V-2 Supply of Raw Materials

V-2-1 Raw Material Requirement

(1) Requirement

The required quantity of raw material are calculated as follows from the production capacity of the cement factory.

(i) Case-1, 1,500 t·cℓ/d (495,000 t·cℓ/y)

Raw Material	Unit consumption (dry-t/t·cℓ)	Quantity (dry-t/y)	Moisture (%)	Quantity (wet-t/y)
Limestone	1.252	619,740	5	652,358
Clay	0.222	109,890	20	137,363
Silica sand	0.078	38,610	5	40,642
Iron ore	0.013	6,435	5	6,774
Gypsum	0.050	24,750		26,053

(ii) Case-2, 1,000 t·cℓ/d (330,000 t·cℓ/y)

Raw Material	Quantity (dry-t/y)	Quantity (wet-t/y)
Limestone	413,160	434,905
Clay	73,260	91,575
Silica sand	25,740	27,095
Iron ore	4,290	4,516
Gypsum	16,500	17,368

(iii) Case-3, 750 t·cℓ/d (247,500 t·cℓ/y)

Raw Material	Quantity (dry-t/y)	Quantity (wet-t/y)
Limestone	309,870	326,179
Clay	54,945	68,681
Silica sand	19,305	20,321
Iron ore	3,218	3,387
Gypsum	12,375	13,026

Note. Unit consumption and moisture in case 2 and 3 are the same as those of in case 1.

(2) Basis of determination of quarry capacity

From above requirement and annual effective working days, the capacities of each process of the quarry shall be determined as follows :

Effective working day 264 d/y 22 d/month

Process	Monthly capacity (t/month)	Daily capacity (t/day)	Hourly capacity (t/hour)
Limestone quarry			
1,500 t·cℓ/d	54,363	2,471	
1,000 t·cℓ/d	36,242	1,647	
750 t·cℓ/d	27,181	1,236	

Process	Monthly capacity (t/month)	Daily capacity (t/day)	Hourly capacity (t/hour)
Crushing			(6.5 h/d)
1,500 t·cℓ/d	54,363	2,471	380
1,000 t·cℓ/d	36,242	1,647	253
750 t·cℓ/d	27,181	1,236	190
Ropeway			(10 h/d)
1,500 t·cℓ/d	54,363	2,471	247
1,000 t·cℓ/d	36,242	1,647	165
750 t·cℓ/d	27,181	1,236	124
Clay quarry			
1,500 t·cℓ/d	11,447	520	
1,000 t·cℓ/d	7,631	347	
750 t·cℓ/d	5,723	260	
Silica sand			
1,500 t·cℓ/d	3,387	154	
1,000 t·cℓ/d	2,257	103	
750 t·cℓ/d	1,693	77	
Iron ore			
1,500 t·cℓ/d	565	26	
1,000 t·cℓ/d	376	17	
750 t·cℓ/d	282	13	
Gypsum			
1,500 t·cℓ/d	2,171	99	
1,000 t·cℓ/d	1,447	66	
750 t·cℓ/d	1,086	49	

V-2-2 Geological Feature of Sindali Limestone Deposit Area and Surrounding

Sindali limestone deposit is located at 86°39' of east longitude and 26°54' north latitude in the north of Gaighat.

There are two routes to access to this area from the proposed site for the cement plant in Gaighat.

The one is a route going upstream along the Trijuga river of which distance is about 26 km.

The other is a route going unstream from the town of Gaighat along the Baruwa river, of which distance is the same as the former route.

In the former route, there is not any road for vehicle available in all season from Gaighat to upstream, and about 15 km upto Bokse village is just bullcart-road in field and river beach of the Trijuga river.

In this section only jeep is useable limited in dry season.
A foot path goes upstream along the main stream of Trijuga river upto Murkuchi village located at the foot of the mountain where limestone deposit is located. The distance upto the foot of the mountain(from Bokse to Murkuchi) is about 12 km, and it takes about 3 hours on foot.
In this route rather many bridges are required.
The river sides are steep precipices at some places, however, it is possible to construct a roadway along the existing foot path on the river bank.
From Murkuchi village to the deposit area, it takes about 2.5 hour on foot through a steep foot path.
Another route is going upstream via Giaghat town and Bokse village and going up to a ridge way at the east of Mandane village and reaches the deposit area. Also on this route a jeep is useable upto Bokse.
The foot path of about 8 km between Bokse and parting point from Baruwa river goes on the river bank all the way.
In this route, the road shall be constructed on the western side of the river. But cutting is required on the all the way of this route except from Gaighat to Bokse.
The deposit sweeps from east to west with a distance of about 1.5 km, and the southern part of the area forms rather steep topogragh and the northern part is gentle slope with gradient the same as the dip angle of the limestone layer. The northern slope is separated from the northern mountains by one of origin streams of the Trijuga river.
The deposit area and the surrounding are covered with tall trees and shrubs, and some parts of the area where surface soil is rather thick are cultivated.
On the surrounding mountains some farmer houses straggle and also in the deposit area several houses exist. The southern slope of the deposit area forms precipices. At the foot of the limestone deposit area, the origin stream has a width of 5 - 15 m and an average depth of 50 cm in dry season.
As the both sides of river are steep and its width is narrow, at the time of heavy rain in the rainy season the water level increases in a short time upto 2 m higher than in dry season.
The river forms large flood plains near Murkuchi village.
The flow of the river is approx. 250 t/h at the time of observation on 1. Feb. 1978.

V-2-3 Weather Condition in Udaipur District

An year is divided into two seasons from the view point of weather condition. One is dry season and the other is rainy season.

The average total rainfall in this district is reported as 2,000 mm and they have about 80 % of the rainfall in 6 months of rainy season which is generally from April to September. Three months of June, July and August they have especially strong rainfall in which outdoor work is sometimes impossible and efficiency of the outdoor work declines. In April, May and September which is called pre-monsoon and after-monsoon respectively, frequency and strongness of rain fall is not such as in June, July and August, and the weather does not effect the efficiency of out-door work so much.

In dry season as it rarely rains and the weather is stable, efficient out-door work can be expected.

We could not obtain any reliable data on the weather of Sindali area, and therefore we suppose the workable day as follows according to the data of the weather in Kathmandu Valley.

(1)	Quarry work	264 d/y
(2)	Under ground transportation	330 d/y
	Crushing	330 d/y
	Ropeway	264 d/y

V-2-4 Outline of Quarry Development Work

An outline of the limestone quarry development work required is as follows.

(i) Construction of an access road from plant site in Gaighat to Sindali

(ii) Construction of an access road from the crushing plant at the foot of the mountain to the quarry

(iii) Deforesting and overburden soil removing

(iv) Construction of waste earth dumping area

(v) Construction of quarry road for transportation and loading of blasted rock

(vi) Construction of a shaft and grizzly room

(vii) Construction of a drift for locomotive transportation

(viii) Construction of a crushing plant

(ix) Construction of storage yard

(x) Procurement and erection of machinery and equipment

(xi) Erection of ropeway from quarry site to the cement plant

(xii) Construction of buildings such as office, worker's room, explosive magazine, and worker's colony.

Basic idea for main works of the above mentioned development are as follows :

(1) Construction of an access road from the plant site to the quarry.

In order to construct a limestone quarry at Sindali area about 8,500 tons of construction material and machinery have to be transported from Gaighat to the quarry site and ropeway route.

And also for the operation of the quarry some kind of material have to be transported.

For these purpose a permanent access road which bears a load of maximum 40 tons shall be constructed.

As mentioned in V-2-1, there are two routes for the access road, one is Trijuga river route and the other is Baruwa river route, and the distance is about 26 km on the both routes.

The required length of bridges is larger on the Trijuga route than on Baruwa river route. However, as the quantity of rock to be excavated is bigger on the Baruwa river route, the road construction cost is estimated to be almost the same on the both routes.

As the Trijuga river route is close to the route of the ropeway, this route will be more convenient for the construction of the ropeway. However as it is possible to transport manually the construction material for the ropeway through another route directly, the Trijuga river route is not essential for the construction. Therefore the route of the access road shall be determined considering the construction cost, the transportation cost of the ropeway construction material and effectiveness for public use.

(2) Deforesting

The area to be quarried in the first stage and the area for the construction of the facilities such as crushing plant shall be deforested.

The area to be deforested shall be minimized to maintain the spectacle of the area and minimize the flow-out of muddy water by rain fall.

And overburden soil shall be stripped in the quarry area and removed after deforesting in order to prevent muddy rain water to flow into quarry which cause a contamination of clay in the limestone material.

(3) Construction of quarry face

A flat area shall be provided at the foot of the quarry face for loading and transportation of ore in advance of operation.

This space shall have a width sufficient for turning of dump trucks and

has to be provided along the overall length of the quarry face.
About 30,000 cu.m of limestone shall be excavated for the preparation of the space. The limestone excavated during the construction period shall be stored at a storage yard which shall be completed previous to the beginning of the excavation.

(4) Construction of shaft and drift

A shaft shall be constructed for the transportation of ore from quarry to the level of the crushing plant.
The shaft shall have a diameter of 5 m and provided with an inclined by-shaft. At the bottom of the shaft a grizzly room, where lumps of ore with larger size for primary crusher shall be blasted into smaller size, shall be provided.
The bottom of the shaft and the crusher room is connected by a drift, which is for the transportation by diesel or electric locomotive, with a dimension of 3.5 m width, 3.5 m height and about 1,800 m length.
As the drift is constructed in schist layers which is assumed to be not sufficiently compact to excavate without lining, in such part concrete lining will be necessary. The drift has to be provided with a drainage with adequate gradient and sufficient section.

(5) Crushing plant and auxiliary facilities

The crushing plant shall be located at the foot of the south side slope, which is the opposite side of the limestone deposit, of the mountain near the exit of the drift. The ropeway station is constructed at this place, too. An storage yard shall be constructed next to the crushing plant using the mountain slope.
An office and an electric room and warehouses shall be located in this area.
A repair shop, worker's rooms, warehouses a compressor room and an explosive magazine shall be located on the ridge in the east of the limestone deposit area.

(6) Ropeway

As it is steep mountain area between the quarry site and the cement plant, it is difficult to connect both sites straight. Therefore, a tentative route on a gentle topography is selected having a bending station.
The actual route shall be determined based on the detailed topographical survey, considering the construction cost.

V-2-5 Essential Condition for the Design of the Limestone Quarry at Sindali Area

The essential conditions for the construction of the limestone quarry in Sindali limestone deposit are pointed out as follows.

(i) Sufficient capacity of the quarry to supply the required quantity of the cement raw material.

(ii) Maintaining safety of workers, facility and machinery.

(iii) Economizing both in construction and operation cost.

(iv) Suitability of design to the situation of Nepal both in the social condition and technical condition.

According to these conditions, a tentative mining plan is made in this report.

The plan for the main parts are as follows :

(1) Mining method

In Nepal use of heavy equipment such as crawler-drill crawler mounted loader is not economical way comapring with labour.

And maintenance of these equipment is difficult and expensive, for service system by manufacturers of the equipment is poor in Nepal.

Therefore, it is important to adopt simple equipment or carry out works manually as far as possible. On that basis, mining in the limestone deposit shall be divided into two periods depending on the mining methods.

° First stage

At the first stage of the operation, slope quarrying shall be adopted, in which drilling and blasting are carried out on a monoclined slope only by labours.

The quarry slope shall be provided previous to the commissioning of operation with sufficient quarry length.

Loading and transportation floor is constructed at 575 m level. Since the gradient of the slope shall be in 45° and 55°, some portion of limestone remains after the slope quarrying. The remained portion is quarried in the second stage. This method is effective in the western part of the limestone deposit and minable reserve is about 18,000,000 tons.

° Second stage

In the eastern part of limestone deposit and the remained part in the first stage, bench cut method is considered in this report. Because in this area construction of shaft which is deeper than 350 m is impossible and complete recover of limestone resource is available by bench cut method.

Also in this stage, the shaft in the first stage is used for vertical transportation. Stopping is carried out slicing floors with a thickness of a bench from up to down.
Ore is loaded by crawler mounted loader on to dump truck to be carried to the shaft or directly hauled to shaft by wheel loader.
As for quarry face length, about 3 times of quarry face length required for one day should be provided considering efficiency of quarry work. (Refer to V-2-7.) Schematic view of quarry are shown in following pages.
In order to minimize the quantity of muddy water due to rain fall and maintain green land as much as possible, the face length should be as small as possible.

(2) Transportation method

Loaded ore on dump trucks at the foot of the quarry slope has to be transported from 750 m level to the crushing plant.
As the surface topographical condition between quarry face and the crushing plant is very steep, it is difficult to construct a road available for dump truck and it is not economical to transport by truck by this road.
Therefore, a vertical shaft connecting the quarry level of 575 m and the drift for the transportation by locomotive should be constructed.
Ore dumped into the shaft is loaded on to mine tubs being controlled by a fingergate provided at the bottom of the shaft. The loaded ore is dumped into a receiving hopper at the crushing plant.
By this method, required machinery is not so much and trouble in operation would be minimized. Furthermore since the underground transportation is not influenced by weather, high rate of operation of the crushing plant can be expectable.
The construction of the vertical shaft and the drift does not require any big machinery but it can be done mainly by labour and it would not be difficult work in Nepal, if it is carried out under a good supervision.

