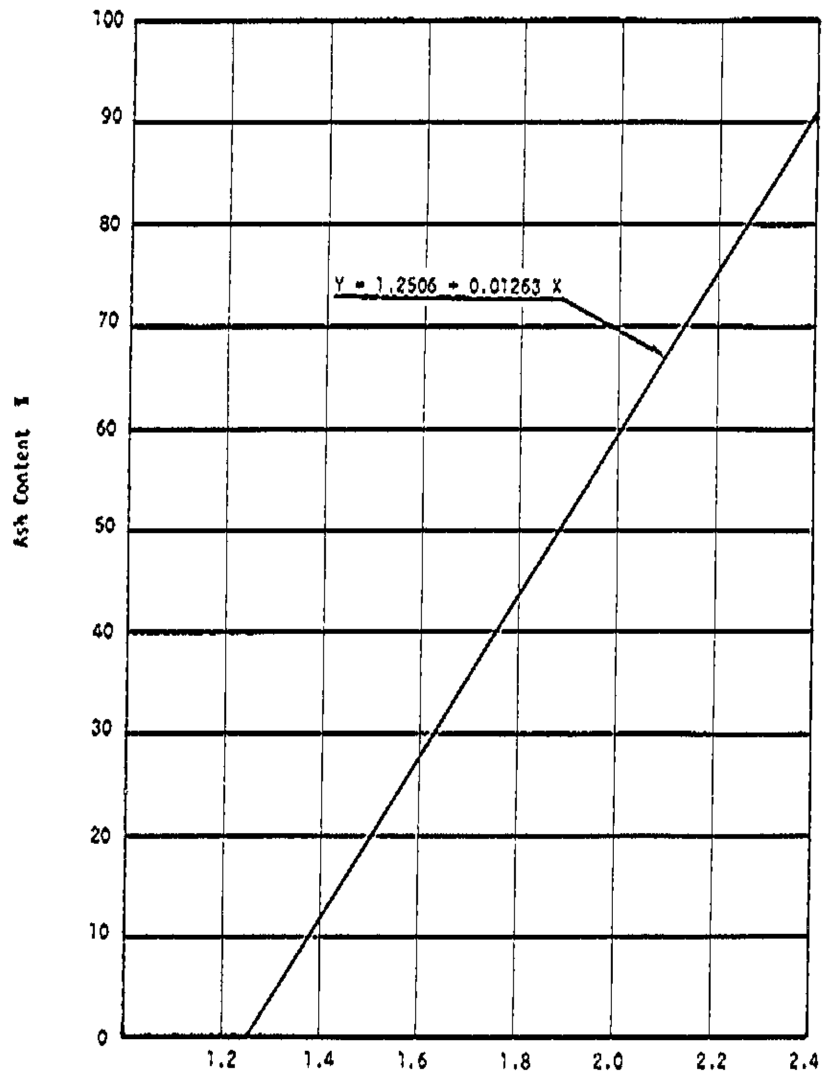


FIGURE 7-3 RELATION BETWEEN ASH CONTENT AND SPECIFIC GRAVITY

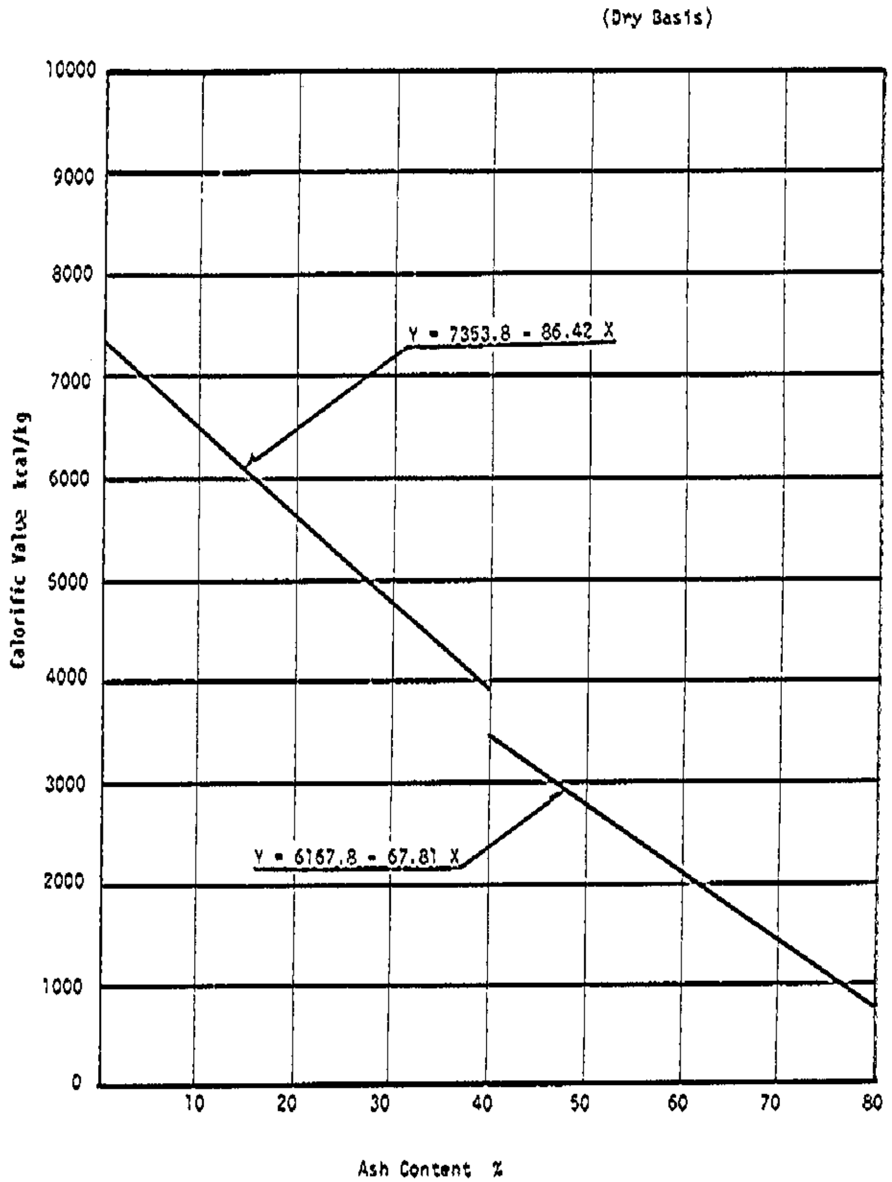


FIGURE 7-4 RELATION BETWEEN ASH CONTENT AND CALORIFIC VALUE

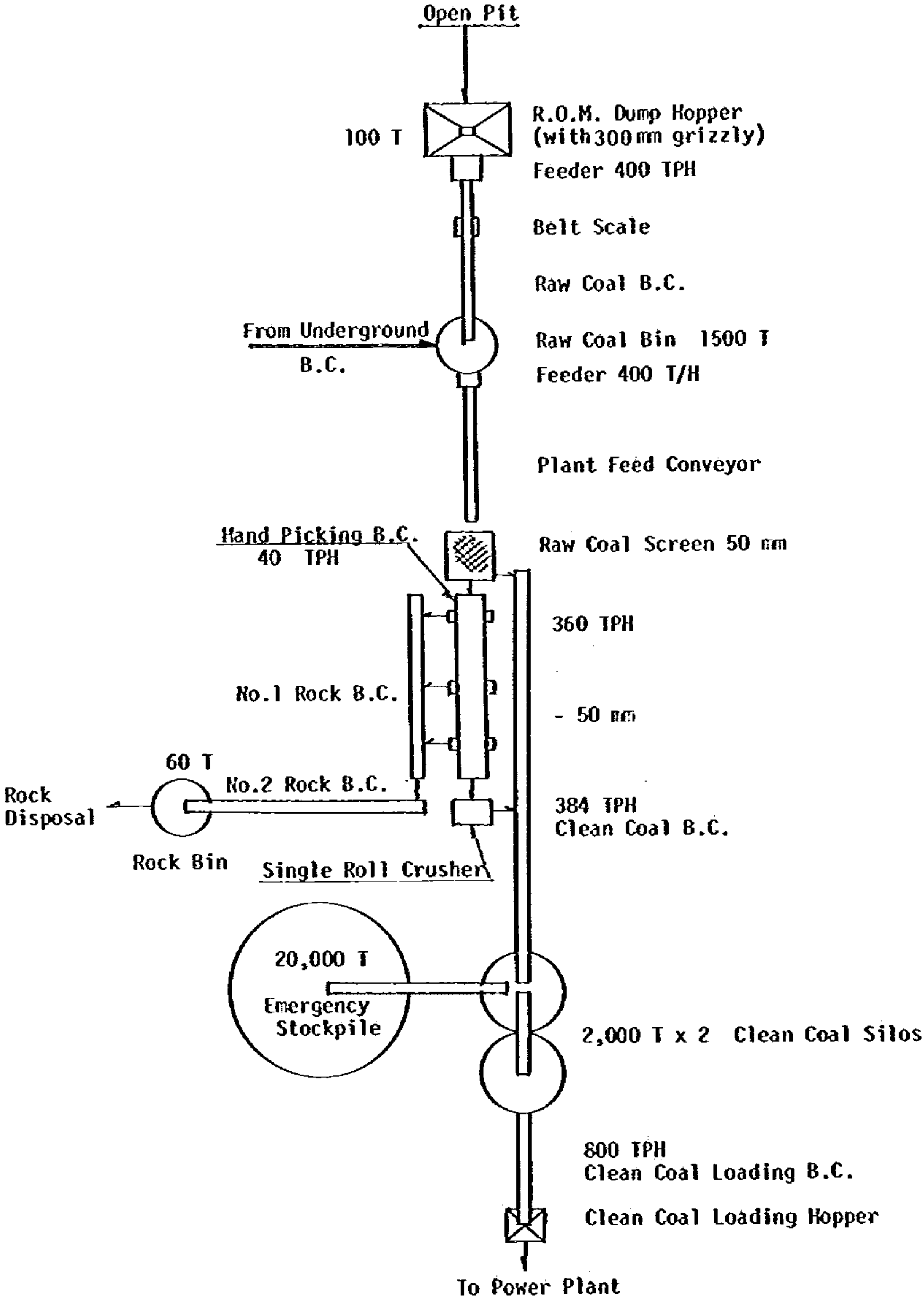


FIGURE 7-5 FLOWSHEET OF UNWASHING PROCESS

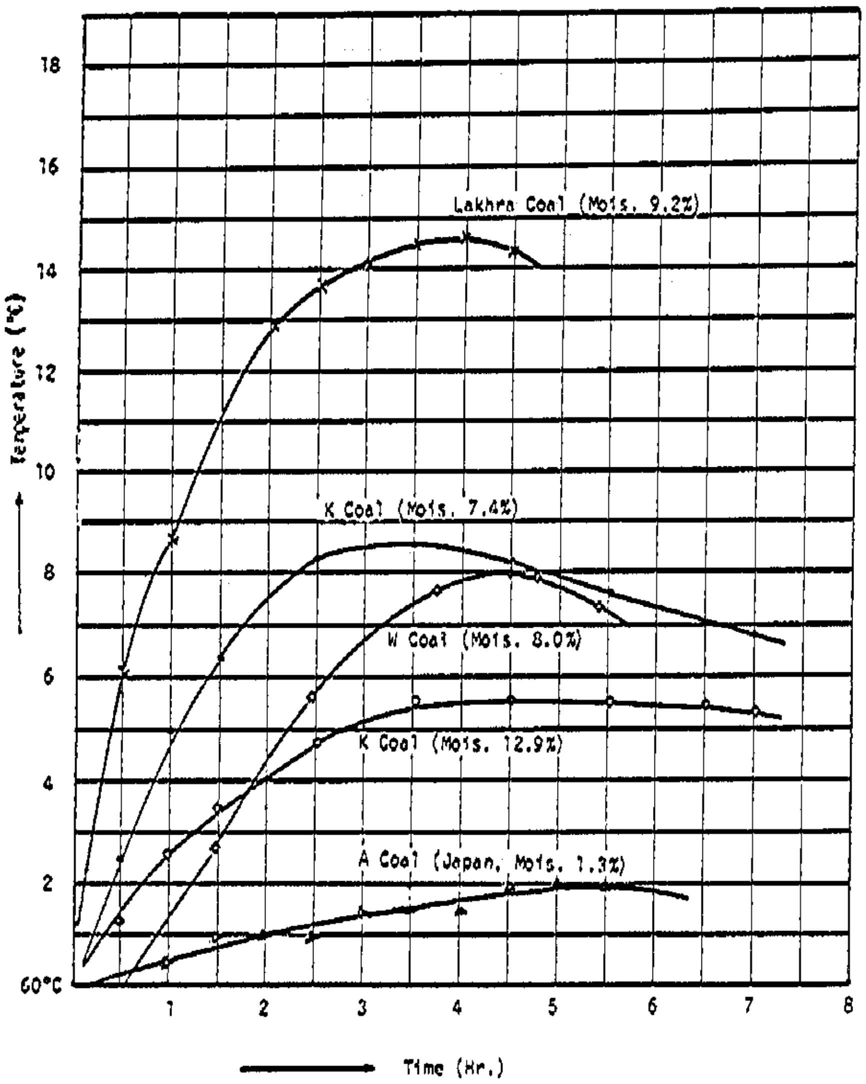


FIGURE 7-6 HEATING CURVES OF TEMPERATURE RISE TEST

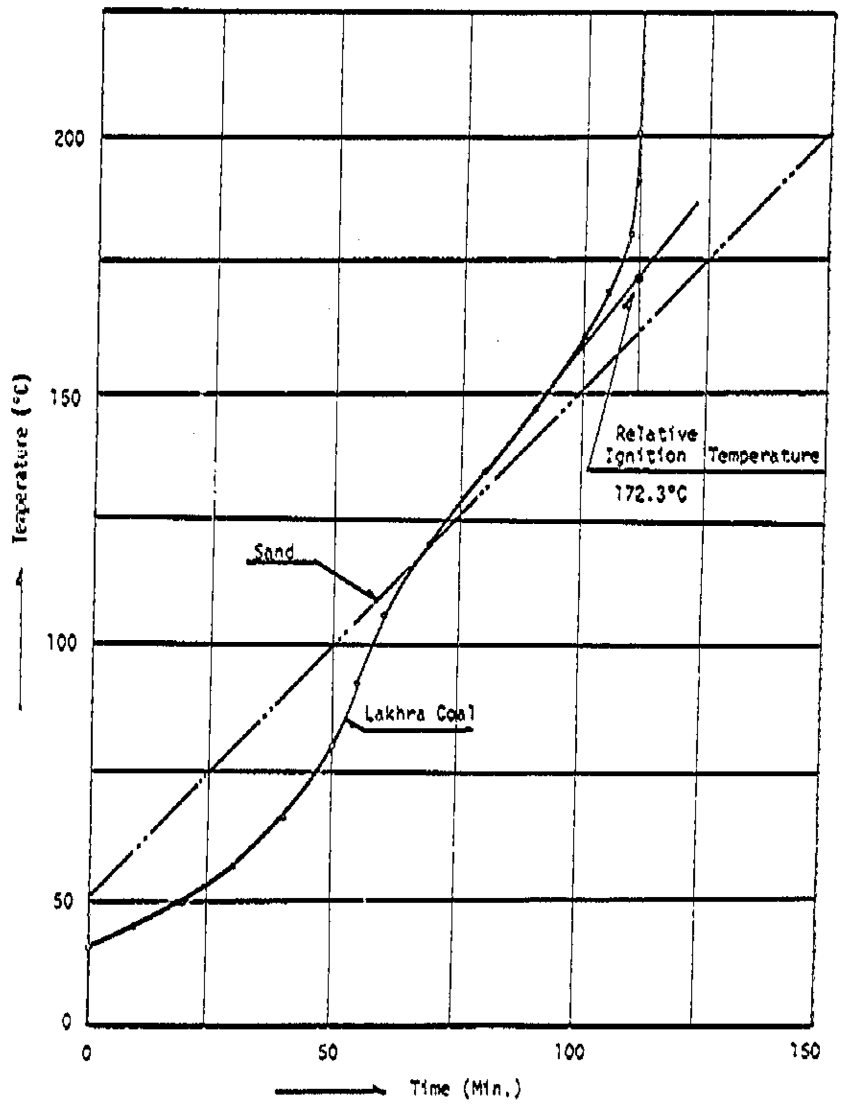


FIGURE 7-7 RELATIVE IGNITION TEMPERATURE TEST

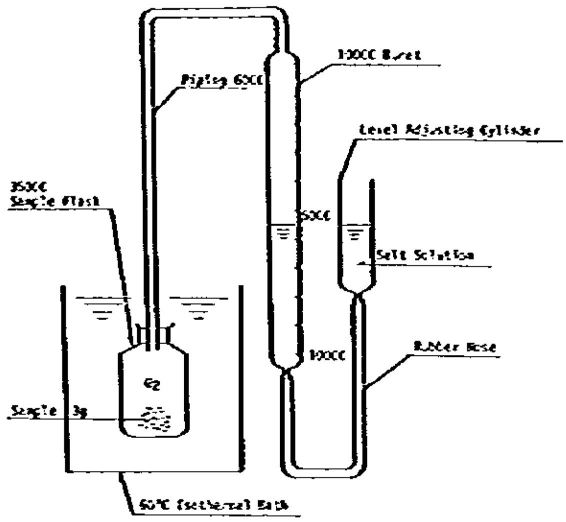


FIGURE 7-8 OXYGEN ABSORPTION TEST

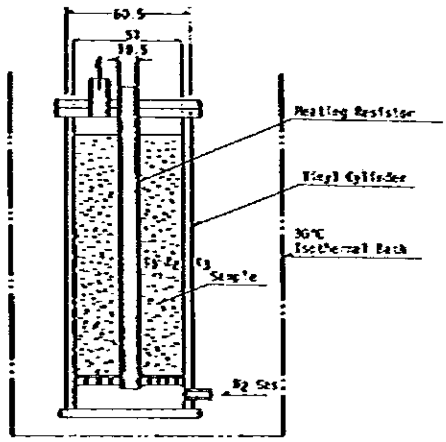


FIGURE 7-9 THERMAL CONDUCTIVITY TEST

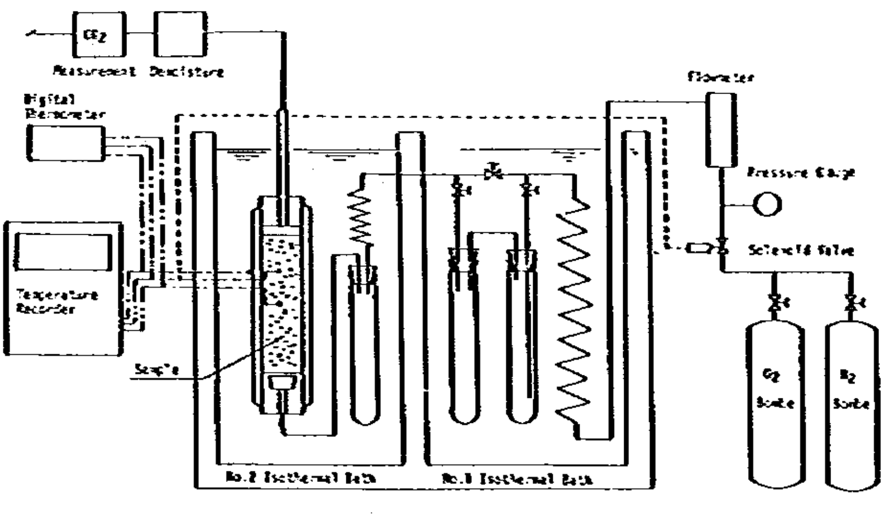


FIGURE 7-10 OXIDATION HEATING TEST

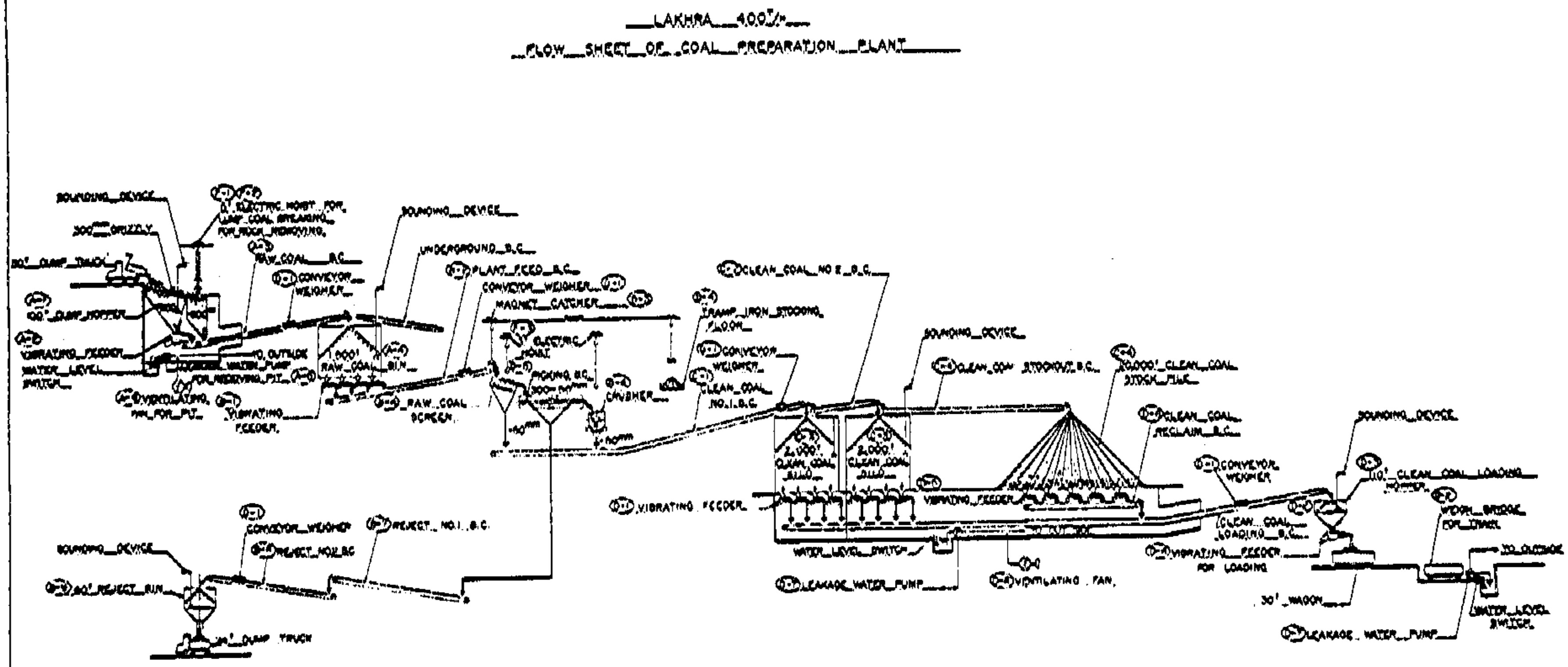


FIGURE 7-11 LAKHRA 400 t/h COAL PREPARATION PLANT — FLOW SHEET

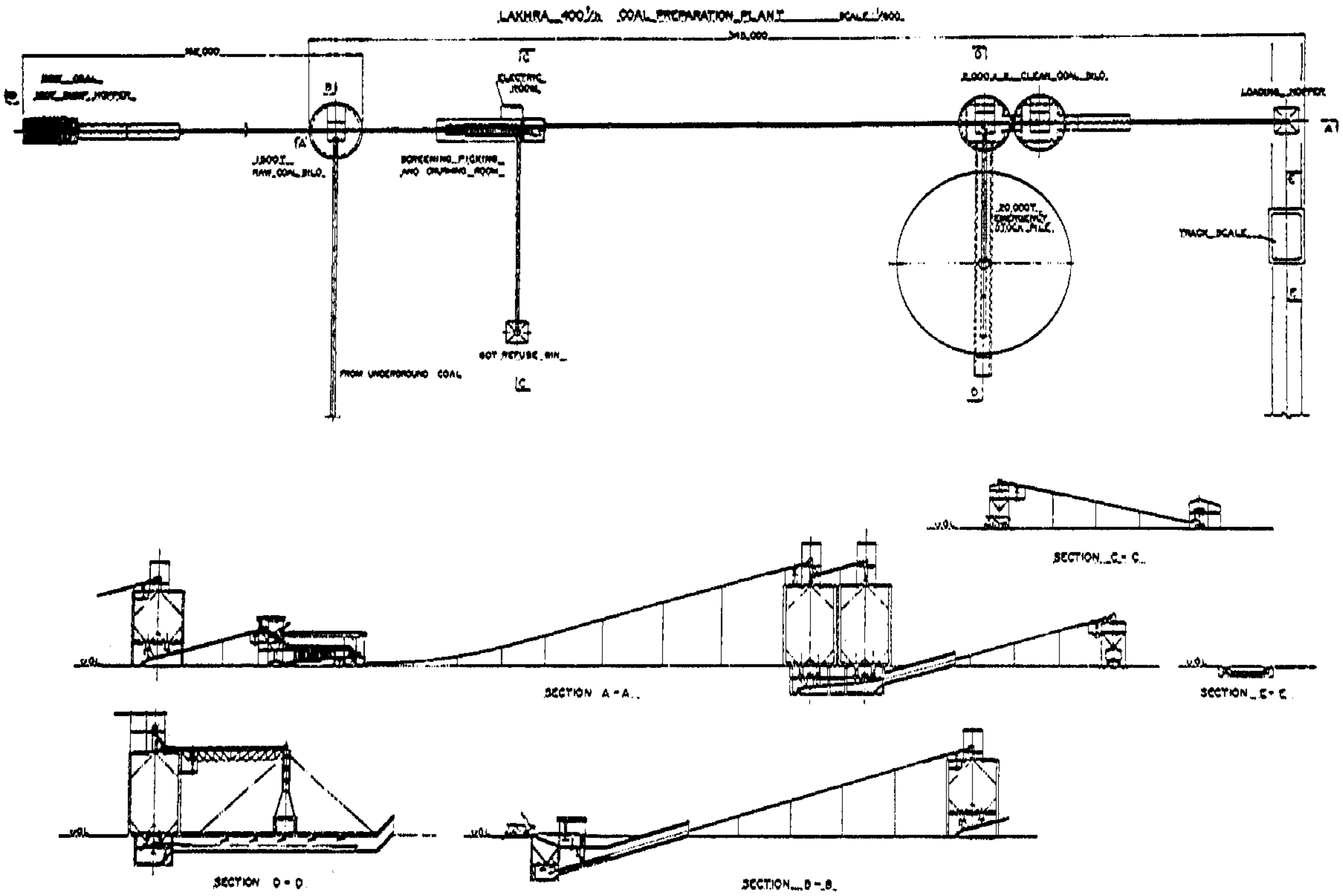


FIGURE 7-12 LAKHRA 400 t/h COAL PREPARATION PLANT — LAYOUT

CHAPTER 8 MANPOWER REQUIREMENT AND OGRANIZATION

8-1 Manpower Requirement

The manpower plan established referred not only to the present status of coal mines in Japan, Canada and U.S. but also the PC-1 form for Lakhra coal mine project submitted by PMDC on February 12, 1976.

The required average manpower in all operating periods will be 1,689 in total, 209 officers and 1,480 workers, and 1,824 maximum, 218 officers and 1,606 workers, during 1988 to 1997. Detailed yearly manpower requirements are shown in Table 8-1 to Table 8-6.

Lakhra Colliery will be planned to operate a mechanized mining system, and especially in the open pit huge electric shovels, rotary drills and other large equipment is planned to be utilized so that the stability of workers is indispensable to maintain high productivity.

Therefore, for this purpose, not only officers but also workers will be employed directly by the implementing agency on a fixed salary or wage basis. However, in consideration of the special circumstances in Pakistani coal mines the coal winning and road heading workers in underground mine will be employed through the contractors and paid on a tonnage basis. On the other hand, such office workers as bearers, peons and sweepers, etc., and the general workers all over the colliery will be employed on a daily basis.

In general, all machines will be controlled by each operator; however, no operators will be posted to such machines as the main ventilation fan on surface and underground local fans and drainage pumps which can be operated automatically and/or by remote control.

8-2 Organization Plan

The organization plan for the colliery has been established with reference to the examples of Japanese coal mines, as well as the existing organizational structure of PMDC coal mine. The organizational structure for Lakhra colliery is shown in figure 8-1. Two deputy general managers, one for operation and the other for affairs, will be appointed under the general manager to assist their superior in each sphere. The deputy general manager operation will serve the management of not only two open pits and underground mine but also such staff sections as planning, training and other technical service sections. On the other hand the deputy general manager affairs will serve the management of such sections as administration, accountant, labour and social welfare, system and hospital.

Each section is managed by the section manager or the mine manager or the officer who is fully responsible to carry out the business concerning his section.

Each section will be devided into some sub-sections if required to carry out the business smoothly and accurately. The new sections which do not exist at present PMDC coal mines and the business concerned are as follows:

(1) Safety Section

The major business of this section will be the supervision and conduct of safety affairs to maintain the safety of all workers and euipment and advice of matters to be improved by each section manager concerned. The section is directly connected to the general manager.

(2) Training Section

Education and training of newly employed technical workers to give them necessary knowledge and techniques required for their new jobs as the new working power at each working site will be carried out in this section.

(3) Open Pit Mine

The section will be carried out such work as stripping, bankshooting, parting and coal loading, haulage, road grading and reclamation, etc.

(4) System Section

The calculation of operating costs, salaries and wages, as well as control of the various spare parts for all equipment and of materials will be carried out in this section by means of computer.

8-3 Training Plan

In order to operate and manage heavy vehicles, machines, and longwall face, workers, technicians and engineers will have to have adequate knowledge and technique. Poor knowledge and technique will greatly influence mining operations of both coal production and its cost. Accordingly, prior to the operation and also positioning of workers and engineers it is necessary to master the technique of operation, inspection, and maintenance. This training will be necessary not only for operating technique, but also from the safety aspect.

8-3-1 Course of Training

(1) Operation

Operating course will divide into two divisions which are called normal course and short period course. It is necessary for three months period training of normal course trainee who has not got a licence for dryving heavy equipment. About one month time period will be necessary for short time trainee who have some sort of license.

(2) Maintenance and Arrangement of Equipment

About three months period will be necessary for the trainee to be learnt the maintenance as well as the practical arrangement plan of equipment. Caliculum is as follows:

(1) Engine course
(2) Body course
(3) Arrangement plan course
(4) Practice of maintenance
(5) Practice of arrangement

8-3-2 Trainee and Place

To learn the maintenance and arrangement of equipment, especially for engineer(s) of the heavy equipment maintenance shop, it is necessary to send him to Japan. To learn the operating technique, trainee have to undergo educational course on site during construction.

For the drifting method of underground mine, three months period will be necessary for mastering the technique. As for the longwall technique at least 6 months period will be necessary for the training in Japan.

FIGURE 8-1

ORGANIZATION STRUCTURE
LAKHRA COLLIERY

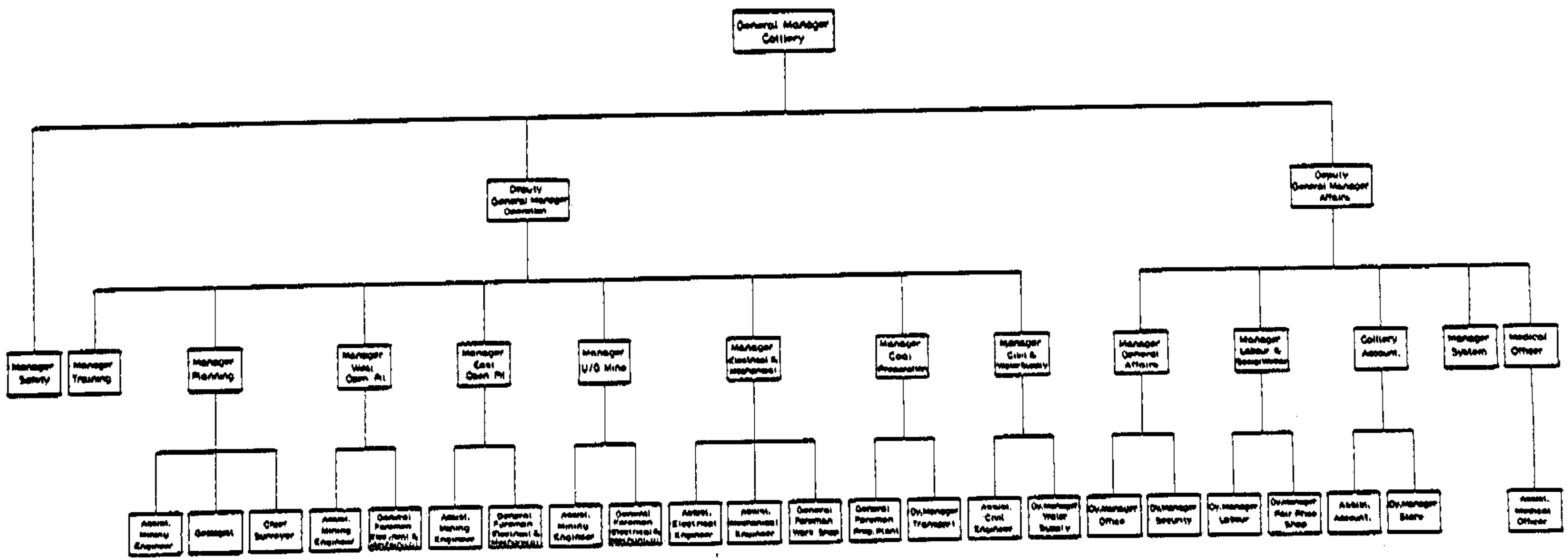


TABLE 8-1

MANPOWER REQUIREMENT
(SUMMARY)

Section	Description	1983	1984	1985	1986	1987	1988 - 1997	1998 - 2010	2011 - 2012	2013 - 2014	2015	Average
		Capital			Operating							
Underground Mine	Officers	3	29	35	41	47	47	44	38	-	-	40
	Workers	9	170	236	452	615	615	573	380	-	-	514
	Sub-Total	12	199	271	493	662	662	617	418	-	-	554
Open Pit	Officers	44	50	50	50	50	50	50	50	44	50	50
	Workers	294	354	354	354	360	360	360	360	360	298	358
	Sub-Total	338	404	404	404	410	410	410	410	410	342	408
Administration	Officers	63	78	88	95	107	111	111	111	94	94	109
	Workers	129	199	253	372	472	518	518	518	413	413	497
	Sub-Total	192	277	341	467	579	629	629	629	507	507	606
Preparation Plant	Officers	-	-	5	10	10	10	10	10	10	10	10
	Workers	-	-	22	72	85	113	113	113	113	113	111
	Sub-Total	-	-	27	82	95	123	123	123	123	123	121
TOTAL	Officers	110	157	178	196	214	218	215	209	154	148	209
	Workers	432	723	865	1,250	1,532	1,606	1,564	1,371	886	824	1,480
	Sub-Total	542	880	1,043	1,446	1,746	1,824	1,779	1,580	1,040	972	1,689

TABLE 5 - 2

MANPOWER REQUIREMENT
(UNDERGORUND MINE)

Sheet 1

Description	Year: 1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	1986-2012 Average	1986-2015 Average
	Capital			Operating								
Officer												
Mine Manager	1	1	1	1	1	1	1	1	-	-	1	1
Deputy Mine Manager	-	2	2	2	2	2	2	2	-	-	2	2
Assistant Mining Engineer	-	3	3	3	3	3	3	3	-	-	3	3
Longwall Face Foremen	-	-	-	6	12	12	12	6	-	-	11	10
Pillar Splitting Foremen	-	-	-	-	-	-	3	3	-	-	2	1
Road Heading Foremen	1	6	12	12	12	12	6	6	-	-	9	8
Ventilation Foremen	-	1	1	1	1	1	1	1	-	-	1	1
Road Maintenance Foremen	-	4	4	4	4	4	4	4	-	-	4	3
Haulage Foremen	-	3	3	3	3	3	3	3	-	-	3	3
Electrical & Mechanical Foremen	-	7	7	7	7	7	7	7	-	-	7	6
Safetylamp Room Foremen	-	1	1	1	1	1	1	1	-	-	1	1
Office Clerk	1	1	1	1	1	1	1	1	-	-	1	1
Sub-Total	3	29	35	41	47	47	44	38	-	-	45	40
Workers												
Longwall Face Workers	-	-	-	129	258	258	237	129	-	-	233	210
Pillar Splitting Workers	-	-	-	-	-	-	21	21	-	-	12	11
Road Heading Workers	7	42	84	84	84	84	42	42	-	-	61	55
Ventilation Workers	-	5	5	17	20	20	20	13	-	-	19	17
Maintenance Workers	-	9	33	66	66	66	66	33	-	-	64	57
Haulage Workers	-	36	36	62	90	90	90	62	-	-	87	78
Electrical & Mechanical Workers	-	16	16	30	30	30	30	16	-	-	29	26
Machine Operators	-	21	21	23	26	26	26	23	-	-	25	23
Safetylamp Room Workers	-	10	10	10	10	10	10	10	-	-	10	9
Electrical & Mechanical Store Workers	-	6	6	6	6	6	6	6	-	-	6	5
Office Workers	2	25	25	25	25	25	25	25	-	-	25	23
Sub-Total	9	170	236	452	615	615	573	380	-	-	571	514
Total	12	199	271	493	662	662	617	418	-	-	616	554

TABLE 8 - 2

MANPOWER REQUIREMENT
(UNDERGROUND MINE)

