II-3 Supply and Demand of Cement

II-3-1 Actual Conditions of Supply and Demand of Cement

(1) Nepal

(i) Present state of supply and demand of cement

Cement has come into use in Nepal mainly since the early 1950's. However, relevant statistical data date back only to fiscal 1958/59. Until very recently Nepal has been totally dependent on imported cement to meet her needs, and most of this has come in from India. However, India suffers from a perpetual shortage of cement, and has not always been in a position to satisfy Nepal's needs.

The quota system has been adopted between Nepal and India and this quota has been decided jointly every year. As is shown hereafter, Nepal's requirements have not been fully met and have been subjected to extreme fluctuations every year.

Fiscal year	Nepalese requirements	Indian pledge and supply
1975/76	100,000 tons	30,000 tons
1976/77	100,000 tons	100,000 tons
1977/78	150,000 tons	40,000 tons

Under these circumstances, Nepal has been obliged to cover the shortage by importing from third countries other than India.

Thus Nepal has been subjected to international price fluctuations, unstable supply and unreliable delivery. It follows that cement consumption in Nepal has naturally been discouraged and surpressed.

To relieve the shortage, the need to have a cement plant of her own in the country has been keenly felt for many years and construction efforts have been made many times, but delayed. It was only in 1975 that the first cement plant in Nepal came into being. However, the production capacity of 48,000 tons per annum is too small to meet the domestic demand.

On the other hand, cement demand has shown rapid growth in the successive development plans and the annual average rate of growth reached a little over 11 per cent during this 10 year period. According to the current fifth plan, Nepal has decided to build another plant with an annual capacity of 260,000 tons during the plan period to attain self-sufficiency and it is expected to be completed by December, 1981. Past consumption records and imports breakdown by countries are as follows :

Table 2-3-1 Consumption Records of Cement in Tons

Fiscal year *1	Production	Import	Foreign aid *2	Consumption	Moving average *5	Aid ratio %	Per capita consumption kg
1958/59		3,635		3,635		-	0.4
1959/60		10,143		10,143		-	1.1
1960/61		6,252		6,252	13,725	-	0.7
1961/62		6,493	1,000	7,493	21,601	13.3	0.8
1962/63		37,764	3,336	41,100	35,258	8.1	4.2
1963/64		26,070	16,949	43,019	51,613	39.4	4.4
1964/65		47,338	31,087	78,425	57,101	39.6	7.9
1965/66		55,788	32,241	88,029	61,665	36.6	8.7
1966/67		16,561	18,371	34,932	67,373	52.6	3.4
1967/68		39,351	24,567	63,918	71,128	38.4	6.1
1968/69		44,800	26,763	71,563	71,189	37.4	6.6
1969/70		53,042	44,157	97,199	82,577	45.4	8.7
1970/71		41,358	46,975	88,333	91,167	53.2	7.6
1971/72		*3 (49,520)	*4 (42,350)	(91,870)	108,566	46.1	7.8
1972/73		*3 (79,350)	*4 (27,520)	(106,870)	132,195	25.8	8.9
1973/74		*3 (120,860)	*4 (37,700)	(158,560)	145,692	23.8	12.9
1974/75	14,000	149,224	*4 (52,120)	(215,340)	172,360	24.2	17.1
1975/76	29,565	55,657	*4 (70,600)	(155,820)		45.3	12.1
1976/77	42,036	106,184	*4 (76,990)	(225,210)		34.2	17.2

*1 Nepalese fiscal year refers to the period from July 16 to July 15 of the next year.

Figures in brackets are estimated.

*2 Cement used for the foreign aid projects has been supplied by the donor countries and such quantities do not form a part of the ordinary import amount.

*3 As is shown in Table 2-3-2, imports from India for the period from 1971/72 to 1973/74 include cement appropriated for foreign aid projects. To eliminate the foreign aid portion, we have set up a correlation equation between the quantity of cement supplied by India for foreign aid projects (y) and the amount of Indian aid (x) relating Table 2-3-3 to Table 2-3-4. Thus, we have obtained the following equation :

$$y = 307\ x - 10,134$$

From the above equation, the values of (y) are calculated respectively at 21,670, 15,930 and 24,470 tons for the fiscal years 1971/72, 1972/73 and 1973/74. As these quantities are estimated to be supplied for Indian aid projects, ordinarily imported quantities from India are calculated by deducting the above mentioned quantities from the total import.

*4 The quantity of cement supplied by donor countries (y) for the fiscal years 1971/72 to 1976/77 is calculated by relating (y) to the amount of foreign aid (x) mentioned in Table 2-3-4 : namely,

$$y = 240\,x - 15{,}727$$

*5 As the annual consumption shows irregular fluctuations, we have calculated a 5-year moving average for the purpose of estimating future demand.

Table 2-3-2 Import Breakdown by Countries in Tons

Fiscal year	India	China	U.S.S.R.	North Korea	South Korea	Hong-kong	Thai-land	Burma	Japan	Others	Total
1958/59	3,635										3,635
1959/60	10,143										10,143
1960/61	6,252										6,252
1961/62	6,493										6,493
1962/63	5,904		31,860								37,764
1963/64	5,046	5,080	15,944								26,070
1964/65	14,776	15,240	17,322								47,338
1965/66	19,200	9,159	27,429								55,788
1966/67	5,480	6,081	5,000								16,561
1967/68	20,528	10,050	8,773								39,351
1968/69	31,678	13,122									44,800
1969/70	40,850	12,192									53,042
1970/71	33,310	8,048									41,358
1971/72	*1 61,185	5,000		5,000							71,185
1972/73	*1 59,000	20,850	7,934	5,000						2,500	95,284
1973/74	*1 45,000	24,184		6,648	26,700	32,000	5,800	5,000			145,332
1974/75	30,000	15,484		7,000	23,200	38,608	22,920	5,000	7,012		149,224
1975/76	30,000	16,451		871	2,279		5,270		646	140	55,657
1976/77	100,000	6,184									106,184

*1 Imports from India for the fiscal years 1971/72 to 1973/74 include cement appropriated for foreign aid projects.

Table 2-3-3 Breakdown of Foreign Aid Supply by Countries in Tons

Fiscal year	India	China	U.S.S.R.
1961/62	1,000	-	-
1962/63	1,966	200	1,170
1963/64	12,441	3,338	1,170
1964/65	26,269	3,648	1,170
1965/66	27,440	4,801	-
1966/67	10,035	4,801	3,535
1967/68	13,544	7,488	3,535
1968/69	22,723	4,040	-
1969/70	29,117	15,040	-
1970/71	31,935	15,040	-

Table 2-3-4 Foreign Aid in Grants (Rs. in millions)

Fiscal year	Foreign aid	Breakdown by countries					
		India	U.S.A.	China	U.S.S.R.	U.K.	Others
1962/63	83.7	not available					
1963/64	165.9						
1964/65	182.8						
1965/66	175.3	93.0	57.9	16.2	5.0	-	3.2
1966/67	142.2	77.6	34.9	24.6	4.9	-	0.2
1967/68	158.1	95.9	32.2	26.2	3.1	0.2	0.5
1968/69	185.9	106.5	38.5	37.6	1.2	1.3	0.8
1969/70	243.7	139.5	43.7	48.5	4.5	5.1	2.4
1970/71	270.7	125.4	59.7	47.2	2.7	17.4	18.3
1971/72	242.0	103.6	48.0	53.2	5.0	17.0	15.2
1972/73	180.2	84.9	41.3	24.3	-	14.8	14.9
1973/74	222.6	112.7	31.9	34.3	-	19.6	24.1
1974/75	282.7	not available					
1975/76	359.7						
1976/77	386.3						

The actual cement consumption for various development activities is shown in Table 2-3-5.

Table 2-3-5 Cement Consumption by Development Activities in Tons

Heading	1973/74			1974/75		
	Public sector	Private sector	Total	Public sector	Private sector	Total
Transport and communication	20,721	8,279	29,000	29,956	9,944	39,900
Agriculture, land reform, irrigation and forest	20,826	9,224	30,050	37,762	13,548	51,310
Industry, commerce, power, tourism and mining	10,443	3,507	13,950	22,109	7,841	29,950
Panchayat, education, health and social services	10,826	4,194	15,020	9,004	2,396	11,400
Defence	12,720	6,560	19,280	7,500	2,463	9,963
Total	75,536	31,764	107,300	106,331	36,192	142,523
Component ratio (%)	(70.4)	(29.6)	(100)	(74.6)	(25.4)	(100)

Table 2-3-6 shows the breakdown of cement used for individual infrastructural projects taken from a part of the public sector figure in Table 2-3-5.

Table 2-3-6 Cement Consumption by Infrastructural Projects in Tons

Project	1973/74	1974/75
Irrigation	17,000	26,435
Road	12,558	21,863
Electricity	847	12,355
Industries *[1]	4,062	4,724
Drinking water	1,000	3,555
Aviation	3,405	3,016
Education	2,698	1,043
Total	41,570	69,791

*[1] Includes the private sector.

Regional consumption for cement in the public sector is shown in Table 2-3-7.

Table 2-3-7 Cement Consumption by Regions in Tons

Fiscal year	Far western development region	Western development region	Central development region	Eastern development region	Unspecified	Total
1973/74	15,036	11,199	39,020	7,546	4,542	77,343
Component ratio (%)	(19.4)	(14.5)	(50.5)	(9.8)	(5.8)	(100)
1974/75	18,560	9,123	30,076	13,445	35,092	106,296
Component ratio (%)	(17.5)	(8.6)	(28.3)	(12.6)	(33.0)	(100)

On the assumption that the component ratios of the far western, western, central and eastern development regions in the private sector are respectively 2, 8, 70 and 20 based on the opinion of the parties concerned, and that the ratio between the public sector and the private sector is 3 to 1, it may be seen that, while the central region has decreased its relative weight, the eastern and far western regions have grown in importance and that the emphasis has been put more on equalizing the development of each region than placing the traditional priority merely on the central region, as shown in Table 2-3-8.

Table 2-3-8 Estimated Regional Consumption in both Sectors as a Percentage

Fiscal year	Far western development region	Western development region	Central development region	Eastern development region
1973/74	15.0	13.1	58.6	13.3
1974/75	17.9	11.2	51.6	19.3

(ii) Demand forecast

(a) Trend analysis

Trend analysis is applied to the linear, quadratic and Gompertz curve equations. Respective equations and correlative coefficients are shown as under, of which the most appropriate is the quadratic equation.

The linear equation

$$y = 9.7\,t + 11.2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$r = 0.965$

where, y : estimated annual cement consumption (tons in thousands)

t : years elapsed from 1960/61

r : correlative coefficient

The quadratic equation

$$y = 0.45\,t^2 + 3.36\,t + 24.96 \quad \ldots\ldots\ldots \quad (2)$$

$r = 0.980$

The Gompertz curve equation

$$y = 617.4 \times 0.035^{0.94^t} \quad \ldots\ldots\ldots\ldots \quad (3)$$

$r = 0.978$

(b) Correlation analysis

Correlation analysis is carried out on the basis of the simple correlation with the real GDP based on 1964/65.

$$y = 82.7\,x - 423.8 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$r = 0.931$

where, x : real GDP (Rs. in billions)

Although the future cement consumption here is estimated on the assumption of the future real growth rate at 2.5 per cent, the result varies considerably depending on how much GDP is estimated. Actual records of GDP are shown in Table 2-3-9.

Table 2-3-9 Actual Records of GDP

Fiscal year	Population in millions	GDP at current prices		GDP at constant prices (1964/65)		
		GDP Rs.in millions	Per capita Rs	GDP Rs.in millions	Per capita Rs	Growth rate %
1964/65	10.1	5,602	555	5,602	555	-
1965/66	10.3	6,909	671	5,996	582	7.0
1966/67	10.5	6,411	611	5,902	562	Δ 1.6
1967/68	10.7	7,173	670	5,942	555	0.7
1968/69	10.9	7,985	733	6,207	569	4.5
1969/70	11.2	8,768	783	6,367	568	2.6
1970/71	11.6	8,938	771	6,291	542	Δ 1.2
1971/72	11.8	10,369	879	6,487	550	3.1
1972/73	12.1	9,969	824	6,456	534	Δ 0.5
1973/74	12.3	12,808	1,041	6,865	558	6.3
1974/75	12.6	15,074	1,196	7,102	564	3.5

From the above Table the annual average rates of growth for the third plan period (1965/66 ~ 1969/70) and the fourth plan period (1970/71 ~ 1974/75) are calculated at 2.7 per cent and 2.2 per cent respectively and at 2.4 per cent for the total period. However, for the fiscal years 1975/76 and 1976/77 the growth rates are respectively estimated at Δ0.1 per cent (nominal rate of growth 3.6 per cent and rate of price rise 3.7 per cent) and 1.1 per cent (nominal rate of growth 2 per cent and rate of price rise 0.9 per cent).

(c) Estimation based on similar cases

It is very difficult to make a fair comparison when considering several different countries because they are not alike in terms of their stage of economic development, historical background and geographical factors. However, Nepal is still in the initial stage of her development and to provide similar cases we have selected some neighboring countries in Asia for the 10 year period from 1951 to 1961. Their annual average rate of cement increase was as follows :

India	9.7 %
Pakistan	9.4 %
Thailand	10.9 %
Vietnam	7.8 %

Moreover, the Department of Mines and Geology of Nepal, the World Bank/UNIDO Co-operative Program Mission and the Asian Development Bank have estimated 10 per cent increase per annum. However, Holtec Engineers Private, Ltd. of India has estimated 9 per cent. Taking these matters into consideration, we have made two kinds of estimation based on the following equations.

$$y = 172\ (1 + 0.09)^t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$y = 172\ (1 + 0.10)^t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

where, y : estimated annual cement consumption (tons in thousands)

t : years elapsed from 1974/75

(d) Estimated results

From the above equations, future cement consumption will be estimated as shown in Table 2-3-10. (Please refer to Fig. 2-3-1 Cement Demand Forecast in Nepal.)

Table 2-3-10 Cement Demand Forecast by Respective Methods
(Tons in thousands)

Fiscal year	(1)	(2)	(3)	(4)	(5)	(6)
1977/78	176	212	196	172	223	229
1978/79	186	231	210	187	243	252
1979/80	196	251	224	203	265	277
1984/85	244	365	295	285	407	446
1989/90	293	501	360	378	627	718
1994/95	341	659	417	483	964	1,157

Among the above estimations we have adopted the forecast conducted by the equation (5) as the basis for this report. The reasons are as follows :

- It very often happens that a country shows a high rate of increase in the initial stages of economic development when the size is still small and that this high rate continues until the country comes up to a certain level. This is a general rule which can be observed in the case of many developing countries.
- Past consumption records do not always show a steady growth pattern. Because Nepal has not been able to import cement in unrestricted quantities when needed for the following reasons ; first, until recently Nepal has been so dependent on imports that she has been influenced by internal production factors of exporting countries, in particular the Indian supply and demand situation. Second, in the case of shortage of cement import from India, Nepal has suddenly been obliged to import urgently from other countries, thus having to contend with international price fluctuations. Due to these limitations, it may be said that past data merely indicate the apparent consumption and that they do not correctly reflect the real demand situation of the country.
- Cement required for foreign aid projects has been supplied by donor countries over and above the ordinary import quantities and there are no exact records of these quantities.

- Standard construction works have been executed with materials other than cement as far as possible, even when cement should have been used. Further, even in the case of using cement, Nepal has adopted construction methods which allowed minimum use of the available amount.
- To relieve the cement shortage, in addition to the regular import some quantities of cement have been brought in over the long Indian border. Such imports do not, of course, appear in official statistics.
- Taking all these factors into consideration, the data made public only represent the minimum consumption, and by adding 10 to 20 per cent more to the published data based on the opinion of the parties concerned, we would probably get more accurate consumption or real demand level figures.
- With the commencement of indigenous production of cement, it is fully expected that the use of cement will be encouraged in many fields where it has formerly been limited to minimum quantities. And, as the country develops economically, above all, in terms of industrial development, cement will be required in ever larger quantities more rapidly than the growth of GDP.
- For these reasons, it is not overstating the case even if we base our estimation on the forecast using equation (5).

In this connection, per capita consumption using equation (5) is calculated as follows :

Fiscal year	Per capita consumption
1977/78	16.6 kg
1978/79	17.7 kg
1979/80	18.9 kg
1984/85	25.9 kg
1989/90	35.6 kg
1994/95	48.9 kg

The above per capita consumption is not entirely unrealizable as compared with the actual consumption records in other developing countries. (Please refer to Table 2-3-21 Per capita Cement Consumption in Asian Countries.)

(iii) Cement price

(a) Import price

The actual records for 1974/75 are shown in Table 2-3-11.

Table 2-3-11 Import Price of Cement

Countries of origin	Quantity in tons	Unit price per ton	Rs. equivalent	Delivery terms
Burma	5,000	US$ 70.00	735	CIF Calcutta
South Korea	23,200	US$ 65.19	684	CIF Calcutta
Hongkong	25,000	US$ 62.00	651	CIF Calcutta
Hongkong	13,605	US$ 66.00	693	CIF Calcutta
Thailand	5,800	US$ 66.00	693	CIF Calcutta
North Korea	7,000	£ 25.00	625	CIF Calcutta
China	5,484	£ 27.00	675	CIF Calcutta
China	1,500	£ 16.00	400	CIF Calcutta
China	17,500	£ 26.00	650	CIF Calcutta
India	17,500	US$ 46.70	490	FOR Raxaul

Import prices of cement have greatly fluctuated between US$ 40 to 70, and on top of this, the average transportation time from different points of supply (e.g. Burma, Hongkong, Korea, Thailand, China) to Calcutta is 3 weeks and then transportation from Calcutta to Kathmandu takes a week, and includes a big physical loss in transit. As a result, the overall price of cement imported from the countries other than India is excessively expensive by the time it reaches Kathmandu, as shown in Table 2-3-12.

