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Japan International Cooperation Agency (JICA)
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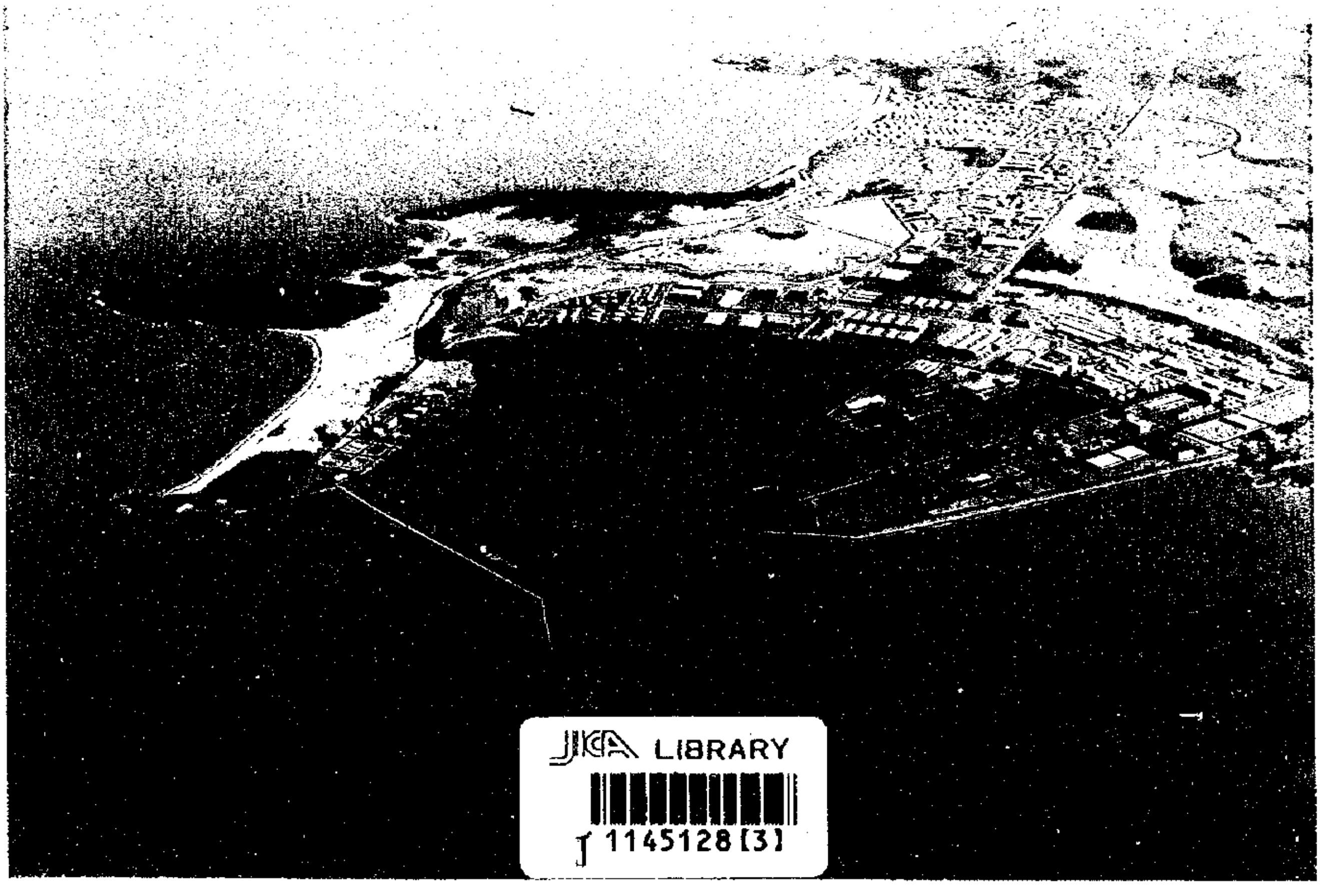
NO. 52

THE STUDY ON THE PORT DEVELOPMENT PLAN IN THE KEY AREA OF THE CENTRAL REGION IN THE SOCIALIST REPUBLIC OF VIETNAM

FINAL REPORT

DUNG QUAT

AUG 1998



THE OVERSEAS COASTAL AREA DEVELOPMENT INSTITUTE OF JAPAN(OCDI)
JAPAN PORT CONSULTANTS,LTD(JPC)

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JR
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(As of December, 1997)

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Ministry of Transport (MOT),The Socialist Republic of Vietnam

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PREFACE

In response to a request from the Government of the Socialist Republic of Vietnam, the Government of Japan decided to conduct the study on the port development plan in the key area of the central region and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Vietnam a study team headed by Mr. Yukio Nishida, senior executive director of the Overseas Coastal Area Development Institute of Japan, from February 1997 to May 1998.

The team held discussions with the officials concerned of the Government of Vietnam, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to officials concerned of the Government of the Socialist Republic of Vietnam for their close cooperation extended to the team.

August 1998

Kimio Fujita

Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

August 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency

Sir,

I have the honor to submit herewith the Report for the Study on the Port Development Plan in the Key Area of the Central Region in the Socialist Republic of Vietnam.

The study team which consists of the Overseas Coastal Area Development Institute of Japan (OCDI) and Japan Port Consultants, Ltd. (JPC), headed by myself, conducted a survey in the study area from February 1997 to May 1998 as per the contract with the Japan International Cooperation Agency.

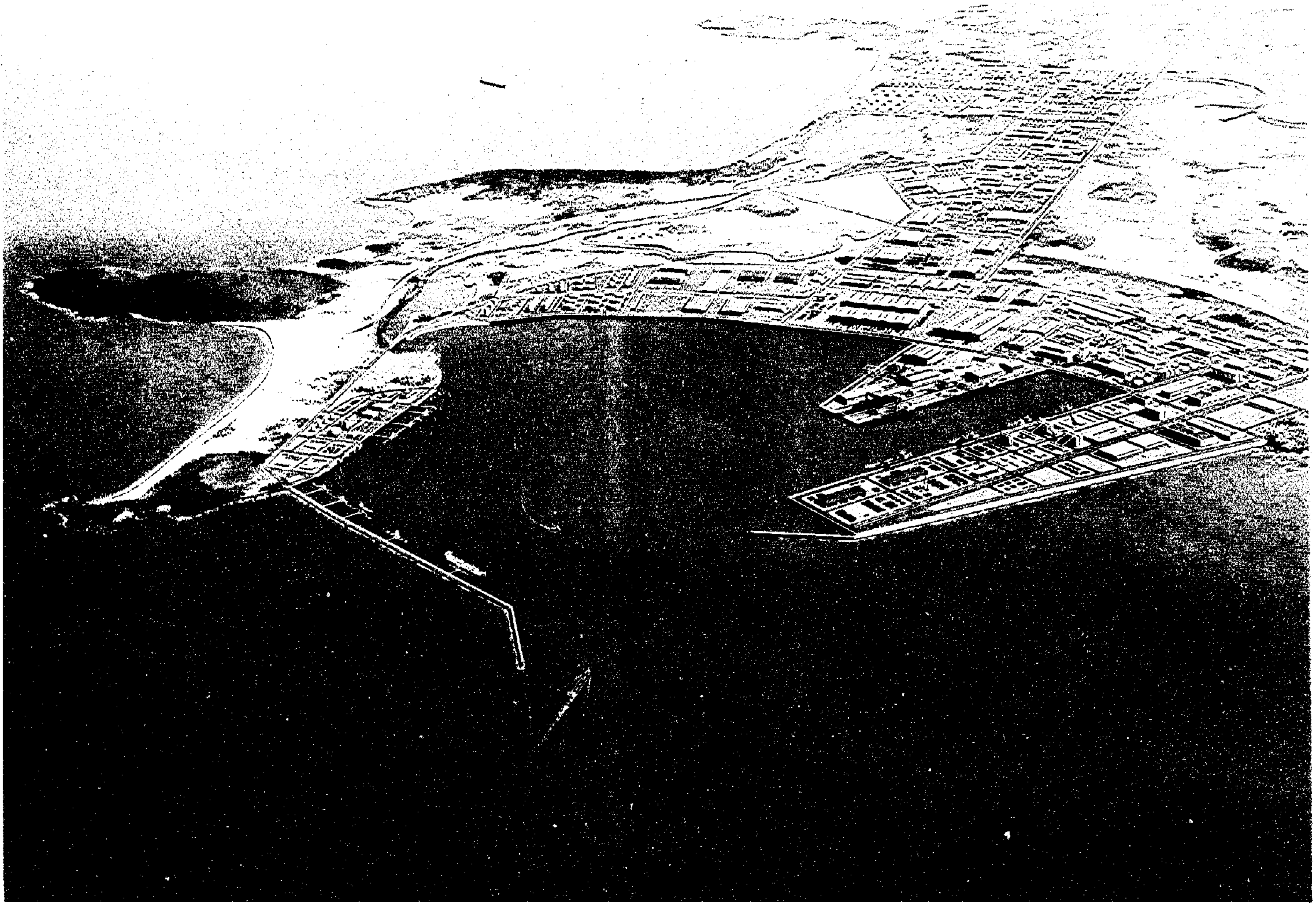
In line with the scope of work agreed upon in September 1996 between both governments, long term development plans (target year 2020) of the three study areas, namely, Chan May, Lien Chieu and Dung Quat have been formulated. In addition, a short term development plan (target year 2010) of the selected area, Lien Chieu has been formulated and a feasibility study has been conducted. Furthermore, initial stage development plans of other two areas, Chan May and Dung Quat, have been formulated and a pre-feasibility study has been conducted in accordance with the discussion with the Government of Vietnam.

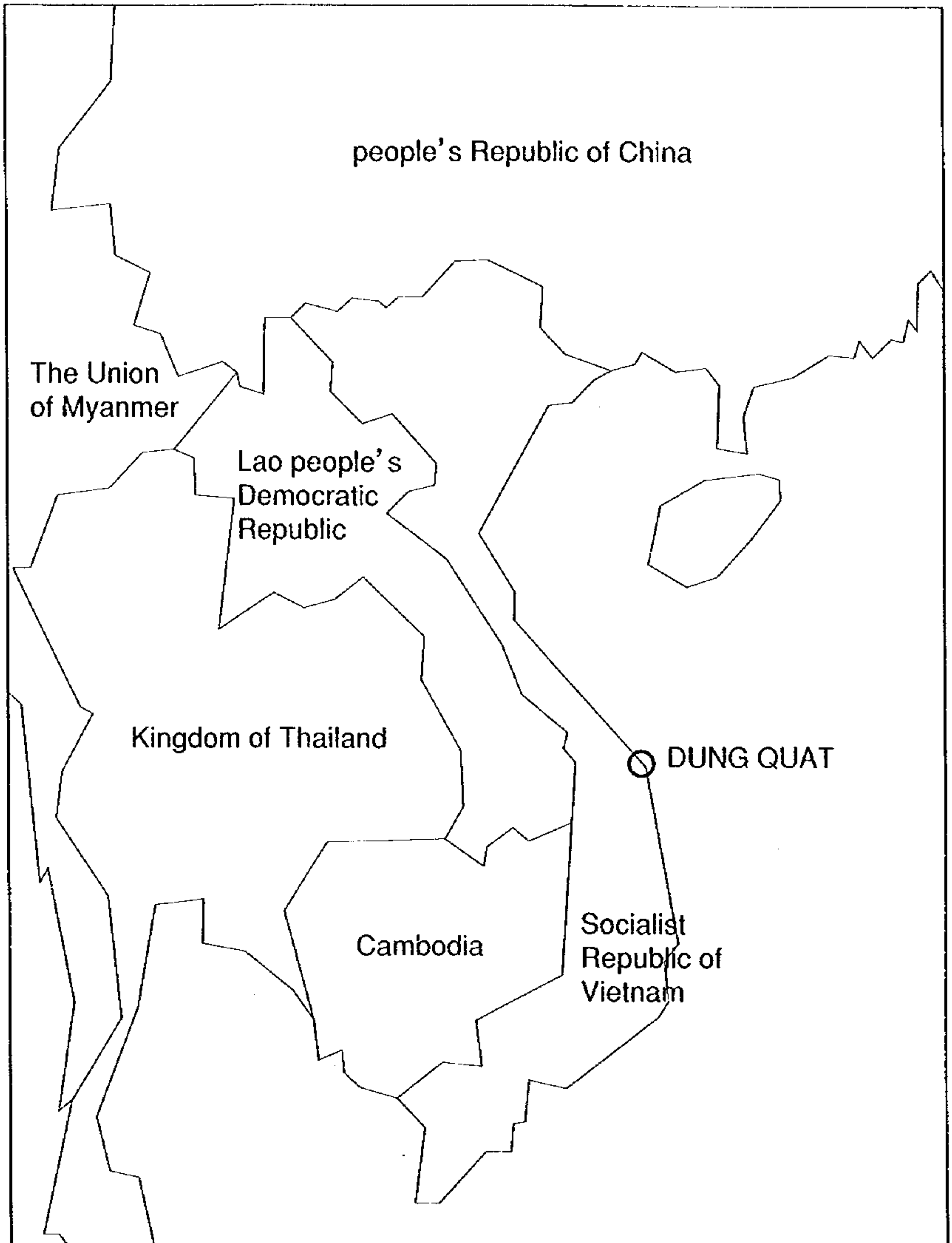
On behalf of the study team, I would like to express my deepest appreciation to the Government of Vietnam, Ministry of Transport and other authorities concerned for their brilliant cooperation and assistance and for the heartfelt hospitality which they extended to the study team during our stay in Vietnam.

I am also greatly indebted to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Transport, the Overseas Economic Cooperation Fund, Japan and the Embassy of Japan in Vietnam for giving us valuable suggestions and assistance during the preparation of this report.

Respectfully,

Yukio Nishida
Leader of the Study Team for the Study
on the Port Development Plan
in the Key Area of the Central Region





Location Map

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Abbreviations

ADB	Asian Development Bank
ASEAN	Association of South-East Asian Nations
AFTA	ASEAN Free Trade Area
BOD	Biochemical Oxygen Demand
BOQ	Bill of Quantity
BOT	Build-Operate-Transfer
CDL	Chart Datum Level
CFC	Conversion Factor for Consumption
CFS	Container Freight Station
CM	Chan May
CIF	Cost, Insurance and Freight
COD	Chemical Oxygen Demand
CY	Container Yard
DEPIZA	Quangnam-Danang Export Processing and Industrial Zones Authority
DQ	Dung Quat
DWT	Dead Weight Tonnage
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EPZ	Export Processing Zone
FCL	Full Container Load
FDI	Foreign Direct Investment
FIRR	Financial Internal Rate of Return
FOB	Freight on Board
FTZ	Free Trade Zone
GDP	Gross Domestic Product
GRT	Gross Registered Tonnage
GSO	General Statistics Office
HHWL	Highest High Water Level
HWL	Mean Monthly-Highest Water Level
IEE	Initial Environmental Examination
ICOR	Incremental Capital Output Ratio
ISP	Initial Stage Development Plan
IWB	Inland Waterway Bureau
IZ	Industrial Zone
JICA	Japan International Cooperation Agency

JPC	Japan Port Consultants, Ltd.
LC	Lien Chieu
LLWL	Lowest Low Water Level
LWL	Mean Monthly-Lowest Water Level
MHHWSL	Mean Higher High Water Springs Level
MHMC	Marine Hydro-meteorological Center
MLLWSL	Mean Lower Low Water Springs
MOC	Ministry of Construction
MOSTE	Ministry of Science, Technology and Environment
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
MSL	Mean Sea Level
NEA	National Environment Agency
OCDI	Overseas Coastal Area Development Institute of Japan
ODA	Official Development Assistance
OECF	Overseas Economic Cooperation Fund, Japan
PETROLIMEX	Vietnam National Petroleum Export-Import Co.
PMU	Project Management Unit
Ro/Ro	Roll on/Roll off
SCF	Standard Conversion Factor
SS	Suspended Solid (Material)
TEDI	Transport Engineering Design Incorporation
TDSI	Transport Development and Strategy Institute
TEU	Twenty Footer Equivalent Unit
VINALINES	Vietnam National Shipping Lines
THB	Thai Baht
VINAMARINE	Vietnam National Maritime Bureau
VMS	Vietnam Maritime Safety Agency
VSC	Vietnam Steel Corporation
VNCC	Vietnam Cement Corporation
VND	Vietnam Dong

Abstract (Dung Quat)

1. Background

Central region of Vietnam has not enjoyed the economic boom prevailing in the south and north region. To cope with this situation, the national government proposed or approved several projects in the region including the East West Transport Corridor, Dung Quat oil refinery, the South North Highway through Hai Van tunnel and industrial zone development as well as agricultural development. Transportation infrastructures including port facilities are in poor condition in the region to serve for economic development.

2. Objectives of the Study

This study aims at formulating long-term port development plans for Chan May, Lien Chieu, and Dung Quat and at proposing the initial stage development plan for the three sites, which consists of a package of port facilities required for the first stage of a new port development. The study also includes the financial analysis and environmental impact assessment for a selected initial stage development plan. The objectives of the Study are:

1) to formulate long-term port development plans for the period up to the year in and around 2020 for the three development sites;

2) to formulate an initial stage plan encompassing the package of port facilities to be developed at the first stage of the development; and

3) to make a financial analysis and environmental impact study for a selected initial stage development plan to assess the feasibility of the project as a short term development plan up to the year in and around 2010.

3. Master Plan for Dung Quat Port

Dung Quat Port is planned to serve firstly for the oil refinery to be built in the hinterland. Requirements for the new port are two deep sea tanker berths, four berths for coastal shipping tankers, two deep sea bulk berths for scrap metals, and 10 berths for coastal shipping cargoes. Two oil dolphin berths with -13 m draft and three oil dolphin berths for coastal ships are designed along the main breakwater. East wharf has two alongside berths for general cargo trampers with a depth of 8 m and three oil dolphin berths for coastal tankers. West wharf is designed to cater to Panamax bulk carriers and general cargo trampers carrying mainly steel scrap, manufacturing goods, agricultural products, and other breakbulk cargoes. The main breakwater has a length of 1,660 m and the west breakwater is 2,170 m. Dredging of 5 million m^3 is required for the approach channel and to secure a turning basin with a depth of -13 m. Land reclamation is planned for the east and west wharves with a total area of 137 ha.