(Continued) Sheet 2

Description		1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	1986-2012 Average	1986-2015 Average
		Capital			Operating								
Longwall Face Workers													
Chief Workers	*2	-	-	-	2	4	4	4	2	-	-	4	3
Miners	*2	-	-	-	78	156	156	138	78	-	-	138	125
Prop Drawers	*2	-	-	-	12	24	24	24	12	-	-	23	20
Stablemen	*2	-	-	-	8	16	16	16	8	-	-	15	14
Prop Checkers	*2	-	-	-	2	4	4	4	2	-	-	4	3
Packers	*2	-	-	-	8	16	16	16	8	-	-	15	14
Pullbackmen	*2	-	-	-	4	8	8	8	4	-	-	7	7
Face Maintenancemen		-	-	-	10	20	20	20	10	-	-	19	17
Shot Firers	*3	-	-	-	5	10	10	7	5	-	-	8	7
Sub-Total		-	-	-	129	258	258	237	129	-	-	233	210
Pillar Splitting Workers													
Miners	*3	-	-	-	-	-	-	18	18	-	-	10	9
Shot Firers	*3	-	-	-	-	-	-	3	3	-	-	2	2
Sub-Total		-	-	-	-	-	-	21	21	-	-	12	11
Road Heading Workers													
Miners	*3	5	30	60	60	60	60	30	30	-	-	43	39
Loaders	*3	1	6	12	12	12	12	6	6	-	-	9	8
Shot Firers	*3	1	6	12	12	12	12	6	6	-	-	9	8
Sub-Total		7	42	84	84	84	84	42	42	-	-	61	55
Ventilation Workers													
Bratticemen		-	5	5	10	10	10	10	6	-	-	10	9
Flyash Packers		-	-	-	4	4	4	4	4	-	-	4	3
Gas Patrols		-	-	-	3	6	6	6	3	-	-	5	5
Sub-Total		-	5	5	17	20	20	20	13	-	-	19	17
Entry Maintenance Workers													
Panel Maintenancemen		-	3	3	6	6	6	6	3	-	-	6	5
Track Maintenancemen		-	5	10	10	10	10	10	10	-	-	10	9
Gate Maintenancemen (include rock dusters)		-	-	17	44	44	44	44	17	-	-	42	38
Shot Firers		-	1	3	6	6	6	6	3	-	-	6	5
Sub-Total		-	9	33	66	66	66	66	33	-	-	64	57

*2: 2 shifts/day, *3: 3 shifts/day

TABLE 8 - 2

(Continued)

MANPOWER REQUIREMENT
(UNDERGROUND MINE)

Sheet 3

Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	1986-2012 Average	1986-2015 Average
	Capital			Operating								
Haulage Workers												
Surface Workers												
Diesel Locomotive Drivers	-	3	3	5	5	5	5	5	-	-	5	5
Shunters	-	3	3	5	5	5	5	5	-	-	5	5
Tippler Men	-	2	2	2	2	2	2	2	-	-	2	2
Tippler Helpers	-	6	6	6	6	6	6	6	-	-	6	5
Underground Workers												
Battery Locomotive Drivers	-	6	6	15	27	27	27	15	-	-	26	23
Shunters Battery Locomotive	-	6	6	15	27	27	27	15	-	-	26	23
Shunters Pitmouth	-	5	5	5	5	5	5	5	-	-	5	4
Shunters Pit Bottom	-	5	5	5	5	5	5	5	-	-	5	4
Shunters Junction & Each Panel	-	-	-	4	8	8	8	4	-	-	7	7
Sub-Total	-	36	36	62	90	90	90	62	-	-	87	78
Electrical & Mechanical Workers												
Electricians	-	4	4	7	7	7	7	4	-	-	7	6
Electricians Apprentices	-	4	4	8	8	8	8	4	-	-	8	7
Mechanics	-	4	4	7	7	7	7	4	-	-	7	5
Mechanics Apprentices	-	4	4	8	8	8	8	4	-	-	7	7
Sub-Total	-	16	16	30	30	30	30	16	-	-	29	26
Machine Operators												
Surface Workers												
Air Compressor Operators	-	3	3	3	3	3	3	3	-	-	3	3
Air Compressor Helpers	-	3	3	3	6	6	6	3	-	-	5	5
Main Slope Hoist Operators	-	3	3	3	3	3	3	3	-	-	3	3
Main Slope Hoist Helpers	-	3	3	3	3	3	3	3	-	-	3	3
Underground Workers												
Chain Conveyor Operators	-	2	2	2	2	2	2	2	-	-	2	2
B. L. Battery Chargingmen	-	3	3	3	3	3	3	3	-	-	3	3
B. L. Battery Chaging Assistants	-	4	4	6	6	6	6		-	-	6	5
Sub-Total	-	21	21	23	26	26	26	23	-	-	25	24
Safetylamp Room Workers												
Safetylamp Issuers	-	3	3	3	3	3	3	3	-	-	3	3
Safetylamp Workers	-	3	3	3	3	3	3	3	-	-	3	3
Gas Detector Supervisor	-	1	1	1	1	1	1	1	-	-	1	1
Gas Detector Repair Men	-	3	3	3	3	3	3	3	-	-	3	3
Sub-Total	-	10	10	10	10	10	10	10	-	-	10	10
Electrical & Mechanical Store Workers												
Issuers	-	3	3	3	3	3	3	3	-	-	3	3
Supervisors	-	3	3	3	3	3	3	3	-	-	3	3
Sub-Total	-	6	6	6	6	6	6	6	-	-	6	6

TABLE 8-2

MANPOWER REQUIREMENT
(UNDERGROUND MINE)

(Continued) Sheet 4

Description	Year											
	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	1986-2012 Average	1986-2015 Average
	Capital			Operating								
Office Workers												
Junior Clerks	-	9	9	9	9	9	9	9	-	-	9	9
Office Attendants/Oilermen	-	10	10	10	10	10	10	10	-	-	10	10
Checkmen	-	6	6	6	6	6	6	6	-	-	6	6
Sub-Total	-	25	25	25	25	25	25	25	-	-	25	25
Total	7	170	236	452	615	615	573	380	-	-	571	514

TABLE 8 - 3

MANPOWER REQUIREMENT
(WEST OPEN PIT)

Sheet 1

Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013 2014	2015	Average
	Capital			Operating							
Officers											
Mine Manager	1	1	1	1	1	1	1	1	1	1	1
Deputy Mine Manager	2	2	2	2	2	2	2	2	2	2	2
Assistant Mining Engineer	3	3	3	3	3	3	3	3	3	2	3
Stripping Foremen	3	3	3	3	3	3	3	3	3	2	3
Bankshooting Foremen	2	2	2	2	2	2	2	2	2	1	2
Partings & Coal Loading Foremen	-	2	2	2	2	2	2	2	2	2	2
Haulage Foremen	2	3	3	3	3	3	3	3	3	2	3
Road Grading Foreman	1	1	1	1	1	1	1	1	1	1	1
Reclamation Foreman	1	1	1	1	1	1	1	1	1	1	1
Electrical Foremen	3	3	3	3	3	3	3	3	3	2	3
Mechanical Foremen	3	3	3	3	3	3	3	3	3	2	3
Office Clerk	1	1	1	1	1	1	1	1	1	1	1
Sub-Total	22	25	25	25	25	25	25	25	25	19	25
Workers											
Stripping Workers	24	24	24	24	24	24	24	24	24	12	24
Bankshooting Workers	21	21	21	21	21	21	21	21	21	11	21
Parting & Coal Loading Workers	-	18	18	18	18	18	18	18	18	18	18
Haulage Workers	42	57	57	57	57	57	57	57	57	39	56
Road Grading Workers	10	10	10	10	10	10	10	10	10	10	10
Reclamation Workers	10	10	10	10	10	10	10	10	10	10	10
Electrical Workers	6	6	6	6	6	6	6	6	6	4	6
Mechanical Workers	6	6	6	6	6	6	6	6	6	4	6
Office Workers	32	32	32	32	32	32	32	32	32	20	31
Sub-Total	151	184	184	184	184	184	184	184	184	128	182
Total	173	209	209	209	209	209	209	209	209	147	207

TABLE 8-3

MANPOWER REQUIREMENT
(WEST OPEN PIT)

(Continued) Sheet 2

Description		1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
		Capital			Operating							
Stripping												
Shovel Operator	11.5 m^3	6	6	6	6	6	6	6	6	6	3	6
Helpers		6	6	6	6	6	6	6	6	6	3	6
Oilers		6	6	6	6	6	6	6	6	6	3	6
Groundmen		6	6	6	6	6	6	6	6	6	3	6
Sub-Total		24	24	24	24	24	24	24	24	24	12	24
Bankshooting												
Drillers	9 7/8"	4	4	4	4	4	4	4	4	4	2	4
Helpers		8	8	8	8	8	8	8	8	8	4	8
Dozer Operators		4	4	4	4	4	4	4	4	4	2	4
Shooters		5	5	5	5	5	5	5	5	5	3	5
Sub-Total		21	21	21	21	21	21	21	21	21	11	21
Parting Coal Loading												
Drillers	80 m/m	-	2	2	2	2	2	2	2	2	2	2
Helpers		-	4	4	4	4	4	4	4	4	4	4
Dozer Operators		-	2	2	2	2	2	2	2	2	2	2
Scraper Operators		-	4	4	4	4	4	4	4	4	4	4
Hydraulic Exvator Operators		-	2	2	2	2	2	2	2	2	2	2
Shooters		-	4	4	4	4	4	4	4	4	4	4
Sub-Total		-	18	18	18	18	18	18	18	18	18	18
Haulage												
Truck Drivers	120 t	24	30	30	30	30	30	30	30	30	12	29
Truck Drivers	46 t	2	10	10	10	10	10	10	10	10	10	10
Greasemen		4	5	5	5	5	5	5	5	5	5	5
Machinist & Welders Helper		4	4	4	4	4	4	4	4	4	4	4
Crossing Watchmen		6	6	6	6	6	6	6	6	6	6	6
Motor Patrols		2	2	2	2	2	2	2	2	2	2	2
Sub-Total		42	57	57	57	57	57	57	57	57	39	56
Road Grading												
Grader Operators		2	2	2	2	2	2	2	2	2	2	2
Dozer Operators		2	2	2	2	2	2	2	2	2	2	2
Sprinkler		1	1	1	1	1	1	1	1	1	1	1
General Workers		5	5	5	5	5	5	5	5	5	5	5
Sub-Total		10	10	10	10	10	10	10	10	10	10	10

TABLE 8-3

MANPOWER REQUIREMENT
(WEST OPEN PIT)

(Continued) Sheet 3

Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
	Year										
	Capital			Operating							
Reclamation											
Dozer Operators	2	2	2	2	2	2	2	2	2	2	2
Scraper Operator	1	1	1	1	1	1	1	1	1	1	1
Crusher Operators	2	2	2	2	2	2	2	2	2	2	2
Front End Loader	1	1	1	1	1	1	1	1	1	1	1
Truck 46 t	1	1	1	1	1	1	1	1	1	1	1
General Workers	3	3	3	3	3	3	3	3	3	3	3
Sub-Total	10	10	10	10	10	10	10	10	10	10	10
Electrical Workers											
Electricians	3	3	3	3	3	3	3	3	3	2	3
Helpers	3	3	3	3	3	3	3	3	3	2	3
Sub-Total	6	6	6	6	6	6	6	6	6	4	6
Mechanical Workers											
Mechanics	3	3	3	3	3	3	3	3	3	2	3
Helpers	3	3	3	3	3	3	3	3	3	2	3
Sub-Total	6	6	6	6	6	6	6	6	6	4	6
Office Clerks											
Junior Clerks	13	13	13	13	13	13	13	13	13	13	13
Attendants	4	4	4	4	4	4	4	4	4	4	4
Time Keepers	3	3	3	3	3	3	3	3	3	3	3
Aprentices	12	12	12	12	12	12	12	12	12	-	11
Sub-Total	32	32	32	32	32	32	32	32	32	20	31
Total	151	184	184	184	184	184	184	184	184	128	182

TABLE 8-4

MANPOWER REQUIREMENT
(EAST OPEN PIT)

Sheet 1

Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
	Capital			Operating							
Officers											
Mine Manager	1	1	1	1	1	1	1	1	1	1	1
Deputy Mine Manager	2	2	2	2	2	2	2	2	2	2	2
Assistant Mining Engineer	3	3	3	3	3	3	3	3	3	3	3
Stripping Foremen	3	3	3	3	3	3	3	3	3	3	3
Bankshooting Foremen	2	2	2	2	2	2	2	2	2	2	2
Partings & Coal Loading Foremen	-	2	2	2	2	2	2	2	2	2	2
Haulage Foreman	1	1	1	1	1	1	1	1	1	1	1
Road Grading Foremen	2	3	3	3	3	3	3	3	3	3	3
Reclamation Foreman	1	1	1	1	1	1	1	1	1	1	1
Electrical Foremen	3	3	3	3	3	3	3	3	3	3	3
Mechanical Foremen	3	3	3	3	3	3	3	3	3	3	3
Office Clerk	1	1	1	1	1	1	1	1	1	1	1
Sub-Total	22	25	25	25	25	25	25	25	25	25	25
Workers											
Stripping Workers	24	24	24	24	24	24	24	24	24	24	24
Bankshooting Workers	21	21	21	21	21	21	21	21	21	21	21
Parting & Coal Loading Foremen	-	16	16	16	16	16	16	16	16	16	16
Haulage Workers	36	47	47	47	53	53	53	53	53	47	53
Road Grading Workers	9	9	9	9	9	9	9	9	9	9	9
Reclamation Workers	9	9	9	9	9	9	9	9	9	9	9
Electrical Workers	6	6	6	6	6	6	6	6	6	6	6
Mechanical Workers	6	6	6	6	6	6	6	6	6	6	6
Office Clerk	32	32	32	32	32	32	32	32	32	32	32
Sub-Total	143	170	170	170	176	176	176	176	176	170	176
Total	165	195	195	195	201	201	201	201	201	195	201

TABLE A-4

MANPOWER REQUIREMENT
(EAST OPEN PIT)

(Continued)

Sheet 2

Description		1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
		Capital			Operating							
Stripping												
Shovel Operators	11.5 m^3	6	6	6	6	6	6	6	6	6	6	6
Operators Helpers	"	6	6	6	6	6	6	6	6	6	6	6
Oilers	"	6	6	6	6	6	6	6	6	6	6	6
Groundmen	"	6	6	6	6	6	6	6	6	6	6	6
Sub-Total		24	24	24	24	24	24	24	24	24	24	24
Bankshooting												
Drillers	9 7/8"	4	4	4	4	4	4	4	4	4	4	4
Helpers	"	8	8	8	8	8	8	8	8	8	8	8
Dozer Operators		4	4	4	4	4	4	4	4	4	4	4
Shooters		5	5	5	5	5	5	5	5	5	5	5
Sub-Total		21	21	21	21	21	21	21	21	21	21	21
Parting Coal Loading												
Drillers	80 m/m	-	2	2	2	2	2	2	2	2	2	2
Helpers	"	-	2	2	2	2	2	2	2	2	2	2
Dozer Operators		-	2	2	2	2	2	2	2	2	2	2
Scraper Operators		-	4	4	4	4	4	4	4	4	4	4
Hydraulic Exvator Operators		-	2	2	2	2	2	2	2	2	2	2
Shooters		-	4	4	4	4	4	4	4	4	4	4
Sub-Total		-	16	16	16	16	16	16	16	16	16	16
Haulage												
Truck Drivers	120 t	18	24	24	24	30	30	30	30	30	24	30
Truck Drivers	46 t	2	6	6	6	6	6	6	6	6	6	6
Greasemen		4	5	5	5	5	5	5	5	5	5	5
Machinist & Welder's Helper		4	4	4	4	4	4	4	4	4	4	4
Crossing Watchmen		6	6	6	6	6	6	6	6	6	6	6
Motor Patrols		2	2	2	2	2	2	2	2	2	2	2
Sub-Total		36	47	47	47	53	53	53	53	53	47	53
Road Grading												
Grader Operators		2	2	2	2	2	2	2	2	2	2	2
Dozer Operators		2	2	2	2	2	2	2	2	2	2	2
Sprinkler		1	1	1	1	1	1	1	1	1	1	1
General Workers		4	4	4	4	4	4	4	4	4	4	4
Sub-Total		9	9	9	9	9	9	9	9	9	9	9

TABLE 8-4

MANPOWER REQUIREMENT
(EAST OPEN PIT)

(Continued) Sheet 3

Description	Year										Average
	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	
	Capital			Operating							
Reclamation											
Dozer Operators	2	2	2	2	2	2	2	2	2	2	2
Scraper Operator	1	1	1	1	1	1	1	1	1	1	1
Crusher Operators	2	2	2	2	2	2	2	2	2	2	2
Front End Loader	1	1	1	1	1	1	1	1	1	1	1
Truck 46 t	1	1	1	1	1	1	1	1	1	1	1
General Workers	2	2	2	2	2	2	2	2	2	2	2
Sub-Total	9	9	9	9	9	9	9	9	9	9	9
Electrical Workers											
Electricians	3	3	3	3	3	3	3	3	3	3	3
Electricians Helpers	3	3	3	3	3	3	3	3	3	3	3
Sub-Total	6	6	6	6	6	6	6	6	6	6	6
Mechanical Workers											
Mechanics	3	3	3	3	3	3	3	3	3	3	3
Mechanics Helpers	3	3	3	3	3	3	3	3	3	3	3
Sub-Total	6	6	6	6	6	6	6	6	6	6	6
Office Clerk											
Junior Clerks	13	13	13	13	13	13	13	13	13	13	13
Attendants	4	4	4	4	4	4	4	4	4	4	4
Time Keepers	3	3	3	3	3	3	3	3	3	3	3
Apprentices	12	12	12	12	12	12	12	12	12	12	12
Sub-Total	32	32	32	32	32	32	32	32	32	32	32
Total	143	170	170	170	176	176	176	176	176	170	176

TABLE 8-3

MANPOWER REQUIREMENT
(ADMINISTRATION)

Sheet 1

Section	Description	Year										Average
		1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	
		Capital			Operating							
Management	Officer											
	General Manager	1	1	1	1	1	1	1	1	1	1	1
	Deputy General Manager	2	2	2	2	2	2	2	2	2	2	2
	Clerks/Typist	3	3	3	3	3	3	3	3	3	3	3
	Sub-Total	6	6	6	6	6	6	6	6	6	6	6
	Workers											
	Office Attendants	3	3	3	3	3	3	3	3	3	3	3
	Total	9	9	9	9	9	9	9	9	9	9	9
General Affairs	Officers											
	Manager	1	1	1	1	1	1	1	1	1	1	1
	Deputy Manager	1	1	1	1	1	1	1	1	1	1	1
	Clerks/Typists	1	1	2	2	3	4	4	4	2	2	4
	Deputy Manager Security	1	1	1	1	1	1	1	1	1	1	1
	Security Inspectors	3	3	3	3	3	3	3	3	3	3	3
	Clerk	1	1	1	1	1	1	1	1	1	1	1
	Pesh Imams	1	1	2	2	3	4	4	4	2	2	4
	Sub-Total	7	9	11	11	13	15	15	15	11	11	15
	Workers											
	Head Telephone Operator	-	-	-	1	1	1	1	1	1	1	1
	Telephone Operators	-	-	-	3	3	3	3	3	3	3	3
	Cooks	1	1	1	1	2	2	2	2	2	2	2
	Vehicle Drivers	20	20	20	20	20	20	20	20	20	20	20
	Security Guards	3	3	3	6	6	6	6	6	6	6	6
	Armed Guards	3	3	3	9	9	9	9	9	9	9	9
	Junior Clerks	2	2	3	6	8	8	8	8	7	7	8
	Watchmen	3	9	12	21	42	42	42	42	30	30	40
	Office Attendants	3	6	8	11	13	13	13	13	11	11	12
	Sub-Total	35	44	50	78	104	104	104	104	89	89	101
	Total	42	53	61	89	117	119	119	119	100	100	116

TABLE 8 - 5

MANPOWER REQUIREMENT
(ADMINISTRATION)

(Continued) Sheet 2

Section	Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
		Year										
		Capital			Operating							
Accounting	Officers											
	Accountant	1	1	1	1	1	1	1	1	1	1	1
	Assistant Accountant	1	1	1	1	1	1	1	1	1	1	1
	Account Assistants	1	1	1	4	5	5	5	5	4	4	5
	Cashier	1	1	1	1	1	1	1	1	1	1	1
	Clerks	1	1	1	2	2	2	2	2	2	2	2
	Deputy Manager Store	1	1	1	1	1	1	1	1	1	1	1
	Store Keepers	1	3	3	3	5	5	5	5	3	3	5
	Sub-Total	7	9	9	13	16	16	16	16	13	13	16
	Workers											
	Junior Clerks	4	6	7	15	25	25	25	25	20	20	23
	Office Attendants	2	2	2	2	2	2	2	2	2	2	2
	General Workers	2	2	3	4	5	5	5	5	3	3	5
	Sub-Total	8	10	12	21	32	32	32	32	25	25	30
	Total	15	19	21	34	48	48	48	48	38	38	46
Labor & Social Welfare	Officers											
	Manager	1	1	1	1	1	1	1	1	1	1	1
	Deputy Manager Labor	1	1	1	1	1	1	1	1	1	1	1
	Supervisors, Employ	1	1	1	1	1	1	1	1	1	1	1
	Supervisors, Control	-	3	3	3	3	3	3	3	3	3	3
	Deputy Manager Fairprice Shop	-	-	1	1	1	1	1	1	1	1	1
	Sales Supervisors	-	-	1	1	2	2	2	2	1	1	2
	Account Assistant	-	-	1	1	1	1	1	1	1	1	1
	Clerk/Cashier	-	-	1	1	1	1	1	1	1	1	1
	Office Clerk	1	1	1	1	1	1	1	1	1	1	1
	Sub-Total	4	7	11	11	12	12	12	12	11	11	12
	Workers											
	Junior Clerk	1	4	4	6	7	7	7	7	6	6	6
	Salesmen	-	-	-	2	4	4	4	4	2	2	4
	Cooks	-	-	-	1	2	2	2	2	1	1	2
	Office Attendants	2	2	2	5	5	5	5	5	5	5	5
	General Workers	-	-	-	3	6	6	6	6	3	3	6
	Sub-Total	3	6	6	17	24	24	24	24	17	17	23
	Total	7	13	17	28	36	36	36	36	28	28	35

TABLE 8-5

MANPOWER REQURIEMENT
(ADMINISTRATION)

(Continued) Sheet 3

Section	Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
		Capital			Operating							
Civil & Water Supply	**Officers**											
	Manager	1	1	1	1	1	1	1	1	1	1	1
	Assistant Civil Engineer	1	1	1	1	1	1	1	1	1	1	1
	Overseas, Civil	1	1	1	1	1	1	1	1	1	1	1
	Deputy Manager Water Supply	1	1	1	1	1	1	1	1	1	1	1
	Water Supply Foremen	1	1	1	4	4	4	4	4	4	4	4
	Office Clerk	1	1	1	1	1	1	1	1	1	1	1
	Sub-Total	7	7	7	10	10	10	10	10	10	10	10
	Workers											
	Draftmen/Survey Assistants	2	2	2	2	2	2	2	2	2	2	2
	Civil Workers	4	4	4	4	8	8	8	8	4	4	7
	Capenter Snop Workers	-	-	3	3	3	6	6	6	3	3	5
	Pump Station Workers	-	-	-	18	18	18	18	18	18	18	18
	Plumbers	-	-	2	2	2	2	2	2	2	2	2
	Sewage Station Workers	-	-	-	-	9	9	9	9	9	9	9
	Junior Clerks	1	1	2	2	2	3	3	3	2	2	3
	Office Attendants	3	3	4	4	4	4	4	4	4	4	4
	General Workers	6	6	16	18	18	30	20	20	16	16	20
	Sub-Total	16	16	33	53	66	72	72	72	60	60	70
	Total	23	23	40	63	76	82	82	82	70	70	80
Electrical & Mechanical	**Officers**											
	Manager	1	1	1	1	1	1	1	1	1	1	1
	Assistant Engineers	2	2	2	2	2	2	2	2	2	2	2
	General Foremen, Work Shop	1	1	1	1	1	1	1	1	1	1	1
	Electrical & Material Foremen	2	4	4	4	4	4	4	4	4	4	4
	Work Shop Foremen	1	2	2	2	4	4	4	2	2	2	4
	Office Clerk	1	1	1	1	1	1	1	1	1	1	1
	Sub-Total	8	11	11	11	11	13	13	13	11	11	13
	Workers											
	Electrical Workers	1	2	4	4	7	10	10	10	7	7	9
	Mechanical Workers	1	2	4	4	8	12	12	12	8	8	11
	Substation Workers		3	6	6	6	6	6	6	6	6	6
	Power House Workers	3	6	6	6	6	6	6	6	6	6	6
	Work Shop Workers	-	20	30	60	70	102	102	102	70	70	95
	Junior Clerk	1	1	2	2	3	4	4	4	3	3	4
	Office Attendants	3	4	5	5	5	5	5	5	5	5	5
	Sub-Total	9	38	57	87	105	145	145	145	105	105	136
	Total	17	49	68	98	116	158	158	158	116	116	149

TABLE 8-5

MANPOWER REQUIREMENT
(ADMINISTRATION)

(Continued) Sheet 4

Section	Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
		Capital			Operating							
System	Officer											
	Manager	-	1	1	1	1	1	1	1	1	1	1
	Analyst/Clerk	-	1	1	1	1	1	1	1	1	1	1
	Sub-Total	-	2	2	2	2	2	2	2	2	2	2
	Workers											
	Key Punchers	-	1	1	2	3	3	3	3	3	3	3
	Junior Clerk	-	1	1	1	1	1	1	1	1	1	1
	Office Attendants	-	1	1	1	2	2	2	2	2	2	2
	Sub-Total	-	3	3	4	6	6	6	6	6	6	6
	Total	-	5	5	6	8	8	8	8	8	8	8
Training	Officer											
	Manager	1	1	1	1	1	1	1	1	1	1	1
	Trainer	2	2	6	6	6	6	6	6	2	2	5
	Office Clerk	1	1	1	1	1	1	1	1	1	1	1
	Sub-Total	4	4	8	8	8	8	8	8	4	4	7
	Workers											
	Training Assistants	4	4	8	12	12	12	12	12	4	4	11
	Junior Clerks	2	2	2	2	2	2	2	2	2	2	2
	Office Attendants	3	3	3	3	3	3	3	3	3	3	3
	Sub-Total	9	9	13	17	17	17	17	17	9	9	16
	Total	13	13	21	25	25	25	25	25	13	13	23

TABLE 8-5

MANPOWER REQUIREMENT
(ADMINISTRATION)

(Continued) Sheet 5

Section	Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
		Year										
		Capital			Operating							
Planning	Officers											
	Manager	1	1	1	1	1	1	1	1	1	1	1
	Assistant Engineer	2	2	2	2	2	2	2	2	2	2	2
	Junior Engineer	3	3	3	3	3	3	3	3	3	3	3
	Explosive Foreman	1	1	1	1	1	1	1	1	1	1	1
	Geologist	1	1	1	1	1	1	1	1	1	1	1
	Assistant Geologists	2	2	2	2	2	2	2	2	2	2	2
	Drilling Foremen	2	2	2	2	2	2	2	2	2	2	2
	Surveyor	1	1	1	1	1	1	1	1	1	1	1
	Assistant Surveyor	3	3	3	3	3	3	3	3	3	3	3
	Office Clerk	1	1	1	1	1	1	1	1	1	1	1
	Sub-Total	17	17	17	17	17	17	17	17	17	17	17
	Workers											
	Explosive Carriers	-	9	9	9	9	9	9	9	9	9	9
	Explosive Truck	-	3	3	3	3	3	3	3	3	3	3
	Drillers	4	4	4	4	4	4	4	4	3	3	4
	Draftmen	3	3	3	3	3	3	3	3	3	3	3
	Junior Clerks	4	4	4	4	4	4	4	4	4	4	4
	Drilling Helpers	12	12	12	12	12	12	12	12	6	6	11
	Survey Helpers	12	12	12	12	12	12	12	12	6	6	11
	Office Attendants	5	5	5	5	5	5	5	5	5	5	5
	Sub-Total	40	52	52	52	52	52	52	52	39	39	50
	Total	57	69	69	69	69	69	69	69	56	56	67
Safety	Officers											
	Manager	1	1	1	1	1	1	1	1	1	1	1
	Safety Crew	1	1	1	1	4	4	4	4	1	1	3
	Office Clerk	1	1	1	1	1	1	1	1	1	1	1
	Sub-Total	3	3	3	3	6	6	6	6	3	3	5
	Workers											
	Safety Assistants	2	2	2	2	4	4	4	4	2	2	4
	Junior Clerks	1	1	1	1	2	2	2	2	1	1	2
	Office Attendants	3	3	3	3	3	3	3	3	3	3	3
	Sub-Total	6	6	6	6	9	9	9	9	6	6	9
	Total	9	9	9	9	15	15	15	15	9	9	14

TABLE 8-5

MANPOWER REQUIREMENT
(ADMINISTRATION)

(Continued) Sheet 6

Section	Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
		Capital			Operating							
Medical	Officers											
	Medical Officer	-	1	1	1	1	1	1	1	1	1	1
	Assistant Medical Officers	-	1	1	1	2	2	2	2	2	2	2
	Lady Assistant Medical Officers	-	-	-	-	2	2	2	2	2	2	2
	Office Clerk	-	1	1	1	1	1	1	1	1	1	1
	Sub-Total	-	3	3	3	6	6	6	6	6	6	6
	Workers											
	Head Nurse	-	1	1	1	1	1	1	1	1	1	1
	Nurses	-	2	4	6	10	10	10	10	10	10	10
	Health Visitor	-	-	-	-	1	1	1	1	1	1	1
	Midwives	-	-	-	-	2	2	2	2	2	2	2
	Head Compounder	-	1	1	1	1	1	1	1	1	1	1
	Compounders	-	1	1	2	3	3	3	3	3	3	3
	Sanitary Inspectors	-	-	-	-	2	2	2	2	2	2	2
	Junior Clerks	-	1	1	2	2	2	2	2	2	2	2
	First Aid Attendants	-	1	3	3	3	3	3	3	3	3	3
	Ambulance Driver	-	1	1	1	1	1	1	1	1	1	1
	Sweepers	-	2	2	10	20	20	20	20	20	20	19
	First Aid Helpers	-	2	6	6	6	6	6	6	6	6	6
	Cooks	-	-	-	2	2	2	2	2	2	2	2
	Sub-Total	-	12	18	34	54	54	54	54	54	54	53
	Total	-	15	21	37	60	60	60	60	60	60	59

TABLE 8-6

MANPOWER REQUIREMENT
(PREPARATION PLANT)

Section	Description	1983	1984	1985	1986	1987	1988-1997	1998-2010	2011-2012	2013-2014	2015	Average
		Capital			Operating							
Coal Preparation & Transport	Officers											
	Manager	-	-	1	1	1	1	1	1	1	1	1
	General Foreman, Plant	-		1	1	1	1	1	1	1	1	1
	Plant Foremen	-	-	-	3	3	3	3	3	3	3	3
	Deputy Manager, Transport	-	-	1	1	1	1	1	1	1	1	1
	Transport Foremen	-	-	1	3	3	3	3	3	3	3	3
	Office Clerk	-	-	1	1	1	1	1	1	1	1	1
	Sub-Total	-	-	5	10	10	10	10	10	10	10	10
	Workers											
	Patrols	-	-	2	2	2	2	2	2	2	2	2
	Central Control Men	-	-	2	2	2	2	2	2	2	2	2
	Other Plant Workers	-	-	-	18	18	18	18	18	18	18	18
	Transport Workers	-	-	3	3	3	3	3	3	3	3	3
	Junior Clerks	-	-	4	8	8	8	8	8	8	8	8
	Office Attendants	-	-	4	6	6	10	10	10	10	10	10
	Head Pickers	-	-	-	12	16	40	40	40	40	40	38
	General Workers	-	-	7	21	30	30	30	30	30	30	30
	Sub-Total	-	-	22	72	85	113	113	113	113	113	111
	Total	-	-	27	82	95	123	123	123	123	123	121

TABLE

SUMMARY OF PRODUCTIVITY

(CLEAN COAL TONNES/MAN-SHIFT)

Description	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
UNDERGROUND MINE															
Production	131	232	231	235	242	235	242	273	258	250	250	248	244	252	260
Manpower	493	662	662	662	662	662	662	662	662	662	662	662	617	617	617
Productivity	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.4	1.3	1.3	1.3	1.2	1.3	1.4	1.4
OPEN PIT															
Production	602	732	971	972	972	992	991	968	969	967	969	968	973	973	964
Manpower	404	410	410	410	410	410	410	410	410	410	410	410	410	410	410
Productivity	5.0	6.0	7.9	7.9	7.9	8.1	8.1	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.8
MINE TOTAL															
Production	733	964	1,202	1,207	1,214	1,227	1,233	1,241	1,227	1,217	1,219	1,216	1,217	1,225	1,224
Manpower	1,446	1,746	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,824	1,779	1,779	1,779
Productivity	1.7	1.8	2.2	2.2	2.2	2.2	2.3	2.3	2.2	2.2	2.2	2.2	2.3	2.3	2.3

Description	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
UNDERGROUND MINE																
Production	267	268	268	268	251	251	247	257	256	256	242	153	-	-	-	
Manpower	617	617	617	617	617	617	617	617	617	617	418	418	-	-	-	
Productivity	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.4	1.9	1.2	-	-	-	1.3
OPEN PIT																
Production	970	970	969	978	981	984	985	988	989	974	975	960	961	961	961	
Manpower	410	410	410	410	410	410	410	410	410	410	410	410	410	410	342	
Productivity	7.9	7.9	7.9	8.0	8.0	8.0	8.0	8.0	8.0	7.9	7.9	7.8	7.8	7.8	9.4	7.8
MINE TOTAL																
Production	1,237	1,238	1,237	1,246	1,232	1,235	1,232	1,245	1,245	1,230	1,217	1,113	961	961	961	
Manpower	1,779	1,779	1,779	1,779	1,779	1,779	1,779	1,779	1,779	1,779	1,580	1,580	1,040	1,040	972	
Productivity	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.6	2.3	3.1	3.1	3.3	2.3

CHAPTER 9 COAL TRANSPORTATION

9-1 General Description

In order to supply the coal tonnages required for power station in Jamshoro of approximately 1,200,000 tonnes per annum (as received basis) i.e. 4,000 tonnes per day, the railway system between mine site and power station will be provided for the distance of 64.5 km. For this purpose, the new railway of 27.5 km long having the same gauge with existing Pakistan National Railway from preparation plant to Khanot will be provided and connected with the existing one at Khanot, and new spur track of 5 km long near power station site will be provided. All facilities inclusive of loading and unloading facilities, etc. and equipment will be provided by this plan. However, operation and management will be left to the Pakistan National Railway.

Commuting train between Khanot and mine site will be scheduled at slack time during waiting period for loading, but railway transportation of materials and equipment will be available at slack time in the middle of the night.

9-2 Outline of Transportation Diagram

9-2-1 Transportation System and Diagram

(1) Coal Transportation

The clean coal stocked in clean coal silo at preparation plant will be delivered to wagon by the vibrating feeder. A train comprised of 24 wagons loaded with the 840 tonnes of coal. Coal will be transported from here to the stockpile near power station via new railway to Khanot, existing railway, and new spur track and unloaded. Empty wagons will return on the same route. New railway track will be provided with a single track, and time required for round trip between mine and power station will be approximately 202 minutes, and during this time period next train will be ready to start after loading. Two formation of trains and five round trips will be provided for transportation purpose. The diagram is shown in Fig. 9-1.

(2) Men Transportation

Commuting train between Khanot and mine site will be scheduled at four round trips in a day at the slack time during waiting period for loading.

(3) Materials and Equipment Transportation

Materials and equipment transportation will be available at slack time in the middle of the night.

9-2-2 Main Transportation Equipment

(1) Locomotive

Numbers of locomotive will be planned at 2 units for use and 1 unit for standby.

Major specifications are as follows:

Total length	18,000 mm
Total width	2,970 mm
Total height	3,954 mm
Own weight	84 t
Drive method	Diesel-electric drive
Motor output	825 kw x 2 units

(2) Wagon

Numbers of wagon will be planned at 48 units for use and 5 units for standby.

Major specifications are as follows:

Total length	13,900 mm
Total width	7,700 mm
Total height	3,290 mm
Own weight	18.3 t
Load	35 t

(3) Passenger Coach

4 coaches will be planned for each seating capacity of 80 persons.

(4) Loading Equipment

Loading equipment at preparation plant:	110 t hopper, 800 t/min vibrating feeder
Inspection shades for locomotives and wagons:	300 m² x 2 houses
Workshops:	450 m² x 2
Fuel tanks:	20 kℓ x 1
Washing facility:	1 lot

(5) Tracks

Length of main line	27.5 km
Length of spur	5 km
Gauge	1,676 mm
Rail size	40 N kg/m
Frogs	#10 x 20

(6) Signal Equipment

Signal equipment and telephones will be provided.