Table 2-3-12 Example of Landed Cost of Imported Cement at Kathmandu(1974/75)

Heading	US$ per ton	Rs. equivalent
CIF Calcutta price	67.60	710
Port charges, transportation, etc. up to Raxaul	24.19	254
FOR Raxaul price	91.79	964
Customs duty (33 %)	25.90	272
Sales tax (20 %)	13.65	143
Transportation from Raxaul to Kathmandu	16.19	170
Total	147.53	1,549

On the other hand, the current retail price imported from India is Rs 48 per bag (Rs 960 per ton) in Kathmandu and Hilly regions and Rs 42 (Rs 840 per ton) in Terai regions (e.g. Biratnagar, Birganj).

(b) Price of domestic cement

Table 2-3-13 shows the price breakdown of the cement produced by Himal Cement Company destined for the Kathmandu valley as of January, 1978.

Table 2-3-13 Price Breakdown of Himal Cement

Heading	Rs. per bag
Ex-factory price	36.82
Excise duty	2.50
Sales tax	4.72
Total	44.04
Commission (including handling charges)	1.76
Retail price	45.80
(Retail price per ton)	(916)

(2) India

(i) Present state of supply and demand of cement

Past records of supply and demand of cement in India are shown in Table 2-3-14.

Table 2-3-14 Supply and Demand Records of Cement (Tons in thousands)

Fiscal year *1	Production	Import	Export	Consumption	Export ratio(%)	Per capita consumption(kg)
1957/58	5,810	308	36	6,080	0.6	16
1958/59	6,270	56	39	6,180	0.6	16
1959/60	6,820	4	152	6,670	2.2	17
1960/61	7,970	2	116	7,790	1.5	18
1961/62	8,250	29	91	8,180	1.1	19
1962/63	8,590	16	40	8,560	0.5	19
1963/64	9,360	4	56	9,300	0.6	20
1964/65	9,700	2	39	9,660	0.4	20
1965/66	10,820	3	36	10,550	0.3	22
1966/67	11,050	1	22	11,030	0.2	22
1967/68	11,300	1	32	11,270	0.3	22
1968/69	12,240	-	173	11,770	1.4	22
1969/70	13,800	-	160	13,460	1.2	25
1970/71	14,350	-	153	13,830	1.1	26
1971/72	15,070	-	199	14,760	1.3	27
1972/73	15,550	1	198	15,500	1.3	28
1973/74	14,700	-	124	14,880	0.8	26
1974/75	14,810	-	310	14,260	2.1	24
1975/76	17,300	-	401	16,060	2.3	27
1976/77	18,850	-	819	18,620	4.3	31

*[1] Indian fiscal year refers to the period from April to March of the next year.

From the above the annual average growth rate of cement industry is calculated at 6.4 per cent. Such growth is not so big, however, India has not only managed to meet the demand of neighboring countries such as Nepal, Bangladesh, Bhutan, etc., but also, in recent years, made great efforts to export to the Middle East (e.g. Iran, Oman and United Arab Emirates). Table 2-3-15 shows the regional records of supply and demand of cement.

Table 2-3-15 Supply and Demand Records of Cement by Region
(Tons in thousands)

Fiscal year	Supply and demand	North	East	West	South	Total
1973/74	Production	2,560	2,540	4,340	5,260	14,700
	Consumption	4,370	2,720	3,960	3,830	14,880
1974/75	Production	2,250	2,410	4,700	5,450	14,810
	Consumption	4,170	2,540	3,870	3,680	14,260
1975/76	Production	2,700	2,840	5,440	6,320	17,300
	Consumption	4,640	3,220	4,170	4,030	16,060
1976/77	Production	2,710	3,130	5,910	7,100	18,850
	Consumption	5,610	3,580	4,540	4,890	18,620

* Regionwise states are shown in Table 2-3-16.

In terms of region the North has always suffered from considerable deficiency, next in order is the East and both regions have been covered by the surplus of the South and the West.

For reference, we give here Table 2-3-16 showing the number of cement plants, production capacity, per capita income, population and area by region and state. (Please refer to Fig. 2-3-2 Cement Factories in Indian Subcontinent as of 1976.)

Table 2-3-16 Number of Cement Plants, Capacity, Per capita Income, Population and Area by Region and State

Region	State	Number of plants	Capacity (Tons in thousands)	Per capita income (IC)	Population (in millions)	Area (Sq km in thousands)
North	Haryana	2	650	(1,217)	11.2	44.2
	Himachal Pradesh			1,050	3.6	55.7
	Jammu and Kashmir			883	5.1	222.2
	Punjab			1,580	14.9	50.4
	Rajasthan	5	2,280	(819)	29.0	342.2
	Uttar Pradesh	2	910	781	96.1	294.4
	Chandigarh				0.3	0.1
	Delhi				5.7	1.5
	Total	9	3,840		166.2	1,010.7
East	Arunachal Pradesh				0.5	83.6
	Assam	1	200	850	17.3	78.5
	Bihar	7	2,408	(718)	61.7	173.9
	Manipur				1.2	22.4
	Meghalaya	1	84		1.1	22.5
	Mizoram				0.4	21.1
	Nagaland				0.5	16.5
	Orissa	2	798	785	24.4	155.8
	Sikkim				0.2	7.3
	Tripura				1.7	10.5
	West Bengal	1	400	1,046	49.7	87.9
	Total	12	3,890		158.7	680
West	Gujarat	6	2,281	(1,038)	30.2	196.0
	Madhya Pradesh	6	3,329	793	47.1	442.8
	Maharashtra	2	600	1,330	56.3	307.8
	Goa, Daman and Diu				0.9	3.8
	Dadra and Nagar Haveli				0.1	0.5
	Total	14	6,210		134.6	950.9
South	Andhra Pradesh	6	2,026	919	47.9	276.8
	Karnataka	6	2,052	785	32.4	191.8
	Kerala	1	30	(861)	23.9	38.9
	Tamil Nadu	7	3,622	851	45.4	130.1
	Andaman and Nicobar Islands				0.1	8.3
	Pondicherry				0.5	0.5
	Total	20	7,730		150.2	646.4
Grand total		55	21,670	Average 1,005	609.7	3,288

* Figures are as of 1976. However, those showing per capita income are actual records for 1975/76, those in brackets are for 1974/75.

(ii) Supply and demand forecast

The forecast for supply and demand of cement is shown in Table 2-3-17.

Table 2-3-17 Supply and Demand Forecast by Region
(Tons in thousands)

Heading	Fiscal year	Mark	North	East	West	South	Total
Demand	1978/79 *[1]	(1)	6,500	4,000	5,000	5,300	20,800
	1983/84 *[2]	(2)	10,000	6,300	7,700	8,000	32,000
Capacity required*[3]	1978/79	(3)	7,650	4,700	5,900	6,250	24,500
	1983/84	(4)	12,500	7,900	9,600	10,000	40,000
Capacity to be increased under active implementation	1978/79	(5)	200	400	980	650	2,230
	1983/84	(6)	2,500	–	800	1,200	4,500
Capacity to be increased by industrial licenses and letters of intent already covered but not under active implementation		(7)	3,252	2,752	2,675	4,372	13,051
Capacity installed	1976/77	(8)	3,840	3,890	6,210	7,730	21,670
Capacity expected	1978/79	(9)	4,040	4,290	7,190	8,380	23,900
Capacity gap	1978/79	(10) =(9)-(3)	Δ3,610	Δ410	+1,290	+2,130	Δ600
	1983/84	(11) =(9)+(6) -(4)	Δ5,960	Δ3,610	Δ1,610	Δ420	Δ11,600
Capacity gap after reckoning (7)	1983/84	(12) =(7)-(11)	Δ2,708	Δ858	+1,065	+3,952	+1,451

*[1] 1978/79 refers to the final year of the fifth plan.

*[2] 1983/84 refers to the final year of the sixth plan now under preparation.

*[3] Capacity utilization is estimated at 80 to 85 per cent of production capacity.

As the annual average growth rate of cement demand is estimated at 8 %, the above table shows that supply and demand of cement just balances on a nationwide scale on condition that all the plans of expansion works and construction of new plants already approved by the authorities will have been completed by 1983/84.

However, even in that case, the North will still be short of cement in large quantities and the East is anticipated to be in short supply to some degree.

(iii) Cement price

In India, the production, distribution and selling price of cement are controlled by the Government and generally adjusted every quarter of the year.

FOR destination price per ton for the period from January 7 to March 31, 1978 is as follows :

	Indian currency	Rs. equivalent
FOR price of unpacked cement	248.65	346
Excise duty	65	90
Packing charges	41.63	58
Total FOR price	355.28	494

The retail price consists of the above FOR price, sales tax (IC 10.6~37.6) imposed by both the Central Government and the State Government, and incidentals including (a) handling and local transport charges (IC 5.75 ~ 19.5), (b) godown charges (IC 0.49 ~ 4.0), (c) stockist's margin of profit (IC 5.0 ~ 16.0) and (d) additional transport charges (IC 0 ~33.7), if any, allowed by the State Government. Accordingly, the retail price varies slightly in respective states, however, it is assumed at IC 400 or so (≒ Rs 560) on the average.

Since the end of 1977 India has launched cement importation and the CIF price is estimated at around US$ 52 per ton. The above price control is equally applied to imported cement.

(3) Bangladesh

(i) Present state of supply and demand of cement

Past records of supply and demand of cement in Bangladesh is shown in Table 2-3-18.

Table 2-3-18 Supply and Demand Records of Cement

(Tons in thousands)

Fiscal year *1	Production	Import	Consumption	Per capita consumption kg
1972/73	31	320	351	5
1973/74	52	400	452	6
1974/75	127	330	457	6
1975/76	157	220	377	5
1976/77	308	340	648	8

*1 Bangladeshi fiscal year refers to the period from July to June of the next year.

Bangladesh is said to have attained an all-time consumption level of 800 thousand tons in 1964. She has not yet caught up with this record after separation from Pakistan in December, 1971.

(ii) Supply and demand forecast

According to the authorities concerned, the annual average rate of growth is estimated at 7 per cent as follows :

Fiscal year	Tons in thousands
1977/78	800
1978/79	1,000
1984/85	1,500

On the other hand, the following two plants are currently in operation:

° Chhatak Cement Factory
  Capacity : 90 thousand tons per annum
  Limestone is imported from Meghalaya, India.

° Chittagong Cement Clinker Grinding Factory
  Capacity : 300 thousand tons per annum
  Clinker is imported from overseas countries.

For the future plan of constructing new plants and expanding existing plants, the following 4 projects have been decided with a view to attaining self-sufficiency by 1985.

° Expansion of Chhatak Cement Factory
  Capacity to be increased : 60 thousand tons per annum
  Completion date : 1980

° Khulna Cement Clinker Grinding Factory
  Capacity : 300 thousand tons per annum
  Completion date : 1981
  Clinker will be imported from overseas countries until Jaipurhat project mentioned below is actualized.

° Surma Cement Factory
  Capacity : 300 thousand tons per annum
  Completion date : 1983
  Limestone will be imported from Meghalaya, India.

° Jaipurhat Limestone Mining and Cement Works
  Capacity : 1,000 thousand tons per annum
  Completion date : 1985

In addition to the above projects, there is another one in the planning stage as yet undecided as follows :

- Baglibazar Cement Factory

  Capacity : 150 thousand tons per annum

(iii) Cement price

In Bangladesh there is a large demand in the public sector and great quantities of cement are imported every year. The CIF price for 1977/78 is estimated at around US$ 52 per ton.

Though the ex-factory price of domestic cement is assumed at Tk 52 or so (≒ Rs 45) per bag, the same price is applied to both the imported cement and domestic cement, and the retail price is said to be Tk 62 to 67 (≒ Rs 53 to 58) per bag, namely, Tk 1,240 to 1,340 (≒ Rs 1,060 to 1,160) per ton including tax, transportation, commission, etc., only with a slight variation in different localities.

II-3-2 Prospective Market Situation

(1) Domestic market

As stated in II-3-1, (1) (ii) (d), we have adopted the forecast given by the equation (5) as the basis for future domestic demand.

Based on this equation, the projected supply and demand is shown in Table 2-3-19.

Table 2-3-19 Supply and Demand Forecast (Tons in thousands)

Fiscal year	Demand	Production			Supply and demand gap	Udaipur 750t/d case *3		Udaipur 1,000t/d case		Udaipur 1,500t/d case	
		Himal *1	Hetauda *2	Total		Production	Gap	Production	Gap	Production	Gap
1977/78	223	43		43	Δ180						
1978/79	243	43		43	Δ200						
1979/80	265	43		43	Δ222						
1980/81	288	43		43	Δ245						
1981/82	314	43	91	134	Δ180						
1982/83	343	43	195	238	Δ105						
1983/84	374	43	221	264	Δ110						
1984/85	407	43	234	277	Δ130	182	+52	243	+113	364	+234
1985/86	444	43	234	277	Δ167	208	+41	277	+110	416	+249
1986/87	484	43	234	277	Δ207	234	+27	312	+105	468	+261
1087/88	527	43	234	277	Δ250	260	+10	347	+97	520	+270
1988/89	574	43	234	277	Δ297	260	Δ37	347	+50	520	+223
1989/90	627	43	234	277	Δ350	260	Δ90	347	Δ3	520	+170
1990/91	683	43	234	277	Δ406	260	Δ146	347	Δ59	520	+114
1991/92	744	43	234	277	Δ467	260	Δ207	347	Δ120	520	+53
1992/93	811	43	234	277	Δ534	260	Δ274	347	Δ187	520	Δ14
1993/94	884	43	234	277	Δ607	260	Δ347	347	Δ260	520	Δ87
1994/95	964	43	234	277	Δ687	260	Δ427	347	Δ340	520	Δ167

*[1] The production capacity of Himal Cement Plant is 48,000 tons per annum.

*[2] Hetauda Cement Plant is expected to be completed in December, 1981 with an annual capacity of 260,000 tons. Annual changes in production depend on a rise of utilization.

*[3] Extensions of the Udaipur project will be required respectively in 1990/91 in case of 750 t/d, in 1992/93 in case of 1,000 t/d and in 1994/95 in case of 1,500 t/d.

(2) Export potentiality

(i) India

(a) Though small in export ratio, India has been exporting cement and gradually increasing the quantity. Meanwhile India has finally taken action to import cement in part since the end of 1977. This is not due to a change of policy, but a temporary phenomenon to meet the controlled construction demand, to implement export contracts with foreign countries and to make up for the shortage of expected production caused by power cuts.

(b) The excess of demand over supply is currently said to be more than 2 million tons, however, from the point of basic industrial policy which follows the line that whatever can be produced in India should be produced in India, it is inconceivable that India will make up for the entire amount of cement shortage by using imported cement. India will probably cope with this situation by either postponing or restraining construction demand or using materials other than cement, and cement import will be limited to urgent and indispensable requirements.

(c) To make up for the regional shortage of cement, India is going to set up mini cement plants with a capacity of 150 to 200 tons per plant per day. For this purpose, the Cement Research Institute of India has already carried out investigations and modifications of the designs made by some organizations and about 43 sites in 19 states have been selected as possible.

(d) However, as shown in Table 2-3-17, with the mere capacity to be increased currently under active implementation, it will necessarily invite a large quantity of cement shortage, so that it is required to promote those projects with such industrial licenses and letters of intent as are already covered but not under active implementation, although it is most unlikely that all those projects will be materialized

within the time limit. Even if they are all realized, regional imbalance still exists and the later the construction starts, the bigger the supply and demand gap will increase.
The import of cement is, therefore, expected to continue to some extent until the gap is filled.

(e) While the import quantity for 1977/78 is anticipated one million tons, such quantity may be expected to continue for the next few years under existing circumstances. It is also considered that in order to make good regional imbalance, India will take such co-existent steps as continue to import to the deficit areas on the one hand and promote the export from the surplus areas on the other hand.

(f) Regarding Bihar which is the nearest state on the Indian side to the project site, this state is said to have only about 20 million tons of limestone reserves, and also have very few mines fit for large-scale exploitation, though with many deposits.
All the 7 plants within the state are unevenly located in the southern part, having 2.4 million tons of production capacity, while the whole state merely consumes 1.2 million tons.
Incidentally, per capita consumption of this state compared with the East and all India is shown in Table 2-3-20.

Table 2-3-20 Per capita Consumption in kg

Fiscal year	Bihar	East	All India
1971/72	16.2	17.1	26.9
1972/73	16.9	19.0	27.6
1973/74	17.0	18.0	26.0
1974/75	14.6	16.1	24.3
1975/76	15.0	19.0	26.9
1976/77	19.7	21.1	30.5

For the above, per capita consumption in Bihar has been ranked in the lower level among the eastern states not to mention all India. Likewise, per capita income in this state remains low. However, taking the potentiality of development into consideration, cement demand is expected to increase steadily.

(ii) Bangladesh

(a) Bangladesh, as stated in II-3-1, (3)(ii), is aiming at self-sifficiency by 1985, so that she is expected to import 400 to 500 thousand tons of cement every year until the said year.

(b) In addition, per capita consumption will amount to 15 kg by 1985 and accordingly, future increases are fully expected. From this point of view, it is most unlikely that import will be reduced immediately.

(c) Apart from the question as to whether the expansion works and/or new construction works will be carried out as scheduled or not, the import of limestone and/or clinker will continue to some extent because of the difficulty of exploiting domestic raw materials.