(3) Design and crushing plant

For the transportation by ropeway the maximum size of ore from the crushing plant should be smaller than 100 mm in the biggest dimension.
On the other hand particle sice of ore fed to the receiving hopper should be 800 mm maximum.
In order to minimize the capacity of the crusher, a grizzly vibrating feeder of which clearance is 100 mm should be installed at the bottom of the receiving hopper, and only over size particle should be fed into

Fig. 5-2-1 SCHEMATIC VIEW of 1ST STAGE

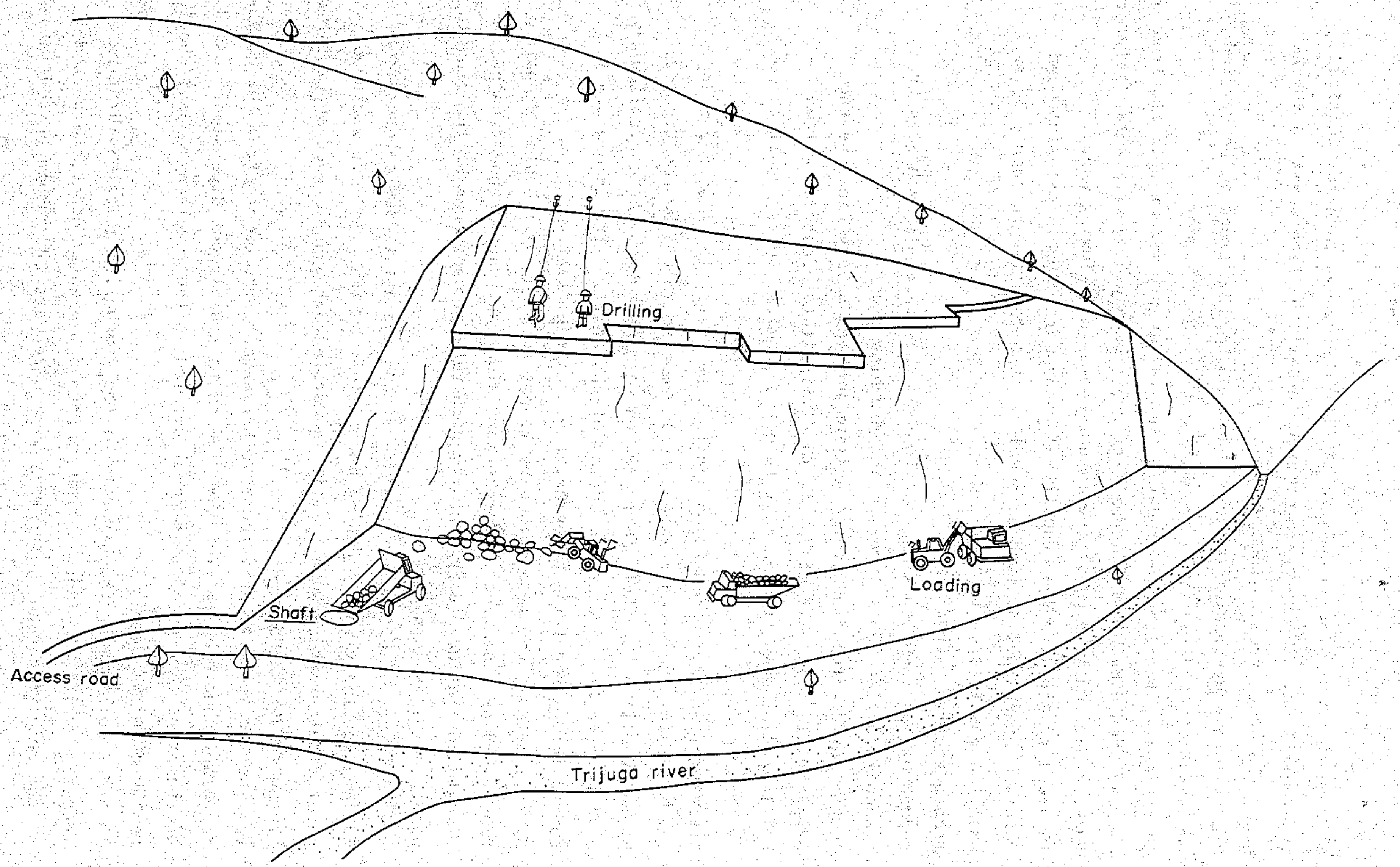
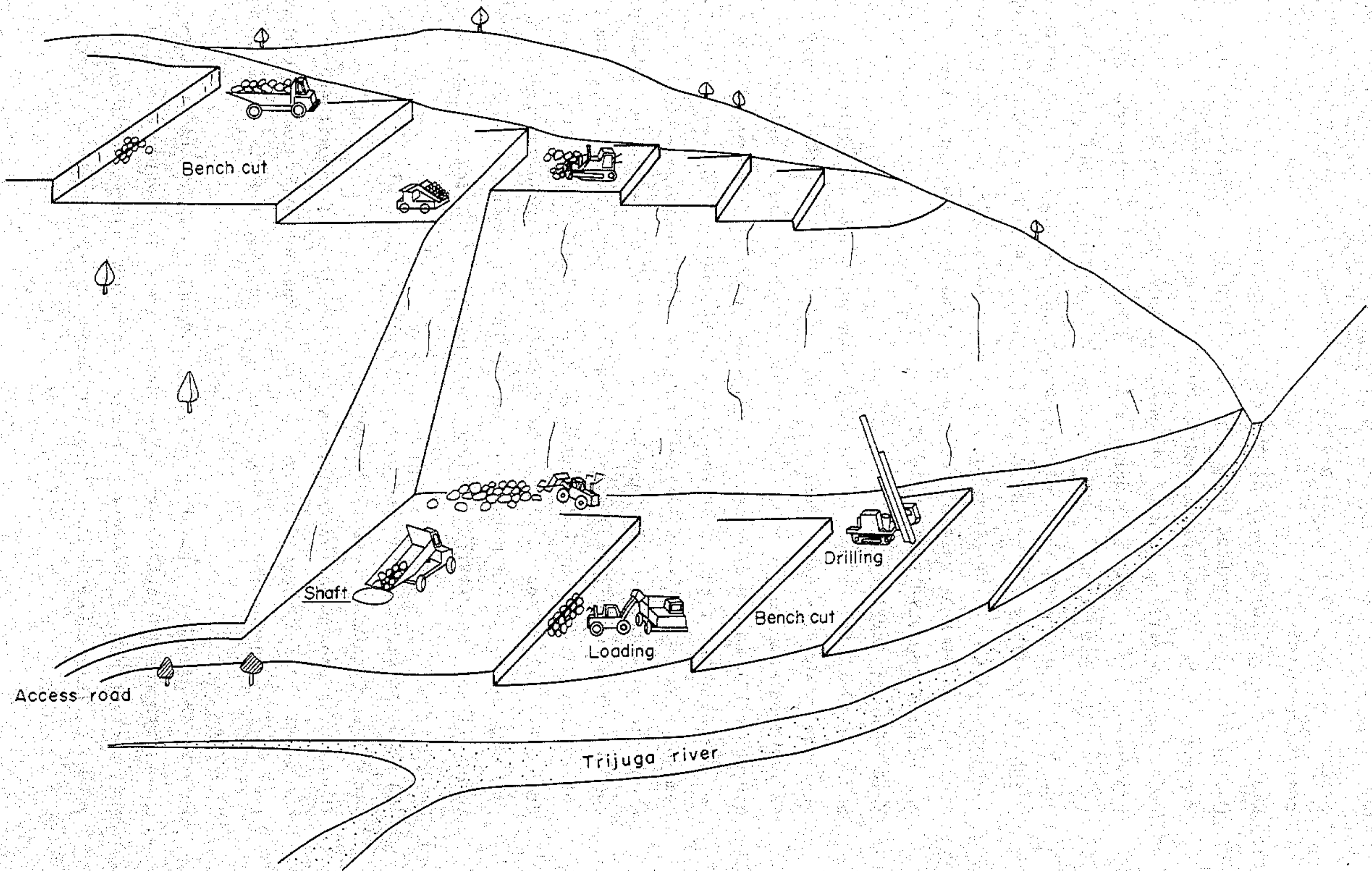


Fig. 5-2-2 SCHEMATIC VIEW of 2ND STAGE



the primary crusher. A single toggle jaw crusher is preferable as the primary crusher, as it is simple in mechanism, economical in price and easy in maintenance.

(4) Design of open storage yard at the quarry site

Quarry work is influenced by weather condition and the operation of ropeway is also irregular depending on the weather condition. Under this condition, in order to minimize the capacities of the both processes, and to enable transportation of material to the cement plant even in the time of maintenance or repair of crushing plant, quarrying and ropeway processes shall be dependent each other. For this purpose, a storage facility which has adequate capacity shall be provided before loading station of the ropeway. The required capacity of the storage should be as much as half of the monthly transportation capacity. An open storage yard would be sufficient.

(5) Waste dumping facility

Since previous to quarrying, the overburden soil and dolomitic rock shall be removed, a sufficient area for dumping of the soil and rock is required near the quarry. The volume to be dumped is estimated 650,000 cubic meters in loose. The area for the dumping of earth has to have suitable topographic condition to prevent flowing out. As the dumping area two valleies, which located at north east side of the deposit area, are considered. The one has big capacity and suitable topographic condition for establishing a dam. However as there is water stream in this valley and the catchment area of this valley is large, sufficient drainage shall be considered. The distance of the road for the transportation of waste earth is about 400 m, and the construction of the road would not be difficult, since the route is on the rather gentle slope.

The mountain slope around the valley is cultivated at places, but other part is covered with forest or shlub.

The other proposed valley is located adjuscent to the deposit and it has gradient of 20 degree in average and it has not big capacity because its average gradient is steep with about 20 degree, and the depth is not so large.

This river also has suitable place to construct a dam at the junction point with the Trijuga river. Eventhough there is a water spring at the upper stream of this river valley, the water underflows in this valley. This river has not large catchment area, but as it contacts with the limestone deposit, it should be better not to use this valley as waste earth dumping area.

(6) Transportation of limestone

As to transport limestone from quarry to the proposed cement plant in Gaighat following two means are considered.

(i) Truck transportation by a proper road newly constructed

(ii) Ropeway transportation

In the above two means the ropeway transportation is considered to be more economical than the truck transportation as a result of cost comparison. The transportation by ropeway is drived by electric power not by oil energy and it is according with the policy of Nepalese government. Accordingly the ropeway transportation is adopted in this study. Eventhough the topographical condition is severe for construction of the ropeway, for transportation of construction material for the ropeway, the construction of the ropeway is possible.

The total length of the ropeway is estimated to be about 19 km.

The capacity of ropeway shall be based on an operation hour of 10 hours per day considering that in case the capacity of the cement factory is expanded to double of the present plan and ropeway is operated for 20 or 24 hours a day.

The tentative route of the ropeway in this study is selected in a map with scale of 1/63,360.

In implementation stage the actual route should be determined based on a detailed topographical survey, and adequate type or ropeway shall be selected for the topographical condition.

(7) Water supply

About 400 t/d of clean water is required for the operation of limestone quarry as drinking water and cooling water of air compressors.

The Trijuga river is an only water source which is available for the requirement throughout all season.

The river water gets muddy in rainy season because landsliding often occurs at the upriver.

Therefore, in order to obtain clean water also in rainy season an well taking riverbed water shall be made, furthermore water treatment facility for drinking water shall be provided. The amount of flow water of the river is observed to be about 250 t/hour even in dry season and it will be sufficient for the supply to the quarry site.

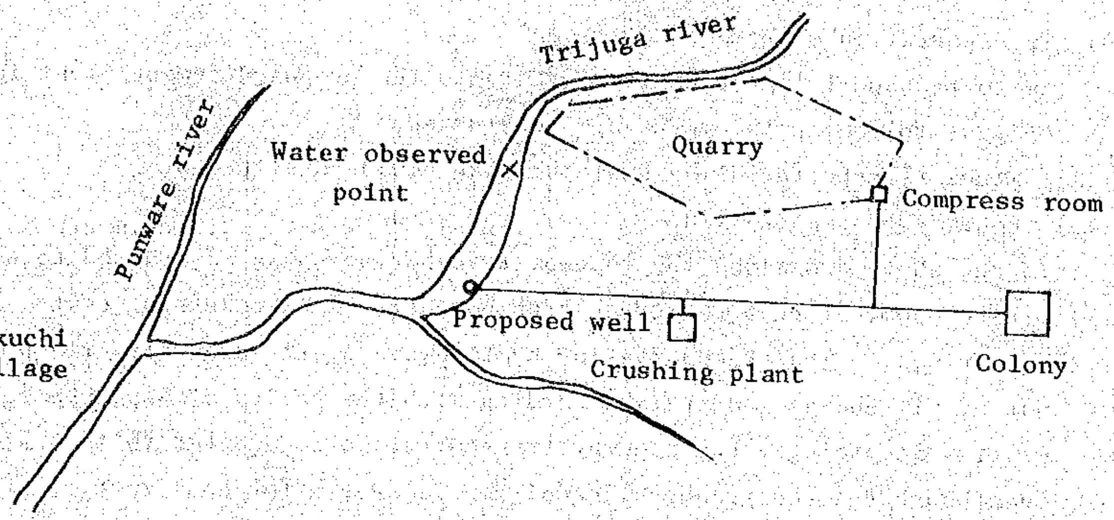


Fig. 5-2-3 Water Supply Route

V-2-6 Process of Limestone Quarry

(1) Flow sheet

Process No.	Process
1.	Drilling and Blasting
2.	Secondary blasting
3.	Loading
4.	Dump truck transportation
5.	Shaft
6.	Grizzly room
7.	Locomotive transportation
8.	Receiving hopper
9.	Grizzly feeder
10.	Jaw crusher
11.	Belt feeder
12.	Belt conveyor
13.	Storage yard
14.	Vibrating feeder / Vibrating feeder
15.	Belt conveyor
16.	Ropeway loading hopper
17.	Ropeway
	Cement plant
18.	Air compressor (to Drilling and Blasting, Secondary blasting, Grizzly room)

(2) Outline of specification of main machinery and equipment

process No.	Machinery	Quantity (clinker base)			Specification
		1,500 t/d	1,000 t/d	750 t/d	
1.	Hand hammer	18	12	9	18 kg class, dry type
	Blasting tools	5	4	4	
2.	Hand hammer	6	4	3	
3.	Loader	5	4	3	2.2 cu.m bucket,200 ps
4.	Dump truck	10	7	5	quarry type, 6 t cap., 295 ps
5.	Shaft	1	1	1	5 m dia. 150 m deep
6.	Grizzly room	1	1	1	
	Hand hammer	3	3	3	leg drill, 20 kg class
7.	Finger gate	1	1	1	
	Diesel locomotive	3	2	2	20 t class, 153 ps
	Mine tub	24	16	12	6 cu.m
	Damper	1	1	1	
8.	Receiving hopper	150 t	100 t	100 t	
9.	Grizzly feeder	1	1	1	450 t/h, 1,500 mm x 3,600 mm, 15 kW
10.	Jaw crusher	1	1	1	100 mm at open side
	(capacity)	(235 t/h)	(160 t/h)	(120 t/h)	
11.	Belt feeder	1	1	1	1,500 mmW x 10 mL
	(capacity)	(450 t/h)	(300 t/h)	(225 t/h)	
12.	Belt conveyor	1	1	1	900 mmW x 50 mL
	(capacity)	(450 t/h)	(300 t/h)	(225 t/h)	
13.	Open storage yard	1	1	1	minimum capacity
	(capacity)	(30,000t)	(20,000t)	(15,000t)	
14.	Vibrating feeder	1	2	2	
	(capacity)	(225 t/h)	(150 t/h)	(120 t/h)	
15.	Belt conveyor	1	1	1	900 mmW x 100 mL
	(capacity)	(250 t/h)	(180 t/h)	(130 t/h)	
16.	Ropeway loading hopper	1	1	1	
	(capacity)	(250 t/h)	(180 t/h)	(130 t/h)	Mono-cable system Distance : 19 km Backet capacity : 450 kg
17.	Ropeway	1	1	1	
	(capacity)	(250 t/h)	(180 t/h)	(130 t/h)	
18.	Air compressor	3	2	2	16 cu.m/min, 75 kW

V-2-7 Operation of Limestone Quarry

(1) Drilling and blasting

Blast holes are drilled vertically by hand hammers with a depth of 4 m and a diameter of about 35 mm.