4. Initial Stage Development Plan

The development of Dung Quat Port is possible if industrial development of their hinterlands is realized and the demand for a new port is confirmed. Since a new port development generally requires a large initial investment in breakwater and/or channel dredging at the first stage, an appropriate scale of development is necessary for the project to be feasible. ISP is proposed as a package plan for the first stage of development in Dung Quat. To serve for the planned oil refinery in the hinterland, one dolphin berth for 50,000 DWT class tankers and four dolphin berths for coastal tankers are proposed for ISP as well as two conventional berths with an alongside depth of –8 m. A 970 m section of the main breakwater is planned for ISP, of which a 370 section can be developed for the urgent need for product oil transportation.

5. Cost Estimates for Dung Quat Port Development

The costs of implementing the Master Plan are estimated at US$353 million in which the costs for ISP is US$119 million.

6. Economic Analysis

The results of the economic analysis indicate that port development projects of each site are viable from the viewpoint of the national economy. Economic Internal Rate of Return of ISP is shown below including sensitivity tests.

	EIRR of ISP	Sensitivity tests[1]
Dung Quat:	20.8 %	18.2 %

7. Overall Evaluation of the Project

Maritime transportation borne by the port development will greatly contribute to the development of the central region through foreign currency earnings, job creation, trade promotion and industrial development. However, the development of a new port requires a fairly large capital investment in breakwaters and reclamation work in the deep sea area, so that financial feasibility is very critical in connection with construction cost and port revenues. As seen from EIRR, the port development projects in Dung Quat are economically effective and will have no particular difficulty in technical, environmental aspects. Consequently, the timing of the development of Dung Quat Port should be carefully decided in connection with the development of the planned oil refinery.

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[1] subject to 10% increase in development costs and 10% decrease in economic benefits

1. Introduction

In accordance with the scope of work agreed upon on September 07, 1996, between the Japan International Cooperation Agency and the Ministry of Transport of Vietnam, the Study Team for the Port Development Plan in the Key Area of the Central Region of Vietnam and has carried out a field survey on social/natural conditions in the project area since February 1997. Based on the on-site studies and analysis, the Study Team prepared the Progress Report in May 1997, the Interim Report in September 1997, the Supplement in November 1997, and the Discussion Paper in January 1998. The study team implemented the study in close collaboration with the Transport Engineering Design Incorporation and in consultation with the Steering Committee comprising members from the Ministry of Planning and Investment, Ministry of Transport, Transport Development Strategy Institute, Vinamarine and other related agencies.

This draft final report has been prepared for JICA and MOT of Vietnam in accordance with the clause F. 4. (Draft Final Report) of the scope of work and will be finalized after receiving comments from the relevant organizations.

1.1 Background

The Vietnamese economy, particularly in the south and north regions, has advanced remarkably in recent years, however the central region lags behind the north and the south and thus advancing this area has a priority of the national government. The central region is also expected to be the gateway to Lao PDR and Northeast Thailand as part of the East-West Transport Corridor Project, which involves the regional countries, international funding agencies, and donor countries.

To encourage the development of the central region and to improve the transport infrastructure for the East-West Transport Corridor, port development projects are proposed in several coastal areas of the central region. In particular, port development in Chan May, Lien Chieu and Dung Quat is of interest to the national government not only for the development of the central region but also for international transit.

Hinterlands of the three planned ports have a total population of about 6,000,000, which is less than 10% of the total of Vietnam, and agriculture is the main industry. To achieve a balanced development of the country, great efforts are being made to develop the central region, in particular to develop the infrastructure in the region, in which roads and ports are expected to trigger economic development of the region. By providing the region with a maritime transportation means, ports will inspire investors to establish their manufacturing factories, cargo distribution centers and other commercial facilities in the hinterland.

The growth of maritime transportation generally exceeds the growth of national production at the early stage of economic evolution as many countries have experienced a long waiting queue at the beginning of economic booms.

Strategic port development in the central region will therefore play a key role in accelerating the economic development not only in the central region but also southern Laos and Northeast Thailand. Taking into account that the development of a new port requires a large investment and a long period of construction, special attention is required to increase the capacity of ports in advance and to meet the future demand.

1.2 Regional Development in Vietnam

The Vietnamese economy is projected to grow from 9-10% a year until the end of the decade and 10-11% a year from 2000 to 2010. Cargo and passenger transportation will increase accordingly. However, the basic transportation facilities, i.e. roads, railways and ports are undeniably poor in Vietnam and it may discourage foreign investment in the country, particularly, in remote areas from the two core cities, Ho Chi Minh and Hanoi.

Gross Domestic Product per capita in the central region is quite lower than the national average and the gap will increase if proper measures are not taken by the government. Dung Quat Industrial Development Project will launch the first oil refinery in the country which will accelerate economic growth in the region. Danang City, provinces of Thua Thien-Hue, Quang Nam and Quang Ngai also have their own development plans and ports will play a key role in the successful implementation of those projects. In addition, international highway project between Northeast Thailand and Central Vietnam through Lao PDR requires the development of a gateway port for international freight transportation.

The central area has the potential to be the third core of the country if proper development is conducted together with the development of transportation infrastructure. However, poor transport network and facilities are one of the bottlenecks of regional development. Strategic development of the transport system is now a crucial requirement for harmonious growth of the country.

1.3 Development of Mekong Region

Greater Mekong Sub-region is comprised of Cambodia, Socialist Republic of Vietnam, Lao People's Democratic Republic, People's Republic of China (Yunnan Province), Myanmar and Thailand. Except for Thailand, the GDP per capita of these countries ranges between US$200 and US$300. The development of this region will play a key role in Southeast Asia for the next decade and thus many international aid agencies and donor countries are extending financial and technical assistance.

The sixth conference on Subregional Economic Cooperation[1] held in August 1996 noted the importance of subregional cooperation in the transport sector highlighting the following:

1) detailed engineering is ongoing for the Phnom Phen-Ho Chi Minh City section of the Bangkok-Vung Tau Road (R1);

2) for the East-West Corridor (Center Option of R2) from Mukdahan/Savannakhet along Route No.9 to Dong Ha and Danang Port, technical assistance is about to be approved;

3) civil works for the Champassak Road Improvement Project, including the portion of the road from Pakse, Lao PDR, to the Cambodian border are about to commence;

4) three additional road projects

The above mentioned projects, R1 and R2, are nominated as pilot projects to mitigate nonphysical barriers to cross border movements of goods and people. Given that such barriers will be reduced, the central area of Vietnam is expected to serve as a gateway for the East-West Transport Corridor (R2).

A feasibility study on the East-West Transport Corridor Project was carried out in 1996 under ADB's technical assistance scheme to evaluate several existing/planned routes linking Vietnam and Northeast Thailand through Laos. The steering committee, consisting of representatives of the countries and funding agencies, selected the Route No.9 for

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[1] / Greater Mekong Subregion Sixth Conference on Subregional Economic Cooperation, Kunming, Yunnan Province, People's Republic of China, 28-30 August 1996

development at the first stage. The steering committee recently held a meeting in December 1997 to discuss the details of the reconstruction of the Route No.9 in Laos, the construction of the second Thai-Lao Mekong River Bridge, and upgrading of facilities at Tien Sa Port in Danang, Vietnam.

1.4 Objectives of the Study

This study aims at formulating long-term port development plans for Chan May, Lien Chieu, and Dung Quat and at proposing the initial stage development plan for the three sites, which consists of a package of the port facilities required for the first stage of a new port development. The study also includes the financial analysis and environmental impact assessment for a selected initial stage development plan. The objectives of the Study are:

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3) to make a financial analysis and environmental impact study for a selected initial stage development plan to assess the feasibility of the project as a short term development plan up to the year in and around 2010.

In addition to the above mentioned objectives, the aim of a JICA development study is to provide the counterpart organizations with well analyzed information derived from the implementation of the study and to transfer the basic port planning technology through the course of the study to officials of the counterpart organization.

1.5 Implementation of the Study

The study covers the three development sites, namely, Chan May in Thua Thien-Hue Province, Lien Chieu in Danang City and Dung Quat in Quang Ngai Province. Implementation of the study was divided into the following four phases.

Phase 1 (Fact Finding) : Review of relevant development plans; Observation of offshore waves, on-site winds, and other natural consitions; Collection and analysis of socio-economic statistics; International transportation in Laos and Northeast Thailand; Survey on natural and social environment

Phase 2 (Masterplan): Demand forecast; Formation of long-term development plans; Analysis of data obtained from field surveys; Initial Environmental Examination; Preliminary economic and financial analysis; Seminar on port development

Phase 3 (Survey for ISP and EIA): Review of masterplan; Formation of initial stage development plans; Second survey of natural conditions; Soil investigation; Survey for EIA; Second survey of international transit cargo.

Phase 4 (ISP and Feasibility Analysis): Proposal of ISP, Design of port facilities; Cost estimates; Economic analysis; Financial analysis and EIA study for a selected project; Seminar on the study.

1.6 Study Organization

The study team collaborated with the counterpart team organized by TEDI and TDSI. A steering committee was established by the MPI, MOT and other related organizations to direct and coordinate the study. Members of the steering committee, counterpart team and JICA study team are listed below:

Members of the Steering Committee

Mr. Pham Quang Tuyen	Leader, Vice Minister of MOT
Mr. Nguyen Vuong Ta	Director, Department of Infrastructure and Urban, MPI
Dr. Tran Doan Tho	Director, Planning & Investment Department, MOT
Mr. Bui Duc Nhuan	Vice Chairman, Vinamarine, MOT
Mr. Tran Van Dung	Chairman, TEDI, MOT
Mr. Nguyen Vinh Loc	Vice Director, Department of International Cooperation, MOT
Mr. Pham Dinh Vinh	General Director, Management Project Unit of Eastern Sea Construction, MOT
Mr. Nguyen Quang Bau	Director, Transport Development Strategy Institute, MOT
Mr. Nguyen Ngoc Tran	General Director, Management Project Unit No. 85, MOT

Members of Counterpart Team

Mr. Tran Van Dung	Leader, Chairman, TEDI
Dr. Nguyen Ngoc Hue	Director, TEDI port, TEDI
Mr. Nguyen Xuan Chien	Manager Technical Department, TEDI
Mr. Tran Trung	Business Management Department, TEDI
Mr. Nguyen Van Tien	Port Department, TEDI
Ms. Ngo Thuy Quynh	Port Department, TEDI
Ms. Le My Hanh	Technical Department, TEDI
Mr. Pham Van Xuan	Environmental Expert, TEDI
Ms. Nguyen Thi Vuot	Demand Forecast Expert, TDSI
Mr. Nguyen Dinh Tranh	Technical Department, TEDI
Ms. La Hong Hanh	Port Department, TEDI
Mr. Le Toan Thanh	International Cooperation Department, TEDI

Members of JICA Study Team

Mr. Yukio Nishida	Leader, Overall Management, OCDI
Mr. Sumio Suzuki	Deputy Leader, Port Planning/Environmental Consideration, OCDI
Mr. Toshihiko Kamemura	International Freight Transportation, OCDI
Mr. Naoki Kudo	Demand Forecast/Economic Analysis, OCDI
Mr. Motoshi Koga	Port Management & Operations/Financial Analysis,OCDI
Mr. Kohei Nagai	Natural Conditions, JPC
Mr. Takahisa Sogabe	Facility Design/Soil Investigation, JPC
Mr. Kiyoshi Watanabe	Construction Planning/Cost Estimates, JPC
Mr. Stephen R. Nicholls	Natural Environment Study, JPC
Prof. Dr. Nguyen Van Truong	Social Environment Study, JPC
Mr. Yuuichi Sasaki	Coordination(1), OCDI
Mr. Hideki Kobayashi	Coordination(2), OCDI
Mr. Masahiro Nakamura	Coordination(3), OCDI
Mr. Ryu Mizukoshi	Interpreter, OCDI

2. Overview of the Project Area

2.1 Socio-economic Conditions

2.1.1 Geography

Dung Quat is located in the province of Quang Ngai. Quang Ngai was amalgamated with Binh Dinh to form Nghia Binh province after 1975. In 1989 it was separated as an independent province, reassuming back to its original name. Quang Ngai is bordering Quang Nam-Da Nang province in the north, Binh Dinh province in the south, KonTum province in the southwest, parted by Truong Son Mountain and the Eastern Sea in the east.

Quang Ngai has mountains on one side and sea on the other, which together bends the thin rural land strip. Three-fourths of the total 5,168 km² territory are mountains and bare hills. Topographically the province is tilted eastwards and divided into four zones: plain, midland, highland and island.

The rivers in Quang Ngai are short and steep sloped. Water levels are high in rainy seasons and shallow in dry seasons. Consequently, a large volume of alluvial soil is eroded and brought into the sea during rainy seasons.

2.1.2 Population, including labor force

Presently Quang Ngai has a population of 1,200,000, the third biggest in the south central coastal provinces and the highest population density (229 people / km²) in the three study areas (Quang Ngai, Thua Thien Hue, Danang city).

Labor resources are relatively abundant in Quang Ngai. Approximately 46.5% of the population are at the working age, of which almost all are capable of working. Nearly 80% of the total work force is engaged in agriculture and forestry. Comparison of the labor force within the study areas is shown in Table 2.1.2.

Table 2.1.2 Population and Labor Force of Study Area in 1995

		Labor (thous. Persons)			
Provinces	Population	Total	Agriculture & Forestry	Industry & Construction	Services
Thua Thien-Hue	1,003.0	406.6	271.5	49.5	85.6
Q.Nam - Da Nang	1,984.0	933.6	669.3	105.2	159.1
Quang Ngai	1,184.0	551.1	443.2	35.2	72.7

Source: General Statistical Office

2.1.3 Climate

In the coastal areas of central Vietnam the climate is hot and dry from the end of winter to the beginning of summer, with heavy rainfalls from the end of summer to the beginning of winter. Temperature, rainfall, and humidity of the study area are shown in Table 2.1.3.

Table 2.1.3 Monthly Weather Conditions in 1995

Month	**Quang Ngai City**		
	Temp. (°C)	Humidity (%)	Rainfall (mm)
January	22.0	87	49.4
February	22.2	87	84.7
March	23.9	87	57.8
April	26.9	83	1.0
May	28.3	85	66.8
June	29.5	78	51.0
July	28.7	81	31.8
September	29.0	80	6.1
August	26.3	85	396.3
October	25.9	90	1,186.1
November	23.3	93	634.2
December	22.4	86	207.4
Total			2,772.6

Source: Hydro-Meteorological Date Center

2.1.4 Land Use

In Quang Ngai province, the area agricultural land is less than average of the whole country because most of the territory is mountainous and hilly. Land use of the whole country and Quang Ngai Province (South Central Coast) is shown in Table 2.1.4.

Table 2.1.4 Structure of Land Use in 1994

Unit: %

	Whole country	North mount. and midland	Red River Delta	North Central Coast	South Central Coast	Central Highland	North east south	Mekong river delta
Total Area	100	100	100	100	100	100	100	100
Agricultural land	22.2	11.7	56.6	13.1	12.0	11.2	40.9	67.1
Forestry land	30.0	19.8	4.4	36.8	41.1	58.1	21.8	7.7
Special land	3.4	2.2	14.9	3.2	3.2	1.6	6	4.2
Residential land	2.2	1.9	6.9	1.3	1.2	0.9	3.7	4.2
Waste land	42.2	64.5	17.2	45.5	42.4	28.1	27.1	16.9

Source: Statistical Yearbook 1995 (General Statistical Office)

2.1.5. Gross Domestic Product

The past war has left Quang Ngai with a poor economy, weak infrastructure and backward materials. It is still one of the poor provinces in the country.

Despite these difficulties, the province's economy has achieved fairly vivid growth in recent years. The GDP growth rate of the province was only 2.2% in 1991 and 2.4% in 1992, but the province's economy in1993 started to prosper with the GDP growth rate reaching 5.9%, creating the momentum for development in the forthcoming years. The GDP growth rate in 1994 was 10.9% and it is estimated to hit 13% in 1995. In 1994 the GDP value of Quang Ngai was around US$176.2 million, as indicated in Table 2.1.5. It accounts for 0.8% of the GDP of the whole country.

Table 2.1.5 GDP and GDP per Capita in 1994

Province	GDP (Million USD)	GDP per Capita (USD)
Whole Country	21,021.0	288.0
Thua Thien-Hue	253.0	252.2
Quang Nam-Da Nang	488.2	246.1
Quang Ngai	176.2	148.8

Source: Port Traffic Demand Survey For Master Plan Study on Coastal Shipping Rehabilitation and Development Project in Vietnam (JICA-TESI).

2.1.6 Industries

(1) Agriculture

Quang Ngai possesses 88,663 hectares of agricultural and arable land, comprising 17% of the province's natural areas. About 80 % of the population are engaged in agriculture and the agricultural sector plays an important role in the economy of the province. In 1994 the agricultural sector produced about 42% of the province's GDP.

The climatic conditions are favorable for growth of various crops and animals: such as rice, sugar cane, cinnamon, cashew nut, cocoa, buffaloes, cows, pigs and so on. Rice and sugar cane are the notable and traditional crops for the farmers' livelihood. Sugar cane is planted in more than 10,000 ha. Specialty products made from sugar cane in Quang Ngai such as sugar-loaf, sugar-candy, transparent candy are popular throughout the country. The processing industry is one of the prosperous businesses that is leading the region.

While sugarcane brings economic prosperity to the province, rice is grown to ensure food stability. An area of 35,000 ha is spared for the rice field. Corn, potatoes, and cassava are also planted as staple foods. Table A.2.1.6.(1). shows the acreage and production of major industrial crops in the study area.

(2) Forestry

Quang Ngai has a forest area of more than 103,850 ha. However, because there are few rich forests (12% of the total), the timber reserves are disproportionally small. Annually the forests supply Quang Ngai with over 25,000 m^3 of timber for construction and civil carpentry as well as for export.

Besides timber, cinnamon is a specialty of Quang Ngai. The area of cinnamon crop is expanding year by year. The current yield of cinnamon is 400 to 500 tons. 【cf. Table A.2.1.6.(1) Acreage and Production of Major Industrial Crops in Study Area】

(3) Fisheries

The rivers of Quang Ngai are normally dried up during the dry season and flooded during the rainy season, and therefore are of low use. But the sea coastline running along the continental shelf creates favorable conditions for fisheries development. Deep trenches and emerging hills in the offshore area are advantages as well as the water depth of 200 m at a distance of 24 mile from the shoreline. Such an environment could potentially yield 60,000 tons of various shrimp, fish and crab species such as black tiger prawn, king prawn, blue crab, grouper and so on. It is no wonder that fisheries is identified as one of the key economic sectors in the province.