9-3 Basis for Operating Cost Calculation

(1) Fuel Consumption: 4,800 ℓ/day

(2) Manpower Requirements: 60 persons

(3) Maintenance Costs:

- o Wagons & rail — 2 % of C&F price
- o Signal, communication, & safety apparatus — 1 % of C&F price
- o Life of locomotive for R & I — 15 years

9-4 Design for Transportation

9-4-1 Condition

(1)	Coal quantity to be transported		1,200,000 t/year 4,000 t/day
(2)	Distance		64.5 km
(3)	Maximum gradient loaded		−20/1,000
(4)	Average speed	loaded	55 km/h
		empty	60 km/h
(5)	Operating hours		18 hours/day

9-4-2 Diagram

				(minutes)
(1)	Time required for one round trip of one train			(minutes)
	(a)	Travelling hour	loaded wagon	74
	(b)	Travelling hour	empty wagon	68
	(c)	Exchanging hour of locomotive at loading point		10
	(d)	Waiting time at Khanot for inflow on P.N.R.		15
	(e)	Unloading hour		20
	(f)	Waiting time at power station for inflow on P.N.R.		15
		Total:		202

(2)	Numbers of round trip	5 times
(3)	Numbers of wagon per train	24 wagons
(4)	Coal quantity per train	840 tonnes

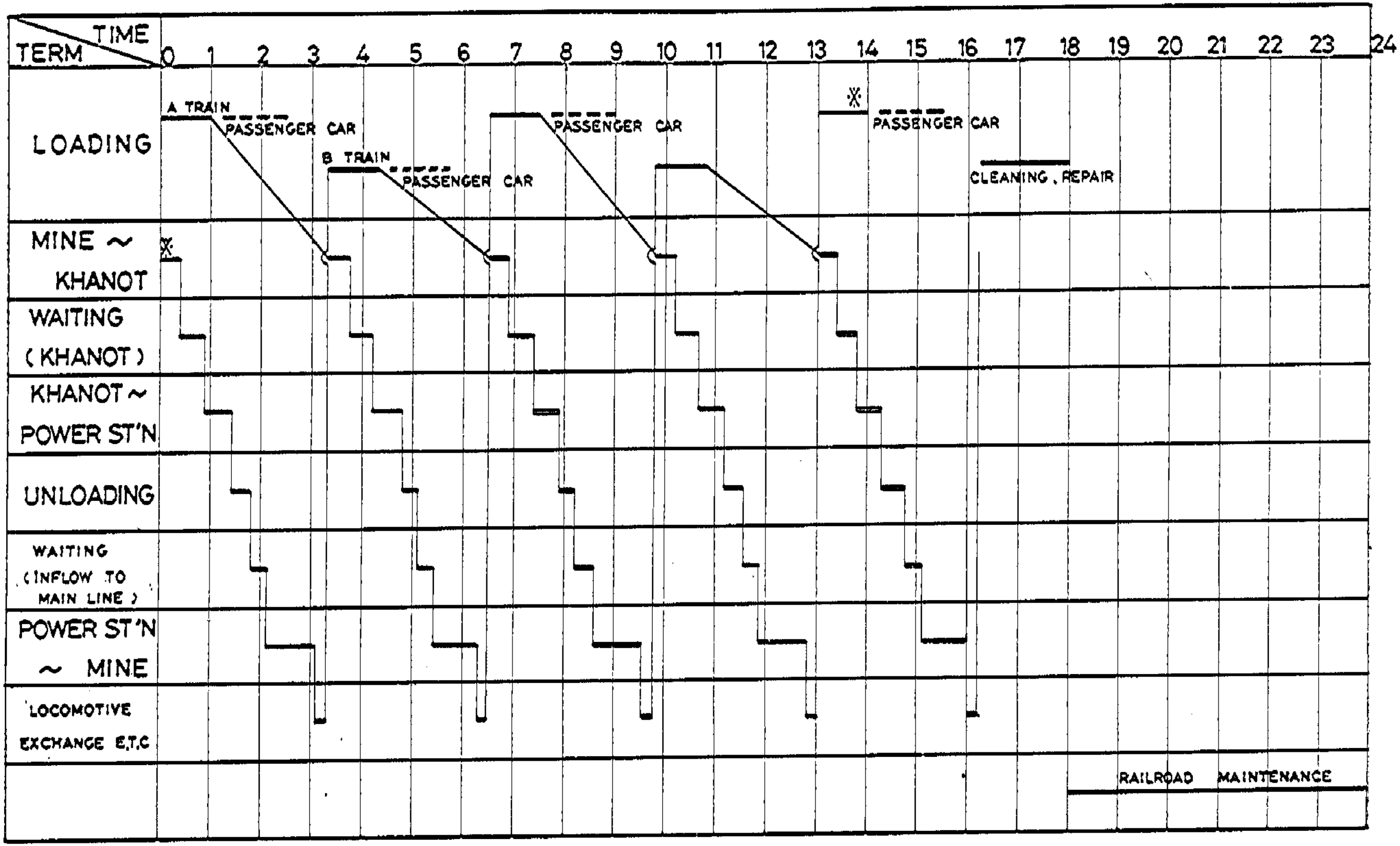


FIGURE 9-1 TRAIN DIAGRAM

CHAPTER 10 EQUIPMENT LIST

The procurement of equipment after detailed design and approval of this project will be conducted by consultant as earliest opportunity. Mechanical equipment, electrical equipment, civil facilities, mining equipment, and a part of capital cost required for this feasibility study are shown in this list, following the items underground mine, open pit, surface facilities, preparation plant, and railway as classified by PMDC.

Machines and materials which will be purchased and/or used for three year periods from 1983 to 1985 are shown in this list.

The cost estimation in foreign currency shows C&F value. The cost estimation in local currency shows L1, L2 value. L1 shows the import duty of 40 % for C&F price, insurance of 1 % for F.O.B. price, and inland transportation cost of 2 % for F.O.B. price.

L2 shows the materials which will be purchased in Pakistan, erection fee, and installation cost.

EQUIPMENT LIST

(INCLUSIVE OF A PART OF CAPITAL COST)

NOTE 1: The equipment shown in this list and within this study is defined in type and manufacturer for this study ONLY. The equipment purchased, should this project be approved, will be determined with respect to both type and manufacturer at the time of purchase.

NOTE 2: F : Foreign currency
L1 : Tax, Insurance & Inland transportation charge
L2 : Local charge

UNDERGROUND MINE

A – (iii) MACHINERY & EQUIPMENT

a) Coal Mining Machinery

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Face Conveyor Double Chain Type 40 kw x 100 t/hour x 120 m	F L1 L2 T.	3	1,253	3,759 1,613 – 5,372	Included in Development Labour Cost	3,759 1,613 – 5,372
Stage Loader Double Chain Type 22.5 kw x 100 t/hour x 60 m	F L1 L2 T.	3	828	2,484 1,068 – 3,522	ditto	2,484 1,068 – 3,522
V Type Chain Conveyor 15 kw x 50 t/hour x 100 m	F L1 L2 T.	2	553	1,106 476 – 1,582	ditto	1,106 476 – 1,582
Hydraulic Prop 2.0 m x 200 kg/cm²	F L1 L2 T.	1,500	6.35	9,525 4,096 – 13,621	ditto	9,525 4,096 – 13,621
Link Bar 1.2 m	F L1 L2 T.	1,500	2.06	3,093 1,330 – 4,423	ditto	3,093 1,330 – 4,423
Plunger Pump with Piping 40 kw x 60 ℓ/min. x 200 kg/cm²	F L1 L2 T.	3	738	2,214 952 – 3,166	ditto	2,214 952 – 3,166
Air Auger 2 kw x 2.2 m³/min. x 1500 r/m	F L1 L2 T.	15	5.07	76 33 – 109	ditto	76 33 – 109
Coal Pick 0.4 kw x 0.9 m³/min. x 1.6 kg/m	F L1 L2 T.	20	2.15	43 18 – 61	ditto	43 18 – 61
Slurry Pump 11 kw x 0.2 m³/min.	F L1 L2 T.	2	137.5	275 118 – 393	ditto	275 118 – 393
Slurry Mixer 5.5 kw x 0.5 m³ x 2 cistern x 2	F L1 L2 T.	2	92	184 79 – 263	ditto	184 79 – 263
Spare Parts for Face Conveyor and Stage Loader (20% of C & F Price)	F L1 L2 T.	6	208.5	1,251 534 – 1,785	– – – –	1,251 534 – 1,785

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Spare Parts for V-Type Chain Conveyor (20% of C & F Price)	F L1 L2 T.	2	111	222 95 – 317	– – – –	222 95 – 317
Spare Parts for Others (10% of C & F Price)	F L1 L2 T.			1,542 663 – 2,205	– – – –	1,542 663 – 2,205
Sub-Total	F L1 L2 T.			25,774 11,075 – 36,849	– – – –	25,774 11,075 – 36,849

b) Road Heading Machine

Description	C.	No.	Unit Price	Materials	Installation	Total
Side Tipping Loader 0.6 m³ x 21 m³/min x 30 kw	F L1 L2 T.	2	650	1,300 558 – 1,858	Included in Development Labour Cost	1,300 558 – 1,858
Gate End Loader (Home Made) 20 m/min. x 6 m³/min x 7.5 kw	F L1 L2 T.	4	109	436 188 – 624	ditto	436 188 – 624
Coal Pick 0.4 kw x 0.9 m³/min x 1.6 kg/m	F L1 L2 T.	13	2.2	28 12 – 40	ditto	28 12 – 40
Air Jack Hammer 5 kg/m x 3.9 m³/min x 5.5 kw	F L1 L2 T.	12	19.7	236 102 – 338	ditto	236 102 – 338
Rod & Bit Rod 22ϕ x 1.5 m ~ 2.7 m Bit dia. 32 ~ 40 mm	F L1 L2 T.	100	1.02	102 44 – 146	ditto	102 444 – 146
Spare Parts for Above (10% of C & F)	F L1 L2 T.			210 90 – 300	– – – –	210 90 – 300
Sub-Total	F L1 L2 T.			2,312 994 – 3,306	– – – –	2,312 994 – 3,306

UNDERGROUND MINE

c) Transportation Machinery (000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Single Drum Winder	F	1	4,329	4,329	–	4,329
28 m/m x 150 m/min x 200 kw	L1			1,848	–	1,848
Drum 1750 m/m x 1500 m/m	L2			–	50	50
	T.			6,177	50	6,227
Single Drum Winder	F	1	299	299	Included in	299
16 m/m x 70 m/min. x 20 kw	L1			188	Development	128
	L2			–	Labour Cost	–
	T.			427		427
Single Drum Winder	F	2	223	446	ditto	446
14 m/m x 60 m/min x 15 kw	L1			191		191
	L2			–		–
	T.			637		637
Material Cars	F.	10	34	340	ditto	340
2,800(L) x 1,000(W) x 500(H)	L1			145		145
m/m	L2			–		–
	T.			485		485
Mine Cars 2.0 m^3	F	200	39	7,800	ditto	7,800
3,050(L) x 1,280(W) x 1,050(H)	L1			7,331		3,331
m/m	L2			–		–
	T.			11,131		11,131
Wire Rope	F	1	69	69	ditto	69
28 m/m x 1,500 m	L1			29		29
	L2			–		–
	T.			98		98
Wire Rope	F	1	16	16	ditto	16
16 m/m x 1,000 m	L1			7		7
	L2			–		–
	T.			23		23
Wire Rope	F	1	14	14	ditto	14
14 m/m x 1,200 m	L1			6		6
	L2			–		–
	T.			20		20
Tippler	F	2	1,418	2,836	–	2,836
75 kw x 3.3 r.p.m	L1			1,211	–	1,211
	L2			–	30	30
	T.			4,047	30	4,077
Belt Conveyor	F	1	1,890	1,890	–	1,890
20 kw x 750 m/m x 150 m	L1			807	–	807
	L2			–	40	40
	T.			2,697	40	2,737
Vibrating Feeder	F	2	56	112	Included in	112
F22-DT	L1			48	Development	48
100 t/h x 1.5 kw	L2			–	Labour Cost	–
	T.			160		160

UNDERGROUND MINE

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Conveyor Scale NW-590 150 t/h	F L1 L2 T.	1	132	132 57 – 189	Included in Development Labour Cost	132 57 – 189
Battery Locomotive 10 t BL10-HX-610 10 km/h x 1,750 kg x 25 kw/2	F L1 L2 T.	2	2,140	4,280 1,828 – 6,108	ditto	4,280 1,828 – 6,108
Battery Locomotive 8t BL8-HX-610 8 km/h x 1,400 kg x 16 kw/2	F L1 L2 T.	5	1,635	8,175 3,490 – 11,665	ditto	8,175 3,490 – 11,665
Diesel Locomotive 6 t DM100 16 km/h x 1500 kg x 50 kw	F L1 L2 T.	2	367	734 315 – 1,049	ditto	734 315 – 1,049
Spare Parts for Battery Locomotive (20% of C & F)	F L1 L2 T.			2,470 1,055 – 3,525	– – – –	2,470 1,055 – 3,525
Spare Parts for Others (10% of C & F)	F L1 L2 T.			1,975 843 – 2,818	– – – –	1,975 843 – 2,818
Sub-Total	F L1 L2 T.			35,917 15,339 – 51,256	– – 120 120	35,917 15,339 120 51,376

d) Drainage Machinery

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Turbine Pump 1.4 m³/min. x 180 m x 55 kw	F L1 L2 T.	2	125	250 107 – 357	Included in Development Labour Cost	250 107 – 357
Turbine Pump 0.5 m³/min. x 280 m x 45 kw	F L1 L2 T.	1		107 46 – 153	ditto	107 46 – 153
Submarsible Pump 0.4 m³/min. x 100 m x 15 kw	F L1 L2 T.	1	40	40 17 – 57	ditto	40 17 – 57

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Submarsible Pump 0.2 m³/min. x 9 m x 1 kw	F L1 L2 T.	2	4.5	9 4 – 13	Included in Development Labour Cost	9 4 – 13
Spare Parts (10% of C & F)	F L1 L2 T.			41 17 – 58	– – – –	41 17 – 58
Sub-Total	F L1 L2 T.			447 191 – 638	– – – –	447 191 – 638

(e) Ventilation Machinery

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Main Fan 500 m³/min. x 200 m/m Aq x 300 kw	F L1 L2 T.	1	2,016	2,016 861 – 2,877	– – 30 30	2,016 861 30 2,907
Local Fan 290 m³/min. x 100 m/m Aq x 7.5 kw	F L1 L2 T.	2	112	224 96 – 320	Included in Development Labour Cost	224 96 – 320
Local Fan 500 m³/min. x 100 m/m Aq x 15 kw	F L1 L2 T.	3	133	399 170 – 569	ditto	399 170 – 569
Ventilation Tube 600 m/m ϕ	F L1 L2 T.	2,500	0.22	550 235 – 785	ditto	550 235 – 785
Ventilation Tube 760 m/m ϕ	F L1 L2 T.	750	0.25	188 80 – 268	ditto	188 80 – 268
Spare Parts (5% of C & F)	F L1 L2 T.			169 73 – 242	ditto	169 73 – 242
Sub-Total	F L1 L2 T.			3,546 1,515 – 5,061	– – 30 30	3,546 1,515 30 5,091

UNDERGROUND MINE

(f) Air & Water Machinery

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Air Compressor TW75E 7 kg/cm² x 12 m³/min. x 75 kw	F L1 L2 T.	1	298	298 128 — 426	 5 5	298 128 5 431
Air Compressor BTD-1CC 8.5 kg/cm²/x 51.2 m³/min. x 240 kw	F L1 L2 T.	2	977	1,954 834 30 2,788	 30 30	1,954 834 30 2,818
Turbine Pump 0.4 m³/min. x 100 m x 15 kw	F L1 L2 T.	2	76	152 64 — 216	Included in Development Labour Cost	152 64 — 216
Spare Parts (10% of C & F)	F L1 L2 T.			240 103 — 343	— — — —	240 103 — 343
Sub-Total	F L1 L2 T.			2,644 1,129 — 3,773	— — 35 35	2,644 1,129 35 3,808

(g) Other Machinery

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Portable Methanometer 0 ~ 10%	F L1 L2 T.	60	7.4	444 191 — 635	Included in Development Labour Cost	444 191 — 635
Portable Methanometer 0 ~ 100%	F L1 L2 T.	10	7.4	74 32 — 106	ditto	74 32 — 106
CO Mask 2 hours	F L1 L2 T.	700	0.37	259 111 — 370	ditto	259 111 — 370
Portable Gas Alarm	F L1 L2 T.	8	20	160 68 — 228	ditto	160 68 — 228
Safety Lamp with Helmet & Belt	F L1 L2 T.	700	2.3	1,610 691 — 2,301	ditto	1,610 691 — 2,301

(g) Other Machinery (000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Safety Shoess	F L1 L2 T.	700	0.15	105 45 — 150	Included in Development Labour Cost	105 45 — 150
CO Detector	F L1 L2 T.	10	2.5	25 11 — 36	ditto	25 11 — 36
O_2 Self Rescue	F L1 L2 T.	30	2.5	75 32 — 107	ditto	75 32 — 107
Survey Instrument	F L1 L2 T.	1	92	92 39 — 131	ditto	92 39 — 131
Spare Parts (5% of C & F)	F L1 L2 T.			142 61 — 203	ditto	142 61 — 203
Sub-Total	F L1 L2 T.			2,986 1,281 — 4,267	— — — —	2,986 1,281 — 4,267
Total	F L1 L2 T.			73,626 31,525 — 105,150	— — 185 185	73,626 31,524 185 105,335

UNDERGROUND MINE

(V) PRELIMINARY EXPENSES (000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Travel Expense	F L1 L2 T.	4 men	27.5	110 – – 110	– – – –	110 – – 110
Fee	F L1 L2 T.	360 days	4.5	1,620 – – 1,620	– – – –	1,620 – – 1,620
Total	F L1 L2 T.			1,730 – – 1,730	– – – –	1,730 – – 1,730

(VI) CONSTRUCTION & DEVELOPMENT (000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Arched Support	F	2,996	1,536	4,602	Included in	4,602
22.7 kg/m 3 pieces	L1	set		1,967	Development	1,967
2.947 m x 2, 3,200 m x 1	L2			—	Labour Cost	—
(with tie lod, bolt & nut)	T.			6,569		6,569
I – Beam 3.0 m	F	1,334	0.458	611	ditto	611
22.7 kg/m	L1	set		261		261
(with tie lod)	L2			—		—
	T.			872		872
I – Beam 3.6 m	F	306	0.55	168	ditto	168
22.7 kg/m	L1	set		72		72
(with tie lod)	L2			—		—
	T.			240		240
Rail 22 kg/m	F	10,449	0.2117	2,212	ditto	2,212
(with fish plate, spike and	L1	m		945		945
sleeper)	L2			—		—
	T.			3,157		3,157
Rail 15 kg/m	F	2,493	0.1388	346	ditto	346
(with fish plate, spike and	L1	m		147		147
sleeper)	L2			—		—
	T.			493		493
Pipe 8"	F	950	0.196	186	ditto	186
(with joint)	L1	m		79		79
	L2			—		—
	T.			265		265
Pipe 6"	F	1,810	0.1292	234	ditto	234
(with joint)	L1	m		100		100
	L2			—		—
	T.			334		334
Pipe 4"	F	3,530	0.0945	334	ditto	334
(with joint)	L1	m		143		143
	L2			—		—
	T.			477		477
Pipe 3"	F.	1,525	0.0668	102	ditto	102
(with joint)	L1	m		44		44
	L2			—		—
	T.			146		146
Pipe 2"	F	2,000	0.0334	67	ditto	67
(with joint)	L1	m		26		26
	L2			—		—
	T.			93		93
Pipe 1"	F	1,375	0.016	22	ditto	22
(with joint)	L1	m		9		9
	L2			—		—
	T.			31		31

UNDERGROUND MINE

(000's Rupees)

Description	C.	No.	Unit Price	Materilas	Installation	Total
Millisecond Detonator 1.5 m	F L1 L2 T.	156,600 No.	0.0061	955 408 — 1,363	Included in Development Labour Cost	955 408 — 1,363
Ventilation Tube 660 m/m ϕ	F L1 L2 T.	380 m	0.22	84 34 — 118	ditto	84 34 — 118
Timber	F L1 L2 T.	1,180 m^3	0.1	— — 118 118	ditto	— — 118 118
Explosive Ammonium Nitrate	F L1 L2 T.	28,670 kg	0.018	— — 516 516	ditto	— — 516 516
Machine Oil	F L1 L2 T.	66,000 ℓ	0.005	— — 330 330	ditto	— — 330 330
Compressor Oil	F L1 L2 T.	350,000 ℓ	0.01	— — 3,500 3,500	ditto	— — 3,500 3,500
Fuel Oil	F L1 L2 T.	35,600 ℓ	0.0045	— — 160 160	ditto	— — 160 160
Rock Dust	F L1 L2 T.	200 kg	0.75	— — 150 150	ditto	— — 150 150
Concrete Cement, Sand, Aggregate	F L1 L2 T.	86 m^3	1.1	— — 95 95	ditto	— — 95 95
Miscellaneous Air Hose 2", Water Hose 1" Blasting Wire	F L1 L2 T.			152 66 — 218	— — 9 9	152 66 9 227
Sub-Total	F L1 L2 T.			10,075 4,301 4,869 19,254	— — 9 9	10,075 4,301 4,878 19,254

UNDERGROUND MINE

(000's Rupees)

Description	C.	No.	Unit Price	Materials	Installation	Total
Machine Maintenance	F L1 L2 T.			143 60 – 203	– – 80 80	143 60 80 283
Portal	F L1 L2 T.			– – 310 310	Included in Development Labour Cost	– – 310 310
Power	F L1 L2 T.			– – 2,791 2,791	– – – –	– – 2,791 2,791
Sub-Total	F L1 L2 T.			143 60 3,101 3,304	– – 80 80	143 60 3,181 3,384
TOTAL	F L1 L2 T.			10,218 4,361 7,970 22,549	– – 89 89	10,218 4,361 8,059 22,638

OPEN PIT

A (iii) MACHINERY & EQUIPMENT (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation & Erection	Total
Blast hole drill 45R x 9-7/8" ϕ	F	4	9,950	39,800	1,990	41,790
	L1			16,995	–	16,995
	L2			–	398	398
	T.			56,795	2,388	59,183
Rotary drill HBM15K/HY (80 mm ϕ)	F	2	3,780	7,560	302	7,862
	L1			3,228	–	3,228
	L2			–	76	76
	T.			10,788	378	11,166
Power shovel P & H 2100 11.5 m^3	F	4	14,850	59,400	3,564	62,964
	L1			25,364	–	25,364
	L2			–	1,188	1,188
	T.			84,764	4,752	89,516
Hydraulic excavator WH30 6.0 m^3	F	2	3,570	7,140	214	7,354
	L1			3,049	–	3,049
	L2			–	143	143
	T.			10,189	357	10,546
Wheel loader KHI 110Z 5.6 m^3	F	4	3,020	12,080	362	12,442
	L1			5,158	–	5,158
	L2				242	242
	T.			17,238	604	17,842
Motor Scraper WS 23S 24 m^3	F.	7	3,665	25,655	770	26,425
	L1			10,955	–	10,955
	L2			–	513	513
	T.			36,610	1,283	37,893
Motor grader GD 705R-2	F	4	1,145	4,580	137	4,717
	L1			1,956	–	1,956
	L2			–	92	92
	T.			6,536	229	6,765
Bulldozer D 355A	F	19	3,070	58,330	583	58,913
	L1			24,907	–	24,907
	L2			–	2,333	2,333
	T.			83,237	2,916	86,153
Bulldozer D 155A	F	6	2,040	12,240	122	12,362
	L1			5,226	–	5,226
	L2			–	489	489
	T.			17,466	611	18,077
Rear dump truck HD 1200 120 t	F	18	9,720	174,960	3,500	178,460
	L1			74,707	–	74,707
	L2			–	5,248	5,248
	T.			249,667	8,748	258,415
Rear dump truck HD 460 460	F	12	3,540	42,480	849	43,329
	L1			18,138	–	18,138
	L2			–	1,275	1,275
	T.			60,618	2,124	62,742

OPEN PIT

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation & Erection	Total
Explosives truck	F L1 L2 T.	2	360	720 307 – 1,027	– – 14 14	720 307 14 1,041
Water Truck KB 122	F L1 L2 T.	2	731	1,462 624 – 2,086	– – 29 29	1,462 624 29 2,115
Crusher KAP-35	F L1 L2 T.	2	280	560 239 – 799	– – 11 11	560 239 11 810
Stores truck TK20	F L1 L2 T.	2	260	520 222 – 742	Included in Development Labour Cost	520 222 – 742
Fuel truck	F L1 L2 T.	2	260	522 222 – 742	– – – –	522 222 – 742
35 t Truck crane TG-350M	F L1 L2 T.	1	1,740	1,740 743 2,483	17 70 87	1,757 743 70 2,570
6 t Truck crane TS-60L	F L1 L2 T.	1	467	467 199 – 666	5 – 19 24	472 199 19 690
Site vehicle Pick-up	F L1 L2 T.	12	72	864 369 – 1,233	Included in Development Labour Cost	864 369 – 1,233
Drainage pump EH 1530	F L1 L2 T.	4	31	124 52 – 176	– – 2 2	124 52 2 178
Mobilewelding unit	F L1 L2 T.	2	129	258 110 – 368	Included in Development Labour Cost	258 110 – 368
4000W Lighting set	F L1 L2 T.	4	90	360 154 – 514	4 – 14 18	364 154 14 532

OPEN PIT

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation & Erection	Total
Cargo truck TK20	F L1 L2 T.	4	260	1,040 444 – 1,484	Included in Development Labour Cost	1,040 444 – 1,484
Sub-Total	F L1 L2 T.			452,860 193,368 – 646,228	12,419 – 12,156 24,575	465,279 193,368 12,156 670,803
Spare Parts Blast hole drill	F L1 L2 T.	4	3,262	13,048 5,614 – 18,662	Included in Development Labour Cost	13,048 5,614 – 18,662
Spare parts Rotary drill	F L1 L2 T.	2	1,240	2,480 1,059 – 3,539	ditto –	2,480 1,059 – 3,539
Spare parts Power shovel	F L1 L2 T.	4	5,280	21,120 9,018 – 30,138	ditto –	21,120 9,018 – 20,138
Spare parts Hydraulic excavator	F L1 L2 T.	2	906	1,812 774 – 2,586	ditto –	1,812 774 – 2,586
Spare parts Wheel loader	F L1 L2 T.	4	968	3,872 1,653 – 5,525	ditto –	3,872 1,653 – 5,525
Spare parts Motor scraper	F L1 L2 T.	7	1,198	8,386 3,581 – 11,967	ditto –	8,386 3,581 – 11,967
Spare parts Motor grader	F L1 L2 T.	4	371	1,484 634 – 2,118	ditto –	1,484 634 – 2,118
Spare parts Bulldozer D 355A	F L1 L2 T.	19	1,048	19,912 8,502 – 28,414	ditto – – –	19,912 8,502 – 28,414
Spare parts Bulldozer D 155A	F L1 L2 T.	6	685	4,110 1,755 – 5,865	ditto –	4,110 1,755 – 5,865

OPEN PIT

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation & Erection	Total
Spare parts Rear dump truck HD 1200	F L1 L2 T.	18	3,564	64,152 27,393 — 91,545	ditto —	64,152 27,393 — 91,545
Spare parts Rear dump truck HD 460	F L1 L2 T.	12	1,296	15,552 6,642 — 22,194	ditto —	15,552 6,642 — 22,194
Spare parts Others	F L1 L2 T.	1	2,000	2,000 854 — 2,854	ditto —	2,000 854 — 2,854
Sub-Total	F L1 L2 T.			157,928 67,479 — 225,407	— — — —	157,928 67,479 — 225,407
TOTAL	F L1 L2 T.			610,788 260,847 — 871,635	12,419 — 12,156 24,575	623,207 260,847 12,156 896,210

OPEN PIT

(VI) CONSTRUCTION & DEVELOPMENT

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation & Erection	Total
Parts supply Truck tyre Explosives Sub-Total	F F F			67,610 30,700 81,252 179,562	Included in Labour Cost	67,612 30,700 81,252 179,562
Custom duty etc.	L1			76,672	–	76,672
Repair materials Electric power Fuel, oil Sub-Total	L2 L2 L2			13,522 4,450 116,081 134,053	ditto –	13,522 4,450 116,081 134,053
TOTAL	F L1 L2 T.			179,562 76,672 134,053 390,287	ditto	179,562 76,672 134,053 390,287

SURFACE FACILITIES

A PRODUCTION FACILITIES

(i) LAND AND IMPROVEMENT

(000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Earth work for surface buildings	F L1 L2 T.	20,000 m^2	0.0062	– – 124 124	– – 124 124
Earth work for site of buildings	F L1 L2 T.	190,000 m^2	0.00042	– – 80 80	– – 80 80
Earth work for roads (Coal haulage road) 20 m wide	F L1 L2 T.	6 km	3.2	– – 19 19	– – 19 19
Earth work for roads (inside mine) 10 m wide	F L1 L2 T.	3 km	1.6	– – 5 5	– – 5 5
Earth work for roads (outside mine) 10 m wide	F L1 L2 T.	30 km	1.6	– – 48 48	– – 48 48
Earth work for railway (Narrow gauge) 5 m wide	F L1 L2 T.	4 km	0.8	– – 3 3	– – 3 3
Sub-Total	F L1 L2 T.			– – 279 279	– – 279 279

SURFACE FACILITIES

(ii) BUILDINGS

a) FACTORY BUILDINGS

(000's Rupees)

Description	C.	No.	Unit Price	Installation Materials	Total
Sub station 25 m x 50 m Reinforced concrete and brick construction	F L1 L2 T.	 1,250 m²	 0.81	– – 1,013 1,013	– – 1,013 1,013
Power house 6 m x 25 m Reinforced concrete and brick construction	F L1 L2 T.	 150 m²	 0.81	– – 121 121	– – 121 121
Compressor room 8 m x 25 m Reinforced concrete and brick construction	F L1 L2 T.	 200 m²	 0.81	– – 162 162	– – 162 162
Posting room, Safty lamp room etc. 20 m x 45 m Reinforced concrete and brick construction	F L1 L2 T.	 900 m²	 0.81	– – 729 729	– – 729 729
Main winding room 10 m x 12 m Reinforced concrete and brick construction	F L1 L2 T.	 120 m²	 0.81	– – 97 97	– – 97 97
Sub-winding room 5 m x 6 m Reinforced concrete and brick construction	F L1 L2 T.	 30 m²	 0.81	– – 24 24	– – 24 24
Fan room 5 m x 6 m Reinforced concrete and brick construction	F L1 L2 T.	 30 m²	 0.81	– – 24 24	– – 24 24
Sub-Total	F L1 L2 T.			– – 2,170 2,170	– – 2,170 2,170

SURFACE FACILITIES

b) ROADS

(000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Coal haulage road Asphalted 10 m effective wide	F L1 L2 T.	6 km	360	– – 2,160 2,160	– – 2,160 2,160
Inbye road Asphalted 3.5 m effective wide road	F L1 L2 T.	3 km	140	– – 420 420	– – 420 420
Outbye road Asphalted 3.5 m effective wide Road from Khanot to mines at Lakhra etc.	F L1 L2 T.	30 km	140	– – 4,200 4,200	– – 4,200 4,200
Sub-Total	F L1 L2 T.			– – 6,780 6,780	– – 6,780 6,780

c) WATER SUPPLY FACILITIES

1) Water Intake FAcilities

(000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Pontonns 6 m x 30 m Steel structure	F L1 L2 T.	1 lot		– – 124 124	– – 124 124
Pump house 3 m x 6 m Timber construction	F L1 L2 T.	18 m²	0.72	– – 13 13	– – 13 13
Sand basin 4 m x 30 m x 2 mH x 2 lot Reinforced concrete construction	F L1 L2 T.	240 m³	1.82	– – 437 437	– – 437 437
Sub-Total	F L1 L2 T.			– – 574 574	– – 574 574

SURFACE FACILITIES

2) Water Purification Facilities (000's Rupees)

Description	C.	No.	Unit Price	Installation Materials	Total
(A light weel) Well for flow of water control 2 m x 6 m x 3 mH Reinforced concrete construction	F L1 L2 T.	36 m³	1.82	– – 66 66	– – 66 66
Coagulation basin etc. 10 m x 30 m x 3 mH x 2 2 m x 2 m x 3 mH 1,956 m³ 4 m x 12 m x 3 mH Reinforced concrete construction	F L1 L2 T.	1,956 m³	1.82	– – 3,560 3,560	– – 3,560 3,560
Rapid filter 8 m x 4 m x 3 mH x 2 lot Reinforced concrete construction	F L1 L2 T.	192 m³	1.82	– – 349 349	– – 349 349
Clear water reservoir 10 m x 10 m x 3.5 mH Reinforced concrete construction	F L1 L2 T.	350 m³	1.82	– – 637 637	– – 637 637
Chlorination room 2 m x 3 m Timber construction	F L1 L2 T.	6 m²	0.72	– – 4 4	– – 4 4
Sub-Total	F L1 L2 T.			– – 4,616 4,616	– – 4,616 4,616

3) Water Distribution Facilities (000's Rupees)

Description	C.	No.	Unit Price	Installation Materials	Total
Service reservoir (Mine site) 10 m x 10 m x 5.5 mH Reinforced concrete construction	F L1 L2 T.	550 m³	1.82	– – 1,001 1,001	– – 1,001 1,001
Service reservoir (Colony) 10 m x 28 m x 5.5 mH Reinforced concrete construction	F L1 L2 T.	1,540 m³	1.82	– – 2,803 2,803	– – 2,803 2,803
Sub-Total	F L1 L2 T.			– – 3,804 3,804	– – 3,804 3,804
Total	F L1 L2 T.			– – 8,994 8,994	– – 8,994 8,994

SURFACE FACILITIES

(iii) MACHINERY & EQUIPMENT

(a) Water Supply Equipment (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Turbine pump 1.1 m^3/min. x 185 mH x 55 kw	F L1 L2 T.	4	92	368 158 – 526	Included in Labour Cost	368 158 – 526
Turbine pump 1.7 m^3/min. x 90 mH x 45 kw	F L1 L2 T.	3	77	231 99 – 330	ditto	231 99 – 330
Turbine pump 2.6 m^3/min. x 55 mH x 37 kw	F L1 L2 T.	3	72	216 92 – 308	ditto	216 92 – 308
Turbine pump 1.7 m^3/min. x 30 mH x 15 kw	F L1 L2 T.	3	41	123 52 – 175	ditto	123 52 – 175
Cleaning equipment 1 lot (Settling pond cleaning & local pump, Pipe etc.)	F L1 L2 T.	1 lot		205 88 – 293	ditto	205 88 – 293
Spare parts of pump etc. Amount price x 5%	F L1 L2 T.	1 lot		57 24 – 81	ditto	57 24 – 81
Installation of pump etc. Total weight 50 t	F L1 L2 T.	 1 lot		– – – –	 40 40	– – 40 40
Sub-Total	F L1 L2 T.			1,200 513 – 1,713	– – 40 40	1,200 513 40 1,753

SURFACE FACILITIES

(b) Pipelines

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Ductile cast iron pipe JWWA G110 250A x 1,000 m	F L1 L2 T.	1,000 m	0.47/m	470 202 – 672	Included in Labour Cost	470 202 – 672
Ductile cast iron pipe JWWA G110 200A x 29,000 m	F L1 L2 T.	29,000 m	0.37/m	10,730 4,605 – 15,335	ditto	10,730 4,605 – 15,335
Ductile cast iron pipe JWWA G110 150A x 1,000 m	F L1 L2 T.	1,000 m	0.28/m	280 120 – 400	ditto	280 120 – 400
Ductile cast iron pipe JWWA G110 50A x 6,000 m	F L1 L2 T.	6,000 m	0.14/m	840 360 – 1,200	ditto	840 360 – 1,200
Spare parts of pipes Amount price x 3%	F L1 L2 T.	1 lot		370 160 – 530	ditto	370 160 – 530
Burying pipes cost 250A 13 km x 1 km 200A 11 km x 29 km 150A 10 km x 1 km 50A 7 km x 6 km	F L1 L2 T.	1 lot		– – – –	– – 384 384	– – 384 384
Earthwork cost 150 ~ 250A 4.7 km x 31 km 50A 9.4 km x 6 km	F L1 L2 T.	1 lot		– – – –	– – 202 202	– – 202 202
Sub-Total	F L1 L2 T.			12,690 5,447 – 18,137	– – 586 586	12,690 5,447 586 18,723

(c) Machine Repairshop

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Mechanical workshop Lathe, Shaper Drilling machine, Screw cutting etc.	F L1 L2 T.	1 lot		877 375 – 1,252	Included in Labour Cost	877 375 – 1,252
Blacksmith's shop Anvil, Roots blower, Smith hearth, Air hammer etc.	F L1 L2 T.	1 lot		284 123 – 407	ditto	284 123 – 407
Foundry shop Cupola, Turbo fan, Mill etc.	F L1 L2 T.	1 lot		380 163 – 543	ditto	380 163 – 543
Wood-working plant Circle saw, Belt saw, Wood lathe, Hand planer etc.	F L1 L2 T.	1 lot		603 260 – 863	ditto	603 260 – 863
Metal working shop Electric welding, Gas welding, Hack saw, Pipe cutter etc.	F L1 L2 T.	1 lot		310 133 – 443	ditto	310 133 – 443
Mine car repairshop Drilling machine, Welding Blowtorch, Hydraulic jack etc.	F L1 L2 T.	1 lot		93 40 – 133	ditto	93 40 – 133
Other Measure instrument Spare parts Installation etc.	F L1 L2 T.	1 lot		213 91 – 304	– – 45 45	213 91 45 349
Sub-Total	F L1 L2 T.			2,760 1,185 – 3,945	– – 45 45	2,760 1,185 45 3,990

(d) Heavy Vehicle Repairshop (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Repair bay Overhead crane, Hydraulic press, ARC welder, Bearing heater, Hydraulic jack etc.	F L1 L2 T.	1 lot		734 315 — 1,049	Included in Labour Cost	734 315 — 1,049
Engine specialization Engine cart, Parts wagon, Jib crane, Overhead crane, Valve lifter, Tachometer etc.	F L1 L2 T.	1 lot		524 224 — 748	ditto	524 224 — 748
Power train specialization Bench vice, Cylinder stand, Parts cleaner etc.	F L1 L2 T.	1 lot		29 12 — 41	ditto	29 12 — 41
Welding & Fabrication area Hydraulic press, ARC welder Semiautomatic welder, High speed cutter, Annil etc.	F L1 L2 T.	1 lot		106 45 — 151	ditto	106 45 — 151
Dynamometer room Absorption, Fuel tank, Cooling tower Overhead crane etc.	F L1 L2 T.	1 lot		397 171 — 568	ditto	397 171 — 568
Radiator repair room Jib crane, Repair stand Gas cutting tool Radiator tester etc.	F L1 L2 T.	1 lot		88 38 — 126	ditto	88 38 — 126
Component cleaning room Steam cleaner Hot water cleaner etc.	F L1 L2 T.	1 lot		29 12 — 41	ditto	29 12 — 41
Battery maintenance room Water purifier, Bench vice, Battery charger etc.	F L1 L2 T.	1 lot		219 94 — 313	ditto	219 94 — 313
Machine shop Lathe, Milling machine, Drilling machine, Sawing machine grinder etc.	F L1 L2 T.	1 lot		408 176 — 584	ditto	408 176 — 584
Electric component special Test bench, Armature lathe, Dryer, Motor puller set etc.	F L1 L2 T.	1 lot		114 49 — 163	ditto	114 49 — 163
Fuel injection pump special Pump test stand, P.T pump tester, Nozzle tester, Parts cleaner etc.	F L1 L2 T.	1 lot		186 81 — 267	ditto	186 81 — 267

