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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Austria

MARKET STUDY ON LIGHTWEIGHT AGGREGATES IN SINGAPORE, HONG KONG, AND THE PHILIPPINES

May 1990

FINAL REPORT

SGV
CONSULTING
SYCIP, GORRES, VELAYO & CO.

THE SGV GROUP
INTERNATIONAL MAILING ADDRESS:
P.O. BOX 7658 MAIA AIRMAIL EXCHANGE
1300 METRO MANILA, PHILIPPINES

LOCAL MAILING ADDRESS:
P.O. BOX 256 MAKATI CPO
1256 MAKATI, METRO MANILA

SGV
CONSULTING
SYCIP, GORRES, VELAYO & CO.
SGV DEVELOPMENT CENTER
105 DE LA ROSA ST., LEGASPI VILLAGE
1200 MAKATI, METRO MANILA, PHILIPPINES

TELEPHONE: (632) 817-03-01
(632) 819-30-11

FACSIMILE NO.: (632) 817-41-93
(632) 819-08-72

TELEX: 45086 PM
45832 PM
63743 SGV PN

CABLE: CERTIFIED MANILA

May 28, 1990

United Nations Industrial Development Organization
P.O. Box 300
A-1400 Vienna
Austria

Attention: Mr. S. Morozov
Chief, Contracts Section

Gentlemen·

Re: Contract No. 89/131 LM
Preparation of ASEAN Market Studies

We are pleased to submit our final report on Market Study on Lightweight Aggregates in Singapore, Hong Kong, and the Philippines. This is one of the four market studies commissioned by UNIDO to help the Committee on Industry, Minerals, and Energy (COIME) identify, prepare, and promote projects for the ASEAN Industrial Joint Ventures (AIJV) programme. The report compilation was coordinated by the International Team Leader of Project No. DP/RAF/85/010.

This market study aims to:

- identify the uses of aggregates in each of the three country markets;
- forecast demand for aggregates;
- determine the competitive price at which Liapor can be sold;
- forecast demand for Liapor; and
- recommend potential AIJV promoters to act as sales agents or distributors for Liapor.

SGV & CO.

The market data in the report consists primarily of secondary information obtained from trade publications and government agencies and are supplemented with key informant interviews with selected aggregate manufacturers and distributors in the countries covered. We were assisted in the data gathering by our offices in Singapore and Hong Kong.

We will be glad to discuss any question you may have on this report.

Very truly yours,

SGV & Co.

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1. EXECUTIVE SUMMARY

1.1 PRODUCT COVERAGE

Aggregates are inert granular materials which, when bound together, form concrete, mastic, mortar, and plaster. Aggregates are classified into two: normalweight and lightweight. Normalweight aggregates - normally used in mass and reinforced concrete - include natural sand, gravel, crushed stones and pebbles, and granite. Lightweight aggregates include pumice, foamed slag, fly ash, expanded clay, shale, and slate, exfoliated vermiculite, diatomite, scoria, and expanded volcanic glasses such as perlite. Aggregates do not include finely divided or pulverized stone or sand sometimes used with cement that are more properly termed as admixture or filler.

Lightweight aggregates when mixed with cement result in concrete which is light in weight and low in thermal conductivity. The density of ordinary normalweight concrete ranges from about 2240 to 2400 kilograms per cubic meter (kg. per cu. m.), while that of most lightweight concretes ranges from 640 to 1600 kg. per cu. m. All types of lightweight concrete are subject to high shrinkage, except those made with expanded clays, shales, and scoria. The strength of lightweight concrete varies considerably; that is, it will be almost inversely proportional to the weight of the aggregate. Comparisons, however, are not always easily made because of the difficulty of making concrete mixes that have the type of aggregate as the sole variable. Relatively high strength is obtained with expanded clay and shale; intermediate strength with pumice, scoria, and expanded slag; and low strength with diatomites, perlite, and exfoliated vermiculite. On the other hand, the insulating properties of the last group are better than those of the first group. However, even crushed clay and shale concrete have four times the insulating value of ordinary concrete.

Using lightweight aggregates instead of normalweight aggregates reduces the dead weight of buildings and other structures with consequent savings in cost, especially in terms of the foundation. Precast blocks and slabs made of lightweight concrete cost less to transport than dense materials, and are faster and cheaper to erect. Furthermore, lightweight aggregates are better insulators, thereby minimizing expensive energy losses.

The proposed product, Liapor, is a lightweight aggregate of expanded shale. Its raw material is extracted by open-face mining, and is carefully prepared, pulverized, and pelletized into small round pellets. The shale pellets are burned in large rotary kilns at approximately 1200°C (2200°F) without artificial admixtures or chemical air-entraining agents. The organic substances inside the shale burn, with the resulting gases causing the pellets to expand. At the same time, the outer skin is sintered. In this way, light shale spheres with fine pores are produced, which have an aerated core and high compressive strength. Its porous structure and light weight give Liapor a high thermal insulation and thermal inertia. During production, the size, weight, and strength of Liapor are carefully controlled, which makes its appearance and quality consistent. Liapor weighs from 300 to 800 kg. per cu. m., and its thermal conductivity is between 0.10 to 0.20 watt per meter Kelvin.

Liapor is used mainly for construction purposes. With its outstanding physical and technical properties, Liapor is an ideal material for producing low density, high insulating lightweight blocks. Furthermore, precast cellar window frames, lintels, rolling shutter cases and floor slabs can be made using Liapor lightweight concrete and Liapor lightweight mortar. The use of Liapor walls and building components protects against expensive energy losses. At present, the materials used for these purposes in Singapore, Hong Kong, and the Philippines are the lightweight aggregates pumice, exfoliated vermiculite, and perlite. This study discusses the lightweight aggregates presently used in Singapore, Hong Kong, and the Philippines.

Since Liapor can substitute for normalweight aggregates, this report also discusses the market of currently used normalweight aggregates in the three countries covered. The normalweight aggregates used by the three country markets are sand, gravel, crushed stones and pebbles, and granite.

1.2 BACKGROUND ON THE CONSTRUCTION INDUSTRY

1.2.1 Singapore

The contribution of Singapore's construction industry to gross domestic capital formation decreased steadily from 1984 to 1988. However, the sector recovered in 1989 due to the strength of the domestic economy, booming tourism, public housing refurbishment plans, and strong interest in the Singapore property sector from Hong Kong.

Based on estimated expenditures of the construction industry, construction activity in 1989 was led by the public sector.

Sector	Value (in US$000)	%
Public	915,405.25	71.5
Private	364,704.10	28.5
Total	1,280,109.35	100.0

The demand for construction jobs from 1990 to 1992 in terms of value is projected by the Construction Industry Development Board of Singapore, as follows:

	(Value in US$000,000)		
Sector	1990	1991	1992
Public	2,040	1,850	1,660
Private	1,120	975	620
Total	3,160	2,825	2,280

1.2.2 Hong Kong

The construction industry of Hong Kong contributed US$2.05 billion to gross domestic product (GDP) in 1987, up from its contribution of US$1.56 billion in 1984. However, during the four-year period, the industry's percentage share to total GDP declined from 5.3 per cent in 1984 to a low 4.6 per cent in 1987.

In terms of floor area of completed buildings, an increase from 1.93 million square meters in 1984 to 2.80 million square meters in 1987 was recorded. Building activities peaked in 1985 at 2.90 million square meters.

In 1987, Hong Kong's expenditures on building and construction was fuelled by private sector activities, as follows:

Sector	Value (in US$000,000)	%
Private	1,575.16	65.5
Public	828.80	34.5
Total	2,403.96	100.0

It must be noted that the colony's construction industry and its entire economy will be affected by the takeover of the People's Republic of China (P.R.O.C.) in 1997.

1.2.3 Philippines

The construction industry in the Philippines has been experiencing a boom since 1987, making it one of the bigger income sources of the country. The industry's contribution to total national income in 1988 was 4.3 per cent, and went up to 4.6 per cent in 1989. The industry's real income (gross value added at constant 1972 prices) in 1989 reached US$222 million, an eight per cent increase from the 1988 level. The industry's outstanding performance during both years was initiated mainly by the private sector.

In 1988, private and public construction in floor area was as follows:

	(in thou. sq. m.)	
Type of Construction	Private	Public
Residential buildings	3,645.64	989.93
Nonresidential	3,367.70	557.82
Others	1,008.81	-
Total	8,022.15	1,547.75

1.3 DEMAND

1.3.1 Historical Demand

1.3.1.1 Singapore

The lightweight aggregates used in Singapore are pumice, slag wool, exfoliated vermiculite, and expanded clays. Based on interviews, these lightweight aggregates are not commonly used by the construction industry.

The total estimated consumption by Singapore of these aggregates from 1987 to 1989, based on imports, are as follows:

Year	Lightweight Aggregate Consumption (in metric tons)
1987	7,403.00
1988	8,417.00
1989	10,745.33

On the other hand, the normalweight aggregates used in Singapore are sand, gravel, and granite. These aggregates are used by the construction industry.

The table below shows the total estimated consumption of these aggregates by the vertical construction industry in Singapore from 1984 to 1989:

Year	Normalweight Aggregate Consumption (in cu. m.)
1984	6,889,123.38
1985	4,580,787.02
1986	3,874,546.08
1987	2,843,950.20
1988	3,270,542.74
1989	3,761,124.14

Consumption of normalweight aggregates broken down by total construction (that is, vertical and infrastructure construction) could not be inferred because of the lack of data on infrastructure construction in Singapore.

1.3.1.2 Hong Kong

Based on interviews, lightweight aggregates are not commonly used by Hong Kong's construction industry.

Hong Kong imports the lightweight aggregate pumice for domestic consumption. Consumption of pumice from 1986 to 1989, based on imports, is as follows:

Year	Lightweight Aggregate Consumption (in metric tons)
1986	27,672.08
1987	50,172.45
1988	42,677.09
1989	64,428.73

Hong Kong also uses the normalweight aggregates sand and gravel. These aggregates are used for construction purposes.

The following table shows the estimated consumption of normalweight aggregates by vertical construction from 1984 to 1989.

Consumption of normalweight aggregates by total construction (that is, vertical and infrastructure construction) could not be inferred because of the lack of data on infrastructure in Hong Kong.

Year	Normalweight Aggregate Consumption (in cu. m.)
1984	1,456,926.61
1985	2,476,122.43
1986	2,036,891.68
1987	2,081,306.55
1988	2,393,502.54
1989	2,752,527.91

1.3.1.3 Philippines

The lightweight aggregates used in the Philippines are perlite, exfoliated vermiculite, expanded clays, and expanded slags. Based on interviews, these aggregates are used primarily for nonconstruction purposes.

The total estimated consumption by the Philippines of these aggregates from 1986 to 1989, based on interviews and foreign trade statistics, are as follows:

Year	Lightweight Aggregate Consumption (in metric tons)
1986	30,354.19
1987	30,346.94
1988	26,436.40
1989	32,746.68

The normalweight aggregates used by the Philippine construction industry are sand and gravel. These aggregates are used for vertical and infrastructure construction.

The following table shows the total estimated consumption of these aggregates by the vertical construction industry in the Philippines from 1985 to 1988.

Year	Normalweight Aggregate Consumption (in cu. m.)
1985	2,261,596.55
1986	2,077,798.53
1987	2,945,738.71
1988	3,954,427.55

As in the case of Singapore and Hong Kong, consumption of normalweight aggregates by total construction (that is, vertical and infrastructure) could not be inferred because of the lack of data on infrastructure construction in the Philippines.

1.3.2 Projected Demand

1.3.2.1 Singapore

Singapore's projected demand for lightweight aggregates in 1990, 1991, 1992, 1995, 1997, and 2000 is shown below:

Year	Lightweight Aggregate Demand (in metric tons)
1990	12,360
1991	14,210
1992	16,340
1995	24,850
1997	32,870
2000	49,990

According to Singapore's Construction Industry Development Board, Singapore's consumption of aggregates increased by 15 per cent from the third quarter of 1988 to the same quarter of 1989. This rate was applied to the 1989 estimated consumption of lightweight aggregates to project demand until 2000.

The projected demand for normalweight aggregates for selected years between 1990 to 2000 is shown in the following table:

Year	Normalweight Aggregate Demand (in cu. m.)
1990	4,325,290
1991	4,974,090
1992	5,720,200
1995	8,699,710
1997	11,505,360
2000	17,498,220

The 15 per cent growth rate used in projecting demand for lightweight aggregates was applied to the 1987 estimated consumption of normalweight aggregates by vertical construction in Singapore to project demand from 1990 until 2000.

1.3.2.2 Hong Kong

Projected demand for pumice, the lightweight aggregate used by Hcng Kong, for the years 1990, 1991, 1992, 1995, 1997, and 2000 is shown below:

Year	Lightweight Aggregate Demand (in metric tons)
1990	85,690
1991	113,970
1992	151,580
1995	356,610
1997	630,810
2000	1,484,070

Demand is projected to grow by 33 per cent yearly, which is the average annual growth rate of Hong Kong's imports of pumice stone, emery, and corundum from 1986 to 1989.

The following table shows the projected demand for normalweight aggregates in Hong Kong for selected years up to 2000. Demand up to 1994 is projected by applying a 15 per cent annual growth rate on the estimated consumption in 1987. The 15 per cent growth rate is the average annual growth rate in floor area of combined residential and nonresidential construction in Hong Kong from 1984 to 1987.

Year	Normalweight Aggregate Demand (in cu. m.)
1990	3,165,410
1991	3,640,220
1992	4,186,250
1995	6,089,950
1997	7,368,840
2000	9,807,920

From 1995 to 2000, demand for normalweight aggregates is projected to grow at an annual rate of 10 per cent. A lower growth rate was assumed in view of the probable decline in construction activity and importation of normalweight aggregates prior to and after the takeover of the colony by P.R.O.C. in 1997.

1.3.2.3 Philippines

Projected demand for lightweight aggregates in the Philippines from 1990, 1991, 1992, 1995, 1997, and 2000 is shown below. Demand is projected by applying on local production for domestic consumption and on imports of lightweight aggregates the average annual growth rate of 2.5 per cent in estimated consumption of lightweight aggregates from 1986 to 1989.

Year	Lightweight Aggregate Demand (in metric tons)
1990	33,570
1991	34,400
1992	35,260
1995	37,980
1997	39,900
2000	42,970

The projected demand for sand and gravel for selected years between 1990 to 2000 is shown below. For the years 1990 to 1992, demand is projected by applying to the 1988 estimated consumption of normalweight aggregates the projected growth rate of 17.4 per cent for the construction industry contained in the updated Medium-Term Development Plan of the National Economic Development Authority (NEDA). For the period beyond 1992, the last year covered in the NEDA plan, a more conservative growth rate of 10 per cent was used.

Year	Normalweight Aggregate Demand (in cu. m.)
1990	5,450,290
1991	6,398,640
1992	7,512,010
1995	9,998,480
1997	12,098,160
2000	16,102,660

1.4 SUPPLY

1.4.1 Local Production

1.4.1.1 Singapore

There are no available data on the total production of lightweight and/or normalweight aggregates by Singapore. However, Singapore exported certain aggregates from 1987 to 1989.

Singapore's domestic exports of lightweight and normalweight aggregates in 1989 were as follows:

Commodity	Volume (in MT)	Value (in US$000)
Pumice stone and other natural abrasives	57.33	83.70
Slag, rock, and other mineral wools, exfoliated vermiculite, expanded clays, and other similar materials	101.33	128.93
Natural sands	229.33	10.13
Pebbles, gravel, macadam, and other similar materials for road use	160.00	17.55
Crushed or broken granite *	8,450.00	27.33

* 1988 Exports.

1.4.1.2 Hong Kong

There are no available data on the total production of lightweight and/or normalweight aggregates by Hong Kong. However, Hong Kong also made domestic exports of certain aggregates from 1986 to 1988. There were no domestic exports of aggregates as of September 1989.

Hong Kong last exported the following lightweight and normalweight aggregates either in 1987 or in 1988:

Commodity	Volume (in MT)	Value (in US$)
Pumice stone, emery, and corundum [1]	12	4,818
Sand [1]	5	1,487
Gravel, pebbles, crushed stones, and tarred macadam [2]	88	5,130

Notes: 1) 1987 Exports.
2) 1988 Exports.

1.4.1.3 Philippines

Based on interviews and data from the Bureau of Mines and Geosciences, Philippine production volume and value of perlite, sand, and gravel in 1988 were as follows:

Commodity	Unit	Volume	Value (in US$000)
Perlite	metric ton	27,216.00	1,327.01
Sand and gravel	thou. cu. m.	14,842.27	57,210.71

The table below shows Philippine exports of perlite, sand, and other normalweight aggregates in 1988:

Commodity	Volume (in MT)	Value (in US$000)
Perlite	800.00	200.00
Sand	4,824.14	327.89
Pebbles, crushed or broken stones, granules, chippings, and powder of stones	26,706.01	2,093.12

1.4.2 Imports

1.4.2.1 Singapore

Singapore imported the following lightweight and normalweight aggregates for domestic consumption in 1989:

Commodity	Volume (in MT)	Value (in US$000)
Pumice stone and other natural abrasives	1,517.33	1,947.38
Slag, rock, and other mineral wools, exfoliated vermiculite, expanded clays, and other similar materials	9,228.00	8,373.42
Natural sands	898,398.67	9,540.50
Pebbles, gravel, macadam, and other similar materials	7,986.66	521.77
Crushed or broken granite	141,621.33	1,120.50

1.4.2.2 Hong Kong

Hong Kong's 1989 imports of lightweight and normalweight aggregates for domestic consumption were as follows:

Commodity	Volume (in MT)	Value (in US$000)
Pumice stone, emery, and corundum	64,428.73	8,794.30
Sand	1,398,605.34	7,096.67
Gravel, pebbles, crushed stones, and tarred macadam	6,626,489.33	29,436.37

1.4.2.3 Philippines

Based on foreign trade statistics, the Philippines imported lightweight aggregates in 1988 amounting to 20.40 MT valued at US$7,190. Imports of lightweight aggregates fall under the classification exfoliated vermiculite, expanded clays, expanded slags, and other similar expanded mineral materials.

The Philippines did not import sand and gravel from 1986 to 1988.