The boreholes are arranged with a distance of 1.25 m from quarry face and with a span of 1.0 ~ 1.5 m.

Blasting line progress upwards from the foot of quarry slope.

When the blasting line reaches to top of the slope, hanging rocks on the slope should be swept away to maintain safety of workers before new blasting line starts at the foot of the slope.

Drilling workers on the quarry slope should near safety rope to be prevented from falling.

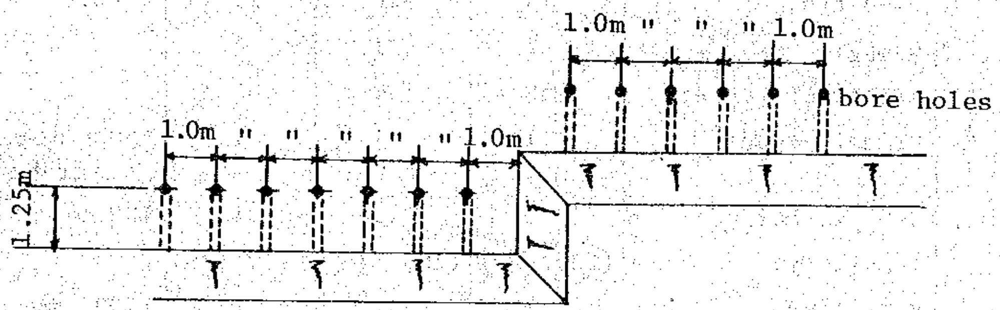


Fig. 5-2-4 Example of Blasting Pattern Plan

(2) Loading and transportation in quarry

Blasted ore piled at the foot of the quarry slope is loaded on to dump trucks by crawler mounted loader and transported to a vertical shaft. The ore is dumped into the shaft there. Bigger lumps of ore are broken by blasting on the quarry floor using hand hammers previous to the loading.

(3) Blasting in grizzly room and locomotive transportation

Ore in the shaft flows out on to grizzly bars in an underground chamber located at the bottom of the shaft. The grizzly bars are installed with clearance of 60 - 80 cm, on which over-size lumps are blasted again. At the bottom of the chamber a loading chute with a pneumatically operated finger gate is installed and ore is loaded into mine tubs drawn by diesel or electric driven locomotive. Then it is transported to the crushing plant by a drift and ore is dumped into the receiving hopper.

(4) Crushing

Ore in the receiving hopper is drawn continuously by a vibrating grizzly feeder installed at the bottom of the hopper.

Ore is screened on the feeder at a size of around 100 mm, and over-size portion is fed to a primary jaw crusher to be crushed into smaller than 100 mm and under-size portion falls directly on a belt feeder.

The ore gathered on the belt feeder is transferred on a belt conveyor and transported to an open storage yard.

(5) Storage and ropeway transportation

Ore in the storage yard is drawn on to a belt conveyor by vibrating feeders to be sent to the loading station of the ropeway.

Ore is continuously loaded into buckets with a capacity of 420 kg by a rotary chute and transported to the cement plant at Gaighat.

V-2-8 Measure for Prevention of Pollution against Surroundings and Safety

(1) Safety measure

Quarry work is composed of many dangerous works, therefore, full attention shall be payed to the safety of workers and security of the machinery and facilities in the quarry.

The following measures shall be considered in the development and operation of the quarry.

(i) Machinery and equipment

(a) The machinery and equipment which manufactured in accordance with international standard shall be adopted.

(b) The facilities which is constructed in the quarry shall be in conformity to internationally approved standard.

(c) Standards for the safety of the work and operation and maintenance manual shall be prepared and all workers should be trained on them.

(d) The facilities for the repair of quarry equipment shall be built in the quarry.

(ii) Safety of worker

(a) An experienced manager should be asigned to control the quarry works in the organization to maintain the safety.

(b) The facilities shall be constructed in accordance with the codes and standards approved internationally.

(c) The training necessary for safety operation made for workers prior to the operation.

Kind and position of each worker shall be determined taking account of not only his skillness but safety operation.

(d) The operation standard shall be prepared every work for safety operation.

(2) Prevention of pollution

Sindali limestone mine

The limestone deposit is located in a mountain area.

Therefore, the development of the mine would not make any pollution against the surroundings, if adequate measures are considered.

(i) Dust pollution

In the operation of the limestone quarry, dusting from drilling work of blast holes and blasting are considered.

The dusting from drilling work is not so much and the dusting from blasting is only once or twice a day and it is momentary, therefore both will not make any serious problem.

Dusting from hauling by truck also foreseen, but this could be avoided by water spray on the ground which is prevailing method in the opencast mining.

(ii) Noise

Noise from quarry equipments will not make any problem, for the houses of the local people are far from the operational area.

(iii) Mudwater

The outflow water from opencast quarry is muddy in rain.

In case of opencast quarry, prevention of the flowing out of muddy water is impossible unless precipitation ponds are provided to discharge the clean overflow.

In this district it has heavy rain in the rainy season and there is no space to construct precipitation ponds, and it is impossible to adopt the precipitation pond system.

Therefore, special attention to reduce the quantity of the muddy water are required in the planning of the quarry.

(a) The area to be deforested shall be minimized to minimize the quantity of muddy water.

(b) The stripping of the overburden soil shall be done as completely as possible to reduce the quantity of mud containing rainfall water.

(c) Complete drainages shall be provided around the dumpping area to prevent flowing into.

(d) In the planning of stripping, the care must be taken to minimize the quantity of water which flows into the area.

The measures mentioned above will minimize the quantity of muddy water and therefore the serious effect on the quality of Trijuga river water can be avoided.

The problem of mudwater mentioned above is caused only in rainy season, and according to the information obtained from villagers, in the season the river water is used to get muddy due to the landslides at upstream.

V-2-9 Clay

(1) Development of clay quarry

Beltar clay deposit forms low hill covered with trees and no special problem is foreseen on the development of the quarry.

No paved road has been constructed to Beltar both from Fatehpur and Gaighat, and only in dry season a jeep can reach through seasonal road from the both towns mentioned above.

Since the development of clay quarry can be made by labour force or bulldozers and no large scale equipment is required, it is not necessary to construct any new access road from the existing public road to the quarry.

The thickness of the deposit is so small and the area is so large that muddy water will flow out in rainy season.

In order to prevent the pollution caused by muddy water, the deforesting and the stripping of the overburden should be minimized and the drainage should be provided around the quarry.

(2) Operation of clay quarry

The clay deposit is excavated by labour force on the inclined face made like stair having a height of 5 m. The clay excavated is loaded on a dump truck with a belt conveyor manually at the bottom of the inclined face.

In order to save the loading time three belt conveyors are used for each truck.

The dump truck conveys the clay directly to Gaighat. Since the face moves quickly, no fixed facility is installed.

To prevent muddy water plantation is recommended at the places where excavation is completed.

The road, which will be extended with progress of excavation, should be well maintained for transportation in rainy season by filling sand and gravel.

Since the efficiency of the quarry works in the rain will be lowered due to sticky nature of clay, it is recommended to suspend the work in the rain.

For this a clay storage of sufficient capacity should be installed in the plant.

(3) Transportation of clay

The following two methods for transportation of clayey material from Beltar to Gaighat were examined.

(i) Transportation by dump truck through the road to be constructed.

(ii) Transportation by a ropeway

The results shows that the former is advantageous and therefore the transportation by truck is adopted in this report.

Although no water flows in Duwar river, which flows at the west of the quarry, in dry season, it is said that water level reaches as high as about 1.5 m on strong rainy days in rainy season. Accordingly the construction of bridge for rainy season is desirable. The construction cost of bridge, however, too expensive because of width of river(300 m) to be borne by the Project cost.

Unless the bridge is constructed for public purpose, the tentative stock of clay having a capacity corresponding the quantity to be used during high water period is required.

V-2-10 Silica Sand

Excavation and transportation of siliceous material

Silica sand, which is siliceous material, is widely distributed in the southern side of Trijuga river in the vicinity of Gaighat and therefore excavated as siliceous raw material for the Project.

Since the place of excavation moves as progress of works, the excavation and loading on truck by man power and transportation by truck are planned. The road for transportation is prepared by a bulldozer, wherever necessary. Although no special fixed equipment is provided, if sand and gravel are mixed in silica sand in actual operation, a screening equipment will be required at the plant.

Since the silica sand occurs in the flood plains of Trijuga river and its tributaries, the excavation in rainy season is expected to be expected to be difficult, and besides the road between the deposit and the plant site is not so reliable in rainy season, too, it is recommended to make a tentative storage of silica sand having a capacity meeting the quantity to be used in rainy season.

V-2-11 Flow Sheet

Clay		Silica Sand	
No.	Process	No.	Process
1.	Excavation (man power) ↓	1.	Excavation (man power) ↓
2.	Loading (Portable belt conveyor) ↓	2.	Loading (Portable belt conveyor) ↓
3.	Transportation (Truck) ↓	3.	Transportation (Truck) ↓
	Plant		Plant

V-2-12 Supply of Iron Ore and Gypsum

Hematite produced at Phulchoki located suberb of Kathmandu shall be used as ferrous material.

In this report, the cost of this material is estimated at the purchasing price on C/F plant site basis.

Gypsum shall be imported from India and its cost is also estimated at the purchasing price on C/F plant site basis.

V-2-13 Land Requirement

For the construction of facilities and quarrying the following area of land are required.

The area required for the construction of the access road from Gaighat to Murkuchi village is not included.

(1)	Limestone quarry	117 ha.
(2)	Access road to quarry (Murkuchi ~ Quarry)	2 ha.
(3)	Crushing plant and auxiliary facility	2 ha.
(4)	Colony	3 ha.
(5)	Ropeway route (10 mW x 19 kmL)	19 ha.
(6)	Access road in clay quarry	0.5 ha.
(7)	Clay excavation area	2 ha./annum
	(The area excavated shall be returned to land owner.)	

V-2-14 Manning Plan

(1) Number of workers

The number of workers required for supply of raw materials are as shown in Table 5-2-1 and 5-2-2.

Since the excavation and loading in clay and silica sand deposit can be performed easily, those works are to be carried out by contractors.

(i) Limestone quarry

Table 5-2-1 Manning Plan of Limestone Quarry

Job	Number of workers		
	1,500 t·cℓ/d	1,000 t·cℓ/d	750 t·cℓ/d
Manager	1	1	1
Engineer	7	7	7
Assistant	3	3	3
Foreman	5	5	5
Drill man	25	17	13
Compressor operator	3	2	2
Blaster	5	4	3
Secondary blasting	10	7	5
Loader operator	5	4	3
Dump truck operator	9	6	5
Grizzly blaster	3	3	3
Loading man	2	2	2
Locomotive operator	4	4	2
Crusher man	5	5	5
Mechanic	5	4	4
Ropeway	30	30	30
Electric room	2	2	2
Total	125	106	95

(ii) Clay quarry and silica sand quarry

Table 5-2-2 Manning Plan of Clay and Silica Sand Quarry

Job	Number of workers		
	1,500 t·cℓ/d	1,000 t·cℓ/d	750 t·cℓ/d
Clay quarry			
Foreman	5	3	3
Dump truck operator	16	11	8
Excavation and loading	159	106	80
Mechanic	5	3	3
Total	185	123	94
Silica sand quarry			
Foreman	1	1	1
Dump truck operator	5	3	2
Excavation and loading	38	25	19
Total	44	29	22

(2) Required skill and training

It may be impossible to obtain all the skilled workers or engineers at Gaighat district and surroundings.

The engineers engaged in the mining department should have expert knowledge in his field and ability to make the knowledge practical in the field work.

Especially in the beginning of operation, operation by many unskilled workers is obliged, therfore he should have sufficient experiences on safety control.

The manager engaged in the mining department should have the ability on cost management, labour management in addition to technical knowledge.

As those personnel can not be obtained immediately, the training in field for sufficient period is required for the personnel.

The foreman of each section should have the experiences of actual works and leadership.

The workers for almost all jobs except electricity and mechanical repair can be trained in field during a period of about 6 months by an instructor.

V-2-15 Construction Cost of Quarry

The construction cost for quarry development and its breakdown are shown in Table 5-2-3.