SURFACE FACILITIES

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Turbocharger specialization & Tool room Hydraulic press, Hot oil bath, Hand truck etc.	F L1 L2 T.	1 lot		26 10 – 36	Included in Labour Cost	26 10 – 36
Undercarriage repair shop Truck link repair machine Overhead crane etc.	F L1 L2 T.	1 lot		619 266 – 885	ditto	619 266 – 885
Undercarriage repair shop Roller & Idler press, Jib crane, Overhead crane etc.	F L1 L2 T.	1 lot		928 399 – 1,327	ditto	928 399 – 1,327
Preventive maintenance shop Air compressor Pump & Tester etc.	F L1 L2 T.	1 lot		799 343 – 1,142	ditto	799 343 – 1,142
Tyre service shop Overhead crane, Tyre mounting, Hydraulic jack, Air compressor etc.	F L1 L2 T.	1 lot		323 138 – 461	ditto	323 138 – 461
Painting & Cleaning shop Ventilating fan, Painting equipment, Car cleaner, Steam cleaner etc.	F L1 L2 T.	1 lot		140 60 – 200	ditto	140 60 – 200
Hydraulic test room Hydraulic tester, Work bench etc	F L1 L2 T.	1 lot		106 45 – 151	ditto	106 45 – 151
Other Measure instrument Spare parts Installation etc.	F L1 L2 T.	1 lot		488 208 – 696	– – 64 64	488 208 64 760
Sub-Total	F L1 L2 T.			6,263 2,686 – 8,949	– – 64 64	6,263 2,686 64 9,013

SURFACE FACILITIES

(e) Power House Machinery (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Mobile Generator 100 kVA, 400 V, 3 phase, 50 Hz Sled mounted type	F L1 L2 T.	2	192	384 165 – 549	– – 1 1	384 165 1 550
Emergency Generator 500 kVA, 3.3 kV, 3 phase c/w Switches & Panels	F L1 L2 T.	2	770	1,540 658 – 2,198	– – 11 11	1,540 658 11 2,209
Spare parts for 5 years Operation for mobile Generator	F L1 L2 T.	1 lot		156 66 – 222	– – – –	156 66 – 222
Spare parts for 5 years for Emergency generator	F L1 L2 T.	1 lot		616 263 – 879	– – – –	616 263 – 879
Sub-Total	F L1 L2 T.			2,696 1,152 – 3,848	– – 12 12	2,696 1,152 12 3,860

(f) Electrical Workshop (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Overhead crane 5 ton x 10 m Travelling type	F L1 L2 T.	1		97 42 — 139	Included in Development Labour Cost	97 42 — 139
Test Operation Device 3.3 kV, 400 V, 230 V & 24 V, Oil immersed self cooling type	F L1 L2 T.	1		141 60 — 201	ditto	141 60 — 201
Induction Regulator 3 phase, 50 kVA, 230 V ± 230 V	F L1 L2 T.	1		134 57 — 191	ditto	134 57 — 191
Grinding Machine Bench type	F L1 L2 T.	1		15 6 — 21	ditto	15 6 — 21
Coil Winding Machine Manual operation type	F L1 L2 T.	1		18 8 — 26	ditto	18 8 — 26
Instruments Apparatus and Tools, etc.	F L1 L2 T.	1		295 126 — 421	ditto	295 126 — 421
Sub-Total	F L1 L2 T.			700 299 — 999	— — — —	700 299 — 999
TOTAL	F L1 L2 T.			26,309 11,282 — 37,591	— — 747 747	26,309 11,282 747 38,338

A – iv) ELECTRICAL EQUIPMENT INSTALLATION

a) Surface Power Distribution (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Overhead power line 33 kV	F L1 L2 T.	10	287.5	2,875 1,225 – 4,100	– – 76 76	2,875 1,225 76 4,176
Overhead power line 3.3 kV	F L1 L2 T.	4	172.5	690 294 – 984	– – 21 21	690 294 21 1,005
Mine substation 4,000 kVA, 33 kV, 3.3 kV, 50 Hz c/w 4,000 kVA oil immersed 3 phase transformer, 1ry & 2ry circuit breakers, switchgears, etc.	F L1 L2 T.	1		7,978 3,424 – 11,402	– – 38 38	7,978 3,424 38 11,440
Lighting transformer 5 kVA, 3.3 kV to 200 & 100 V, 50 Hz Single phase, oil immersed, c/w switches	F L1 L2 T.	4	4.25	17 7 – 24	– – 1 1	17 7 1 25
Lighting fixture Fluorescent lamp, 100 V 20 W c/w automatic switch	F L1 L2 T.	100	0.53	53 23 – 76	– – 2 2	53 23 2 78
Ditto Mercury lamp, 200 V, 1 kW	F L1 L2 T.	4	10.5	42 18 – 60	– – 2 –	42 18 2 62
Fluorescent Lamp 100 V 20 W, c/w Startor	F L1 L2 T.	200	0.015	3 1 – 4	– – – –	3 1 – 4
Mercury lamp 200 V, 1 kW, c/w Startor	F L1 L2 T.	8	0.25	2 1 – 3	– – – –	2 1 – 3
Miscellaneous	F L1 L2 T.	1 lot		720 306 – 1,026	– – 13 13	720 306 13 1,039
Spare parts for 5 years operation for 33 kV overhead power line	F L1 L2 T.			29 13 – 42	– – – –	29 13 – 42

SURFACE FACILITIES

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Spare parts for 5 year Operation for 3.3 kV overhead power line	F L1 L2 T.			7 3 – 10	– – – –	7 3 – 10
Spare parts for 5 years operation for Mine substation	F L1 L2 T.			406 174 – 580	– – – –	406 174 – 580
Sub-Total	F L1 L2 T.			12,822 5,489 – 18,311	– – 153 153	12,822 5,489 153 18,464

b) Open Pit Power

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Overhead power line 3.3 kV	F L1 L2 T.	14 km	165	2,310 987 3,297	– – 45 45	2,310 987 45 3,342
Mobile substation 2,500 kVA, 33 kV to 3.3 kV, 50 Hz Sled mounted type, c/w 2,500 kVA Oil immersed 3 phase transformer, 1ry & 2ry switchgears, etc.	F L1 L2 T.	2	2,360	4,720 2,022 – 6,742	– – 4 4	4,720 2,022 4 6,746
Mobile switching station 3.3 kV, 600 A, Sled mounted type	F L1 L2 T.	14	50	700 300 – 1,000	– – 4 4	700 300 4 1,004
Trailing cable 3 kV, 3c x 80 mm² with 3c ground wire, Synthetic rubber cable with steel wire braid	F L1 L2 T.	800 m	1.76	1,408 602 – 2,010	– – 4 4	1,408 602 4 2,014
Trailing cable 3 kV, 3c x 22 mm² with 3c ground wire Same as above	F L1 L2 T.	800 m	0.528	422 180 – 602	– – 2 2	422 180 2 604

SURFACE FACILITIES

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Cable coupler 3 kV, for 3c x 80 mm² trailing cable	F L1 L2 T.	4	154	616 264 – 880	Included in Development Labour Cost	616 264 – 880
Cable coupler 3 kV, for 3 c x 22 mm² trailing cable	F L1 L2 T.	4	110	440 188 – 628	ditto	440 188 – 628
Termination Material for 3 kV 3c x 80 mm² & 22 mm² trailing cables	F L1 L2 T.	1 lot		852 364 – 1,216	ditto	852 364 – 1,216
Cable rut for trailing cable	F L1 L2 T.	4	392	1,568 670 – 2,238	ditto	1,568 670 – 2,238
Spare parts for 5 years operation for 3.3 kV overhead power line	F L1 L2 T.			24 10 – 34	– – – –	24 10 – 34
Spare parts for 5 years for mobile substation	F L1 L2 T.			118 50 – 168	– – – –	118 50 – 168
Spare parts for 5 years for mobile switching station	F L1 L2 T.			62 22 – 89	– – – –	62 27 – 89
Sub-Total	F L1 L2 T.			13,240 5,664 – 18,904	– – 59 59	13,240 5,664 59 18,963

c) Underground Mine

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Line switch 3.3 kV, 300 A, Dry type, Explosion proof	F L1 L2 T.	1		55 24 – 79	Included in Development Labour Cost	55 24 – 79

SURFACE FACILITIES

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Line switch 3.3 kV, 100 A, Dry type, Explosion proof	F L1 L2 T.	13	37	481 206 — 687	Included in Development Labour Cost	481 206 — 687
Mine power centre 300 kV, 3.3 kV to 200 V, 50 Hz 3 phase, Dry type Explosion proof	F L1 L2 T.	1		467 200 — 667	ditto	467 200 — 667
Mine power centre 200 kVA Same as above Same as above	F L1 L2 T.	1		433 186 — 619	ditto	433 186 — 619
Mine power centre 150 kVA Same as above	F L1 L2 T.	6	418	2,508 1,077 — 3,585	ditto	2,508 1,077 — 3,585
Air circuit breaker 3.3 kV, 100 A Explosion proof	F L1 L2 T.	8	133	1,064 457 — 1,521	ditto	1,064 457 — 1,521
Air circuit breaker 400 V, 400 A Explosion proof	F L1 L2 T.	9	24	216 92 — 308	ditto	216 92 — 308
Earth relay 400V, for alarm and trip Explosion proof	F L1 L2 T.	9	19	171 73 — 244	ditto	171 73 — 244
Gate end box 400 V, 225 A, Explosion proof	F L1 L2 T.	16	13	208 89 — 297	ditto	208 89 — 297
Gate end box 400 V, 225 A, Reversible Explosion proof	F L1 L2 T.	5	22	110 47 — 157	ditto	110 47 — 157
Gate end box 400 V, 50 A Explosion proof	F L1 L2 T.	5	9.2	46 20 — 66	ditto	46 20 — 66
Gate end box 400 V, 50 A, Reversible Explosion proof	F L1 L2 T.	7	14	98 42 — 140	ditto	98 42 — 140

c) U/G Mine

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Gate end box 400 V, 25 A	F L1 L2 T.	6	8.5	51 22 — 73	Included in Development Labour Cost	51 22 — 73
Control transformer	F L1 L2 T.	7	6.7	47 19 — 66	ditto	47 19 — 66
Push button switch 1-point, for signal Explosion proof	F L1 L2 T.	100	0.36	36 15 — 51	ditto	36 15 — 51
Push button switch 2-points, for remote operation control, Explosion proof	F L1 L2 T.	50	1.28	64 28 — 92	ditto	64 28 — 92
Signal bell 24V, Explosion proof	F L1 L2 T.	20	8.4	168 74 — 242	ditto	168 74 — 242
Mine cable 3 kV, 3c x 100 mm² Armoured cable	F L1 L2 T.	600 m	0.4	240 102 — 342	ditto	240 102 — 342
Mine cable 3 kV, 3c x 50 mm² Armoured cable	F L1 L2 T.	1,400 m	0.264	369 158 — 527	ditto	369 158 — 527
Mine cable 3 kV, 3c x 22 mm² Armoured cable	F L1 L2 T.	1,800 m	0.152	274 117 — 391	ditto	274 117 — 391
Cabtyre cable 600 V, 4c x 50 mm²	F L1 L2 T.	1,200 m	0.355	426 183 — 609	ditto	426 183 — 609
Cabtyre cable 600 V, 4c x 22 mm²	F L1 L2 T.	500 m	0.254	127 54 — 181	ditto	127 54 — 181
Cabtyre cable 600 V, 4c x 14 mm²	F L1 L2 T.	500 m	0.166	83 36 — 181	ditto	83 36 — 181

c) U/G Mine

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Cabtyre cable 600 V, 4c x 5.5 mm²	F	500 m	0.096	48	Included in Development	48
	L1			20		20
	L2			—		—
	T.			68		68
Vinyl cabtyre cable 600 V, 40 x 5.5 mm²	F	1,000 m	0.04	40	ditto	40
	L1			17		17
	L2			—		—
	T.			57		57
Lighting transformer 5 kVA, 400 V to 100 V, Dry type, Explosion proof	F	5	40	200	ditto	200
	L1			86		86
	L2			—		—
	T.			286		286
Lighting fixture Incadescent lamp 100 V 60 W, Explosion proof	F	500 m	0.4	200	ditto	200
	L1			85		85
	L2			—		—
	T.			285		285
Vinyl cord 600 V, 2c x 2 mm²	F	2,500 m		26	ditto	26
	L1			11		11
	L2			—		—
	T.			37		37
Incadescent lamp 100 V, 60 W	F	5,000 m		26	ditto	26
	L1			11		11
	L2			—		—
	T.			37		37
Miscellaneous	F			103	ditto	103
	L1			43		43
	L2			—		—
	T.			146		146
Spare parts for 5 years operation for line switch 3 kV, 100 A	F	1 lot		104		104
	L1			45		45
	L2			—		—
	T.			149	—	149
Spare parts for 5 years operation for mine power centre 300 kVA	F	1 lot		41		41
	L1			18		18
	L2			—		—
	T.			59	—	59
Spare parts for 5 years operation for mine power centre 200 kVA	F	1 lot		41		41
	L1			18		18
	L2			—		—
	T.			59	—	59
Spare parts for 5 years operation for mine power centre 150 kVA	F	1 lot		246		246
	L1			105		105
	L2			—		—
	T.			351	—	351

c) U/G Mine (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Spare parts for 5 years operation for air circuit breaker 3.3 kV, 100 A	F L1 L2 T.	1 lot		312 134 – 446	– – – –	312 134 – 446
Ditto for air circuit breaker 400 V, 400 A	F L1 L2 T.	1 lot		63 27 – 90	– – – –	63 27 – 90
Ditto for earth relay 400 V	F L1 L2 T.	1 lot		72 31 – 103	– – – –	72 31 – 103
Ditto for gate end box 600 V, 225 A	F L1 L2 T.	1 lot		45 19 – 64	– – – –	45 19 – 64
Ditto for gate end box 600 V, 225 A, Reversible	F L1 L2 T.	1 lot		40 17 – 57	– – – –	40 17 – 57
Ditto for gate end box 600 V, 50A	F L1 L2 T.	1 lot		8 3 – 11	– – – –	8 3 – 11
Ditto for gate end box 600 V, 50 A, Reversible	F L1 L2 T.	1 lot		21 9 – 30	– – – –	21 9 – 30
Ditto for gate end box 600 V, 25 A	F L1 L2 T.	1 lot		2 1 – 3	– – – –	2 1 – 3
Ditto for control transformer	F L1 L2 T.	1 lot		9 4 – 13	– – – –	9 4 – 13
Ditto for signal bell	F L1 L2 T.	1 lot		8 3 – 11	– – – –	8 3 – 11
Ditto for lighting transformer	F L1 L2 T.	1 lot		8 3 – 11	– – – –	8 3 – 11

c) Underground Mine (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Spare parts for 5 years operation for lighting fixture	F L1 L2 T.	1 lot		20 9 – 29	– – – –	20 9 – 29
Sub-Total	F L1 L2 T.			9,425 4,040 – 13,465	– – – –	9,425 4,040 – 13,465

d) Communication (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Private telephone exchanger	F L1 L2 T.	1		237 102 – 339	– – 7 7	237 102 7 346
Dial telephone Desk type	F L1 L2 T.	70	0.6	42 18 – 60	Included in Development Labour Cost	42 18 – 60
Dial telephone Wall type	F L1 L2 T.	10	0.8	8 3 – 11	ditto	8 3 – 11
Dial telephone Noise proof	F L1 L2 T.	10	1.7	17 7 – 24	ditto	17 7 – 24
Dial telephone Explosion proof	F L1 L2 T.	10	6.5	65 28 – 93	ditto	65 28 – 93
Telephone cable 0.9 mm x 30P	F L1 L2 T.	1,000 m	0.059	59 25 – 84	ditto	59 25 – 84
Telephone cable 0.9 mm x 20P	F L1 L2 T.	1,000 m	0.042	42 18 – 60	ditto	42 18 – 60

SURFACE FACILITIES

d) Communication (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Telephone cable 0.9 mm x 10P	F L1 L2 T.	2,000 m	0.023	46 20 — 66	ditto	46 20 — 66
Telephone cable 0.9 mm x 5P	F L1 L2 T.	5,000 m	0.016	80 35 — 115	ditto	80 35 — 115
Vinyl cord 600 V, 2c x 2 mm	F L1 L2 T.	200 m	0.01	2 1 — 3	ditto	2 1 — 3
Miscellaneous for telephone system	F L1 L2 T.	1 lot		11 5 — 16	ditto	11 5 — 16
Fixed station for U/G Induction radio system Transmitting output: 5 W max. Receiving output: 3 W max.	F L1 L2 T.	1		56 24 — 80	— — 1 1	56 24 1 81
Mobile station for above Transmitting output: 100 mW Intrinsically safe type	F L1 L2 T.	60	4.94	296 127 — 423	Included in Development Labour Cost	296 127 — 423
Battery charger for above Indoor type 1 charger for 10 mobile station	F L1 L2 T.	6	12.2	73 31 — 104	ditto	73 31 — 104
Antenna for above Vinyl cable 600 V, 1c x 5 mm²	F L1 L2 T.	3,800 m	0.0135	51 21 — 72	ditto	51 21 — 72
Fixed station for open pit wireless system Output 25 W, c/w Antenna & D.C. power equipment	F L1 L2 T.	2	46	92 39 131	— — 3 3	92 39 3 134
Mobile station for above Output 10 W, c/w Antenna	F L1 L2 T.	10	10.6	166 71 — 237	— — 3 3	166 71 3 240
Antenna tower for above 18 m height, triangular type	F L1 L2 T.	1		12 5 — 17	— — 3 3	12 5 3 20

SURFACE FACILITIES

d) Communication (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Spare parts for telephone system	F L1 L2 T.	1 lot		7 3 – 10	– – – –	7 3 – 10
Spare parts for inductive radio system	F L1 L2 T.	1 lot		50 22 – 72	– – – –	50 22 – 72
Spare parts for wireless system	F L1 L2 T.	1 lot		10 4 – 14	– – – –	10 4 – 14
Sub-Total	F L1 L2 T.			1,422 699 17 2,031	– – 17 17	1,422 609 17 2,048
TOTAL	F L1 L2 T.			36,909 15,802 – 52,711	– – 229 229	36,909 15,802 229 52,940

SURFACE FACILITIES

(v) PRELIMINARY EXPENSES (000's Rupees)

Description		No. Required	Unit Price	Materials	Instllation	Total
Drilling machine	F	2	1,000	2,000	Included in	2,000
Wireline system	L1			856	Development	856
c/w Drilling pump, Mixers &	L2			–	Labour Cost	–
Drilling tower, etc.	T.			2,856		2,856
Fuel and oil for above	F	46.2 kℓ	5.2	–	ditto	–
	L1			–		–
	L2			240		240
	T.			240		240
Spare parts for 5 years	F	1 lot		600	ditto	600
operation for above	L1			258		258
	L2			–		–
	T.			858		858
Installation for mobile	F	2	125	250	ditto	250
substation in open pit	L1			–		–
	L2			–		–
	T.			250		250
Ditto for mine substation	F	1		442	ditto	442
	L1			–		–
	L2			–		–
	T.			442		442
Ditto for emergency	F	1 lot		75	ditto	75
generator	L1			–		–
	L2			–		–
	T.			75		75
Ditto for telephone system	F	1 lot		50	ditto	50
	L1			–		–
	L2			–		–
	T.			50		50
Ditto for wireles system	F	1 lot		50	ditto	50
	L1			–		–
	L2			–		–
	T.			50		50
Ditto for inductive radio	F	1 lot		50	ditto	50
system	L1			–		–
	L2			–		–
	T.			50		50
Ditto for micro computor	F	1 lot		46	ditto	46
	L1			–		–
	L2			–		–
	T.			50		50
Total	F			3,563	–	3,563
	L1			1,114	–	1,114
	L2			240	–	240
	T.			4,917	–	4,917

(vi) CONSTRUCTION DEVELOPMENT (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Spare parts for electrical equipment	F L1 L2 T.	1 lot		390 166 281 837	– – – –	390 166 281 837
Fuel and oil for mobile generator	F L1 L2 T.	20.4 kl	5.2	– – 106 106	– – – –	– – 106 106
Ditto for emergency generator	F L1 L2 T.	34.6 kl	5.2	– – 180 180	– – – –	– – 180 180
Power charge	F L1 L2 T.	1,060 MWH	0.518	– – 549 549	– – – –	– – 549 549
Total	F L1 L2 T.			390 166 1,116 1,672	– – – –	390 166 1,116 1,672

SURFACE FACILITIES

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Maintenance Spare parts	F L1 L2 T.	2		191 82 – 273	– – – –	191 82 – 273
Maintenance Repair machine civil & construction	F L1 L2 T.	2		– – 540 540	– – – –	– – 540 540
Material Lubricating oil 100 ℓ/day x 300 day/year	F L1 L2 T.	60,000 ℓ	7	– – 420 420	– – – –	– – 420 420
Sub-Total	F L1 L2 T.			191 82 960 1,233	– – – –	191 82 960 1,233
TOTAL	F L1 L2 T.			581 248 2,076 2,905	– – – –	581 248 2,076 2,905

B. ANCILLARY FACILITIES

(i) OFFICE BUILDING ETC.

(a) Office Building (000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Administration Office 21 m x 70 m x 2F Reinforced concrete and brick construction	F L1 L2 T.	2,940 m²	1.3	– – 3,822 3,822	– – 3,822 3,822
Foremen Office 10 m x 40 m x 2 lot Reinforced concrete and brick construction	F L1 L2 T.	800 m²	1.3	– – 1,040 1,040	– – 1,040 1,040
Mine Office 10 m x 35 m Reinforced concrete and brick construction	F L1 L2 T.	350 m²	1.3	– – 455 455	– – 455 455
Laboratory 5 m x 10 m Reinforced concrete and brick construction	F L1 L2 T.	50 m²	1.3	– – 65 65	– – 65 65
Sub-Total	F L1 L2 T.	4,140 m²		– – 5,382 5,382	– – 5,382 5,382

(b) Work Shop, Shed, Stores and Garrages (000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Lighland Heavy Vehicle Hardstand Fuel strage 10 m x 20 m Steel and brick construction	F L1 L2 T.	200 m²			
Under carriage repair shop 18 m x 36 m Steel and brick construction	F L1 L2 T.	648 m²			
P.M. shop (Protection maintenance) 18 m x 27 m Steel and brick construction	F L1 L2 T.	486 m²			
Parts warehouse 24 m x 54 m Steel and brick construction	F L1 L2 T.	1,296 m²			

SURFACE FACILITIES

(b) Work Shop, Shed, Stores and Garrages (000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Office 18 m x 24 m Steel and brick construction	F L1 L2 T.	432 m^2			
Work shop 42 m x 63 m Steel and brick construction	F L1 L2 T.	2,646 m^2			
Tyre service shop 18 m x 27 m Steel and brick construction	F L1 L2 T.	486 m^2			
Painting bay 18 m x 18 m Steel and brick construction	F L1 L2 T.	324 m^2			
Cleaning bay 18 m x 18 m Steel and brick construction	F L1 L2 T.	324 m^2			
Sub-Total	F L1 L2 T.	6,842 m^2			
Say	F L1 L2 T.	7,000 m^2	0.65	– – 4,550 4,550	– – 4,550 4,550
Work Shops Electrical shop 15 m x 40 m Steel and brick construction	F L1 L2 T.	600 m^2			
Electrical equipment 8 m x 10 m x 10 m x 15 m Steel and brick construction	F L1 L2 T.	230 m^2			
Mine car shop 10 m x 15 m Steel and brick construction	F L1 L2 T.	150 m^2			
Machine shop 12 m x 25 m x 10 m x 20 m Steel and brick construction	F L1 L2 T.	500 m^2			

SURFACE FACILITIES

(b) Work Shop, Shed, Stores and Garrages (000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Machine shop 8 m x 30 m Steel and brick construction	F L1 L2 T.	240 m^2			
Store 8 m x (25 + 30) m Steel and brick construction	F L1 L2 T.	440 m^2			
Store 8 m x 40 m Steel and brick construction	F L1 L2 T.	320 m^2			
Sub-Total	F L1 L2 T.	2,480 m^2			
Say	F L1 L2 T.	2,500 m^2	0.65	– – 1,625 1,625	– – 1,625 1,625
Office Garrages Garrages 10 m x 20 m Steel and brick construction	F L1 L2 T.	200 m^2	0.65	– – 130 130	– – 130 130
Sub-Total	F L1 L2 T.	200 m^2		– – 130 130	– – 130 130
Total	F L1 L2 T.			– – 6,305 6,305	– – 6,305 6,305

SURFACE FACILITIES

(c) Explosive Stores

(000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Explosive stores 10 m x 10 m Reinforced and brick construction	F L1 L2 T.	100 m²	1.89	– – 189 189	– – 189 189
Explosive control 5 m x 6 m Steel and brick construction	F L1 L2 T.	30 m²	0.65	– – 20 20	– – 20 20
Sub-Total	F L1 L2 T.			– – 209 209	– – 209 209

(d) Others

(000's Rupees)

Description	C.	No.	Unit Price	Installation & Materials	Total
Foundation of sub station Concrete (50 m³), Fence (310 m) Ballast (5,350 m², 1,050 m³)	F L1 L2 T.	1 lot		– – 532 532	– – 532 532
Oil storage 50 kℓ Tank and foundation	F L1 L2 T.	1 lot		– – 240 240	– – 240 240
Loading dock Concrete 105 m³, Pit 50 m³	F L1 L2 T.	1 lot		– – 214 214	– – 214 214
Fence of prohibition for invasion	F L1 L2 T.	8 km	25	– – 200 200	– – 200 200
Fuel tanks and foundation 20 kl x 2 lot Tanks and foundation	F L1 L2 T.	2 lot	92	– – 184 184	– – 184 184
Banking of explosive stores Banking (1,440 m³)	F L1 L2 T.	1 lot		– – 4 4	– – 4 4

SURFACE FACILITIES

(d) Others

Description	C.	No.	Unit Price	Installation & Materials	Total
Sewage treatment tank Cess pool (150 m^3) Reinforced concrete construction	F L1 L2 T.	1 lot		– – 100 100	– – 100 100
Sub-Total	F L1 L2 T.			– – 1,474 1,474	– – 1,474 1,474
Total	F L1 L2 T.			– – 13,370 13,370	– – 13,370 13,370

SURFACE FACILITIES

(e) Maintenance

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Maintenance for office buildings administration office, Foremen office, Mine office, Laboratory	F L1 L2 T.	1 lot		– – 54 54	Included in Development Labour Cost	– – 54 54
Ditto for workshop, etc. Light & heavy vehicle hardstand, Workshop & Office garage	F L1 L2 T.	1 lot		– – 44 44	ditto	– – 44 44
Ditto for explosive store, etc. Explosive store	F L1 L2 T.	1 lot		– – 2 2	ditto	– – 2 2
Total	F L1 L2 T.			– – 100 100	– – – –	– – 100 100
GRAND TOTAL	F L1 L2 T.			– – 13,470 13,470	– – – –	– – 13,470 13,470

SURFACE FACILITIES

B – (ii) FURNITURE AND FIXTURE (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Computer 1 x ACOS-250 Model 40 (256 KB) 1 x Magnetic disk (160 MB) Magnetic tape, Printer, Data punch etc.	F L1 L2 T.	1		2,200 940 – 3,140	Included in Development Labour Cost	2,200 940 – 3,140
Furniture and fixture for administration office	F L1 L2 T.	1 lot		– – 876 876	ditto	– – 876 876
Ditto for mine office and other service building	F L1 L2 T.	1 lot		– – 730 730	ditto	– – 730 730
Ditto for miners conteen etc.	F L1 L2 T.	1 lot		– – 584 584	ditto	– – 584 584
Ditto for rest house	F L1 L2 T.	1 lot		– – 292 292	ditto	– – 292 292
Ditto for hospital & dispensaries, etc.	F L1 L2 T.	1 lot		– – 1,460 1,460	ditto	– – 1,460 1,460
Ditto for residential buildings	F L1 L2 T.	1 lot		– – 1,168 1,168	ditto	– – 1,168 1,168
Spare parts for computer	F L1 L2 T.	1 lot		220 94 – 314	– – – –	220 94 – 314
Maintenance for above buildings	F L1 L2 T.	1 lot		– – 51 51	Included in Development Labour Cost	– – 51 51
Total	F L1 L2			2,420 1,034 5,161 8,615	– – – –	2,420 1,034 5,161 8,615

SURFACE FACILITIES

B – (iii) TRANSPORT WITHIN FACTORY (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Personnel car 4 wheel drive, Wagon type	F L1 L2 T.	6	108	648 275 – 923	Included in Development Labour Cost	648 275 – 923
Staff car Limousine	F L1 L2 T.	2	99	198 84 – 282	ditto	198 84 – 282
Ambulance 4 wheel drive c/w standard accessories	F L1 L2 T.	1		79 34 – 113	ditto	79 34 – 113
Maintenance for above	F L1 L2 T.	1 lot		– – 134 134	Included in Development Labour Cost	– – 134 134
Fuel and oil for above	F L1 L2 T.	144.5 kl	5.2	– – 751 751	ditto	– – 751 751
Total	F L1 L2 T.			925 393 885 2,203	– – – –	925 393 885 2,203

PREPARATION PLANT

(ii) BUILDINGS

(a) Factory Buildings

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Building and utility Dump hopper & pit 8,000 W x 18,000 H x 14,000 L 4,000 W x 2,500 H x 25,000 L Concrete construction		1				
Shed for dump hopper 8,000 W x 9,000 L x 4,000 H		1				
Raw coal bin 16,000 ϕ x 24,000 H Concrete construction		1				
Support for crusher 7,000 W x 8,500 L x 15,000 H Steel construction		1				
Shed for picking room 7,000 W x 29,000 L x 10,000 H Steel construction		1				
Clean coal silos 16,000 ϕ x 19,000 H Concrete construction		2				
Clean coal stockpile 64,000 ϕ, with tower and pit Concrete construction		1				
Support for track scale Concrete construction		1				
Tramp iron stocking floor 3,000 W x 3,000 L x 2,000 H Concrete construction		1				
Shed for electric room 5,000 W x 10,000 L x 10,000 H Steel construction		1				
Shed for weigher 4,000 W x 4,000 L x 3,000 Steel construction	F L1 L2 T.	1	→ Sub-Total	5,246 2,252 — 7,498	— — 970 970	5,246 2,252 970 8,468
Exterior Material Slate	F L1 L2 T.			736 311 — 1,047	— — 159 159	736 311 159 1,206

PREPARATION PLANT

(000's Rupees)

Description	C.	No. Required	Unit Price	Materials	Installation	Total
Concrete structure Hopper bin, silo	F L1 L2 T.			– – 9,447 9,447	– – – –	– – 9,447 9,447
Foundation, Painting Temporary work	F L1 L2 T.			– – 10,068 10,068	– – – –	– – 10,068 10,068
TOTAL	F L1 L2 T.			5,982 2,563 19,515 28,060	– – 1,129 1,129	5,982 2,563 20,644 29,189

PREPARATION PLANT

(iii) MACHINERY AND EQUIPMENT

(a) Raw Coal Receiving & Storage (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Dump Hopper, 100 T 8,000 W x 9,000 L x 9,000 H Concrete construction		1				
Vibrating feeder, 400 TPH 1,300 W x 1,650 L x -12° 3.7 kW, 1,500 rpm, Suspention type		1				
Raw coal belt conveyor, 400 TPH 900 W x 143,000 L x 38,500 H 100 m/min, 75 kW, 1,500 rpm Gravity take-up		1				
Raw coal bin, 1,500 T 16,000 ϕ x 17,000 H Concrete construction		1				
Sump pump, 0.5 m^3/min. x 20 mH 5.5 kW, 1,500 rpm Self-priming type	F L1	1	Sub-Total	6,482 2,763	– –	6,482 2,763
Ventilation fan, 30 m^3/min. 100 mm Aq, 2.2 kW, 1,500 rpm	L2 T.	1		– 9,245	1,081 1,081	1,081 10,326

(b) Raw Coal Treatment (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Vibrating feeder, 150 TPH 800 W x 1,200 L x -12° 0.75 kW, 1,500 rpm Suspention type		4				
Plant feed belt conveyor 400 TPH 900 W x 42,000 L x 11,300 H, 100 m/min., 30 kW, 50 rpm Gravity take-up		1				
Magnet catcher 1,200 ϕ, Traveling 15 m/min. 0.75 kW, 1,500 rpm With electric trolley		1				

PREPARATION PLANT

(b) Raw Coal Treatment (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Raw coal screen, 400 TPH 2,200 W x 4,500 L x -15° 900 rpm, 50 mm Opening 22 kW, 1,500 rpm Ripple-flow type		1				
Picking belt conveyor, 40 TPH 15 m/min, 1,400 W x 20,000 L 2.2 kW, 50 rpm, Screen take-up		1				
Single roll crusher, 40 TPH 45 kW, 1,000 rpm		1				
No. 1 Reject belt conveyor, 20 TPH, 60 m/min, 750 W x 17,000 L x 2,500 H 3.7 kW, 50 rpm, Screw take-up		1				
No. 2 Reject belt conveyor, 20 TPH, 60 m/min, 68,000 L x 15,000 H 5.5 kW, 50 rpm, Gravity take-up		1				
Reject bin, 60 T 6,000 W x 6,000 L x 5,500 H Steel construction	F L1 L2 T.	1	→ Sub-Total	8,814 3,765 — 12,579	— — 1,224 1,224	8,814 3,765 1,224 13,803

(c) Clean Coal Storage (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
No. 1 Clean coal conveyor, 384 TPH, 100 m/min, 900W x 160,000 L x 20,000 H 45 kW, 1,500 rpm, Gravity take-up		1				
No. 2 Clean coal conveyor, 384 TPH, 100 m/min, 900 W x 24,000 L x 2,500 H 11 kW, 50 rpm, Screw take-up		1				
Clean coal silos, 2000 T 16,000 ϕ x 19,000 H, Concrete construction		2				

PREPARATION PLANT

(c) Clean Coal Storage

(000's Rupees)

Description	C.	No. Required	Unit Price	Materials	Installation	Total
Clean coal stockout conveyor 384 TPH, 100 m/min 900 W x 45,000 H x 13,000 H 30 kW x 50 rpm, Gravity take-up	 F L1 L2 T.	1	Sub-Total	 6,503 2,771 – 9,274	 – – 1,160 1,160	 6,503 2,771 1,160 10,434

(d) Clean Coal Loading

(000's Rupees)

Description	C.	No. Required	Unit Price	Materials	Installation	Total
Vibrating feeders, 280 TPH 1,100 W x 1,500 L x -10° 2.2 kW, 1,500 rpm, Suspension type		8				
Clean coal loading conveyor 800 TPH, 110 m/min, 1,200 W x 106,000 L x 24,000 H 90 kW, 1,500 rpm, Gravity take-up		1				
Clean coal loading hopper, 110 T 7,000 W x 7,000 L x 6,500 H Steel construction		1				
Vibrating feeder, 800 TPH 1,800 W x 2,000 L x -10° 7.5 kW, 1,500 rpm, Suspension type		1				
Vibrating feeders, 400 TPH 1,300 W x 1,650 L x -12° 3.7 kW, 1,500 rpm, Suspension type		5				
Clean coal reclaim conveyor 800 TPH, 110 m/min 1,200 W x 68,000 L x 2,000 H 30 kW, 50 rpm, Gravity take-up		1				
Sump pump, 0.5 m^3/min Total head 15 m, 3.7 kW, 1,500 rpm, Self-priming type		2				
Ventilating Fan, 100 m^3/min, 150 mm Aq. 7.5 kW, 1,500 rpm	F L1 L2 T.	1	Sub-Total	8,969 3,835 – 12,804	– – 1,177 1,177	8,969 3,835 1,177 13,981

PREPARATION PLANT

(e) Other Equipment (000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Service Hoist Electric hoist for lump coal breaking, 5 T, Lift 8 m 5.5 kW, 1.5 kW, 1,500 rpm with steel hammer		1				
Electric hoist for rock removing 3 T, Lift 8 m 5.5 kW, 1.5 kW, 1,500 rpm with grab bucket		1				
Electric Hoist, 3 T Lift 15 m, 5.5 kW, 1.5 kW 1,500 rpm	F L1 L2 T.	2	Sub-Total	885 380 – 1,265	– – 32 32	885 380 32 1,297
Weigher Conveyor scales For raw coal 2, Clean coal 2, Reject 1		5				
Weight Bridge For freight car	F L1 L2 T.	1		2,412 1,033 – 3,445	– – 64 64	2,412 1,033 64 3,509
Mobil Equipment Dump trukc 24 m³, Model HD 320		1				
Bulldozer 12 Tonne, Model D 53A	F L1 L2 T.	1		3,219 1,369 – 4,588	– – – –	3,219 1,369 – 4,588
Laboratory Equipment Modified acme dryer, Type 1 300 W x 300 L x 300 H 240 V, 1 ϕ, 1 kW		1				
Muffle furnace 150 W x 100 H x 300 L 240 V, 1 ϕ, 4 kW		1				
Total sulphur measurement device 240 V, 1 ϕ		1				
New Model nenken type adiabatic calorimeter, 240 V, 750 W		1				
Riffer sampler, Type 10		1				
Jaw crusher, N. 1023-A 240 V, 0.4 kW						

PREPARATION PLANT

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Horizontal type brown crusher No. 1025-A, 240V, 0.4 kW		1				
Standard testing sieve shaker 240 V, 0.2 kW		1				
Standard sieves 200 mmϕ, 45 mmH Stainless steel Digital balance, NL-200 TP 240 V, 1ϕ	F L1 L2 T.	15 1	→ Sub-Total	283 121 — 404	— — 48 48	283 121 48 452
Total	F L1 L2 T.			6,799 2,903 — 9,702	— — 144 144	6,799 2,903 144 9,846
Spare parts (Preparation plant)	F L1 L2 T.	1		597 255 — 852	— — — —	597 255 — 852
Spare parts	F L1 L2 T.			8,188 3,508 — 11,696	— — — —	8,188 3,508 — 11,696
GRAND TOTAL	F L1 L2 T.			46,352 19,800 — 66,152	— — 4,786 4,786	46,352 19,800 4,786 70,938