Ly Son island, 32 km far from Sa ky seaport and 10 km in area, exemplifies further development of fisheries. It is a place for not only fishing, but also fish processing and fisheries logistic services.

Besides its inherent advantages, typhoons and flooding afflict the province (annually there are 11-13 typhoons). Moreover, the size of the fishing boats, which are mostly small, are limiting the growth of this sector.

(4) Industry

In 1990 the GDP value produced by industry was only 17% of the total GDP value of the province. Present figures show that the ratio has risen to 22.6%

With the introduction of a market oriented economy, many business establishments suffered losses or went bankrupt. For the remaining businesses, in order to exist and develop in these new conditions, they have to fit to the new price mechanisms. Therefore each sector is trying to add value to its products to be competitive in the market. Agricultural, forestry, and fisheries industry is on the track to develop a processing industry as to add value to its products. Table A.2.1.6.(2). shows the gross value of output in Quang Ngai.

(5) Tourism

Quang Ngai is blessed with not only beautiful scenery but cultural remains as well. As an evidence that Quang Ngai has a high potential to attract tourists, the number of tourists coming to Quang Ngai during the past four years has been increasing, despite the lack of proper infrastructure and low service standards. The number of tourists has more than doubled compared with 1991, reaching 78,900 in 1994, of which 10,500 (13.3%) were international tourists. Table 2.1.6. shows the number of tourists visiting the province.

Table 2.1.6 Number of Tourists Visiting Quang Ngai

	1991	1992	1993	1994
Number of tourists	35,200	49,800	65,000	78,900

Source: General Statistic Office

2.1.7 Trade

In the past, by passing commercial centers and markets in Quang Ngai, one could observe only a small quantity and range of goods. Nowadays the situation has changed: goods appear in the markets in increasing quantity and diversified range, while various types of services are developing fast. As mentioned in the industries section, agricultural, forestry and sea products are exported. Machinery, equipment and materials for agricultural, forestry and small craft industry, transport, construction and of consumer goods are imported.

The province has 37 commercial establishments engaged in services and over 140 big and small markets widely distributed all over the province. However, only Quang Ngai provincial town market - the commercial center of the province - has the scale and form that corresponds to the urban area's demand. However, purchasing power of the population is still low due to economic difficulties. Total value of retailing activities and services in 1994 reached VND 814 billion. In future, when living standard of the people is upgraded, Quang Ngai will be a promising market for businessmen.

2.2 Lao PDR and Northeast Thailand

2.2.1 Lao PDR

Five provinces of the south region in Lao PDR, namely Savannakhet, Champasack, Saravane, Attapeu and Sekhong, are recognized as the hinterland of central Vietnamese ports. As shown in Table 2.2.1(1), the population of this area represents 34.5% of the whole country; it accounts for 28% of the country's land area;and 29.2% of the nation's industrial establishments are found here.

Table 2.2.1(1) Economic activities of Lao PDR

	LAO PDR	South Region of Lao PDR
Area(1995) *1	236,800 sq.km	65,865 sq.km(28%)
Road	18,363 km	
Tarred road	2,446 km	
Graveled road	5,138 km	
Earthen road	10,779 km	
Population(Year 1995) *2	4,581,258	1,580,143 (34.5%)
Savannakhet		671,581
Champasack		500,994
Saravane		256,550
Attapeu		87,182
Sekhong		63,836
GDP(1990 constant) *1		
Year 1994	780,657 Mill.Kip	n.a.
Year 1995	835,519 Mill.Kip	
GDP per Capita		
(1990 constant)		n.a.
Year 1994	170,000 Kip(240US$)	
Year 1995	182,000 Kip(256US$)	
	1US$=708.6Kip	
No. of industry-Handicraft		
Establishments(1995) *1	10,826	3,157(29.2%)
Savannakhet		1,285
Champasack		945
Saravane		633
Attapeu		135
Sekhong		159

Source: *1-Basic Statistics about the socio-economic development in the Lao PDR – National Statistics Center

*2-NSC, Committee for planning and Cooperation(20 years Agricultural Statistics)

Others- JICA Study Team, August 1997

Table 2.2.1(2) Major Products in Lao PDR

Product	unit	1994	1995
Rice	Th.tons	1,577.0	1,417.8
Coffee	Th.tons	9.0	8.6
Gypsum	Th.tons	130.0	124.0
Timber	Th.tons	595.0	819.7
Lumber	Th.tons	271.0	288.9
Plywood	Th.tons	1,870.4	2,069.4
Clothing	Th.pieces	12,183.3	20,460.0
Electric Power	Mill. Kwh	1,197.0	1,085.0

Source: Basic Statistics about the socio-economic development in the Lao PDR -National Statistics Center

Table 2.2.1(3) Population in 1995 by hinterland

Province	Share by hinterland (R-9 : R-16/18)	R-9 Savannakhet Area	R-16/18 Pakse Area
Savannakhet	100 : 0	671,581	0
Saravane	50 : 50	128,275	128,275
Sekhong	50 : 50	31,918	31,918
Champasack	0 : 100	0	500,994
Attapeu	0 : 100	0	87,182
Total		831,774	748,369

Source: NSC, Committee for planning and Cooperation

2.2.2 Northeast Thailand

Northeast Region of Thailand includes 19 provinces, namely Nakhon Ratchasima, Buri Ram, Chaiyaphum, Surin, Ubon Ratchathani, Si Sa Ket, Amnat Charoen, Yasothon, Khon Kaen, Kalasin, Maha Sarakham, Roi Et, Udon Thani, Nong Bua Lam Phu, Loei, Nong Khai, Sakon Nakhon, Nakhon Phanom and Mukdahan. Table 2.2.2(1) shows socio-economic data of Thailand and Northeast Region. But the Northeast Region is spread over a wide area and the western part of the region is closer to Bangkok than Vietnamese ports; for example, Nakhon Ratchasima is 259 km away from Bangkok and 383 km away from Mukdahan. The hinterland of the Vietnamese ports is deemed as shown in Table 2.2.2(3) and Figure A 2.2.2. This area is slightly east of the line that connects Sakon Nakhon and Yasothon and is estimated to be 65 km away from Mukdahan and 80 km away from Ubon-Ratchathani.

Table 2.2.2(1) Economic activities of Thailand

		Thailand	Northeast Region		
Area(1995) *1		513,115 sq.km	168,854 sq.km(33%)		
Highway(1994) *1		50,155 km	14,906 km (30%)		
Incl. Graveled road					
Population					
Year 1990*2		56,303,273	19,828,941 (35.2%)		
Year 1994*2		59,095,419	20,542,381 (34.8%)		
Year 1995*5&*2		59,401,000	20,663,191 (34.8%)		
GDP (1988 constant)		(Billion Baht)	(Billion Baht)		
Year 1990*2		1,953	226 (11.6%)		
Year 1994*2		2,688	294 (10.9%)		
Year 1995*5		2,921	319 (10.9%)		
GDP per Capita					
(1988 constant)		(Baht)	(Baht)		
Year 1990		34,700	11,400		
Year 1994		45,500	14,300		
Year 1995		49,200	15,400		
Trade with Vietnam *1	Year 1994	(1,000Baht)			
	Import Total	985,271			
	Wood	300,000 *4	n.a.		
	Leathers	134,000 *4			
	Scrap	102,000 *4			
	Export Total	6,347,530			
	Maize	28,107			
	Sugar	579,883			
	Gypsum	28,398			
	Motorcycles	623,000 *4			
	(Motorcycles 2,530,000 in 1995) *4				
Trade with Lao PDR	Year 1994	(1,000 Baht) *1	(1,000 Baht) *3		
	Import Total	1,738,063	via Ubon Ratchathani		
	Wood	1,490,000 *4	Year	Import	Export
	Wood Prod.	88,000 *4	1994	552,495	362,622
	Scrap	39,000 *4	1995	412,625	514,734
	Export Total	7,291,667	1996	512,897	544,071
	Motorcycle	1,236,000 *4	Transit Cargo		
	Woven Fabrics	267,000 *4	Year	Lao->3rd	3rd->Lao
	Chemical Prd.	167,000 *4	1994	150,800	460,853
	Glutinous	103,689	1995	482,824	1,337,239
	Maize	1,734	1996	403,028	769,020
			via Mukdahan		
			Year	Import	Export
			1994	248,540	1,619,560
			1995	280,960	1,785,390
			1996	239,100	1,769,360
			Transit Cargo		
			Year	Lao->3rd	3rd->Lao
			1996	44,910	1,726,310
Trade with Japan	Year 1994 (,000 Baht) *1		via Mukdahan Custom Office *3		
	Import Total	413,321,079	('95.10-'96.9)		
	Plastic	18,824,093	Export	8,668	(564ton)
	Iron	17,165,898	Import	38,755	(2,524ton)
	Parts(data process)	8,642,381			
	Export Total	194,199,911			
	Prawn	18,502,698			
	Natural rubber	12,861,653			
	Rice	6,283,969			
	Chilled Cuttlefish, squids	5,067,941			
	Cassava, tapioca	2,215,280			

Source: *1-Statistical Yearbook Thailand, Number 42, 1995-National Statistical Office
*2-Economic Indicators 1995-National Statistical Office
*3-Statistical Reports of Region - Northeastern Region 1995
*4-Trade Between Thailand -Indochina 1993-1995 - Department of Foreign Trade, Ministry of Commerce

*5-World Development Indicators 1997, World Bank
Others- JICA Study Team, August 1997

Table 2.2.2(2) Major Products in Thailand

Product	Unit	1992	1993
Rice	Th.tons	20,184	19,440
Tapioca	Th.tons	19,767	19,487
Rubber	Th.tons	1,500	1,580
Lime Stone	Th.tons	7,111	7,455
Sugar	Th.tons	4,857	3,650
Beer	Th.liters	325	415
Steel Bar	Th.tons	975	1,135
Cement	Th.tons	21,711	26,300
Passenger car	Th.pieces	100	144
Pick up	Th.pieces	224	276
Motor bike	Th.pieces	863	1,118

Source : Quarterly Bulletin - Bank of Thailand

Table 2.2.2(3) Population in 1994 by hinterland

Province	Share by hinterland (R-9 : R-16/18)	R-9 Mukdahan Area	R-16/18 Ubon-Ratchathani Area
Mukdahan	100 : 0	312,202	0
Nakhon Phanom	100 : 0	682,627	0
Sakon Nakhon	100 : 0	1,048,901	0
Kalasin	50 : 0	477,563	0
Roi Et	25 : 25	320,737	320,734
Yasothon	50 : 50	268,885	268,885
Amnat Charoen	50 : 50	175,265	175,265
Ubon Ratchathani	0 : 100	0	1,679,867
Si Sa Ket	0 : 100	0	1,384,958
Total(1994)		3,286,179	3,829,712
Total(1995)*		3,303,172	3,849,515

Source : Statistical Reports of Region - Northeastern Region 1995
* JICA Study Team

2.2.3 Greater Mekong Sub-regional Development

(1) Trade Flow

Trade within East Indochina has increased annually but trading volume is still small. In case of Lao total trade volume is small, but trade within East Indochina represents a large portion. Thailand has the same scale of trade with Vietnam as Lao. But Vietnam has a small scale of trade with Lao compared to Thailand.

The traffic data at Lao Bao, Lao-Vietnam border, indicates that the volume of border trade and border traffic has decreased since 1991 and remains at a stable level from 1993 (refer to Table 2.2.3).

Table 2.2.3 Border Trade at Lao Bao

Year	No. of Vehicle	Export-Import(ton)	Transit(ton)	Passenger
1991	55,000 *1	272,000 :*1	24,000 *1	117,000 *1
1992	38,000	165,000	19,000 *1	97,000
1993	27,000	158,000	10,000 *1	40,000
1994	28,000	162,000	n.a.	53,000
1995	32,000	163,000	n.a.	52,000
1996	29,000	134,000	n.a.	50,000

Note: 1.Number of foreigner in number of Passenger is estimated at 3,000-5,000 and is increasing annually.

2.Main direction of cargo flow is going to Vietnam from Thailand.

3.Major commodities imported from Thailand are textile, garment, motorbike and electric household appliances.

4.Major commodity imported from Lao is gypsum.

5.Major commodities exported to Lao are wood, livestock, handicraft, cement, construction material.

Source :*1-TDSI, the Government of Vietnam
Others-Interview to People's Committee of Quangi Tri Province

(2) Future Development

The Road Route 9, Savannakhet - Dong Ha, is a major corridor for current freight transportation between Lao PDR and Vietnam. Major commodities traded are electric products from Thailand, daily goods from China, gypsum from Lao, oil products from Vietnam and so on. Before the political reform of the USSR, cargoes from the eastern countries to Lao via Danang were considerably larger than these days. Cargo traffic flows in East Indochina are shown in Figure 2.2.3. Since AFTA will be authorized in Indochina in the near future, not only the trading volume within Indochina but also the trading route with other economies will change gradually. Four routes shall be examined carefully, in connection with cargo movement via ports in central Vietnam. The volume on Route No. 2 is small at this moment. Although cargoes generated from and consumed in Lao can choose the Vietnamese route or the Thailand route, many customers favor the Thai route because of the good road conditions, frequent services of shipping lines and because of the poor services in Vietnamese ports.

When future traffic is projected in East Indochina, not only road distances but also average running speed, necessary hours to clear the customs and actual transport cost shall be considered. Present major products are listed in Figure 2.2.3 and future major trading commodities will be examined in due course.

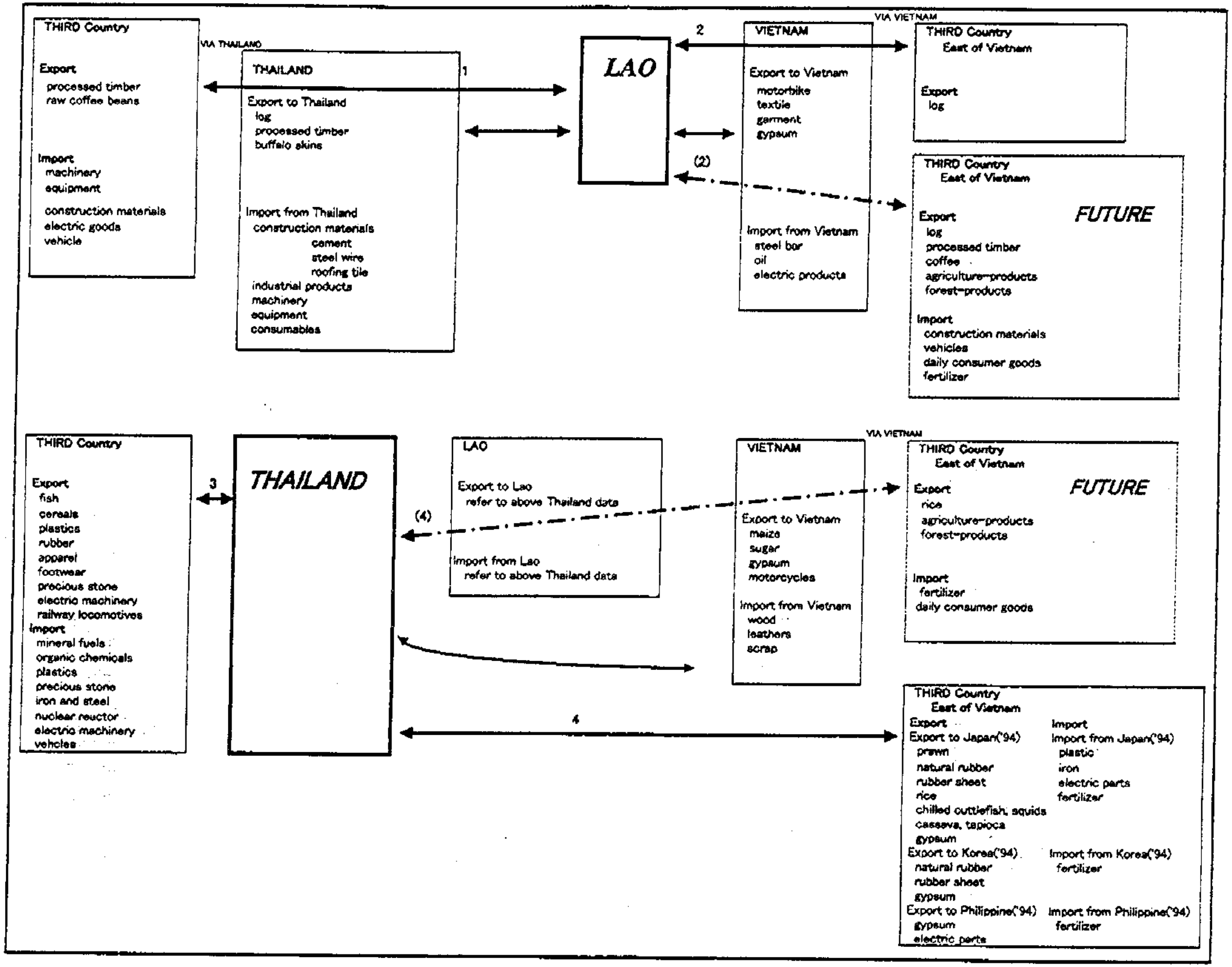


Figure 2.2.3 Trade Flow in Indochina

2.3 Transportation

2.3.1 General

Recently, Vietnamese transport volume has shown an increasing trend corresponding to developments of economy and population. In 1994 freight volume per capita exceeded 1 ton. But passenger transport per capita and passenger traffic transport per capita have not changed since 1980.

Table 2.3.1 Transport volume per capita

Population		Freight (tons/person)	Freight traffic (tons-km/person)	Passenger (times/person)	Passenger Traffic (km/person)
1980	53,630,000*	0.79	183	8.3	257
1985	59,872,000	0.90	212	6.3	225
1990	66,233,000	0.81	189	4.9	179
1994	72,510,000	1.05	278	7.7	231
1995*	73,959,000	1.12	295	8.1	249

Note: * means estimated by the Study Team
Source: Statistical Yearbook 1995 - General Statistical Office

Comparing transport capacities in 1985, 1990 and 1994, railway capacity has not increased but freight transport capacities of trucks and vessels have shown an increasing trend; in particular, the capacity of shipping has increased dramatically.