Table 5-2-3 Construction Cost of Quarry (Rs)

Item	Limestone	Clay	Silica sand	Total
Case-1, Capacity 1,500 t·cℓ/d				
Civil construction	49,752,571	590,000	50,000	50,392,571
Quarry equipment	8,343,400	8,386,560	1,374,048	18,104,008
Crushing and other machinery	15,193,000	-	-	15,193,000
Ropeway	160,245,500	-	-	160,245,500
Total	233,534,471	8,976,560	1,424,048	243,935,079
Case-2, Capacity 1,000 t·cℓ/d				
Civil construction	45,935,861	409,750	50,000	46,395,611
Quarry equipment	6,386,700	5,835,648	872,500	13,094,848
Crushing and other machinery	12,706,000	-	-	12,706,000
Ropeway	131,564,000	-	-	131,564,000
Total	196,592,561	6,245,398	922,500	203,760,459
Case-3, Capacity 750 t·cℓ/d				
Civil construction	43,677,699	329,250	50,000	44,056,949
Quarry equipment	4,789,200	4,505,280	831,324	10,125,804
Crushing and other machinery	10,839,700	-		10,839,700
Ropeway	109,764,300	-		109,764,300
Total	169,070,899	4,834,530	881,324	174,786,753

V-2-16 Cost of Raw Materials

The direct cost and fixed cost of raw materials are shown in Table 5-2-4 ~ 5-2-6.

Case 1, Capacity 1,500 t·cℓ/d

Table 5-2-4 Cost of Raw Materials

Item	Limestone	Clay	Silica sand	Iron ore	Gypsum
Direct cost (Rs/t)	5.83	31.78	13.80	180.00	366.00
Fixed cost (Rs/y)	7,371,099	1,641,000	257,400	-	-
(Repair cpst)	(6,369,099)	(1,422,000)	(248,400)	-	-
(Salaries and wages)	(766,000)	(219,000)	(9,000)	-	-
(Electricity)	(216,000)	-	-	-	-

Note : Figures in parenthesis are breakdown of the fixed cost.(Table 5-2-4~5-2-6)

Case 2, Capacity 1,000 t·cℓ/d

Table 5-2-5 Cost of Raw Material

Item	Limestone	Clay	Silica sand	Iron ore	Gypsum
Direct cost (Rs/t)	5.83	32.62	13.80	180.00	366.00
Fixed cost (Rs/y)	5,586,000	1,118,000	143,700	-	-
(Repair cost)	(4,670,400)	(992,000)	(134,700)	-	-
(Salaries and wages)	(732,000)	(126,000)	(9,000)	-	-
(Electricity)	(183,600)	-	-	-	-

Case 3, Capacity 750 t·cℓ/d

Table 5-2-6 Cost of Raw Materials

Item	Limestone	Clay	Silica sand	Iron ore	Gypsum
Direct cost (Rs/t)	5.83	33.53	13.80	180.00	366.00
Fixed cost (Rs/y)	4,826,197	871,000	133,200	-	-
(Repair cost)	(4,058,197)	(763,000)	(124,200)	-	-
(Salaries and wages)	(606,000)	(108,000)	(9,000)	-	-
(Electricity)	(162,000)	-	-	-	-

V-2-7 Action Points

In case the Project goes to realization, following studies should be necessary.

(1) Limestone quarry

- Mapping of the proposed area for crushing plant
- Mapping of proposed area for waste soil dumping
- Mapping of proposed area for worker's colony
- Survey for the access road between crushing plant and quarry
- Survey of thickness of overburden soil in the proposed quarry area
- Survey for ropeway route
- Survey for the access road from Gaighat to the quarry site

(2) Clay quarry

- Survey for the road from Gaighat to Beltar
- Survey to find other clay deposit in Gaighat area for rainy season
- Observation of water level of the Duwar river in rainy season

V-3 Quality of Raw Materials

V-3-1 Characteristics of Raw Materials

The characteristics of raw materials proposed for the Project are described and discussed hereinafter, based on our test results stated in V-3-2.

(1) Limestone (Sindali deposit)

The part of Sindali limestone deposit to be used for the Project is of high purity for calcareous raw material of portland cement as a whole. It contains CaO of about 53 % as principal composition which corresponds to $CaCO_3$ of about 95 %, and also contain MgO of about 1.5 % on the average. Other compositions such as SiO_2, $A\ell_2O_3$ and Fe_2O_3 are less than 2 % in total.

The amount of minor composition such as Na_2O, P_2O_5 and K_2O, $C\ell$ is about 0.02 %, 0.1 % and less than 0.2 and 0.001 % respectively.

This limestone is composed of calcite as a principal mineral component, and of small amount of dolomite, and little amount of quartz and mica.

The calcite crystal is comparatively well developed having a size of about 1,000 μ on the average, sometimes over 2,000 μ.

Both specific gravity and apparent specific gravity are about 2.7 and moisture content is 0.1 %, and therefore this limestone is compact and rather hard to be ground.

To sum up Sindali limestone is of good quality for manufacturing portland cement.

(2) Clay (Beltar deposit)

Beltar clay deposit is classified into two parts according to the principal chemical composition. One is the northern deposit and southern deposit which contains SiO_2 of about 65 % and 63 % respectively on the average and the other is the eastern deposit which contains higher SiO_2 than the former. SiO_2 content of eastern deposit is about 71 % on the average. However, it can be said that Beltar clay is well balanced in main compositions such as SiO_2, $A\ell_2O_3$ and Fe_2O_3.

The amount of minor composition of Beltar clay such as Na_2O, K_2O, SO_3, P_2O_5 and $C\ell$ is 0.1 ~ 0.2 %, 2 ~ 4 %, 0.01 ~ 0.02 %, 0.03 ~ 0.05 % and 0.00 ~ 0.03 % respectively.

This clay consists of kaolinite, halloysite, mica and feldspar.

The size of quartz crystal varies from 10 μ to 200 μ, and most of the crystals are less than 100 μ.

The size of biotite (a kind of mica) crystal, is over 100 μ and sometimes reaches several hundreds μ in length.
The specific gravity and the apparent specific gravity is about 2.7 and 1.6 ~ 1.7 respectively.
The clay has plasticity and comparatively high moisture content. The moisture measured by our team in dry season was 20 %.
The clay is generally well weathered, fine in particle size and soft.
To sum up Beltar clay is of good quality for manufacturing portland cement.

(3) Silica sand (Trijuga river basin)

The composition of silica sand deposited in the basin of Trijuga river and its trubutaries varies to a certain extent depending on the places. Its SiO_2 content varies in the range of 80 ~ 90 % and mica content varies too. (Refer to V-1.)
Silica sand sample (No. 1) collected from the basin of southern tributary of Trijuga river at about 5 km to the east of Gaighat is of average quality having the following chemical composition.

(%)

SiO_2	Al_2O_3	Fe_2O_3	Na_2O	K_2O
86.1	6.1	1.5	0.72	2.06

Trijuga silica sand mainly consists of such minerals as quartz, feldspar and mica. The specific gravity and unit volume weight at saturated surface dried condition is about 2.6 and 1.2 respectively.
Judging from its quality, Trijuga silica sand is suitable as siliceous additive for manufacturing portland cement.

(4) Ferrous raw material(Phulchoki iron ore)

Iron ore of Phulchoki deposit, one of the proposed ferrous raw material for the Project, mainly consists of the following composition and is of comparatively high purity.

(%)

Fe_2O_3	SiO_2	Al_2O_3
80 ~ 84	8 ~ 9	4 ~ 8

As for the mineral composition, hematite is principal composition and a small quantity of quartz, mica and feldspar are contained too.
Both specific gravity and apparent specific gravity are 4.5. The iron ore is compact and hard.
Judging from its quality, Phulchoki iron ore is suitable as ferrous additive for manufacturing portland cement.

(5) Raw meal

In case ordinary portland cement is produced from the raw materials mentioned above, judging from chemical composition and its dispersion of each raw material it is easy to prepare the raw meal having desired composition.

The content of impurities such as Na_2O, K_2O and $C\ell$ in the raw meal is 0.08, 0.63 and less than 0.001 % respectively and therefore the dry process with a suspension preheater system can be adopted for the Project.

The burnability of the raw meal is almost the same as or a little better than that of the raw meal used in the cement plant in Japan, while the grindability of the former is a little lower than the latter.

Generally speaking this raw meal is suitable for manufacturing ordinary portland cement.

(6) Gypsum (India, Rajasthan)

As cement retarder, gypsum of India is scheduled to be used. The test result of one sample shows that the gypsum consists of 29.7 % of CaO and 40.9 % of SO_3 and the purity calculated from SO_3 content is 88 %. Principal mineral is $CaSO_4 \cdot 2H_2O$ and a small quantity of quartz is observed too.

This gypsum is suitable as retarder of portland cement.

(7) Industrial water

Two samples were taken in our field investigation, one is from Trijuga river near Gaighat and the other is from the well in Motigarha village. The main quality is described as follows.

	pH	Total hardness (as $CaCO_3$)
Trijuga river water	8.55	150 ppm
Motigarha well water	7.50	96 ppm

Though alkalinity is somewhat high these water can be used as industrial water.

(8) Coal (India, Assam mine)

Since Indian coal is used in the Project, Assam coal was tested as an example and the results are described as follows.

Calorific value (Gross)	7,210 Kcal/kg
Ash	10.28 %
Volatile matter	40.84 %
Fixed carbon	48.88 %
Sulfur	3.24 %

Chemical composition of ash SiO_2 59.9 %

Al_2O_3 20.6 %

Fe_2O_3 11.5 %

This coal can be used for clinker burning process satisfactorily.

V-3-2 Test Results of Raw Materials

The samples of each raw material taken and/or obtained by our team in the field were tested mostly in Japan except a part of samples tested by us in the field laboratory.

The sampling positions of the samples tested are described in the attached topographical map G-02, G-20 and G-22 respectively.

Although dolomite which is intercalated in limestone bed is not used for manufacturing portland cement, the test results are described here for reference.

(1) Chemical analysis

(i) Samples

Kind and number of sample tested, number of composition tested, the Table number concerned and test place are described in Table 5-3-1.

(ii) Testing method

The sample for chemical analysis were prepared through the processes such as drying, crushing and grinding.

Table 5-3-1 List of Analyzed Samples

Sample		Quantity of analyzed samples	Quantity of analyzed components	Table of results to be referred	Place carried out
Limestone (Sindali)	Grab sample	87 pcs	2 components	Table 5-3-2	at site
		14 pcs	6 components	Table 5-3-3	in Japan
		7 pcs	11 components		
	Drilling sample	2 pcs	11 components	Table 5-3-4	
Dolomite (Sindali)	Grab sample	17 pcs	2 components	Table 5-3-5	at site
		6 pcs	6 components	Table 5-3-6	in Japan
		1 pc	11 components		
Clay	North deposit (Beltar)	6 pcs	6 components	Table 5-3-7	in Japan
		2 pcs	8 components		
		1 pc	11 components		
	South deposit (Beltar)	8 pcs	6 components		
		2 pcs	8 components		
		2 pcs	11 components		
	East deposit (Beltar)	2 pcs	6 components		
		2 pcs	8 components		
	Gaighat	1 pc	8 components	Table 5-3-8	
Silica sand (Trijuga)		3 pcs	6 components	Table 5-3-9	in Japan
Iron ore (Phulchoki)		1 pc	5 components	Table 5-3-10	in Japan
		1 pc	11 components		
Gypsum (Rajastham)		1 pc	6 components	Table 5-3-11	in Japan
Coal ash (Assam)		1 pc	7 components	Table 5-3-12	in Japan

The following methods were used for chemical analysis.

Method	Composition analyzed
- Gravimetric analysis	: SiO_2, Al_2O_3, Fe_2O_3, SO_3
- Volumetric analysis	: CaO, MgO, Cl
- Flame photometric analysis	: Na_2O, K_2O
- Calorimetric analysis	: P_2O_5, Fe_2O_3

(iii) Results of chemical analysis

The results of chemical analysis are shown in Table 5-3-2 ~ 5-3-12.