PREPARATION PLANT

iv) ELECTRICAL EQUIPMENT

(000's Rupees)

Description		No. Requred	Unit Price	Materials	Installation	Total
Motors 3 kV x 3 ϕ x 50 Hz for over 55 kW, 400 V x 3 ϕ x 50 Hz for up to 55 kW		1				
Power receiving equipment Transformer: 3 kV/400 – 240 V, 3ϕ, 1,000 kVA		1				
Control equipment Control center, Operating panel, Mimic panel, Relapy panel, Local switch		1				
Instrumentation equipment Sounding devices, Conveyor scales		1				
Lighting apparatus Mercury lamp, Incandescent lamp, Fluorescent lamp, Distribution panel		1	→ Sub-Total			
	F			3,747	–	3,747
	L1			1,601	–	1,601
Communication system	L2	1		–	1,193	1,193
Handset station, Speaker	T.			5,348	1,193	6,541

PREPARATION PLANT

(vi) PRELIMINARY EXPENSIVE

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Detail design	F			4,980		–
Supervision & erection	F			5,635		–
	T.			10,615	–	–

(v) CONSTRUCTION & DEVELOPMENT

(000's Rupees)

Description		No. Required	Unit Price	Materials	Installation	Total
Maintenance	F			–	Included in	–
	L1			–	Development	–
	L2			264	Labour Cost	264
	T.			264		264
Materials	F			–	ditto	–
	L1			–		–
	L2			479		479
	T.			479		479
Power	F			–	ditto	–
	L1			–		–
	L2			197		197
	T.			197		197
Total	F			–		–
	L1			–		–
	L2			940		940
	T.			940		940

RAILWAY

A – (i) BUILDINGS

(000's Rupees)

Description	C.	No. Required	Unit Price	Materials	Installation	Total
Check & Repair shop	F			–	–	–
Loco & Wagon repair by 900 m²	L1			–	–	–
Loco. & Wagon check bay 600 m²	L2	1,500 m²	0.65/m²	–	975	975
	T.			–	975	975
Worker house	F			–	–	–
100 m² x 2 houses – 200 m²	L1			–	–	–
	L2	200 m²	0.5/m²	–	100	100
	T.			–	100	100
Storage oil tank	F	1 lot		315	–	315
(include checking instrument	L1			135	–	135
& escape oil tank etc.)	L2			–	–	–
20 kl (3 mϕ x 3 mH) x 1 lot	T.			450	–	450
Cleaning equipment	F	1 lot		525	–	525
(include high water tank &	L1			225	–	225
spray etc.)	L2			–	–	
	T.			750	–	750
Total	F			–	–	840
	L1			840	–	360
	L2			360	–	1,075
	T.			1,200	1,075	2,275

(b) RAIL WAY & OTHERS

(000's Rupees)

Description	C.	No. Required	Unit Price	Materials	Installation	Total
Steel rails 40 kg/m	F	32.5 km	435/km	14,138	–	14,138
(include lateral line)	L1			6,060	–	6,060
Rail 435/km x 32.5 km	L2			–	1,138	1,138
Wage 35/km x 32.5 km	T.			20,198	1,138	21,336
Wooden sleepers	F			–	–	–
Sleepers 521/km x 32.5 km	L1			–	–	–
Wage 38/km x 32.5 km	L2	32.5 km	559/km	–	18,168	18,168
	T.			–	18,168	18,168
Stone ballast	F			–	–	–
Ballast 367/km x 32.5 km	L1			–	–	–
Wage 45/km x 32.5 km	L2	32.5 km	412/km	–	13,390	13,390
	T.			–	13,390	13,390
Turnout & installation	F	20	84	1,680	–	1,680
Turnout #10 x 84/s x 20 set	L1			720	–	720
Wage 3/s x 20 set	L2			–	60	60
	T.			2,400	60	2,460

A – (ii) RAILWAY & OTHERS

(000's Rupees)

Description	C.	No. Required	Unit Price	Materials	Installation	Total
Rise the ground level works (include stone ballast) Ballast 994/km x 32.5 km Wage 104/km x 32.5 km	F L1 L2 T.	32.5 km	1,098/km	– – – –	– – 33,685 35,685	– – 35,685 35,685
Brides and other structures (include staff quarters etc.) 413/km x 32.5 km	F L1 L2 T.	32.5 km	413/km	– – – –	– – 13,423 13,423	– – 13,423 13,423
Rail & Turnout spare parts Amount (F) x 10%	F L1 L2 T.	1 lot		1,582 678 – 2,260	– – – –	1,582 678 – 2,260
Total	F L1 L2 T.			17,400 7,458 – 24,858	– – 81,864 81,864	17,400 7,458 81,864 106,722

A – (iii) MACHINERY & EQUIPMENT (000's Rupees)

Description	C.	No. Required	Unit Price	Materials	Installation	Total
Diesel electric locomotives	F	3	10,000	30,000	–	30,000
DD51 type	L1			12,855	–	12,855
18 mL x 3 mW x 4 mH x 84 t	L2			–	–	–
110 HP x 2 set	T.			42,855	–	42,855
Wagon	F	3	570	30,210	–	30,210
8.8 mL x 2.7 mW x 3.4 mH x 15 t	L1			12,959	–	12,959
Load 35 t	L2			–	–	–
	T.			43,169	–	43,169
Passenger car	F	4	2,025	8,100	–	8,100
80 man/car x 4 car	L1			3,474	–	3,474
	L2			–	–	–
	T.			11,574	–	11,574
Loading belt feeder	F	1	790	790	–	790
Belt width 1,500 mm	L1			339	–	339
Capacity 1,000 t/h	L2			–	–	–
Scale Loadsell type	T.			1,129	–	1,129
Loco. & Wagon etc.	F	1 lot		6,910	–	6,910
Spare parts	L1			2,962	–	2,962
Amount (F) x 10%	L2			–	–	–
	T.			9,872	–	9,872
Workshop equipment	F	1 lot		628	–	628
Lathe, Radial drilling,	L1			269	–	269
Overhead crane, Welding,	L2			–	16	16
Instrument etc.	T.			897	16	913
Railroad maintenance tools	F			1,575	–	1,575
Motor car, Wooden car,	L1			675	–	675
Dump truck etc.	L2			–	–	–
	T.			2,250	–	2,250
Workshop & Railroad mainte.	F	1 lot		110	–	110
Spare parts	L1			47	–	47
Amount (F) x 5%	L2			–	–	–
	T.			157	–	157
Total	F			78,323	–	78,323
	L1			33,580	–	33,580
	L2			–	16	16
	T.			111,903	16	111,919

RAILWAY

A – (iv) ELECTRICAL INSTALLATION

SIGNALL & COMMUNICATIONS (000's Rupees)

Description	C.	No. Required	Unit Price	Materials	Installation	Total
Electric equipment 525/station x two station	F L1 L2 T.	2	525	1,050 450 – 1,500	– – – –	1,050 450 – 1,500
Signall equipment 525/station x two station	F L1 L2 T.	2	525	1,050 450 – 1,500	– – – –	1,050 450 – 1,500
Communication equipment 105/km x 65 km	F L1 L2 T.	65 km	105/km	6,825 2,925 – 9,750	– – – –	6,825 2,925 – 9,750
Spare parts Amount (F) x 5%	F L1 L2 T.	1 lot		446 190 – 636	– – – –	446 190 – 636
Total	F L1 L2 T.			9,371 4,015 – 13,386	– – – –	9,371 4,015 – 13,386
GRAND TOTAL	F L1 L2 T.			105,934 45,413 – 151,347	– – 82,955 82,955	105,934 45,413 82,955 234,302

PART III DEVELOPMENT OF COAL MINE

ANNEX

ANNEX 1

COMPARISON OF SKIP WINDING SYSTEM AND MINE CAR WINDING SYSTEM

The both systems were compared at the technical and economical points of view.

As the results of comparison, mine car winding system is more economical than the skip winding system at both capital costs and operating costs, and also construction period of mine car winding system is earlier than the other.

It can be said that capacity of 1,000 tonnes/day for mine car winding system and 1,000 to 2,000 tonnes/day for skip winding system, more than 2,000 tonnes/day for belt conveyor system is suitable at the economical points of view.

Therefore, mine car winding system was applied for this study.

COMPARISON OF WINDING SYSTEM IN MAIN INCLINED SHAFT

(1) Comparison of Condition

Description		Mine Car Winding System	Skip Winding System	Remarks
Amount of Transportation				
TOTAL	T.P.Y.	276,000	276,000	
Raw Coal	T.P.D.	760	760	
Waste Rock	T.P.D.	160	160	
Distance of Winding	m	550	160	
Inclination of Slope	degree	12	50	
Winding Speed	m/min.	150	150	
Actual Daily Working Hours	hours	12	12*	* 3 hours for Materials and Battery Locomotive.
Transportation Cycle	cycle	70	200	
Type of Main Winding Machine		Single Drum	Single Drum	
Dia. of Rope	m/m	26	34	
Length of Rope	m	600	260	
Maximum Load	kg	20,600	8,900	
Nos. of Car for Winding (Coal)		7	-	
Nos. of Car for Winding (Rock)		6	-	
Weight of Skip & Capacity		-	3 t & 5 m^3	
Sub Winder in Return Slope		20 kW x 16 m/m	75 kW x 26 m/m	
Required Days for Drifting	days	105	330	
Length of Entry	m	500	394*	* Inclined Shaft 160 m, Tippler 234 m
Winding Equipment		Winder, Wire Rope, Winder Room	Winder, Wire Rope, Winder Room	
Dust Collector		No	Necessary	
Belt Feeder		No	Necessary	
Workers	men	10	14	Winding 4, Tippler 4, Feeder 2, Bin 2
Maintenance Cost	%	3	3	

(2) Comparison of Cost
(000's) RUPEES

Description	Mine Car Winding System	Skip Winding System	Remarks
Capital Cost			
Development Cost	2,245	1,466	
Winding Equipment	7,540	13,010	
Dust Collector	-	1,400	
Loading Facility	-	1,130	
Mine Car	13,600	6,800	
TOTAL	23,385	23,806	
Operating Cost	No Defference	No Defference	
Material Cost	1,272	2,226	
Labour Cost	702	714	
Maintenance Cost	221	325	
Power Cost			
TOTAL	2,195	3,265	

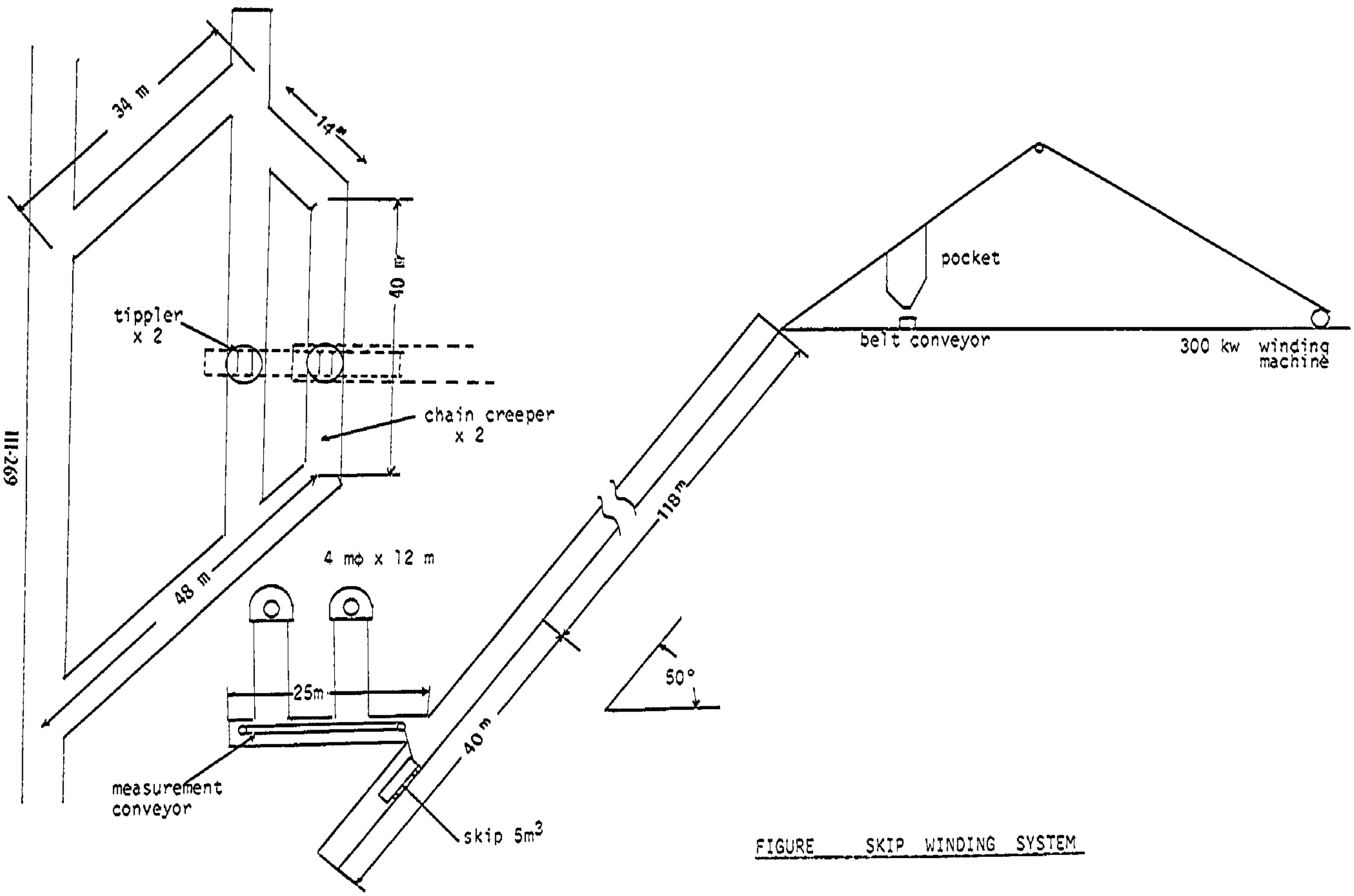


FIGURE SKIP WINDING SYSTEM

ANNEX 2

GEOMECHANICAL ASPECTS ON SIZE OF SAFETY COAL PILLAR FOR PLANNING OF LAKHRA UNDERGROUND MINE

(Application of Displacement Discontinuity Method)

"Displacement Discontinuity Method" can be used for consideration about the geomechanical behaviour of rock influenced by underground excavation, using a small size computer of which CPU time is comparatively slow

Inclined shaft situated near mining panels may be influenced by approaching panels. A geomechanical analysis was ececuted to examine the behavior of rock in the vicinity of the inclined shaft.

It was assumed that a pair of rock inclined shafts (roadways) is situated above the flat coal seam being excavation approaches gradually to the inclined shafts from both sides of shafts (Fig. 1). The rock consists of one kind of isotropic material simply, while the coal seam has a nature submitting to Mohr-Coulomb's law.

What to be Observed

The problem may also point to the observation of behaviour of coal pillar remained for preservation of inclined shafts under the effect of excavation, and accordingly the variation in situation of inclined shaft itself concretely.

It is well known among men of coal mines that the preservation of inclined shaft is considerably difficult when the coal seam which lies below the inclined shaft is entirely excavated.

In order to simulate the phenomena occurring in underground mining activity in numerical view-point, recently a number of computerized processes may be used and there are many kinds of ways how to utilize the data as input and which information to be applied.

Taking characteristics of Displacement Discontinuity Method into consideration, the following hypothesis was set up:

In the roadway, which is an underground opening, under external load, the side wall is often pushed out, the floor swells and support frames are defored. To simplify the explanation of such various phenomena, it was tried to observe how the roof of roadway moves and how the forces concerned change.

As shown in Fig. 4, some calculation points are given on the rectangular section representing a roadway on the roof and in its interior rock, when the excavation approaches to the roadway. The stress or displacement of two calculation points turn about each other at a certain case. Fig. 5 shows graphically such behavior of calculation points.

When one of two points in rock stops or turns over in moving stages of rock, the rock may be collapsed because the rock consists of non-elastic material.

By observing the displacement phenomena of any two points in rock and the excavation which approaches to these points, it is possible to estimate reasonably the limit boundary of safety zone for the position of roadway. In such processing, of course, the calculation of collapse zone or the relax zone is not performed. However, the fundamental object can be satisfied since the limit of elastic safety zone, in which the roadway is not critical, is observed.

Result of Calculation

The displacement and stress concerning inclined shaft was calculated at the point of 40 m and 70 m above the 90 m deep flat coal seam, as drawn in Fig. 6.

Table 1 and Table 2 summarize the relationship between the position of approaching excavation, the vertical displacement and stress.

Fig. 7 represents graphically the displacement of points near the roadway which is shown in Table 1 (a). The relationship between the displacement and approaching excavation is similar at each of four corners of hypothetical roadway profile section.

Fig. 8 indicates graphically the calculated values for two corners of roadway roof shown in Table 1 (b).

In Fig. 9, the displacement of two points, No. 1 and No. 2, in the left side of roadway roof are given on Y-axis and X-axis respectively and the yield points are obviously shown like as the behavior C in Fig. 5.

Fig. 10 show clearly the yield points is stress representation for points No. 1 and No. 2 like in Fig. 9.

The graphical representation of displacement and stress was made for different depths of seam and different intervals between roadway and seam.

Conclusion

The horizontal distance between roadway and excavation, D and the interval between roadway and coal seam, L are plotted on X-axis and Y-axis respectively (Fig. 15). The angle θ depends on the special relationship between D and L.

Compared Fig. 16 (a) with Fig. 16 (b), in which the depth of coal seam is different, it is assumed that the effect D to θ is different in these two cases. In other words, the shape of effect line is different.

From the information derived by this geomechanical analysis, following aspects may be given:

a) The position of excavation, which has influence on the inclined shaft, is related with the depth of coal seam to be excavated.

b) The effect angle toward inclined shaft depends delicately on the depth of coal seam.

c) Under the conditions of given geomechanical characteristics of coal and rock applied in this study, the effect angle ranges between 45 and 50 degrees.

d) The effect angle becomes smaller in case the inclined shaft is situated near the surface or near the coal seam.

Applying Displacement Discontinuity Method, the non-linear characteristics of displacement at the roof of inclined shaft were studied for the purpose of finding the limit of influence by excavation on the inclined shaft and some evaluation was generated.

Furthermore, it will be studied how the various effects interact, for example, due to seam thickness, depth, excavation and size of roadway in the wider view-point of mining space.

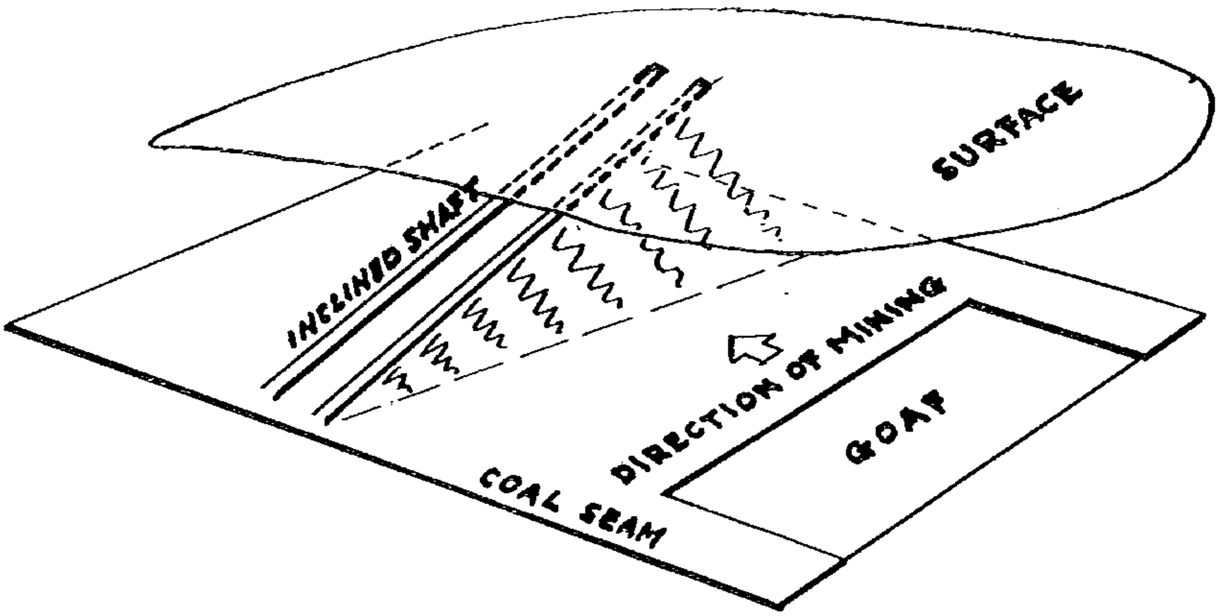


Figure 1 Concept of Problem

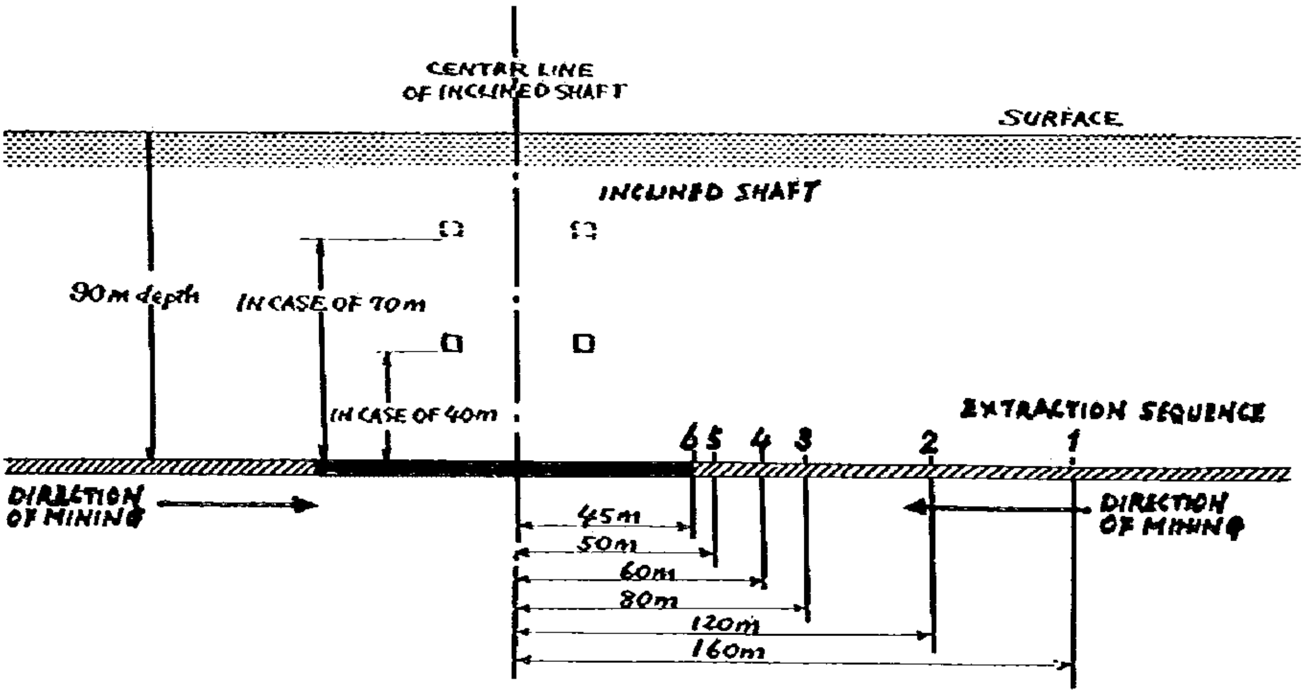


Figure 2 Two Dimensional Model profile on Vertical Profile Section

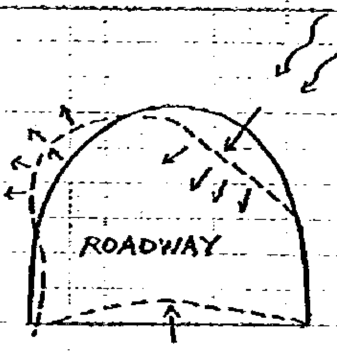


Figure 3. Deformation of Roadway

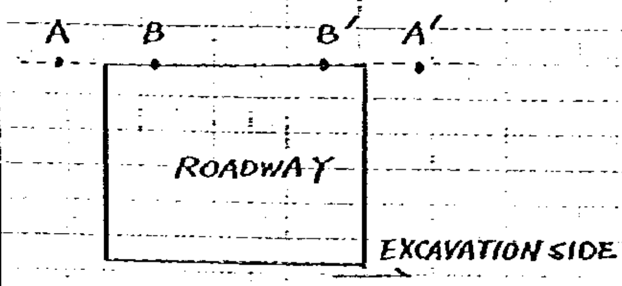


Figure 4. Calculation points

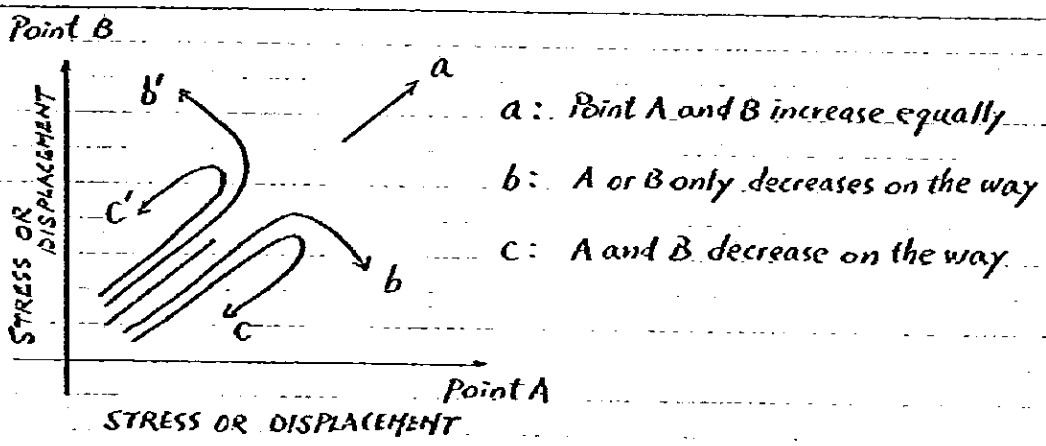


Figure 5. Relationship between Movement of A and B

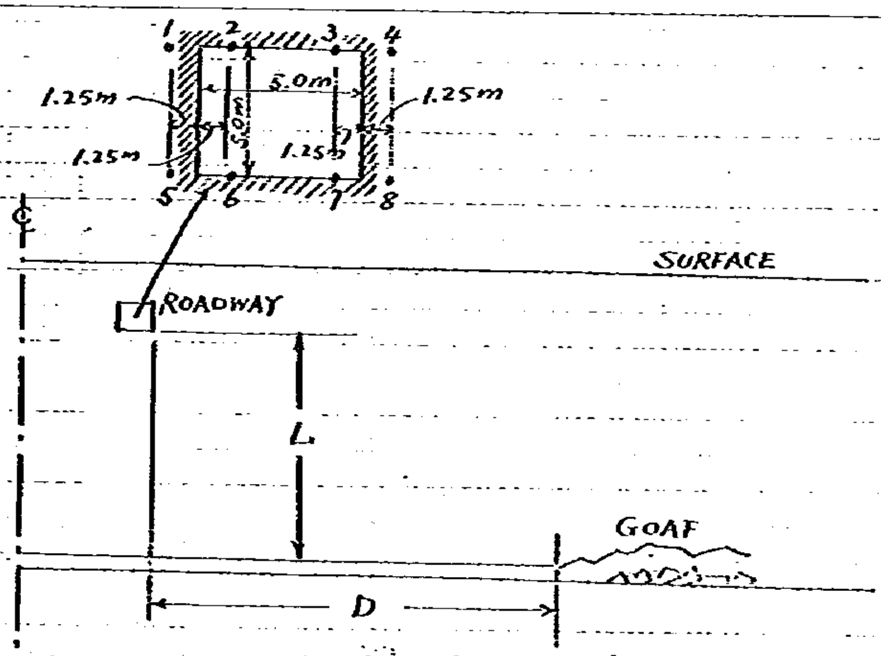


Figure 6 Calculation Points and Excavation

Table 1 Vertical displacement (-: upward, +: downward, unit: 1/1,000 m)

(a) Roadway - seam: 70 m

Excavation Step & Position of excavation	Calculation points (roof) No.1	No.2	No.3	No.4	Calculation points (floor) No.5	No.6	No.7	No.8
Not excavated	-0.0	-0.9	-0.9	-0.0	0.1	-1.0	-1.1	0.1
1 160 m	0.9	-0.7	-0.8	1.0	1.5	-0.9	-1.0	1.5
2 120 m	1.3	-1.2	-1.2	1.4	2.1	-1.4	-1.4	2.2
3 80 m	1.6	-1.9	-1.9	1.5	2.4	-2.1	-2.1	2.3
4 60 m	1.3	-3.3	-3.4	0.9	2.0	-3.5	-3.6	1.4
5 50 m	1.2	-4.4	-4.5	0.7	1.8	-4.5	-4.7	1.2
6 45 m	1.1	-5.5	-5.6	0.5	1.6	-5.7	-5.8	0.9

(b) Roadway - seam: 40 m

Not excavated	-0.1	-0.3	-0.4	-0.1	0.2	-0.8	-0.8	0.2
1 160 m	2.6	2.0	2.0	2.8	3.3	1.5	1.5	3.5
2 120 m	3.8	2.5	2.5	4.1	4.7	2.0	2.0	5.0
3 80 m	4.8	2.7	2.5	4.8	5.9	2.2	2.0	5.8
4 60 m	4.2	0.5	0.2	3.1	5.3	-0.0	-0.4	4.1
5 50 m	3.9	-1.0	-1.4	2.6	4.9	-1.5	-1.9	3.5
6 45 m	3.5	-2.7	-3.1	1.9	4.5	-3.2	-3.6	2.7

Table 2 Vertical stress (+: compressive, -: tensile, unit: t/m^2)

(a) Roadway - seam: 70 m

Excavation step & Position of excavation	Calculation points (roof) No.1	No.2	No.3	No.4	Calculation points (floor) No.5	No.6	No.7	No.8
Not excavated	0.50	-0.02	-0.14	0.49	0.63	-0.11	0.02	0.65
1 160 m	1.39	-0.11	-0.29	1.47	1.59	-0.26	-0.06	1.55
2 120 m	1.73	-0.17	-0.31	1.86	1.99	-0.28	-0.12	1.89
3 80 m	1.91	-0.22	-0.26	1.88	2.15	-0.21	-0.21	2.00
4 60 m	1.60	-0.24	-0.10	1.20	1.66	-0.00	-0.30	1.53
5 50 m	1.49	-0.22	-0.10	1.03	1.52	0.02	-0.28	1.39
6 45 m	1.36	-0.21	-0.07	0.83	1.35	0.05	-0.28	1.23

(b) Roadway - Seam: 40 m

Not excavated	1.48	-0.16	-0.30	1.50	1.68	-0.31	-0.15	1.67
1 160 m	2.23	-0.21	-0.47	2.45	2.58	-0.48	-0.19	2.40
2 120 m	2.50	-0.20	-0.56	2.88	3.00	-0.57	-0.17	2.68
3 80 m	2.89	-0.24	-0.59	3.22	3.44	-0.61	-0.25	3.09
4 60 m	3.05	-0.45	-0.32	2.69	3.25	-0.32	-0.55	3.18
5 50 m	3.01	-0.47	-0.26	2.46	3.11	-0.24	-0.60	3.10
6 45 m	2.94	-0.51	-0.18	2.17	2.90	-0.13	-0.66	2.94

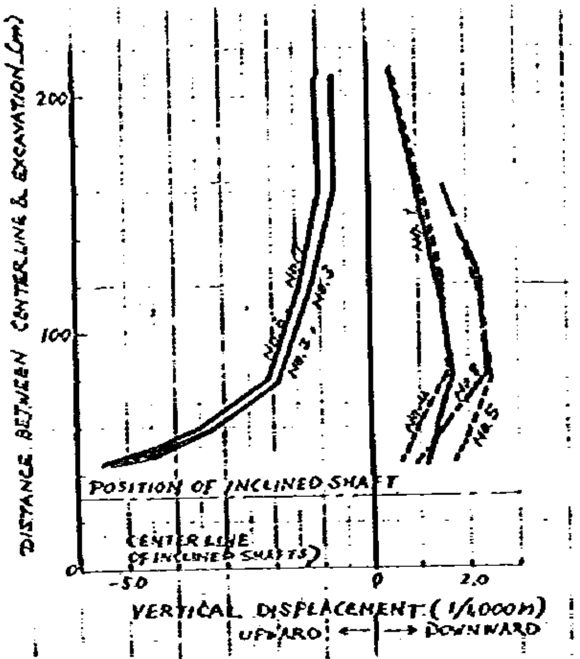


Figure 7. Approaching Excavation and Vertical Displacement of Calculation Points. (Seam Depth: 90m, Shaft: 70m above seam)

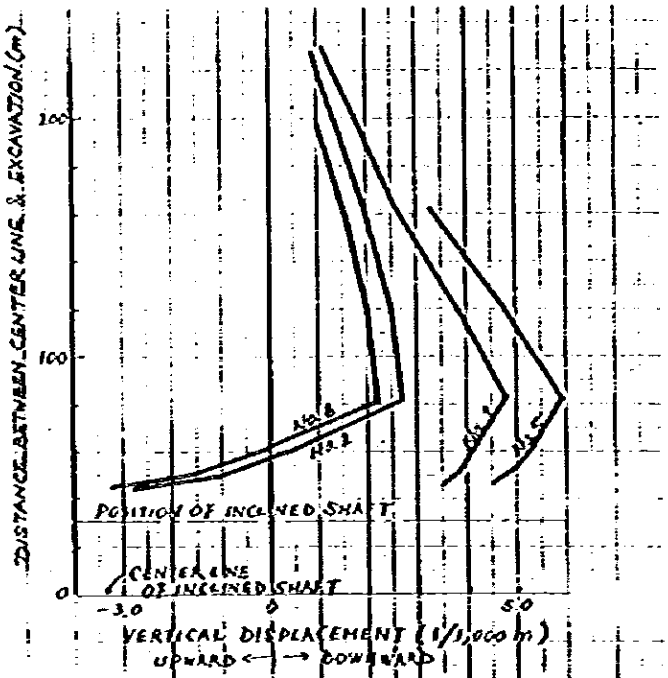


Figure 8. Approaching Excavation and Vertical Displacement of Calculation points (Seam Depth: 90m, Shaft: 40m above seam)

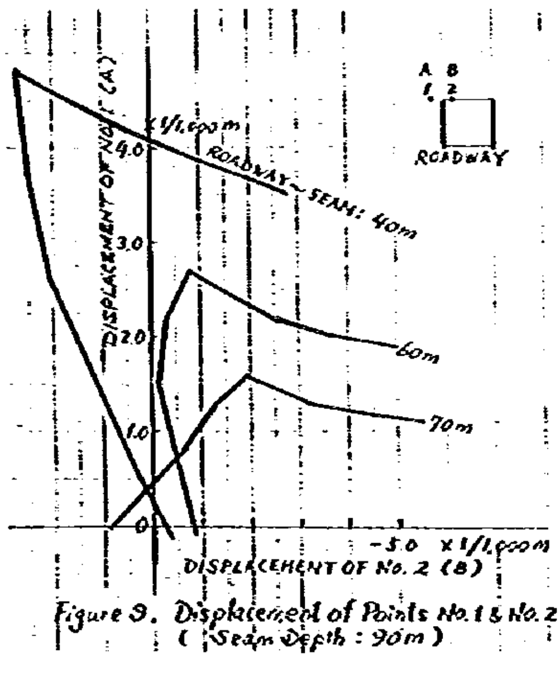


Figure 9. Displacement of Points No.1 & No.2 (Seam Depth: 90m)

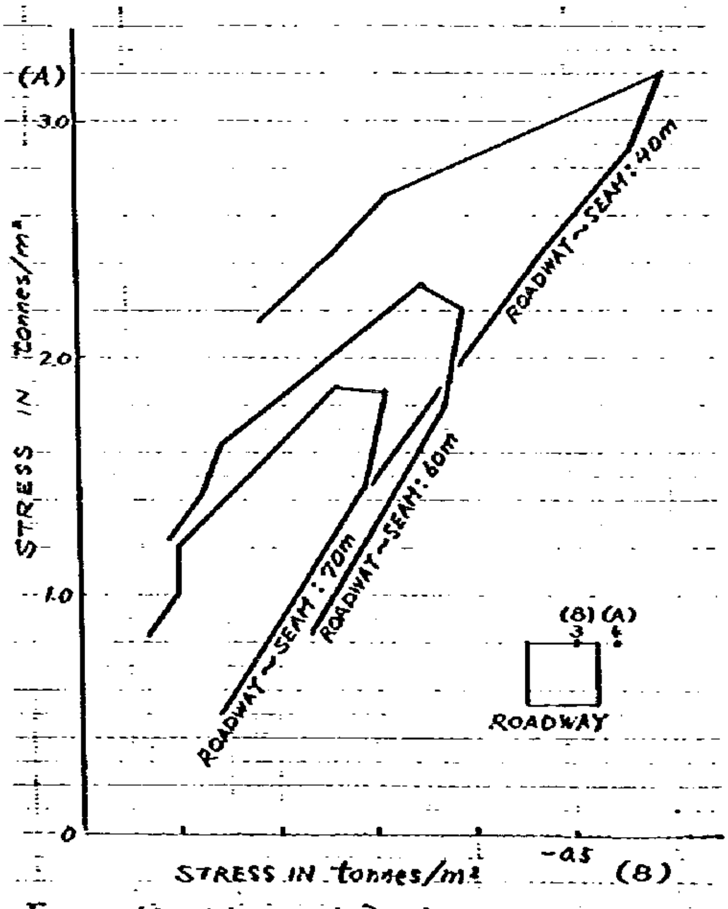


Figure 10 Stress at Points No.3 and No.4 (Seam Depth: 150m)