Domestic cargo has occupied more than 95% of the total freight in Vietnam from the year 1980. In recent years foreign freight traffic has increased in Vietnam and kept a share of 50% of Vietnamese freight traffic in 1995. But average transport distance by foreign freight has not increased.

Land transport is recognized as a major means of freight transportation in Vietnam. Percent shares of freight volume by mode in 1995 are estimated at 5%, 65%, 23% and 7% by rail, land, waterway and sea borne respectively. Sea borne transport is a major mode on a ton-km basis of freight traffic.

Distribution of transport volume of local freight by region is shown in Table A 2.3.8. Red river delta, Eastern south and Mekong river delta are 3 heavy traffic areas in Vietnam. The freight volume of the North Coastal Region including Hue has doubled since

1985 and local freight volume by sea borne transport of this Region has a share of 30% of the total.

2.3.2 Road

(1) General

The total length of road network is estimated at 106,000 km as of January 1st, 1996 in all Vietnam. There are five classifications of roads as follows;

National road	13,633 km
Provincial road	17,205 km
District & village road	66,500 km
Urban road	3,211 km
Special road	5,451 km
Total	106,000 km

(Source: Transport Development and Strategy Institute)

(2) Road Development Projects

Based on interviews with MOT, on-site visits, and information from relevant sources, the Study Team identified the following road development projects in central Vietnam.

1) Highway R-1 (Mucnamquan-Hanoi-Hochiminh City-Namcan, 2,289 km)

Highway R-1 is the main trunk road of the country with a total length of 2,289 km. The whole line shall be rehabilitated and upgraded up to the year 2000. Also, several big bridges along Highway R-1 will be constructed up to the year 2005.

The improvement project of Route 1 funded by ADB from Hanoi to Vinh commenced in 1996. From Vinh to Dong Ha, bidding for the project has been completed.

2) Highway R-14 and R-14B (HCMC-Dakrong, 1069 km)

Highway R-14 is an important highway for central Vietnam, running through the central highland. R-14B connects the central highland with Danang port.

3) R-9 with the East-West Transport Corridor (Laobao-Donghoi, 83 km)

R-9 plays an important role within the subregional economic cooperation schema for East-West Transport project. This improvement project ensures smooth traffic even during the rainy season.

The road is designed to have a width of 12 meters of which the pavement is 7 meter in the section from Cua Viet to 41 kilometers point and to have a width of 9 kilometers of which the pavement is 5 meters in the section from 41 kilometers point to Laobao. Construction commenced on February 26, 1996 with government funds of US$ 10 million.

4) Haivan Tunnel

Haivan Tunnel is one of the big obstacles in transport from North to South. The Haivan tunnel project is given high priority because many people have died in traffic accidents caused by falling rocks.

5) North South Highway

North South Highway will run along the western longitudinal axis and will be the second trans-Vietnam Highway, with Route 1 being the first. It will pass through 14 provinces from Ha Tay to Binh Duong. Major purpose of the highway is to support the potential development of mineral extraction in the north and agriculture in the central mountains.

(3) Improvement in the Road Traffic

To date, city roads are mainly used by motorbikes and bicycles. Rural roads are multi-funtionally used not only for the traffic of motor cars, motorbikes, bicycles and pedestrian, but also for agricultural works and playground, within a maximum width of 12m. Education on traffic rules will be important for upgrading the road traffic.

(4) Distance Table between Major Cities and Ports

Distances between major points in hinterland of the ports in central Vietnam are listed in the following Table 2.3.2 based on distance map in Figure 2.3.2.

Table 2.3.2 Distance Table between Major Cities and Ports

Port	**Chan May**	**Lien Chieu**	**Dung Quat**	**Bangkok**
Origin				
Savannakhet(R-9)	**449**	**479**	**614**	**665**
Pakse *(R-16)*	*407*	*377*	*482*	**765**
Pakse (R-18)	**545**	**515**	**557**	**765**
Mukdahan(R-9)	**469**	**499**	**634**	**645**
Ubon Ratchathani *(R-16)*	*542*	*512*	*617*	**630**
Ubon Ratchathani (R-18)	**680**	**650**	**692**	**630**

Note : Distance through existing route is expressed in bold figures while distance through planning route is in italics.

2.3.3 Railway

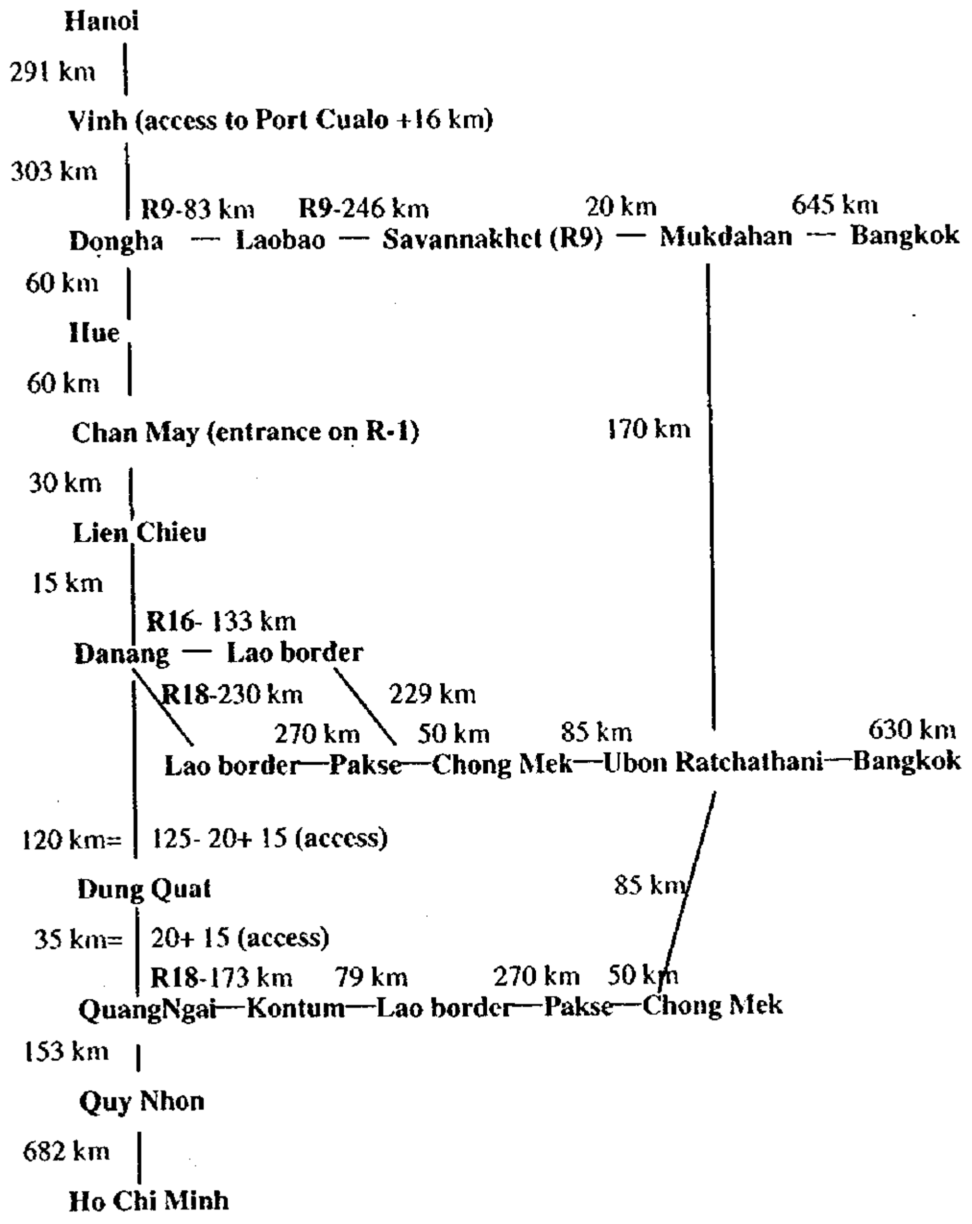
Two types of gauges exist in Vietnam. The standard gauge is 1 meter, and a wider gauge of 1.435 meters was introduced for heavy wagons to support mining and heavy industries in 1960s. The rail network consists of six lines in operation.

Table 2.3.3 List of railway in Vietnam

No.	Lines	Length (km)	Gauge (m)
1.	Hanoi – HCMC	1,730	1.00
2.	Hanoi – Haiphong	102	1.00
3.	Hanoi – Laocai	283	1.00
4.	Hanoi – Langson	148	1.00+1.435 (3 rails)
5.	Hanoi – Thainguyen	75	1.00+1.435 (3 rails)
6.	Thainguyen – Baichay	166	1.435
	Total	2,504	

Source: National Transportation Sector Review 1992 - MOT and UNDP

The number of locomotives has slightly decreased since 1985, and the number of freight train services per day between Hanoi and HCMC is estimated at 6 and total passenger capacity is 930 seats. It is deemed that railway transportation capacity shall be expanded to meet the increasing demand for cargo transportation.



Source: Ban Do Giao Thong Viet Nam(1:1,000,000)
Thailand Highway Map(1:1,125,000)
Viet Nam-Lao-Cam Pu Chia Ban Do Giao Thong(1:500,000)

Figure 2.3.2(1) Road Distance between Major Points

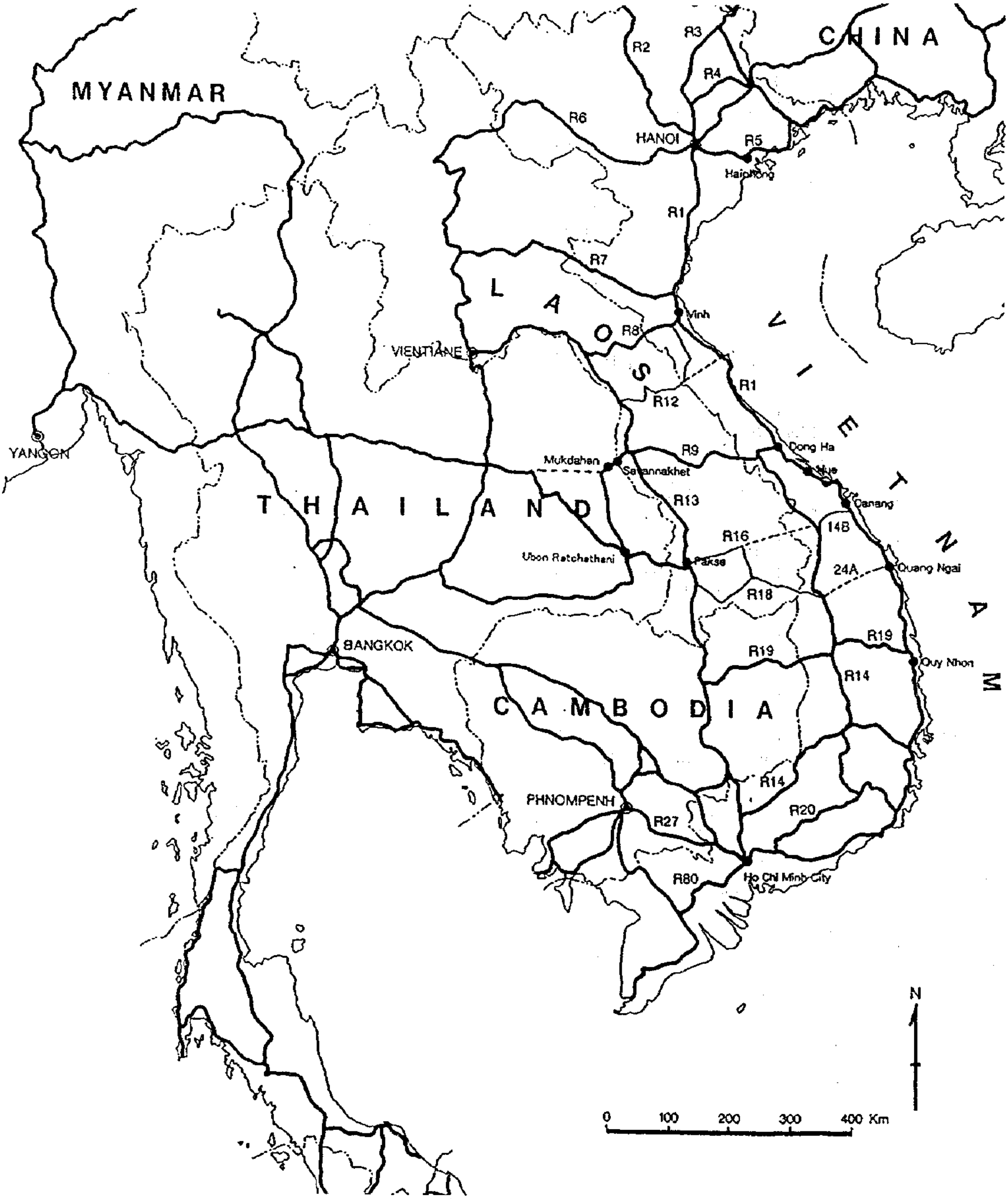


Figure 2.3.2 (2) Road Network in Greater Mekong Subregion

2.3.4 Airport

Of 16 airports in the country, only 4 have international passenger and freight handling capability. They are:

- Hanoi / Noibai
- Hochiminh City / Tansonnhat
- Danang (transfer at HCMC or Hanoi)
- Haiphong (transfer at HCMC)

The other 12 airports offer domestic service. They are:

- Nhatrang
- Hue
- Nasan
- Dalat
- Banmethuot
- Rachgia
- Pleiku
- Vinh
- Phuquoc
- Dienbienphu
- Quynhon
- Tuyhoa

There are two operating airports in the study area:Danang airport and Hue airport. Danang airport possesses two 3048 m long runways. Airbus 320, Tu-134 and ATR-72 are the major aircraft in the airport. The airport is located a few kilometers from the center of Danang. The airport area is 840 ha. Hue airport is located between Hue and Danang and around 15 km from the center of Hue. Fokker 70 and ATR-72 are using the airport. Two flights are available per day to Hanoi and Ho Chi Minh City respectively.

Chu Lai airport is located near Dung Quat industrial zone. The airport was formerly a military air base but is out of use at the moment.

2.3.5 Shipping (Coastal & International)

There were 674 ships registered under the Vietnamese flag during 1994-1995 of which 463 were general cargo, refrigerated or oil tanker vessels mainly used for commercial transport and the balance are mainly tugs, unpropelled barges and fishing boats. These 463 merchant vessels were owned by 175 organizations as shown in the following Table.

Table 2.3.5(1) Shipping Fleet by Type of Ownership

No	Service Type	Owner Type	No. of Owners	Total DWT	Average DWT
1.	Ocean-going	State owned	67	445,295	2,319
		Joint venture	12	278,216	12,646
		Foreign	2	4,792	2,396
		Sub-Total (1)	81	728,303	3,372
2.	Coastal shipping	Local	60	141,678	864
		Government	6	3,480	193
		Co-operative			
		Private	28	29,582	455
		Sub-Total(2)	94	174,740	707
		Grand Total	175	903,043	1,950

Source: Master Plan Study on Coastal Shipping Rehabilitation and Development Project - JICA,1997

Major shipping companies in Vietnam are state-owned or joint venture shipping operators, namely VOSCO, VITRANSCHART and VINASHIP. They are members of VINALINES (Vietnam National Shipping Lines). Many provincial shipping companies have been established by several provincial organizations. SAIGON SHIPPING and DAMATCOSCO are major provincial shipping companies which operate general cargo vessels over 2,000 DWT. Profiles of above companies are shown in the following table.

Total cargo handling volume at major ports was 11,863,600 tons which consisted of exports of 3,903,100 tons, imports of 5,864,500 tons and domestic cargoes of 1,996,800 tons. Major commodities of handled cargoes were expected to be rice, fertilizer, machinery and cement. Details of commodity are shown in Table 2.3.5(3).

Table 2.3.5(2) Outline of Major Shipping Companies

Name	Head Office	No. of Employee	No. of Vessels	DWT
VOSCO	Haiphong	2,000	20	209,098
VITRANSCHART	HCMC	1,250	9	87,315
VINASHIP	Haiphong	980	5	30,668
SAIGON SHIPPING	HCMC	580	6	12,634
DAMATCOSCO	Danang	220	5	6,105

Source: Master Plan Study on Coastal Shipping Rehabilitation and Development Project -JICA 1997

Table 2.3.5(3) Freight volume at major sea ports by major commodity

(unit : 000 tons)

		1990	1992	1994
Total		8,283.0	9,036.8	11,863.6
Export		3,374.3	3,868.9	3,903.1
	Coal	157.6	618.9	10.0
	Rice	1,359.8	1,699.4	1,703.7
	Agro prod.	171,2	188.7	-
	Rubber	53.4	3.6	-
	Timber	598.8	498.9	161.6
	Other	-	-	2,027.7
Import		3,106.7	3,043.9	5,864.5
	Fertilizer	1,140.5	1,275.6	1,361.7
	Machinery	216.2	55.7	506.6
	Metal	401.2	269.1	-
	Food	207.2	268.2	-
	Pyrite ore	81.6	58.5	-
	Chemical	62.4	66.1	107.5
	Others	-	-	3,652.1
Domestic		1,802.0	2,124.0	1,996.8
	Coal	156.7	202.4	-
	Cement	902.8	937.8	-
	Food	254.3	433.5	-
	Plaster	41.4	23.8	-

Note: Major sea ports include Haiphong, Saigon, Danang, Quangninh, Quynhon, Nhatrang, Nghetinh and Cantho

Source: Table 9.12 - Statistical Yearbook 1995 - General Statistical Office

3. Ports

3.1 Danang Port

3.1.1 Location

Danang Port, located in the middle part of the country, has an important position as the third largest seaport of Vietnam. Danang Port is also a very convenient port of Central Vietnam and the Western Highlands as well as Southern and North Eastern Thailand. Also, National Highways 1A and 14B, the International Airport and the North South railway network, are all very near the cultural, commercial and industrial center of Danang.

This port is comprised of two distinct parts: one is in Tien Sa district facing Danang Bay and the other is in Song Han district facing the Han River which is flowing into the bay.