(d) Before exporting cement from Nepal to Bangladesh, the transport route presents the most difficult problem to be overcome. According to the former Treaty of Trade and Transit between Nepal and India, Nepal has been required to route all the foreign trade with countries other than India, not excepting Bangladesh, through Calcutta. Fortunately, however, Nepal has, this time, obtained Indian consent in the following way, "the Government of India agreed to provide necessary overland transit facilities through Radhikapur and such other routes as may be further agreed upon for the conduct of Nepal's trade with and through Bangladesh in order to help Nepal develop and diversify her foreign trade.... The above agreement shall come into force when necessary arrangements / procedures for transit between India and Bangladesh are concluded," as stated in the letters exchanged between Minister of Industry and Commerce, His Majesty's Government of Nepal and Minister of Commerce, Civil Supplies and Co-operation, Government of India on March 17, 1978 in relation to the Treaty of Transit signed on the same date. This will greatly improve Nepalese export position. On the other hand, Bangladesh has been suffering from a cement shortage in the north-western part for a long time and it will be profitable for her to import Nepalese cement in respect of price. However, the details of the letter are still indefinite as to its interpretation and other points, and at this stage there are very many unknown factors.

(3) Summary

(i) Assuming that the future domestic demand is as shown in Table 2-3-19 and that other important factors remain unchanged, it follows that the Hetauda Plant, even if implemented at the earliest possible moment, will still be unable to cover the gap between Nepalese projected demand

and the production from the existing plant and the Hetauda plant. Hence it is necessary to proceed with the Udaipur project as soon as possible. Concerning production scale, please refer to VI-2.

(ii) Taking into account both Indian industrial policy and price competitiveness of Nepalese cement, the commercial aspect of export to India is not always reassuring, however, adjoining Bihar, particularly the northern part of the state is remarkably short of cement. Accordingly, it will probably be possible for Nepal to persuade India to import cement from Nepal instead of supplying the shortage from other areas within India.

In this connection, Nepalese foreign trade balance has been showing a large deficit every year with India amounting to several hundred million rupees per annum. Cement export to India may possibly be treated as a means of payment in kind thus helping to reduce the huge trade deficit.

(iii) Although Bangladesh is planning to become self-sufficient, Nepalese cement is in a better position than that of Bangladesh in terms of raw materials and the price of cement. Thus, providing that the Treaty of Transit is maintained on a long term basis which allows the shortest route from Nepal to Bangladesh to be used, a considerable quantity of export to Bangladesh can be expected.

(iv) As mentioned above, although a variety of restrictions are placed on export to India and/or Bangladesh, export potentiality still exists. If the requirements, especially those stated in (ii) and (iii) above, are amicably settled, Nepal will be able to expect, on a continuous basis, a certain degree of export to these markets. These countries are, of course, doing everything in their power to establish self-sufficiency as soon as possible. This means that Nepal will probably not be able to expect any increase of export quantity, however, it may be said that the earlier this project is realized, the bigger the export potentiality will become.

Table 2-3-21 Per capita Cement Consumption in Asian Countries

Country	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	Remarks
Nepal			0.4	1.1	0.7	0.8	4.2	4.4	7.9	8.7	3.4	6.1	6.6	8.7	7.6	7.8	8.9	12.9	17.1	12.1	Forecast
India	16	16	17	18	19	19	20	20	22	22	22	22	25	26	27	28	26	24	27	31	Nepal
Bangladesh															9	5	6	6	5	8	1980 : 19
Pakistan	12	14	12	14	15	15	19	26	26	26	23	31	29	21	47	36	36	45	45	44	1985 : 26
Sri Lanka	28	22	31	25	30	29	26	24	25	29	25	34	34	31	32	31	35	34	26	27	1990 : 36
Afghanistan	2	3	5	5	6	9	6	10	13	11	12	12	5	5	5	6	6	4	7	8	1995 : 48
Burma	6	8	7	7	7	7	8	8	7	11	7	7	7	6	6	7	7	5	6	7	
Thailand	21	22	22	16	18	29	30	33	39	49	60	66	68	73	72	74	78	74	79	90	India
Laos										15	18	17	14	16	21	14	9	9	10		1983 : 46
Cambodia										33	42	26	24	18	5						
Vietnam	17	18	20	21	22	27	27	26	34	90	75	79	69	49	63	49	42	20	22		Bangladesh
Malaysia	62	58	48	55	69	86	94	98	92	74	62	70	65	66	103	117	130	141	159	150	1985 : 15
Singapore										203	370	451	366	372	426	504	514	541	549	688	
Indonesia	7	5	8	5	8	7	8	8	7	4	4	6	8	10	12	13	17	20	21	21	
Philippines	26	25	28	29	35	32	40	44	50	52	67	75	70	66	67	73	71	66	83	77	
China	12	13	21	23	14	14	14	12	14	15	10	12	13	19	20	22	24	29	34	35	
Hongkong	123	153	167	175	176	223	286	328	350	285	167	159	185	221	321	289	289	301	272	357	
Taiwan	72	80	94	106	112	120	115	120	142	149	180	231	252	252	279	313	354	391	405	496	
South Korea	13	27	25	27	28	37	39	45	55	70	97	121	146	171	174	174	215	229	243	250	
Japan	142	145	169	223	241	283	290	319	313	361	401	447	477	528	544	616	715	639	547	572	

Notes : Pakistan includes Bangladesh up to 1970. Vietnam includes Laos and Cambodia up to 1965.
Malaysia includes Singapore up to 1965. China includes North Korea up to 1960.

Fig. 2-3-1 Cement Demand Forecast in Nepal

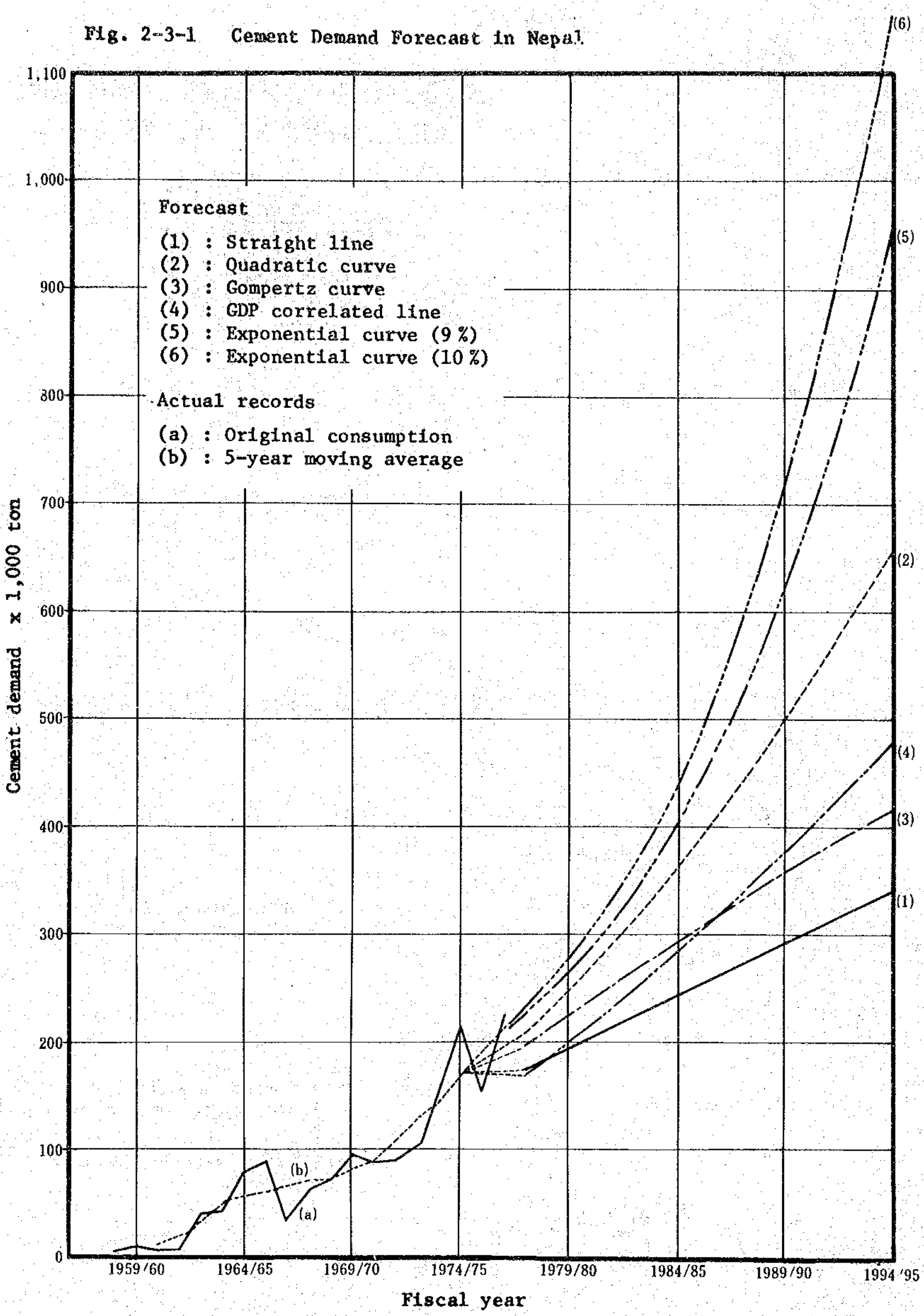
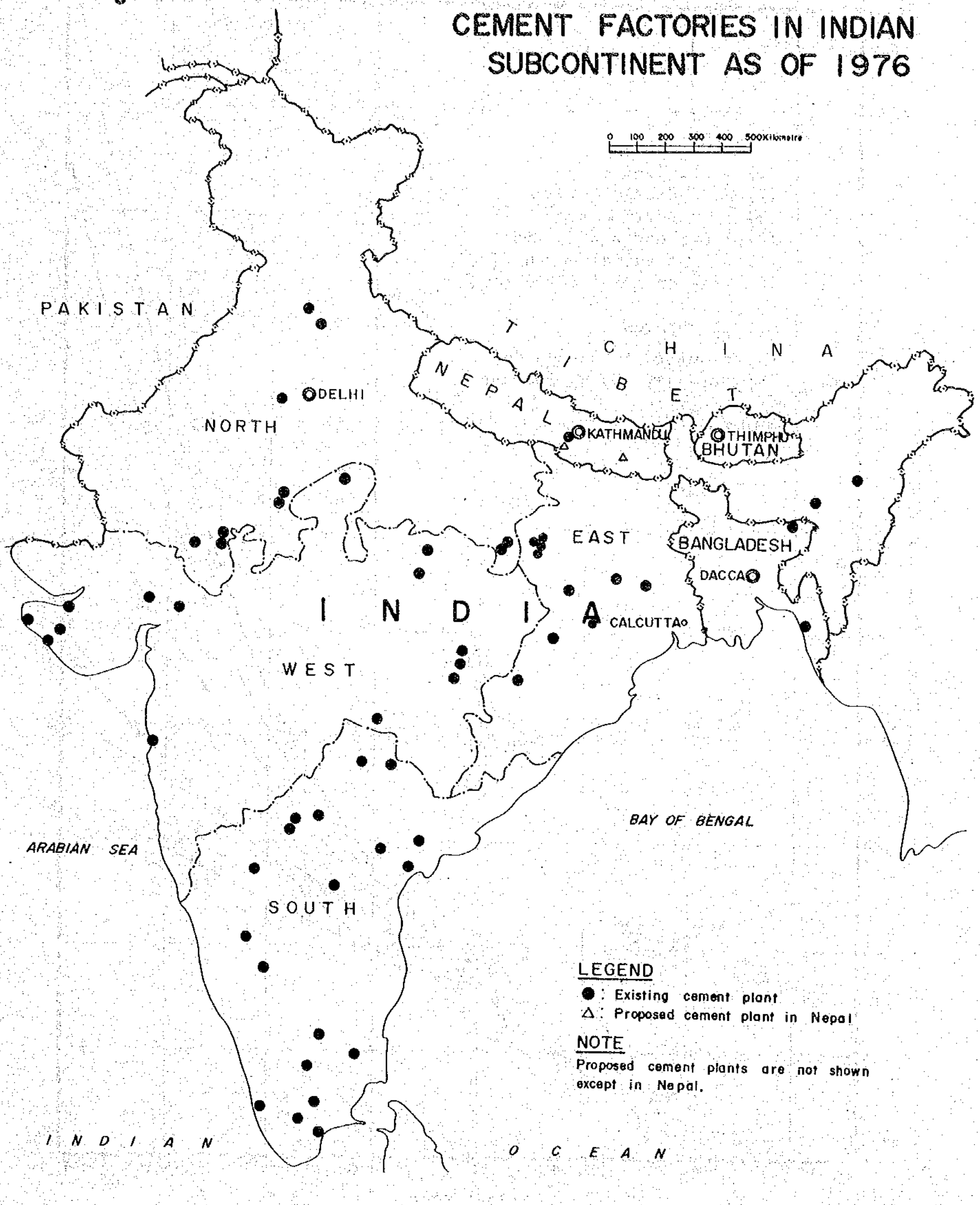


Fig. 2-3-2

CEMENT FACTORIES IN INDIAN SUBCONTINENT AS OF 1976



II-3-3 Actual Condition of Cement Industry in Nepal

The existing cement plant in Nepal is the plant of Himal Cement Co., Ltd. located at Chovar in the suburb of the city of Kathmandu.

Besides, Hetauda Cement Project is now under construction planning.

The outline of both plants are described as follows.

(1) Himal Cement

(i) Name : Himal Cement Co., (Pvt) Ltd.

(ii) Time of starting operation : 1975

(iii) Annual capacity : 48,000 t

Target in 1977/78 : 42,000 t

(iv) Quality of cement (Refer to VII-2.)

Ordinary portland cement

Standard of quality (Indian standard IS 267, 1967)

(v) Raw materials and fuel and their consumption

Limestone and clay : Exploited in the own quarry in the vicinities of the plant

Coke breeze : Products of Durgapur Steel Co., India

Unit consumption

Limestone	: 1,300 kg/t.cement
Clay	: 160 kg/t.cement
Coke breeze	: 160 kg/t.cement (950 ~ 1,000 Kcal/kg.cℓ)
Gypsum	: 60 ~ 70 kg/t.cement
Light diesel oil	: 10 ℓ/t.cement (100 Kcal/kg.cℓ : for drying)

(vi) Main equipment

Raw mill	: Vertical type, capacity 14 t/h
Kiln	: Vertical type, capacity 6.6 ~ 6.7 t/h
Cement mill	: Tube mill, capacity 12 ~ 14 t/h

(vii) Number of personnel about 300

Although the production of the first year was 29,000 t/y which corresponded to about 60 % of the rated capacity, the production has been increased upto 42,000 t/y (target in 1977/78) which corresponds to 88 % of the rated capacity by improving operation ratio supported by a strong demand.

(2) Hetauda cement project

This project is commenced with a loan from Asian Development Bank and is under planning of construction.

(i) Name : Hetauda Cement Industries Ltd.

(ii) Annual capacity : 260,000 t

(iii) Main raw material

Limestone : Bhainse Dobhan deposit

Clay : Lamsure deposit

(iv) Type of process : Dry process with suspension preheater may be adopted.

SECTION III BACKGROUND FOR UDAIPUR CEMENT PLANT

III-1 Nepal's Basic Policy concerning the Udaipur Cement Plant

In February 1974, HMG issued the following six items for the purpose of industrial development in the Fifth Five Year Plan.

(1) Improvements in industrial production and productivity
(2) Creation of employment opportunities to utilize the excess labour engaged in agriculture
(3) Maximum mobilization of local capital, skills and natural resources
(4) Self-reliance in essential consumer goods and construction materials in minimum period
(5) Minimization of regional economic imbalance
(6) Improvement in the balance of payments through increased exports and imports substitution.

Complying with these purposes, in order to make the investment in industrial fields both in public and private sector attractive and encourage them various carefully thought out measures in license system, loan, interest rate, taxes, employment and other facilities has been taken as the development policy.

The priority is given to.

(1) committed industries in the stage of construction
(2) industries producing essential consumer goods and construction materials necessary for developing infrastructure,
(3) industries which utilize local raw material and natural resources, and
(4) minor scale industries except the case a large scale one is required because of technical reasons.

The policy mentioned above seems to aim the extension of industrial sector in the national economy in which agricultural sectors play an overwhelming role.
The plan for establishment of cement plant in Udaipur is very well suited to the six items of purposes described above, and accordingly Nepal's basic policy concerning the Project seems to be based on them.

Concretely speaking, it aims

(1) to mobilize the natural resources in Udaipur district centering around Sindali limestone deposit and Beltar clay deposit,

(2) to utilize labour in neighboring area,

(3) to produce the important construction material necessary for development of infrastructure, namely portland cement,

(4) to accelerate the development of the eastern development region which is behind in development compared with the central development region, and

(5) to improve the international payments by exporting the cement to the neighboring countries such as India and Bangladesh etc. as much as possible.

In order to increase the production capacity of cement in Nepal, the extension of Hetauda Cement plant may be taken into consideration too. However as mentioned above the establishment of cement plant in less developed eastern region is significant and the export of cement to Bangladesh is carried out more advantageously because of its geographical location.

As the limestone deposit is of good quality with few intercalation and therefore can be used as the raw materials of other products than ordinary portland cement, it is advisable to develop the deposit in an early opportunity.

III-2 Positioning of the Establishment of Udaipur Cement Plant in Nepal's Development Policy

Although Sindali limestone deposit was found in the fiscal year 1973/74 in the Fourth Five Year Plan, the detailed investigation including drilling works was carried out in the fiscal year 1975/76 and 1976/77 in the Fifth Five Year Plan.

The detailed investigation of Beltar clay deposit was carried out simultaneously.

The facts that such a large scale investigation was carried out extending over long years only by Nepal show her extraordinary zeal for development of natural resources.

As the feasibility study is under way recently at her request, the implementation of the Project has not been included in the development plan concretely. However it can be said that the expectation for the Project was entertained by whole the country.

On the other hand the expenditure for the industrial development in public sector is 20 ~ 22.4 % in the Fifth Five Year Plan (refer to

Table II-1-1.) in which in addition to hydro-power project the establishment of various industrial plants including portland cement plant and thus her active atitude for the development of industries can be realized. The priority given to the establishment of cement plant is ranked at top except the industries under construction.
(Refer to III-2.)

Besides, the basic industries such as cement industry are given the following incentives.