1.4.3 Prices

The average prices in 1989 of lightweight and normalweight aggregates presently used in Singapore, Hong Kong, and the Philippines are as follows:

	(in US$ per cubic meter)		
Aggregate	Singapore	Hong Kong	Philippines
Lightweight:			
Pumice	898	95	-
Exfoliated vermiculite	86	-	-
Perlite	-	-	6
Expanded clay	431	-	-
Expanded slag	635	-	246*
Normalweight:			
Sand	17	8	6
Gravel	97	6	8
Granite	12	-	-

* Price in 1988.

The preceding table shows that the current prices of lightweight aggregates in Singapore, Hong Kong, and the Philippines are much higher than the prices of normalweight aggregates. The most likely reason for this is that a premium is attached to the inherent advantages, principally lightness and insulating capacity, of lightweight aggregates over normalweight aggregates.

Another possible reason why lightweight aggregates are more expensive is that the country sources of these lightweight aggregates are farther from the three country markets than the country sources of normalweight aggregates. Hence, higher freight rates are incurred. For example, Singapore imports most of its pumice from Japan, and its sand, gravel, and granite from Malaysia. Hong Kong's source of pumice is Indonesia, and of sand and gravel is P.R.O.C.

1.5 ASSESSMENT OF MARKET POTENTIAL

1.5.1 Liapor's Market Position

The following aspects were considered in assessing the market potential of Liapor in Singapore, Hong Kong, and the Philippines:

- Liapor should penetrate the construction industry because Liapor is used mainly for construction purposes. Based on interviews, normalweight aggregates are commonly used by the construction industry of the three countries.

- Liapor's target market was limited to vertical construction, particularly commercial or nonresidential structures. While Liapor can be used for both infrastructure and vertical construction, its features of lightness and high thermal insulation would be appreciated more by building contractors than by infrastructure project contractors.

- Because of its lightness, Liapor is ideal for use in high rise buildings. It can, therefore, meet the aggregate requirements of the prefabricated components used in high rise buildings.

  There may be a market for Liapor in Singapore, Hong Kong, and the Philippines as indicated by the following:

  - Based on recent news articles, both the Singapore and Hong Kong governments are encouraging the use of prefabricated components such as precast floor and wall slabs, and door fittings for vertical construction;

  - Because of limited land space, majority of vertical construction in Singapore and Hong Kong are high-rise buildings; and

  - According to the Construction Industry Authority of the Philippines, contractors for high-rise structures in the Philippines are already looking into possible substitute high-quality construction materials. Developers of these structures have the capacity to pay for superior, although more expensive, construction materials.

- Liapor can technically substitute for all the normalweight aggregates, if its selling price to the end user is competitive with that of the normalweight aggregates.

1.5.2 Determination of Maximum Competitive Product Selling Price

The maximum competitive product selling price (derived price) of Liapor was calculated by:

- computing the savings in raw material, labor, and energy costs that would result if Liapor were to be used instead of normalweight aggregates. The savings is due to the technical advantages (namely, lightness and insulating capacity) of Liapor over normalweight aggregates; and

- adding the total savings to the current average price of the normalweight aggregate with which Liapor is being compared. By doing this, a premium is attached to Liapor's technical advantages over the normalweight aggregates.

The following table compares the current average price of normalweight aggregates with the derived price of Liapor for the three countries. The derived price is the highest price at which Liapor can be sold to the end user to be competitive with normalweight aggregates.

(in US$ per cubic meter)

	Singapore		Hong Kong		Philippines	
	Average Price of Normalweight Aggregate	Derived Price of Liapor	Average Price of Normalweight Aggregate	Derived Price of Liapor	Average Price of Normalweight Aggregate	Derived Price of Liapor
Sand	17.00	53.30	9.00	42.65	6.00	40.28
Gravel	97.00	152.11	6.00	44.55	8.00	46.92
Granite	12.00	51.64	-	-	-	-

As indicated in the preceding table, Liapor in Singapore can be priced to the end user 1.6 times as much as gravel, 3.1 times as much as sand, and 4.3 times as much as granite. The derived prices range from US$51.64 to US$152.11 per cubic meter.

In Hong Kong, Liapor can be priced to the end user at a maximum of US$42.65 per cubic meter vis-a-vis sand, and a maximum of US$44.55 per cubic meter vis-a-vis gravel. At these prices, Liapor would sell at 5.3 times the price of sand, and 7.4 times the price of gravel.

In the Philippines, Liapor can be sold to the end user at a maximum of US$40.28 per cubic meter when positioned against sand, and at a maximum of US$46.92 per cubic meter when positioned against gravel. At these prices, Liapor would sell at 6.7 times the price of sand, and 5.9 times the price of gravel.

To determine the FOB price of Liapor assuming Brunei as the port of origin, the freight cost of Liapor from Brunei to each of these countries should be considered. The freight cost should not exceed the total premium. If it does, the FOB price of Liapor would even have to be lower than the current average price of the normalweight aggregate.

The following table compares the total premium of Liapor vis-a-vis each normalweight aggregate with the freight cost to each country as quoted by a freight company in Brunei.

(in US$ per cubic meter)

	Singapore		Hong Kong		Philippines	
	Total Premium	Freight Rate	Total Premium	Freight Rate	Total Premium	Freight Rate
Sand	36.30	45.00	34.65	150.00	34.28	135.00
Gravel	55.11	45.00	38.55	150.00	38.92	135.00
Granite	39.64	45.00	-	-	-	-

The premiums are a function of the current average price of the normalweight aggregates. Furthermore, the freight rates presented in the table are based solely on the quotation of one shipping company in Brunei, and serve only as an indication of the prevailing freight rates from Brunei to the three countries. According to this company, at present, not too many vessels ply the above routes. For lack of competition, the few vessels which do can therefore charge high freight rates.

As shown in the above table, except for gravel in the case of Singapore, the freight cost of Liapor is higher than the total premium of Liapor vis-a-vis the normalweight aggregates.

1.5.3 Projected Demand for Liapor

Demand for Liapor was projected under two scenarios, as follows:

1.5.3.1 Scenario 1 - Liapor Will be Sold Only in Singapore

Based on the computed premium of Liapor compared with freight rates for Liapor from Brunei to the three countries, as discussed in the previous section, Liapor can be positioned competitively only against gravel in Singapore.

The following table shows the projected demand for gravel and/or granite in Singapore for selected years between 1991 to 2000, as well as the target market and projected market share of Liapor during the period. Singapore's demand for gravel and/or granite for this period is projected to grow yearly by 15 per cent.

(volume in cubic meters)

Year	Demand for Gravel/Granite	Target Market of Liapor	Market Share of Liapor	% Capacity Utilization
1991	1,486,330	133,770	6,688	2
1992	1,709,280	153,835	7,692	3
1995	2,599,610	233,965	11,698	4
1997	3,437,980	309,418	30,942	10
2000	5,228,740	470,587	47,059	16

The market share of Liapor is projected conservatively at five per cent from 1991 to 1995. From 1996 onward, when consumers would be more aware of the advantages of using Liapor, a 10 per cent share of the target market is projected.

Liapor's target market is estimated at nine per cent of projected yearly demand. The nine per cent share is based on the average percentage of floor area of commercial construction to total construction in Singapore from 1984 to 1987.

Demand for Liapor is expected to amount to at most 47,059 cubic meters in 2000. At this level, demand will be 16 per cent of the capacity of the proposed plant in Brunei of 300,000 cubic meters.

1.5.3.2 Scenario 2 - Liapor Will be Sold in Singapore, Hong Kong, and the Philippines

This scenario assumes that the proponent of the Liapor project will be able to sell Liapor in the three countries at competitive rates versus normalweight aggregates. It implies that the proponent will be able to obtain freight rates from Brunei (the proposed plant site of Liapor) to the three countries that are lower than the estimated premiums buyers will attach to Liapor.

On this basis, projected demand for Liapor by the three countries for selected years between 1991 to 2000 would be as follows:

	(volume in cubic meters)				%
Year	Singapore	Hong Kong	Philippines	Total	Capacity Utilization
1991	22,383	72,804	15,997	111,184	37
1992	25,741	83,725	18,780	128,246	43
1995	39,149	121,799	24,996	185,944	62
1997	103,548	294,754	60,491	458,793	153
2000	157,484	392,317	80,513	630,314	210

The market share of Liapor is projected conservatively at five per cent from 1991 to 1995. From 1996 onward, a 10 per cent share of the target market is projected.

By 1991, demand by the three countries is already expected to exceed one-third of the proposed Brunei plant capacity of 300,000 cubic meters during that year. Demand is projected to reach almost two-thirds (185,944 cubic meters) of plant capacity in 1995. By 2000, demand for Liapor will amount to 630,314 cubic meters (210 per cent capacity utilization).

Based on the indicated freight rates obtained in this study, however, Scenario 2 is not a likely possibility.

1.5.4 Distribution and Trade Practices

Based on interviews, sales of lightweight and normalweight aggregates in the three countries are made either directly to consumers or through middlemen.

1.5.5 Possible AIJV Partners

The following companies expressed interest in distributing Liapor on a joint venture basis. However, they did not indicate preferences in trade agreements due to lack of information on the product.

- Lightweight Concrete Group
  Jurong Industrial Estate, Singapore

- SPC Builders
  35 Selegie Road
  Parklane Shopping Mall, Singapore

- Concrete Aggregates Corporation
  Quezon City, Philippines

2. INTRODUCTION

2.1 BACKGROUND AND OBJECTIVES OF THE STUDY

The United Nations Industrial Development Organization (UNIDO) has been assisting the Committee on Industry, Minerals, and Energy (COIME) to identify, prepare, and promote projects for the ASEAN Industrial Joint Venture (AIJV) program. In this connection, UNIDO has engaged the services of SyCip, Gorres, Velayo and Company (SGV) to assist in assessing the market potential of four selected product categories. The product category covered by this study is lightweight aggregates, specifically Liapor, a spherical and porous product of expanded shale.

The report compilation was coordinated by the International Team Leader of Project No. DP/RAF/85/010, who also provided SGV with the materials about the product and the market survey portion of the feasibility study conducted by a European consulting firm.

The technology of Liapor was developed by a German company, and it meets the German standard for a lightweight aggregate to be used by the civil construction industry. Liapor has not yet been introduced to the ASEAN market. Based on a feasibility study conducted by a European consulting firm, a new lightweight aggregate manufacturing plant with a capacity of 300,000 cubic meters per year can be established in Negara Brunei Darussalam.

This market study aims to analyze the market potential for Liapor in three countries, namely Singapore, Hong Kong, and the Philippines. The study focuses on the Singapore market.

For each country market, the study aims to:

- o evaluate the performance of the construction industry during the past recent years;
- o identify the uses of aggregates;
- o forecast demand for aggregates;
- o determine the competitive price at which Liapor can be sold, based on an analysis of the technical and cost advantages of using Liapor, and the willingness of the market to pay a premium for these advantages;

- o forecast demand for Liapor, taking into account the competitive price setup, market penetration ratio, and transportation costs; and
- o recommend potential AIJV promoters to act as sales agents or distributors for Liapor.

2.2 METHODOLOGY

The market data presented in this report consist mainly of available secondary data obtained from trade publications, industry associations, and government agencies. To supplement secondary data, key informant interviews with selected major manufacturers and suppliers of lightweight and normalweight aggregates were conducted.

2.3 PRODUCT COVERAGE

Aggregates are inert granular materials which, when bound together, form concrete, mastic, mortar, and plaster. Aggregates are classified into two: normalweight and lightweight. The normalweight aggregates - normally used in mass and reinforced concrete - include natural sand, gravel, crushed stones and pebbles, and granite. The lightweight aggregates include pumice, foamed slag, fly ash, expanded clay, shale, and slate, exfoliated vermiculite, diatomite, scoria, and expanded volcanic glasses such as perlite. Aggregates do not include finely divided or pulverized stone or sand sometimes used with cement that are more properly termed as admixture or filler.

The materials of lightweight aggregates can be divided into two main groups: natural and artificial. Pumice is the only representative of the natural group. The artificial aggregates consist of materials made by processing artificial or natural products which include foamed or expanded slag, expanded clays, shales, and slates, together with two very light materials, exfoliated vermiculite and expanded perlite. In addition, sintering processes have been developed for producing lightweight aggregate from pulverized fuel ash (fly ash).

Some lightweight aggregates, such as pumice, foamed slag, and fly ash, are used in the manufacture of lightweight non-structural concrete. Artificial and processed aggregates, notably expanded clays and shales, foamed slag, and sintered fly ash pellets, have been used for lightweight structural concrete.

Lightweight aggregates when mixed with cement result in concrete which is light in weight and low in thermal conductivity. The density of ordinary normalweight concrete ranges from about 2240 to 2400 kilograms per cubic meter (kg. per cu. m.), while that of most lightweight concretes from 640 to 1600 kg. per cu. m. All types of lightweight concrete are subject to high shrinkage, except those made with expanded clays, shales, and scoria. The strength of lightweight concrete varies considerably; that is, it will be almost inversely proportional to the weight of the aggregate. Comparisons, however, are not always easily made because of the difficulty of making concrete mixes that have the type of aggregate as the sole variable. Relatively high strength is obtained with expanded clay and shale; intermediate strength with pumice, scoria, and expanded slag; and low strength with diatomites, perlite, and exfoliated vermiculite. On the other hand, the insulating properties of the last group are better than those of the first group. However, even crushed clay and shale concrete have four times the insulating value of ordinary concrete.

Using lightweight aggregates instead of normalweight aggregates reduces the dead weight of buildings and other structures with consequent savings in cost, especially in terms of the foundation. Precast blocks and slabs made of lightweight concrete cost less to transport than dense materials, and are faster and cheaper to erect. Furthermore, lightweight aggregates are better insulators, thereby minimizing expensive energy losses.

The proposed product, Liapor, is a lightweight aggregate of expanded shale. Its raw material is extracted by open-face mining, and is carefully prepared, pulverized, and pelletized into small round pellets. The shale pellets are burnt in large rotary kilns at approximately 1200°C (2200°F) without artificial admixtures or chemical air entraining agents. The organic substances inside the shale burn, with the resulting gases causing the pellets to expand. At the same time, the outer skin is sintered. In this way, light shale spheres with fine pores are produced, which have an aerated core and high compressive strength. Its porous structure and light weight give Liapor a high thermal insulation and thermal inertia. During production, the size, weight, and strength of Liapor are carefully controlled, which makes its appearance and quality consistent. Liapor weighs from 300 to 800 kg. per cu. m., and its thermal conductivity is between 0.10 to 0.20 watt per meter Kelvin.

Liapor is used mainly for construction purposes. With its outstanding physical and technical properties, Liapor is an ideal material for producing low density, high insulating lightweight blocks. Furthermore, precast cellar window frames, lintels, rolling shutter cases and floor slabs can be made using Liapor lightweight concrete and Liapor lightweight mortar. The use of Liapor walls and building components protects against expensive energy losses. At present, the materials used for these purposes in Singapore, Hong Kong, and the Philippines are the lightweight aggregates pumice, exfoliated vermiculite, and perlite. This study discusses the lightweight aggregates presently used in Singapore, Hong Kong, and the Philippines.

Since Liapor can substitute for normalweight aggregates, this report also discusses the market of currently used normalweight aggregates in the three countries covered. The normalweight aggregates used by the three country markets are sand, gravel, crushed stones and pebbles, and granite.

A brief description on the characteristics and uses of the lightweight and normalweight aggregates used in the three country markets follows:

2.3.1 Existing Lightweight Aggregates

2.3.1.1 Pumice

Characteristics

Pumice is a light-colored, porous, frothlike, volcanic glass with a bulk density of about 500 to 900 kg. per cu. m.. It contains 65 to 75 per cent silica, 12 to 15 per cent alumina, and four to five per cent each of soda and potassium. Its specific gravity is 2.3 to 2.4, and its composition makes pumice virtually fireproof. The dead air cells that characterize its internal structure give pumice excellent insulating properties against heat and sound.

Uses

In its powdered or ground form, pumice is used as a heat-insulating, lightweight aggregate in concrete. Those varieties of pumice which are not too weak structurally make a satisfactory concrete with a density of 700 to 1400 kg. per cu. m.. Pumice is also used as an ingredient of plaster and lightweight pozzolana cement, and in the manufacture of bricks; serves as a fine abrasive for polishing; and as a filler in paints and plastics. The minor uses of pumice include insecticides, filtration, absorbents, soil conditioning, and surfacing and ice control of roads.

2.3.1.2 Exfoliated Vermiculite

Characteristics

Vermiculite is a type of mica widely used in the construction industry. It consists of hydrated magnesium aluminum iron silicate characterized by a foliated structure. It occurs in yellowish to brown crystalline plates which can measure up to more than nine inches (228.6 millimeters) across and six inches (152.4 millimeters) in thickness. The specific gravity of the unexpanded, crystalline form varies from about 2.3 to 2.7.

When heated to a temperature of 650 to 1000°C (about 1200 to 1800°F), vermiculite expands to several, or even as many as 30, times its original volume by exfoliation of its thin plates. As a result, the bulk density of exfoliated vermiculite is only 60 to 130 kg. per cu. m. In its exfoliated or expanded form, vermiculite is characterized by low density, low thermal conductivity, resistance to high temperatures, and chemical inertness.

Uses

Vermiculite in expanded form is widely used in many types of thermal and acoustic insulation, as loose fill in buildings, as an aggregate in concrete, and as an ingredient in plaster, insulating concrete, and fireproofing compositions.

2.3.1.3 Perlite

Characteristics

Perlite is a glassy, volcanic rock, with general composition as follows: silicon dioxide, 65 to 75 per cent; aluminum oxide, 10 to 20 per cent; water, two to five per cent; and small amounts of soda ($NaCO_3$), potash (KCO_3), and lime (CaO). Its specific gravity is about 2.4 (unexpanded).

Perlite is often characterized by a minute globular structure and a high percentage of loosely combined water. When heated rapidly above a temperature of 900 to 1100°C, perlite expands many times owing to the evolution of steam and forms a cellular material with a bulk density as low as 30 to 240 kg. per cu. m.. The countless, tiny, glass-sealed bubbles within each particle account for perlite's lightweight, thermal-sound insulating and absorptive properties.

Uses

Expanded perlite is widely used in construction as a lightweight, inert, fire-resistant aggregate with acoustic and thermal insulation value for concrete and plaster. It is also used for nonconstruction purposes, which include:

- o manufacture of thermal insulation pipes and acoustic tiles;
- o as a filter for various products such as beer, hydrogenated vegetable oils, cane sugar, raw sugar liquor, and wax;

- o as a filler in paints and plastics;
- o as a drying agent for powdered agricultural pesticides; and
- o as a grinding aid for herbicides and insecticides.