3.1.2 Port Facility

Tien Sa Port has two piers, each of 186m long, 27.3~29.3m wide, and water depth is -11m, consisting of four berths for 30,000 DWT ships at maximum. A third pier 165m long and water depth -12m is now being under construction for container ships near existing two piers. The total area is 18.3ha, of which the yard occupies 90,000m^2 and 3 warehouses of 15,945m^2 .

Song Han Port, extending along the left bank of the Han river, has a length of 750m with 8 berths of -6 to-7m depth for 5000DWT ships at maximum. The Port occupies an area of 3.4ha where open storage yard of 8,000m^2 and 3 warehouses of 8,225m^2 are being used for cargo handling and storing. The major facilities of each port are summarized in Table 3.1.1

Jetty piers in Tien Sa Port were originally constructed in 1965 to 1966 by the US navy. After the completion of these piers, the first repairing works were done in 1975~1976 and the second were carried out in 1980~1985,then the third, in 1993~1997. Presently No.1 pier is 186m long and 27.3~29.3 m wide. No.2 pier is also186m long and 27.4m~29.4m wide. Crown height is CDL +4.9m .

The structure of the piers are so-called steel jacket type. Units of jacket are usually fabricated in the factory and transported to the construction site and set on the bottom of sea bed. Then, by the piles driven through vertical steel jacket pipes, the jacket structures are fixed. So the construction work is much faster than in cases of other types of piers. The Figure A3.1.1 shows the typical cross section of No.1 and No. 2 jetty piers.

According to the engineer in charge of construction of Da Nang Port, original slabs (decks) were made of wood and they were replaced by concrete slabs then vertical steel piles were filled with concrete at the first repair work stage in 1976. In 1980~1985, the vertical reinforced square concrete piles(40×40cm,21m length) were added on both sides of piers for fender installation. In 1993~1996, the portion of the steel piles at splash zone were covered with concrete to prevent corrosion. Then new reinforced concrete slabs supported by the I- beams were installed on the old slabs. However, due to the difficulty of repairing pipe trusses, horizontal steel pipe trusses located at splash zone had been left without any treatment, thus, they are now severely eroded. There are many small holes can be seen on the horizontal steel member .

To prevent yielding structure, enforced diagonal reinforced concrete square piles are planned to be added just behind outer vertical piles in 1997 and after these reinforced work, new rubber fenders are to be attached at the literal head beam of the fender piles. The repairing work started from 1997 will cost USD 13 million including dredging work.

Berths in Song Han Port were constructed in France sovereign age before 1930. The original structure was made of the wall consisting concrete base blocks and large stones . In 1960', the present concrete pile platforms with a width of 10m were built in front of the original wharves. Figure A3.1.2 shows typical cross section of these wharves. After these initial construction works, partial repairing works have been continued, however original structure remains unchanged. Recently heavy cargoes like 40 feet container are increasing, so that, from the necessity to strengthen piers structure, in 1995, the reinforcement of structure was carried out at a portion of 60m long by driving additional concrete piles between the original piles. There are some places along the wharves where the suction phenomenon of the filled materials behind the original wharves are observed. Port of Da Nang has a plan to add reinforced concrete piles and replace with L-type retain walls instead of existing stone walls to prevent filling material flow by suction force.

Table 3.1.1 Major Facilities in Danang Port

	Tien Sa Port	Song Han Port
1. Berth Facilities		
-Number of Berth	4	8
-Berth Length	732m	750m
-Water Depth	-11m	-6～-7m
2. Cargo Handling Facilities		
-Mobile Crane	16sets(5～80t)	
-Fork Lift	16sets(1.5～42t)	
-Tractor	2sets	
3. Transit Shed and Warehouse		
-CFS	4,320m^2	
-Warehouse	14,850m^2	8,225m^2
4.Open Storage Yard		
-Open Storage Yard	39,400m^2	8,000m^2
-Container Yard	38,000m^2	10,200m^2

3.1.3 Cargo Throughput

The total volume of cargo handled recently in the Port of Danang was 847,900 tons in 1996 and 882,218tons in 1997. The major import commodities are chemical fertilizer, cement, kaolin, iron steel, equipment and tar. The major export commodities are pulp, sand, and food grain. Trends of cargo volume of export/import and domestic by main commodities are shown in Table 3.1.3(1).

The volume of container cargo has been steadily increasing at average growth rate: 15.1% and ratio of empty container in 1997 is 27% as shown in Table 3.1.3(3)

The total ship calls was 317 in 1996 and 411 in 1997. Concerning to share of cargo ship in 1997, 61% were for foreign and 39% were for domestic as shown in Table 3.1.3(2). Furthermore, characteristics of ship calls is shown in Table 3.1.3(4).The total number of unloading ships at Tien Sa district in 1992 was 126 of which 62% were Vietnamese national ships and 16% were of the USSR. On the other hand, the total number of loading ships at Tien Sa district in 1992 was 98 of which 66% were Vietnamese national ships and 11% were of Thailand.

Table 3.1.3(1) Cargo Volume by Main Commodities of Danang Port

(Unit: Ton)

	1994	1995	1996	1997
Quantity	**666,745**	**830,242**	**847,900**	**882,218**
1. Import	**489,811**	**631,657**	**582,057**	**433,489**
- Chemical fertilizer	106,565	200,220	213,511	195,474
- Cement	234,232	259,932	227,537	79,252
- Kaolin	67,227	96,385	47,830	78,570
- Iron steel	24,177	20,069	25,646	420
- Equipment	52,112	47,040	52,005	65,236
- Tar	5,240	5,855	12,715	13674
- Consumer goods and others			2,813	863
2. Export	**119,510**	**149,424**	**198,187**	**279,726**
- Pulp stone	40,800	95,247		
- Silica Sand	14,761	10,867	24,306	62,193
- Food grain	10,123	1,131		
- Stone	6,148		2,378	
- Wasted iron and steel	13,492			5,853
- Consumer goods and others		29,740	171,503	211,680
3. Domestic	**57,424**	**49,151**	**67,656**	**169,003**
a. Domestic import	55,072	45,597	61,886	162,514
- Coal	25,019	23,008	27,841	37,410
- Cement	16,472	8,660	22,799	116,442
- Chemical fertilizer		5,214	4,855	
- Iron steel	8,125	3,490	653	2,628
- Equipment	2,155	1,633	1,673	1,852
- Consumer goods and others			4,065	4,182
b. Domestic - Export	2.352	3,564	5,770	6,489
- Gypsum	1,954			
- The other	398	3,564	5,770	6,489

Source: Danang Port

Table 3.1.3(2) Ship Calls of Danang Port

Sort of Ship	1996	1997
Cargo Ship (Foreign)	217	229
Cargo Ship (Domestic)	64	147
Passenger Ship	36	35
(Total)	317	411

Source: Danang Port Authority

Table 3.1.3(3) Container Cargo Volume

Years		1990	1991	1992	1993	1994	1995	1996	1997
1. Total number of Container (TEU)	Import	873	315	1,562	2,232	2,808	3,652	4,935	5,974
	Export	541	349	1,355	1,930	2,751	3,361	4,168	5,123
1a. Empty Container (TEU)	Import				992	888	1,207	※	※
	Export				618	913	744	2,548	3,012
1b. Full Container (TEU)	Import				1,240	1,920	2,445	※	※
	Export				1,312	1,838	2,617	6,555	8,085
2. Total volume of Container (Ton)	Import	3,957	1,382	12,638	15,640	21,430	29,301	※	※
	Export	6,568	4,738	18,415	23,037	27,786	38,236	65,000	83,000
3. Ship Calls		235	179	202	324	278	261		

※ Import and Export

Source: Danang Port

Table 3.1.3(4) Characteristics of Ship Calls (Tien Sa)
From 01/01/1992 to 01/01/1993

Unloading				Loading			
Nationality of ship	Number of ship	GRT	Volume (ton)	Nationality of ship	Number of ship	GRT	Volume (ton)
Bahamas	8	20,322	13,471	Bahamas	8	20,322	960
Bangda	1	13,125	7	Bangda			
Cuba	1	11,323	10,040	Cuba			
Honduras	0		5,666	Federal	1	2,854	62
				Republic of		385	304
The USSR	19	84,152		Germany	1	55,602	7,561
Malta	1	3,986	63,467	Honduras	6		
South Korea	1	4,058	2,622	The USSR			
Philippines	1	2,000		Malta			
Panama	13	43,229	1,247	South Korea			
Thailand	1		21,128	Philippines	11	27,753	19,202
Turkey	1	4,925	4,217	Panama	6	5,084	80,98
Vietnam	78	130,747	1,097	Thailand			
Federal	1	2,854	109,871	Turkey	65	80,577	37,474
Republic of Germany			125	Vietnam			
Total	126	316,665	223,986	Total	98	192,577	73,659

Source: Danang Port

3.2 Ports in the Key Area of the Central Region

3.2.1 Cua Viet Port

(1) Location

Cua Viet Port is located in the northern part of Quang Tri province, on the right bank at the mouth of the river, and it is administrated by Quang Tri province.

(2) Port Facility

- One reinforced concrete quay with 63.7m for 2000-3000 ton vessels and the throughput capacity of 200,000 ton/year.
- Access channel 2.5km in length and - 5.9m in depth, 8 buoys system and a turning area 132m in diameter.
- Concrete yard: 7200m²
- Jurisdiction area: 8 ha
- The technical system:
  Management office: 450 m²
  Warehouse: 900 m²
  3 ton electronic weighing station
  Electrical and water supply system
- Equipment:
  Tug: 530CV
  Handling cranes
  Lift-truck
- Access road: 14.8km from 1A national road to the port.

(3) Future Plan

In the first stage, 254.4m long wharf will be built to accommodate 5000 ton vessels. Furthermore, the rail of 10.5m in width for operation of cranes, warehouse for packed cargoes (900m²), and a yard for bulk cargoes will be built.

In the second stage, the wharf will be expanded an additional 254.4m (total length of wharf is 508.8m). This will allow accommodation of 4 vessels of 5000 ton capacity simultaneously.

3.2.2 Thuan An Port

(1) General

Thuan An Port is located in the central part of the lagoon Dam Cau Hai, which is 10km away from Hue City. Thuan An Port was built in 1975 by the United States and transferred to the Central Government, which in turn transferred it to the Hue Provincial Government in 1984.

(2) Port Facility

- The port has 3 berths: 92m long and 21m wide berth (3.2m deep at low tide and 8.7m at high tide) , 90m slope berth, and 98m long berth.
- The port has one warehouse of 1,800 m^2
- Cargo handling facilities consist of 4 mobile cranes with a capacity of 10-15tons.

(3) Cargo Volume and Ship Calls

Cargo volume and ship calls are summarized below.

Year 1995	Volume (ton)	Commodities
1. Cargo volume	82,500	
Export	9,500	Rattan and others mainly to China
Import	7,000	Glass and general cargo mainly from China
Coastal In	66,000	Coal : 37,000ton, Cement : 29,000ton
2. Ship Calls	310	Maximum : 600DWT

(4) Future Plan

- Dredging work of 200 to 250 thousand m^3 in front of the wharves and the access waterway to accommodate vessels of 1,000 DWT class.
- Construction of fish port, fuel port and a tourism port

(5) Current Problems

- Due to strong seasonal winds, the port is closed for about three or four months per year.
- The water depth is shallow at the entrance of the lagoon.

3.2.3 My Khe Port

(1) General

My Khe Port is situated in Danang City. It is under the direct administration of My Khe oil depot which is one of the five oil depots of Petrolimex Danang. The port can accommodate ships of 30,000 DWT. It is planned to replace Lien Chieu or Thanh Khe in the future.

(2) Port Facility

- Standard buoy: The bollard connecting soft and hard pipes is placed in order to vessels during the mooring and oil pumping. One standard buoy is of plate steel, 8mm thick, cylinder shape, 0.8m diameter and 0.8m high.

- Buoy, chain and anchor system: There are 4 groups, each group consists of one buoy used to hook mooring vessels, fabricated of plate steel of 8mm, chain of Ø100, 25m long linking the buoy to a steel circle of more than 620mm diameter, diameter of steel of 15.5m.

- Pipeline: 1 steel pipe of 8", 2 steel pipes of 10" laid under the sea. The whole steel pipeline is 1500m long.

3.2.4 Sa Ky Port

(1) General

Sa ky Port is located in Quang Ngai province. Following the improvement project in 1991, the port can accommodate ship of 1,000DWT. Investment capital of the project was approximately US$ 2million.

(2) Port Facility

There is one 50m berth without handling equipment and its cargo handling capacity is 100,000～200,000tons.

(3) Future Plan

Equipment, crane, lighting and others are planned to be installed.

3.3 Ports in the Peripheral Provinces

3.3.1 Vung Ang Port

(1) General

Vung Ang Port is a new port which is planned in Ha Tinh Province based on the agreement between theVietnam government and the LAO government. According to the feasibility study on Vung Ang Port, the hinterland is assumed to be Ha Tinh Province, Quang Binh Province, middle part of LAO and north-eastern part of Thailand. Port facilities and construction cost is estimated as follows.

(2) Facilities and Construction Cost

Facilities	Unit	Volume	Cost Billion VND
Construction			656.38
-Quay	m	1,344	150.75
-Stone embankment	m^2	8,100	1.62
-Breakwater	m	500	149.45
-Building yard	m^3	2,075,000	26.98
-Dredging	m^3	1,100,000	27.50
-Road and yard	m^2	225,400	16.66
-Store-house and architectural construction	m^2	80,466	104.89
-Technical system			13.66
-Others			137.51
Equipment			316.20
(Total)			972.58

3.3.2 Quy Nhon

(1) Location

Quy Nhon Port is located in Quy Nhon City, Binh Dinh province. The bay, sheltered by Phuoc Mai peninsula, is hardly affected by wave and wind and the basin is quite calm.

(2) Port Facility

-The pier was constructed for calling of 10,000 DWT vessel with a depth of 8.5m and a length of 174m with 2berths.

-The wharf has a length of 350m with 1berth and 5,000 DWT .

-The port has one warehouse of 7,500 sq.meters.

-Cargo handling facilities consists of 13 mobile cranes with a capacity of 2-25 tons.

(3) Cargo Handling

Cargo volume trend from 1990 to 1995 and cargo handling volume at Quy Nhon Port are shown in Table 3.3.2. The cargo volume slightly increased in this period. In 1995, import and export volumes were 170,000 tons and 150,000 tons respectively.

Table 3.3.2 Trend in Cargo Volume at Quy Nhon Port

(Unit: thousand tons)

Year	Amount
1990	300
1991	300
1992	340
1993	410
1994	400
1995	450

(4) Current Plan

Container cargo is increasing rapidly, rising from 4600 TEUs in 1994 to 7200 TEUs in 1995. Development plan to cope with the increasing cargo has been decided as follows: two berths of 244 meters in length to accommodate vessels larger than 20,000 DWT will be prepared over an area of 27 hectares with the target year of 2010.

3.3.3 Nha Trang Port

(1) Location

Nha Trang Port is located in Nha Trang City, Khanh Hoa province. The port operator was founded in 1976. Before the large berth was constructed in 1991, barge transport had been operated between an offshore anchorage and the coast. The port is naturally protected by islands.

(2) Port Facility

- The pier was constructed between 1993 and 1995 with a depth of 9.6m, a length of 155m with 2 berths.
- The wharf, repaired in 1979, has a water depth of 6m - 7.5m and a length of 350m with 2berths.
- The port has three warehouses.
- Cargo handling facilities consist of 5 mobile cranes with a capacity of 8-16 tons.

(3) Cargo Handling

Trend in cargo volume from 1990 to 1995 and cargo handling volume are shown in Table 3.3.3. The cargo volume considerably decreased in 1991, however it has increased from 1993. The volume of imports was many times more than that of exports.

Table 3.3.3 Trend in Cargo Volume at Nha Trang Port

Year	Amount (ton)
1990	220,000
1991	150,000
1992	150,000
1993	180,000
1994	210,000
1995	340,000

(4) Current Problems

One of the problems of the port is that the land area within the port is small therefore the yard has been built 3 km away from the port. The narrow and steep access road of the port is another problem that needs improving soon. The 45 days of port closure due to bad weather also causes little affect on port operation. Finally, though land area for development is small and environmentally sensitive, the port will be enhanced as one of the ports which represents the south.

4. Natural Conditions

4.1 Tide

On the coast of the key area of central Vietnam, Tide Table is available for Danang. According to the Table, tides in the Study Areas are semi-diurnal, although the diurnal component is predominant in some months. The tidal levels are relatively low in April and high in October. The tidal level, which is essential for planning, and design of port facilities are shown in Table 4.1.1 for Danang. The mean high water range (average tidal range at full and new moons) is approximately 1 m.

Table 4.1.1 Tidal Levels at Danang

Name	Abbreviation	Water level (m)
Highest High Water Level	HHWL	+ 2.35
Mean Higher High Water Springs	MHHWSL	+ 1.51
Mean Monthly-Highest Water Level	HWL	+ 1.4*
Mean Sea Level	MSL	+ 0.92
Mean Monthly-Lowest Water Level	LWL	+ 0.4*
Mean Lower Low Water Springs	MLLWSL	+ 0.37
Lowest Low Water Level	LLWL	+ 0.07
Chart Datum	CDL	0

Source: Association of Science and Technology on the Sea of Vietnam "Report on Hydro-meteorological Regime in Danang", 1996, based on actual data from 1978 to 1988 (11 years) observed at Son Tra Station, Danang.

* Estimated by calculation of HWL and LWL for 1993-1997 (5 years) by the JICA Study Team based on "Tide Tables, Vol. II, 1993 - 1997" published by the General Department of Hydro-meteorology, i.e. 1.30 m and 0.42 m respectively. The HWL in this table is derived from the fact that the difference between the actual MHHWSL and estimated one from the Tide Table is 0.15 m.

At the mouth of Danang Bay, the Study Team analyzes the tidal level observed by the wave recorder for 30 days from December 18, 1997. The results are summarized in Tables 4.1.2 and 4.1.3. The sum of the amplitudes of the major four tidal components is 57.7 cm. The amplitudes are relatively smaller at the mouth than in the bay.