(1) Exemption of income tax
(For the Project the exemption for more than 18 years can be expected.)
(2) Preferential rates of custom duty for imports of machinery and equipment
(3) Exemption of custom duty for imports of coal
(4) Exemption of custom duty for imports of gypsum
(5) Exemption of excise duty in initial years

(As to the detail of (1) and (5), refer to I-1.)

Although the Project has not been positioned clearly at present, the background which shows the high priority of the Project in the near future can sufficiently be realized.

SECTION IV DEVELOPMENTAL ENVIRONMENT IN UDAIPUR DISTRICT

The main sites of the Project, namely Gaighat, Sindali and Beltar etc. are located in Udaipur district, Sagarmatha zone, Eastern development region in Nepal.

In this section, therefore, the development environment is described centering around Udaipur district.

As for the environmental conditions for the development of Nepal refer to II-2.

IV-1 Natural Conditions

Udaipur district lies to the central south of Sagarmatha zone in the eastern part of Nepal. Gaighat, the proposed plant site for the Project, is located about 20 km south-east of Udaipur Garhi at an altitude of 160 m above sea level.

Gaighat faces the Trijuga river which flows into the Sapta Kosi river. Near Gaighat, the Baruwa river flows into the Trijuga river from the north.

On the south the Siwalik rises to a height of a little less than one thousand meters and separates Udaipur from the Terai region.

On the northwestern side are the hills, where the limestone quarry is located, and on the northeastern side are the hills which range to the south of the Sun Kosi river.

Sindali, where the limestone quarry lies, is located near here upstream on the Trijuga river in the middle of Udaipur Garhi and Gaighat.

Beltar, where the main clay quarry is located, is on the north of the Trijuga river, midway between Gaighat and the confluence where the Trijuga river flows into the Sapta Kosi river.

The Duwar river flows on the west of Beltar to the Trijuga river.

There are no weather stations in Udaipur district but the observed values at Biratnagar Airport are available.

The following is a summary of the data obtained.

(1) Temperature and humidity

The maximum temperature in this region is 32 ~ 34°C (monthly average) late in the dry season (from March to May).

The difference between daytime and night temperature is great and becomes up to 20°C.

In the monsoon season, the maximum temperature is not so high as in the dry season and the temperature difference in a day is small. It is moderate in winter and the monthly average minimum temperature is about 9°C.

It is wet and humid in the monsoon season. Relative humidity ranges from 70 to 95 %. However, in the dry season, it changes to 40 % in the daytime and 100 % at night.
Table 4-1-1 shows the temperature, relative humidity and rainfall shown in the monthly average of Biratnagar Airport and Fig. 4-1-1 shows a typical example of variation of temperature and humidity over a one day period in the monsoon and dry seasons.

(2) Rainfall

Rainfall in Udaipur district varies depending on the local topography. But the observed values at an experimental farm in the neighboring zone, Janakpur, and the data obtained at the towns in the vicinity as shown in Fig. 4-1-2 suggest that the annual rainfall in Gaighat, Sindali and Beltar is around 2,000 mm, a little more than in the Terai region. According to one report, the annual rainfall fluctuates and there is a periodical drought once in every seven or eight years. More than 80 % of the rainfall, as shown in Fig. 4-1-2, is concentrated in the period from June to September.

Heavy lightning occurs continuously over a short period during the monsoon season.

(3) River discharge

Observations of the discharge of the Sun Kosi river have been made. Fig. 4-1-3 shows monthly fluctuation of the discharge. In July and August, the river swells to a volume twenty times that of the latter part of the dry season.

At Gaighat, the Trijuga river swells in summer but does not flood. The depth of water becomes up to 5 meters and people cross the river using boats.
Even in the dry season, it does not dry up.
The Baruwa river, on the other hand, frequently overflows in the rainy season and becomes almost dry in the dry season.
A dam construction plan as a countermeasure against flooding has been proposed.

Fig.4-1-3 Monthly Discharges of the Sun Kosi River

(a) Kampn Ghat (b) Rabuwa Bazar

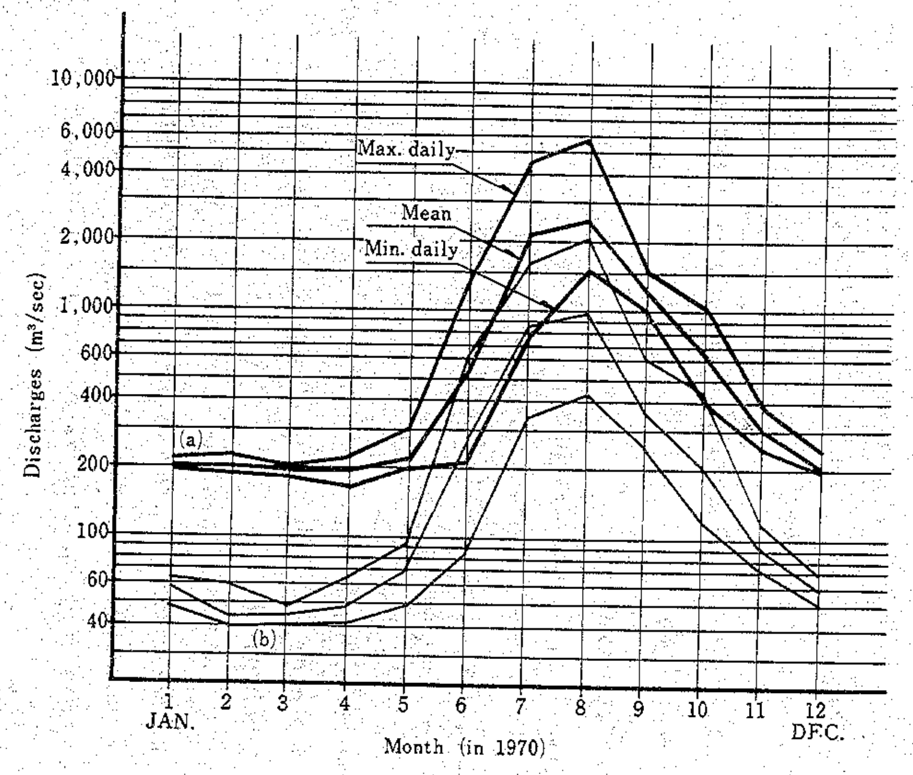


Fig.4-1-1 Typical Hourly Curve for Temperature and Humidity

At Biratnagar Air Port

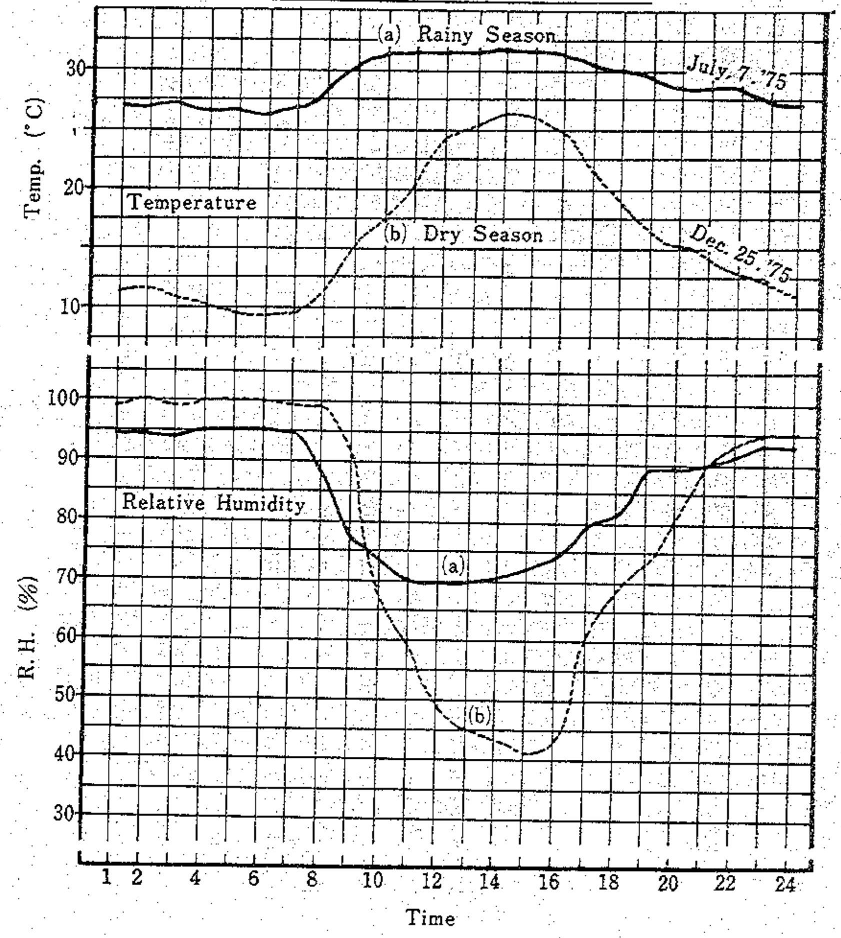


Fig. 4-1-2 RAINFALL IN SAGARMATHA ZONE

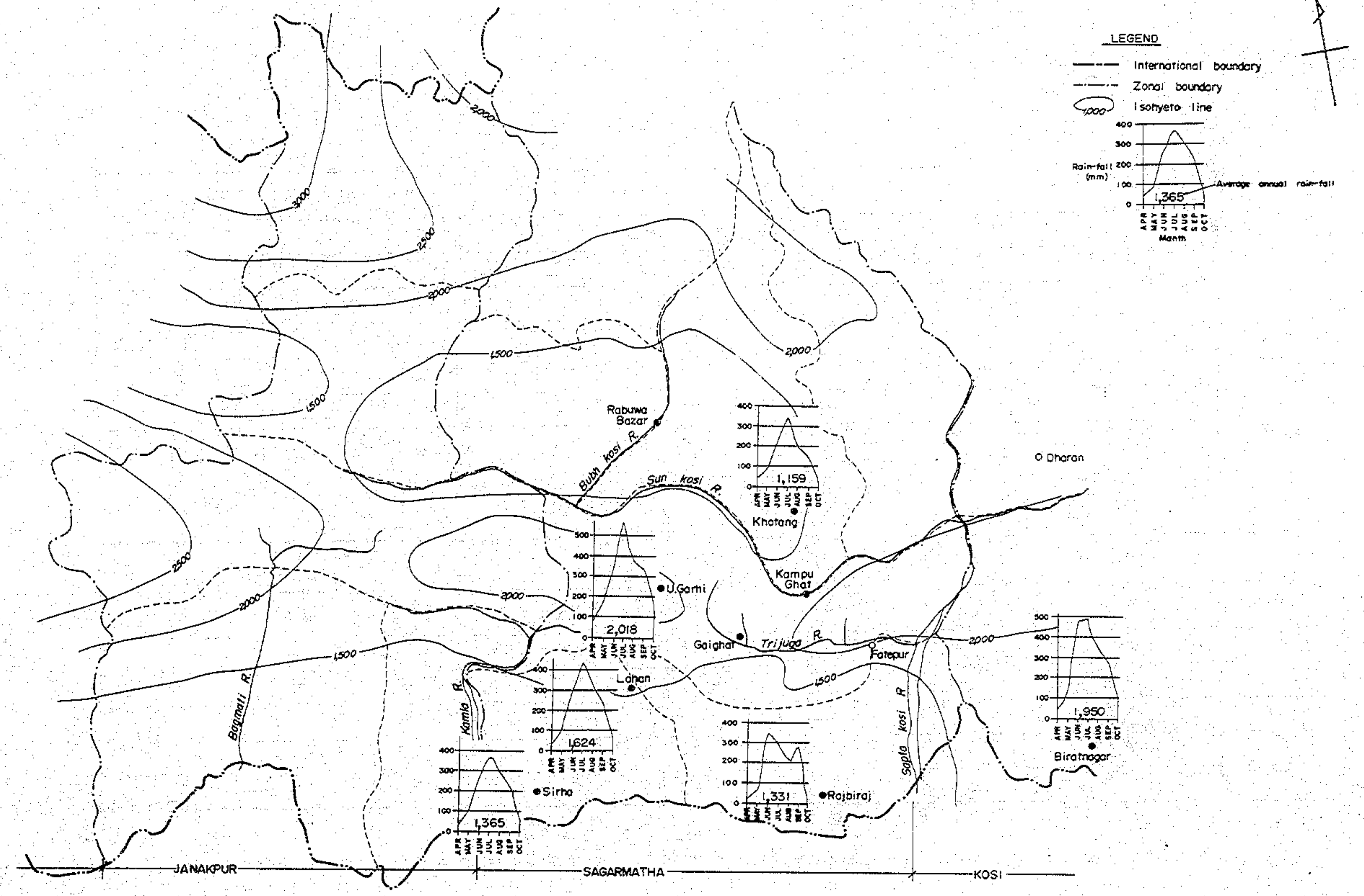


Table 4-1-1 Temperature・Humidity・Rainfall (Monthly Average) at Biratnagar Airport

(Average in 1971 through 1976)

Temperature (°C), R.H. (%), Rainfall (mm)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature	Max.	23.4	25.7	31.4	33.6	32.4	32.0	31.6	31.7	30.8	30.8	28.6	26.8	29.9
	Min.	8.8	10.8	14.7	20.6	23.4	24.8	25.2	25.2	24.2	21.3	14.4	9.0	18.6
R.H.	08 : 40	88	81	63	63	73	85	87	85	84	83	81	87	80
	17 : 40	52	52	38	45	63	73	78	78	79	75	66	62	63
Rainfall	Rainfall	25	11	15	52	130	483	504	355	272	97	6	0	1,950
	No. of rainy days	2	1	2	4	8	17	20	16	14	5	1	0	90

Table 4-1-2 Atmospheric Pressure・Wind Direction・Wind Velocity at Biratnagar Airport

(Average in 1973 through 1976)

Air pressure (m bar), Wind velocity (km/h)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
8 : 40	Air pressure	1,008	1,005	1,003	998	997	993	991	993	998	1,002	1,006	1,008
	Wind velocity	1.5	5.6	7.7	17.8	16.1	11.0	12.2	10.7	10.4	6.2	2.8	1.6
	Wind direction	E	W	E	E	E	E	E	E	E	E	E	E
17 : 40	Air pressure	1,004	1,002	998	994	992	989	988	996	994	997	1,001	1,004
	Wind velocity	4.3	8.1	12.6	12.8	12.6	8.7	9.6	10.4	8.2	5.3	1.8	2.5
	Wind direction	WSW	WSW	W	W	SE	E	E	E	SE	E/W	W	W

As for the Duwar river flowing near the clay quarry, the height of water in the rainy season reaches 3 meters but it is possible to cross the river.

(4) Atmospheric pressure, wind direction and wind velocity

Table 4-1-2 shows the observed values at Biratnagar Airport. Throughout the year, a gentle wind flows from the east (or from the west) and it reaches its maximum late in the dry season.

According to the National Building Code of India - 1970, this district falls into the area where the wind is milder than northern and southern parts of India.

It is recommendable, however, when the Project comes into effect, to continue weather observations for a certain period of time at the plant site proposed, before determining the final plant layout.

(5) Earthquakes

A major earthquake occurred in 1934 and caused a great damage to this district, but no great earthquakes have occurred since 1934.

In the National Building Code of India mentioned above, the eastern region of Nepal is classified into Zone V, the heaviest earthquake zone of the classification in India, but it shows the specified figure in the region is not so great as in Japan.

As yet, there is no National Building Code in Nepal, therefore, the Code of India mentioned above may be applied to the Project.

IV-2 Social Conditions

IV-2-1 Roads Conditions

Since the roads conditions of Udaipur district are described in X-1 centering around the Project, general matters are stated here.

The total length of roads constructed in three zone in eastern development region has reached as long as 952 km in 1978 which corresponds to 23.0 per cent of that of the whole country. The detail is shown Table 4-2-1.

Table 4-2-1 Roads in Different Zones of Eastern Development Region by Classification and Type

(km)

Classification	Zone	Black top	Gravelled	Earth work	Total
Highway	Mechi	54	-	-	54
	Kosi	127	-	-	127
	Sagarmatha	107	-	-	107
Feeder road	Mechi	14	61	70	145
	Kosi	20	2	124	146
	Sagarmatha	62	-	107	169
District road	Mechi	-	11	86	97
	Kosi	-	-	-	-
	Sagarmatha	-	-	50	50
City road	Mechi	3	8	-	11
	Kosi	19	10	5	34
	Sagarmatha	4	5	3	12
Total		410	97	445	952

(Refer to the attached Dwg. C-01 Nepal Road Network)

The existing main roads are the East-west highway which runs through Terai plain of the south and the feeder roads located mainly in the southern side of the East-west highway.

There exist very few roads in the central hilly area and northern mountainous area.

As to the future construction, new East-west highway through the central hilly area and the feeder roads which link this East-west highway to the southern and northern parts of the country.

The topographical survey of the proposed route between Gaighat and Kathauna which is closely related to the Project has been completed.

The number of trucks registered in 1974/75 in Mechi, Kosi and Sagarmatha zone is 139,502 and 63 units respectively and the total is 704 units.

IV-2-2 Labour Conditions in the Vicinity

The population density of the eastern development region and eastern Terai is higher than the country average (refer to II-2-2-(3)) and therefore human resources is not small. In Nepal the migration of population is considerably lively and especially the interchange between Nepal and India is quite a few.

Accordingly the labour necessary for the Project (refer to VIII-2) may be obtained easily in the vicinity.

Since skilled workers and engineers won't be able to be obtained easily, it is necessary to recruit them from the whole country or train them beforehand.

Various statistics on population in Sagarmatha zone and Udaipur district are shown in Table 4-2-2.