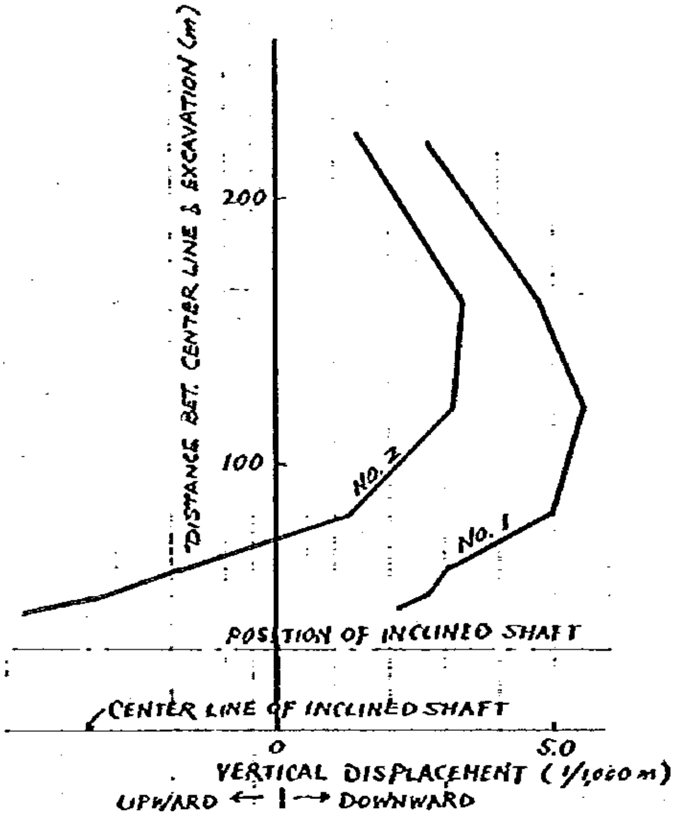


Figure 11. Approaching Excavation and Vertical Displacement of Calculation Points (Seam Depth : 150m, Shaft : 100m above seam)

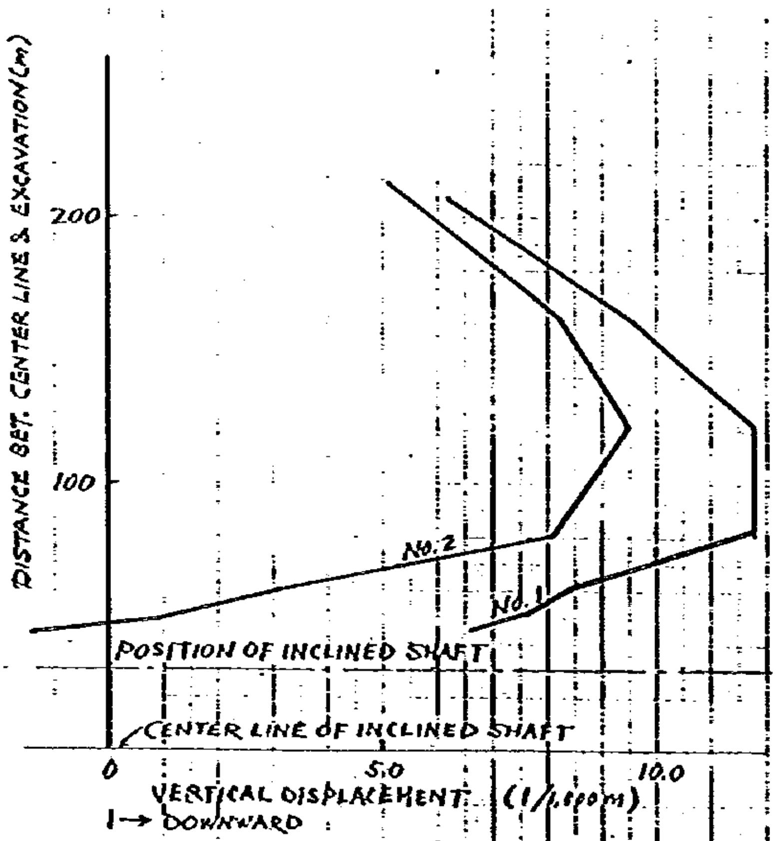


Figure 12 Approaching Excavation and Vertical Displacement of Calculation Points (Seam Depth : 150m, Shaft : 150 above seam)

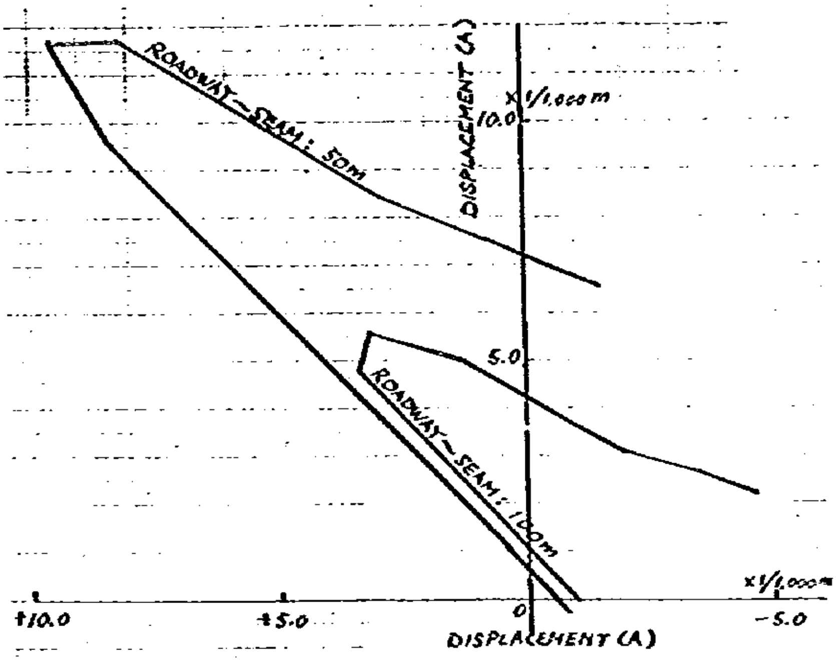


Figure 13. Displacement of Points No.1 and No.2
(Seam Depth : 150m)

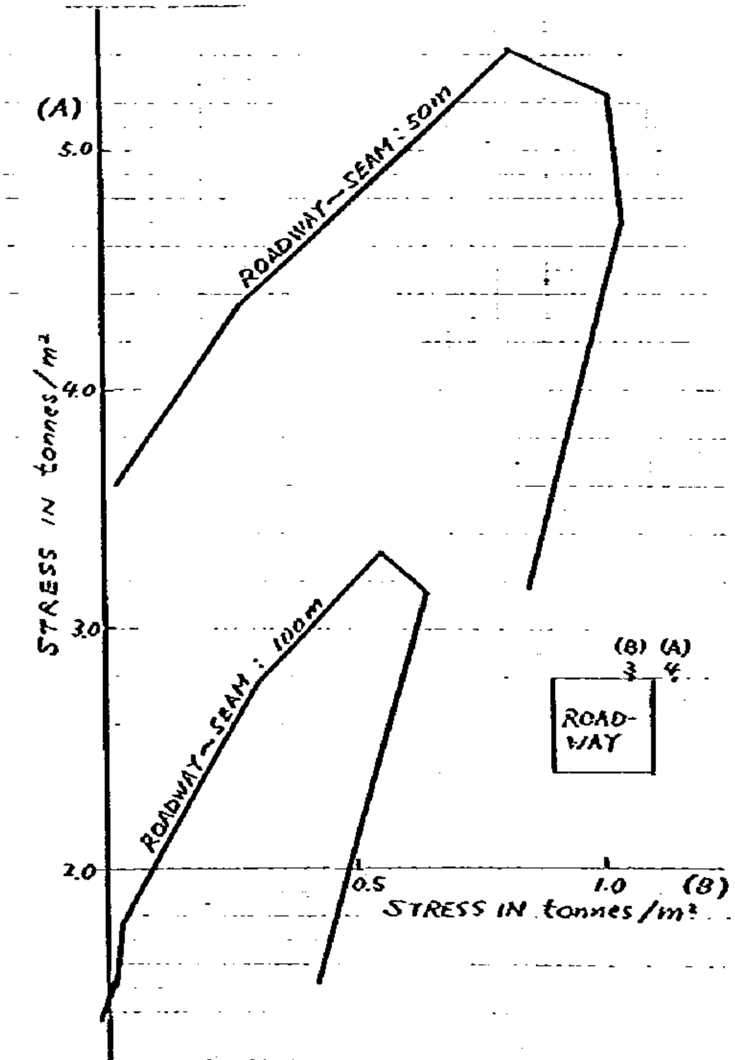


Figure 14. Stress at Points No.3 and No.4
(Seam Depth 150m)

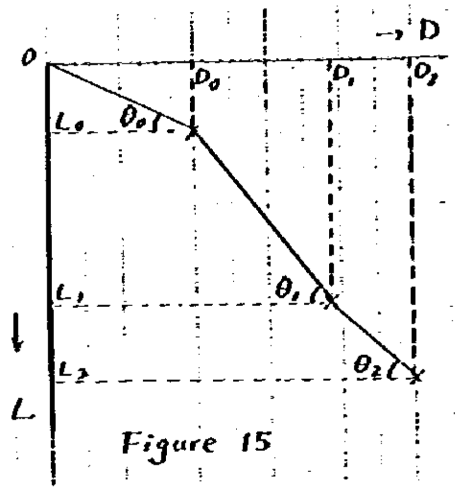


Figure 15

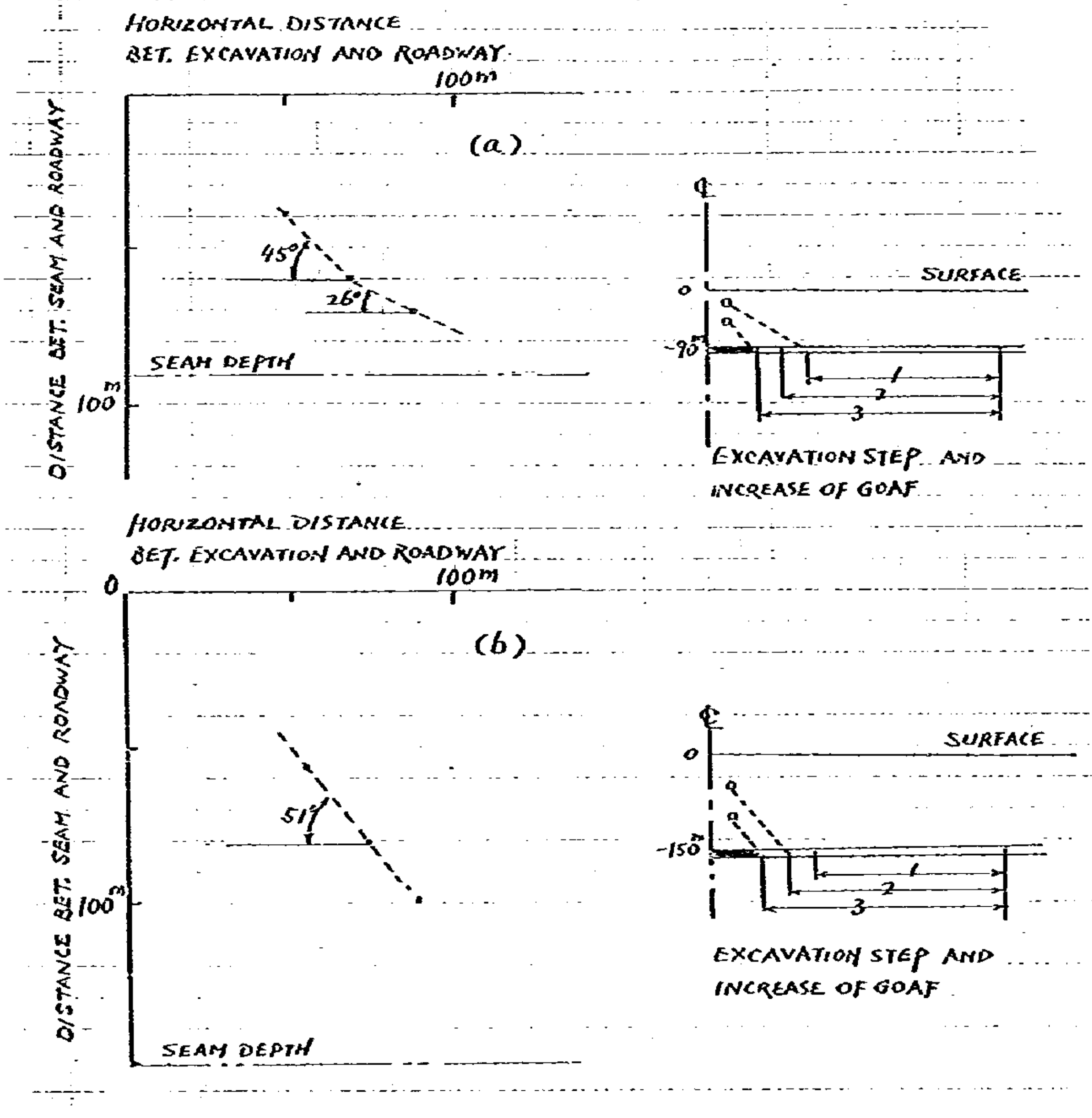


Figure 16 Some examples of effect commencement by approaching excavation to roadway in the model shown in Figure 2.

ANNEX 3

NEW APPROACH TO GEOMECHANICAL CONSIDERATION FOR LAKHRA COAL MINE PLANNING

Recently keen attention has been focused to the design of the underground structure such as tunnels or oil storage tanks as well as the surface structure. It is, of course, very important to clarify the actual behavior of soil or rock materials to establish a sound design criteria of these structures.

It is commonly recognized that the soil and rock foundations are essentially discontinuous materials. Generally speaking, all materials are composed of very large number of particles and it is obvious that their deformation may be controlled not only by the strength of particle itself but also by the intergranular strength. From the stand-point of the solid mechanics, solid are considered as continuum and generally the intergranular strength is not taken into account.

A number of finite element method (FEM) have been proposed in the field of soil and rock mechanics. Most of these methods are based on the continuum mechanics, and continuity of displacement field is assumed even beyond the elastic range of deformation. Application of the existing FEM is limited in analysis of slope stability or bearing power problems where existence of discontinuous faces and slip surfaces cannot be neglected.

In view of such recent status, a new discrete model which might be suitable to the analysis of soil and rock mechanics problem has been presented. This model consists of rigid bodies which are connected by springs distributed over the interelement boundary surfaces and strain energy of a given model is lumped in these spring systems.

In other words, these models consist of finite number of small rigid bodies connected with two types of springs resisting normal as well as shear deformation distributed over the contact area of two neighboring bodies.

This newly proposed discrete model is entitled to "Rigid Body Spring Model" (RBSM) and it can be also derived from FEM models by applying a certain simplification. By the RBSM, it is proved that considerable reduction of computing time may be expected by depending on the computer program to be used. One of obvious advantages of these discrete models is no restriction on the element shape so that the problems like underground structures can be successfully studied.

In planning Lakhra coal mine, the RBSM was applied for judgement of the safety of inclined shafts under the influence of approaching excavation and also for consideration of slope stability in open pit.

Attached figures show how the discrete models are deformed by the influence of mining activity and in which direction compressive and tensile stress may act. In the figure of displacement, a whole model is divided into triangular element drawn in thin lines and after some mining activity, these elements move due to geomechanical effect. Thick lines show this displacement of elements in exaggerated scale in order to make observation easy. In the figure of principal stress, the situation of principal stress at the center of each element is represented by crossed arrows. A pair of facing arrows means compressive stress while a pair of parting arrows means tensile stress, the direction of arrow line indicates the direction of stress or load and the length of line represents the value of stress.

Displacement as well as principal stress depends on the shape of underground or surface structure, information on surface and subsurface geometry, material properties and time and steps of mining activity.

The model was densly divided into smaller elements where considerable variation in displacement and stress is assumable, for example, in the surroundings of roadway and roadheading face to be observed in case of underground mine. Concerning the slope stability for open pit, the model was divided into elements following the sliding block which is common in well-known circular failure analysis.

Some examples of analysis by RBSM applied for Lakhra coal mine planning are shown in attached figure drawn by using the computer graphics.

Lakhra model 1; Rock inclined shaft influenced by approaching coal excavation (Underground problem)

An inclined shaft (left hand side) is situated above the coal seam in which the excavation is approaching (from right hand side). The situations of mining step 2 and 5 are represented.

Lakhra model 2; A main seam entry influenced approaching coal excavation (Underground problem)

A main seam entry (left hand side in coal seam) is situated in same coal seam in which the excavation is approaching (from right hand side). The situation of mining step 2 and 4 are represented.

Lakhra model 3; Highwall of the steepest pit slope influenced by bench cut (Open pit slope stability problem)

The model consists of rock materials interbedded by coal seams. Bench cut (dark part) is performed downwards and stepwise. Bottom and wall of pit are both deformed according to the progress of bench cut. Five steps of bench cut are represented.

Lakhra model 4; Working bench slope influenced by bench cut (Open pit slope stability problem)

In the same geological condition as in that of model 3, the overburden stripping and coal excavation are advancing leftwards while the waste is heaped on the excavated area behind the working pit (left hand side)
Step 1, 3 and 5 are represented (Dark part is the removed part by bench cut).

It is briefly concluded in observation of figures obtained that in any case displacement is remarkably mild and stress distribution also is very stable, consequently in such situation any roadway may not be damaged by the influence of excavation in underground mine, and the all slopes planned in open pit can be maintained in stable condition.