Table 4.1.2 Major Tidal Components at the Mouth of Danang Bay

Components	Abbreviation	Period (hours)	Amplitude (cm)	Phase angle (degree)
Major Lunar Semidiurnal	M 2	12.42	17.9	309.2
Major Solar Semidiurnal	S 2	12.00	6.7	328.4
Luni-solar Diurnal	K 1	23.93	19.7	283.7
Major Lunar Diurnal	O 1	25.82	13.4	254.8

Source: Study Team

Table 4.1.3 Relative Tidal Levels Observed at the Mouth of Danang Bay

Name	Abbreviation	Water level (cm)
Near Highest High Water Level	NHHWL	+ 57.7
High Water of Ordinary Spring Tides	HWOST	+ 24.6
Mean High Water	MHW	+17.9
High Water of Neap Tides	HWONT	+ 11.2
Mean Sea Level	MSL	+ 0.0
Low Water of Neap Tides	LWONP	-11.2
Mean Low Water	MLW	-17.9
Low Water of Ordinary Spring Tides	LWOST	-24.6
Datum Level	DL	-57.7

Source: Study Team

The relationship of sea levels between Danang and Dung Quat is as shown in Table 4.1.4

Table 4.1.4 Relationship of Sea Levels between Danang and Chan May

Area	Mean sea level above CDL (m)	Adjustment of sea level (m)	
		Spring tide	Neap tide
Danang	+ 0.90	0	0
Dung Quat	+ 1.20	+ 0.3	+ 0.1

Source: General Department of Hydrometeorology "Tide Table, Vol. II, 1997"

The relationship of water levels, H, between Son Tra Station in Danang and Dung Quat has been studied by means of regression analysis by the TEDI for the Dung Quat Bay (25 Oct. to 24 Nov. 1995):

$$H\,(\text{Dung Quat Bay}) = 1.11 \times H\,(\text{Danang}) - 2\ \text{cm}\ ^{*}$$

The high tides at Dung Quat occur about 40 minutes earlier than those at Danang.

4.2 Wind

4.2.1 Wind on the Land

Wind in the South East Asia is generally governed by two monsoons, i.e. northeast monsoon in winter and southwest monsoon in summer, although wind direction is strongly affected by local geography.

Wind data on the land near to Dung Quat are available at one station of Hydro-meteorological Service of S.R.Vietnam (HMS), i.e. Quang Ngai. Wind roses at the station are shown in Figures 4.2.1 for the past 10 years (1987-1996). In Quang Ngai, north and north-west winds dominate from October to January. East winds prevail from March to August. Strong wind occurs due to typhoons and storms normally from September to November.

Maximum wind velocity recorded in Quang Ngai station in the past 10 years (1986-1995) is summarized in Table 4.2.1 by month. The most highest wind velocity was 40 m/sec in November from north at Quang Ngai. This strong wind was due to Typhoon 9521 named Zack which landed at about 40 km south of Quang Ngai on 1 November 1995.

Table 4.2.1 Maximum Wind Velocity by Month (1986-1995)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Quang Ngai	10	10	12	12	**20**	16	12	12	12	**28**	**40**	18
	N	SE	SE	NNW	**WSW**	W	SW	E	W	**NNE**	**N**	NNW

Data Source: Hydrometeorological Data Center, 1997 Note: Bold figures are due to typhoons.

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[*] Note: Difference of the datum levels at the two places compared to that of Danang is not clear.

4.2.2 Wind on the Coast and the Sea

(1) Wind Observed at Central Coast and Danang by MHMC

On the coasts and islands of Vietnam, there are 21 stations of the Marine Hydro-meteorological Center (MHMC). Wind roses at northern and central stations are considerably different from those measured on the land. In Danang, for example, north-easterly wind from October to January, easterly wind in April, and south to south-westerly wind in July are predominant, reflecting characteristics of the monsoons.

(2) Wind observed at Chan May by TEDI

Actually observed data on the coast and the sea are invaluable for planning and design of a port. In Chan May, TEDI carried out wind observation at the northern tip of the East Chan May Cape from 27 July to 28 August 1996 (one month). Measurement was made four times a day at 1, 7, 13, and 19 o'clock. Wind directions to be recorded are divided into eight directions. It is quite characteristic that measured wind directions are diverse at NE, SE, SW, and NW directions, forming a cross shape. Lack of southern wind seems to be due to existence of a mountain behind the station.

Wind speed during this period of time was mostly less than 5 m/sec, except those from 1300 hours on 21 August to 1300 hours on 22 August and those from 1300 hours to 1900 hours on 25 August. The maximum wind velocity of 9.5 m/sec from SW was observed at 0100 hours on 22 August.

4.2.3 Wind by Typhoons

Tropical storm and typhoon are defined by a depression with maximum wind speed being more than 17 m/sec. Typhoons on the South China Sea originate usually in the west Pacific and around the Philippines and move to the west, finally attacking Vietnam. Typhoon season normally starts in May in the north Vietnam and in October in the South Vietnam. In central Vietnam, September to November are most active months as shown in Figure A 4.2.2, and approximately two typhoons land every year on the average.

Wind velocity, V, depends on relative location of the place of interest and center of the typhoon, taking account of direction of typhoon movement; distance from the place to the center of the typhoon, r; central air pressure, Pc; and speed of the typhoon, U; let alone local geography. Considering these factors and actual wind records, 30 typhoons that most affected the central region of Vietnam are selected from all the typhoons recorded for a period from 1961 to 1997 (37 years) and tabulated in Table A 4.2.2.

There are only a few typhoons of which maximum wind speed at landing time exceeded 40m/sec at near observatories. There is no typhoon landed between Hue and Danang, except a few tropical depressions (TD) during the above period.

The tracks of typical and representative typhoons are shown in Figure A 4.2.3. These 30 typhoons are candidates of wave hindcast for the discussion of design conditions of port facilities.

4.2.4 Wind Observation at Chan May by the JICA Study Team

The JICA Study Team is carrying out wind observation at the three Study Areas as shown in Table 4.2.3 by means of anemometers brought from Japan. The locations of the wind observation are shown in Figure A 4.2.4.

Table 4.2.3 Wind Observation by the JICA Study Team

Study area	Location	Longitude, E Latitude, N*	Height of the sensor from G.L.	Equipment model	Start time of measurement
Chan May	Center of Chan May coast	108° 00' 08.6" 16° 18' 42.1"	5 m	P-type, No.23-P	7 April 1997
Danang	Hai Van Cement yard at Lien Chieu	108° 07' 26.0" 16° 07' 44.3"	5 m	P-type, No. 23-P	6 April 1997
Dung Quat	Ky Ha Light House	108° 41' 29.4" 15° 28' 53.6"	25 m	Dynavane No.112-3	4 April 1997

* Based on World Geodetic System (WGS) 84

The result of the observation at Ky Ha Light House of average wind velocity is presented in Figure A 4.2.5 in the form of wind rose by month. In general, the wind is governed by the daily land-and-sea-wind system and strongly affected by the local geography at the station. For reference, data of wind observed at Quang Ngai Observatory are collected and compared with those of Ky Ha. Findings on their characteristics are summarized below :

a. The frequent wind directions are ESE to SSE except October to December, when major wind blows from N to E and W. There are relatively small occasions where wind blows from SW and SSW.

b. There is no obstacle around the station which is locating on a flat peninsula without high trees. It is most characteristic that the sea wind blows initially from the north and turns the direction clockwise to the south.

c. On ordinary days, wind is calm at night and starts to blow from the west in the morning, reaching maximum from the east in the afternoon, and settle down in the evening.

d. The maximum average sea wind speed is normally about 10 m/sec, occurring usually in the ESE. The highest maximum average wind speed recorded was 15.7 m/sec from N at 2:00 on 30 October 1997. This is caused by Typhoon 9726 (Lynda). The wind by Typhoon 9721 (Fritz) was not taken due to maintenance period of the equipment.

e. Directional distributions of winds are quite different between Ky Ha and Quang Ngai Observatory.

4.3 Wave

4.3.1 Wave on the South China Sea Provided by the US Navy

Statistics of waves observed by ships at an area off the central coast of Vietnam (a square enclosed by E 112 and E 115 degrees, and by N 11 and 14 degrees) are provided by the U.S. Navy.[1] The data include frequencies of occurrence of wave height in terms of wave period and direction According to this statistics, predominant direction of waves from January to April is NE, from May to September SW, and from October to December again from NE. This means monsoons and typhoons govern the waves in the area.

Maximum wave height of more than 10 m from the east was recorded in October. It is less than 10 m for January, March, November and December; less than 8 m for February, May,

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[1] U.S. Navy "Marine Climatic Atlas of the World, Vol. III Indian Ocean", March 1976

June July, August and September; and less than 6 m in April. These extremely high waves have small probability of occurrence of less than 0.5 %, and they are apparently generated by typhoons.

4.3.2 Waves Observed on the Coast of Vietnam and at Danang by MHMC

MHMC reported wave roses at their marine stations as shown in Figure A 4.3.1. Data at Quy Nhon indicate similar characteristics to the statistics of the U.S. Navy introduced above.

At Son Tra (E 108° 13', N 16° 06') in Danang, MHMC has been carrying out "estimated wave measurement", or visual wave observation, since 1977. The wave roses at Son Tra, which are already shown in Figure A 4.3.1, imply that waves are quite small compared with others stations. In January, waves are small with predominant direction of north. Wave height from the north is about 1.0 to 1.5 m. Frequency of "calm" is 38.8 %. In April and July, most of waves are less than 1 m. Frequency of calm is high, i.e. 45.0 % and 60.6 %, respectively. In October, the predominant directions are northwest and north with frequency of occurrence of about 25 % each. Wave height from the northwest exceeded 2 m. Calm has an occurrence probability of 44.3 %.

The maximum observed wave height from 1978 to 1993 (15 years) was 6.0 m from NW on both 24 May 1989 and 18 September 1990. The former wave was due to Typhoon 8904 (Cecil) and the latter wave was by Typhoon 9018 (Ed).

Probability distribution of wave height at Son Tra prepared by MHMS is shown in Figure A 4.3.2 which is based on monthly maximum height and Fisher-Tipette I distribution. Wave height equivalent to a return period of 50 years is assessed to be 8.0 m and for 100 years to be 9.0 m.

4.3.3 Waves observed at Dung Quat by TEDI

TEDI performed also visual observation of waves at the northern tip of the Dat Vian Ka Cape to the east of Dung Quat Bay from 25 October to 24 November 1995(one month). The water depth of observed waves is about 21 m. The result is given in the form of wave roses.

Waves occurred 58 % from NE, 14 % from N, and 14 % from NW. The rest of 13 % was calm. High waves of more than 2 m and less than 3.5 m occurred once each from NE and NW. The former was generated by Typhoon 9519 (Vivette) and the latter by 9521 (Zack).

4.3.4 Wave Observation at the Mouth of Danang Bay and off Ky Ha by the JICA Study Team

Wave observations have been carried out by the Study Team as shown in Table 4.3.1 and Figure A 4.2.4. The wave meters, which were brought in from Japan, were set on the seabed and had capacities of wave measurement by means of both ultrasonic wave and water pressure. Wave direction can be measured by detecting water particle movement caused by the surface waves. Current is also measured simultaneously.

Table 4.3.1 Wave Observation by the JICA Study Team

Location	Longitude, E Latitude, N*	Water depth of the wave recorder	Equipment model	Start time of measurement
Mouth of Danang Bay, or 9.3 km of Tien Sa Port	108° 15' 34.0" 16° 11' 27.7"	CDL –24m	Wave Hunter 94 Σ	13 Sept. 1997
3.2 km NE of Ky Ha Light House	108° 42' 44.9" 15° 30' 06.5"	CDL -23 m	Wave Hunter Σ	4 April 1997

* Based on World Geodetic System (WGS) 84

The records of waves memorized in IC tips were recovered every one to four months and analyzed to obtain various wave statistics.

(1) Typical Wave Records Taken at Danang and Ky Ha

By the both wave recorders, several representative waves in this sea area were measured successfully, including those by typhoons, tropical depressions and monsoons. Waves by typhoons are due to Typhoon 9721 (*Fritz*) and 9726 (*Lynda*).

1) Wind Waves Generated by Typhoon Fritz

One of the most typical wave records taken at Danang and Ky Ha by the ultrasonic wave recorder is that of Typhoon 9721 on 25 September 1997. The track and central air pressure of Typhoon 9721 is shown in Figure A 4.3.3 and its wave record in Figure A 4.3.4. The Figure illustrates significant and maximum wave heights and periods with main wave directions (direction where wave energy is most concentrated). It is understood that the records are in good quality.

The highest significant wave heights, H_{13}, recorded are 5.7 m (Period T_{13} = 9.7 sec) from the east at Danang (at 1200 hr on 25th) and 5.1 m (T_{13} = 8.7 sec) from the northeast at Ky Ha (at 2200 hr on 24th). The highest maximum wave heights, H_{max}, recorded are 9.0 m (Period T_{13} = 8.7 sec) from the east-north-east at Danang (at 08:00 hr on 25th) and 7.9 m (Period T_{13} = 9.0 sec) from the northeast at Ky Ha (at 2200 hr on 24th).

Their directional wave spectra are analyzed by Extended Maximum Entropy Principle Method (EMEP) and shown in Figure A 4.3.5. The wave spectrum of Ky Ha clearly shows two peaks of energy, i.e. one is at the wave period of about 10 seconds from the northeast and the other is of about 6 seconds from the north. The former is the main wave component which came from the typhoon when it had been at offshore and the latter is additional components from the typhoon when it had approached near the shore.

2) Wind Waves Generated by Typhoon Linda

From the 1st to 3rd of November 1997, a typhoon named *Linda* (Typhoon No. 9726) passed the southern periphery of the Indo-China and caused serious damages and casualties at Baria - Vung Tau to Camau on the coast of southwest provinces. The lowest central air pressure was 985 hPa from 0700 to 1600 (local time) on the 2nd of November. The typhoon was about 730 km apart from Ky Ha and 800 km from Danang at the nearest track in the early morning on the 1st of November. The highest waves generated by the typhoon and recorded at Danang and Ky Ha are:

At Danang,

H_{max}= 6.8 m, T_{max}= 8.8 sec. from the north-east direction
at 0800 on the 1st of November

H_{13}= 4.1 m, T_{13}= 9.8 sec. from the east-north-east direction
at 0200 on the 2nd of November

At Ky Ha,

H_{max}= 6.8 m, T_{max}= 10.0 sec. from the north-east direction
at 2000 on the 1st of November

H_{13}= 4.2 m, T_{13}= 9.8 sec. from the north-east direction
at 1000 on the 2st of November

The above waves observed at Danang and Ky Ha can be considered to have had almost the same magnitude.

3) Swells from a Remote Typhoon

The same series of wave records in Figure A 4.3.4 revealed another important characteristic of waves at the coast of central Vietnam. Both of the waves measured at Danang and Ky Ha on the 15th of September have a very long period of about 16 seconds, although its significant wave height is only about 1.2 m. Their directional wave spectra are shown in Figure A 4.3.6 which demonstrate that the swells came from the east-north-east direction and the longest wave components has a period of more than 30 seconds.

This wave is most probably the swells generated at the northeast area of the Philippines in the west Pacific by Typhoon *Oliwa* (central pressure: 935 hPa) moving to the northwest direction toward Japan. The swells were propagated through the Bashi Channel into the South China Sea. The distance from the central coast of Vietnam to the typhoon was about 3,000 km.

These records are a proof of the existence of long period waves at the central coast of Vietnam.

(2) Statistics of Observed Waves at Danang and Ky Ha.

The wave roses are shown in Figure A 4.3.7 (1) and (2) by season which demonstrates that the dominant wave directions are:

April – May	NE and secondly ENE
June – August	E and secondly ENE
September – November	NE and secondly ENE
December – February	ENE and secondly NE

The frequency distributions of wave occurrence for the whole observation period are tabulated in Table A 4.3.2 (1) and (2).

(3) Correlation between Observed Wind and Wave

At Danang the correlation between wind and waves is not well, because of locality of wind which is strongly affected by mountains.

At Ky Ha the locations of the wind meter and the wave recorder are only about 3.2 km apart. However, the local wind, or its speed and direction, not always corresponds to the wave, or its height and direction. Correlation between wind direction and wind speed or wave height are shown in Figure A 4.3.8 for the data in April 1997. It tells that, when the local wind blows from northwest to north direction, wave height is apt to become high in this month. On the contrary, although the local wind is relatively strong from east to south, waves are rather limited.

4.3.5 Estimate of Waves

(1) Effective Fetch

Waves are generated by wind and grow proportionally to its surface wind speed, fetch (distance over which the wind is blowing), and duration of the wind. The maximum fetch is a physical factor, which can be derived by geography of the sea, in this case, the South China Sea. Supposed a directional spectral distribution of wave component to be cosine, the effective fetch, F_{eff}, is defined by Saville (1954) as:

$$F_{eff} = \Sigma X_i \cos\theta_i / \Sigma \cos\theta_i$$

where X_i is a fetch of θ_i direction.

The effective fetch at Ky Ha / Dung Quat area is as shown in Figure A 4.3.9. The longest effective fetch is 1,370 km to the east. It is noted that the ENE direction is to the West Pacific through the Luzon Straight (Bashi Channel), the effective fetch of which is infinite theoretically. Through the gap of the strait, swells created by large typhoons on the Pacific intrude into the South China Sea.

(2) Estimate of Usual Waves at Dung Quat

Waves generated and propagated by wind in the South China Sea is hindcast from 1 January 1993 to 31 December 1994 (2 hours interval for 2 years) by the method and at the locations as below:

Waves:	Swells by the "3rd generation wave spectral method" based on non-linear energy transfer on the grid of 2.5 degrees interval and Wind waves by "significant wave method" based on Wilson's Equation.
Wind:	Data by European Center for Medium Range Weather Forecast (ECMWF)
Locations:	2 locations at (N15.0 deg. and E 110.0 deg.) and (N 17.5 deg. and 107.5 deg.)

Frequency distributions of offshore deepwater waves are estimated as shown in Table A 4.3.3 (1) and (2) for the above two years. At the both locations, the most frequent wave direction is ENE.

Next, the offshore deep water waves at Dung Quat are interpolated by the waves obtained at the above two locations, which in turn propagated onto the shore at a depth of 16 m, taking account of shoaling, refraction, breaking and diffraction of the waves to obtain the maximum significant waves expected during the two years. The result is given in Table 4.3.4.