Table 4-2-2 Statistics on Population in Sagarmatha Zone and Udaipur District

(1971)

		Sagarmatha zone	Udaipur district
Population	Total	1,313,000(100.0)	112,622(100.0)
	Nepalese	1,308,000(99.6)	112,496(99.9)
	Indian	4,000(0.3)	84(0.07)
	Other	1,000(0.1)	42(0.04)
Average family size (person/house)		5.31	5.49
Population by major industries	Total	518,000(100.0)	50,249(100.0)
	Agriculture etc.	498,000(96.14)	49,274(98.06)
	Services	10,000(1.93)	495(0.99)
	Commerce	6,000(1.15)	284(0.57)
	Manufacturing	3,000(0.58)	175(0.35)
	Others	1,000(0.19)	17(0.03)
Population by religion	Hinduism	1,210,000(92.16)	100,985(89.7)
	Buddhism	66,000(5.03)	11,538(10.2)
	Islamic	37,000(2.82)	179(0.16)
	Other religion	800(0.06)	6(0.01)

Note. The figures in parenthesis show percentage.

Since the above figures were obtained by the census in 1971 those figures seem to have generally increased in 1978.

Table 4-2-2 indicates that population engaged in agriculture is predominantly and in other industries are very few.

IV-2-3 Scale of Towns and Villages

(1) Center of public administration, commerce and traffic (excluding Udaipur district)

The development center of the eastern development region is established in Dhankuta town, Dhankuta district, Kosi zone. The headquarter of Sagarmatha zone is established in Rajbiraj city, Saptari district, Biratnagar, the second largest city in Nepal is situated in the vicinity of Rajbiraj. Both Rajbiraj and Biratnagar are linked to Kathmandu by an air liner.

Besides, as traffic centers there exist the towns such as Itahari, Bharda, Rupani, Kathauna, Lahan, Fathepur etc., and as towns in Indian border Kakarbhitta, Jogbani, Kunauli, Thari and Jayanagar etc. from east to west. (Refer to the attached Dwg. C-01 Nepal Road Network.)

The cities and towns mentioned above seems to play an important role for the implementation of the Project.

(2) Towns and villages in Udaipur district

There are 43 Panchayats in Udaipur district and the headquarter is established in Gaighat.

According to the census in 1971 on the population scale, Panchayats with a population of 1,000 to 4,000 are 39 places, more than 4,000 are 3 places and less than 1,000 is 1 place.

The population of Gaighat, the proposed plant site of the Project is about 8,000 at present and Beltar, neighboring town of the clay deposit is about 3,000 at present.

As the limestone deposit is located in a hilly area, the population in the vicinity is very small and villages such as Sindali etc. are spattered.

The profiles of Gaighat and Beltar are outlined as follows.

(i) Gaighat

Gaighat is located at the upstream of the junction of Trijuga river and Baruwa river.

Since the district headquarter is established in this town most of the buildings belong to the government.

Almost all the inhabitants (95 %) speak Nepali, the rests (5 %) Maithali etc.

Their religion is entirely Hinduism.

In addition to agriculture as the major industry, Gaighat is the commercial center of this area and market is opened once a week.

As public facilities, there are one middle school (students 400), two primary school (students 150 ~ 200), one bank, a couple of restaurants and no hotel.

Neither electricity nor telephone is available.

As medical facilities in addition to a hospital (15 beds) under construction at Bokshe, there exist three dispensaries and two health posts and one doctor and one homeopathy doctor reside at permanently.

Almost all the buildings in the town are made of wood except the hospital.

The traffic facilities available are carts and tractors and the porters are used for mountain path.

Main crops are rice, wheat and oil seeds and there is one rice mill.

(ii) Beltar

Beltar is located to the east of Dwar river.

Although Beltar is a commercial center of this area and market is opened once a week, the main industry is agriculture.

Mother tongues used are Nepali (50 %), Newari (0.5 %) and Maithali (49.5 %). Religion is all Hinduism.

As public facilities, there are one primary school (students 225), one high school (students 47), a couple of restaurants and no hotel.

Neither electricity nor telephone is available.

As medical facilities there exist one health post and one dispensary.

All the buildings are made of wood.

The traffic facilities available are carts and tractors and the porters are used for mountain path.

Main crops are maize, oil seeds, rice, wheat and jute and there is no rice mill.

IV-2-4 Lodging Facilities • Medical Facilities • Diseases

(1) Lodging facilities

In Biratnagar and Rajabiraji which are linked by an air liner there exist small hotels.

In other small towns cheap rooming houses serving as restaurant are rarely found.

Sometimes a guest houses are available in the towns where the governmental organization is established.

No hotel is available in Udaipur district.

(2) Medical facilities

As for Udaipur district refer to IV-2-3.

The number of doctors in the eastern development center is 42 and population per doctor is 72,000.

(3) Diseases

Diseases in Udaipur district are Cholera (April ~ June), Maleria (much decreased recently), Typhaid (March ~ May) and Chicken pox etc. and common diseases such as stomach trouble are not rare.

IV-2-5 Languages

The languages used and their population in Sagarmatha zone and Udaipur district are shown in Table 4-2-3.

Table 4-2-3 Languages used in Sagarmatha Zone and Udaipur District

(1971)

	Sagarmatha zone		Udaipur district	
	Population	%	Population	%
Total population	1,313,480	100.00	112,622	100.00
Nepali	478,791	36.45	56,515	50.18
Maithali	575,176	43.79	15,034	13.35
Bhojpur	131	0.01	-	-
Tamang	28,058	2.14	6,724	5.97
Abadhi	81	0.01	-	-
Tharu	67	0.01	3	0.00
Newari	15,674	1.19	1,850	1.64
Rai Kirati	126,532	9.63	14,506	12.88
Gurung	1,118	0.09	97	0.09
Limbu	83	0.01	27	0.02
Bhote Sherpa	25,198	1.92	189	0.17
Rajbansi	8	0.00	-	-
Satar	551	0.04	1	0.00
Sunuwar	3,943	0.30	167	0.15
Santhali	1,365	0.10	-	-
Magar	-	-	15,684	13.93
Danuwar	-	-	1,083	0.96
Local Languages	20,827	1.59	665	0.59
Other Languages	4,577	0.35	77	0.07

More than ten languages are used both in Sagarmatha zone and Udaipur district. Nepali population is comparatively small and on the other hand the population of Maithali, Rai Kirati and Magar etc. are considerable. Proportion of languages seems to vary from place to place.
The rate of illiterate in Sagarmatha zone and Udaipur district is 87.5% and 89.6 % respectively, by sex for male 87.7 % and 90.6 % respectively and for female 97.3 % and 98.6 % respectively.

SECTION V ASSESSMENT OF RAW MATERIALS (RAW MATERIALS SITUATION)

The reserves and quality of the raw material deposits are important factors to decide the scale and process of a cement plant for its new establishment. Accordingly, taking account of those factors, geological survey was carried out to understand fully the reserves, quality and nature of the raw materials for the Project.

Since the survey of the main raw material deposits, i.e., limestone, clay and siliceous material had been performed by engineers of Department of Mines and Geology, Nepal (hereinafter called DMG) and, therefore, the proposed areas to be exploited had been narrowed down.

Our survey was carried out to confirm the data obtained so far by DMG, and each raw material deposit was assessed further.

According to our schedule with which the geological survey team should grasp the quality and quantity of the limestone deposit at site prior to the dispatch of the main team, 105 pieces of grab-sample collected from the proposed limestone deposit were analyzed chemically, and geological survey was carried out to delineate the boundary of the limestone deposit. As a result, the Sindali limestone deposit, was found to be suitable for the cement raw material. After this interim conclusion, the main technoeconomic team was dispatched in succession immediately to Nepal to perform the feasibility study other than the raw material deposit investigation.

The outline of works on raw materials carried out in Nepal are described as follows.

(1) Confirmation of geological investigation conducted by DMG of each raw material deposit.

(2) Further preparation of a geological map of the limestone deposit.

(3) Additional sampling work of the raw materials.

(4) Advice on one additional drilling at the limestone deposit.

(5) Planning and supervision of 103 additional the test-pitting at the clay deposit.

(6) Studying of all drilling cores.

(7) Chemical analysis

(i) Chemical analysis of CaO and MgO of 105 pieces of limestone grab samples.

(ii) Moisture content in limestone and clay samples.

(8) Study on mining and transportation method of raw materials.

The results of the studies on raw materials are stated hereinafter.

V-1 Geological Investigation

V-1-1 Outline of Geology of Udaipur District

General geology of Sindali - Murkuchi - Gaighat - Beltar area, and the relation between the geology and the cement raw materials are described in this section before describing the detail of each deposit.

The description on this section was made on the basis of "Geological Map of Udaipur - Diktel District, authored by senior Mineral Engineer of DMG, Mr. N.B. Kayastha", "Geology of the Himalayas, authored by Mr. A. Gansser" and "the result of our survey".

The geology of Udaipur district is stratigraphically understood as shown in Table 5-1-1. Namely, in this district, the formations are classified in descending order, into : Quaternary formation, Tertiary Siwalik formation, Cambrian Rasuwa formation of the Paleozoic Era and Pre-Cambrian Trijuga formation. The relation among these formations is understood as follows :

The Main Boundary Fault (hereinafter called MBF), which is a reverse fault (thrust) caused by Himalayan orogenic movement, separates the Terriary Siwaliks from the Pre-Tertiaries. The general trend is east-west, the fault plane dips northerly. The Pre-Tertiaries are in principle metamorphosed by regional metamorphism.

The Rasuwa formation and the Trijuga formation distribute broadly in the northern area of MBF, and their general trends are approximately east-west, dipping northerly.

In Sindali area, their general trends are NW and the formations dips northerly.

Across the formations mentioned above, Trijuga river and its tributaries such as Baruwa river and Babiya river etc. are developed.

Sand, gravel and clay were transported by water of those rivers and deposited discordantly on the Tertiary Siwaliks at the low land.

Table 5-1-1 Stratigraphy of Udaipur District

Formation name	Geological age	Layer	Cement raw material
	Quaternary	(8) Sand, gravel and clay	Sand : Siliceous material Clay : Argillaceous material
Unconformity			
Siwalik formation	Tertiary	(7) Upper : mainly conglomerate (6) Middle : mainly sandstone (5) Lower : mainly alternation of sandstone and mudstone	
Thrust (MBF)			
Rasuwa formation	Cambrian Period, Paleozoic Era	(4) Schist and quartzite	
Trijuga formation	Pre-Cambrian	(3) Upper : Limestone and dolomite (2) Middle : Phyllite and quartzite (1) Lower : Dolomite and shale	Limestone : Calcareous material

Note :

The classification of the Siwaliks by Mr. A. Gansser seems to differ from that of Mr. N.B. Kayastha in the viewpoint of geological understanding.

In this report, Mr. A. Gansser's theory was adopted.

V-1-2 Sindali Limestone Deposit

(1) History of investigation and survey method

In accordance with the program of Nepal Bureau of Mines (hereinafter called NBM, which is the previous name of Department of Mines and Geology) to explore the potentiality of the limestone in Mahabharat range extending almost from east to west during the Fourth Five Years Plan, Mr. Umesh Jha, senior mining engineer, discovered chemical grade limestone in Tawa Khola and its tributaries in Udaipur district of Sagarmatha zone in the fiscal year 1972 - 1973.

In the fiscal year 1973 - 1974 one exploration trip was undertaken to find out if there is any sizeable deposit in and around Tawa Khola and further eastern area of known occurrence for detailed exploration work to be undertaken.

In the course of this investigation, a sizeable deposit of high grade limestone was discovered in Sindali in the eastern part of Udaipur district by Mr. G.R. Manandhar and his party. This deposit is on the upper stream of Trijuga river and its branches.

In the fiscal year 1974 - 1975, systematic channel sampling was done in Sindali together with topographical surveying and mapping. The result of chemical analysis of these samples was favourable. In the fiscal years 1975 - 1977 drilling works were carried out in Sindali by the parties of Mr. D.B. Khattri and Mr. U. Jha. The result of chemical analysis of the core samples collected was also good.

The present detailed survey was executed by experts of JICA with regards to the geological investigation, mining and transportation methods in co-operation with experts of DMG.

On the other hand, chemical analysis and physical test of the samples collected from the field and the drilling cores were performed in the laboratories, both in the field and Tokyo as a check analysis. Otherwise all the chemical analysis were performed in the laboratory of DMG.

The amount and method of survey executed by DMG (NBM) and JICA are shown as below :

- Previous survey by DMG (NBM)
  1. Area explored and mapped : 113 ha. (Scale 1 : 1,000)
  2. Trenches excavated : 73 m
  3. Drilling holes : 22 holes (Total length 1,672.7 m) (Interval of holes : approx. 150 m)

4. Samples (for chemical analysis)

Surface	:	456 pieces
Drilling holes	:	446 pieces

- Survey by JICA in co-operation with DMG

1. Area surveyed geologically	:	Approx. 100 ha (Scale 1 : 1,000)
2. Test-pits dug	:	2 pits
3. Drilling hole (additional hole)	:	1 hole (91.50 m depth)

Note :

Actual drilling work was done by DMG on JICA's advice.

4. Samples

Surface	:	261 pieces, out of which 133 pieces were analyzed.
Drilling hole	:	22 pieces, all the samples were analyzed.

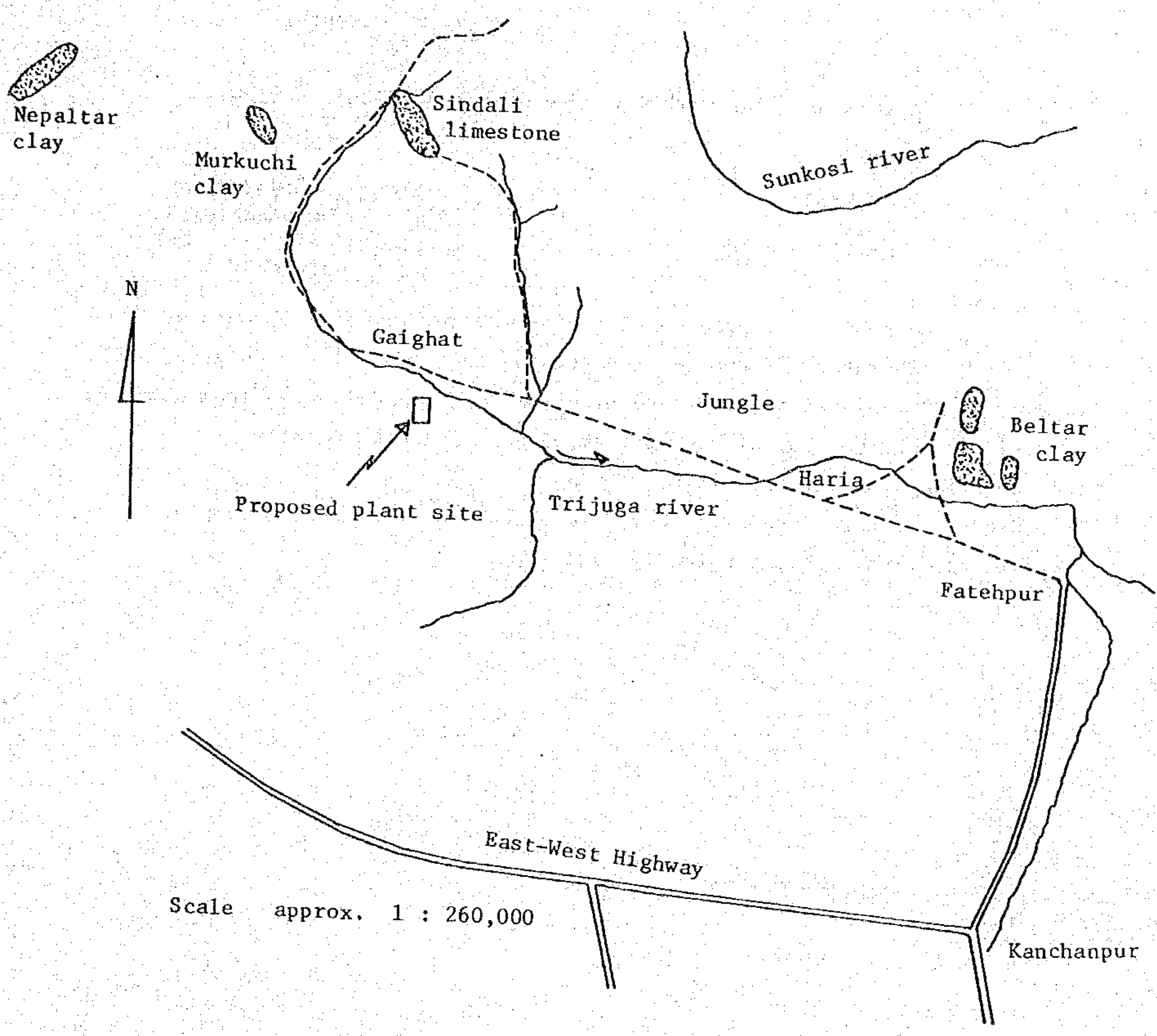
Note :

1. Composite powdered samples of BH-10 and 16 were obtained at the laboratory of DMG for re-studying the chemical composition.
2. 261 pieces of limestone grab-samples were collected from surface, and then 133 pieces of them were analyzed chemically.

(2) Location and accessibility

Sindali limestone deposit occurs in Sindali on the upper stream of Trijuga river, as shown in Fig. 5-1-1.

Fig. 5-1-1 Location Map or Raw Material Deposits



Approach to Gaighat from Kanchanpur on the East-west highway is as follows :

Kanchanpur $\frac{\text{Paved road}}{\text{14 km}}$ Fatehpur $\frac{\text{Seasonal road}}{\text{31 km}}$ Gaighat

It takes about 2 hours by jeep on the seasonal road from Fatehpur to Gaighat. This seasonal road runs along Trijuga river and old river bed, and crosses the tributaries and main stream of Trijuga river at about 10 places. The surface of the road is covered with sand and gravel.

There are two routes to approach to the limestone deposit from Gaighat. One is in the following manner :

Jeep is available for first 2 km to the north-north-west from Gaighat along Baruwa river, after that a foot path continues for a distance of about 6.4 km along the river, then further to the north-west for a distance of about 11 km up to the deposit on the slope of the mountain.