2.3.1.4 Expanded Clay, Shale, and Slate

Characteristics

Expanded clay, shale, and slate are obtained by heating suitable raw materials in a rotary kiln to a temperature of 1000 tc 1200°C (about 1800 to 2200°F) when expansion of the material takes place due to the generation of gases which become entrapped in a viscous pyrpoplastic mass. This porous structure is retained on cooling so that the apparent specific gravity of the expanded material is lower than before heating. Often, the raw material is reduced to the desired size before heating, but crushing after expansion may also be applied. Expansion can also be achieved by the use of a sinter strand. Here, the moistened material is carried by a traveling grate under burners so that heating gradually penetrates the full depth of the bed of the material. Its viscosity is such that the expanded gases are entrapped. As with the rotary kiln, either the cooled mass is crushed or initially pelletized material is used.

The process of expansion is more often carried out in a rotary kiln rather than the use of sintering grates. The density of expanded shale and clay aggregates when made in a rotary kiln is 300 to 650 kg. per cu. m., while the density of those made by the sinter strand process is 650 to 900 kg. per cu. m.

Uses

Expanded clay and shale can produce concrete with a density usually within the range of 1400 to 1800 kg. per cu. m., although values as low as 800 kg. per cu. m. have been obtained. Concrete made with expanded clay or shale aggregates has a higher strength than when any other lightweight aggregate is used.

2.3.1.5 Expanded Slag

Characteristics

Slag is a nonmetallic product that separates in the smelting of metals. It is formed from the earthy materials in the ore and from the flux. The term usually refers to iron blast-furnace slag. The chemical composition of blast-furnace slag falls within the range of 30 to 42 per cent silica, 10 to 14 per cent alumina, 36 to 45 per cent lime, one to three per cent sulfur, about two per cent magnesia, and some ferric and manganese oxide. The sulfur present is mainly in the form of sulfides which do not corrode metals to any appreciable extent. Slag is alkaline, and this alkalinity generally prevents corrosion.

Expanded slag is produced with a bulk density varying between 300 to 1100 kg. per cu. m., depending on the details of the cooling process, and to a certain degree, on the particle size and grading.

Uses

Slag is the raw material for the manufacture of portland cement and mineral wool.

2.3.2 Normalweight Aggregates

2.3.2.1 Sand and Gravel

Characteristics

Sand and gravel are unconsolidated granular materials resulting from natural disintegration and abrasion of rocks. They are composed of the more resistant minerals which have been able to withstand for a long period the destructive effects of weather and transport. Most sand and gravel used in mortars and concrete are obtained from river and glacial deposits. Other sources are crushed friable sandstones and sea sands. The latter need to be well-washed on account of the presence of soluble salts. The division between sand and gravel is an arbitrary one based on size; for concrete, material which will pass a 3/16 inch mesh is usually classed as sand, and larger material as gravel. Sand weighs about 1520 kg. per cu. m., while gravel weighs about 1490 kg. per cu. m.

The particles of sand generally consist each of an individual mineral, and by far the most common mineral is quartz. Other minerals remaining from the weathering of rocks are present in small amounts, and of these, feldspars, and the clays derived from them, rank next in importance. Flakes of mica and black grains of iron ores may be present in small amounts. Some sands contain a certain amount of organic matter, derived usually from associated loam, which in some cases seriously retards the hardening of concrete.

Gravel is composed of a variety of minerals, and the individual pebbles are often heterogeneous. Flint and chert (both minutely crystalline forms of silica distinct from quartz), quartz, quartzite, and granite are the common constituents of gravel, but sandstone and limestone gravels are also found. Gravel is used in both the crushed and uncrushed condition. The former tends to be sharper and more angular in character than the rounded and smooth uncrushed material. It has often been considered that sharpness is a desirable characteristic in an aggregate, and that it ensures a better bond between cement and aggregate. Sharp aggregates give less workable mixes, requiring somewhat more water than rounded aggregates, and for a given workability, the compressive strength tends to be reduced.

Uses

More than one-half of the sand and gravel produced is consumed in concrete construction, either highways or buildings. About two-thirds of all gravel is used for paving (including concrete, bituminous, and cheaper construction); and the balance is used chiefly in buildings and for railroad ballast. More sand is used in building than in paving, but these uses together account for over three-fourths of the consumption, the balance being special sands and a small amount of railroad ballast and miscellaneous-purpose sand.

2.3.2.2 Granite

Characteristics

Granite is a coarse- or medium-grained intrusive igneous rock which is rich in quartz and feldspar. This rock is formed by the cooling of magma (melted silicate). It is usually found in dikes or fissures inserted between rocks. It forms irregular masses of extremely variable size, ranging from less than eight kilometers in dimension, to hundreds or thousands of square kilometers in area. The principal constituent of granite is feldspar. Minor minerals in granite may include muscovite, biotite, amphibole, and pyroxene. Granite weighs about 1490 kg. per cu. m.

Uses

Granite is used as paving block and as a building stone. At present, granite quarrying is geared towards the material's use in highway construction and as facing of large industrial and commercial buildings.

3. THE SINGAPORE MARKET

3.1 BACKGROUND ON THE CONSTRUCTION INDUSTRY

3.1.1 Industry Structure

The construction industry of Singapore engages in infrastructure development, upgrading work, and construction of buildings.

The industry, considered to be the powerhouse of Singapore's economy in the early 1980s, experienced a decline in the mid-80s. In terms of contribution to gross domestic capital formation, the construction industry's performance worsened from 1984 to 1988. From US$5.52 billion in 1984, gross domestic capital formation for construction (at 1985 market prices) dropped to US$3.20 billion in 1988, averaging an annual decrease of about 13 per cent. (See Table 1.)

Table 1
GROSS DOMESTIC CAPITAL FORMATION IN SINGAPORE
1984-1988
(value in 1985 market prices, million US$)

Construction	1984	1985	1986	1987	1988
Residential buildings	3,070.41	2,393.15	1,708.74	1,486.09	1,538.41
Nonresidential buildings	1,921.38	1,492.96	1,019.15	862.01	949.71
Others	531.01	662.30	1,035.96	1,091.93	715.71
Total	5,522.80	4,548.41	3,763.85	3,440.03	3,203.83

Source: Singapore Department of Statistics.

However, signs of a recovery emerged by late 1989, with the sector growing in the third quarter, after four and a half years of decline. The strength of the domestic economy, booming tourism, public housing refurbishment plans, and strong interest in the Singapore property sector from Hong Kong are factors operating for a sustained recovery in the next few years.

In 1989, the total estimated value of construction projects amounted to US$1.28 billion. Of this amount, the public sector accounted for 71.5 per cent, or US$915.41 million, while the private sector accounted for 28.5 per cent or US$364.70 million. (See Table 2.)

Table 2
ESTIMATED EXPENDITURES OF THE CONSTRUCTION INDUSTRY IN SINGAPORE
1989
(value in thousand US$)

Sector	Value	%
Public	915,405.25	71.5
Private	364,704.10	28.5
Total	1,280,109.35	100.0

Source: Construction Industry Development Board.

Total construction dropped at an average of about 22 per cent from 1984 to 1987. Floor area of completed construction in 1987 amounted to 7.16 million square meters, down from the four-year high of 14.99 million square meters in 1984. Public construction accounted for the bulk of construction during the four years. (See Table 3.)

Table 3
CONSTRUCTION PROJECTS COMPLETED IN SINGAPORE
1984-1987
(floor area in thousand square meters)

Year	Public	%	Private	%	Total
1984	11,662.10	78	3,327.40	22	14,989.50
1985	8,545.50	75	2,878.40	25	11,423.90
1986	6,231.00	69	2,809.90	31	9,040.90
1987	5,504.40	77	1,655.60	23	7,160.00

Source: Yearbook of Statistics of Singapore, 1987.

3.1.2 Public Sector

In the public sector, 62 per cent or US$567.00 million went to building projects, mainly to residential buildings. Infrastructure development reached US$348.40 million, with sewerage and drainage projects contributing the highest value. (See Table 4.)

Table 4
ESTIMATED EXPENDITURES OF PUBLIC SECTOR PROJECTS
IN SINGAPORE
1989
(value in thousand US$)

Type	Estimated Expenditures	
	Value	%
Buildings		
Residential	243,406.06	27
Health care	91,125.40	10
Institutional	87,682.88	10
Factories	66,470.92	7
Commercial	39,133.30	4
Recreational	26,071.99	3
Others	13,111.93	1
Sub-total	567,002.48	62
Infrastructure		
Sewerage and drainage	106,515.47	12
Ports and airports	96,542.30	10
Roads and bridges	76,190.96	8
Communications	15,136.94	2
Utilities	7,998.78	1
Others	46,018.32	5
Sub-total	348,402.77	38
Total	915,405.25	100

Source: Construction Industry Development Board.

In terms of floor area, public construction declined at an average rate of 22 per cent from 1984 to 1987. (See Table 5.) From 11.66 million square meters in 1984, floor area of public sector construction projects dropped to 5.50 million square meters in 1987. During the four-year period, residential buildings accounted for from 81 per cent to 88 per cent of total floor area of public construction.

Table 5
PUBLIC CONSTRUCTION IN SINGAPORE BY TYPE OF CONSTRUCTION
1984-1987
(floor area in thousand square meters)

	Residential		Commercial		Industrial		Institutional		Others		Total	
Year	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)
1984	9,960.10	-	464.50	-	583.10	-	604.60	-	49.80	-	11,662.10	-
1985	7,511.60	(24.58)	272.60	(41.31)	349.00	(40.15)	411.50	(31.94)	0.80	(98.39)	8,545.50	(26.72)
1986	5,099.70	(32.11)	274.00	0.51	44.00	(87.39)	812.90	97.55	0.40	(50.00)	6,231.00	(27.08)
1987	4,480.90	(12.13)	212.50	(22.45)	-	(100.00)	671.80	(17.36)	139.20	34,700.00	5,504.40	(11.66)

Source: Yearbook of Statistics of Singapore, 1987.

3.1.3 Private Sector

In the private sector, 54 per cent or US$198.70 million went to construction of commercial buildings. On the other hand, residential construction accounted for 17 per cent, or US$60.70 million. (See Table 6.)

Despite the smaller share of private sector construction in total 1989 project value for construction as compared to public sector construction, the Construction Industry Development Board (CIDB) of Singapore expects the former to get more than half of total contracts in 1990.

Table 6
ESTIMATED VALUE OF PRIVATE SECTOR BUILDING PROJECTS IN SINGAPORE
1989
(value in thousand US$)

Type of Project	Estimated Contract Value	%
Commercial	198,703.99	54
Residential	60,699.64	17
Hotel	46,068.95	13
Health care	43,790.82	12
Others	15,440.70	4
Total	364,704.10	100

Source: Construction Industry Development Board.

As shown in Table 7, completed construction by the private sector in 1987 amounted to 1.66 million square meters, half the level recorded in 1984. Private construction declined yearly by an average 21 per cent. The sharpest drop registered during the four-year period was from the 1986 level of 2.81 million, to the 1987 level.

The CIDB projects that the construction industry will contribute nine to 11 per cent of the country's gross domestic product (GDP) in the following years. This is much higher than the 6.8 per cent contribution of construction to GDP in 1988.

The construction industry of Singapore is faced with challenges such as labor shortage, and higher expectations on quality from consumers. Singapore's Ministry of National Development has recognized that the use of precast components and mechanized methods of building construction will help solve these problems as well as upgrade the construction industry.

Projected construction demand from 1990 to 1992, in terms of value of construction jobs, is shown in Table 8.

Table 7
PRIVATE CONSTRUCTION IN SINGAPORE BY TYPE OF CONSTRUCTION
1984-1987
(floor area in thousand square meters)

	Residential		Commercial		Industrial		Institutional		Others		Total	
Year	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)
1984	1,257.10	-	1,041.80	-	948.00	-	68.60	-	11.90	-	3,327.40	-
1985	1,709.90	36.02	455.60	(56.27)	635.90	(32.92)	49.40	(27.99)	27.60	131.93	2,878.40	(13.49)
1986	1,151.20	(32.67)	1,174.60	157.81	429.20	(32.51)	39.80	(19.43)	15.10	(45.29)	2,809.90	(2.38)
1987	611.70	(46.86)	608.90	(48.16)	360.70	(15.96)	72.20	81.41	2.10	(86.09)	1,655.60	(41.08)

Source: Yearbook of Statistics of Singapore, 1987.

Table 8
PROJECTED CONSTRUCTION DEMAND IN SINGAPORE
1990-1992
(value in million US$)

Sector	1990	1991	1992
Public	2,040	1,850	1,660
Private	1,120	975	620
Total	3,160	2,825	2,280

Note: Conversion rate of US$1: Singapore $1.9753 was used based on the average 1989 conversion rate.

Source: Construction Industry Development Board.

3.2 DEMAND

3.2.1 Historical Demand

3.2.1.1 Existing Lightweight Aggregates

Singapore uses the lightweight aggregates pumice, slag wool, exfoliated vermiculite, and expanded clays. Table 9 shows the estimated consumption by Singapore of these aggregates from 1987 to 1989, based on imports for domestic consumption.

Based on interviews, lightweight aggregates are not commonly used in Singapore for construction purposes.

Table 9
ESTIMATED CONSUMPTION OF LIGHTWEIGHT AGGREGATES IN SINGAPORE
1987-1989
(volume in metric tons; value in thousand US$ CIF)

Commodity	1987		1988		1989	
	Volume	Value	Volume	Value	Volume	Value
Pumice stone and other natural abrasives	96.00	155.74	481.00	625.62	1,517.33	1,947.38
Slag wool, rock wool, and other mineral wools, exfoliated vermiculite, expanded clays, and other similar materials	7,307.00	7,982.27	7,936.00	7,431.43	9,228.00	8,373.42

Note: 1989 figures were annualized.

Source: Singapore Trade Statistics.

3.2.1.2 Normalweight Aggregates

On the other hand, the normalweight aggregates used in Singapore are sand, gravel, and granite. These aggregates are used by the construction industry.

Table 10 summarizes the estimated consumption of normalweight aggregates by the vertical construction industry in Singapore from 1984 to 1989. About 70 per cent of total consumption pertains to sand, while the remaining 30 per cent pertains to gravel and granite.

Consumption by vertical construction declined at an average annual rate of 11 per cent during the six-year period. Consumption was highest in 1984 at 6.89 million cubic meters. Consumption by type of usage is broken down in the succeeding tables.

Consumption of normalweight aggregates broken down by total construction (that is, vertical and infrastructure construction) could not be inferred because of the lack of data on infrastructure construction in Singapore.

Table 10
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES BY VERTICAL CONSTRUCTION IN SINGAPORE
1984-1989
(volume in cubic meters)

Year	Normalweight Aggregate Consumption
1984	6,889,123.38
1985	4,580,787.02
1986	3,874,546.08
1987	2,843,950.20
1988	3,270,542.74
1989	3,761,124.14

Source of basic data: Yearbook of Statistics of Singapore, 1987.

Prefabricated Walls

Based on inferred data during the period 1984 to 1989, estimated consumption of normalweight aggregates for prefabricated walls was highest in 1984 at 443,410 cubic meters. Consumption over the six-year period declined at an average rate of five per cent. (See Table 11.)

Table 11
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES FOR PREFABRICATED WALLS IN SINGAPORE
1984-1989
(volume in cubic meters)

Year	Nonresidential	Residential	Total
1984	126,021.12	317,389.10	443,410.22
1985	44,347.50	296,818.92	341,166.42
1986	62,185.35	219,396.74	281,582.09
1987	54,467.00	206,030.71	260,497.71
1988	62,637.05	236,935.32	299,572.37
1989	72,032.61	272,475.61	344,508.22

Source of basic data: Yearbook of Statistics of Singapore, 1987.

Usage of prefabricated walls by residential and nonresidential construction from 1984 to 1987 and the equivalent normalweight aggregate consumption were inferred in the following manner:

a. The basic data used were the number and floor area of residential and nonresidential structures completed yearly in Singapore.

b. All structures were assumed to be single detached units having four exterior walls. The average area of an exterior wall was estimated by multiplying:

   - o the square root of the quotient of the floor area and the number of total structures constructed, to represent the length of the wall; by
   - o a standard wall height of 4.0 meters. The resulting area is multiplied by 4, under the assumption that each structure has 4 equal sides.

c. Each wall has an average thickness of 0.2 meter.

d. To estimate the equivalent sand volume requirement, the total concrete volume (area of the wall multiplied by the thickness of the wall) is multiplied by 1.0 cubic meter.

e. To estimate consumption of normalweight aggregates for 1988 and 1989, a 15 per cent growth rate was applied on the 1987 estimated consumption. The 15 per cent rate was based on the increase in Singapore's demand for aggregates from the third quarter of 1988 to the same quarter of 1989.

Other Uses

Normalweight aggregates are also used in structural parts (that is, beams and columns), roof tiles, and roof and floor slabs of buildings. The biggest consumption of normalweight aggregates was in 1984 at 6.45 million cubic meters. From 1984 to 1989, normalweight aggregate consumption for structural and roofing purposes declined at an annual average rate of 12 per cent. (See Table 12.)

Table 12
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES FOR STRUCTURAL PARTS AND ROOFING IN SINGAPORE
1984-1989
(volume in cubic meters)

Year	Beams			Columns			Roof Tiles (Residential	Roof and Floor Slabs (Nonres.)	Total Normalweight Aggregate Consumption
	Residential	Nonres.	Total	Residential	Nonres.	Total			
1984	4,757,274.00	252,036.04	5,009,310.04	2,959.88	14,941.33	17,901.21	73,781.91	1,344,720.00	6,445,713.16
1985	3,437,896.53	5,097.96	3,442,994.49	3,148.88	2,029.16	5,178.04	60,948.07	730,500.00	4,239,620.60
1986	2,137,155.75	17,865.58	2,155,021.33	2,538.00	3,861.33	6,399.33	41,463.33	1,390,080.00	3,592,963.99
1987	1,510,526.73	9,309.62	1,519,836.35	2,747.25	2,844.50	5,591.75	34,004.39	1,024,020.00	2,583,452.49
1988	1,737,105.74	10,706.06	1,747,811.80	3,159.34	3,271.18	6,430.52	39,105.05	1,177.623.00	2,970,970.37
1989	1,997,671.60	12,311.97	2,009,983.57	3,633.24	3,761.85	7,395.09	44,970.81	1,354,266.45	3,416,615.92

Source of basic data: Yearbook of Statistics of Singapore, 1987.