Table 4.3.4 Estimated Usual Maximum Waves at Dung Quat

1993 - 1994

Wave direction	Offshore (deep water)		At site (-11 m)	
	H_{13} (m)	T_{13} (sec)	H_{13} (m)	T_{13} (sec)
NNW	1.5	4.8	1.4	4.8
N	4.8	8.4	2.9	7.2
NNE	4.2	8.1	3.7	8.4
NE	3.8	9.9	3.4	9.9
ENE	4.0	8.3	3.5	8.3
E	3.1	7.3	2.7	7.3

Source : JICA Study Team

(3) Hindcast Waves by Typhoons in the Past

1) Verification of the Method of Wave Hindcast

Wave hindcast method employed here is a wave spectral method called MRI-JWA Model, which was developed by the Meteorological Research Institute and Japan Weather Association. The model deals with a typhoon by assuming circular isobars and computes the wind field taking account of the gradient wind, frictional resistance on the sea surface and the wind accompanied by the movement of the typhoon. The growth, propagation and decay of the waves are calculated only in the deep sea based on the energy balance equation of two dimensional wave spectrum in consideration of growth by wind, energy dissipation by breaking and internal friction, energy loss by adverse wind, etc.

The wave calculations are done by a zooming method on the three fields covering the whole South China Sea as well as the sea surrounding the Philippines as the Large Field and the central coastal area of Vietnam as the Small Field. The particulars and maps of the three fields are presented in Table 4.3.5 and Figure A 4.3.10.

Table 4.3.5 Particulars of the Fields of Typhoon Wave Calculation

Field	Grid number	Grid interval (km)	Time step (minutes)	Calculation period	Boundary Condition
Large	31 x 21	100	120	Whole life of the typhoon	Treated as land
Medium	31 x 29	50	60	Whole life of the typhoon	Grids of the Large Field
Small	111 x 101	5	7.5	48 hours around the peak of waves	Grids of the Medium Field

Source: JICA Study Team

This model is applied to Typhoon *Fritz* and the results of the wave calculation are compared at Danang and Dung Quat (Ky Ha) as shown in Figure A 4.3.11 (1) and (2). The actual and hindcast waves coincide with each other very well at the peak. In other words, this model is proved to be applicable and useful for the purpose of this study.

2) Hindcast Waves by the Past 30 Typhoons

Wave hindcasts are carried out based on the above method for the past 30 typhoons from 1961 to 1997, which were selected from the most affected typhoons to the central coast of Vietnam. The results at Chan May, Danang and Dung Quat (Ky Ha) are shown in Table A 4.3.6.

The highest waves obtained were those generated by Typhoon *Harriot* (No. 7112). The significant wave heights are 10.6 m, 10.8 m and 8.4 m at Chan May, Danang and Dung Quat (Ky Ha), respectively. It is understood by the U.S. Navy's statistics that there *is* a possibility of these extraordinary high waves, which can be generated by a typhoon in the South China Sea.

3) Statistical Deepwater Waves by Typhoons at Dung Quat

In order to evaluate the design offshore deepwater waves for a certain return period, the above results of hindcast waves by the past 30 typhoons are analyzed by means of statistical treatment. The results are shown in Figure A 4.3.12 which is the best fitting distribution, applying the Weibull distribution with an exponent, k, of 2.0.

The significant wave height, $H_{1/3}$, and its period, $T_{1/3}$, are 8.8 m and 13.5 sec., respectively, for the return period of 50 years. They are denoted hereinafter as H_0 and T_0, respectively, as the offshore deepwater wave to be considered in the design of port facilities.

(4) Waves by Typhoons Estimated in the Planned Port at Dung Quat

1) Locations of Wave Calculation and Calculation Method of Wave Propagation

The locations of the calculation of waves in the harbor are shown in Figure A 4.3.13. The calculation method of wave propagation from the offshore deepwater to these locations takes account of the following conditions:

a. Tidal level : H.W.L. = C.D.L. + 1.7m

b. Refraction of irregular waves due to shallow water of parallel contour lines (Refraction coefficient: K_r, refracted wave angle: α_p)

c. Diffraction of irregular waves due to cape(s) by the energy dispersion method (Diffraction coefficient: K_{d1}).

d. Diffraction of irregular waves due to breakwater(s) by diffraction diagrams (Diffraction coefficient: K_{d2}).

e. Shoaling and breaking of irregular waves in the harbor (Combined shoaling and breaking coefficient: K_{sb})

2) Waves Estimated in the Planned Port of Dung Quat

The wave directions of the above offshore deepwater wave are taken as the northeast, east-northeast and east for safe estimate. The wave period is assumed not to change for simplification of the calculation.

The results of the calculation are summarized in Table A 4.3.7. The estimated highest significant wave height, $H_{1/3}$, and maximum wave height, H_{max}, are 6.6 m and 11.2 m, respectively, at the Locations MS1.

4.4 Current

Ocean current in the South China Sea and off the coast of central Vietnam is shown in Figure A 4.4.1. The surface current changes by the effect of monsoons on the sea. Along the central coast of Vietnam, the current direction is predominantly northerly (from north) except the southwest monsoon in summer when the current flows opposite. The speed of the current in this area is not high, or less than 1.3 knots.

More detailed information on the average current in the northwest South China Sea is provided by the Japan Oceanographic Data Center (JODC) as the monthly average current from 1953 to 1994 (42 years).

4.5 Storm Surge

Storm surge, which is caused by low air pressure and wind tide due to typhoons as well as effects of coastal topography, is important for port planning and coastal protection planning where strong typhoons attack. Along the coastline of Vietnam, storm surge is one of the critical problems at the inner area of the Gulf of Tongking.

In the Study Areas, according to a research now undergoing at the Center for Marine Environment Survey, Research & Consultation (CMESRC), Institute of Mechanics, in Hanoi, probability of occurrence of storm surge height at Danang is 95 % for 50 cm, 4% for 100 cm, 1% for 150 cm and less than 0.1% for higher than 200 cm based on data from 1950 to 1990.

Actual storm surges at Son Tra in Danang, and Chan May Bay were measured simultaneously on 1 November 1995.[1] They were caused by Typhoon 9521 (Zack) which was one of the most severe typhoons affected the Study Areas in the past 40 years. The heights of storm surges at Danang and Chan May were about 35 cm and 32 cm, respectively.

In the Study Areas, the issue of the effect of storm surge can be considered not very critical. In the port and coastal planning, however, the Highest High Water Level (HHWL) at Danang, i.e. CDL +2.35 m, can be taken account for planning and design of relevant facilities.

It is noted that the Dung Quat Bay has quite particular geography, among others existence of the cape with mountains to the east and the direction of the coastline open to the north. Because of it, the most dangerous wind directions in view of storm surges are north to north west.

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[1] Dept, River & Marine Engg, Institute of Physics-HCM City Branch "Report on Study and Investigation for Establishment of Chan May Deep Sea Port and Industrial Zone in Thua Thien-Hue Province" Dec. 1995.

Such strong wind can be created by typhoons passing not only south side but also north side of the Dung Quat Bay.

4.6 Rainfall

Rainfall volume and its intensity are important factors to discuss design of drainage system in port planning, river discharge of sediment, and other environmental subjects.

The annual volume of rainfall in the past 10 years (1986 to 1995) is on average 1,784 mm at Quang Ngai (max: 2,773 mm in 1995, min: 1,553 mm in 1988)

The data of monthly maximum daily rainfall (maximum of daily rainfall in each month) are statistically analyzed by the Study Team for the above 10 years and the result is shown in Figure 4.6.1. This Figure 4.6.1 reveals that, as far as the daily rainfall intensity is concerned, the extreme maximum in the above period of 10 years was 424 mm/day at Quang Ngai on 19 November 1987. It was not due to typhoons, but possibly by tropical depressions.

These intense rainfall can cause flood and enormous river discharge into the sea.

4.7 Sediment Transport

4.7.1 Sediment Supply in the Study Areas

Provision of sediment from a river and transport of the sediment in a coastal water is an important subject from the viewpoint of port and coastal planning as well as environmental conservation. Accumulation of sediment and erosion of seabed and coast due to phenomena such as "siltation" and "littoral drift" could cause serious problems sometimes.

Sediment from rivers in the central region of Vietnam is supplied mainly in rainy season normally from September to December with abundant rainfall and accompanied floods.

In the Study Area, there are two river systems , one is large, i.e. the Tra Bong River, and the other is small, i.e. the Moi River. The approximate dimensions of the river systems are shown in Table 4.7.1. These rivers are not major ones in the country such as the Red River and the Mekong River. The length of the Moi River is not long.

Table 4.7.1 River Systems at the Study Area

Study Area	Name of River	Length of Main* Stream (km)	Basin Area* (km^2)	Average Sediment Supply **(m^3/day)
Dung Quat Bay	Tra Bong River	60	760	25 - 100
	Moi River	7	19	4 - 18

* Based on 1/250,000 maps published by the General Department of Land Administration. ** Estimated

4.7.2 General Features of Beach Erosion and Siltation in the Study Areas

According to a study by the Marine Hydrometeorological Center (MHMC)[1] beaches neighboring the Study Areas are suffering from a large scale erosion. Examples of critical beaches are the sand dunes in Thua Thien - Hue Province and beaches at the mouth of the Cua Dai River, i.e. the exit of the Thu Bon River, in Quan Nam Province. Major reasons of the beach erosion can most probably be attributed to development of dams along the rivers and exposure of the beaches to high waves during the NE monsoon.

According to studies by the Institute of Oceanography, Nha Trang, the residual direction of sediment transport along the central coasts is from north to south.

4.7.3 Sediment Distribution Analysis by the JICA Study Team

In order to know the trend of the sediment transport in the Study Areas, the JICA Study Team carried out sea bottom sediment sampling at 100 points each in the Chan May Bay, Danang Bay, and Dung Quat Bay in April and May 1997. The samples were analyzed by sieve tests and settlement tests to draw particle size distribution and to derive median diameter, d_{50}.

Figure 4.7.1 shows the percentage distribution of clay and silt (diameter < 63 microns) in Dung Quat Bay. High concentration of silt/clay of more than 50 % is observed at the sheltered area by the Dat Vian Ka Cape, which implies the movement of sediment to the area from the shore area.

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[1] MHMC, Polish Academy of Science & Fredric R. Harris : "Vietnam Coastal Zone Vulnerability Assessment and First Steps towards Integrated Coastal Zone Management" 1995

4.7.4 Possibility of Erosion and Accumulation of Beach

The beach at the Dung Quat Bay has not been studied from the viewpoint of the coastal system yet. In detailed coastal engineering study is necessary to find the actual phenomena prevailing at the sites.

A preliminary view of the Study Team is that the beach between the Ky Ha and the Dat Vian Ka Capes is a kind of pocket beach, and its coastline seems to be rather stable under the present conditions without any marine structures.

In order to estimate the change of the shoreline due to construction of Dung Quat Port , One Line Theory is applied to the beach at the Dung Quat Bay area.

One Line Theory is based on an understanding that the longshore sediment movement is mainly governed by the energy flax of the incident waves that approach the beach with a certain angle to the bottom contours and shoreline configuration. The volume of sediment movement is simply governed by two terms, one is by declined angle of the incident waves to shoreline (coefficient of transport: K_1) and the other is by slope of wave height of breakers to the longshore direction (coefficient of transport: K_2). Various parameters involved in the calculation including K_1 and K_2 are determined by observed data and verification of present change of the shoreline. Then, the same parameters will be applied to the calculation of prediction of shoreline movement for future layout of port facilities.

The most important parameter is waves, which are taken from the data of wave hindcast from January 1993 to December 1994. Sediment diameter (D_{50}) is from the measurement by the JICA Study Team. River discharge is based on the estimate of the Team. The values of K_1 and K_2 are as follows:

$$K_1 = 0.040 \quad \text{and} \quad K_2 = 1.000$$

The result of the calculation of the cases of ISP and Master Plan is shown in Figure A 4.7.2 In the Dung Quat Port, no serious change in the shoreline might be expected. However, when the breakwater will be constructed and extended, careful observation of the change in the shoreline should be carried out and, if necessary, appropriate measures should be taken. On the other hand, there could be some influences to the beach on the left side of the mouth of Tra Bong River.

4.8 Soil Conditions

4.8.1 Soil Strata in Dung Quat Area

According to the soil boring investigations conducted by TEDI, the surface layer consists of medium sand with small gravel. However, this sand layer can not be found from place to place. The surface sand likely exists near the shoreline and near the inlet of the small river located on the foot of the cape Co Co. Under this surface layer, there exists gray colored sandy clay. This sandy clay has values of 5 to 10 N and 10 to 15m thickness. At the bottom, there appears rock. The rock is black-blue colored granite and the surface of the rock are weathered.

Figure 4.8.1 shows the locations of boring holes and Figure 4.8.2 shows estimated typical soil profile.

4.8.2 Classification of Soils at Dung Quat Area

In classifying soils, coarse grained soils can be classified by grain size and fine grained soils as well as by consistency. By the Japanese Unified Soil Classification Standard ,the soil with a grain size of more than 74μ to 2.0mm is defined as sand and under 74μ to 5μ as silt, then under 5μ as clay.

Table 4.8.1 shows a typical composition ratio of soft soils classified by grain size at Dung Quat planning areas.

Table4.8.1 Composition Ratio of Soft Soil Classified by Grain Size

	Gravel %	Sand %	Silt %	Clay %	Total %
Dung-No.2layer	3.5	46.5	17.5	32.5	100
Dung-No.3layer	3.0	80.0	7.0	10.0	100
Dung-No.3alayer	3.5	45.5	19.0	32.0	100
Dung-No.4layer	4.0	65.0	7.0	24.0	100
Dung-No.5layer	2.0	59.5	13.0	25.5	100

Source: JICA Team' calculation based on the data from TEDI

According to this figure softer layers are composed of 20% silt under 50μ particle size(above and under 74μ particle size % is not measured, so instead of 74μ ,50μ is adopted as a classifying boundary of sand and silt) and 30% clay under 5μ particle size . These soils' natural moisture content is 20～70%,which means low plastic soil.

The consistency is a qualitative description of engineering potential of a cohesive soil, and closely related to its mechanical properties. The consistency is expressed by the liquid limit and plastic limit. Figure 4.8.3 shows the relationship between the liquid limit and plasticity index obtained by soil test using boring samples of the planning site in Dung Quat. We can notice two groups in this figure, relatively high plastic group and low plastic group. The high plastic group is the soil obtained from just inside sea area of near Co Co Cape where are well sheltered from strong wave action and particle size is rather small.

According to this figure, we can understand that the soils are mostly classified into cohesive soils such as sandy clay, silt and clay, which have low plastic property.(cf. Figure 4.8.4 :dots are in the CL area) This means ,if the layers consist of these soils are loaded by the weight of structures, the subsidence of under-foundation will not occur so much quantitatively. However further examination should be needed to evaluate subsidence of under-foundation using the results of such soil tests as consolidation, stress and strain etc.