Table 5-3-2 Chemical Analysis of Sindali Limestone
(Grab samples, analyzed at site)

(wt.% in dry basis)

Sample No.	CaO	MgO	Sample No.	CaO	MgO	Sample No.	CaO	MgO	Sample No.	CaO	MgO
S-002	46.4	0.8	S-068	54.7	0.7	S-128	49.9	4.6	S-206	53.9	0.9
S-004	47.7	0.5	S-070	54.4	0.7	S-130	53.2	1.1	S-210	53.8	1.0
S-006	54.1	0.5	S-072	54.2	0.4	S-132	54.6	0.6	S-213	53.8	0.9
S-008	54.4	0.6	S-074	54.4	0.7	S-135	52.7	1.8	S-214	53.9	0.7
S-012	53.4	1.0	S-076	53.8	0.4	S-136	49.8	4.9	S-220	47.4	4.6
S-014	54.1	0.7	S-078	55.1	0.5	S-138	53.9	0.9	S-221	53.0	1.8
S-016	46.7	5.8	S-080	53.9	0.5	S-140	53.9	1.0	S-222	54.8	0.5
S-018	52.4	0.7	S-082	53.1	1.2	S-142	49.2	6.0	S-230	54.2	0.4
S-020	53.4	1.1	S-090	54.2	0.9	S-150	54.0	0.8	S-232	54.0	1.0
S-022	54.0	0.6	S-092	49.6	0.8	S-151	54.2	0.9	S-234	53.9	0.8
S-024	53.6	1.3	S-096	52.5	1.6	S-158	54.2	0.8	S-237	53.8	1.6
S-028	54.8	0.4	S-098	53.6	1.6	S-164	54.4	0.9	S-238	54.0	1.4
S-040	53.5	0.9	S-100	53.9	1.2	S-168	53.6	0.6			
S-042	52.1	1.1	S-102	50.1	3.0	S-170	53.8	0.9	Average	53.1	1.2
S-044	51.7	4.2	S-104	54.0	0.6	S-172	53.2	1.9			
S-046	53.9	1.0	S-106	52.6	0.8	S-176	53.2	1.4			
S-048	54.9	0.7	S-108	52.2	0.6	S-182	44.7	5.8			
S-050	54.5	0.8	S-112	52.5	0.8	S-183	53.9	1.4			
S-052	53.2	0.6	S-114	53.7	0.9	S-189	54.7	0.9			
S-054	53.2	0.7	S-116	53.8	1.6	S-191	54.2	0.6			
S-056	53.6	0.7	S-118	53.9	1.1	S-193	53.5	0.8			
S-060	54.6	0.6	S-120	53.2	0.9	S-194	52.2	1.0			
S-062	53.0	0.7	S-122	52.8	0.8	S-197	52.2	1.0			
S-064	54.2	0.6	S-124	53.9	0.7	S-200	53.9	1.6			
S-066	54.9	0.3	S-126	54.5	0.4	S-203	54.3	0.6			

Table 5-3-3 Chemical Analysis of Sindali Limestone
(Grab samples)

(wt. % in dry basis)

Sample No.	L.O.I	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total	P_2O_5	Cl
S-045	43.3	0.6	0.1	0.14	53.8	1.5	-	-	-	99.44	-	-
S-053	42.8	1.4	1.0	0.1	53.3	1.0	0.14	0.02	0.17	99.93	0.056	0.000
S-065	43.4	0.9	0.3	0.1	53.9	0.5	0.01	0.02	0.15	99.28	0.077	0.000
S-079	42.5	2.3	0.8	0.2	52.0	1.3	0.22	0.04	0.27	99.63	0.073	0.000
S-089	43.2	1.3	0.4	0.17	52.1	1.9	-	-	-	99.07	-	-
S-099	43.8	0.5	0.2	0.21	52.6	1.9	-	-	-	99.21	-	-
S-101	43.0	2.0	0.4	0.20	52.1	1.4	-	-	-	99.10	-	-
S-109	43.6	0.6	0.2	0.07	53.7	1.3	-	-	-	99.47	-	-
S-115	43.4	0.5	0.2	0.1	53.1	1.9	0.00	0.02	0.02	99.24	0.044	0.000
S-192	43.8	0.5	0.4	0.2	53.8	1.1	0.01	0.02	0.08	99.91	0.142	0.000
S-196	43.2	1.0	0.3	0.12	53.5	0.8	-	-	-	98.92	-	-
S-205	42.3	1.7	1.9	0.3	52.1	1.2	0.02	0.02	0.36	99.90	0.126	0.000
S-211	43.5	0.5	0.4	0.1	53.5	1.6	0.02	0.02	0.02	99.66	0.050	0.000
S-216	43.7	0.4	0.3	0.07	53.8	1.0	-	-	-	99.27	-	-
S-217	43.5	0.3	0.1	0.07	53.8	1.0	-	-	-	98.77	-	-
S-228	42.9	0.8	0.3	0.18	53.5	1.3	-	-	-	98.98	-	-
S-235	42.9	1.3	0.9	0.18	52.4	1.3	-	-	-	98.98	-	-
S-251	43.5	0.8	0.4	0.13	52.8	1.8	-	-	-	99.43	-	-
S-253	43.7	1.0	0.3	0.16	51.0	3.0	-	-	-	99.16	-	-
S-255	42.7	1.6	0.4	0.19	52.8	1.3	-	-	-	98.99	-	-
S-261	43.4	1.1	0.6	0.19	52.8	1.0	-	-	-	99.09	-	-
Average	43.2	1.0	0.5	0.2	53.0	1.4	0.06	0.02	0.15	99.53	0.081	0.000

Table 5-3-4 Chemical Analysis of Sindali Limestone
(Drilling core samples)

(wt. % in dry basis)

Sample No.	L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total	P_2O_5	Cl
BH-10 *[1]	43.4	0.8	0.4	0.2	53.1	1.7	0.01	0.02	0.13	99.76	0.106	0.000
BH-16 *[2]	43.3	0.8	0.5	0.2	53.1	1.7	0.01	0.02	0.08	99.71	0.111	0.000
Average	43.3	0.8	0.4	0.2	53.1	1.7	0.01	0.02	0.10	99.63	0.108	0.000

(Note) *[1] : Sample No. BH-10 is prepared from 15 core samples (No. 1, 2, 3, 4, 5, 7, 9, 10, 13, 14, 15, 16, 17, 18, 19) taken from drilling hole No. 10.

*[2] : Sample No. BH-16 is prepared from 17 core samples (No. 1 ~ 17) taken from drilling hole No. 16.

Table 5-3-5 Chemical Analysis of Sindali Dolomite
(Grab samples, analyzed at site)

(wt. % in dry basis)

Sample No.	CaO	MgO	Sample No.	CaO	MgO	Sample No.	CaO	MgO	Sample No.	CaO	MgO
S-010	30.9	20.4	S-036	30.7	20.5	S-094	31.4	20.3	S-148	30.1	18.8
S-026	27.3	12.5	S-038	31.0	20.7	S-110	39.6	13.1	S-162	31.1	20.1
S-030	31.2	20.0	S-041	31.6	20.1	S-134	34.3	18.2			
S-032	32.3	20.0	S-058	31.9	20.0	S-144	26.6	17.4	Average	31.3	19.0
S-034	30.9	20.4	S-084	30.5	20.6	S-146	30.1	20.6			

Table 5-3-6 Chemical Analysis of Sindali Dolomite
(Grab samples)

(wt/ % in dry basis)

Sample No.	L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total	P_2O_5	Cl
S-029	46.4	0.9	0.3	0.3	32.2	19.6	0.00	0.04	0.04	99.78	0.085	0.004
S-149	45.8	1.1	0.8	1.29	31.1	19.1	-	-	-	99.19	-	-
S-160	45.6	1.4	0.6	0.48	31.6	19.2	-	-	-	98.88	-	-
S-223	46.1	0.9	0.6	0.36	32.5	18.6	-	-	-	99.06	-	-
S-248	44.9	0.9	0.5	0.21	36.4	15.8	-	-	-	98.71	-	-
S-250	36.1	10.0	9.1	0.55	32.2	11.1	-	-	-	99.05	-	-
S-257	46.4	0.2	0.2	0.23	32.2	19.9	-	-	-	99.13	-	-
Average	44.5	2.2	1.7	0.5	32.6	17.6	0.00	0.04	0.04	99.14	0.085	0.004

Table 5-3-7 Chemical Analysis of Beltar Clay

(wt. % in dry basis)

	Sample No.	L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total	P_2O_5	Cl
Northern deposit	B-28	7.2	61.0	20.6	7.6	0.2	0.7	0.02	0.13	2.10	99.55	0.054	0.000
	B-30	7.3	60.3	20.2	7.4	0.4	0.7				96.3		
	B-54	6.1	61.7	19.8	6.0	0.2	0.9		0.17	3.54	98.41		
	B-55	6.4	69.5	15.2	5.1	0.2	0.7				97.1		
	B-80	4.9	68.1	16.6	5.2	0.2	1.1				96.1		
	B-1030	6.0	60.8	20.4	6.4	0.2	1.5				95.3		
	B-1340	4.8	67.2	17.4	5.4	0.2	1.2				96.2		
	B-1390	4.7	68.1	16.6	5.3	0.2	1.2				96.1		
	B-1430	3.9	72.0	13.8	4.4	0.2	1.1		0.17	2.90	98.47		
	Average	5.7	65.4	17.8	5.9	0.2	1.0	0.02	0.16	2.85	99.03	0.054	0.000
Southern deposit	B-1230	6.4	61.2	19.2	6.9	0.2	1.1	0.01	0.21	4.04	99.26	0.026	0.004
	B-1270	6.8	58.8	21.6	7.3	0.2	1.2				95.9		
	B-1290	6.6	58.9	20.8	7.2	0.2	1.2				94.9		
	B-1510	5.6	63.8	19.1	5.8	0.2	1.2				95.7		
	B-1540	5.7	66.3	16.9	6.2	0.2	0.9		0.13	2.57	98.90		
	B-1560	5.6	63.8	18.6	5.8	0.2	1.1				95.1		
	B-1580A	4.2	69.6	15.2	4.6	0.4	1.1				95.1		
	B-1590A	5.9	61.7	20.2	6.2	0.2	1.1				95.3		
	B-1600	5.2	66.7	16.9	5.2	0.2	1.2				95.4		
	B-1630	6.2	60.8	20.1	6.4	0.2	1.1				94.8		
	B-1810	5.5	64.4	18.4	6.1	0.2	1.1		0.17	3.20	99.07		
	B-1830	6.1	61.0	19.6	6.8	0.2	1.2	0.02	0.19	3.87	98.98	0.047	0.004
	Average	5.8	63.1	18.9	6.2	0.2	1.1	0.02	0.18	3.42	98.92	0.036	0.004
	Average of Northern & Southern	5.8	64.1	18.4	6.1	0.2	1.1	0.02	0.17	3.17	99.06	0.042	0.003
Eastern deposit	2.1.1	5.5	66.4	17.4	5.1	0.2	1.1		0.17	2.99	98.86		
	2.1.3	5.4	67.8	17.2	5.0	0.2	0.8				96.4		
	2.1.4	3.5	77.6	11.9	2.8	0.4	0.5				96.7		
	2.1.5	4.7	72.8	13.6	3.9	0.2	0.8		0.17	2.27	98.44		
	Average	4.8	71.2	15.0	4.0	0.2	0.8		0.17	2.63	99.00		
	Grand Average	5.6	65.2	17.9	5.8	0.2	1.0	0.02	0.17	3.05	98.94	0.042	0.003

Table 5-3-8 Chemical Analysis of Gaighat Clay

(wt. % in dry basis)

Sample No.	L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Total
GJ-31	7.7	59.5	16.4	10.8	0.4	1.2	0.25	3.16	99.41

Table 5-3-9 Chemical Analysis of Trijuga River Silica Sand

(wt. % in dry basis)

Sample No.	L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Total
No. 1	1.4	86.1	6.1	1.5	0.4	0.3	0.72	2.06	98.58
No. 2	0.7	91.6	3.8	0.6	0.4	0.0	0.29	1.18	98.57
Gaighat	1.6	81.7	8.0	2.4	1.2	0.9	0.97	1.68	98.45

Table 5-3-10 Chemical Analysis of Phulchoki Iron Ore

(wt. % in dry basis)

Sample No.	L.O.I.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Total	P_2O_5	Cl
No. 1	1.1	8.0	7.8	80.0	1.2	0.4	0.01	0.04	0.46	99.01	0.017	0.000
No. 2	1.7	8.4	4.0	83.3	1.2	-	-	-	-	98.6	-	-

Table 5-3-11 Chemical Analysis of Gypsum

(wt. % in dry basis)

Sample No.	Combined water	SiO_2	Al_2O_3	Fe_2O_3	CaO	SO_3	Total
Rajasthan	18.5	5.9	1.1	0.4	29.7	40.9	96.5

Table 5-3-12 Chemical Analysis of Ash of Assam Coal

(wt. % in dry basis)

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Total
Assam coal ash	59.9	20.6	11.5	1.1	1.1	1.09	1.52	96.81

(2) Physical test

(i) Specific gravity

Testing method

The specific gravity was measured by powder method with a pycnometer. The results are shown in Table 5-3-13.

Table 5-3-13 Specific Gravity

Sample		Specific gravity
Sindali limestone	S-042	2.70
Sindali limestone	S-057	2.70
Sindali dolomite	S-031	2.86
Beltar clay	B-28	2.66
Beltar clay	B-1230	2.67
Beltar clay	B-1830	2.69
Trijuga river sand	No. 1	2.63
Phulchoki iron ore	No. 1	4.53

(ii) Apparent specific gravity

Testing method

Several lumps of sample having a diameter of 10 ~ 40 mm were dried and weighed. Then the lumps were covered by thin paraffine coating and weighed both in air and water. The apparent specific gravity was calculated using those data.

As for silica sand unit volume weight at saturated surface dry condition was measured.

The results are shown in Table 5-3-14.

Table 5-3-14 Apparent Specific Gravity

Sample		Apparent specific gravity
Sindali limestone	S-042	2.69
Sindali limestone	S-057	2.68
Sindali dolomite	S-031	2.82
Beltar clay	B-28	1.56
Beltar clay	B-1230	1.68
Beltar clay	B-1830	1.69
Trijuga river sand	No. 1	1.24 *
Phulchoki iron ore	No. 1	4.44

(Note) * The test result is indicated in unit volume weight in saturated surface dry condition.

(iii) Moisture content

Testing method

The samples collected for measurement of moisture were preserved in a tightly closed container to prevent vaporization of moisture and then the moisture content was measured by drying method.

The results are shown in Table 5-3-15.

Table 5-3-15 Moisture Content

(wt. %)

Sample		Moisture content
Sindali limestone	S-206	0.1
Sindali limestone	S-210	0.1
Sindali limestone	S-228	0.1
Sindali limestone	S-232	0.1
Beltar clay	B-1230	20.0
Beltar clay	B-1830	20.0
Trijuga river sand	No. 1	5.9
Trijuga river sand	No. 3	4.4

The moisture content of raw materials varies depending on the weather condition during the sampling.

Especially for clay and silica sand this tendency is considerable.

Since the samples of mentioned in Table 5-3-15 were taken in dry season, the moisture content in wet season will be more.

(3) X-ray diffraction analysis

(i) Testing method

The samples were pulverized finely and tested with the following apparatus.

Apparatus

Automatic recording X-ray diffractometer attached with Cu target X-ray tube and graphite monochrometer.

(Geigerflex, Rigaku Denki Co., Ltd.)

(ii) X-ray diffraction patterns

X-ray diffraction patterns are shown in Fig. 5-3-1 ~ 5-3-12.

(iii) Results of analysis

Table 5-3-16 summarizes the minerals determined by the analysis on the X-ray diffraction patterns shown in Fig. 5-3-1 ~ 5-3-12.