Another is as follows :

Jeep is available for first 11 km to the west-northwest from Gaighat along Trijuga river, after that foot path continues for a distance of about 11 km to the north then north-north-east along the river up to Murkuchi, and further continues to the north-east for a distance of about 3 km up to the deposit on the slope of the mountain.

In other word, Sindali is located about 14 km to the north-northwest of Gaighat in a straight line.

The distance between Sindali limestone deposit and the proposed plant site at Gaighat is also about 14 km in a straight line.

Quarrying and transportation of the limestone are studied in V-2.

(3) Topography and vegetation

In the area surveyed, the limestone deposit distributes broadly on the eastern slope of the ridge with NNW - SSE direction.

The limestone deposit (including dolomite layer) occurs approximately along the slope plane, therefore, the deposit occupies extensively over the slope notwithstanding that the formation is actually not so thick.

The lowest level in the area is at an altitude of about 500 m in the northern area along the upper stream of Trijuga river.

On the other hand, the highest point in the area is an altitude of about 910 m in the southern ridge. Accordingly, the elevation in this area is maximum about 410 m.

Generally speaking, the slope angle in the area composed of the deposit gives about 25 to 40 degrees from horizontal plane.

However, there are cliffs and nearly vertical slopes locally, especially many inaccessible cliffs exist to the north-western area of the line connecting between BH-18 and BH-19.

There is extensive thick talus mainly composed of limestone boulders on the foot of the east-northern slope facing Trijuga river.

There exist cultivated lands in the southern area with gentle slope covered with thick top-soil. Although the rest area is covered by scattered bushes with medium dense forest, prominent exposures and boulders are found easily.

The boundery line between the deposit and the schist quartzite member exists nearly on the valley line in the eastern and east-northern area.

(4) Geology and deposit

The formations recognized in Sindali are classified, in ascending order, into : Trijuga formation belonging to the Pre-Cambrian Period and Rasuma formation belonging to the Cambrian Period of the Paleozoic Era. Trijuga formation broadly comprises the phyllite and quartzite in the middle horizon and the limestone and dolomite in the upper horizon. General strike of these formations is NW and dip is to the north. The detailed description of each formation is as follows :

(i) Trijuga formation (Pre-Cambrian Period)

(a) Phyllite and quartzite member

This member which underlies the limestone and dolomite consists chiefly of muscovite phyllite coloured in dark or light grey, chlorite phyllite coloured in light bluish grey to pale greenish grey and quartzite. Phyllite is generally weathered into brownish colour on the surface.

According to the result of the drilling, the graphite - muscovite phillites coloured in greyish black are recognized in some drilling holes at the contact zone with the limestone and dolomite. This fact suggests the existence of possible fault between the phyllite, quartzite member and the limestone, dolomite member.

However judging from the surrounding geological conditions, the existence of this carboniferous phyllite is not the sure evidence for the fault plane.

This member has a general trend of N 50° ~ 60°W, dipping to the north about 20° in the southern area. But in the western area, the strike varies from N 30°E to N 30°W and the dip is about 30° to the east. In the extreme northern area, facing Trijuga river, the strike is N 5°E and the dip is steeper i.e., 70° to the east, as shown in the attached drawings (G-03 to 17).

(b) Limestone and dolomite member

This member which overlies the phyllite and quartzite member is chiefly composed of the limestone and dolomite. The thickness of this member reached as thick as maximum 110 m in the central area, and the maximum width of its distribution is 460 m.
This member extends about 1,500 m in the direction of the north-south.
At some-places, the limestone occurs in the form of isolated lenses in schist. The thickness of this member varies under the influence of the topographical feature. The present topography was formed by continuous erosion after orogenic movement, accordingly in the area strongly eroded, its thickness is naturally reduced. On the contrary, in the area weakly eroded, its thickness increases comparatively.
On the other hand, its original thickness must be variable depending upon the sedimentary circumstance.
Therefore, the present thickness is considered to be formed under the influence of the erosion in addition to the variation of the primary thickness.

Generally describing, the lower part is mainly composed of the limestone, and the upper is of the dolomite.
Strictly describing, the dolomite distributes broadly in the upper portion of the southern area with the maximum width of 460 m and with the maximum thickness of about 25 m. The continuous extension is of about 900 m in the direction of the north-south.
This dolomite layer thinns out to the north and terminates. This dolomite layer is intercalated with the lenticular limestone.
There are other lenticular dolomites at places with thickness of 1.5 to 15 m than the main dolomite layer. These lenses of the dolomite occur in principle in the higher portion, i.e., along the western ridge.
There exist other lenses of the dolomite on the slope of the mountain. These dolomites occur chiefly around the area of BH-7 to 10, BH-15 and BH-20. The geological structure around BH-20 is complicated influenced by NE system faults, accordingly the

dolomite thickens up to maximum 40 m at some places.

In the lithological point of view, the limestone is hard, medium to coarse grained crystalline in texture and is predominently dark grey with bluish shade but some varieties such as limestone with calcite veinlet, with carbonaceous black band, with schistosity rich in muscovite, etc. are recognized.
The limestone is classified into the bedded limestone and the massive, but well-bedded limestone occurs rarely.
The dolomite is hard, fine grained in texture, as compared with the limestone texture, and is light or dark grey. The dolomite is highly jointed and friable in nature probably due to the faults at places.
The dolomite can be easily distinguished from the limestone by its typical elephant hide weathering on the outcrops.

In the viewpoint of the geological structure, the general trend of this member is N40° to 60°W, and dipping 20° to 60° to the north-east. But, exceptionally, in the northern area, the layer dips steeper i.e. 70° to the north-east.
At some places, its strike and dip vary irregularly due to the fault and folding. And there are locally brecciated zone caused by fault and rare large fissures. As mentioned above, the geological structure of the northern area is disturbed to some extent.
The thick talus belonging to the Quaternary, which is composed of the limestone boulders, distributes on the northern foot of the mountain facing Trijuga river.
The boulders of the gneiss are also recognized in the limited area on the slope.

(ii) Rasuwa formation (Cambrian Period)
This member which overlies stratigraphically the limestone and dolomite mentioned above chiefly consists of garnet - muscovite - quartz - biotite schist, quartz - feldspar - biotite schist, both coloured in dark to blackish grey, and quartzite.
The schist is generally weathered into light brown on surface.
The grade of metamorphism varies to some extent, accordingly the schist contains phyllitic schist of the lower metamorphic grade.

The general trend of this member is N20° ~ 50°W, and the layer dips 30° ~ 60° to the northeast.

This member in general occurs in the eastern area of the valley existing at the eastern limit of the deposit. However, in the area around BH-11, this member occurs as the overburden of the deposit.

And the top-soil of the deposit contains the fragments of the schist and quartzite, especially in the southern area.

(5) Drilling

The drilling work was done by DMG at 22 points prior to JICA's survey. Judging from the result of 22 drilling holes and the present geological survey, it was difficult to understand the geological structure of the area around B-11. So a drilling hole and 2 test-pits were made by DMG upon JICA's request in the area around BH-11 where many fragments of the schist and quartzite were scattered on the surface.

As a result of this survey, the geology of this area was almost completely comprehended.

As shown in Table 5-1-2, the direction of all the drilling holes was 220° (S 40°W) that means approximately a right angle to the strike of the layer. Most of the drilling holes were penetrated at 60 degrees to the horizontal plane. A drilling hole with the gentlest angle is 25 degrees at BH-17.

The highest core recovery was 93.51 % in BH-3 and the lowest was 72.65 % in BH-22. The poor core recovery is mainly due to friability of the limestone.

22 drilling holes were made over a grid spacing of approximately 150 m, and an additional one is located close to BH-11.

The result of chemical analysis on cores performed both by DMG and JICA is shown in V-3.

(6) Reserves

The reserves of the limestone and dolomite and the quantity of the waste were calculated based on the result of the present and previous survey under the following conditions.

The map and sections for calculation are shown in the attached drawings (G-01 ~ G-17).

(i) Basic condition for calculation

(a) The area calculated : approx. 51.2 ha

(b) The map used for : 1 : 1,000 topographic map

(c) The area calculated was divided into 3 blocks, namely block A, B

Table 5-1-2 Result of Drilling

Drilling hole No.	Height (m)	Direction	Angle from horizontal plane	Depth drilled (m)	Thickness of top-soil and/ or weathered rock (m)	Recovery ratio (%)
BH-1	856.82	220°	63°	49.95	9.15	89.33
2	797.45	220°	60°	61.75	4.55	86.19
3	877.23	220°	60°	59.55	0	93.51
4	811.62	220°	60°	74.65	11.00	91.64
5	731.08	220°	60°	58.45	0	75.27
6	879.30	220°	60°	49.60	3.30	92.16
7	776.22	220°	60°	48.00	0	75.10
8	686.72	220°	60°	56.55	0	81.48
9	859.32	220°	60°	53.00	0	92.83
10	767.2	220°	60°	69.35	0	92.35
11	699.8	220°	60°	97.85	2.50	73.88
12	830.2	220°	60°	76.50	0	93.30
13	748.6	220°	60°	106.20	0	93.35
14	621.4	220°	60°	119.20	10.70	84.96
15	775.6	220°	60°	65.85	3.40	80.87
16	675.2	220°	45°	67.60	0	92.96
17	546.8	220°	25°	140.30	17.00	72.79
18	674.5	220°	45°	35.65	0	88.85
19	566.3	220°	55°	99.80	0	76.67
20	646.6	220°	40°	97.30	3.40	87.10
21	547.3	220°	55°	102.20	7.40	80.51
22	520.9	220°	45°	83.85	0.60	72.65
23		220°	60°	91.50	6.15	98.41
Total				1764.15		

Notes :

(1) The recovery ratio of BH-1 to 10 shows the average value of overall cores.

(2) The recovery ratio of BH-11 to 23 shows the average value of the limestone and dolomite, excluding the foot wall.

and C, then the reserves were calculated respectively.

(d) Final angle of faces in the proposed quarry : assumed to be 55 degrees to the horizontal plane.

(e) The angle of the boundary plane between block A and B for calculation : 55° to the horizontal plane, toward block A.
The angle of the boundary plane between block A and C : 90° to the horizontal plane.

(f) The proposed mining level :
Area of section No. 1 to 15 : S.L. 500 m
Area of section No. 16 to 28 : Trijuga river level

(g) The vertical cross section : 50 m interval
Section area of each section was calculated as shown in Table 5-1-4.
Formula used : Simpson's Formula

- In case section number is odd.

$$V = \frac{L}{3}\{a_1 + a_n + 4 \times (a_2 + a_4 + ---) + 2 \times (a_3 + a_5 + ---)\}$$

- In case section number is even.

$$V = \frac{L}{3}\{a_1 + a_{n-1} + 4 \times (a_2 + a_4 + ---) + 2 \times (a_3 + a_5 + ---)\}$$

$$+ \frac{1}{2} \times (a_{n-1} + a_n) \times L$$

where

V : whole volume (m^3)
L : interval between each vertical section (m)
a_1 : area of cross section (m^2)

Note :
The volume of the dolomite intercalation in block B was calculated as follows :
Volume (m^3) = sectional area (m^2) x 50 m (elongation)

(h) Apparent specific gravity
both of limestone and dolomite : 2.7

(i) Safety ratio for the accuracy of the survey and calculation : 0.95
Reserves calculated mean the proved reserves.

(j) The volume of the top-soil and the schist overburden was estimated based on the result of the field survey and drilling as follows :
Volume (m^3) = Σ grid area (100 m x 100 m) x estimated thickness for each grid
(Rf : attached drawing G-18)

The result of the calculation is shown in Table 5-1-3.

Table 5-1-3 Reserves of Limestone and Dolomite, and Volume of Top-Soil (including schist)

Block	Area (m^2)	Reserves of limestone (t)	Reserves of dolomite overburden (t)	Reserves of dolomite intercalation (t)	Volume of top-soil and schist overburden (m^3)	Average thickness of overburden (m)
A	372,620	57,710,000	830,000		720,000	2.1
B	84,120	10,330,000	2,120,000 (including limestone of 140,000 t)	180,000	400,000	3.8
C	55,870	5,500,000	1,130,000		100,000	1.7
Total	512,610	73,540,000	4,260,000 (including limestone of 140,000 t)		1,220,000	Average 2.3

(ii) Calculation (Rf. Table 5-1-4)

- Block A

1. Limestone

Whole volume $V_{A-L} = \frac{50}{3}\{a_1 + a_{23} + 4 \times (a_2 + a_4 + a_6 + a_8 + a_{10} + a_{12} + a_{14} + a_{16} + a_{18} + a_{20} + a_{22}) + 2 \times (a_3 + a_5 + a_7 + a_9 + a_{11} + a_{13} + a_{15} + a_{17} + a_{19} + a_{21})\}$

$= 23,151,250\ (m^3)$

Volume of the overburden covering limestone $V'_{A-L} = 651,370\ (m^3)$

Reserves $M_{A-L} = (V_{A-L} - V'_{A-L}) \times 2.7 \times 0.95$

$= 57,712,190 \fallingdotseq 57,710,000\ (t)$

2. Dolomite (intercalated and covering)

Whole volume $V_{A-D} = \frac{50}{3}\{a_5 + a_{23} + 4 \times (a_6 + a_8 + a_{10} + a_{12} + a_{14} + a_{16} + a_{18} + a_{20} + a_{22}) + 2 \times (a_7 + a_9 + a_{11} + a_{13} + a_{15} + a_{17} + a_{19} + a_{21})\}$

$= 395,410\ (m^3)$

Volume of the overburden covering dolomite $V'_{A-D} = 71,200\ (m^3)$

Reserves $M_{A-D} = (V_{A-D} - V'_{A-D}) \times 2.7 \times 0.95$

$= 831,590 \fallingdotseq 830,000\ (t)$

- Block B

1. Limestone (Almost all the deposit are covered with dolomite.)

Whole volume $V_{B-L} = \frac{50}{3} \{a_1 + a_{11} + 4 \times (a_2 + a_4 + a_6 + a_8 + a_{10}) + 2 \times (a_3 + a_5 + a_7 + a_9)\} + \frac{50}{2} \times (a_{11} + a_{12})$

$= 4{,}028{,}300\ (m^3)$

Reserves $M_{B-L} = V_{B-L} \times 2.7 \times 0.95$

$= 10{,}332{,}580 \fallingdotseq 10{,}330{,}000\ (t)$

2. Dolomite (covering limestone)

Whole volume $V_{B-D} = \frac{50}{3} \{a_1 + a_{11} + 4 \times (a_2 + a_4 + a_6 + a_8 + a_{10}) + 2 \times (a_3 + a_5 + a_7 + a_9)\} + \frac{50}{2} \times (a_{11} + a_{12})$

$= 1{,}229{,}130\ (m^3)$

Volume of the overburden $V'_{B-D} = 402{,}820\ (m^3)$

Reserves $M_{B-D} = (V_{B-D} - V'_{B-D}) \times 2.7 \times 0.95$

$= 2{,}119{,}480 = 2{,}120{,}000\ (t)$

Note :

This reserves include the reserves of limestone intercalation as calculated below :

Limestone reserves $M'_{B-L} = \frac{50}{3} \{[a_3] + [a_9] + 4 \times ([a_4] + [a_6] + [a_8]) + 2 \times ([a_5] + [a_7]\} \times 2.7 \times 0.95 = 142{,}140 \fallingdotseq 140{,}000\ (t)$

Accordingly, strictly describing, 2,120,000 ton mentioned above is divided into dolomite of 1,980,000 t and limestone of 140,000 t.

3. Dolomite (intercalated)

Reserves $M'_{B-D} = \{(a_3 \times 50) + (a_6 \times 50)\} \times 2.7 \times 0.95$

$= 179{,}550 \fallingdotseq 180{,}000\ (t)$

- Block C

1. Limestone

Whole volume $V_{C-L} = \frac{50}{3} \{a_{23} + a_{27} + 4 \times (a_{24} + a_{26}) + 2 \times a_{25}\} + \frac{50}{2} \times (a_{27} + a_{28})$

$= 2{,}232{,}060\ (m^3)$

Volume of the overburden covering limestone $V'_{C-L} = 84{,}970\ (m^3)$

Reserves $M_{C-L} = (V_{C-L} - V'_{C-L}) \times 2.7 \times 0.95$

$= 5,507,280 \doteqdot 5,500,000$ (t)

2. Dolomite (intercalated and covering)

Whole volume $V_{C-D} = \frac{50}{3} \{a_{23} + a_{27} + 4 \times (a_{24} + a_{26}) + 2 \times a_{25}\} + \frac{50}{2} \times (a_{27} + a_{28})$

$= 458,330$ (m^3)

Volume of the overburden $V'_{C-D} = 14,620$ (m^3)

Reserves $M_{C-D} = (V_{C-D} - V'_{C-D}) \times 2.7 \times 0.95$

$= 1,138,110 \doteqdot 1,130,000$ (t)

Table 5-1-4 Sectional Area for Reserves Calculation

Section No.	Block A (m^2)		Block B (m^2)			Block C (m^2)	
	Limestone	Dolomite	Limestone	Dolomite* (covering)	Dolomite (inter-calated)	Limestone	Dolomite
1	650		1,675	525			
2	100		6,450	1,800			
3	1,225		6,675	[25]3,125	600		
4	2,300		11,450	[75]1,875			
5	4,675		12,750	[200]3,475			
6	9,275	300	9,850	2,900	800		
7	13,175	150	6,575	[1,050]3,800			
8	13,375	0	9,675	[125]3,800			
9	13,300	100	7,575	3,200			
10	29,925	750	2,625	475			
11	30,925	525	2,300	700			
12	32,550	1,700	2,800	[75] 1,225			
13	44,550	1,300					
14	52,600	925					
15	53,700	675					
16	41,150	25					
17	31,150	975					
18	22,150	125					
19	16,400	75					
20	15,575	0					
21	11,900	25					
22	12,825	125					
23	19,125	275				19,125	275
24						10,675	6,400
25						9,125	125
26						6,350	0
27						4,550	550
28						1,100	25

* The figures in parenthesis [ ] are included in the corresponding figures without parenthesis respectively and mean the area of limestone included in the dolomite covering.