The volume of normalweight aggregates consumed for structural parts and roofing was inferred from data on the number and floor area of residential and nonresidential structures built annually from 1984 to 1987. Normalweight aggregate consumption in 1988 and 1989 was projected by applying a 15 per cent increase per year on the 1987 consumption. The assumptions for the structural parts and roofing are shown below.

Beams

a. The average number of prefabricated beams per side of a residential structure is equal to one half the square root of the quotient of the floor area and the number of total structures constructed.

b. The average number of prefabricated beams per side of a nonresidential structure is equal to the square root of the quotient of the floor area and the number of total structures constructed.

c. Beams have an average span of 6 meters. The depth of a beam is equal to or greater than 10 per cent of the span. The base of the beam is 50 per cent of the beam's depth.

d. Class A concrete mix was used. Class A concrete mix requires 1.0 cubic meter of gravel and 0.5 cubic meter of sand for every cubic meter of concrete.

Columns

a. Residential structures have 9 prefabricated concrete columns, each with a height of 4.0 meters.

b. The average number of prefabricated columns in nonresidential structures was determined by getting the square root of the quotient of the floor area and the number of residential structures.

c. For residential structures, the sectional area of each columns conforms to the American Concrete Institute requirement of 0.0625 square meter. The average length of a column is 4.0 meters.

d. For residential structures, the length and width of each column measures 0.2 meter, while the height of the column measures 4.0 meters.

e. All structures use Class A concrete mix.

Roof Tiles (Residential Structures)

a. The slope of the roof is approximately 14 degrees with a 1.0 meter overhang on all sides.

b. The tiles have an overlap of 15 per cent.

c. The roofing material has an average thickness of 0.125 meter.

d. Class A mortar mix was used. Class A mortar mix requires 1.0 cubic meter of sand for every cubic meter of concrete.

Flat Roof and Floor Slabs (Nonresidential Structures)

a. Each structure uses one floor slab and one roof slab, both prefabricated units.

b. The slabs have a thickness of 0.2 meter.

c. Class A concrete mix was used.

3.2.2 Demand Projections

3.2.2.1 Existing Lightweight Aggregates

Table 13 presents Singapore's projected demand for existing lightweight aggregates from 1990 to 2000. According to CIDB, Singapore's consumption of aggregates increased by 15 per cent from the third quarter of 1988 to the same quarter of 1989. This rate was applied to the 1989 estimated consumption of lightweight aggregates by Singapore to project demand for the years until 2000.

In 1990, demand for lightweight aggregates is expected to reach 12,360 MT. Demand is projected at 16,340 MT, 24,850 MT, and 49,990 MT in 1992, 1995, and 2000, respectively.

Table 13
PROJECTED DEMAND FOR EXISTING LIGHTWEIGHT AGGREGATES
IN SINGAPORE
1990-2000
(volume in metric tons)

Year	Pumice stone and other natural abrasives	Slag, rock, and other mineral wools, exfoliated vermiculite, expanded clays, and other similar materials	Total Lightweight Aggregate Demand
1990	1,750	10,610	12,360
1991	2,010	12,200	14,210
1992	2,310	14,030	16,340
1995	3,510	21,340	24,850
1997	4,640	28,230	32,870
2000	7,060	42,930	49,990
Average Annual Growth Rate, 1990-2000 (%)			15

3.2.2.2 Normalweight Aggregates

Table 14 presents Singapore's projected demand for normalweight aggregates for selected years between 1990 to 2000. The 15 per cent growth rate used in projecting demand for lightweight aggregates was applied to the 1987 estimated consumption of normalweight aggregates by vertical construction in Singapore to project demand until 2000.

Table 14
PROJECTED DEMAND FOR NORMALWEIGHT AGGREGATES
IN SINGAPORE
1990-2000
(volume in cubic meters)

Year	Normalweight Aggregate Demand
1990	4,325,290
1991	4,974,090
1992	5,720,200
1995	8,699,710
1997	11,505,360
2000	17,498,220
Average Annual Growth Rate, 1990-2000 (%)	15

In 1990, demand for normalweight aggregates is expected to reach 4.33 million cubic meters, Demand is projected at 5.72 million cubic meters, 8.70 million cubic meters, and 17.50 million cubic meters in 1992, 1995, and 2000, respectively.

3.3 SUPPLY

3.3.1 Local Production

There are no available data on the total production of lightweight and/or normalweight aggregates by Singapore.

3.3.2 Imports

3.3.2.1 Existing Lightweight Aggregates

Pumice Stone and Other Natural Abrasives

Singapore's imports of pumice stone and other natural abrasives for domestic consumption grew by an impressive 298 per cent from 1987 to 1989. From a low 96 MT in 1987 valued at US$155,740, imports for domestic consumption shot up to 481 MT, valued at US$625,620 in 1988, and to its highest at 1,517 MT, valued at US$1.95 million, in 1989. (See Table 15.)

The bulk (66 per cent) of Singapore's imports of pumice stone and other natural abrasives in 1989 was sourced from Japan. Singapore's second biggest supplier was the United States, which exported 429 MT, about 23 per cent of Japan's export volume in the same year.

Slag, Rock, and Other Mineral Wools, Exfoliated Vermiculite, Expanded Clays, and Other Similar Materials

Singapore's imports of slag, rock, and other mineral wools, exfoliated vermiculite, expanded clays, and other similar materials for domestic consumption in 1989 amounted to 9,228 MT, valued at US$8.37 million. These were the highest import volume and value recorded during the period 1987 to 1989. Imports increased from 7,307 MT in 1987 to 7,936 MT in 1988. However, during these same years, import value decreased from US$7.98 million to US$7.43 million. Singapore's imports of slag, rock, and other mineral wools, exfoliated vermiculite, expanded clays, and other similar materials grew by an average of 12 per cent from 1987 to 1989. (See Table 16.)

Table 15
IMPORTS OF PUMICE STONE AND OTHER NATURAL ABRASIVES OF SINGAPORE BY COUNTRY OF ORIGIN
1987-1989
(volume in metric tons; value in thousand US$ CIF)

Country of Origin	1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Japan	28.00	69.33	7	196.00	306.60	18	1,884.00	1,729.36	66
United States	113.00	141.98	28	433.00	306.60	39	429.33	305.78	1[illegible]
People's Republic of China	174.00	29.91	44	239.00	54.16	22	141.33	27.68	5
Others	85.00	91.16	21	243.00	224.11	21	386.67	375.29	14
Total Imports	400.00	332.38	100	1,111.00	891.47	100	2,841.33	2,438.11	100
Less: Re-exports	304.00	176.64	76	630.00	265.85	57	1,324.00	490.73	47
Imports for Domestic Consumption	96.00	155.74	24	481.00	625.62	43	1,517.33	1,947.38	53

Note: 1989 figures were annualized.

Source: Singapore Trade Statistics.

Table 16
IMPORTS OF SLAG, ROCK, AND OTHER MINERAL WOOLS, EXFOLIATED VERMICULITE, EXPANDED CLAYS, AND OTHER SIMILAR MATERIALS OF SINGAPORE BY COUNTRY OF ORIGIN
1987-1989
(volume in metric tons; value in thousand US$ CIF)

Country of Origin	1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Malaysia	1,390.00	1,160.02	18	1,622.00	1,489.76	18	2,122.67	1,757.71	21
United States	1,227.00	1,821.94	16	2,040.00	2,626.71	22	1,848.00	2,125.59	19
United Kingdom	960.00	632.95	12	1,710.00	1,238.32	19	1,814.67	1,165.73	18
Japan	1,811.00	1,457.26	23	1,387.00	1,419.70	15	1,709.33	1,408.73	17
Hong Kong	n.a.	n.a.	-	9.00	16.40	*	n.a.	n.a.	-
Others	2,441.00	3,353.59	31	2,375.00	2,033.90	26	2,465.33	2,723.63	25
Total Imports	7,829.00	8,425.76	100	9,143.00	8,824.79	100	9,960.00	9,181.39	100
Less: Re-exports	522.00	443.49	7	1,207.00	1,393.36	13	732.00	807.97	7
Imports for Domestic Consumption	7,307.00	7,982.27	93	7,936.00	7,431.43	87	9,228.00	8,373.42	93

* Less than 1.

n.a. - Not available.

Note: 1989 figures were annualized.

Source: Singapore Trade Statistics.

Malaysia was Singapore's biggest supplier in 1989, when it exported 2,123 MT to Singapore. In that year, Malaysia accounted for 21 per cent of total Singapore imports. It was closely followed by the United States, the United Kingdom (U.K.), and Japan, which accounted for 19 per cent, 18 per cent, and 17 per cent, respectively, of Singapore's 1989 imports.

In 1988, Singapore sourced less than one per cent (nine MT) of its imports from Hong Kong.

3.3.2.2 Normalweight Aggregates

Natural Sands

Singapore's imports of natural sands for domestic consumption declined steadily from 1987 to 1989. As shown in Table 17, import volume for domestic consumption dropped slightly from 1.29 million in 1987 to 1.26 million in 1988. Despite this decrease, however, import value went up from US$10.29 million to US$10.99 million for the same period. Imports decreased by a greater margin in 1989 to 898,399 MT valued at US$9.54 million. Negative growth of an average 16 per cent was registered during the three-year period.

Almost 99 per cent of Singapore's imports in 1989 came from Malaysia, Singapore's biggest supplier during the three-year period. In that year, imports from this country amounted to 972,585 MT, valued at US$6.06 million. The United States accounted for almost one per cent of Singapore imports in the same year, when it exported 8,980 MT valued at US$3.32 million.

Imports from the Philippines grew from 178 MT in 1987, to 248 MT in 1988, and to 293 MT in 1989. However, these accounted for less than one per cent of Singapore's imports during the three-year period.

Table 17
IMPORTS OF NATURAL SANDS OF SINGAPORE BY COUNTRY OF ORIGIN
1987-1989
(volume in metric tons; value in thousand US$ CIF)

Country of Origin	1987 Volume	1987 Value	1987 %	1988 Volume	1988 Value	1988 %	1989 Volume	1989 Value	1989 %
Malaysia	1,274,277.00	8,644.82	98	1,238,907.00	7,697.77	96	972,585.33	6,058.83	99
United States	2,526.00	873.22	*	11,464.00	2,512.92	1	8,980.00	3,316.96	1
Philippines	177.69	18.52	*	248.49	22.86	*	293.33	33.08	*
Thailand	17,690.00	107.79	2	33,627.00	243.99	3	n.a.	n.a.	-
Others	3,448.31	895.54	*	3,148.51	986.38	*	3,560.01	1,117.80	*
Total Imports	1,298,119.00	10,539.89	100	1,287,395.00	11,463.92	100	985,418.67	10,526.67	100
Less: Re-exports	10,625.00	253.09	1	26,150.00	469.59	2	87,020.00	986.17	9
Imports for Domestic Consumption	1,287,494.00	10,286.80	99	1,261,245.00	10,994.33	98	898,398.67	9,540.50	91

* Less than 1.

n.a. - Not available.

Note: 1989 figures were annualized.

Sources: Singapore Trade Statistics
Foreign Trade Statistics of the Philippines.

Pebbles, Gravel, Macadam, and Other Similar Materials

On the other hand, Singapore increased its imports of pebbles, gravel, macadam, and other similar materials for domestic consumption from 1987 to 1989. Imports for domestic use grew from 6,676 MT in 1987, to 7,853 MT in 1988, and to 7,987 MT in 1989. An average annual growth of nine per cent was recorded during the three-year period. (See Table 18.)

Malaysia was undisputably Singapore's top supplier in 1989, when it accounted for 70 per cent of total Singapore imports during that year. On the other hand, the Philippines accounted for seven per cent, when it exported 707 MT valued at US$60,750. Taiwan was Singapore's third biggest supplier in 1989, when imports from this country amounted to 532 MT.

Imports from the Philippines rose steadily, from a low 439 MT valued at US$24,220 in 1987, to its highest in 1989.

Table 18
IMPORTS OF PEBBLES, GRAVEL, MACADAM, AND OTHER SIMILAR MATERIALS
OF SINGAPORE BY COUNTRY OF ORIGIN
1987-1989
(volume in metric tons; value in thousand US$ CIF)

Country of Origin	1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Malaysia	6,433.00	150.52	85	9,374.00	300.64	81	6,962.67	174.83	70
Philippines	439.00	24.22	6	463.54	35.28	4	706.67	60.75	7
Taiwan	147.00	15.19	2	477.00	70.56	4	532.00	70.20	5
Others	529.00	167.62	7	1,225.46	273.31	11	1,787.99	382.72	18
Total Imports	7,548.00	357.55	100	11,540.00	679.79	100	9,989.33	688.50	100
Less: Re-exports	872.00	97.82	12	3,687.00	83.48	32	2,002.67	166.73	20
Imports for Domestic Consumption	6,676.00	259.73	88	7,853.00	596.31	68	7,986.66	521.77	80

Note: 1989 figures were annualized.

Sources: Singapore Trade Statistics
Foreign Trade Statistics of the Philippines.

Crushed or Broken Granite

As with imports of natural sand, Singapore's imports of crushed or broken granite for domestic consumption decreased during the three-year period. From 750,513 MT in 1987, import volume shrank to 589,152 MT in 1988, and to 141,621 MT in 1989, or by an average of 57 per cent per year. (See Table 19.)

During the three years, Malaysia cornered almost all of Singapore's imports. Imports from this country were highest in 1987 at 750,382 MT, and lowest in 1989 at 148,273 MT.

Table 19
IMPORTS OF CRUSHED OR BROKEN GRANITE OF SINGAPORE BY COUNTRY OF ORIGIN
1987-1989
(volume in metric tons; value in thousand US$ CIF)

Country of Origin	1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Malaysia	750,382.00	3,645.30	100	588,954.00	3,364.64	100	148,273.33	974.70	100
Others	337.00	56.04	*	494.00	44.72	*	741.33	201.83	*
Total Imports	750,719.00	3,701.34	100	589,448.00	3,409.36	100	149,014.66	1,176.53	100
Less: Re-exports	206.00	9.98	*	296.00	14.41	*	7,393.33	56.03	5
Imports for Domestic Consumption	750,513.00	3,691.36	100	589,152.00	3,394.95	100	141,621.33	1,120.50	95

* Less than 1.

Note: 1989 figures were annualized.

Source: Singapore Trade Statistics.

3.3.3 Exports

"Exports" in this section refers to domestic exports. This pertains to exports of Singapore origin and comprise primary commodities grown, produced or processed in Singapore.

Singapore exported lightweight and normalweight aggregates from 1987 to 1989.

3.3.3.1 Existing Lightweight Aggregates

Pumice Stone and Other Natural Abrasives

Singapore's domestic exports of pumice stone and other natural abrasives grew at an average annual rate of 657 per cent from 1987 to 1989. As shown in Table 20, exports in 1989 reached 57 MT, up from the 1987 volume of one MT.

In 1989, 81 per cent of Singapore's exports, or 47 MT, went to Malaysia, while 16 per cent, or nine MT, went to New Caledonia.

Singapore's 1987 and 1988 statistics do not present a breakdown of exports of pumice stone and other natural abrasives by country of destination.

Table 20
EXPORTS OF PUMICE STONE AND OTHER NATURAL ABRASIVES OF SINGAPORE BY COUNTRY OF DESTINATION
1987-1989
(volume in metric tons; value in thousand US$ FOB)

Country of Destination	1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Malaysia	n.a.	n.a.	-	n.a.	n.a.	-	46.67	70.88	81
New Caledonia	n.a.	n.a.	-	n.a.	n.a.	-	9.33	12.15	16
Others	n.a.	n.a.	-	n.a.	n.a.	-	1.33	0.67	3
Total	1.00	0.95	100	36.00	9.94	100	57.33	83.70	100

n.a. - Not available.

Note: 1989 figures were annualized.

Source: Singapore Trade Statistics.

Slag, Rock, and Other Mineral Wools, Exfoliated Vermiculite, Expanded Clays, and Other Similar Materials

From 1987 to 1989, Singapore's domestic exports of slag, rock, and other mineral wools, exfoliated vermiculite, expanded clays, and other similar materials declined at an average annual rate of about 22 per cent. Export volume dropped from 165 MT in 1987 to 120 MT in 1988, but increased in value from US$233,620 to US$274,300. In 1989, both export volume and value dropped to 101 MT and US$128,930, respectively. (See Table 21.)

Singapore's biggest markets for 1989 were Malaysia and P.R.O.C., which accounted for 38 per cent and 26 per cent, respectively, of total Singapore exports during that year. Malaysia imported 39 MT valued at US$29,030, while P.R.O.C. bought 27 MT valued at US$16,200. Other big markets were India, which imported nine MT, and Thailand, which imported seven MT.

Table 21
EXPORTS OF SLAG, ROCK, AND OTHER MINERAL WOOLS, EXFOLIATED VERMICULITE, EXPANDED CLAYS, AND OTHER SIMILAR MATERIALS OF SINGAPORE BY COUNTRY OF DESTINATION
1987-1989
(volume in metric tons; value in thousand US$ FOB)

Country of Destination	1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Malaysia	53.00	52.71	32	24.00	50.69	20	38.67	29.03	38
People's Republic of China	n.a.	n.a.	-	13.00	32.30	11	26.67	16.20	26
India	n.a.	n.a.	-	n.a.	n.a.	-	9.33	15.53	9
Thailand	n.a.	n.a.	-	n.a.	n.a.	-	6.67	31.73	7
Brunei	63.00	148.62	38	68.00	168.46	57	n.a.	n.a.	-
Papua New Guinea	25.00	18.04	15	n.a.	n.a.	-	n.a.	n.a.	-
Sri Lanka	19.00	11.87	12	n.a.	n.a.	-	n.a.	n.a.	-
Others	5.00	2.38	3	15.00	22.85	12	19.99	36.44	20
Total	165.00	233.62	100	120.00	274.30	100	101.33	128.93	100

n.a. - Not available.

Note: 1989 figures were annualized.

Source: Singapore Trade Statistics.

Brunei was Singapore's biggest market in 1987 and 1988. Exports to Brunei went up in 1988, as did Brunei's share in total Singapore exports (from 38 per cent to 57 per cent).