Table 5-3-16 Results of X-ray Diffraction Analysis

Sample	Mineral recognized by X-ray diffraction analysis
Sindali limestone S-053	Calcite, (Quartz), (Mica)
Sindali limestone S-065	Calcite, (Quartz), (Mica), ((Dolomite))
Sindali limestone S-211	Calcite, (Dolomite), ((Quartz)), ((Mica))
Sindali dolomite S-029	Dolomite, Calcite, (Quartz), ((Mica))
Beltar clay B-28	Quartz, Mica, Halloysite, (Kaolinite), (Feldspar)
Beltar clay B-1230	Mica, Quartz, Feldspar, Halloysite, Kaolinite
Beltar clay B-1830	Mica, Quartz, Halloysite, Feldspar, Kaolinite
Trijuga river silica sand No. 1	Quartz, Feldspar, Mica
Trijuga river silica sand No. 2	Quartz, Feldspar, ((Mica))
Phulchoki iron ore No. 1	Hematite, Quartz, Mica, Feldspar
Phulchoki iron ore No. 2	Hematite, Quartz, Mica, Feldspar
Rajasthan gypsum	Gypsum, ((Quartz))

Note : Underlined minerals are recognized as minerals with strong intensity in the diffraction patterns, minerals in ( ) are with weak intensity and those in (( )) are with very weak one.

List of X-ray Diffraction Diagram

Sign of Minerals

Sign	Mineral	Molecular formula
C	Calcite	$CaCO_3$
D	Dolomite	$CaCO_3 \cdot MgCO_3$
F	Feldspar	-
G	Gypsum	$CaSO_4 \cdot 2H_2O$
H	Halloysite	$Al_2Si_2O_{10}(OH)_4 \cdot 2H_2O$
He	Hematite	Fe_2O_3
K	Kaolinite	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$
M	Mica	-
Q	Quartz	SiO_2