(iii) Explanation of reserves

(a) This deposit is classified into three blocks, namely block A (37.2 ha) which is the main limestone deposit, block B (8.4 ha) in which the limestone layer underlies the dolomite layer having thickness of maximum 25 m, and block C (5.6 ha) in which the dolomite occurs rather irregularly in and on the limestone layer due to the disturbed geological structure.
The area occupying the deposit amounts to approximately* 51.2 ha. This deposit crosses the Trijuga river in the extreme northern area surveyed and still extends to the northeast.

(b) In block A, the limestone reserves are about 57,700,000 t excluding the dolomite overburden and intercalation of about 800,000 t.
The dolomite occurs in the form of bed and/or lense in the limestone layer. Judging from the dolomite occurrence, selective mining is easy in this case. The average thickness of the top-soil overburden including the schist overburden in part is estimated to be about 2.1 m and its volume to be removed before mining amounts to about 720,000 m^3 in block A.

(c) In block B, adjacent to the eastern limit of block A in the direction of the north-south, the dolomite layer having thickness of maximum 25 m overlies the limestone. The reserves of underlying limestone is 10,300,000 t, and overlying dolomite is 2,100,000 t in amount which includes the limestone lenses of 140,000 t.
And the dolomite intercalation in the underlying limestone mentioned above is 180,000 t in amount. The average thickness of the top-soil overburden is estimated to be about 3.8 m and its volume is calculated to be about 400,000 m^3 in block B.

(d) In block C, to the north of block A, the limestone reserves amount to about 5,500,000 t.
The selective mining is supposed to be little difficult since the dolomite appears rather irregularly due to the disturbance of the geological structure effected by faults.
The dolomite reserves are 1,130,000 t in block C.
The average thickness of the top-soil overburden is estimated to be 1.7 m and its volume amount to about 100,000 m^3 in block C.

(e) The total amount of the limestone, dolomite and overburden (waste) in this deposit is about 73,500,000 t, about 4,200,000 t including limestone of 140,000 t and about 1,200,000 m^3 respectively.

(f) The limestone in block A is the most favourable from the mining, geological and quality points of view.
Some parts of the deposit in block B and C should also be mined with economical method.
The mineable reserves are calculated to be about 51,400,000 t in case economical recovery ratio is assumed to be 70 percentage all over the whole reserves.

(g) The reserves mentioned in this section are proved reserves.

(h) For the reference, the dolomite covering the limestone in block B is prospective for other industrial uses.
The waste dolomite for cement plant is also of utility value for other industries.

(i) In general, the top-soil covering the deposit contains the fragments of schist, quartzite and muscovite flakes.
This top-soil is considered to be unsuitable as the cement argillaceous material by following reasons :
- The chemical component of top-soil is supposed to fluctuate to a great extent.
- Alkali component due to the schist fragments and the muscovite flakes is contained to some extent in the top-soil.
Especially, the schist crops out around BH-11.

(7) Quality

The brief description is made regarding limestone quality in this section because the description is made in detail in V-3.
Roughly describing, the limestone is uniform in quality except the dolomite layer and intercalation, and the chemical composition as cement raw material can be maintained as follows :

CaO : more than 52 % on the average
MgO : less than 1.5 % on the average

Any harmful impurities do not be contained beyond allowable limit in this limestone.

In conclusion, this limestone is suitable as the cement raw material.

V-1-3 Clay Material (Beltar Deposit)

(1) History of inspection

In order to find out suitable clay deposit for cement manufacturing, detailed exploration work was carried out in Udaipur district by Mr. D. B. Khattri and Mr. U. Jha, members of D M G in the fiscal years of 1975/77. Then some clay deposits were investigated at Mohanpur, Murkuchi, Kaijanpur Gairan, Jhora and Beltar. All the clay occurrences except Beltar were confirmed to be small pockets, and therefore the members of D M G carried out detailed survey including topographical surveying and test-pitting at Beltar in the fiscal years of 1975/77, and according to them total reserves of 1,500,000 t of clay were obtained.

Making reference to these data, in co-operation with D M G JICA's geologists performed detailed investigation extensively in Beltar.

Kind and quantities of previous and prestent exploration works are simply shown as follows.

(i) Previous survey by D M G

(a) Geological investigation and topographical survey
: about 56 ha (northern deposit)

(b) Test pit
94 pits were dug on the grid of 70 m x 100 m and amounted to 323.7 m in depth at northern deposit.
5 pits were dug and amounted to 15.5 m in depth at southern deposit.
These pits were already buried and detailed sectional data from Pit No. 1 to No. 48 of northern deposit couldn't be got by our team.

(c) Sampling for chemical analysis
249 samples were collected from these pits.

(ii) Present survey by JICA in co-operation with DMG

(a) Geological mapping (scale 1/1,000) : about 220 ha

(b) Topographical survey (scale 1/1,000)
carried out by DMG on the advice of JICA's experts : about 175 ha

(c) Test pit
31 pits were dug at intervals of 100 m and amounted to 81.8 m in depth at the surrounding area of the northern deposit.
71 pits were dug at intervals of 200 m or 100 m and amounted to 328.3 m in depth at southern deposit and its surrounding area.
Only one pit was dug at eastern deposit, it's depth was 0.9 m.

16 points out of 102 pits were made by hand auger drilling instead of pitting.

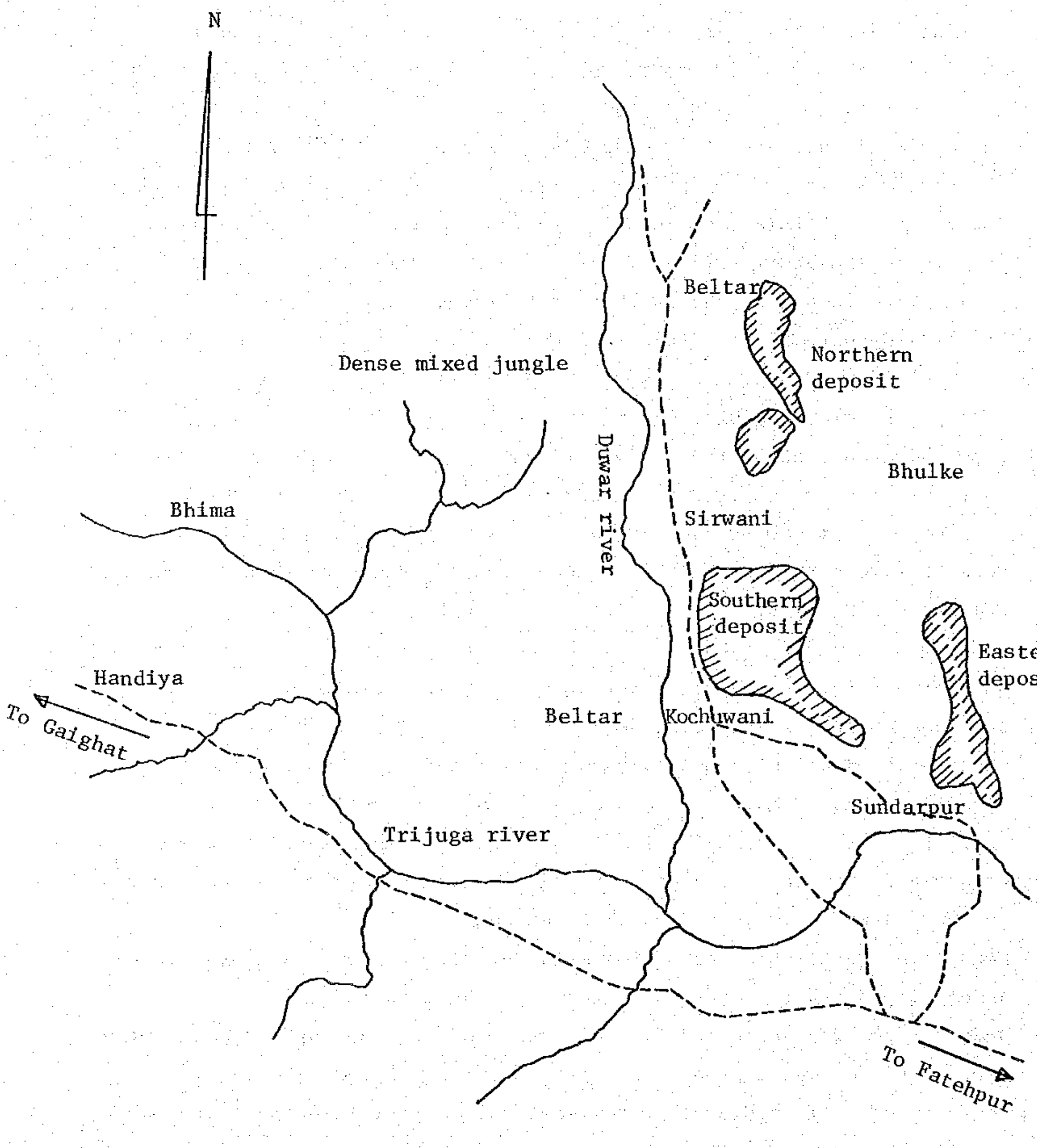
(2) Location and accessibility

Beltar clay deposit is located about 21 km to the east of Gaighat, the proposed plant site. Position of clay deposit is to the north of the Trijuga and to the east of Duwar river, one of tributaries of the Trijuga. Converning the access to Beltar, one can reach by jeep through seasonable road for a distance from 10 to 13 km from Fatepur once crossing the main stream of Trijuga and driving mostly on the old river bed of Duwar river, while from Beltar to Gaighat jeep can reach the proposed plant site via the old river bed of Duwar river and the seasonable road along the Trijuga for a distance of 21 km.

Beltar clay deposit is divided into northern, southern and eastern deposit. Strictly speaking this district contains Beltar, Sirwani, Aunsiya, Kechuwahi and the other villages, but all of these villages are named generically Beltar in this report.

The location map is shown in Fig. 5-1-2.

Fig. 5-1-2 Location Map of Beltar Clay Deposit



Scale 1 : 50,000

(3) Topography and vegetation

Beltar are shows almost flat feature with gentle unduration of 5 or 6 m at most. In other word, shallow valley, rice and other fields and grass land are distributed in almost flat area with depth of 5 or 6 m at most. Most of lowlands have the direction of north to south.
The level of this district generally becomes lower by lower toward the southern part and the end of the clay deposit borders on the rice fields and others firms. On the other hand, an old river bed of Duwar river is located to the west of the deposit. Regarding the relation between Duwar river and this clay deposit, there is a flat land, like river terrace to the east of Duwar river and a few meters higher one exists, as mentioned above to the further east of the former.
Level difference between this region like river terrace and the eastern one gets larger toward the north. There exists Larna river further east of the clay deposit.
Concerning vegetation there are cultivated lands as farm or rice field in somewhere growing shrubs and grasses poorly big trees in the eastern area of Duwar river such as Beltar, Siruwani, Aunsiya and Kechuwahi. However toward the north bushes become denser and somewhere like jungle.

(4) Geology and deposit

Sand, gravel and clay beds, probably belonging to the upper Tertiary or Quarternary formation, are distributed in Beltar district.
The sand and gravel are composed by sandstone, quartzite and schist. The gravel is occupied mostly with pebbles and granules rarely with cobbles and boulders. Occasionally the sand and gravel are weathered completely or incompletely at the upper part. Their origins are Cambrian or Pre-cambrian schist and quartzite, as well as sandstone and conglomerate of Tertiary Siwalik formation.
Among the area consisting of the sand, gravel and clay bed, such zones as bearing thick clay beds are good for clay deposit.
Judging from the geological circumstances of surrounding area, the basement of these beds is considered Tertiary Siwalik formation.
The clay deposit is distributed almost horizontally forming a sedimentary clay layer. The clay is coloured in reddish brown or yellowish brown at northern deposit but at southern and eastern deposit it shows generally yellowish brown or brown.
The clay is weathered soft and plastic but partially sandy. The base of the clay bed is composed of sand and gravel, which appear also at

times as intercalation.

It was recognized by test-pitting and auger drilling that the thickness of the clay beds reaches as thick as 7.7 m at maximum in the northern deposit and 7.15 m in the southern deposit.

The average thickness of the clay beds in the eastern deposit is estimated to be 3 m.

The distance between the northern end of northern deposit and the southern end of southern deposit is about 3.5 km.

(5) Test-pitting and hand auger drilling

Before our investigation, DMG already finished survey in the northern deposit. However available reserves of the clayey material suitable for cement manufacturing were only 1,500,000 t in this area. It was necessary to increase the reserves of the clay by extending the region as compared with the mineable reserves of Sindali limestone deposit. Additional works such as test-pitting and hand auger drilling were carried out by our team.

The area and results of our additional works are shown below :

(i) Northern deposit

Making test pits at northern and southern extensional area of the deposit explorated by DMG, the survey were performed.

Then, it was proved that the northern extensional area was rich in sand and gravel, and not suitable for clayey material, whereas in the southern extensional part additional good clay was acquired.

But available reserves were less than 1,500,000 t because of omitting the eastern part, in calculation, where the clay bed is thin.

(ii) Southern deposit

As there were considerable possibility of getting suitable clay in the southern deposit judging from five test pits made by DMG, additional test pits including hand auger drilling were made.

The area of clay distributed was comprehended.

On the contrary, the result of test pits made in the region between northern deposit and southern deposit indicated that this region had small distribution of clay bed, which was very thin, and so it is not suitable as clay deposit.

(iii) Eastern deposit

Judging from the results of geological survey and a test-pit, this clay deposit is expected to be almost of the same quality as the southern deposit.

On the other hand, the result of the survey on the surrounding area of this deposit, showed that there existed suitable clay in the western extensive area, although the extensive distribution of clay deposit toward the north and east could not be expected.

(6) Reserves

The available reserves of Beltar clay deposit were calculated separately dividing it into three parts, namely northern, southern and eastern deposit.

Among them the reserves of northern deposit and southern one were regarded as proved reserves, because many test pits were made in both areas, and the topographical map with contour on a scale of 1 : 1,000 was prepared in the former while the location and elevation map of test pits and hand auger drilling holes on a scale of 1 : 1,000 without contour was made in the latter.

Eastern deposit was considered probable reserves as calculation was performed based on geological survey and a test pit.

Calculation of reserves was made under the following conditions.

(i) Basic conditions

(a) Northern deposit and southern deposit

At first the geological sections passing the pits at a interval of about 100 m were prepared.

The volume was calculated by multiplying each sectional area by 100 m and summing up the products.

(b) Eastern deposit

The volume was calculated by multiplying the probable area of clay distributed by the probable thickness of it.

(c) Apparent specific gravity of clay : 1.6 t/m^3

(d) Recovery ratio

0.8 was adopted in the northern and southern deposit and 0.7 in the eastern one. The ratios mentioned above are determined taking account of the matters that the bottom clay should be left to prevent from getting mixed with sand and gravel when it is excavated near the lower part of the clay bed, and somewhere in marches is clay a little.

(e) Blackish brown top soil

Since the top-soil can be used as clayey materials by removing roots of plant, it was included in the clay reserves.

(f) Accuracy of calculation

The field works in northern and southern deposit were done by mapping on a scale of 1 : 1,000. But calculation of reserves was made using maps having scale of 1 : 2,000 which was compiled, for the sake of convenience, and attached to the report. Result of calculation are shown in table 5-1-5.

Table 5-1-5 Available Reserves of Beltar Clay Deposit

Deposit	Accuracy	Area (m^2)	Reserves (t)	Average thickness of clay bed (m)
Northern deposit	Proved	350,000	1,340,000	3.0
Southern deposit	Proved	1,040,000	5,210,000	3.9
Eastern deposit	Probable	290,000	970,000	3.0
Total	Proved	1,390,000	6,550,000	3.7
	Probable	290,000	970,000	3.0
	Grand total	1,680,000	7,520,000	3.6

(ii) The process of calculation

(a) Northern deposit and southern deposit

Section No.	Section areas (m^2)	Section No.	Section area (m^2)
N_1 - N_1'	1,410	S_1 - S_1'	3,460
N_2 - N_2'	1,150	S_2 - S_2'	5,360
N_3 - N_3'	1,210	S_3 - S_3'	3,810
N_4 - N_4'	870	S_4 - S_4'	3,110
N_5 - N_5'	560	S_5 - S_5'	4,170
N_6 - N_6'	470	S_6 - S_6'	2,180
N_7 - N_7'	280	S_7 - S_7'	4,660
N_8 - N_8'	460	S_8 - S_8'	3,680
N_9 - N_9'	570	S_9 - S_9'	3,990
N_{10} - N_{10}'	1,050	S_{10} - S_{10}'	3,950
N_{11} - N_{11}'	810	S_{11} - S_{11}'	1,470
N_{12} - N_{12}'	850	S_{12} - S_{12}'	900
N_{13} - N_{13}'	840	Total	40,740 m^2
Total	10,530 m^2		

Available reserves of northern deposit

$10.530\ m^2 \times 100\ m \times 1.6\ t/m^3 \times 0.8 = 1,347,840\ t \doteqdot 1,340,000\ t$

Available reserves of southern deposit

$40,740\ m^2 \times 100\ m \times 1.6\ t/m^3 \times 0.8 = 5,214,720\ t \doteqdot 5,210,000\ t$

(b) Eastern deposit

$290,000 m^2 \times 3 m \times 1.6 t/m^3 \times 0.7 = 974,400 t \doteqdot 970,000 t$

(iii) Comments on reserves of clay

(a) Proved available reserves are about 6,500,000 t, besides them probable available reserves are considered to be about 1,000,000 t in Beltar district.

(b) Considering the size of clay deposit and geographical conditions, it is good to begin the excavation from the southern end or south-western part of southern deposit.