3.3.3.2 Normalweight Aggregates

Natural Sands

As shown in Table 22, Singapore's domestic exports of natural sands in 1989 amounted to 229 MT valued at US$10,130, up from the 1987 figure of 169 MT valued at US$4,270. Exports of natural sands grew yearly by an average 16 per cent from 1987 to 1989. Singapore's trade statistics do not present a breakdown of exports by country of destination.

Table 22
EXPORTS OF NATURAL SANDS OF SINGAPORE
1987-1989
(volume in metric tons; value in thousand US$ FOB)

Year	Volume	Value
1987	169.00	4.27
1988	123.00	2.48
1989	229.33	10.13

Note: 1989 figures were annualized.

Source: Singapore Trade Statistics.

Pebbles, Gravel, Macadam, and Other Similar Materials

Singapore's domestic exports of pebbles, gravel, macadam, and other similar materials fluctuated greatly from 1987 to 1989. From its highest level in 1987, exports plummeted to 51 MT, less than three per cent of the prior year's volume of 2,476 MT. Singapore's performance improved in 1989, when its export volume trebled to 160 MT. Export value, however, did not fluctuate as greatly as did volume. From US$15,190 in 1987, export value went down to US$14,410. Export value was highest in 1989 at US$17,550. (See Table 23.)

During all three years, Malaysia was Singapore's main market, accounting for 100 per cent, 86 per cent, and 72 per cent, respectively, of Singapore's exports in 1987, 1988, and 1989.

Table 23
EXPORTS OF PEBBLES, GRAVEL, MACADAM, AND OTHER SIMILAR MATERIALS OF SINGAPORE BY COUNTRY OF DESTINATION
1987-1989
(volume in metric tons; value in thousand US$ FOB)

	1987			1988			1989		
Country of Destination	Volume	Value	%	Volume	Value	%	Volume	Value	%
Malaysia	2,473.00	12.82	100	44.00	13.91	86	114.67	14.18	72
Others	3.00	2.37	*	7.00	0.50	14	45.33	3.37	28
Total	2,476.00	15.19	100	51.00	14.41	100	160.00	17.55	100

* Less than 1.

Note: 1989 figures were annualized.

Source: Singapore Trade Statistics.

Crushed or Broken Granite

Singapore's domestic exports of crushed or broken granite increased in 1988 to 8,450 MT, approximately 141 times its export volume in 1987. There were no exports of this commodity as of September 1989. (See Table 24.)

Brunei was Singapore's sole market in 1988. There is no breakdown of countries of destination for exports of crushed or broken granite in 1987.

Table 24
EXPORTS OF CRUSHED OR BROKEN GRANITE OF SINGAPORE BY COUNTRY OF DESTINATION
1987-1989
(volume in metric tons; value in thousand US$ FOB)

Country of Destination	1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Brunei	n.a.	n.a.	-	8,450.00	27.33	100	-	-	-
Others	n.a.	n.a.	-	-	-	-	-	-	-
Total	60.00	0.47	100	8,450.00	27.33	100	-	-	-

n.a. Not available.

Note: There were no exports of crushed or broken granite as of September 1989.

Source: Singapore Trade Statistics.

3.3.4 Prices

Table 25 shows the average prices in 1989 of existing lightweight and normalweight aggregates in Singapore.

Table 25
AVERAGE PRICES OF EXISTING LIGHTWEIGHT AND NORMALWEIGHT AGGREGATES IN SINGAPORE
1989
(in US$ per cubic meter)

Aggregate	Average Price
Lightweight:	
Pumice	898
Exfoliated vermiculite	86
Expanded clay	431
Expanded slag	635
Normalweight:	
Sand	17
Gravel	97
Granite	12

Source: Singapore Trade Statistics.

The prices were computed by dividing the 1989 total value of imports for domestic consumption by total import volume for domestic consumption (in metric tons) of the respective aggregates. The unit price in metric tons was converted to unit price per cubic meter by taking into account the weight of each aggregate.

The lightweight aggregates currently imported by Singapore cost from US$86 to US$898 per cubic meter. On the other hand, the prices of imports of normalweight aggregates range from US$12 to US$97 per cubic meter. This is despite the fact that a cubic meter of lightweight aggregate usually weighs less than a cubic meter of sand or gravel.

The most likely reason why the lightweight aggregates are more expensive than normalweight aggregates is because of the premium attached to the former's inherent advantages - that is, lightness and insulating capacity - over the latter. Another possible cause for the large difference in prices is the freight component. Singapore imported its normalweight aggregates - sand, gravel, and granite - in 1989 mainly from Malaysia. On the other hand, it sourced most of its pumice from Japan, and its imports of other lightweight aggregates from various countries (Malaysia, United States, United Kingdom, and Japan). Malaysia and Singapore are situated beside each other, and the aggregates were most probably transported by land. On the other hand, Singapore's imports of lightweight aggregates from the countries mentioned above were probably transported by sea, and involved higher freight rates.

Another possible reason why pumice costs more is because in the foreign trade statistics classification of Singapore, pumice is lumped together with other natural abrasives, which may be more expensive.

3.4 TARIFF

Singapore does not impose any tariff on lightweight and normalweight aggregates.

4. THE HONG KONG MARKET

4.1 BACKGROUND ON THE CONSTRUCTION INDUSTRY

4.1.1 Industry Structure

Construction follows the twists and turns of the property market and the general economy. Two years of double-digit growth in Hong Kong's gross domestic product (GDP), plus a simultaneous run-up in real estate prices rivaling the boom of the early 1980s, is giving Hong Kong's builders a chance to recover from the lean years of 1983 to 1986. Rapid economic growth in 1986 and 1987 increased the demand for office space, raising rentals, and more favorable mortgage terms attracted more people into the housing market. Developers therefore invested heavily in large office and housing projects which are now being completed.

In terms of value in current prices, the industry contributed US$2.05 billion to GDP in 1987, up from its contribution of US$1.56 billion in 1984. For the period 1984 to 1987, the construction industry's contribution posted an average annual growth rate of nine per cent. (See Table 26.)

However, the industry's percentage share to total GDP declined steadily from 5.3 per cent in 1984, to 5.0 per cent in 1985 to 4.8 per cent in 1986, and to its lowest at 4.6 per cent in 1987.

Table 26
CONTRIBUTION OF THE CONSTRUCTION SECTOR OF HONG KONG TO GROSS DOMESTIC PRODUCT
1984-1987
(value in current prices, million US$)

Year	Contribution of the Construction Industry	%
1984	1,564.56	5.3
1985	1,545.65	5.0
1986	1,732.09	4.8
1987	2,053.42	4.6

Source: Hong Kong Government Information Services.

In 1987 and 1988, capital formation of the construction industry posted positive growth rates of 6.8 and 3.0 per cent, respectively. In 1986, however, a slight decrease of 0.2 per cent in the capital formation of the industry was recorded, due to the poor performance of the public sector during that year. (See Table 27.)

Table 27
PERCENTAGE CHANGES IN CAPITAL FORMATION OF CONSTRUCTION IN HONG KONG 1986-1988

	1986	1987	1988
Total Construction	-0.2	6.8	3.0
Private	1.6	5.9	5.5
Public	-3.4	8.4	-1.5

Source: Asia Yearbook, 1989.

Capital formation of the industry's private sector increased by 5.5 per cent in 1988, following a slowdown at 1.6 per cent in 1986, and a peak of 5.9 per cent in 1987. Public sector construction, on the other hand, posted positive growth, at 8.4 per cent, only in 1987. In 1986 and 1988, public sector construction declined by 3.4 per cent and 1.5 per cent, respectively.

Another indicator of construction growth in Hong Kong is the increase in floor area of completed buildings. As shown in Table 28, floor area of completed buildings increased from 1.93 million square meters in 1984 to 2.80 million square meters in 1987, representing an average annual growth rate of 13 per cent. Building activities peaked in 1985 at 2.90 million square meters.

Nonresidential structures accounted for the bulk of construction from 1984 to 1987, except in 1985 when combined residential and nonresidential structures made up the bulk of construction.

Table 28
COMPLETED CONSTRUCTION IN HONG KONG BY TYPE OF CONSTRUCTION
1984-1987
(floor area in thousand square meters)

	Residential		Nonresidential		Combined Residential and Nonresidential		Total	
Year	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)	Area	% Inc. (Dec.)
1984	176.54	-	1,125.07	-	632.55	-	1,934.16	-
1985	271.39	53.73	1,205.32	7.13	1,426.46	125.51	2,903.17	50.10
1986	357.13	31.59	1,129.47	(6.29)	1,062.37	(25.52)	2,548.97	(12.20)
1987	641.15	79.53	1,192.38	5.57	963.84	(9.27)	2,797.37	9.75

Source: Hong Kong Annual Digest of Statistics, 1988.

Table 29 compares the number of buildings built during the first six months of 1988 and 1989. From 945 in 1988, the total number of buildings completed decreased by 21.5 per cent to 742 in 1989. Residential structures formed the bulk of completed buildings in both years, accounting for 70 per cent and 64 per cent, respectively, of the total buildings constructed in 1988 and 1989. According to Hong Kong's Government Information Services, the increase in household incomes and plans for home ownership contributed to the demand for residential structures.

Table 29
NUMBER OF BUILDINGS COMPLETED IN HONG KONG
1988-1989

	January-June			
Type of Building	1988	%	1989	%
Residential	663	70	478	64
Industrial	50	5	50	7
Commercial	11	1	13	2
Others	221	24	201	27
Total	945	100	742	100

Source: Hong Kong General Chamber of Commerce.

From 1984 to 1987, the construction industry was fuelled by private sector activities. The sector accounted for 66 per cent of building and construction expenditures in 1987. Building and construction expenditures of the private sector increased from US$1.43 billion in 1984 to US$1.58 billion in 1987, or at an annual average rate of three per cent. On the other hand, the public sector's expenditures declined yearly at an average rate of seven per cent from 1984 to 1987. Public sector expenditures were lowest in 1986 at US$772.26 million, and highest in 1984 at US$1.02 billion. Total expenditures of the construction industry in 1987 amounted to US$2.40 billion, a seven per cent increase from the 1986 figure of US$2.25 billion. However, the whole period showed a slight annual average decrease of 0.59 per cent. (See Table 30.)

Table 30
EXPENDITURES ON BUILDING AND CONSTRUCTION
IN HONG KONG
1984-1987
(at constant 1980 prices, in million US$)

Year	Private Sector	%	Public Sector	%	Total
1984	1,427.42	58	1,019.69	42	2,447.11
1985	1,460.52	65	803.64	35	2,264.16
1986	1,475.77	66	772.26	34	2,248.03
1987	1,575.16	66	828.80	34	2,403.96

Source: Hong Kong Government Secretariat.

It must be noted that the colony's construction industry, along with Hong Kong's entire economy, will definitely be affected by the takeover of P.R.O.C. in 1997.

At present, the most pressing problem facing Hong Kong's construction industry is shortage of both skilled and unskilled laborers. The Hong Kong government's Housing Department is considering steps to force contractors on its projects to improve working conditions to attract workers, such as a ban on Sunday or holiday work, better-enforced safety precautions, and improved canteen and toilet facilities. However, what is needed are more fundamental moves towards automation, which include the use of on- and off-site prefabrication of a variety of building elements, including precast floor and wall slabs, and door fittings.

Hong Kong contractors have been slow to embrace automation because of several reasons. Congested building sites make it difficult to find room on-site for precasting any part of a building. Furthermore, Hong Kong's narrow, winding roads discourage the transport of building elements from one location to another. Occasional typhoon conditions of high winds and driving rain make the jointing of large prefabricated units much trickier.

Despite these problems, however, the Housing Department is developing housing blocks that will include standardized components that presumably will be more amenable to prefabrication.

4.2 DEMAND

4.2.1 Historical Demand

4.2.1.1 Existing Lightweight Aggregates

Hong Kong uses the lightweight aggregate pumice. Demand for pumice from 1986 to 1989, based on imports for domestic consumption, is as follows:

Table 31
ESTIMATED CONSUMPTION OF LIGHTWEIGHT AGGREGATES IN HONG KONG
1986-1989
(volume in metric tons; value in thousand US$ CIF)

Year	Volume	Value
1986	27,672.08	5,072.77
1987	50,172.45	7,253.55
1988	42,677.09	5,167.16
1989	64,428.73	8,794.30

Note: 1989 figures were annualized.

Source: Hong Kong Trade Statistics.

Based on interviews, lightweight aggregates are not commonly used in Hong Kong for construction purposes.

4.2.1.2 Normalweight Aggregates

Hong Kong also uses the normalweight aggregates sand and gravel. Table 32 shows the estimated consumption of normalweight aggregates by vertical construction in Hong Kong from 1984 to 1989. About 70 per cent of total consumption pertains to sand, while the remaining 30 per cent pertains to gravel.

Consumption of normalweight aggregates by total construction (that is, vertical and infrastructure construction) could not be inferred because of the lack of data on infrastructure construction in Hong Kong.

Consumption by vertical construction grew at an average annual rate of about 14 per cent during the six-year period. Consumption was highest in 1989 at 2.75 million cubic meters, and lowest in 1984 at 1.46 million cubic meters. Consumption by structural use is broken down in the succeeding tables.

The same assumptions used in estimating consumption by Singapore from 1984 to 1987 for prefabricated walls, beams, columns, roof tiles, and roof and floor slabs were used for the Hong Kong market. To estimate consumption in 1988 and 1989, a 15 per cent growth rate was applied on the 1987 estimate. The 15 per cent rate was based on the average annual growth in floor area of combined residential and nonresidential construction in Hong Kong from 1984 to 1987.

Table 32
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES
BY VERTICAL CONSTRUCTION IN HONG KONG
1984-1989
(volume in cubic meters)

Year	Normalweight Aggregate Consumption
1984	1,456,926.61
1985	2,476,122.43
1986	2,036,891.68
1987	2,081,306.55
1988	2,393,502.54
1989	2,752,527.91

Source of basic data: Hong Kong Annual Digest of Statistics, 1988.

Prefabricated Walls

As shown in Table 33, consumption of normalweight aggregates for prefabricated walls during the period 1984 to 1989 was lowest in 1984 at 97,473 cubic meters. Consumption grew at an annual average of nine per cent.

Table 33
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES
FOR PREFABRICATED WALLS IN HONG KONG
1984-1989
(volume in cubic meters)

Year	Residential	Non-Residential	Total
1984	10,839.97	86,632.55	97,472.52
1985	14,243.22	95,863.21	110,106.43
1986	18,040.90	85,144.26	103,185.16
1987	28,185.29	86,260.38	114,445.67
1988	32,413.08	99,199.44	131,612.52
1989	37,275.05	114,079.35	151,354.40

Source of basic data: Hong Kong Annual Digest of Statistics, 1988.

Other Uses

Consumption of normalweight aggregates by Hong Kong for structural parts (beams and columns), roof tiles, and roof and floor slabs grew at an average of about 14 per cent annually from 1984 to 1989. Consumption was highest in 1989 at 2.60 million cubic meters, and lowest in 1984 at 1.36 million cubic meters. (See Table 34.)

Table 34
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES FOR STRUCTURAL PARTS AND ROOFING IN HONG KONG
1984-1989
(volume in cubic meters)

Year	Beams			Columns			Roof Tiles (Residential)	Roof and Floor Slabs (Nonres.)	Total Normalweight Aggregate Consumption
	Residential	Nonres.	Total	Residential	Nonres.	Total			
1984	34,501.60	257,231.26	291,732.86	219.38	11,717.50	11,936.87	1,209.55	1,054,574.81	1,359,454.09
1985	62,052.69	705,264.77	767,317.46	246.38	17,545.20	17,791.57	1,839.16	1,579,067.81	2,366,016.00
1986	84,835.14	516,442.05	601,277.18	300.38	14,612.25	14,912.62	2,414.37	1,315,102.35	1,933,706.52
1987	175,016.12	479,030.64	654,046.76	408.38	14,374.79	14,783.17	4,299.63	1,293,731.32	1,966,860.88
1988	201,268.54	550,885.24	752,153.78	469.64	16,531.01	17,000.65	4,944.57	1,487,791.02	2,261,890.02
1989	231,458.82	633,518.02	864,976.84	540.08	19,010.66	19,550.74	5,686.26	1,710,959.67	2,601,173.51

Source of basic data: Hong Kong Annual Digest of Statistics, 1988.

4.2.2 Demand Projections

4.2.2.1 Existing Lightweight Aggregates

Table 35 shows projected demand for the years 1990, 1991, 1992, 1995, 1997, and 2000 for existing lightweight aggregates based on Hong Kong's imports of pumice stone, emery, and corundum. Demand is projected to grow 33 per cent yearly, which is the average annual growth rate of Hong Kong's imports of the above products from 1986 to 1989.

Table 35
PROJECTED DEMAND FOR EXISTING LIGHTWEIGHT AGGREGATES IN HONG KONG
1990-2000
(volume in metric tons)

	Lightweight Aggregate Demand
1990	85,690
1991	113,970
1992	151,580
1995	356,610
1997	630,810
2000	1,484,070
Average annual growth rate, 1990-2000 (%)	33

4.2.2.2 Normalweight Aggregates

Table 36 shows the projected demand for the period 1990 to 2000 for normalweight aggregates in Hong Kong. Demand up to 1994 is projected by applying a 15 per cent annual growth rate on the estimated consumption in 1987. The 15 per cent growth rate is the average annual growth rate in floor area of combined residential and nonresidential construction (such as combined office and residential condominiums) in Hong Kong from 1984 to 1987.

From 1995 to 2000, demand for normalweight aggregates is projected to grow at an annual rate of 10 per cent. A lower growth rate was assumed in view of the probable decline in construction activity and importation of normalweight aggregates prior to and after the takeover of the colony by P.R.O.C. in 1997.

Demand for normalweight aggregates is expected to reach 3.17 million cubic meters in 1990. Demand in 1992, 1995, and 1997 is expected to reach 4.19 million cubic meters, 6.09 million cubic meters, and 7.37 million cubic meters, respectively. By the year 2000, demand is projected at 9.81 million cubic meters.

Table 36
PROJECTED DEMAND FOR NORMALWEIGHT AGGREGATES
IN HONG KONG
1990-2000
(volume in cubic meters)

Year	Normalweight Aggregate Demand
1990	3,165,410
1991	3,640,220
1992	4,186,250
1995	6,089,950
1997	7,368,840
2000	9,807,920
Average annual growth rate, 1990-2000 (%)	12

4.3 SUPPLY

4.3.1 Local Production

There are no available data on the total production of lightweight and/or normalweight aggregates by Hong Kong.