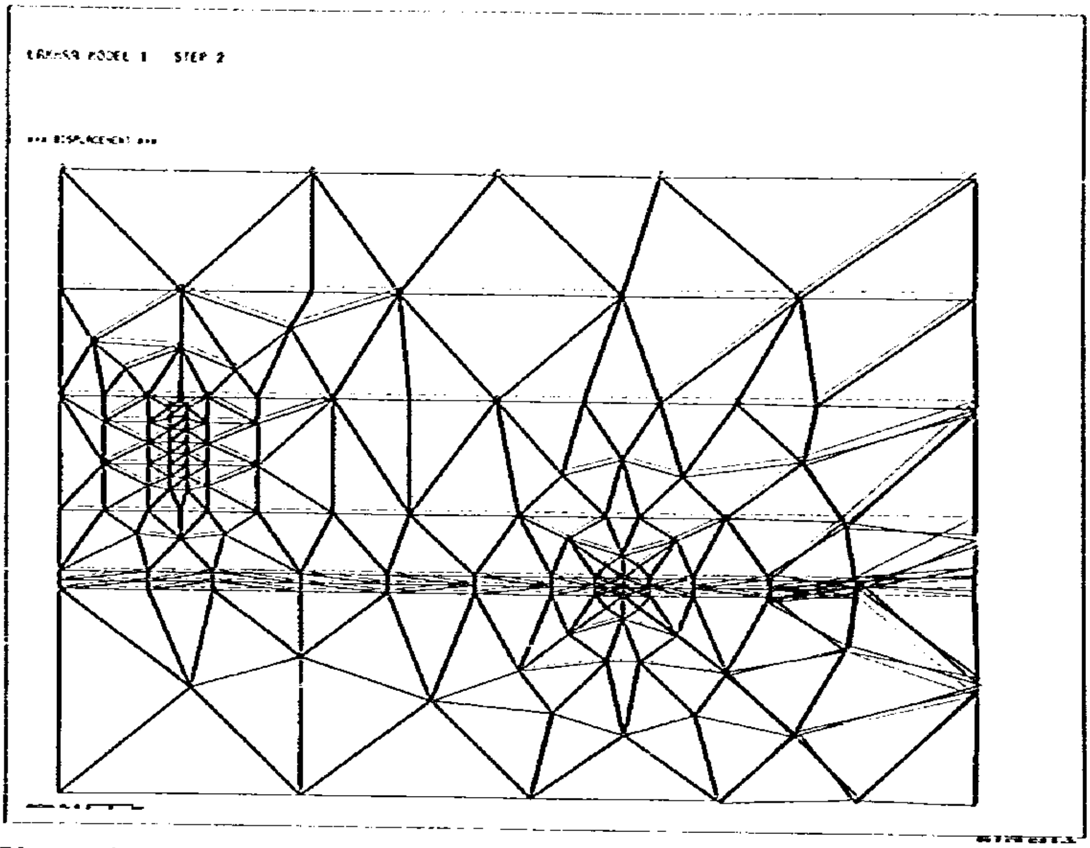


Figure 1 Lakhra model 1 - Step 2 Displacement

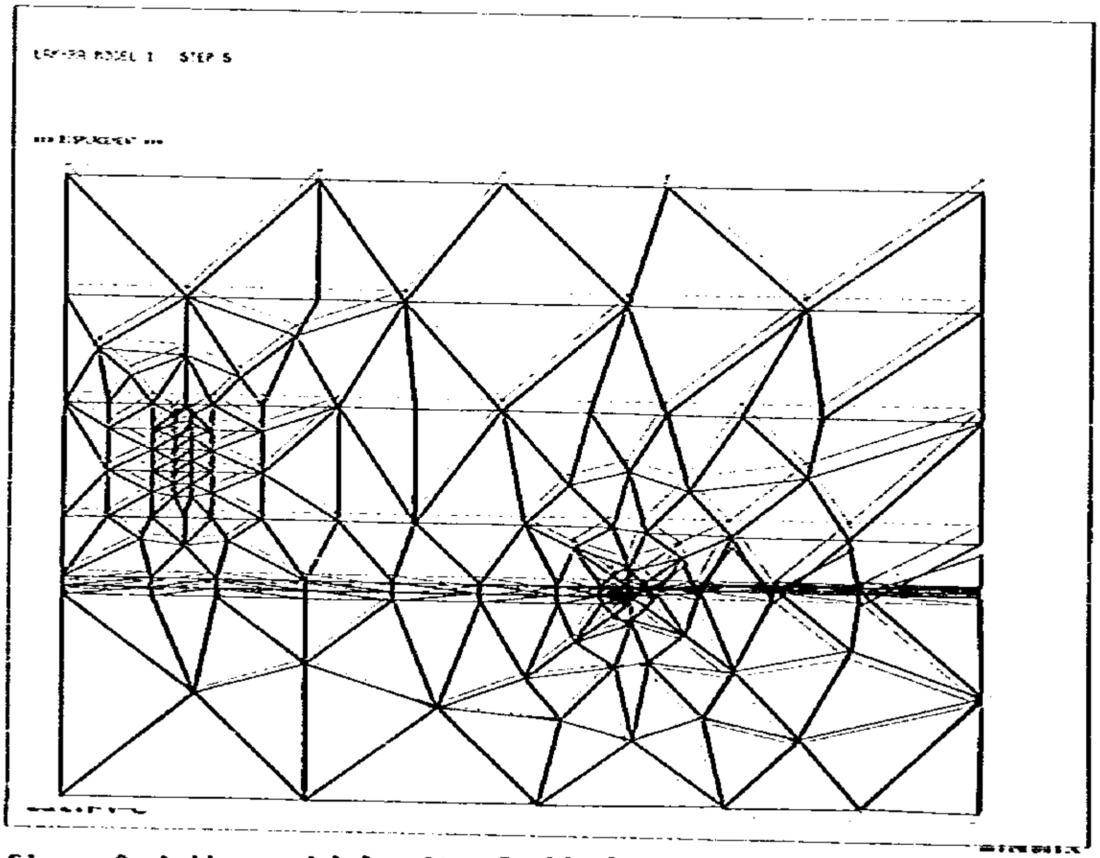


Figure 2 Lakhra model 1 - Step 5 Displacement

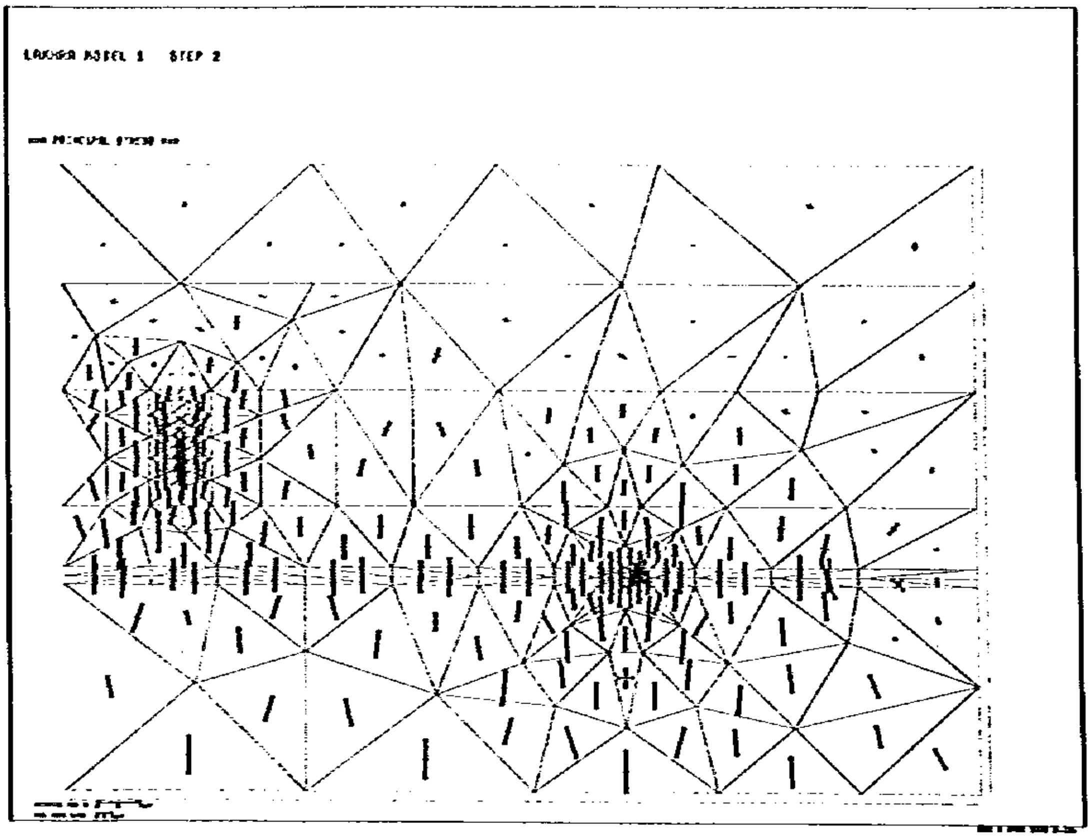


Figure 3 Lakhra model 1 - Step 2 Principal stress distribution

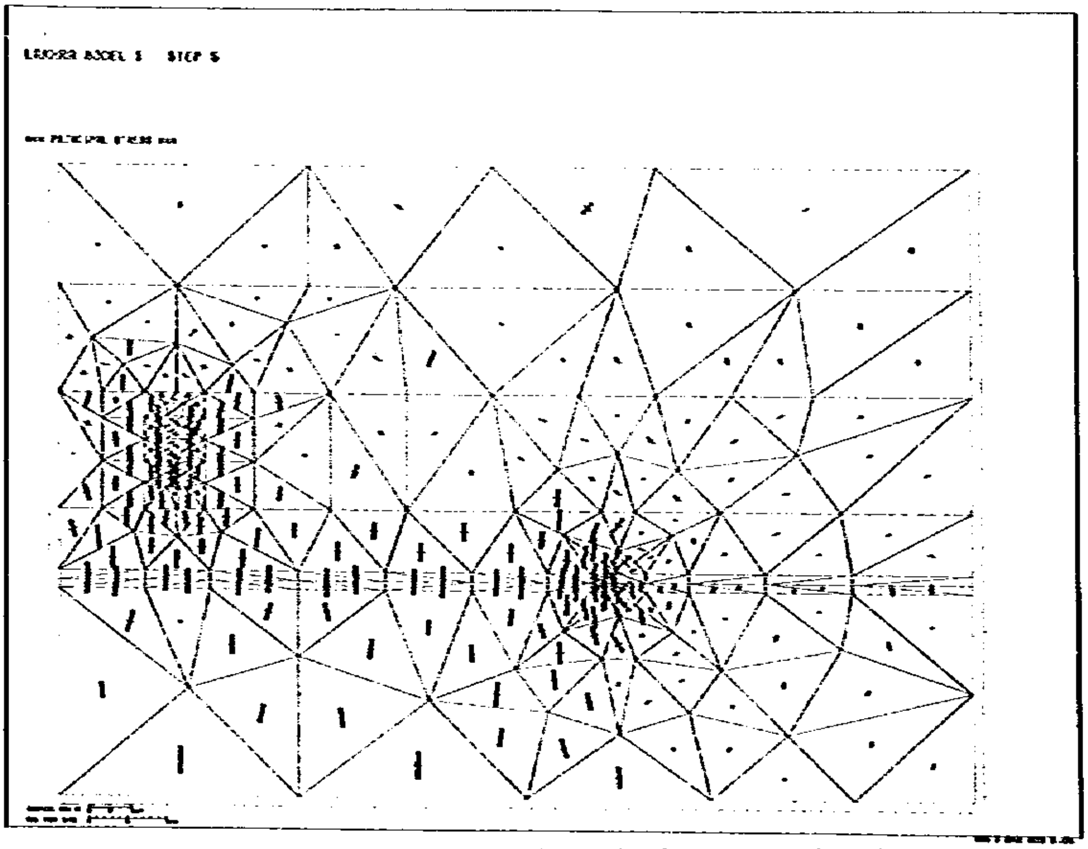


Figure 4 Lakhra model 1 - Step 5 Principal stress distribution

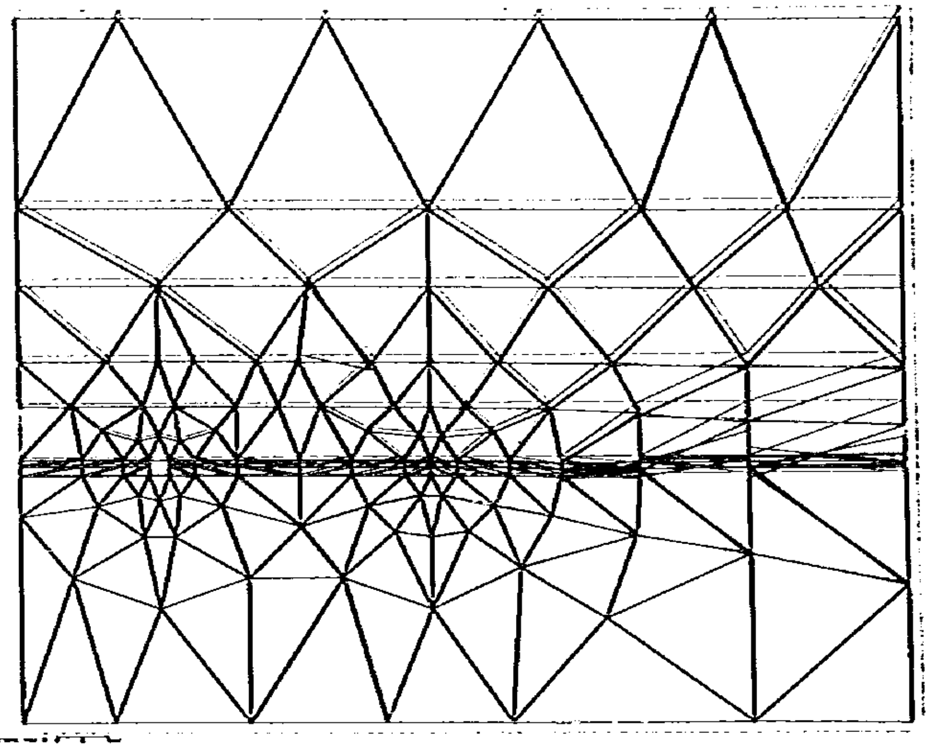


Figure 5 Lakhra model 2 - Step 2 Displacement

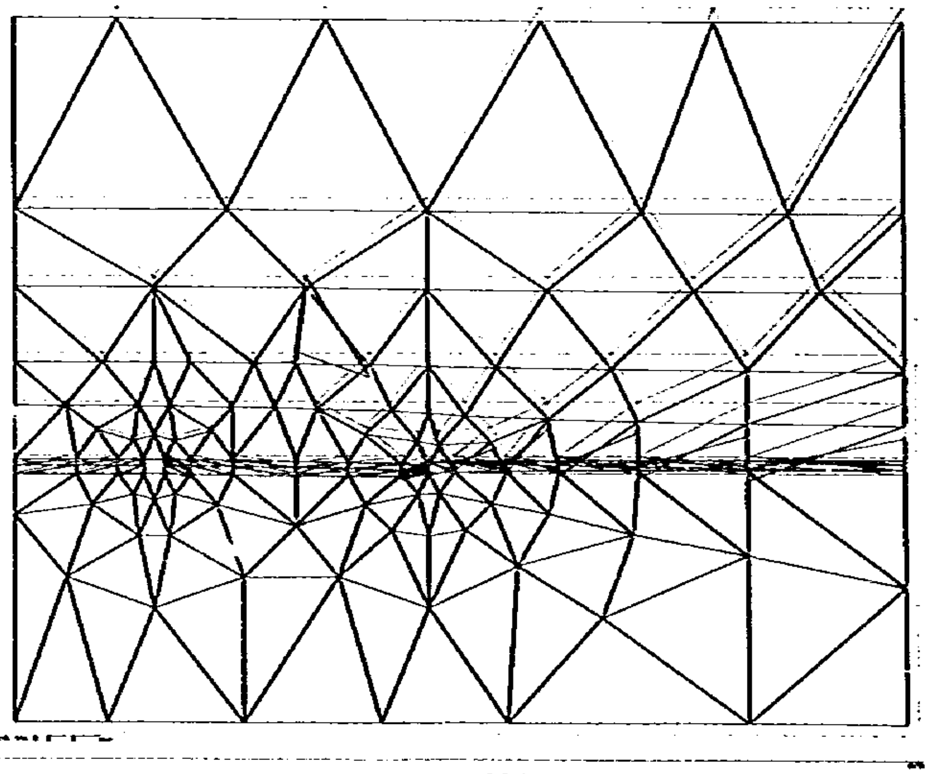


Figure 6 Lakhra model 2 - Step 4 Displacement

Figure 7 Lakhra model 2 - Step 2 Principal stress distribution

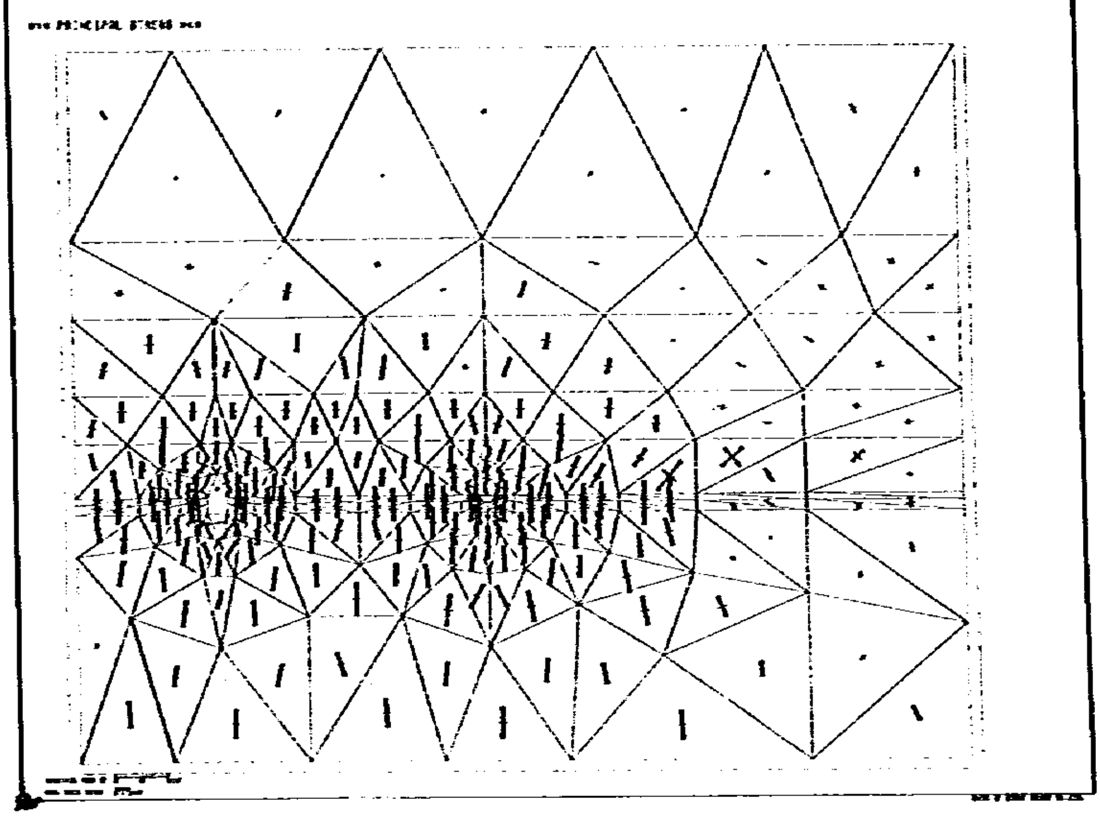


Figure 8 Lakhra model 2 - Step 4 Principal stress distribution

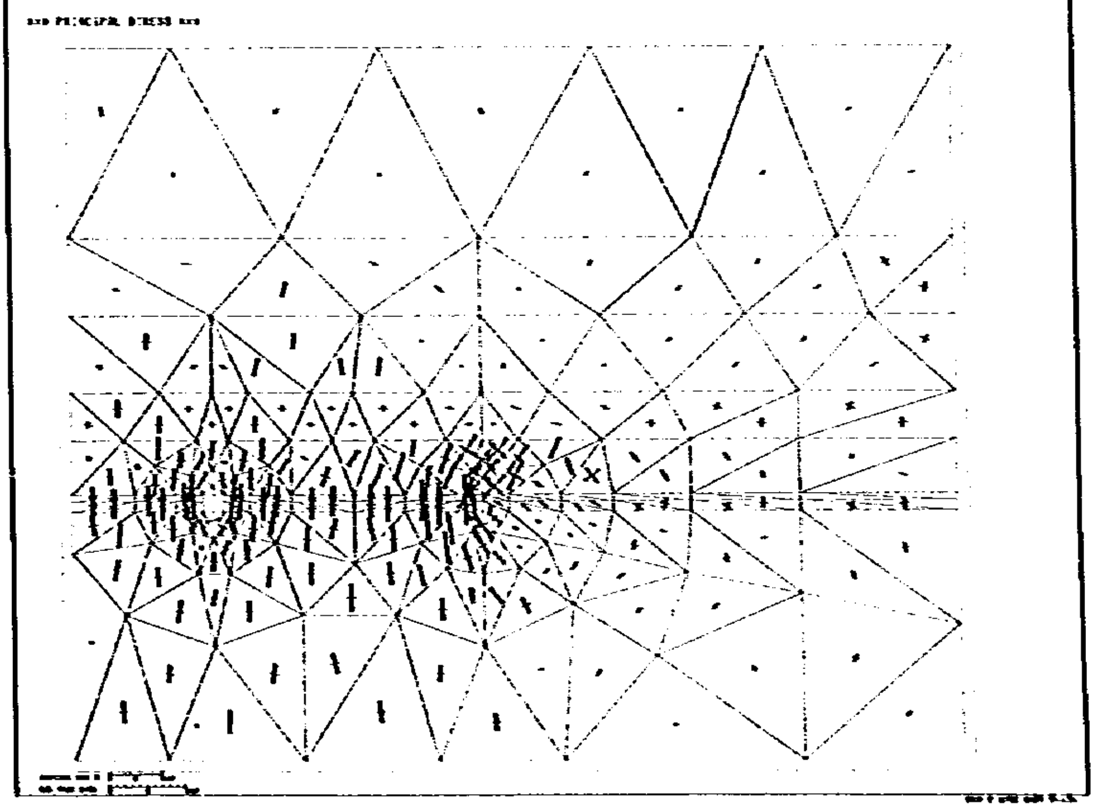


Figure 9 Lakhra model 3 - Sept 1 Displacement

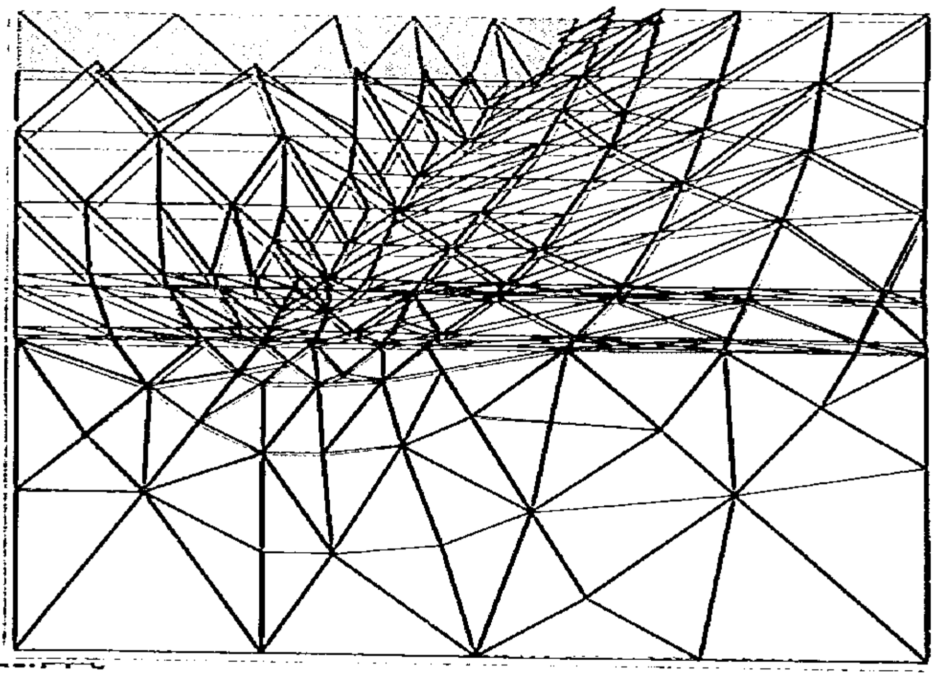


Figure 10 Lakhra model 3 - Step 2 Displacement

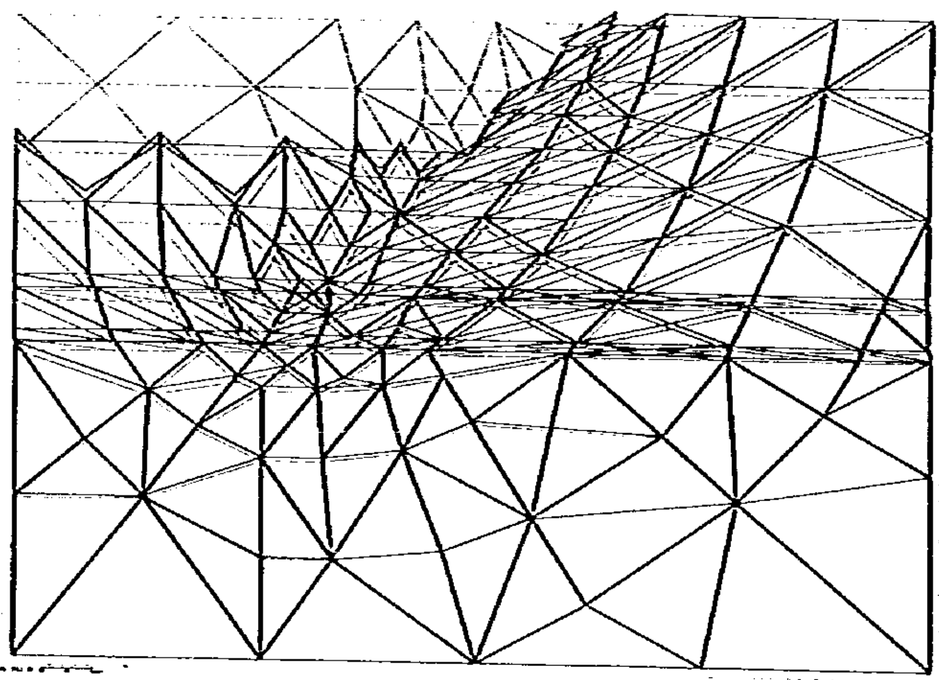


Figure 11 Lakhra model 3 - Step 3 Displacement

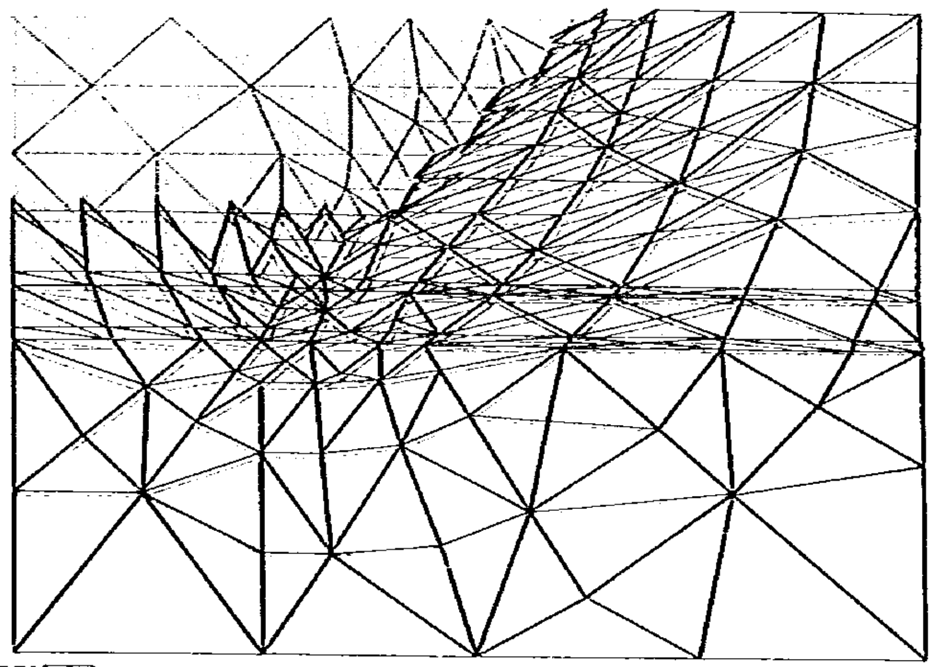


Figure 12 Lakhra model 3 - Step 4 Dispalcement

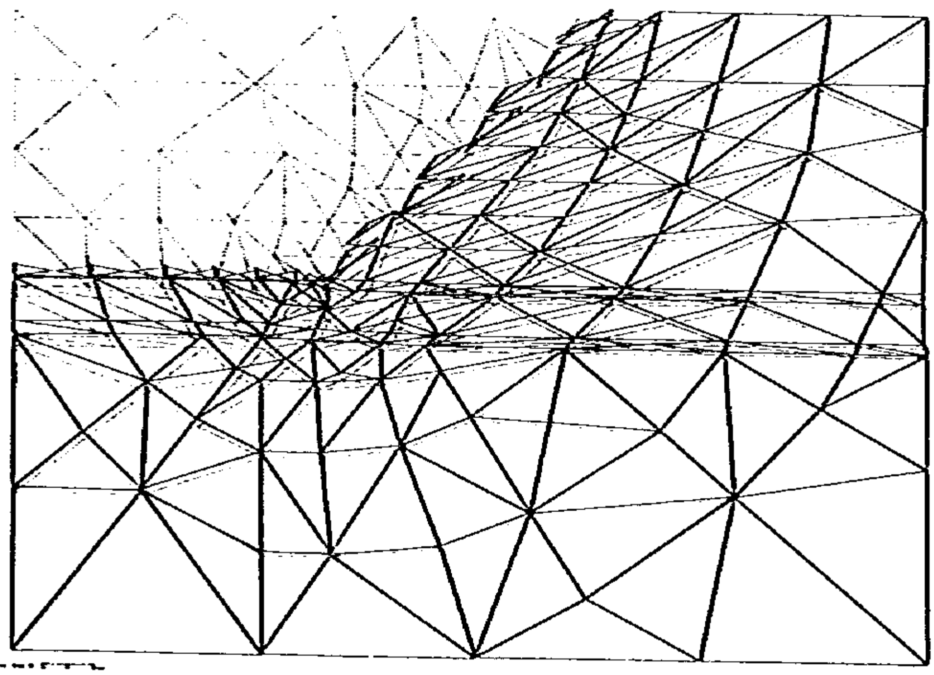


Figure 13 Lakhra model 3 - Step 5 Displacement

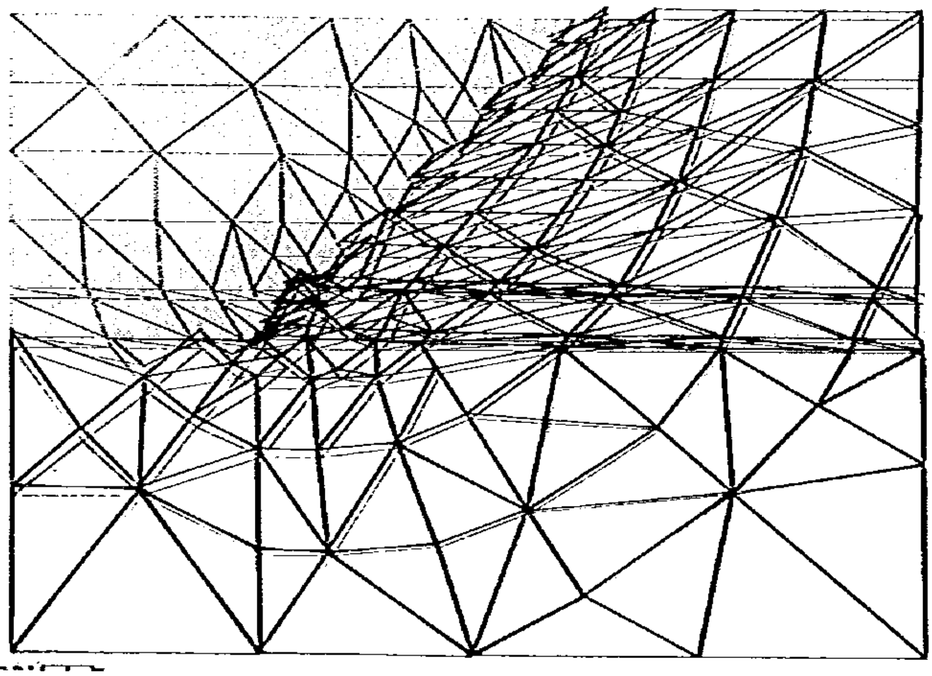


Figure 14 Lakhra model 3 - Step 1 Principal stress distribution

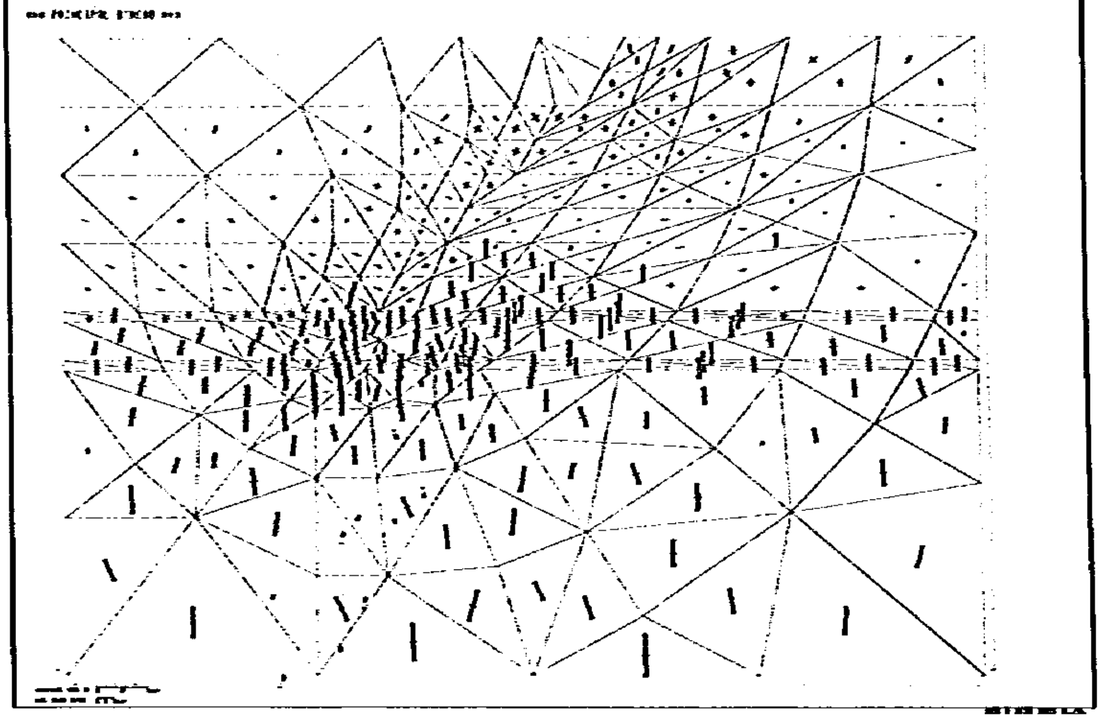
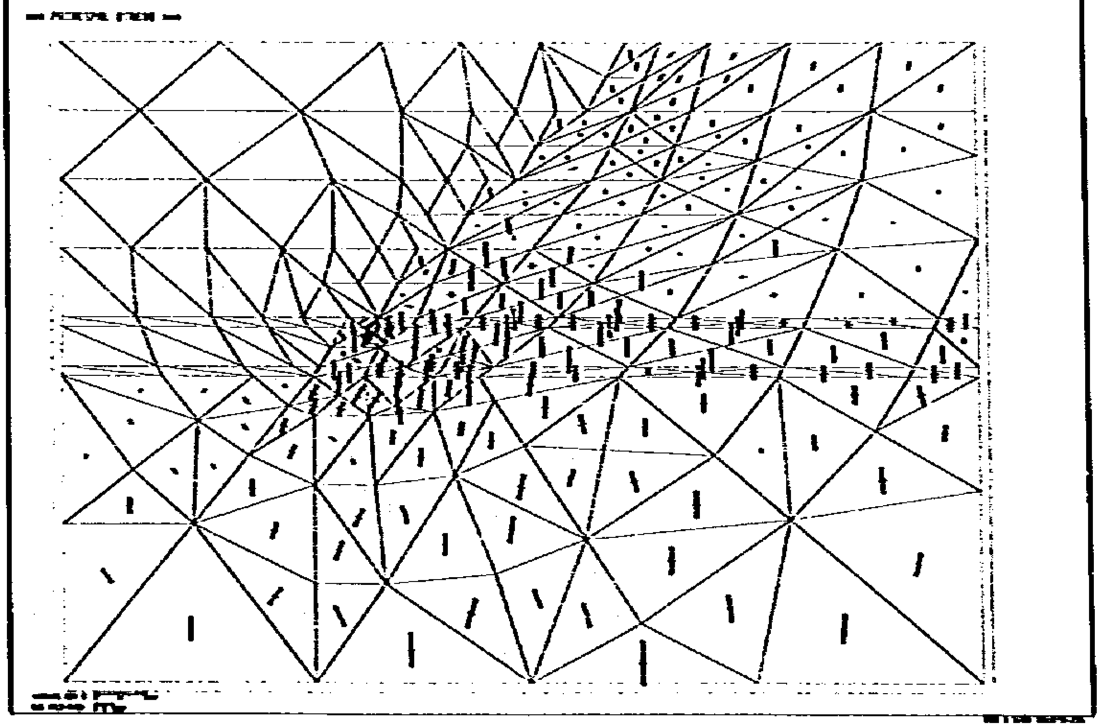


Figure 15 Lakhra model 3 - Step 5 Principal stress distribution



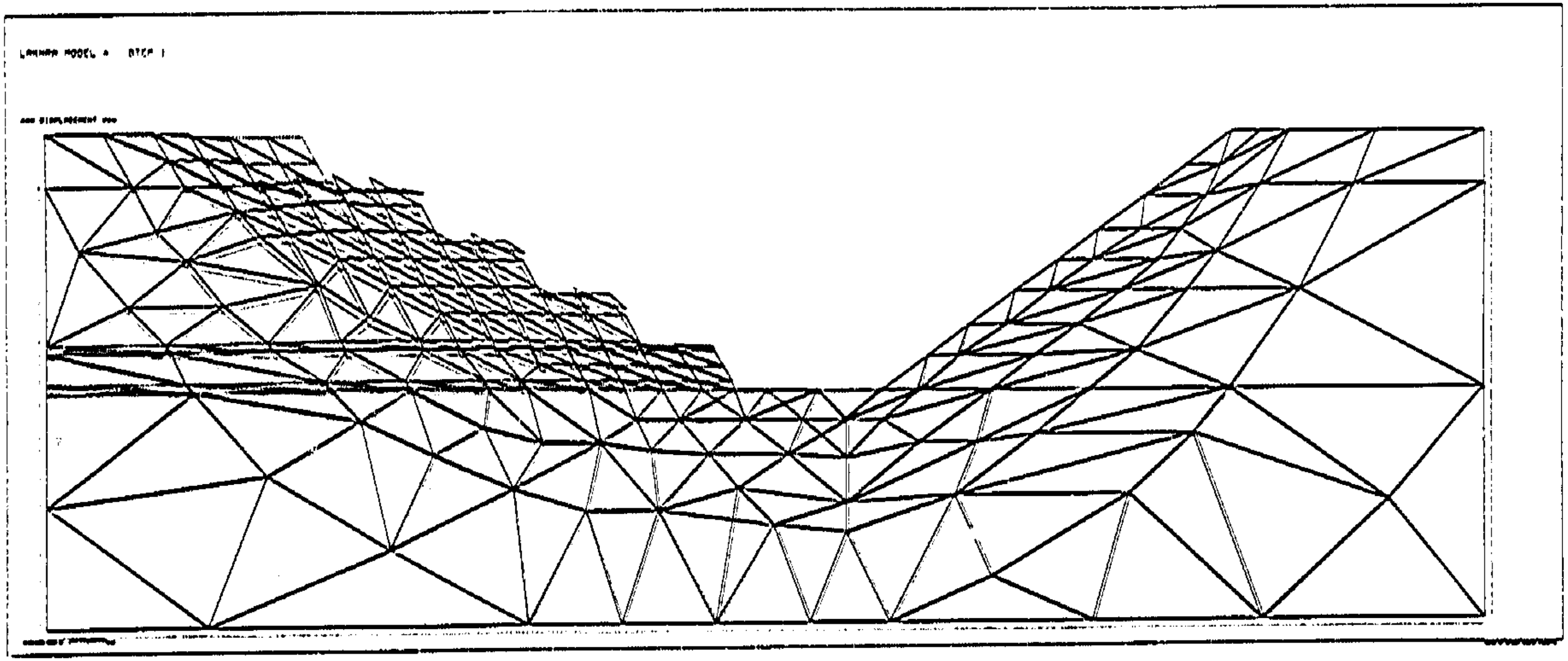


Figure 16 Lakhra model 4 - Step 1 Displacement

Figure 17 Lakhra model 4 - Step 3 Displacement

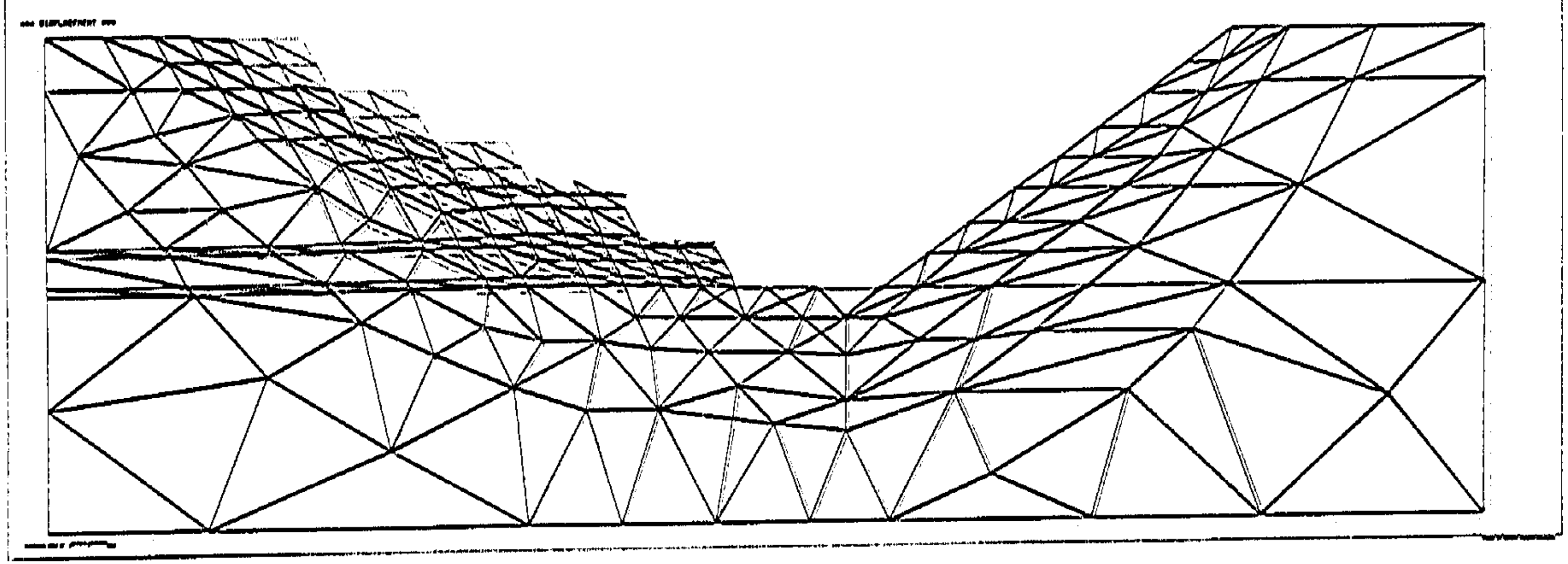


Figure 17 Lakhra model 4 - Step 3 Displacement

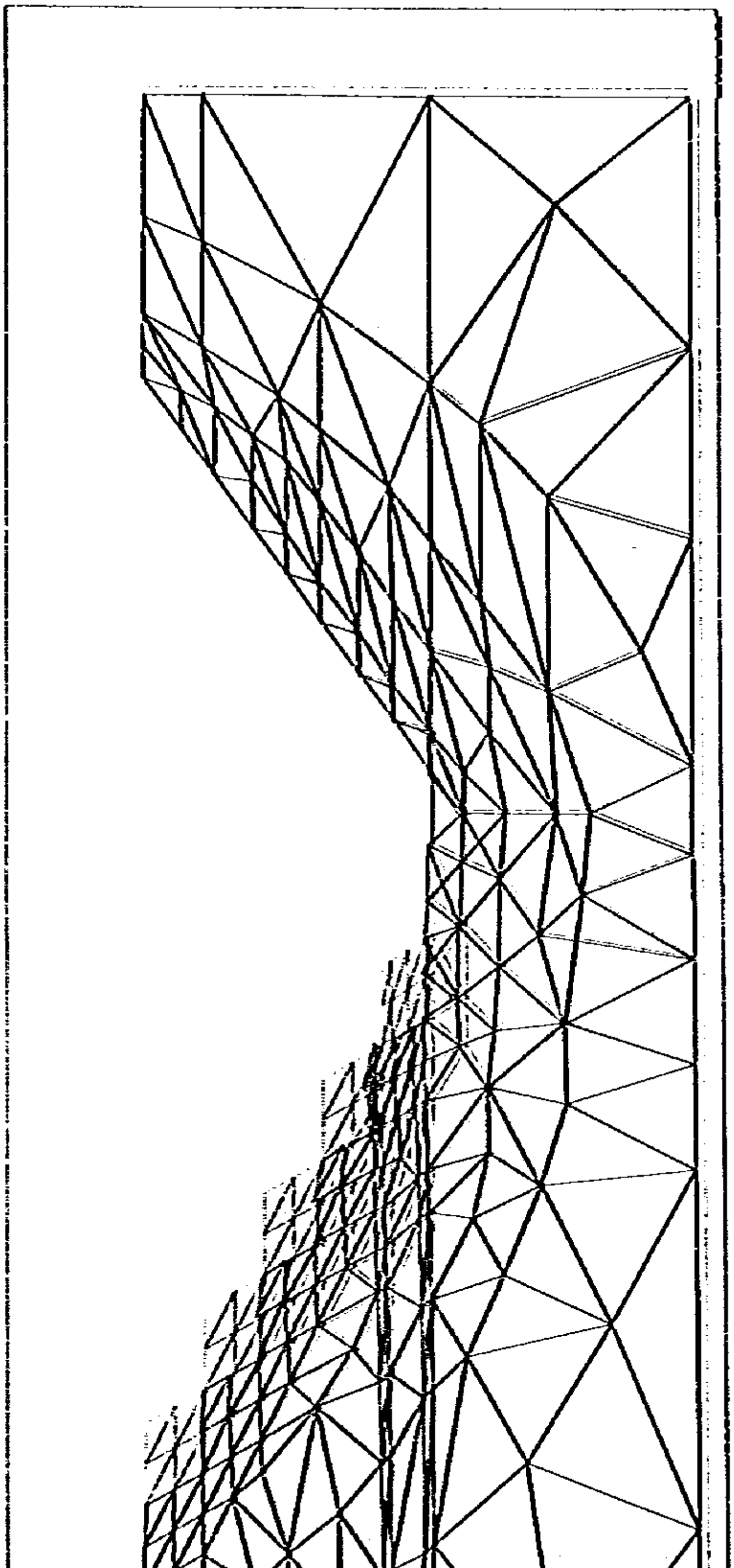


Figure 18 Lakhra model 4 - Step 5 Displacement

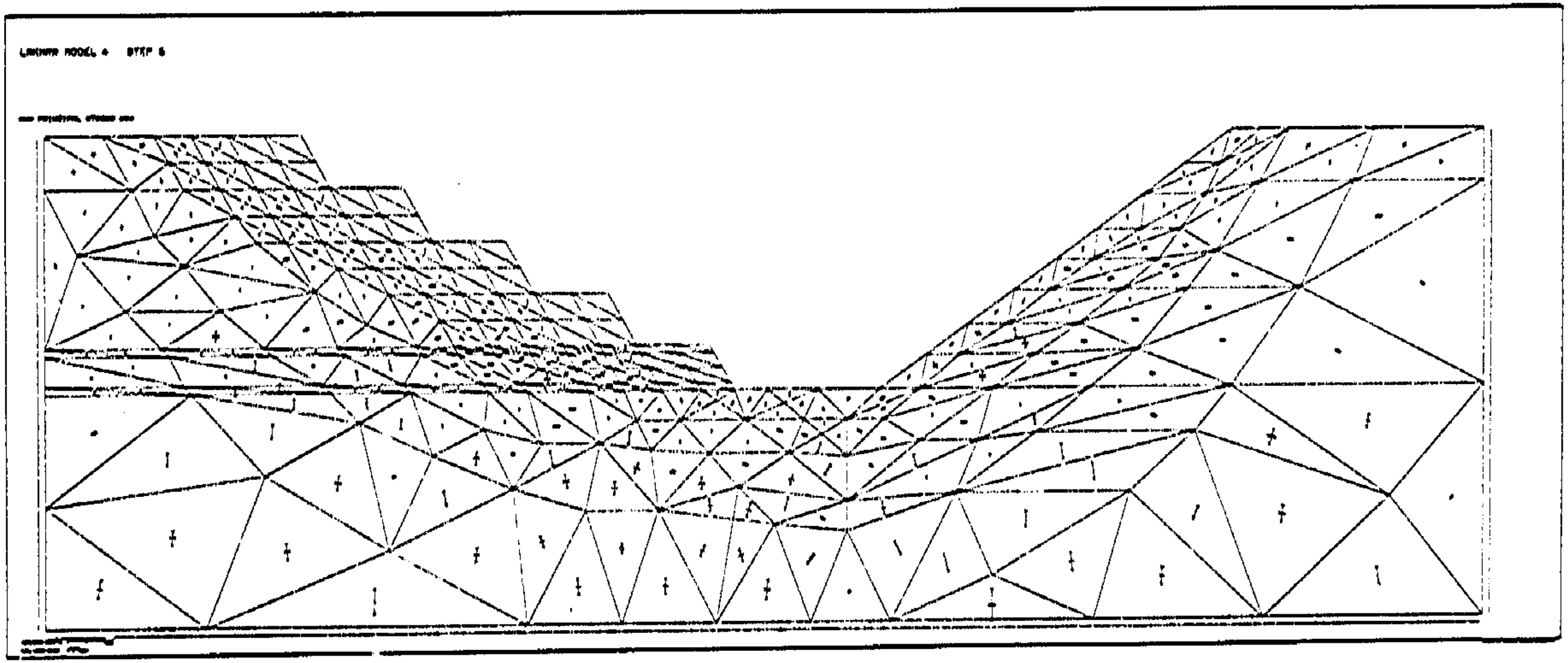


Figure 19 Lakhra model 4 - Step 5 Principal stress distribution

ANNEX 4

OVERBURDEN DRILLING AND BLASTING

Blasthole Diameter

In all open pits, the overburden must be drilled and blasted before stripping. From the practical view-point of drilling operation, the difference in materials to be stripped does not greately alter the drillability in Lakhra's condition.

Vertical drilling is preferred over horizontal drilling because it is faster with the weight of the drill on the bit and loading of explosives is accomplished by gravity.

Rotary drills using tricone bits were developed for the petroleum industry. Bits capable of drilling an 8-inch (203 mm) to 17-inch (432 mm) diameter hole are commonly used today.

Concerning the explosives, ammonium nitrate fuel oil (ANFO) has become the prime blasting agent used for open pit mining, due to its low comparative cost, ease of handling and good blasting quantities.

The large diameter of the holes, the greater the hole spacing and burden. The power content per hole also increase with the diameter. This causes greater vibration and increased level of noise. The objective of using smaller diameter holes is to reduce seismic shock, thus cutting down on the production of fines.

The environmental aspects of blasting have become very important. On the other hand, blasting effect must be good for overburden loading and hauling in bench cut system.

In Lakhra open pit, crawler-mounted rotary drills with tricone bit of 9-7/8 inches in diameter are selected as overburden drilling machines, due to its reasonable purchase price, maneuvability, ease of maintenance and its popularity in every kinds of mining industries in the world.

Blasthole Spacing

Blasting techniques determine the fragmentation degree, which greatly influences the productivity and maintenace costs of shovel and truck.

To improve blasting technique, it is necessary to know how the explosive force acts, how rock resists this force and how rock-failure occurs. The many factors that determine the economics of blasting (borehole pattern and diameter, bench height, burden, spacing, explosive cost etc.) create difficulties when correlation is attempted between cause and effect in blasting phenomena.

The overburden in Lakhra coal project area is well stratified rock and favorable for blasting. The blasting efficiency and rock fragmentation will be improved by reasonable combination of borehole diameter, spacing and explosives consumption per cubic meter of overburden.

It is customary to select spacing smaller than the burden. The blasthole spacing in bituminous coal overburden is selected typically from 7.5 x 7.5m for 9 inches of hole diameter of 12 x 12m for 15 inches of hole diameter.

The blasthole spacing for overburden bank shooting in Lakhra open pit is determined 7 x 8 m for 9-7/8 inches of hole diameter. This spacing will be sufficient for preparing the overburden to be digged by powerful electric quarry-mine shovel. The most effective spacing will be defined after some operational trials and experiences in practice.

ANFO Charge Weight

ANFO explosive will be applied for blasting of overburden, partings as well as coal seams where required. The explosive is not particularly strong, but because it is used in loose form it fills the borehole completely and therefore has a high loading density and a good blasting effect. It is used normally column charges.

For blasting of overburden, the ANFO charge weight can be expressed reasonably by the following relationship:

$$L = C \cdot D \cdot W \cdot H$$

where:
- L = ANFO charge weight in kg
- C = Blasting factor (C = g.e.d.f(n))
- D = Spacing of boreholes in m x m
- W = Burden in m
- H = Bench height in m

where;
- g is factor dependent on stiffness of rock against blasting.
- e is factor dependent on detonation pressure.
- d is factor dependent on explosive charge in blasthole.
- f(n) is coefficient dependent on n(n = r/W), where r is the radius of surface round made by stress cone.
- f(n) is expressed as $f(n) = \sqrt{1 + n^2} - 0.41)^2$

All of above mentioned parameters and factors for Lakhra open pit are determined and the ANFO charge weight per bulk m^3 of overburden to be blasted is derived as follows:

D=7 m, W=7 m, H=14 m, g=0.4 (for medium hard limestone and sandstone), e=1.1 (for ANFO), d=1.0 (for perfect stemming), n=1.0 (r=8 m, W=8 m).

Then, the following values are derived applying above-mentioned relationship:

Blasting factor (C)	0.4 x 1.1 x 1.0 x 1.0 = 0.44
Charge weight (L)	0.44 x 8.0 x 7.0 x 14.0 = 344.96 (kg)
Volume of overburden blasted:	8.0 x 7.0 x 14.0 = 784 (bank m^3)
Powder factor:	344.96/784 = 0.44 (kg/m^3)

Penetration Rate of Blasthole Drilling

Rolling cutter bits can penetrate soft formations as well as very hard formations. The penetration rates are 10 to 25 m/h for very hard sandstone, 30 to 90 m/h for clays, shales and soft sandstone and are often restricted more by the ability of the machine to remove the cutting than by the ability of the bit to penetrate.

Moves and rig set-ups are required frequently in drilling operations. Other non penetrating time is used to add stem where required and for routine maintenance.

Under blasthole drilling conditions with rolling-cutter bits, thrust up to 8,000 lb/in. of bit diameter may be required. The optimum rpm for rolling cutter bits must be determined at each operation by test. This optimum usually will be between 50 and 100 rpm. A rotary speed of less than 50 rpm is used frequently to start the hole.

According to the laboratory tests on rock samples of proposed area, the unaxial compressive strength ranges from 141.9 to 957.3 kg/cm^2 for Laki limestone, the hardest in that area, and extends much lower values for other strata.

The penetration rate in Lakhra's conditions is calculated by the following relationship, estimating necessary parameters as belows:

Penetration rate: $P = (61 - 28 \log_{10} Sc)\ (W/\phi)\ (RPM/300)$

where: Sc = Compressive strength in psi
W/ϕ = Weight per inch of bit diameter in lb/in. x 10^{-3}
RPM = Revolutions per minute of the drill pipe or bit

Estimation for the penetration ratio under Lakhra's condition:

$Sc = 700\ kg/cm^2 = 9,957$ psi
$W/\phi = 7$
RPM = 100 rpm
Penetration ratio: $P = (61 - 28 \cdot \log_{10} 9,957) \cdot 7 \cdot 100/300$
$= 77.23$ ft/h
$\doteqdot 23.5$ m/h

ANNEX 5

COMPUTER SIMULATION OF SHOVEL/TRUCK PROBLEM

Various simulation techniques have been used to evaluate a new shovel, a new truck, a new conveyor or some piece of equipment. Too often, the particular equipment application is studied by applying fudge factors based on experience which will hopefully produce an accurate evalutation upon which the mine can make a judgement. The equipment runs by itself hardly in an ideal situation. It is often penalized because of unavoidable interference by other operations as mining is a synthesized activity of various kinds of operations.

A simulation program developed here and coded by FORTRAN IV was applied to solve the productivity of shovel/truck system. The program allows to simulate the loading performance of shovel, hauling capacity of trucks and the variation in utilization of equipment according to the number of trucks in a simulation model representing hypothetical open pit.

In order to properly utilize the program for open pit operation of Lakhra coal project, some specific information was reasonably assumed as input data based on the mining studies by JICA Survey Team in Pakistan. The productivity of shovel/truck system in Lakhra coal mine was estimated after the consideration of various output figures derived from the simulation which enables thousand times of events to execute.

Electric Shovel (11.5m^3 dipper) and Trucks (120 tonnes) for Overburden Removal.