(c) Another available reserves will be obtained in the western extension of the eastern deposit through detailed examination in future.

(7) Quality

Detailed comments on quality are described in V-3. An outline of quality is mentioned below.

Beltar clay material is suitable as manufacturing of portland cement both in chemical composition and physical properties. Average chemical composition of Beltar clay is as follows.

(%)

Deposit	SiO_2	Al_2O_3	Fe_2O_3
Northern deposit	65.96	17.50	5.65
Southern deposit	63.48	18.78	6.08
Eastern deposit	71.15	15.02	4.20

Though K_2O contained varies from 2 % to 4 %, which is perhaps originated from muscovite included in this clay, this clay is suitable as raw material of portland cement.

Average silica modulus of the clay fluctuates to a certain extent and average values are 2.85 in northern deposit, 2.55 % in southern one and 3.70 in eastern one respectively. Judging from the values mentioned above, it is necessary to use some siliceous materials.

As the clay is reddish brown or yellowish brown or brown in colour, soft, plastic and sticky it may be difficult to a certain extent to handle the clay in a rainy season.

However if the clay is not drenched with rain during excavation, this problem will be solved.

Although the clay is covered with blackish brown top soil 0.2 m to 0.5 m in thickness, including organix matter, it is possible to make use of the top soil as clayey material by removing roots of plant.

(8) Clay deposit other than Beltar

Other clay deposits were confirmed, and they are as almost same as Beltar deposit in quality but smaller in scale.

They are distributed near the proposed plant site at Gaighat and Murkuchi situated upper stream of the Trijuga. According to DMG's survey, the clay of Murkuchi where two test-pits were made, was considered to have about 200,000 t of reserves.

Besides, DMG made four test pits at Nepaltar 7.6 km to the west-north-west of Murkuchi, and the reserves of the clay deposit were estimated to be 500,000 t. However since it is difficult to transport Nepaltar clay to Gaighat, this clay deposit is not prospective for the Project.

V-1-4 Siliceous Material

As for siliceous materials, silica sand in the basin of the Trijuga is suitable. This silica sand is broadly distributed along the Trijuga over the area of about 20 km between Gaighat and Ford, south of Beltar. However, since this sand contains many impurities, for example, pebbles of the schist and muscovite, it is necessary to pick up the silica sand of poorly bearing those impurities.

Especially the silica sand distributed along the Trijuga main stream contains more impurities than the one in the basin of the southern tributaries of the Trijuga, and therefore the latter is better in quality.

These tributaries are called Lahan river, Babiya river, Kung river, Baruwa river and Handiya river, respectively. They join to the main Trijuga at the points 1.5 km, 4.4 km, 8.9 km, 11.5 km and 16 km respectively from the proposed plant site.

There occurs adundant suitable silica sand of higher grade along each tributaries.

The silica sand is sedimented almost horizontally with several meters thickness on the old river bed and contains little quantity of pebbles and others.

Quality of silica sand is described in V-3. The sand contains more than 85 % of SiO_2, and is suitable as siliceous material for producing portland cement.

V-1-5 Iron Ore

The iron ore deposit at Phulchoki was investigated by Indian Consulting Company, Messr. M.N. DASTUR AND CO. (P) LTD., in 1975. It occurs on the southern slope of Mt. Phulchoki, about 26 km to the south east of the city of Kathmandu.

The height of the deposit is about 2,500 m above sea level.

The iron ore is mainly composed of hematite.

The thickness of the deposit is considered to be 22 m or so, and divided into three types, namely compact and massive one, fine grained and pisolitic one and oölitic one.

This iron ore contains quartz, chlorite, muscovite, feldspars and others as impurities.

Reserves of iron ore are regarded as 5,000,000 t.

The average of chemical composition is as follows.

Fe 52 ~ 58 %

SiO_2 10 ~ 15.6 %

$A\ell_2O_3$ 3 ~ 5 %

This iron material can be used for producing portland cement.

The results of chemical analysis made by our team are shown in V-3.

Besides the iron ore mentioned above, the import of iron ore from India will be possible, too.

V-1-6 Gypsum

Gypsum to be used for the Project is imported from India.

The gypsum from Rajastan India, is suitable as cement retarder.

V-1-7 Relation between Reserves and its Duration

The main raw materials, limestone in Sindali, clay in Beltar and silica sand in the basin of the Trijuga, are all suitable for the Project, both in quality and quantity. As for ferrous material Phulchoki iron ore or Indian iron ore will be used. Gypsum for the Project will be imported, too.

The relation between the capacity of the cement plant and the duration of the reserves is shown below.

Table 5-1-6 Relation between Capacity if Cement Plant and Duration of Reserves

Kind of the raw materials	Available reserves (t)	Duration of the reserves (years) Capacity of the plant 750 t·cℓ/d	1,000 t·cℓ/d	1,500 t·cℓ/d
Limestone	*1 51,400,000	160	120	80
Clay	*2 6,550,000	84	63	42
Silica sand	*3 abundant	sufficient	sufficient	sufficient

Notes :

*[1] Available reserves are 70 % of whole reserves of 73,540,000 t, refer to V-1-2.

*[2] This figure is total of the proved ones both at northern deposit and southern deposit, and besides the probable ones exist at eastern deposit.

*[3] The distribution area is too extensive to estimate the reserves, however, it is no problem to obtain the sufficient and suitable silica sand.

V-1-8 Description on Test-Pits and Hand Auger Drilling Holes in Beltar Clay Deposit

Description on test-pits and hand auger drilling holes in Beltar clay deposit is shown in Table 5-1-7.

Table 5-1-7 Results of Test Pits and Hand Auger Drilling Holes in Beltar Clay Deposit

Note { B means test pit
Ah means hand auger drilling hole

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-1			0		Sand and gravel rich
B-2			2.4		Reddish brown clay
B-3			6.4		Same as above
B-4			7.7		
B-5			1.7		
B-6			4.5		
B-7			4.7		Reddish brown clay
B-8			3.1		
B-9			0		Reddish brown clay
B-10			4.4		Reddish brown clay, few sand and gravel in the clay that was dug
B-11			5.4		Reddish brown clay

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-12			1.3		Brown clay same as B-10
B-13			0		
B-14			3.1		Reddish brown clay
B-15			3.3		Same as above
B-16			4.4		
B-17			1.7		
B-18			4.0		Reddish brown clay Some pebble of quartzite in the clay that was dug
B-19			3.9		Reddish brown clay
B-20			3.1		Same as above breccia of quartzite rich in the clay that was dug
B-21			4.2		
B-22			2.4		
B-23			1.4		Reddish brown clay
B-24			3.0		Reddish brown clay with little sand and gravel
B-25			2.9		
B-26			1.7		Brown clay little sandy
B-27			2.5		Reddish brown clay
B-28			3.5		
B-29			2.8		Reddish brown clay
B-30			4.1		Same as above pebble rich in the clay that was dug
B-31			1.6		Brown clay and little sandy one. Rich conglomerate in the clay that was dug

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-32			0		
B-33			2.9		
B-34			3.3		Reddish brown clay
B-35			2.5		Same as above pebble rich in the clay that was dug
B-36					Reddish brown clay with weathered sand and gravel that is composed of granule of quartzite and schist
B-37			0		Reddish brown clay
B-38			2.5		Same as above with few pebble
B-39			3.8		Reddish brown clay
B-40			1.6		
B-41			2.1		Brown clay with pebble
B-42			1.0		Reddish brown clay
B-43			4.3		Brown clay
B-44			2.1		Brown clay but reddish a little
B-45			3.8		Reddish brown clay
B-46			3.2		Reddish brown clay
B-47			2.5		Same as above
B-48			0.9		Brown clay
B-49		0.67	1.50		Same as above but partially sandy
B-50		0.22	0.86		Sandy a little brown clay
B-51		0.48	1.82		Reddish brown clay

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-52		0.25	0.89		
B-53		0.31	1.60		
B-54		0.17	0.96		Brown clay
B-55		0.31	1.24		Reddish brown clay
B-56		0.18	1.37		
B-57		0.15	1.83		Brown clay sandy a little
B-58		0.43	3.95	0.95	Brown clay
B-59		0.27	3.42		
B-60		0.19	1.39		Brown clay and little sandy
B-61		0.30	2.65		Brown clay
B-62		0.35	2.53		
B-63					
B-64		0.32	3.03		
B-65		0.31	3.54		Brown clay
B-66		0.12	2.58		
B-67		0.27	2.00		Brown clay
B-68		0.25	2.61	0.62	Same as above
B-69		0.27	2.81		
B-70		0.32	0.83		Brown clay
B-71		0.26	2.22	1.10	Same as above reddish a little
B-72			0	1.00	
B-73		0.24	2.21	1.13	Mixed with sand and gravel from surface
B-74		0.22	0.86		
B-75		0	2.21	0.79	
B-76		0.28	1.83	0.37	Brown clay and yellowish one a little Little pebble in the clay that was dug
B-77		0.42	6.10		Brown clay sandy a little
B-78		0.30	3.85		Brown clay

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-79		0.40	3.13		Same as above sandy a little
B-80		0.30	3.65		Brown clay
B-81		0.36	4.48		Same as above
B-82		0.30	2.93		Reddish brown clay
B-83		0.30	3.00		Brown clay
B-84		0.37	4.22		Same as above
B-85		0.35	3.81		Same as above sandy a little
B-86		0.40	3.68		Brown clay
B-87		0.36	4.00		Same as above
B-88		0.28	3.69		Same as above
B-89		0.25	4.00	0.25	Same as above
B-90		0.30	3.00		Same as above
B-91		0.33	4.70		Brown clay sandy a little
B-92		0.28	3.72		Brown clay
B-93		0.25	3.00		Same as above
B-94		0.30	1.41		Same as above yellowish a little
B-95	4.60		4.25	0.35	
B-96	5.25		2.35	2.90	Brown clay partially sandy
B-97	4.30		4.30		Brown clay
B-98	2.20		2.20		Same as above
B-99	2.75		2.75		Same as above
B-950	2.10	0.15	1.15		Reddish brown clay
B-960	2.00	0.10	1.10		Brown clay
B-990	3.20	0.40	2.80		Yellowish brown clay and little sandy
B-1000	1.30	0.30	0		
B-1010	0.35				Brown clay with sand, granule and pebble of schist and quartzite

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-1020	0.60				Reddish brown clay with rich sand, pebble and cobble of quartzite and schist which is less than quartzite
B-1030	4.90	0.30	4.60		Brown clay
B-1040	3.80	0.30	3.50		Same as above
B-1050	2.80	0.20	2.60		Reddish brown clay
B-1060	1.50	0.50	1.00		Brown clay
B-1070	2.00	0.45	1.55		Same as above with sand and gravel rich
B-1080	1.50	0.35	1.15		Reddish brown clay and little sandy
B-1090	1.30	0.40		0.90	Brown sandy clay with sand and gravel
B-1100	1.50	0.40	0.75		Brown clay
B-1110	2.00	0.40	1.10		Same as above sandy a little
B-1130	5.10	0.42	4.68		Brown clay
B-1140	2.40	0.25	1.25		Same as above
B-1150	3.00	0.30	1.10		(Yellowish) brown clay
B-1170	1.15	0.30	0.40		Sandy clay with little sand granule and pebble
B-1190	2.80	0.30	0.50		Sandy clay with little sand and pebble
B-1210	2.10	0.80	0.80		Brown sandy clay River sediments in appearance Not consolidated
B-1220	6.60	0.20	6.40		Yellowish brown clay and brown one confirmed with hand auger drilling in the lower part

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-1230	6.70	0.10	6.60		Yellowish brown clay confirmed with hand auger drilling in the lower part
Ah-1250	5.40	0.20	5.20		Yellowish brown clay
B-1260	4.90	0.10	4.90		Brown clay
B-1270	6.00	0.30	5.57		Brown clay up to 1 meter, the other is yellowish brown confirmed with hand auger drilling in the lower part
B-1290	5.82	0.25	5.57		Brown clay from 0 to 1 and from 2 to 4 meter yellowish brown clay from 1 to 2 and from 5 to bottom
Ah-1300	4.96	0.20	4.76		
B-1310	2.54	0.20	2.34		Yellowish brown clay
B-1320	6.30	0	6.30		Same as above
B-1330	1.75	0.15	1.60		Brown clay
B-1340	5.70	0.10	at least 5.60		Same as above
B-1350	2.00	0.10	1.30		Same as above
B-1360	3.80	0.10	2.50		Yellowish brown clay
B-1370	3.60	0	3.20	0.10	Brown clay intercalating gravel bed near 1 meter
B-1380	3.70	0.25	0.75		Brown clay
B-1390	5.05	0.15	at least 4.30	0.60	Yellowish brown clay
B-1400	4.30	0.25	3.35	0.70	Same as above
B-1410	2.92	0.30	2.40		Brown clay
B-1420	4.30	0.20	3.80	0.30	Yellowish brown clay

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-1430	5.00	0.30	4.50		Same as above
B-1510	5.60	0.20	5.20	0.20	(Yellowish) brown clay confirmed with hand auger drilling in the lower part
B-1520	3.50	0.25	2.30	0.95	From 0.4 to 0.7 m brown clay with few gravel from 0.7 to 3.2 m yellowish brown clay
Ah-1521	2.40	0	2.40		Yellowish brown clay
B-1530	6.90	0.20	at least 6.70		Brown or yellowish brown clay
B-1535	4.00	0.15	3.20		
B-1540	2.48	0	1.35		Yellowish brown clay
Ah-1560	6.20	0.25	at least 5.95		From 0.25 to 1.20 meter brown clay from 1.20 to 3.20 meter yellowish brown clay sandy a little the other is brown one.
B-1570A	8.00	0.45	7.15		(Yellowish) brown clay in the upper part reddish brown clay confirmed with hand auger drilling in the lower part
B-1570B	4.90	0.35	at least 3.45	1.20	
B-1580A	6.50	0.40	at least 5.35	river sediments in appearance	From 0.4 to 1.65 meter little sandy brown clay the other is yellowish brown one.
B-1580B	4.80	0.25	at least 3.30	1.25	
B-1590A	4.70	0.35	at least 2.10	2.25 river sediments in appearance	Yellowish brown clay

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-1590B	5.40	0.40	3.40	1.60	Sandy brown clay
B-1600	6.35	0.50	at least 5.00	0.85 river sediments in appearance	Yellowish brown clay
B-1610	2.90	0	2.90		Brown clay
B-1620	1.50	0	1.00		Same as above
B-1630	3.20	0.20	3.00		Yellowish brown clay
B-1640	3.30	0.20	2.30		Same as above
B-1650	0.80	0	0		
B-1660	5.10	0.15	4.95		(Yellowish) brown clay confirmed with hand auger drilling in the lower part
B-1665	3.25	0.30	2.30	0.65	(Yellowish) brown clay
Ah-1670	1.10	0.20	0.90		Dark brown clay
B-1670	3.40	0.40	1.35	1.85	Reddish or yellowish brown clay
B-1680	4.25	0.30	2.25	2.70 river sediments in appearance	Dark brown clay with little sand and gravel
B-1690	6.50	0.30	5.05	1.15 same as above	Brown clay and little sandy
Ah-1700	6.20	0.30	at least 5.63	0.27	From 0.3 to 2.8 meter sandy clay The other is yellowish brown clay.
Ah-1710	6.20	0.40	at least 5.80 but under water level		Yellowish brown clay
B-1720	1.30	0	0.85		Same as above
B-1730	1.90	0	1.80	0.10	Same as above
B-1750	4.70	0	4.15	0.55	Same as above
B-1760	2.80	0.20	1.80		Same as above
B-1770	2.20	0.25	1.60		Same as above
B-1790	5.70	0.50	3.20	1.55	Reddish or yellowish brown clay partially sandy

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-1795	5.50	0.55	at least 3.25	1.70	Reddish or yellowish brown clay
B-1800	4.95	0.45	4.15	0.35	Same as above
B-1805	3.25	0.50	at least 2.75		Yellowish brown clay
Ah-1810	5.20	0.30	at least 4.10	0.80	Brown clay in the upper part yellowish brown one in the lower part
B-1815	4.90	0.30	3.60	0.40	Reddish or yellowish brown clay
Ah-1820	6.20	0.30	at least 5.80	0.10	Yellowish brown clay
Ah-1830	6.20	0.40	at least 5.20	0.60	Yellowish brown clay in the upper part reddish brown clay in the lower part
B-1840	2.20	0	1.70		Yellowish brown clay
B-1850	2.35	0	2.00		Same as above
B-1890	3.90	0	1.40	1.60	Same as above
B-1900	4.00	0.10	2.20	1.60	Reddish or yellowish brown clay
B-1905	5.00	0.50	2.60	1.90	Same as above
B-1910	4.00	0.50	1.85	0.50	Yellowish brown clay partially sandy
B-1915	4.70	0.55	2.55	1.60	Reddish or yellowish brown clay
B-1920	6.20	0.60	at least 4.30	1.30	Same as above partially sandy
B-1930	7.60	0.30	at least 7.00	0.30	Same as above
B-1935	5.70	0.35	at least 5.10	0.25	Reddish or yellowish brown clay
B-1940	6.35	0.70	at least 3.55	2.10	Same as above partially sandy

Pit No.	Depth of pit (m)	Thickness of top soil (m)	Thickness of clay bed including top soil (m)	Thickness of waste (sand and gravel) (m)	Remarks
B-1945	3.85	0.50	1.75	1.60	Yellowish brown clay
B-1950	7.00	0.30	5.00	1.70	Reddish or yellowish brown clay partially sandy
B-1960	4.50	0.50	4.00		Reddish or yellowish brown clay
B-1970	2.70	0.25	2.45		Yellowish brown clay
B-1980	4.70	0.10	4.60		Yellowish brown clay
B-1990	1.70	0.20	1.50		Reddish or yellowish brown clay
B-2000	1.90	0	1.45	0.45	Same as above partially sandy
S-1000	0.90	0.10	0		