Fig. 5-3-1 Sindali Limestone S-053

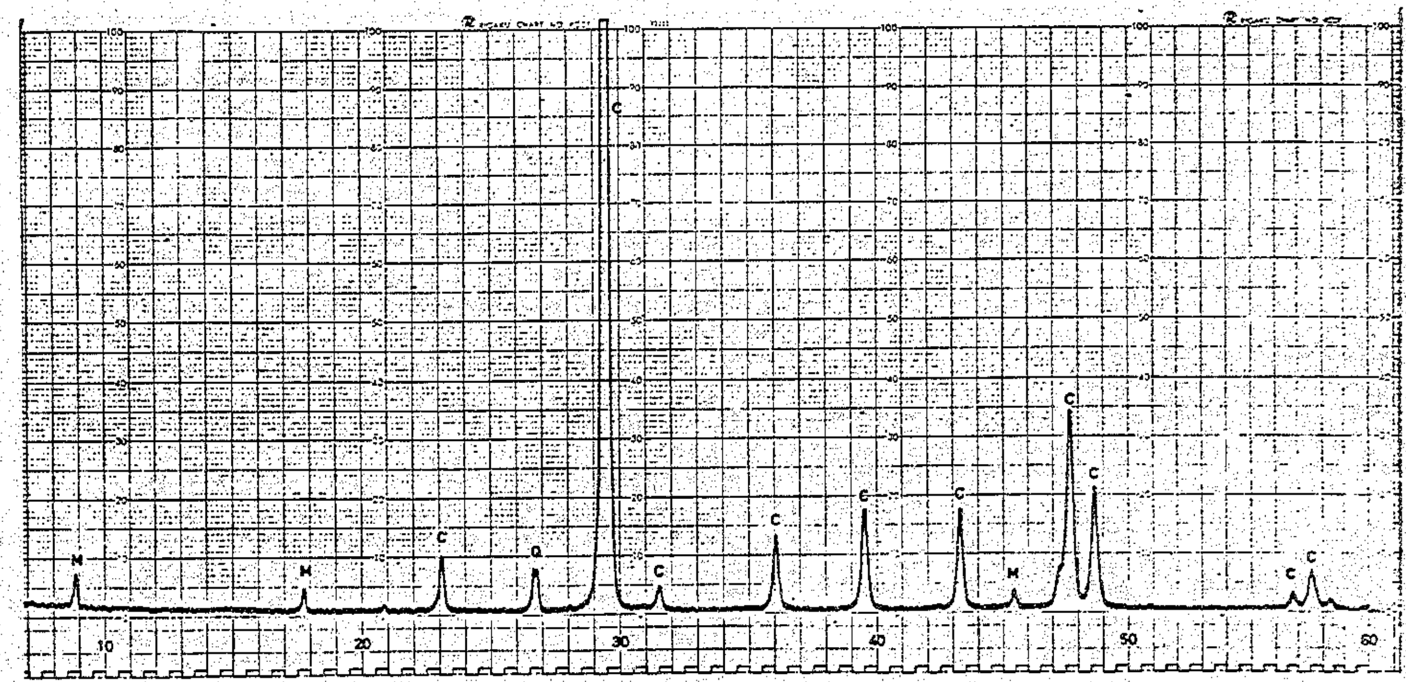


Fig. 5-3-2 Sindali Limestone S-065

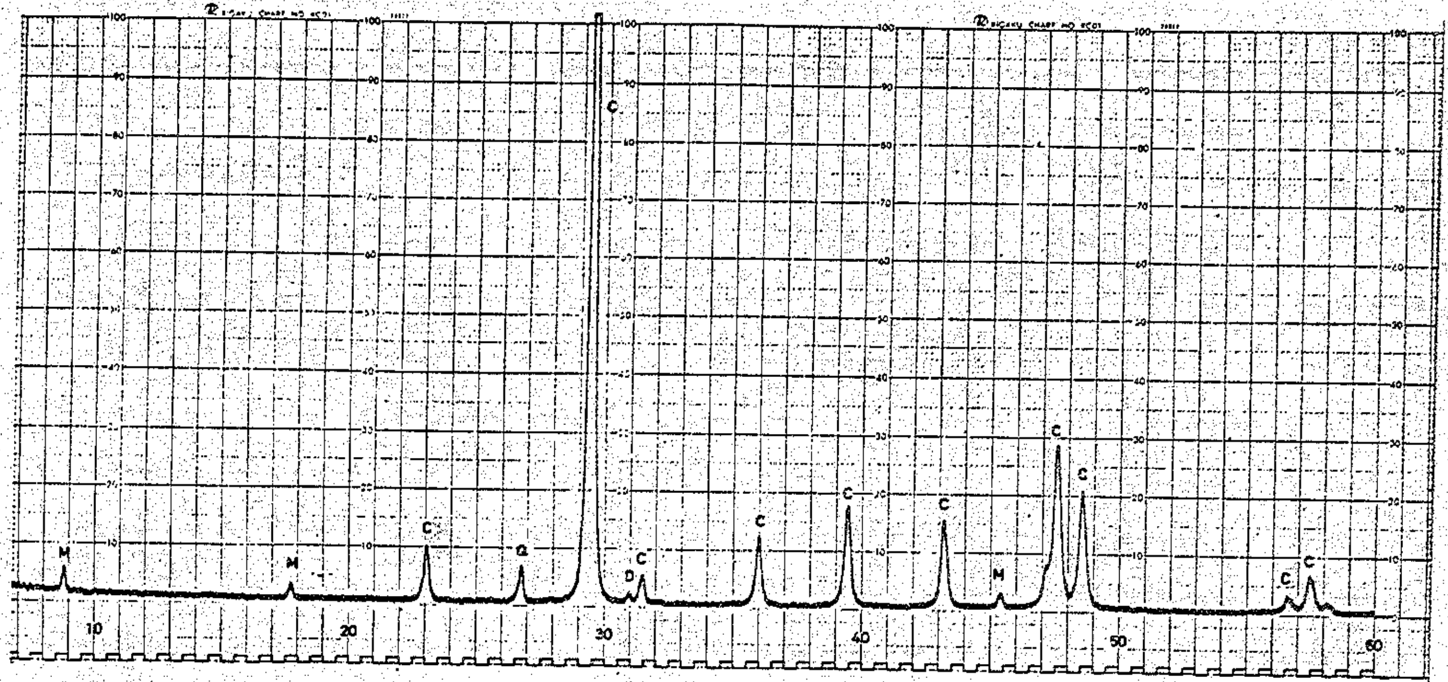


Fig. 5-3-3 Sindali Limestone S-211

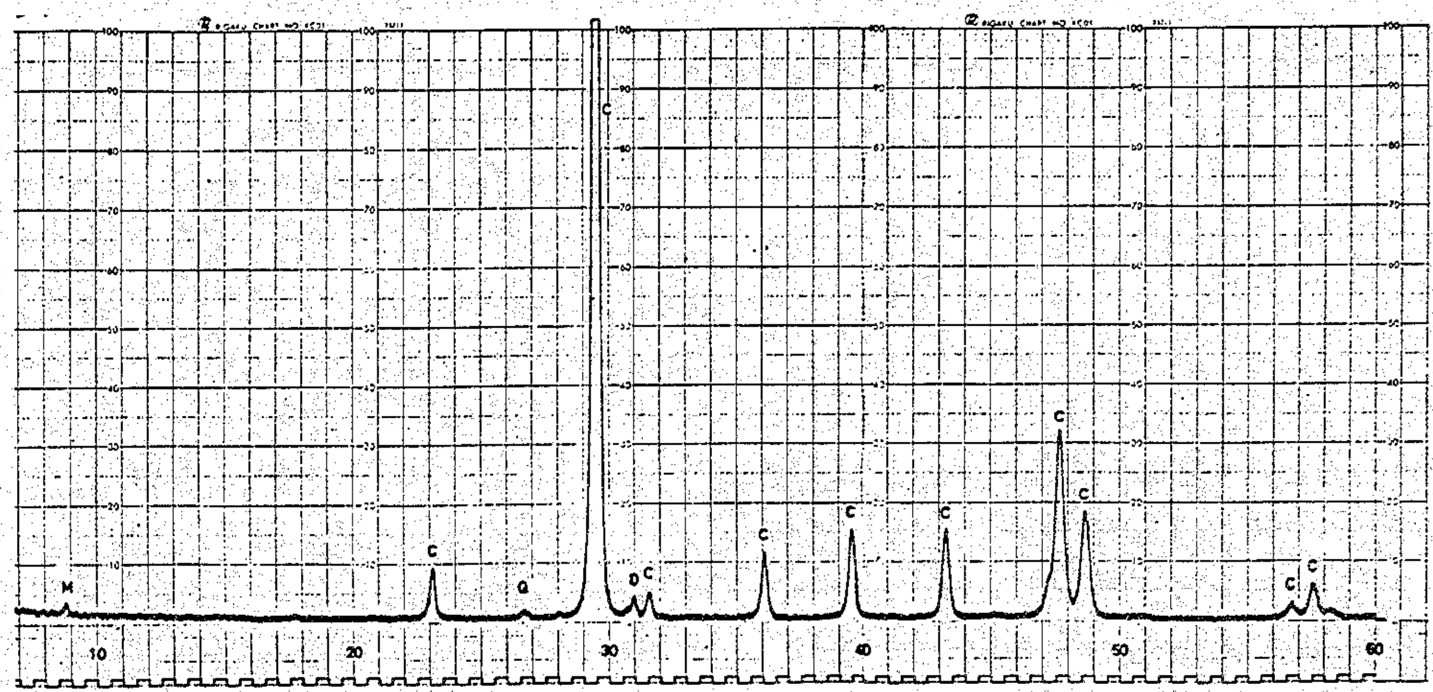


Fig. 5-3-4 Sindali Dolomite S-029

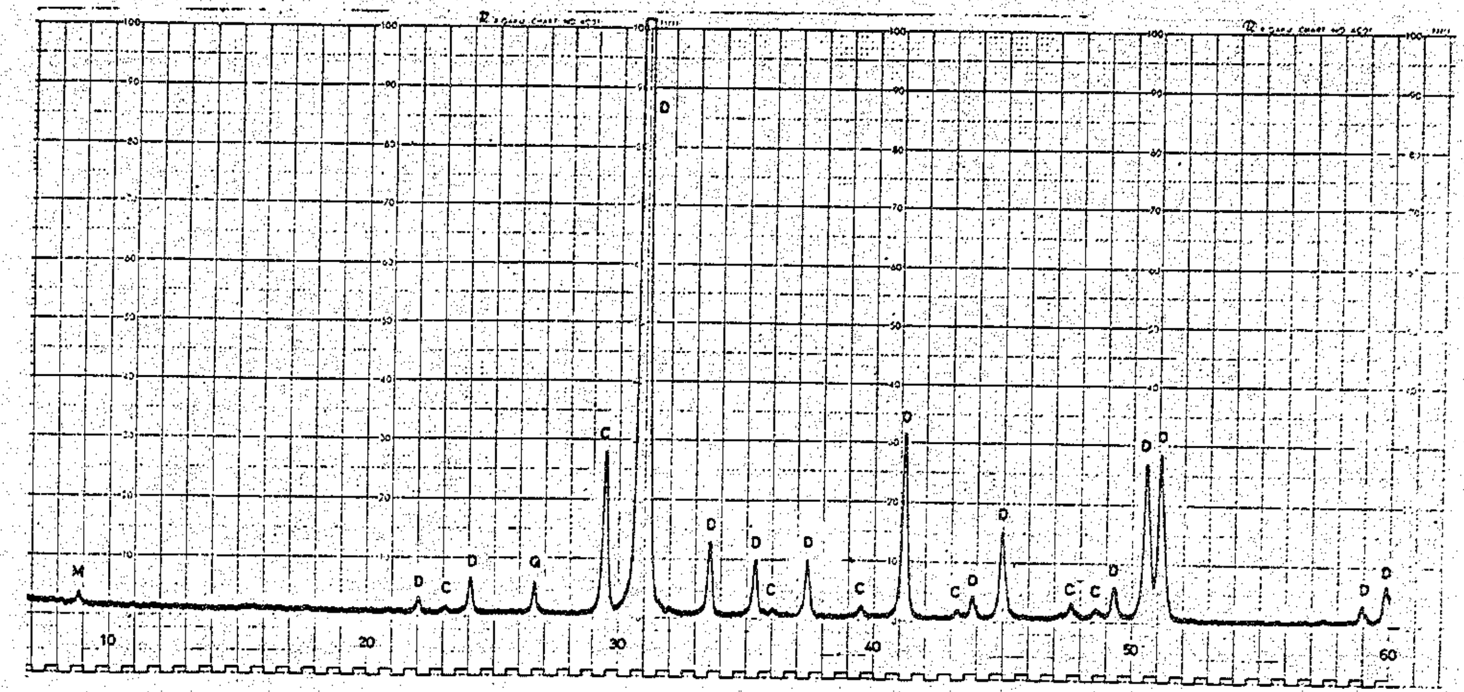


Fig. 5-3-5 Beltar Clay B28

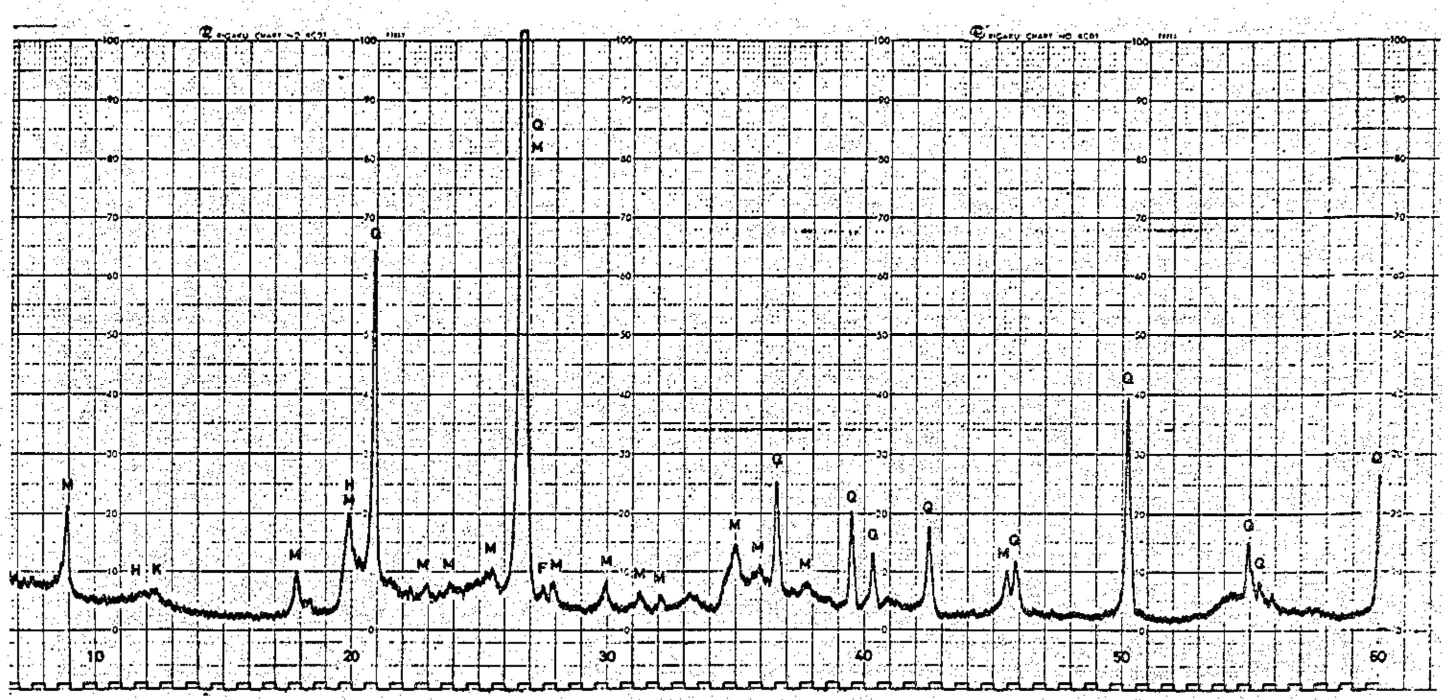


Fig. 5-3-6 Beltar Clay B1230

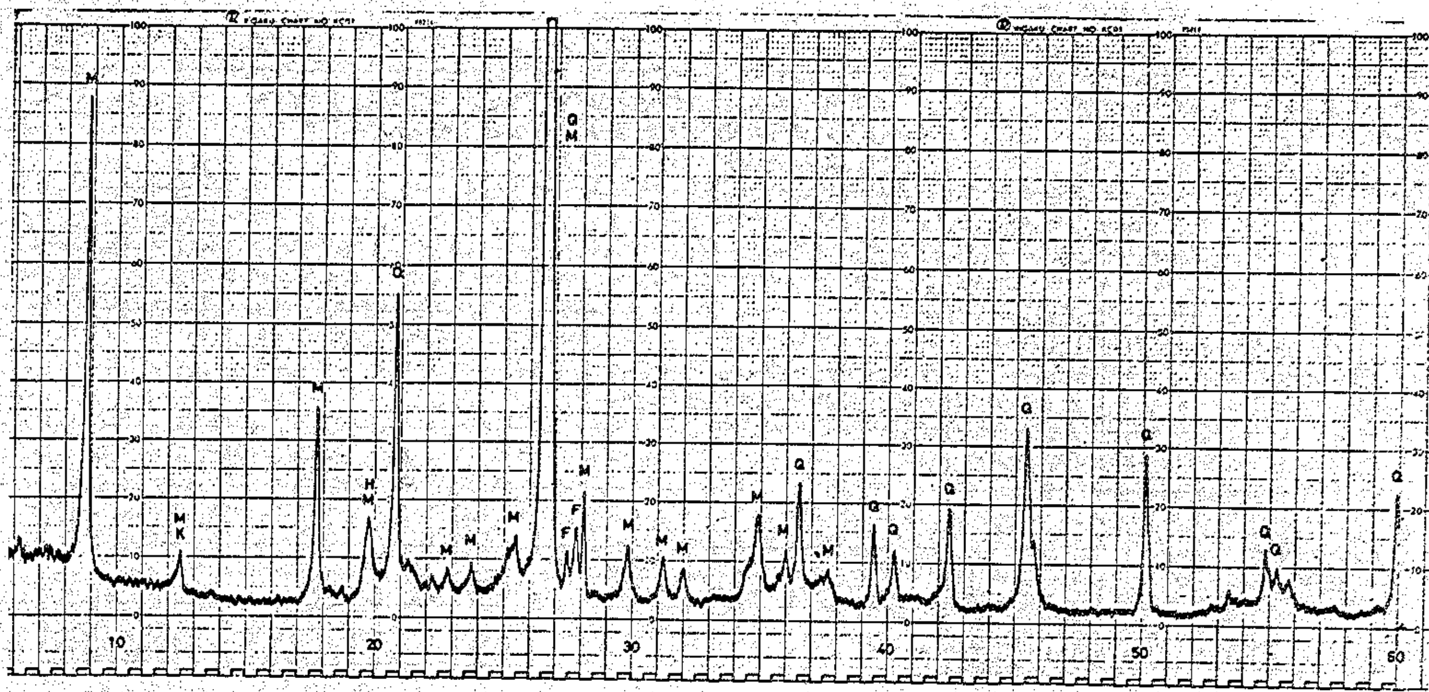


Fig. 5-3-7 Beltar Clay B1380

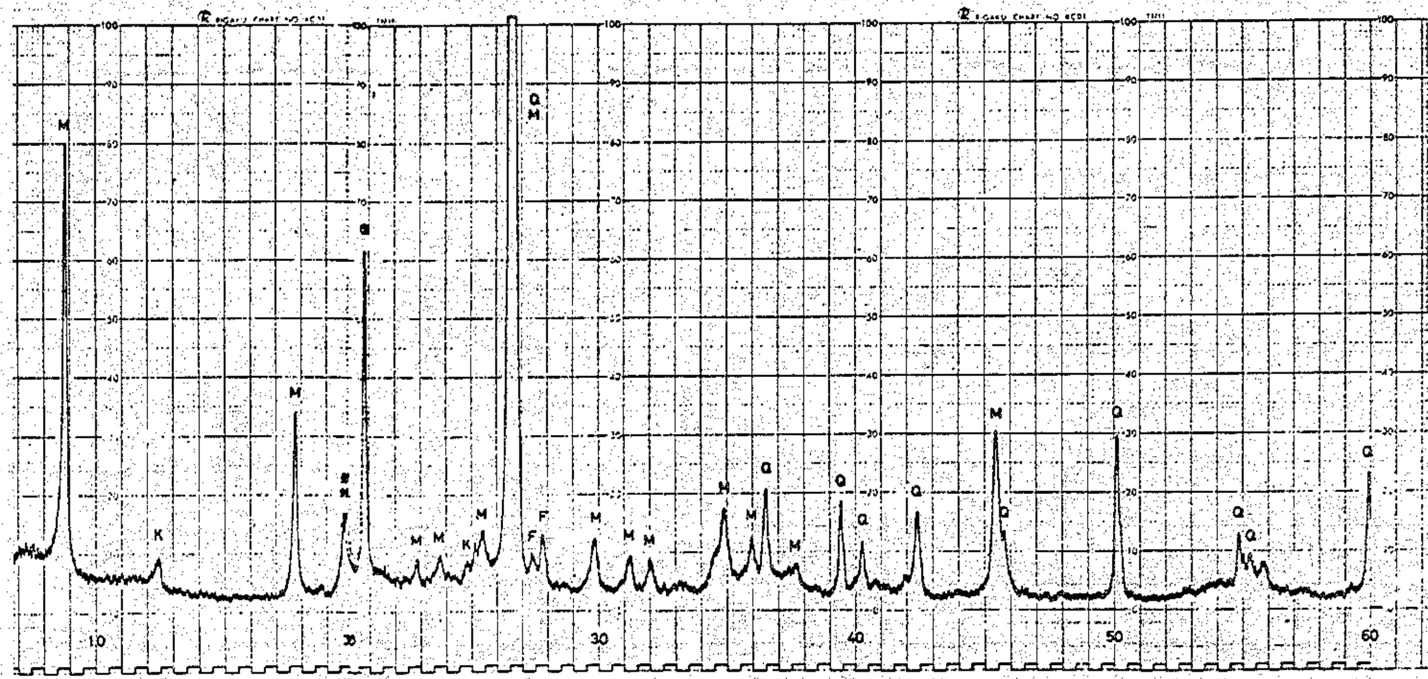


Fig. 5-3-8 Trijuga Silica Sand No. 1

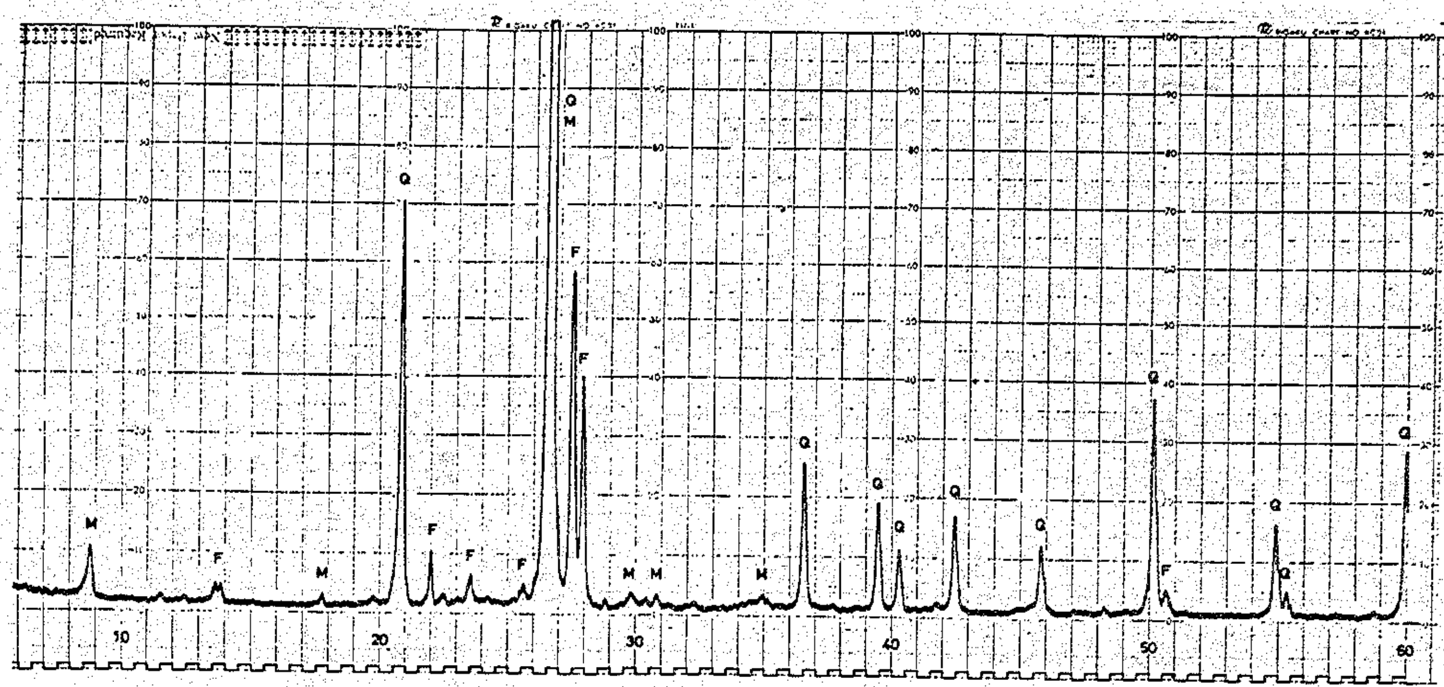


Fig. 5-3-9 Trijuga Silica Sand No. 3

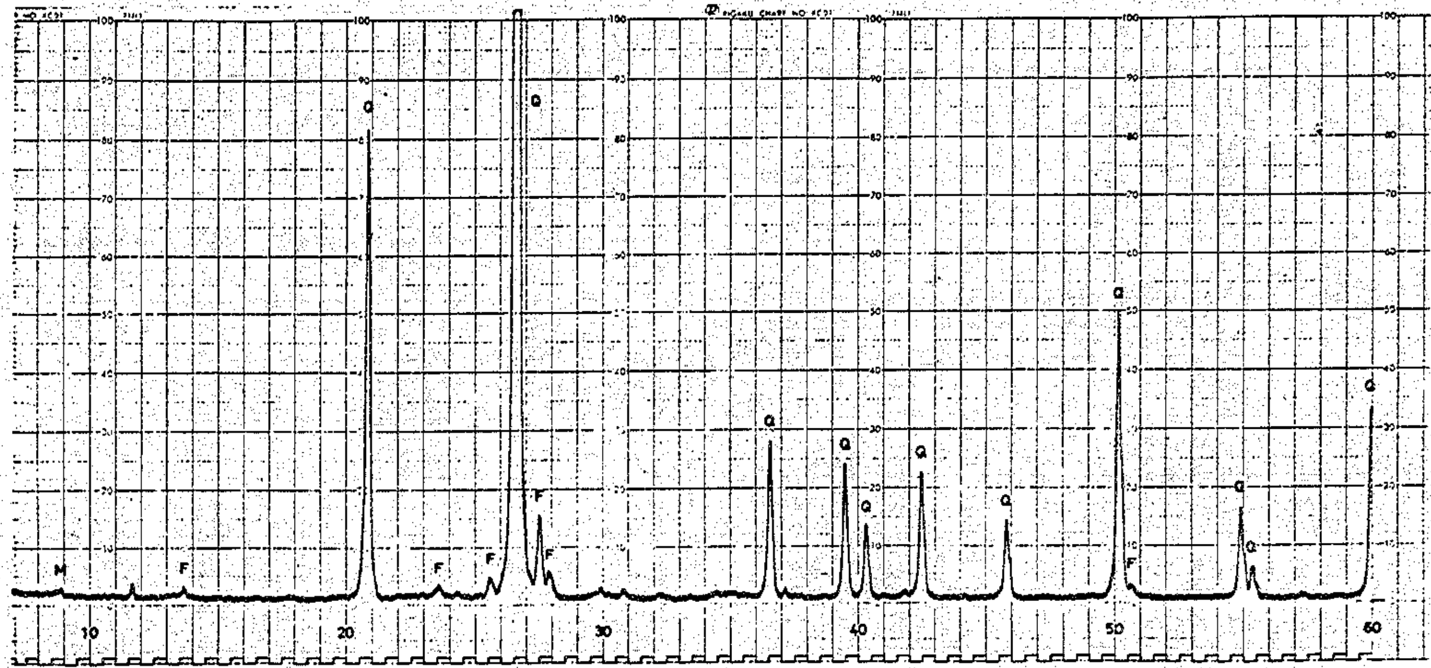


Fig. 5-3-10 Phulchoki Iron Ore No. 1

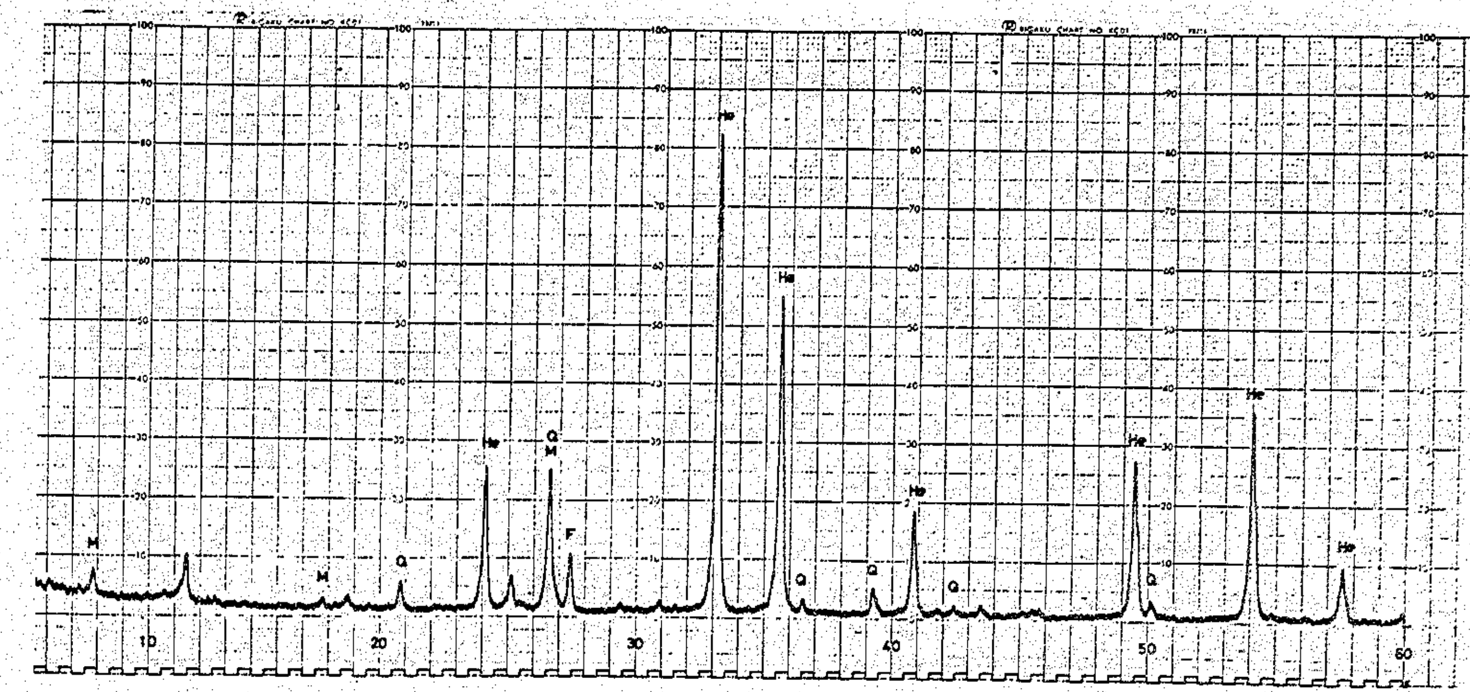
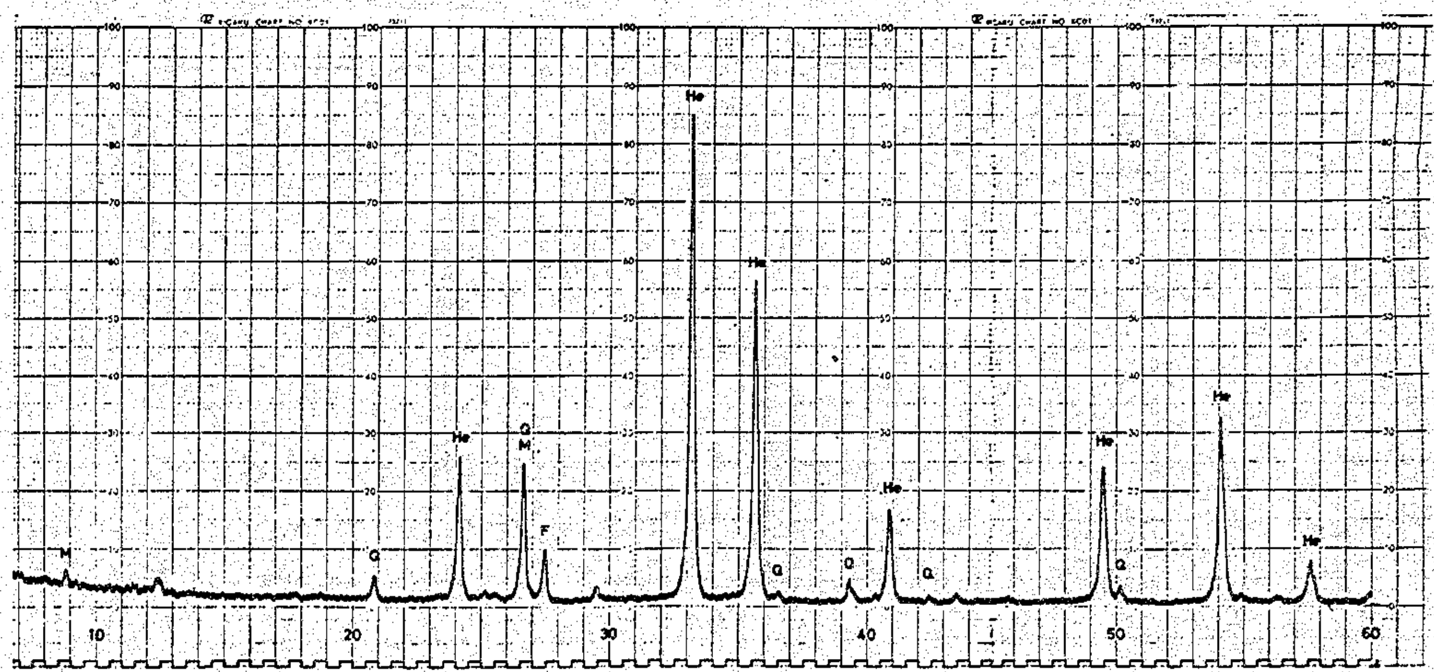


Fig. 5-3-11 Phulchoki Iron Ore No. 2



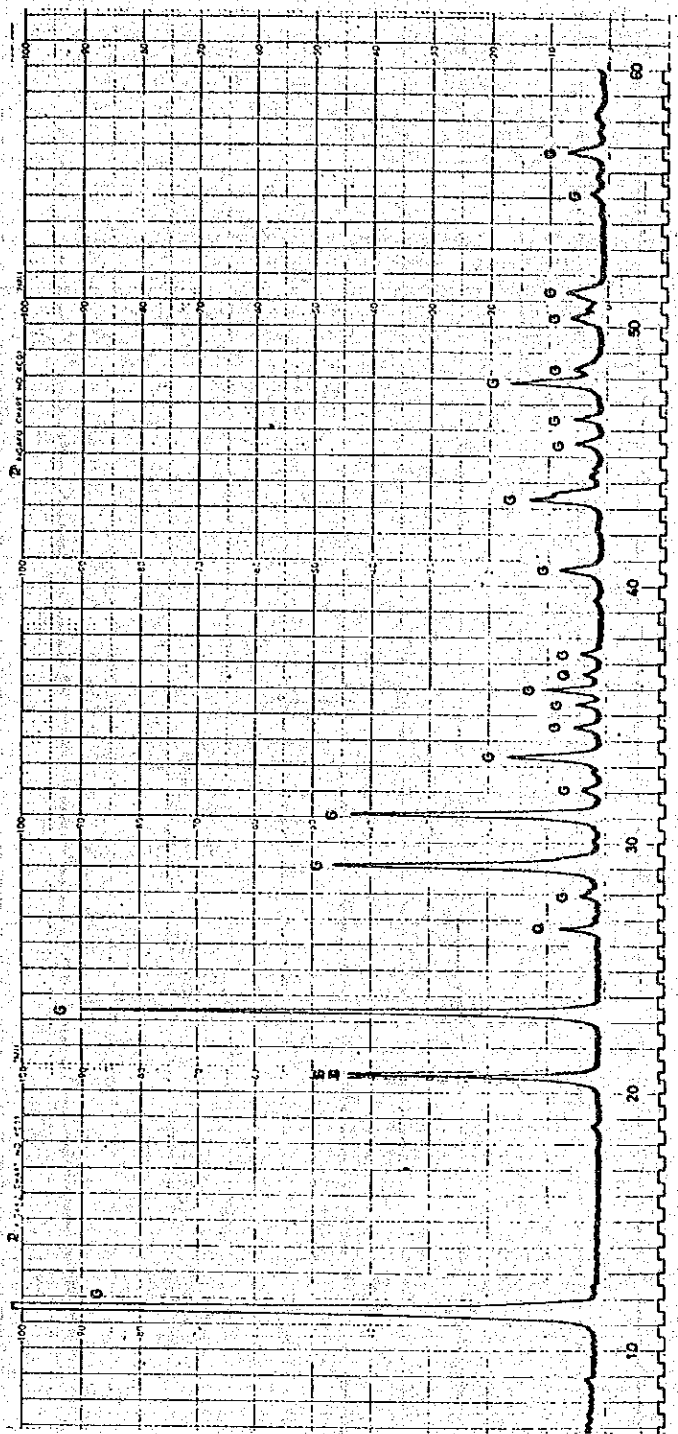


Fig. 5-3-12 Rajasthan Gypsum

(4) Microscopic observation of sliced sample

(i) Testing method

The samples were sliced to about 30 micron thick and then observed by a polarizing microscope and the microscopic photographs were taken.

(ii) Results of microscopic observation

The microscopic photographs are shown in Photo 5-3-1 ~ 5-3-5, and the detailed explanation is described in pages of the photographs respectively. The minerals observed by the polarizing microscope are summarized in Table 5-3-17.

Table 5-3-17 Results of Microscopic Observation

Sample	Minerals observed	Size of chrystals
Sindali limestone S-053	Calcite	Calcite : average about 1,000 μ
Sindali limestone S-065	Calcite Dolomite (a little)	Calcite : average about 1,000 μ
Sindali limestone S-211	Calcite Dolomite (a little)	Calcite : average about 1,000 μ
Sindali dolomite S-029	Dolomite Calcite (a little)	Dolomite: 100 ~ 200 μ
Beltar clay B-28	Quartz Mica Kaolinite	Quartz : 10 ~ 200 μ

List of Microscopic Photographs

Photo 5-3-1	Sindali limestone sample	S-053
Photo 5-3-2	Sindali limestone sample	S-065
Photo 5-3-3	Sindali limestone sample	S-211
Photo 5-3-4	Sindali dolomite sample	S-029
Photo 5-3-5	Beltar clay sample	B-28