Main input data are as belows:

Total hour per shift	480 min.
Transportation (lunch) loss	40 min.
Propel time factor	0.85 (Shovel), 1.00 (Truck)
Mech. availability of shovel	0.75
Mech. availability of truck	0.70
Capacity of equipment	Shovel dipper 11.5m^3 Max. payload of truck 120 tonnes
Skillness factor	0.80

Distribution of loading performance of shovel;

	Lowest	Most likely	Highest
Cycle time (min.)	0.42	0.58	0.75
Spot time (min.)	0.30	0.40	0.45

Performance of truck (average);

	Travel Speed km/h	Accel km/sec^2	Decel km/sec^2
Loaded Benches in pit	20.0	0.28	0.28
Loaded Slope (upward)	10.0	0.19	0.19
Loaded Graded flat land	20.0	0.28	0.28
Loaded Bad flat land	18.0	0.19	0.19
Empty Bad flat land	20.0	0.28	0.28
Empty Graded flat land	30.0	0.28	0.28
Empty Slope (downward)	15.0	0.19	0.19
Empty Benches in pit	25.0	0.28	0.28

The following figures were obtained on the model with typical haulage routes:

	Lowest	Most likely	Highest
Average travel speed (km/h)	12.85	18.85	21.85
Spot time at loading site (min.)	0.40	0.50	0.80
Waste discharge time (min.)	0.35	0.50	0.60

A part of simulation results is shown as belows (operation on the three shifts/day):

One Way (km)	No. of trucks	Av. Speed (km/h)	Effective (hrs/yr)	Amount of O/B (10^3 tonnes/yr)	Availability of shovel
2.5	4	18.1	4,273	2,616	0.546
2.5	5	18.1	3,895	2,971	0.630
2.5	4	18.85	4,273	2,660	0.568
2.5	5	18.85	3,790	2,971	0.633
3.0	4	18.23	4,315	2,306	0.480
3.0	5	18.23	4,153	2,749	0.600
3.0	4	18.87	4,294	2,350	0.498
3.0	5	18.87	4,126	2,793	0.610
3.0	4	19.55	4,336	2,439	0.516
3.0	5	19.55	4,053	2,926	0.620
3.5	4	18.88	4,347	2,128	0.449
3.5	5	18.88	4,305	2,616	0.567

After considering the result of simulation executed as a case study, the overburden stripping and loading productivity was determined to be 137m^3/truck/h as an average by the combination of one shovel and four or five trucks.

Hydraulic Excavator (6.0m^3 bucket) and Trucks (46 tonnes) for Coal Loading and Hauling.

The simulation of this problem was executed in like the abovementioned case and the results were obtained to be applied to the determination of coal loading and hauling productivity. Consequently, the productivity of said operation was determined to be 104.4 tonnes/truck/h in West open pit and 95.7 tonnes/truck/h in East open pit.

ANNEX 6

COMPARISON OF COSTS FOR TRANSPORTATION SYSTEMS

System	Description	Total cost for 30 years (000's Rs)	Remarks
Railway (Preparation plant to Khanot)	Depreciation	221,400	Depreciation: 30 years Salvage value: 10% Interest: Foreign; 8.75% Local ; 12.5 % Operating cost: for 30 years Transportation capacity: 1.2 million tonnes/year
	Interest: Foreign	77,840	
	Local	50,550	
	Sub-Total	128,390	
	Operating cost	446,610	
	TOTAL	796,400	
Truck (Preparation plant to Khanot)	Depreciation	197,100	
	Interest: Foreign	88,480	
	Local	34,727	
	Sub-Total	123,207	
	Operating cost	1,011,750	
	TOTAL	1,332,057	
Difference		535,657	

The cost of the railway system is equivalent to approximately 60 % of the truck cost and more economical than the truck system, therefore, the former has been planned in this report.

Transportation Cost

System	Description	Foreign (000's Rs)	Local (000's Rs)	Total (000's Rs)
Railway (Preparation plant to Khanot)	Capital cost	105,934	128,420	234,354
	Contingency	5,264	6,382	11,646
	Total	111,198	134,802	246,000
	Operating cost per year	2,454	12,433	14,887
	Depreciation per year	3,336	4,044	7,380
Truck (Preparation plant to Khanot)	Capital cost	120,553	38,325	208,878
	Contingency	5,842	4,280	10,122
	Total	126,395	92,605	219,000
	Operating cost per year	4,140	29,585	33,725
	Depreciation per year	3,792	2,778	6,570

ANNEX 7

RESIDENTIAL AREA

A required residential area in Khanot is based on manpower requirement which consists of 218 officers and 1,308 workers, and additional 20 % of total manpower for other residents.

The residential area is assumed to be six times of the total housing construction area and additional 10 % of the total for a public usage. The total area is estimated to be approximately 700,000m². Construction cost is not estimated in this report except water supply cost from a reservoir to the residential area.

The estimated basis of the area is as follows;

1. Housing Construction Area

(1) Officers

Type A	252m²	x	1 =	252m²
Type B	223m²	x	2 =	446m²
Type C	177m²	x	14 =	2,478m²
Type D	117m²	x	36 =	4,212m²
Type E	79.2m²	x	168 =	13,306m²
TOTAL			221	20,694m² ≑ 21,000m²

(2) Workers

Type F 51.1m² x 1,308 = 66,839m² ≑ 67,000m²

(3) Other Residents

(21,000 + 67,000) x 20% = 17,600 ≑ 18,000m²

2. Residential Area

(1)	For officers	21,000m² x 6	= 126,000m²
(2)	For workers	67,000m² x 6	= 402,000m²
(3)	For other	18,000m² x 6	= 108,000m²
	Sub-Total		636,000m²
(4)	For public	636,000m² x 10% =	64,000m²
	TOTAL		700,000m²

ANNEX 8

COAL PREPARATION – WASHING SYSTEM

1. Plant Feed Coal

Since the washing system is adopted for only coarse coal of more than 12 mm in size, the raw coal ash content from each mining area is divided as follows at 12 mm in size.

	Open pit West	Open pit East	Underground mine
+12 mm raw coal ash %	27.0	22.6	23.8
-12 mm raw coal ash %	23.2	19.6	20.8
Total	25.1	21.1	22.3

Adding 5 % of the rock dilution in the raw coal for the open pit areas and 4 % for the underground mine and assuming that 70 % of the total dilution is contained in the raw coal of more than 12 mm in size and 30 % is contained in the raw coal of less than 12 mm in size, the ash content of the plant feed coal in each size are as follows;

	Open pit West	Open pit East	Underground mine
+12 mm plant feed coal ash %	30.4	26.3	26.7
-12 mm plant feed coal ash %	24.8	21.3	22.1
Total	27.6	23.8	24.4

2. Over 12 mm Jig Feed Coal

The ash content of over 12 mm Jig feed coal from each mining area are changed as follows by hand picking.

	Ash content % Before picking	Ash content % Jig feed
Open pit west	30.4	26.5
Open pit east	26.3	22.1
Underground mine	26.7	22.5

The washabilities of the above Jig feed coal are estimated from the data of several float and sink tests described in the geological report, and the washabilities are shown in Table 1, 2 and 3, and its curves are shown in Fig. 1, 2 and 3.

Summarizing these washability data at 1.8 specific gravity separation, the near gravity material of over 12 mm plant feed coal produced from each mining area are 6.8, 8.0 and 8.0 % respectively. Accordingly, these washabilities are simple comparatively and it can be satisfactorily washed with a Jig washer. The clean coal ash content at this time indicate 14.1, 13.7 and 14.0 % respectively and resemble each other, and the theoretical yield indicate 78.4, 82.3 and 82.6 % of considerable high value. The clean coal produced from a Jig washer indicate low ash content comparatively and it is suitable for briquetting use because a certain sulphur reduction by washing.

3. Jig Washer Performance

A Jig washer performance of over 12 mm raw coal at 1.8 specific gravity is estimated as follows.
Imperfection (I) of Jig washer is applied as 0.15 of a standard Jig performance in Japan.

	Open pit West	Open pit East	Underground Mine
Near gravity Dp ± 0.1	6.8	8.0	8.0
Imperfection I	0.15	0.15	0.15
Probable error Ep	0.12	0.12	0.12
S. G. of separation Dp	1.80	1.80	1.80
Raw coal ash %	26.5	22.1	22.5
Clean coal ash %	14.3	14.1	14.4
Reject ash %	67.8	56.3	57.5
Theoretical yield %	78.9	83.4	83.4
Recovery efficiency %	97.6	97.1	97.4
Estimated yield %	77.0	81.0	81.2

4. Clean Coal Quality of Washing System

When the coal for power plant use is produced by blending over 12 mm washed coal and under 12 mm unwashed coal, the clean coal quality from each mining area are shown as under.

a) Open Pit West

		Air dried	As received
Moisture	%	8.2	25.0
Ash	%	20.4	16.7
V. M.	%	36.5	29.8
T. S.	%	5.6	4.6
Cal. V.	kcal/kg	5000	4080
Yield	%	85.4	85.4

b) Open Pit East

		Air dried	As received
Moisture	%	11.4	25.0
Ash	%	18.2	15.4
V. M.	%	35.7	30.2
T. S.	%	4.7	4.0
Cal. V.	kcal/kg	5045	4270
Yield	%	87.3	87.3

c) Underground Mine

Moisture	%	9.0	25.0
Ash	%	18.8	15.5
V. M.	%	36.4	30.0
T. S.	%	5.8	4.8
Cal. V.	kcal/kg	4940	4070
Yield	%	87.4	87.4

d) Whole Areas

Moisture	%	9.3	25.0
Ash	%	19.4	16.1
V. M.	%	36.2	30.0
T. S.	%	5.4	4.5
Cal. V.	kcal/kg	5000	4135
Yield	%	86.4	86.4

5. Flowsheet Criteria

The description of the raw coal receiving and hand picking system are omitted due to same as the unwashing system. A feed rate of the raw coal to the washing plant after hand picking is 384 t/h and its size is under 50 mm. The 50 x 0 mm raw coal will be screened with dry method at 12 mm in size and the over 12 mm material will be cleaned by a Jig washer and under 12 mm material will be unwashed product. A ratio of the 12 mm oversize to the 12 mm undersize at the screen is estimated 40 to 50.

Jig washer feed coal 384 t/h x 0.444 = 170 t/h

Considering the size variation of the Jig feed coal, maximum capacity of the Jig washer is estimated with 200 t/h.

Jig washer clean coal	170 t/h x 0.788 =	134 t/h
-12 mm unwashed coal	384 t/h x 0.556 =	214 t/h
Total clean coal		348 t/h
Jig washer reject	170 t/h x 0.212 =	36 t/h
Hand picking reject	400 t/h x 0.04 =	16 t/h
Total reject		52 t/h
Total raw coal		400 t/h

6. Flowsheet

Fig. 4 shows a flowsheet of the raw coal treatment and the washing system. The raw coal receiving, storage and hand picking systems are same as unwashing system. In this washing system, the raw coal after treatment at the hand picking plant will be screened at 12 mm in size and then over 12 mm coarse material will be cleaned by a Jig washer and under 12 mm fine coal will be unwashed product.

The 50 x 0 mm raw coal treated at the hand picking plant will be fed to a dry vibrating screen through a plant feed belt conveyor and screened at 12 mm in size. The 50 x 12 mm raw coal from a 80 tonne service hopper will be washed by a 170 t/h Baum Jig washer through two vibrating feeders. The Jig washer consists of one compartment and the coarse raw coal is cleaned at 1.8 specific gravity, with removing the reject of high specific gravity. The reject from the Jig washer is stored into a 150 tonne reject bin after joining with the hand picking reject through two reject conveyors, and from here it is dumped to the reject disposal area by a truck.

The overflow product from the Jig washer will be dewatered by a 1 mm opening vibrating screen through a 0.8 mm pre-dewatering stationary screen. The dewatered clean coal will joint together with under 12 mm unwashed fine coal and will be stored to two 2,000 tonne clean coal silos through a clean coal conveyor. The clean coal loading and emergency storage systems are same as unwashing system.

The dewatering screen undersize will go to a 20 m static thickener and the thickener overflow will be pumped to a head tank to be recycled to the Jig washer. The 200 m³ pump sump will sufficiently hold the surplus recycled water when the plant shut down, and the water will not be discharged to the any plant outside. The thickener underflow will be dewatered in a screen-bowl centrifuge and the dewatered cake will fall onto the Jig washer clean coal conveyor. The slurry from the centrifuge will back to the thickener.

7. Capital Cost

		Foreign (000's Rs)	Local (000's Rs)	Total (000's Rs)
1.	Raw coal receiving & handling	22,170	12,702	34,872
2.	Washing equipment	18,784	10,074	28,858
3.	Clean coal storage & loading	17,172	9,851	27,023
4.	Electrical equipment	6,375	4,397	10,772
5.	Steel structure & housing	11,562	7,232	18,794
6.	Auxiliary equipment	8,473	3,760	12,233
7.	Spare parts	15,504	6,642	22,146
8.	Engineering & installation	16,074	–	16,074
9.	Temporary work & operation	–	6,088	6,088
10.	Concrete structure	–	21,520	21,520
	Total	116,144	82,266	198,380

The estimates reflect 1980 June price levels.

Material price escalation and contingency are not included.

TABLE 1

FLOAT AND SINK TEST

SAMPLE: LAKHRA COAL
OPEN CUT WEST

DATE: AUGUST 1980

SIZE: 50-12 MM

Specific gravity	a		b	c	d	e	f	g	h	i	j
	Weight (%)	Ash (%)	$\Sigma W_{n-1} + \frac{W_n}{2}$	W·A	ΣW·A	ΣW	$\frac{\Sigma W \cdot A}{\Sigma W}$	Total W·A −ΣW·A	100 −ΣW·A	$\frac{g}{h}$	±0.1 SG
− 1.30	9.80	4.70	4.90	46.06	46.06	9.80	4.70	2.604.17	90.20	28.87	
1.30 ~ 1.35	9.10	4.90	14.35	44.59	90.65	18.90	4.80	2.559.58	81.10	31.56	
1.35 ~ 1.40	22.30	6.10	30.05	136.03	226.68	41.20	5.50	2.423.55	58.80	41.22	48.80
1.40 ~ 1.50	17.40	15.10	49.90	262.74	489.42	58.60	8.35	2.160.81	41.40	52.19	26.60
1.50 ~ 1.60	9.20	23.90	63.20	219.88	709.30	67.80	10.46	1.940.93	32.20	60.28	15.90
1.60 ~ 1.70	6.70	33.60	71.15	225.12	934.42	74.50	12.54	1.715.81	25.50	67.29	10.60
1.70 ~ 1.80	3.90	43.60	76.45	170.04	1.104.46	78.40	14.09	1.545.77	21.60	71.56	6.80
1.80 ~ 1.90	2.90	51.00	79.85	147.90	1.252.36	81.30	15.40	1.397.87	18.70	74.75	4.50
1.90 ~ 2.00	1.60	54.60	82.10	87.36	1.339.72	82.90	16.16	1.310.51	17.10	76.64	3.00
2.00 ~ 2.10	1.40	58.00	83.60	81.20	1.420.92	84.30	16.86	1.229.31	15.70	78.30	
2.10 ~ +	15.70	78.30	92.15	1.229.31	2.650.23	100.00	26.50	.00	.00	.00	
~											
~											
−											

TABLE 2

FLOAT AND SINK TEST

SAMPLE: LAKHRA COAL
OPEN CUT EAST

DATE: AUGUST

SIZE: 50-12 MM

Specific gravity	a		b	c	d	e	f	g	h	i	j
	Weight (%)	Ash (%)	$\Sigma W_{n-1} + \frac{W_n}{2}$	W·A	ΣW·A	ΣW	$\frac{\Sigma W \cdot A}{\Sigma W}$	Total W·A −ΣW·A	100 −ΣW·A	$\frac{g}{h}$	±0.1 SG
– 1.30	6.30	5.90	3.15	37.17	37.17	6.30	5.90	2,172.64	93.70	23.19	
1.30 ~ 1.35	5.50	6.30	9.05	34.65	71.82	11.80	6.09	2,137.99	88.20	24.24	
1.35 ~ 1.40	19.20	7.40	21.40	142.08	213.90	31.00	6.90	1,995.91	69.00	28.93	59.60
1.40 ~ 1.50	28.90	10.50	45.45	303.45	517.35	59.90	8.64	1,692.46	40.10	42.21	39.20
1.50 ~ 1.60	10.30	19.80	65.05	203.94	721.29	70.20	10.27	1,488.52	29.80	49.95	18.20
1.60 ~ 1.70	7.90	30.20	74.15	238.58	959.87	78.10	12.29	1,249.94	21.90	57.07	12.10
1.70 ~ 1.80	4.20	39.30	80.20	165.06	1,124.93	82.30	13.67	1,084.88	17.70	61.29	8.00
1.80 ~ 1.90	3.80	46.50	84.20	176.70	1,301.63	86.10	15.12	908.18	13.90	65.34	7.00
1.90 ~ 2.00	3.20	52.20	87.70	167.04	1,468.67	89.30	16.45	741.14	10.70	69.27	6.00
2.00 ~ 2.10	2.80	57.60	90.70	161.28	1,629.95	92.10	17.70	579.86	7.90	73.40	
2.10 ~ +	7.90	73.40	96.05	579.86	2,209.81	100.00	22.10	.00	.00	.00	
~											
~											
–											

TABLE 3

FLOAT AND SINK TEST

SAMPLE: LAKHRA COAL UNDERGROUND

DATE: OCTOBER 1980

SIZE: 50-12 MM

Specific gravity	a		b	c	d	e	f	g	h	i	j
	Weight (%)	Ash (%)	$\Sigma W_{n-1} + \frac{W_n}{2}$	W·A	ΣW·A	ΣW	$\frac{\Sigma W \cdot A}{\Sigma W}$	Total W·A −ΣW·A	100 −ΣW	$\frac{g}{h}$	±0.1 SG
− 1.30	7.60	5.50	3.80	41.80	41.80	7.60	5.50	2.208.30	92.40	23.90	
1.30 ~ 1.35	6.80	5.90	11.00	40.12	81.92	14.40	5.69	2.168.18	85.60	25.33	
1.35 ~ 1.40	20.30	7.00	24.55	142.10	224.02	34.70	6.46	2.026.08	65.30	31.03	52.70
1.40 ~ 1.50	25.60	11.90	47.50	304.64	528.66	60.30	8.77	1.721.44	39.70	43.36	35.80
1.50 ~ 1.60	10.20	21.10	65.40	215.22	743.88	70.50	10.55	1.506.22	29.50	51.06	18.00
1.60 ~ 1.70	7.80	31.20	74.40	243.36	987.24	78.30	12.61	1.262.86	21.70	58.20	12.10
1.70 ~ 1.80	4.30	40.60	80.45	174.58	1.161.82	82.60	14.07	1.088.28	17.40	62.54	8.00
1.80 ~ 1.90	3.70	47.90	84.45	177.23	1.339.05	86.30	15.52	911.05	13.70	66.50	6.60
1.90 ~ 2.00	2.90	52.90	87.75	153.41	1.492.46	89.20	16.73	757.64	10.80	70.15	5.50
2.00 ~ 2.10	2.60	57.70	90.50	150.02	1.642.48	91.80	17.89	607.62	8.20	74.10	
2.10 ~ +	8.20	74.10	95.90	607.62	2.250.10	100.00	22.50	.00	.00	.00	
~											
~											
−											

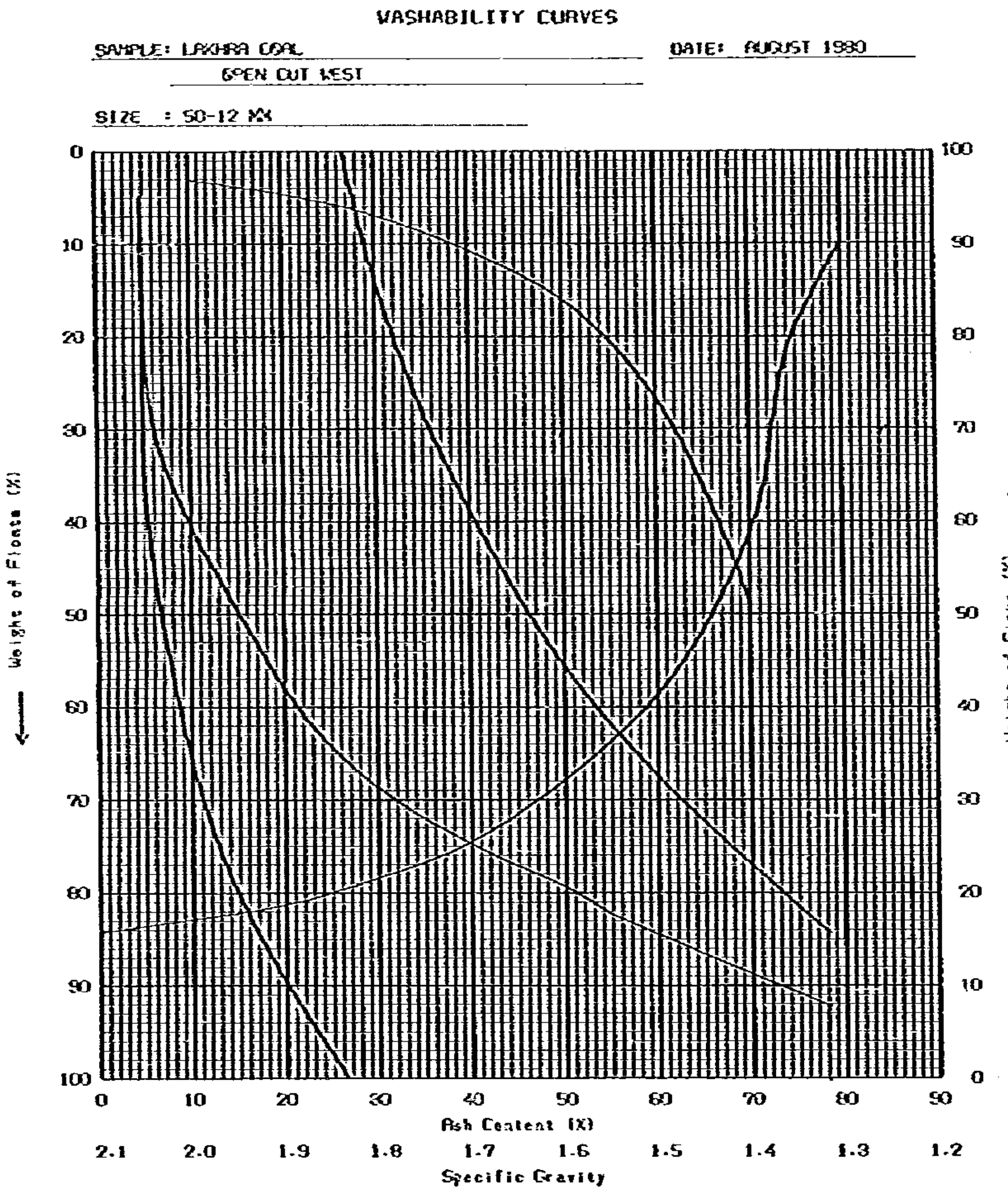


FIGURE 1 WASHABILITY CURVES

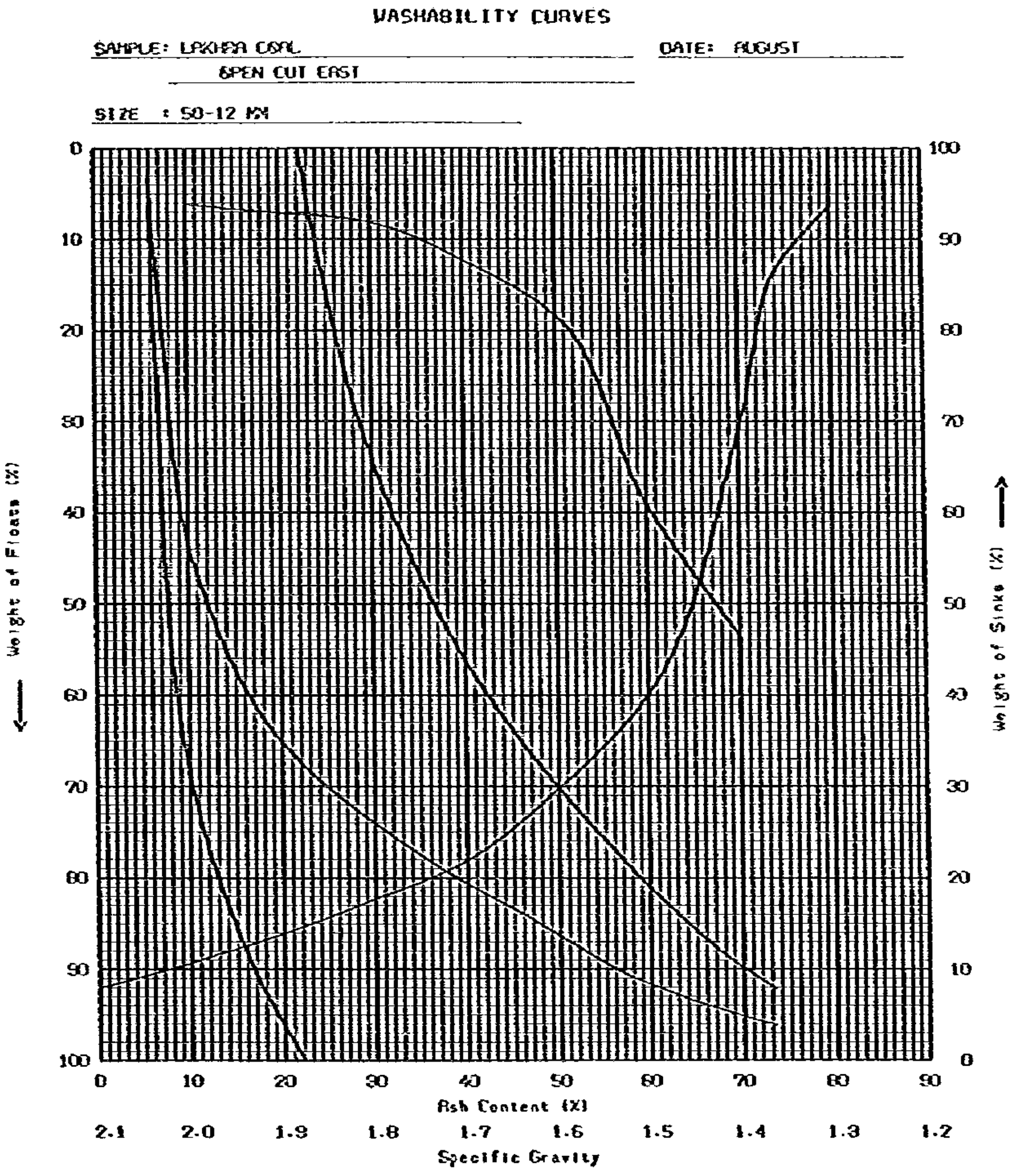


FIGURE 2 WASHABILITY CURVES

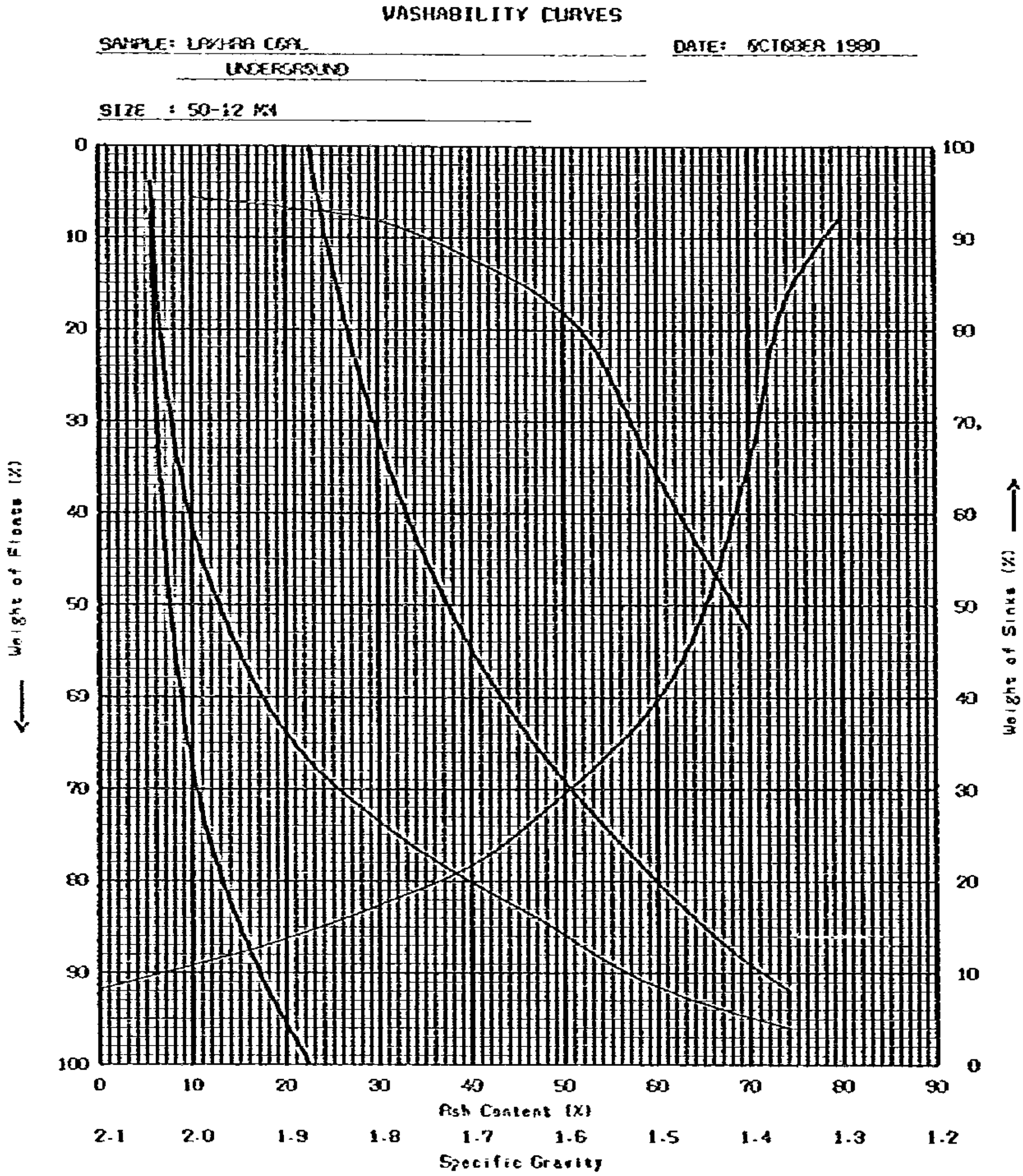


FIGURE 3 WASHABILITY CURVES

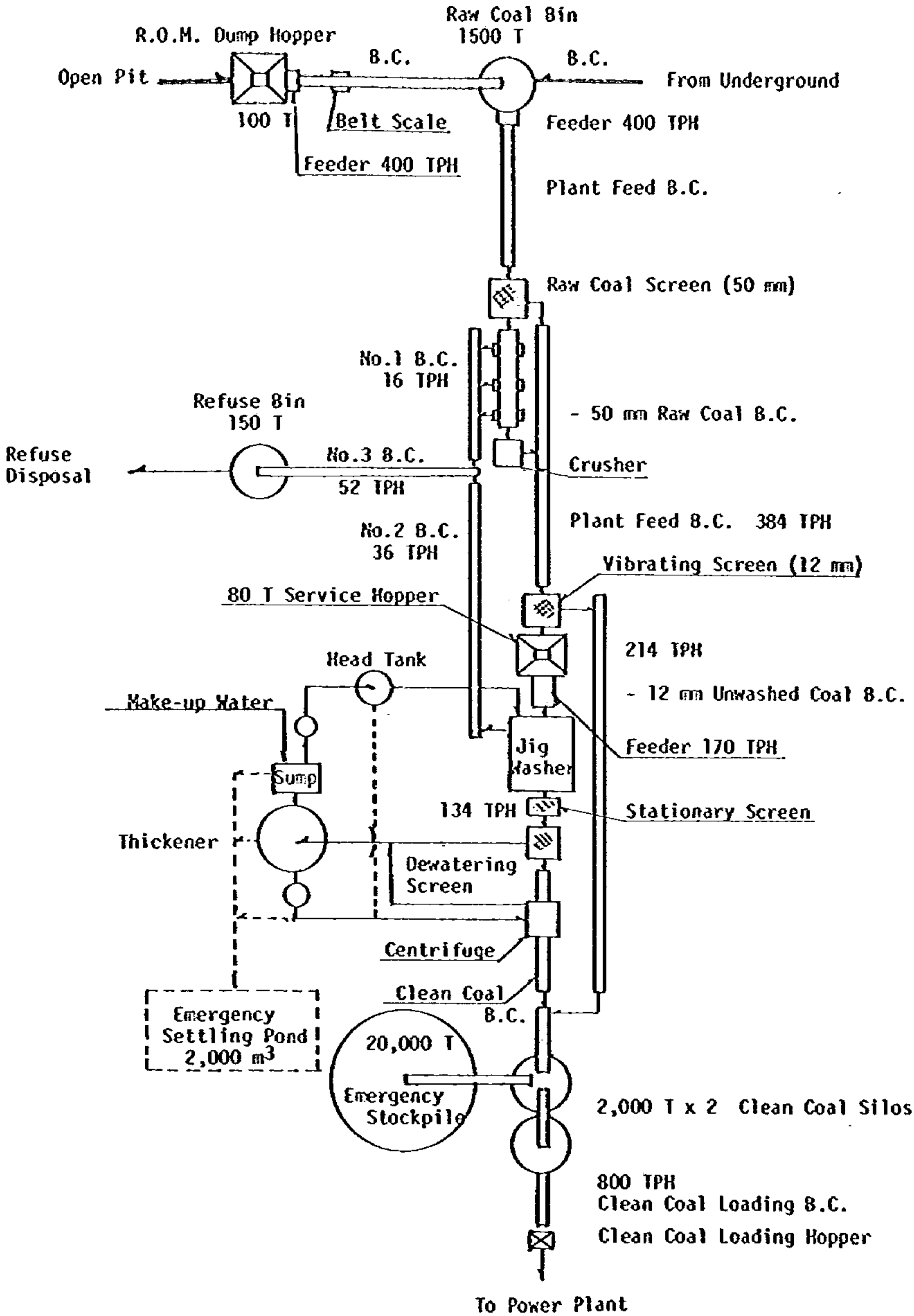


FIGURE 4 FLOWSHEET OF WASHING SYSTEM

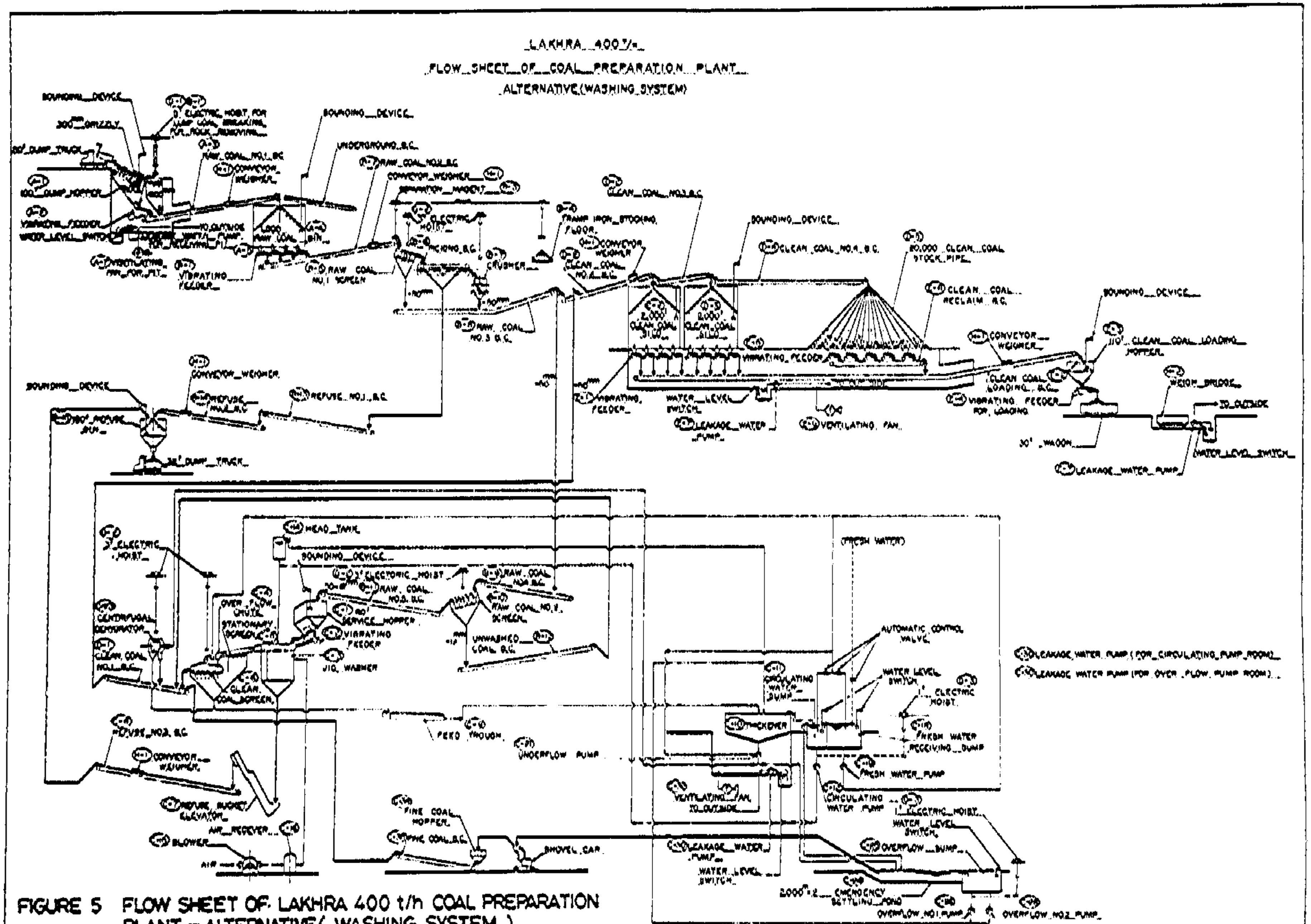


FIGURE 5 FLOW SHEET OF LAKHRA 400 t/h COAL PREPARATION PLANT - ALTERNATIVE (WASHING SYSTEM)