4.3.2 Imports

4.3.2.1 Existing Lightweight Aggregates

Pumice Stone, Emery, and Corundum

Hong Kong's imports of pumice stone, emery, and corundum for domestic consumption grew yearly at an average rate of about 33 per cent from 1986 to 1989. Imports were highest in 1989 at 64,429 MT valued at US$8.79 million. In 1986, Hong Kong posted imports of 27,672 MT at US$5.07 million, which increased in both volume and value to 50,172 MT and US$7.25 million, respectively, the following year. In 1988, however, imports for domestic consumption fell to 42,677 MT valued at US$5.17 million. Hong Kong increased its imports for domestic consumption again in 1989. (See Table 37.)

Table 37
IMPORTS OF PUMICE STONE, EMERY, AND CORUNDUM OF HONG KONG BY COUNTRY OF ORIGIN
1986-1989
(volume in metric tons; value in thousand US$ CIF)

Country of Origin	1986			1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%	Volume	Value	%
Indonesia	13,747.13	2,448.69	50	44,630.37	6,585.20	73	53,009.82	6,953.43	85	81,540.05	11,448.88	89
People's Republic of China	6,249.07	1,013.61	23	10,305.65	1,530.18	17	6,944.93	1,179.67	14	3,711.97	824.17	6
Japan	6,595.66	1,367.44	24	3,858.62	1,074.99	6	554.44	149.38	1	300.15	85.76	*
Others	1,069.22	243.03	3	2,161.06	489.63	4	2,040.25	542.14	3	6,271.47	1,327.19	7
Total Imports	27,672.08	5,072.77	100	60,955.70	9,680.00	100	62,549.44	8,824.62	100	91,823.64	13,686.99	100
Less: Re-exports	-	-	-	10,783.25	2,426.45	18	19,872.35	3,657.46	32	27,394.91	4,892.69	30
Imports for Domestic Consumption	27,672.08	5,072.77	100	50,172.45	7,253.55	82	42,677.09	5,167.16	68	64,428.73	8,794.30	70

* Less than 1.

Note: 1989 figures were annualized.

Source: Hong Kong Trade Statistics.

In 1989, 89 per cent of total Hong Kong imports came from Indonesia, which exported 81,540 MT of pumice stone, emery, and corundum valued at US$11.45 million to Hong Kong. P.R.O.C. was Hong Kong's second biggest source of imports in that year. Import volume and value from this country was recorded at 3,712 MT and US$824,170, respectively.

4.3.2.2 Normalweight Aggregates

Sand

As shown in Table 38, Hong Kong's imports of sand for domestic consumption in 1989 amounted to 1.40 million MT. Imports of sand were highest in 1988 at 1.58 million MT, and lowest in 1987 at 1.26 million MT. Hong Kong's imports grew by a low three per cent during the four-year period.

Almost all of Hong Kong's imports of sand were sourced from P.R.O.C. in 1989, as well as in the earlier years. In 1989, P.R.O.C. supplied Hong Kong with about 1.40 million MT valued at US$6.85 million. Taiwan and Japan, which were the next two major suppliers, exported 625 MT and 375 MT, respectively, in the same year. Both countries accounted for less than one per cent of total Hong Kong imports.

Imports by Hong Kong from Singapore fluctuated during the four-year period, registering its highest volume in 1986 at 308 MT. Imports from the Philippines also fluctuated, with import volume peaking at 220 MT in 1988, and dipping to its lowest the following year to 48 MT.

Table 38
IMPORTS OF SAND OF HONG KONG BY COUNTRY OF ORIGIN
1986-1989
(volume in metric tons; value in thousand US$ CIF)

Country of Origin	1986			1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%	Volume	Value	%
People's Republic of China	1,270,824.00	5,617.65	100	1,258,658.00	5,886.26	100	1,579,361.00	7,923.59	100	1,397,366.67	6,954.32	100
Taiwan	724.00	52.06	*	1,037.00	66.86	*	857.00	85.66	*	625.33	75.19	*
Japan	1,052.00	25.40	*	177.00	28.02	*	969.00	55.37	*	374.67	70.51	*
United States	99.00	38.33	*	226.00	117.26	*	238.00	86.65	*	122.67	22.54	*
United Kingdom	98.00	35.13	*	45.00	23.46	*	46.00	27.47	*	98.67	31.24	*
Singapore	308.00	6.57	*	-	-	-	0.81	12.11	*	70.67	14.12	*
Philippines	94.00	4.14	*	179.00	14.22	*	320.00	2.05	*	48.00	1.95	*
Others	96.00	15.47	*	399.00	44.04	*	2,094.19	153.63	*	198.66	26.80	*
Total Imports	1,273,295.00	5,792.65	100	1,260,721.00	6,180.12	100	1,583,786.00	8,346.53	100	1,398,605.34	7,096.67	100
Less: Re-exports	639.00	89.29	*	532.00	185.78	*	582.00	64.70	*	-	-	*
Imports for Domestic Consumption	1,272,656.00	5,703.36	100	1,260,189.00	5,994.34	100	1,583,204.00	8,281.83	100	1,398,605.34	7,096.67	100

* Less than 1.

Note: 1989 figures were annualized.

Source: Hong Kong Trade Statistics.

Gravel, Pebbles, Crushed Stone, and Tarred Macadam

In 1989, Hong Kong imported for domestic consumption 6.63 million MT of gravel, pebbles, crushed stone, and tarred macadam, valued at US$29.44 million. Volume-wise, imports grew steadily from 4.85 million MT in 1986, to 6.52 million MT in 1987, and to 6.75 million MT in 1988. However, in terms of value, imports increased from US$26.52 million in 1986 to US$32.23 million in 1987, then dropped to US$31.88 million in 1988. Both import volume and value declined in 1989 from the 1988 level. (See Table 39.)

As in the case of sand, almost all of Hong Kong's imports of gravel, pebbles, crushed stone, and tarred macadam came from P.R.O.C. in 1989, as well as in 1986 to 1988. In 1989, imports from P.R.O.C. amounted to 6.63 million MT valued at US$29.37 million. The Philippines was the second biggest source, registering exports to Hong Kong of 4,709 MT, valued at US$218,970.

Philippine exports to Hong Kong increased slightly from 3,069 MT in 1986, to 3,252 MT in 1987, and to 3,332 MT in 1988. This increased by 41 per cent to its 1989 level.

Imports from Singapore were nonexistent in 1986 and 1987, and minimal in 1988 and 1989.

Table 39
IMPORTS OF GRAVEL, PEBBLES, CRUSHED STONES,
AND TARRED MACADAM OF HONG KONG BY COUNTRY OF ORIGIN
1986-1989
(volume in metric tons; value in thousand US$ CIF)

Country of Origin	1986			1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%	Volume	Value	%
People's Republic of China	4,590,111.00	24,604.35	95	6,461,037.00	31,675.18	100	6,748,365.00	31,448.11	100	6,625,672.00	29,366.75	100
Philippines	3,069.42	221.16	*	3,252.48	249.32	*	3,331.90	230.45	*	4,709.33	218.97	*
Singapore	-	-	-	-	-	-	0.02	4.92	*	26.67	17.77	*
Macau	251,485.00	1,574.08	5	35,367.00	219.61	*	-	-	-	-	-	-
Others	4,299.58	209.51	*	20,749.52	180.67	*	2,747.08	382.70	*	1,177.33	107.75	*
Total Imports	4,848,945.00	26,608.10	100	6,520,406.00	32,324.78	100	6,754,444.00	32,066.18	100	6,631,585.33	29,711.24	100
Less: Re-exports	1,357.00	89.93	*	1,704.00	96.59	*	5,970.00	185.70	*	5,096.00	274.87	*
Imports for Domestic Consumption	4,847,588.00	26,519.17	100	6,518,702.00	32,228.20	100	6,748,474.00	31,880.48	100	6,626,489.33	29,436.37	100

* Less than 1.

Note: 1989 figures were annualized.

Source: Hong Kong Trade Statistics.
Foreign Trade Statistics of the Philippines.

4.3.3 Exports

"Exports" in this section refers to domestic exports. This pertains to exports of Hong Kong origin and comprise primary commodities grown, produced or processed in Hong Kong.

Domestic exports of lightweight and normalweight aggregates were made by Hong Kong from 1986 to 1988. There were no domestic exports of aggregates as of September 1989.

4.3.3.1 Existing Lightweight Aggregates

Pumice Stone, Emery, and Corundum

Hong Kong exported 12 MT of pumice stone, emery, and corundum valued at US$4,818 to Malaysia in 1987. There were no other exports of these products by Hong Kong from 1986 to 1989.

4.3.3.2. Normalweight Aggregates

Sand

Hong Kong exported sand only once during the four-year period 1986 to 1989. In 1987, exports amounting to five MT with value at US$1,487 were made to P.R.O.C.

Gravel, Pebbles, Crushed Stone, and Tarred Macadam

On the other hand, for the same period, Hong Kong exported gravel, pebbles, crushed stone, and tarred macadam only in 1986 and 1988. Hong Kong registered exports of 56 MT in 1986, and 88 MT in 1988. (See Table 40.)

In 1986, Hong Kong's sole market was P.R.O.C. In 1988, exports to P.R.O.C. decreased to less than half of the 1986 volume. In the same year, Hong Kong penetrated the Taiwan market, when it exported 61 MT valued at US$4,270.

Table 40
EXPORTS OF GRAVEL, PEBBLES, CRUSHED STONES, AND TARRED MACADAM OF HONG KONG BY COUNTRY OF DESTINATION
1986-1989
(volume in metric tons; value in thousand US$ FOB)

Country of Destination	1986			1987			1988			1989		
	Volume	Value	%	Volume	Value	%	Volume	Value	%	Volume	Value	%
Taiwan	-	-		-	-	-	61.00	4.27	69	-	-	-
People's Republic of China	56.00	7.08	100	-	-	-	27.00	0.86	31	-	-	-
Total	56.00	7.08	100	-	-	-	88.00	5.13	100	-	-	-

Note: There were no exports of gravel, pebbles, crushed stones, and tarred macadam in 1987 and as of September 1989.

Source: Hong Kong Trade Statistics.

4.3.4 Prices

The average prices in 1989 of existing lightweight and normalweight aggregates in Hong Kong are shown in Table 41:

Table 41
AVERAGE PRICES OF EXISTING LIGHTWEIGHT AND NORMALWEIGHT AGGREGATES IN HONG KONG
1989
(US$ per cubic meter)

Aggregate	Average Price
Lightweight:	
Pumice	95
Normalweight:	
Sand	8
Gravel	6

Source: Hong Kong Trade Statistics.

The prices were computed by dividing the 1989 total value of imports for domestic consumption by total import volume for domestic consumption (in metric tons) of the respective aggregates. The unit price in metric tons was converted to unit price per cubic meter by taking into account the weight of each aggregate.

In 1989, pumice, the only lightweight aggregate imported by Hong Kong, was priced higher per cubic meter than normalweight aggregates. Pumice cost about 12 times as much as sand, and 16 times as much as gravel. This is despite the fact that by reason of their respective densities, a cubic meter of pumice weighs less than a cubic meter of sand or gravel.

The most likely reason why pumice is more expensive than sand and gravel is because of the premium attached to pumice's advantages of lightness and insulating capacity over the latter. Still another possible cause for the large difference in price is the freight component. Hong Kong sourced its sand and gravel from P.R.O.C., and its pumice mainly from Indonesia. Since Indonesia is farther from Hong Kong than P.R.O.C., the cost of transporting aggregates from Indonesia to Hong Kong would definitely be higher than that of transporting from P.R.O.C. to Hong Kong.

Another possible reason why pumice costs more is because in Hong Kong's foreign trade statistics, pumice is lumped together with emery and corundum, which may be more expensive.

4.4 TARIFF

Hong Kong does not impose any tariff on lightweight and normalweight aggregates.

5. THE PHILIPPINE MARKET

5.1 BACKGROUND OF THE CONSTRUCTION INDUSTRY

5.1.1 Industry Structure

The Philippine construction industry engages in the following activities: new construction, addition, alteration, demolition, and repair of residential and nonresidential buildings, bridges, streets, railways, other general engineering construction, and special trade construction (for example, electrical work, plumbing, and masonry).

Since 1987, there has been an increase in construction activity in the country which has made the industry one of the bigger income sources. In 1988, construction accounted for 4.3 per cent of national income. Its contribution increased to 4.6 per cent in 1989. In 1988 and 1989, 43 per cent and 41 per cent, respectively, of the gross domestic capital formation was sourced from this sector. As shown in Table 42, the industry's real income (gross value added at constant 1972 prices) in 1989 reached US$222 million, an eight per cent increase from the 1988 level.

Table 42
GROSS VALUE ADDED OF THE CONSTRUCTION INDUSTRY
IN THE PHILIPPINES BY TYPE OF CONSTRUCTION
1984-1989
(value in constant 1972 prices, million US$)

	Public		Private		Total	
Year	Value	% Inc./ (Dec.)	Value	% Inc./ (Dec.)	Value	% Inc./ (Dec.)
1984	111	-	240	-	351	-
1985	82	(26.30)	147	(38.82)	229	(34.86)
1986	69	(7.48)	97	(34.17)	166	(27.50)
1987	71	3.40	122	25.97	193	16.17
1988	70	1.30	136	11.55	206	6.85
1989	73	8.25	149	9.52	222	7.66

Source: 1988 Philippine Statistical Yearbook.
National Income Accounts, National Statistical Coordination Board.

5.1.2 Private Sector

The outstanding performance of the industry during the past years was initiated mainly by the private sector. In 1989, private construction's share to the gross value added of the industry at US$149 million was double that of the public sector.

In terms of floor area, private building construction increased by a high 47.1 per cent from 1986 to 1987, (4.05 million square meters to 5.95 million square meters), and by 34.8 per cent to 1988 (8.02 million square meters). (See Table 43.) Private construction in 1989 is estimated at 8.36 million square meters. During these years, residential construction accounted for the bulk of private construction.

Table 43
FLOOR AREA OF PRIVATE BUILDING CONSTRUCTION IN THE PHILIPPINES
BY TYPE OF BUILDING
1984-1989
(floor area in thousand square meters)

Year	Residential		Nonresidential		Additions/Alterations and Repairs		Total	
	Area	% Inc/(Dec)	Area	% Inc/(Dec)	Area	% Inc/(Dec)	Area	% Inc/(Dec)
1984	3,444.30	-	1,901.46	-	336.32	-	5,682.08	-
1985	2,109.57	(38.75)	1,458.34	(23.30)	307.41	(8.60)	3,875.32	(31.80)
1986	2,125.13	0.74	1,582.51	8.51	337.94	9.93	4,045.58	4.39
1987	3,118.15	46.73	2,370.21	49.78	463.01	37.01	5,951.37	47.11
1988	3,645.64	16.92	3,367.70	42.08	1,008.81	117.88	8,022.15	34.80
1989	4,069.04	11.61	3,801.16	12.87	493.34	(51.10)	8,363.54	4.26

Note: 1989 figures were annualized.

Source: National Statistics Office.

5.1.3 Public Sector

In 1987 and 1988, public construction made up for its mediocre performance in 1986. In 1987, construction in terms of floor area reached 645 thousand square meters, up from 501 thousand in 1986. In 1988, construction grew significantly by 139.9 per cent, or 1.5 million square meters. Residential construction, which accounted for the bulk of construction in 1988, posted very high increases in 1987 and 1988, peaking at about 990 thousand square meters in 1988, or a 580.4 per cent increase from the 1987 level. Similarly, public buildings, hospitals and health buildings, and streets and bridges posted increases in floor area or length in 1988. Only the construction of educational buildings slowed down. (See Table 44.)

Table 44
PUBLIC CONSTRUCTION IN THE PHILIPPINES BY TYPE OF CONSTRUCTION
1985-1988
(length in thousand linear meters; area in thousand square meters)

Year	Residential Buildings		Public Buildings		Educational Buildings		Hospitals and Health Buildings		Total Floor Area		Streets and Bridges	
	Floor Area	% Inc. (Dec.)	Floor Area	% Inc. (Dec.)	Floor Area	% Inc. (Dec.)	Floor Area	% Inc. (Dec.)	Floor Area	% Inc. (Dec.)	Length	% Inc. (Dec.)
1985	48.91	-	412.99	-	241.66	-	36.12	-	739.68	-	877.82	-
1986	22.90	(53.18)	269.31	(34.79)	197.78	(18.16)	10.90	(69.82)	500.89	(32.28)	467.87	(46.70)
1987	145.49	535.33	211.53	(21.45)	274.35	38.72	13.70	25.69	645.07	28.78	566.25	21.03
1988	989.93	580.41	289.39	36.81	245.54	(10.50)	22.89	67.08	1,547.75	139.94	700.40	23.69

Source: National Statistics Office.

The Philippine construction industry is constrained foremost by the lack of construction materials. In 1988 and 1989, local production of cement, wood products, and reinforcing steel was not enough to meet the demand by both the private and public sectors. The resulting scarcity of these materials has pushed up prices. This, coupled with increasing labor cost, has resulted in higher construction expenses.

Despite these constraints, however, the government is still optimistic about the prospects of the construction industry. Based on the updated Development Plan for 1987 to 1992 of the National Economic Development Authority (NEDA), construction is projected to grow at an average annual rate of 17.4 per cent, one of the highest rates for the different sectors. This is in line with the government's recognition of infrastructure's role in inducing and directing development in specific areas and in the country as a whole.

5.2 DEMAND

5.2.1 Historical Demand

5.2.1.1 Existing Lightweight Aggregates

Based on secondary data and interviews, the lightweight aggregates used in the Philippines are expanded perlite, exfoliated vermiculite, expanded clays, and expanded slag.

As shown in Table 45, domestic consumption of lightweight aggregates in 1989 reached 32,747 MT, valued at US$1.76 million. Consumption remained fairly constant in 1986 and 1987 at 30,354 MT and 30,347 MT, respectively. It plunged to its lowest in 1988 at 26,436 MT, before reaching its peak in 1989. Domestic consumption of lightweight aggregates grew at an average annual rate of 2.5 per cent from 1986 to 1989.

Table 45
ESTIMATED CONSUMPTION OF LIGHTWEIGHT AGGREGATES IN THE PHILIPPINES
1986-1989
(volume in metric tons; value in thousand US$)

Year	Volume	Value
1986	30,354.19	1,191.39
1987	30,346.94	1,186.32
1988	26,436.40	1,134.20
1989	32,746.68	1,763.03

Sources: In erviews
Foreign Trade Statistics of the Philippines.

Domestic Consumption by Usage

In the Philippines, lightweight aggregates are used mainly for nonsconstruction purposes. The most common use of lightweight aggregates is insulation. In 1988, the manufacture of preformed insulation pipes used up 10,566 MT, accounting for 40 per cent of total lightweight aggregate consumption in that year. (See Table 46.) Other industrial uses of lightweight aggregates accounted for another 40 per cent of total consumption.

In 1988, only 5,283 MT (about 20 per cent of total consumption) of lightweight aggregates was used by the construction industry. This includes the volume of lightweight aggregates which went into the manufacture of lightweight hollow blocks, and for lightweight concrete cast in the construction site.

Table 46
ESTIMATED CONSUMPTION OF LIGHTWEIGHT AGGREGATES
IN THE PHILIPPINES BY USAGE
1988
(volume in metric tons; value in thousand US$)

Usage	Volume	Value	%
Insulation	10,566.40	450.80	40
Other industrial uses	10,566.40	450.80	40
Construction	5,283.20	225.40	20
Others	20.40	7.19	*
Total	26,436.40	1,134.19	100

* Less than 1.

Sources: Foreign Trade Statistics of the Philippines
Interviews.

5.2.1.2 Normalweight Aggregates

Sand and gravel are used in the Philippines for both vertical and infrastructure construction. Table 47 shows the estimated normalweight aggregate consumption by vertical construction in the Philippines from 1985 to 1988. About 78 per cent of total consumption pertains to sand, while the remaining 22 per cent pertains to gravel.

Consumption of normalweight aggregates by vertical consumption grew at an average annual rate of 20 per cent from 1985 to 1988. Consumption was lowest in 1986 at 2.08 million cubic meters, and highest in 1988 at 3.95 million cubic meters.

Consumption of normwalweight aggregates broken down by total construction (that is, vertical and infrastructure construction) could not be inferred because of the lack of data on infrastructure construction in the Philippines.

Table 47
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES
BY VERTICAL CONSTRUCTION IN THE PHILIPPINES
1985-1988
(volume in cubic meters)

Year	Normalweight Aggregate Consumption
1985	2,261,596.55
1986	2,077,798.53
1987	2,945,738.71
1988	3,954,427.55

Source of basic data: National Statistics Office.

The succeeding tables present a breakdown of consumption of vertical construction by type of application.

Concrete Hollow Blocks

Based on inferred data, consumption of aggregates by concrete hollow blocks (CHBs) in the Philippines amounted to 1.23 million cubic meters in 1988, the highest level recorded during the period 1985 to 1988. Consumption of aggregates for CHBs increased at an average annual rate of 18 per cent. (See Table 48.)

Table 48
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES
FOR CONCRETE HOLLOW BLOCKS IN THE PHILIPPINES
1985-1988
(volume in cubic meters)

Year	Residential	Non-Residential	Total
1985	513,832.55	234,704.05	748,536.60
1986	502,556.43	163,223.07	665,779.50
1987	742,714.70	216,992.35	959,707.05
1988	965,135.75	265,658.74	1,230,794.49

Source of basic data: National Statistics Office.

Usage of CHBs by residential and nonresidential construction from 1985 to 1988 and the equivalent normalweight aggregate consumption were inferred in the following manner:

a. The basic data used were the number and floor area of residential and nonresidential structures completed yearly in the Philippines.

b. All structures were assumed to be single detached units having four exterior walls. The average area of an exterior wall was estimated by multiplying:

   o the square root of the quotient of the floor area and the number of total structures constructed, to represent the length of the wall; by a standard wall height of 4.0 meters. The resulting area is multiplied by 4, under the assumption that each structure has 4 equal sides.

c. In computing for the number of CHBs used in each structure, the following assumptions were made:

   - o 12.5 CHBs are used for each square meter of exterior wall.
   - o The CHBs used are non-loadbearing with a minimum compressive strength of 3,000 pounds per square inch.

d. The number of CHBs is multiplied by .012 cubic meter, the volume of concrete needed for one CHB. To estimate the equivalent sand volume requirement, the total concrete volume is multiplied by 1.0 cubic meter.

Other Uses

Table 49 shows the estimated consumption of normalweight aggregates used for structural parts and roofing of buildings from 1985 to 1988. In 1988, normalweight aggregate consumption was estimated at 2.72 million cubic meters, the highest estimate during the four-year period. From 1985 to 1988, consumption grew at an annual average rate of 22 per cent.

The same assumptions used in estimating consumption by Singapore and Hong Kong for beams, columns, roof tiles, and roof and floor slabs were used in estimating consumption by the Philippines. However, reinforced concrete technology was assumed in the construction of beams, columns, and roof and floor slabs. This is because based on interviews, demand for prefabricated units during the period was minimal.

Table 49
ESTIMATED CONSUMPTION OF NORMALWEIGHT AGGREGATES FOR STRUCTURAL PARTS AND ROOFING IN THE PHILIPPINES
1985-1988
(volume in cubic meters)

Year	Beams			Columns			Roof Tiles (Residential)	Roof and Floor Slabs (Nonres.)	Total Normalweight Aggregate Consumption
	Residential	Nonres.	Total	Residential	Nonres.	Total			
1985	81,605.03	36,038.34	117,643.37	71,671.50	14,327.40	85,998.90	19,951.68	1,289,466.00	1,513,059.95
1986	82,630.12	1,026.14	83,656.26	68,893.88	3,434.17	72,328.05	19,734.75	1,236,300.00	1,412,019.06
1987	129,069.90	1,568.60	130,638.50	99,036.00	4,782.98	103,818.98	29,700.18	1,721,874.00	1,986,031.66
1988	200,382.78	2,678.51	203,061.29	117,740.25	6,542.53	124,282.78	40,976.98	2,355,312.00	2,723,633.05

Source of basic data: National Statistics Office.

5.2.1 Demand Projections

5.2.1.1 Existing Lightweight Aggregates

Table 50 shows the projected domestic demand for lightweight aggregates in the Philippines during the period 1990 to 2000. Demand is projected by applying on local production for domestic consumption and on imports of lightweight aggregates the average annual growth rate of 2.5 per cent in estimated consumption of lightweight aggregates from 1986 to 1989.

Table 50
PROJECTED DEMAND FOR EXISTING LIGHTWEIGHT AGGREGATES IN THE PHILIPPINES
1990-2000
(volume in metric tons)

Year	Lightweight Aggregate Demand
1990	33,570
1991	34,400
1992	35,260
1995	37,980
1997	39,900
2000	42,970
Average annual growth rate, 1990-2000 (%)	2.5

5.2.1.2 Normalweight Aggregates

As shown in Table 51, domestic demand for normalweight aggregates is expected to reach 5.45 million cubic meters in 1990, 7.51 million cubic meters in 1992, 10.00 million cubic meters in 1995, and 16.10 million cubic meters in 2000. For the years 1990 to 1992, demand is projected by applying on the 1988 estimated consumption of normalweight aggregates the projected growth rate of 17.4 per cent for the construction industry contained in the updated Medium-Term Development Plan of the National Economic Development Authority (NEDA). For the period beyond 1992, the last year covered in the NEDA plan, a more conservative growth rate of 10 per cent was used.

Table 51
PROJECTED DEMAND FOR NORMALWEIGHT AGGREGATES IN THE PHILIPPINES
1990-2000
(volume in cubic meters)

Year	Normalweight Aggregate Demand
1990	5,450,290
1991	6,398,640
1992	7,512,010
1995	9,998,480
1997	12,098,160
2000	16,102,660
Average annual growth rate, 1990-2000 (%)	11

5.3 SUPPLY

5.3.1 Local Production

5.3.1.1 Existing Lightweight Aggregates

Perlite

As shown in Table 52 below, the 1989 estimated production volume of perlite by the local industry, based on sales volume in the domestic and export markets, was 34,992 MT valued at US$1.99 million, the highest during the period 1986 to 1989. The industry grew at an average of about four per cent over the four-year period.

Table 52
PRODUCTION OF PERLITE IN THE PHILIPPINES
1986-1989
(volume in metric tons; value in thousand US$)

Year	Volume	Value
1986	31,104.00	1,308.47
1987	31,104.00	1,296.39
1988	27,216.00	1,327.01
1989	34,992.00	1,988.03

Source: Interviews.

5.3.1.2 Normalweight Aggregates

Sand and Gravel

Based on statistics of the Bureau of Mines and Geosciences, local production of sand and gravel grew at an average annual rate of 0.44 per cent during the period 1984 to 1988. Production volume was lowest in 1985 at 11.13 million cubic meters. From then on, however, production volume picked up steadily, peaking at 14.84 million cubic meters in 1988. However, production value was lowest during this year at US$57.21 million. (See Table 53.)

Table 53
PRODUCTION OF SAND AND GRAVEL IN THE PHILIPPINES
1984-1988
(volume in thousand cubic meters; value in thousand US$)

Year	Volume	Value
1984	14,583.93	68,397.51
1985	11,134.62	57,554.68
1986	12,481.75	59,910.72
1987	13,782.73	67,676.97
1988	14,842.27	57,210.71

Source: Bureau of Mines and Geosciences.

5.3.2 Imports

5.3.2.1 Existing Lightweight Aggregates

Exfoliated Vermiculite, Expanded Clays, Expanded Slags, and Other Similar Mineral Materials

Based on foreign trade statistics, imports of lightweight aggregates consisted of exfoliated vermiculite, expanded clays, expanded slags, and other similar mineral materials. During the period 1986 to 1988, import volume of lightweight aggregates was highest in 1988 at 20 MT. However, in terms of value, imports were highest in 1987 at US$9,930, when import volume was lowest (five MT). Imports grew at an average annual rate of 29 per cent. (See Table 54.)

During the three years, imports were sourced from different countries, namely South Korea, Italy, and the Federal Republic of Germany (F.R.G.).

Table 54
IMPORTS OF EXFOLIATED VERMICULITE,
EXPANDED CLAYS, EXPANDED SLAGS,
AND OTHER SIMILAR MINERAL MATERIALS
OF THE PHILIPPINES BY COUNTRY OF ORIGIN
1986-1988
(volume in metric tons; value in thousand US$ CIF)

Year	Country of Origin	Volume	Value
1986	South Korea	12.24	2.92
1987	Italy	4.99	9.93
1988	Federal Republic of Germany	20.40	7.19

Source: Foreign Trade Statistics of the Philippines.

5.3.2.2 Normalweight Aggregates

Sand and Gravel

The Philippines did not import sand and gravel from 1986 to 1988.

5.3.3 Exports

5.3.3.1 Existing Lightweight Aggregates

Perlite

Based on interviews, perlite is the only lightweight aggregate that the Philippines exported from 1986 to 1989. As shown in Table 55, the Philippines exported 2,245 MT of perlite in 1989, valued at US$225,000. This represents an increase of 181 per cent from the 1988 export volume of 800 MT. Exports in 1986 and 1987 were estimated to be at the same level of 762 MT. During the four-year period, the Philippines sold expanded and unexpanded perlite to Japan, Thailand, South Korea, and Taiwan.

Table 55
EXPORTS OF PERLITE OF THE PHILIPPINES
1986-1989
(volume in metric tons; value in thousand US$ FOB)

Year	Volume	Value
1986	762.05	120.00
1987	762.05	120.00
1988	800.00	200.00
1989	2,245.32	225.00

Source: Interviews.

5.3.3.2 Normalweight Aggregates

Natural Sand

Philippine exports of natural sand in 1988 were 4,824 MT valued at US$327,890, the highest export volume and value recorded during the period 1986 to 1988. On the other hand, exports were lowest in 1986 at 2,628 MT valued at US$164,340. Exports increased yearly by an average of 35 per cent. (See Table 56.)

Japan was the Philippines' main market for natural sand in 1988, accounting for 41 per cent of total Philippine exports. Imports by Japan amounted to 1,978 MT valued at US$158,590. Closely following Japan was the United States, which imported 1,374 MT.

Exports to Singapore climbed from 128 MT valued at US$5,260 in 1986, to 178 MT valued at US$8,210 in 1987, to 248 MT valued at US$11,350 in 1988. However, the percentage share of exports to Singapore went up slightly from five per cent in 1986 to six per cent in 1987, before dropping back to five per cent in 1988.

Table 56
EXPORTS OF NATURAL SAND OF THE PHILIPPINES BY COUNTRY OF DESTINATION
1986-1988
(volume in metric tons; value in thousand US$ FOB)

Country of Destination	1986			1987			1988		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Japan	601.02	50.14	23	1,080.49	78.71	35	1,977.57	158.59	41
United States	794.84	45.71	30	919.67	43.87	30	1,374.15	83.57	28
Northern Ireland	315.76	19.80	12	359.08	22.31	12	416.64	26.74	9
Singapore	127.83	5.26	5	177.69	8.21	6	248.49	11.35	5
Federal Republic of Germany	154.30	11.60	6	95.26	5.86	3	203.59	11.30	4
Hong Kong	420.15	17.35	16	85.64	3.06	3	106.50	3.63	2
Others	213.83	14.48	8	340.65	23.68	11	497.20	32.71	11
Total	2,627.73	164.34	100	3,058.48	185.70	100	4,824.14	327.89	100

Source: Foreign Trade Statistics of the Philippines.

Hong Kong was a big buyer of the Philippines' natural sand in 1986, when it accounted for 16 per cent of total Philippine exports, or 420 MT. In 1987, however, exports to Hong Kong plummeted to about one-fifth its prior year's volume, or 86 MT. Exports to Hong Kong went up to 107 MT in 1988. Interestingly enough, however, export value to Hong Kong in 1987 and 1988 did not differ much - US$3,060 in 1987, and US$3,630 in 1988.

Pebbles, Crushed or Broken Stones, Granules, Chippings, and Powder of Stones

Philippine exports from 1986 to 1988 of pebbles, crushed or broken stones, granules, chippings, and powder of stones grew yearly at an average rate of 33 per cent. From 15,106 MT valued at US$1.04 million in 1986, export volume and value rose to 20,459 MT and US$1.50 million, respectively, in 1987, and to 26,706 MT and US$2.09 million in 1988. (See Table 57.)

In 1988, as in the two earlier years, Philippine exports went mostly to Japan, with exports to this country amounting to 21,177 MT. Japan's share in total Philippine exports that year reached 79 per cent. Hong Kong was the Philippines' second biggest market, importing 12 per cent of Philippine exports.

Hong Kong imported bigger quantities of pebbles, crushed or broken stones, granules, chippings, and powder of stones each year. Hong Kong's imports went up from 3,069 MT in 1986, to 3,252 MT in 1987, to 3,332 MT in 1988.

Philippine exports to Singapore went down from 495 MT in 1986, to 439 MT in 1987, then increased slightly in 1988.

During the three-year period, Brunei was an export market of the Philippines only in 1986, when exports to Brunei amounted to 69 MT.

Table 57
EXPORTS OF PEBBLES, CRUSHED OR BROKEN STONES,
GRANULES, CHIPPINGS, AND POWDER OF STONES OF THE PHILIPPINES
BY COUNTRY OF DESTINATION
1986-1988
(volume in metric tons; value in thousand US$ FOB)

Country of Destination	1986			1987			1988		
	Volume	Value	%	Volume	Value	%	Volume	Value	%
Japan	10,995.82	800.97	73	16,319.74	1,244.37	80	21,177.46	1,736.79	79
Hong Kong	3,069.42	154.87	20	3,252.48	191.78	16	3,331.90	192.83	12
Taiwan	-	-	-	93.23	8.52	*	797.66	26.71	3
Trust Territory, Pacific Islands	35.95	3.07	*	95.16	16.50	*	486.00	67.82	2
Singapore	494.63	33.60	3	439.00	22.95	2	463.54	29.41	2
Brunei	69.00	3.18	*	-	-	-	-	-	-
Others	441.39	42.78	3	259.22	18.72	2	449.45	39.76	2
Total	15,106.21	1,038.47	100	20,458.83	1,502.84	100	26,706.01	2,093.12	100

* Less than 1.

Source: Foreign Trade Statistics of the Philippines.

5.3.4 Prices

Table 58 shows the average prices in 1989 of existing lightweight and normalweight aggregates used in the Philippines.

Table 58
AVERAGE PRICES OF EXISTING LIGHTWEIGHT AND NORMALWEIGHT AGGREGATES IN THE PHILIPPINES
(US$ per cubic meter)
1989

Aggregate	Average Price
Lightweight:	
Perlite	6
Expanded slag	246 *
Normalweight:	
Sand	6
Gravel	8

* Price in 1988.

Sources: Foreign Trade Statistics of the Philippines
Construction Industry Authority of the Philippines.

Except for expanded slag, the prices above pertain to locally produced aggregates. In 1989, perlite, sand, and gravel were priced almost similarly per cubic meter, although perlite comes out more expensive because a cubic meter of perlite weighs less than a cubic meter of sand or gravel. The higher price of perlite would probably be due to a premium attached to perlite's inherent advantages, principally lightness and insulating capacity, over normalweight aggregates.

To compute for the price of expanded slag, the 1988 total value of imports for domestic consumption was divided by total import volume for domestic consumption (in metric tons). The unit price in metric tons was then converted to unit price per cubic meter by taking into account the weight of expanded slag.

Again, the most likely reason for the higher price of expanded slag is the premium attached to the advantages of expanded slag over normalweight aggregates. Another possible cause for the large difference in price is the freight component. Expanded slag, which was imported from F.R.G., cost US$246 per cubic meter, 31 to 41 times as much as sand and gravel. The cost of transporting expanded slag all the way from Europe to the Philippines probably comprised a large part of the import price.

5.4 TARIFF

The tariff rates in 1988 on lightweight and normalweight aggregates are presented in Table 59. Sand and gravel are subject to a 10 per cent tariff. Expanded perlite, exfoliated vermiculite, expanded clays, and expanded slag, which are classified as expanded mineral materials, are subject to a 20 per cent tariff rate.

Table 59
TARIFF RATES ON LIGHTWEIGHT AND NORMALWEIGHT AGGREGATES
IN THE PHILIPPINES
1988

Item	Rate of Duty (%)
Exfoliated vermiculite, expanded clays, foamed slag, and similar expanded mineral materials	20
Sand	10
Gravel, pebbles, broken or crushed stone	10

Source: Harmonized Commodity Description and Coding System of the Philippines, Philippine Tariff Commission, 1988.

6. ASSESSMENT OF MARKET POTENTIAL

6.1 LIAPOR'S MARKET POSITION

The following aspects were considered in assessing the market potential of Liapor in Singapore, Hong Kong, and the Philippines:

- Liapor should penetrate the construction industry because Liapor is used mainly for construction purposes. Based on interviews, normalweight aggregates are commonly used by the construction industry of the three countries.

- Liapor's target market was limited to vertical construction, particularly commercial or nonresidential structures. While Liapor can be used for both infrastructure and vertical construction, its features of lightness and high thermal insulation would be appreciated more by building contractors than by infrastructure project contractors.

- Because of its lightness, Liapor is ideal for use in high rise buildings. It can, therefore, meet the aggregate requirements of the prefabricated components used in high rise-buildings.

  There may be a market for Liapor in Singapore, Hong Kong, and the Philippines as indicated by the following:

  - Based on recent news articles, both the Singapore and Hong Kong governments are encouraging the use of prefabricated components such as precast floor and wall slabs, and door fittings for vertical construction;

  - Because of limited land space, majority of vertical construction in Singapore and Hong Kong are high-rise buildings; and

- According to the Construction Industry Authority of the Philippines, contractors for high-rise structures in the Philippines are already looking into possible substitute high-quality construction materials. Developers of these structures have the capacity to pay for superior, although more expensive, construction materials.

o Liapor can technically substitute for all the normalweight aggregates, if its selling price to the end user is competitive with that of the normalweight aggregates.

6.2 DETERMINATION OF MAXIMUM COMPETITIVE PRODUCT SELLING PRICE

The maximum competitive product selling price (derived price) of Liapor was calculated by:

o computing the savings in raw material, labor, and energy costs that would result if Liapor were to be used instead of normalweight aggregates. The savings is due to the technical advantages (namely, lightness and insulating capacity) of Liapor over normalweight aggregates; and

o adding the total savings to the current average price of the normalweight aggregate with which Liapor is being compared. By doing this, a premium is attached to Liapor's technical advantages over the normalweight aggregates.

To quantify the technical advantages of Liapor over normalweight aggregates, premium factors were computed based on the cost savings in the following areas:

o raw materials - reduction in the quantity of aggregates needed if Liapor were to be used instead of a normalweight aggregate;

o direct labor - reduction in manhours if a lighter aggregate is used; and

- o energy - reduction in energy required to cool a building due to the difference in insulating capacity between Liapor and normalweight aggregates.

The formula used to arrive at the premium factors is as follows:

$$P_L = P_N + 0.04(P_N) + P_N[0.30 - [0.30[0.75(W_L/W_N) + 0.25]]] + NPV_{(20\%,\ 20\ yrs.)}[(0.20)(C_E)(P_{oil}/TOE)(1\ sq.m./3.35\ cu.m.)(1-K_L/K_N)]$$

where:

P_L = price of Liapor in US$ per cubic meter

P_N = price of the normalweight aggregate in US$ per cubic meter

4% = percentage savings per cubic meter of aggregate if a lightweight aggregate is used instead of a normalweight aggregate

30% = direct labor cost expressed as a percentage of raw material cost

75% = percentage of direct labor cost affected by the weight of the aggregate used

25% = percentage of direct labor cost unaffected by the weight of the aggregate used

W_L = weight of Liapor in kg. per cubic meter

W_N = weight of the normalweight aggregate in kg. per cubic meter

$NPV_{(20\%,\ 20\ yrs.)}$ = net present value at 20 per cent for 20 years

20%	= percentage of energy cost affected by a change in the thermal conductivity of an insulating material
C_E	= energy consumption in tons of oil equivalent (TOE) per square meter
P_{oil}/TOE	= price of oil per ton of oil equivalent
1 m^2/3.35 m^3	= the volume of aggregate required in cubic meters per square inch of wall area
K_L	= thermal conductivity of Liapor in watt per meter Kelvin
K_N	= thermal conductivity of the normalweight aggregate in watt per meter Kelvin

6.2.1 Raw Materials

Generally, a four per cent savings per cubic meter of aggregate is realized if a lightweight aggregate is used instead of a normalweight aggregate.

6.2.2 Direct Labor

All other factors being constant, handling a lighter aggregate requires less effort than handling a heavier one. Less effort means less direct labor manhours, resulting in savings in direct labor cost.

Hence, the direct labor manhours required in constructing a building using Liapor will be less than when a normalweight aggregate is used.

Specifically, 75 per cent of direct labor cost is assumed to be directly affected by the weight of the aggregate used. The remaining 25 per cent of direct labor cost is affected by other factors such as the complexity of the construction operations, the level of technology used, manpower skills, and weather conditions.

In the Philippines, direct labor cost is normally 30 per cent of raw material cost. The same ratio of direct labor cost to raw material cost was assumed for Singapore and Hong Kong.

Table 60 shows the weight per cubic meter of Liapor and normalweight aggregates used in determining the premium factor for direct labor in the formula.

Table 60
WEIGHT OF LIAPOR AND NORMALWEIGHT AGGREGATES
(in kilogram per cubic meter)

Aggregate	Weight
Normalweight:	
Sand	1,520
Gravel	1,490
Granite	1,490
Liapor	550

Sources: Liapor brochure
Concrete Technology by Neville and Brooks
Chemistry of Cement and Concrete by F.M.Lea.

6.2.3 Energy

Based on studies, a change in the aggregate used for walls can affect up to 20 per cent of the annual energy requirement for cooling a building. The exact increase or decrease in energy requirement, and subsequently in energy cost, is determined by the "K" value, or thermal conductivity, of the aggregate.

Unlike savings in raw materials and labor which are realized at the time of construction, savings in energy cost is realized throughout the useful life of a building. Generally, a building has a useful life of 20 years. To determine the savings in energy cost during the life of the building at the time of construction, the net present value of the yearly savings is computed using a hurdle rate of 20 per cent.

Table 61 shows the "K" value of Liapor and normalweight aggregates used to determine the energy premium factor in the above formula.

Table 61
"K" VALUE OF LIAPOR AND NORMALWEIGHT AGGREGATES
(in watt per meter Kelvin)

Aggregate	"K" Value
Normalweight:	
Sand	1.18
Gravel	10.27
Granite	10.27
Liapor	0.15

Sources: Liapor brochure
Concrete Technology by Neville and Brooks
Chemistry of Cement and Concrete by F. M. Lea.

Table 62 shows the premium factors computed when Liapcr is compared with the normalweight aggregates currently used in the three countries. The premium factors for raw materials and direct labor are in percentages, while the premium factor for energy is already expressed in dollars.

Table 62
PREMIUM FACTORS OF LIAPOR

	Premium Factor (in %)		
Aggregate	Raw Material	Labor	Premium for Energy (US$/cu. m.)
Sand	4.00	14.36	33.18
Gravel	4.00	14.19	37.46
Granite	4.00	14.19	37.46

To compute for the total premium, the premium factors for raw materials and direct labor are multiplied by the current (in this case, average) price of the normalweight aggregate being compared with Liapor, and added to the premium for energy.

Table 63 shows the savings realized if Liapor is used instead of normalweight aggregates. Using Liapor instead of normalweight aggregates is clearly more advantageous. In all three countries, gravel is the normalweight aggregate which Liapor has the biggest advantage over.

Table 64 compares the current average price of normalweight aggregates with the derived price of Liapor for the three countries.

Table 64
AVERAGE PRICE OF NORMALWEIGHT AGGREGATES VS. DERIVED PRICE OF LIAPOR
(in US$ per cubic meter)

	Singapore		Hong Kong		Philippines	
	Average Price of Normalweight Aggregate	Derived Price of Liapor	Average Price of Normalweight Aggregate	Derived Price of Liapor	Average Price of Normalweight Aggregate	Derived Price of Liapor
Sand	17.00	53.30	8.00	42.65	6.00	40.28
Gravel	97.00	152.11	6.00	44.55	8.00	46.92
Granite	12.00	51.64	-	-	-	-

The derived price is the highest price at which Liapor can be sold to the end user to be competitive with normalweight aggregates. At the derived price, the end user would be indifferent in his choice of aggregate, because the cost of aggregates incurred in constructing a building would be the same whether Liapor or normalweight aggregates are used. However, setting the price of Liapor above the price of the normalweight aggregates but lower than the derived price would result in savings to the end user, and would, therefore, be financially advantageous to him.

As can be seen in the preceding table, Liapor in Singapore can be priced to the end user 1.6 times as much as gravel, 3.1 times as much as sand, and 4.3 times as much as granite. The derived prices range from US$51.64 to US$152.11 per cubic meter.

In Hong Kong, Liapor can be priced to the end user at a maximum of US$42.65 per cubic meter vis-a-vis sand, and a maximum of US$44.55 per cubic meter vis-a-vis gravel. At these prices, Liapor would sell at 5.3 times the price of sand, and 7.4 times the price of gravel.

Table 63
SAVINGS GNERATED/(LOSS INCURRED) USING LIAPOR VS. NORMALWEIGHT AGGREGATES

	Singapore				Hong Kong				Philippines			
	Raw Material	Labor	Energy	Total	Raw Material	Labor	Energy	Total	Raw Material	Labor	Energy	Total
sand	0.68	2.44	33.18	36.30	0.32	1.15	33.18	34.65	0.24	0.86	33.18	34.28
gravel	3.88	13.77	37.46	55.11	0.24	0.85	37.46	38.55	0.32	1.14	37.46	38.92
granite	0.48	1.70	37.46	39.64	-	-	-	-	-	-	-	-

In the Philippines, Liapor can be sold to the end user at a maximum of US$40.28 per cubic meter when positioned against sand, and at a maximum of US$46.92 per cubic meter when positioned against gravel. At these prices, Liapor would sell at 6.7 times the price of sand, and 5.9 times the price of gravel.

To determine the FOB price of Liapor assuming Brunei as the port of origin, the freight cost of Liapor from Brunei to each of these countries should be considered. The freight cost should not exceed the premium. If it does, the FOB price of Liapor would even have to be lower than the current average price of the normalweight aggregate.

Table 65 compares the total premium of Liapor vis-a-vis each normalweight aggregate with the freight cost to each country as quoted by a freight company in Brunei.

Table 65
TOTAL PREMIUM OF LIAPOR VS. FREIGHT RATE FROM BRUNEI
(in US$ per cubic meter)

	Singapore		Hong Kong		Philippines	
	Total Premium	Freight Rate	Total Premium	Freight Rate	Total Premium	Freight Rate
Sand	36.30	45.00	34.65	150.00	34.28	135.00
Gravel	55.11	45.00	38.55	150.00	38.92	135.00
Granite	39.64	45.00	-	-	-	-

Source of freight rate data: Interview with a freight company in Brunei.

The premiums are a function of the current average price of the normalweight aggregates. Furthermore, the freight rates presented in the table are based solely on the quotation of one shipping company in Brunei, and serve only as an indication of the prevailing freight rates from Brunei to the three countries. According to this company, at present, not too many vessels ply the above routes. For lack of competition, the few vessels which do can therefore charge high freight rates.

As shown in the above table, except for gravel in the case of Singapore, the freight cost of Liapor is higher than the total premium of Liapor vis-a-vis the normalweight aggregates.

6.3 PROJECTED DEMAND FOR LIAPOR

Demand for Liapor was projected under two scenarios, as follows:

6.3.1 Scenario 1 - Liapor Will be Sold Only in Singapore

Based on the computed premium of Liapor compared with freight rates for Liapor from Brunei to the three countries, as discussed in the previous section, Liapor can be positioned competitively only against gravel in Singapore.

Table 66 shows the projected demand for gravel and/or granite in Singapore for selected years between 1991 to 2000, as well as the target market and projected market share of Liapor during the period. Singapore's demand for gravel and/or granite is projected to grow by 15 per cent.

Table 66
PROJECTED DEMAND FOR GRAVEL AND/OR GRANITE IN SINGAPORE AND PROJECTED MARKET SHARE OF LIAPOR
1991-2000
(volume in cubic meters)

Year	Demand for Gravel/Granite	Target Market of Liapor	Market Share of Liapor	% Capacity Utilization
1991	1,486,330	133,770	6,688	2
1992	1,709,280	153,835	7,692	3
1995	2,599,610	233,965	11,698	4
1997	3,437,980	309,418	30,942	10
2000	5,228,740	470,587	47.059	16

The market share of Liapor is projected conservatively at five per cent from 1991 to 1995. From 1996 onward, when consumers would be more aware of the advantages of using Liapor, a 10 per cent share of the target market is projected.

Liapor's target market is estimated at nine per cent of projected yearly demand. The nine per cent share was based on the average percentage of floor area of commercial construction to total construction in Singapore from 1984 to 1987.

Demand for Liapor is expected to amount to at most 47,059 cubic meters in the year 2000. At this level, demand will be 16 per cent of the capacity of the proposed plant in Brunei of 300,000 cubic meters.

6.3.2 Scenario 2 - Liapor Will be Sold in Singapore, Hong Kong, and the Philippines

This scenario assumes that the proponent of the Liapor project will be able to sell Liapor in the three countries at competitive rates versus normalweight aggregates. It implies that the proponent will be able to obtain freight rates from Brunei (the proposed plant site of Liapor) to the three countries that are lower than the estimated premiums buyers will attach to Liapor.

On this basis, the projected demand for normalweight aggregates and the projected market share of Liapor in each country are shown below.

6.3.2.1 Singapore

Table 67 presents the projected total normalweight aggregate demand of Singapore for selected years from 1991 to 2000, as well as the target market and projected market share of Liapor during the same years. During this period, Singapore's consumption of aggregates is projected to grow by 15 per cent.

Liapor's target market is estimated at nine per cent of projected yearly demand. The nine per cent share was based on the average percentage of floor area of commercial construction to total construction in Singapore from 1984 to 1987.

Table 67
PROJECTED DEMAND FOR NORMALWEIGHT AGGREGATES IN SINGAPORE AND PROJECTED MARKET SHARE OF LIAPOR
1991-2000
(volume in cubic meters)

Year	Total Aggregate Requirements	Target Market of Liapor	Market Share of Liapor
1991	4,974,090	447,668	22,383
1992	5,720,200	514,818	25,741
1995	8,699,710	782,974	39,149
1997	11,505,360	1,035,482	103,548
2000	17,498,220	1,574,840	157,484

6.3.2.2 Hong Kong

Table 68 shows the projected demand for normalweight aggregates in Hong Kong for selected years during the period 1991 to 2000, as well as the target market and projected market share of Liapor. Total demand up to 1994 is projected to grow 15 per cent yearly. From 1995 onward, demand for normalweight aggregates is projected to grow annually by 10 per cent.

A 40 per cent share was used to determine the target market of Liapor, based on the average percentage of floor area of combined residential and nonresidential construction to total construction from 1984 to 1987.

Table 68
PROJECTED DEMAND FOR NORMALWEIGHT AGGREGATES IN HONG KONG AND PROJECTED MARKET SHARE OF LIAPOR
1991-2000
(volume in cubic meters)

Year	Normalweight Aggregate Demand	Target Market of Liapor	Market Share of Liapor
1991	3,640,220	1,456,088	72,804
1992	4,186,250	1,674,500	83,725
1995	6,089,950	2,435,980	121,799
1997	7,368,840	2,947,536	294,754
2000	9,807,920	3,923,168	392,317

6.3.2.3 Philippines

Table 69 shows the projected demand for normalweight aggregates in the Philippines for selected years from 1991 to 2000, and the target market and projected market share of Liapor during the period. Demand for normalweight aggregates in 1991 and 1992 is projected to grow by 17.4 per cent. A more conservative growth rate of 10 per cent was applied from 1993 onward.

A target market of five per cent of projected demand for normalweight aggregates is assumed for Liapor. The five per cent market share was based on the percentage of the number of high rise buildings to total buildings in the Philippines in 1980. This was the year when a census of occupied dwelling units was last undertaken by the National Statistics Office. Examples of high-rise buildings are apartments, accessoria, condominiums, hotels, lodging houses, dormitories, and commercial and industrial buildings.

Table 69
PROJECTED DEMAND FOR NORMALWEIGHT AGGREGATES IN THE PHILIPPINES AND PROJECTED MARKET SHARE OF LIAPOR
1991-2000
(volume in cubic meters)

Year	Normalweight Aggregate Demand	Target Market of Liapor	Market Share of Liapor
1991	6,398,640	319,932	15,997
1992	7,512,010	375,601	18,780
1995	9,998,480	499,924	24,996
1997	12,098,160	604,908	60,491
2000	16,102,660	805,133	80,513

6.3.2.4 Overall Market vs. Brunei Plant Capacity

Table 70 shows the projected demand for Liapor by the three countries for selected years from 1991 to 2000.

By 1991, demand by the three countries is already expected to exceed one-third of the proposed Brunei plant capacity of 300,000 cubic meters during that year. Demand is projected to reach almost two-thirds (185,944 cubic meters) of plant capacity in 1995. By 2000, demand for Liapor will amount to 630,314 cubic meters (210 per cent capacity utilization).

Based on the indicated freight rates obtained in the study, however, Scenario 2 is not a likely possibility.

Table 70
PROJECTED DEMAND FOR LIAPOR BY SINGAPORE, HONG KONG, AND THE PHILIPPINES
1991-2000
(volume in cubic meters)

Year	Singapore	Hong Kong	Philippines	Total	% Capacity Utilization
1991	22,383	72,804	15,997	111,184	37
1992	25,741	83,725	18,780	128,246	43
1995	39,149	121,799	24,996	185,944	62
1997	103,548	294,754	60,491	458,793	153
2000	157,484	392,317	80,513	630,314	210

6.4 DISTRIBUTION AND TRADE PRACTICES

Based on interviews, sales of lightweight and normalweight aggregates in the three countries are made either directly to consumers or through middlemen.

6.5 POSSIBLE AIJV PARTNERS

The following companies expressed interest in distributing Liapor on a joint venture basis. However, they did not indicate preferences in trade agreements due to lack of information on the product.

- Lightweight Concrete Group
  Jurong Industrial Estate, Singapore
- SPC Builders
  35 Selegie Road
  Parklane Shopping Mall, Singapore
- Concrete Aggregates Corporation
  Quezon City, Philippines