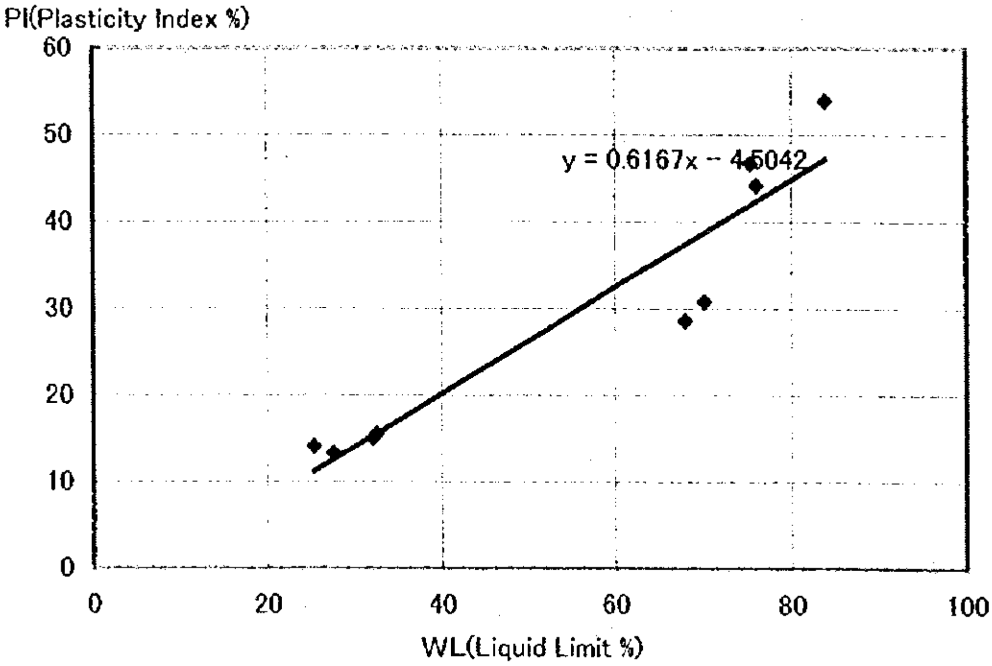


Figure 4.8.3 Relation between Plasticity Index and Liquid Limit in Dung Quat

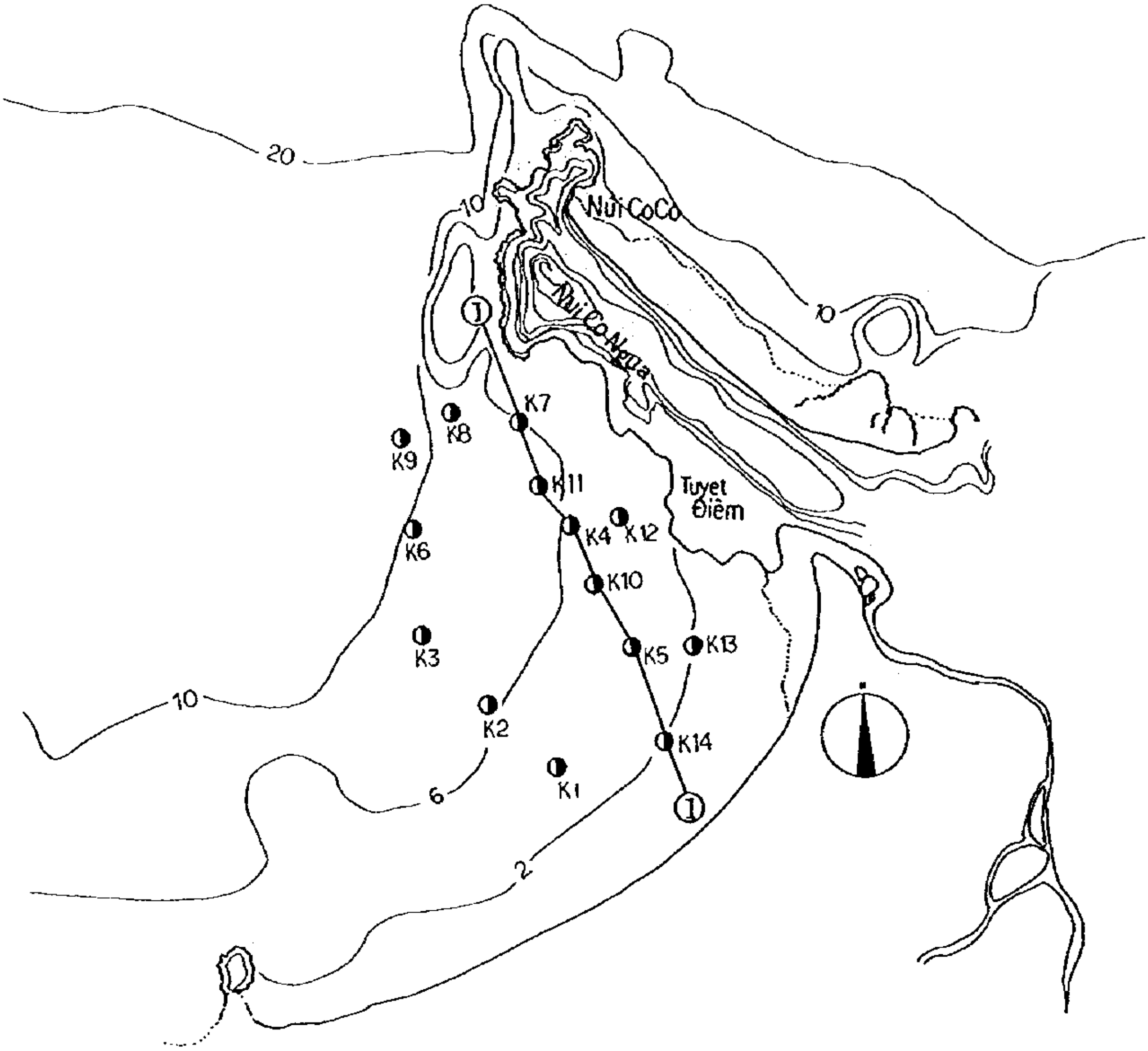


Figure 4.8.1 Location Map of Bore Holes at Dung Quat

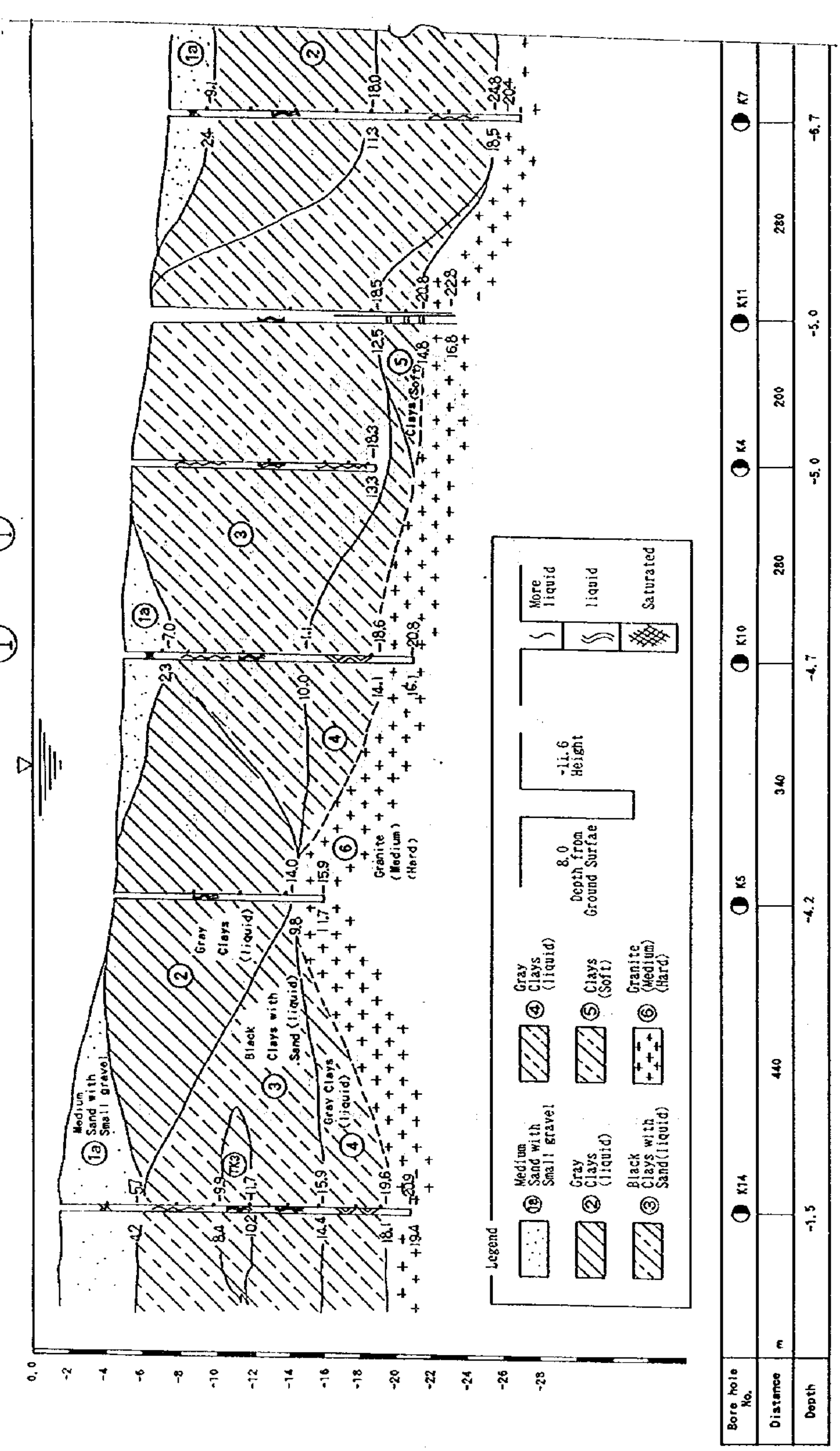


Figure 4.8.2 Typical Soil Profile of Dung Quat

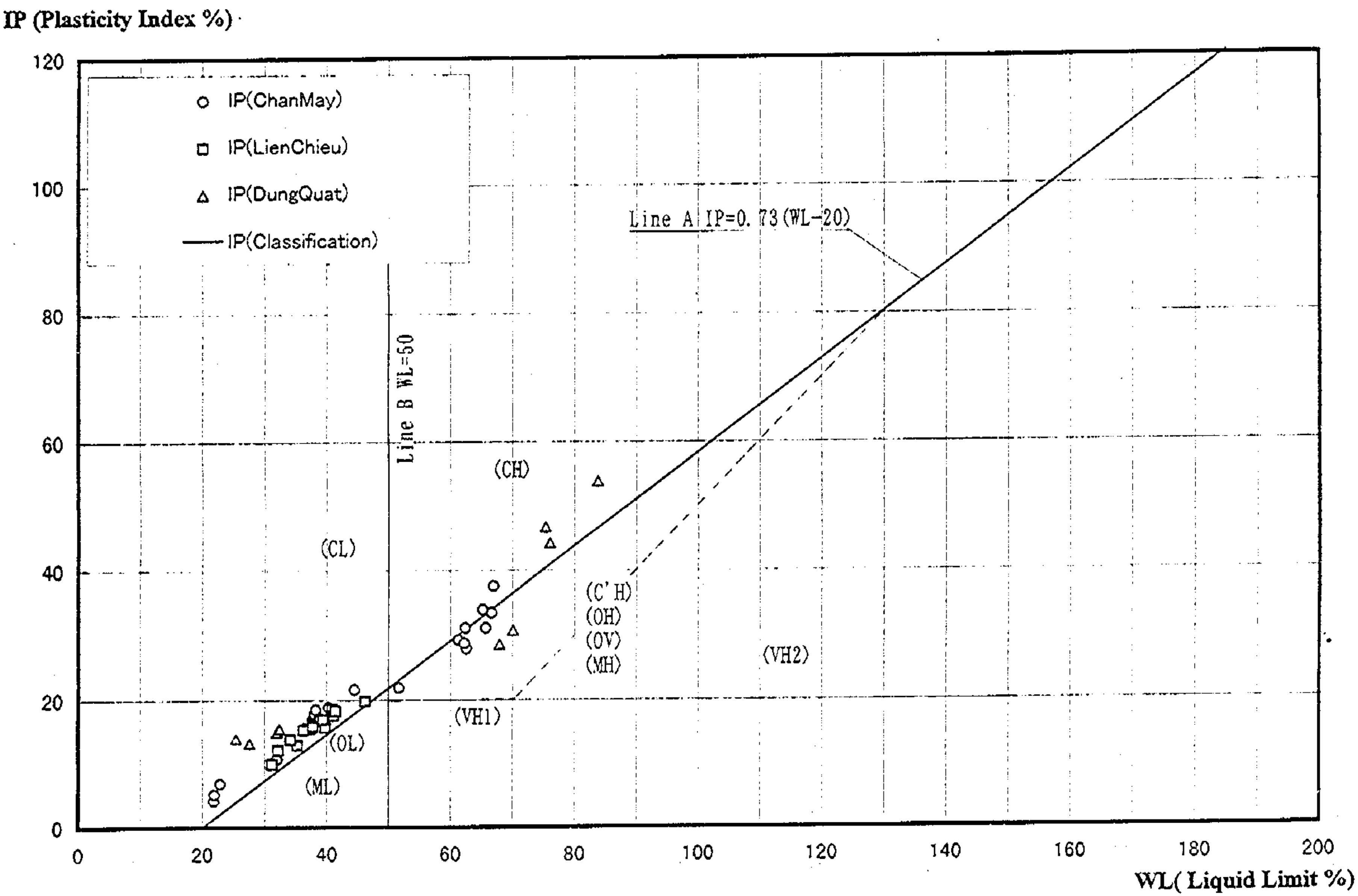


Figure 4.8.4 Plasticity Classification Chart by Japanese Standard

4.8.2 Result of Soil Investigation

(1) Soil Boring

To make supplement and confirm the existing soil data for planning and designing port facilities, soil investigations in Dung Quat have been carried out from the end of August to the early November. The numbers of boring are four of which locations with before-executed bore holes are shown in Figure4.8.5.

The drilling work was carried out by XY-1B rotary boring machine made in PRC(Peoples Republic of China) which was set on the pontoon fabricated by two wooden boats with each loading capacity of 40 ton.

Figure 4.8.6(1)~4.8.6(4)show soil profiles and the results of standard penetration test (SPT) of each bore holes. The elevations of bores in Dung Quat are from –4.4m to –14.7m and bearing layers appear –20m~-25m.

The upper layers of each bore are mostly cohesive soils, however we could conduct SPT through all bore length. N-value of upper cohesive soil is mostly under 5.

(2) Result of Soil Test

To evaluate soil characteristics 51 soil samples of four sites in number were taken and various soil test were executed. Results of these soil tests are tabulated in Table A4.8.2. These results shall be analyzed for useful data.

Particle size analysis shows that soils classified as clay contain 30 % of clay and 40% of silt, and 30 % of sand(c.f. Figure4.8.7)

Using one of these testing results, unconfined compression tests, strength of soft layers can be estimated. Figure 4.8.8 shows the relation between cohesion of a soft soil layer and its elevation. In these figures values of cohesion obtained by triaxial compression test before executed by TEDI are also doted as a reference.

The values of cohesion in Dung Quat are distributed between 0.25~0.8 kgf/cm^2. These values are two or three times as large as those of Chan May and Lien Chieu. It needs more analysis in detail, however Dung Quat has less problem for soft soil foundation.

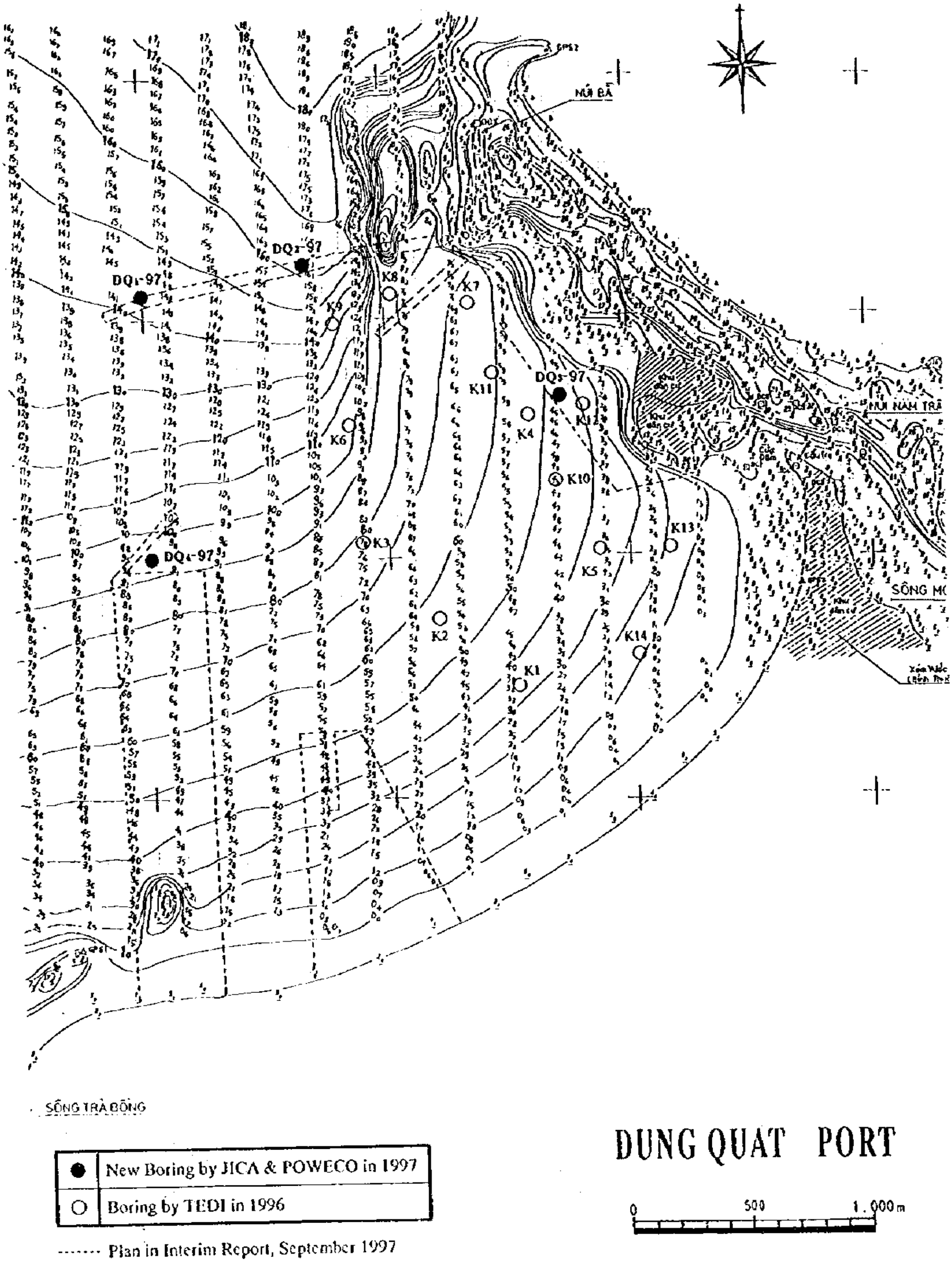


Figure 4.8.5 Location of Boring in Dung Quat

BOREHOLE No: DQ_{1-97}

Depth (m): 24.80

Coordinate (m): N = 1705100

E = 584000

Elevation (m): -14.70

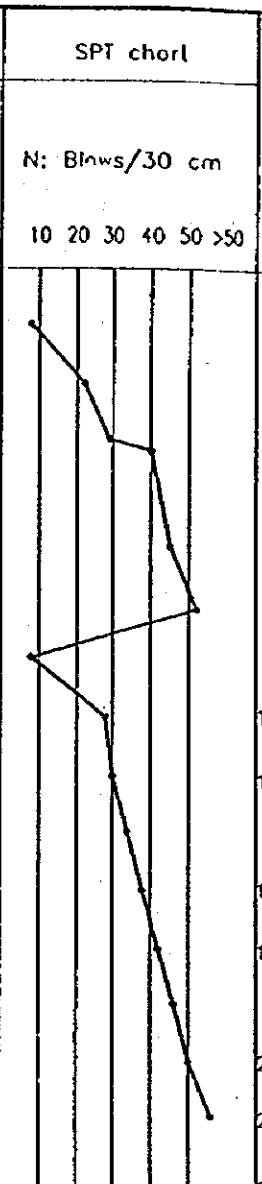
Location: Binh Thuan - Binh Son - Quang Ngai

Date commenced: 02-09-1997

Date completed: 03-09-1997

Layer	Elevation (m)	Depth (m)	Thickness (m)	Symbol	SOIL AND ROCK DESCRIPTION
1	-17.10	2.40	2.40	⁘ °	Silty sand with shells, grey, loose
2	-25.20	10.50	8.10	⁘	Well graded sand with silt, light grey, medium dense to very dense, water saturation
3b	-39.50	24.80	14.30	▨	Sandy lean clay, green-grey, Medium stiff to hard.

SPT Test					
Depth (m)	Blows/15cm	Blows/10cm			N
	N_0	N_1	N_2	N_3	
1.50	2	2	3	3	8
3.10	5	6	7	9	22
4.60	10	8	10	11	29
5.90	13	12	13	15	40
7.50	14	13	15	16	45
9.20	14	14	17	21	52
10.50	3	3	2	3	8
12.10	5	8	9	13	28
13.70	7	6	10	14	30
15.20	9	10	9	15	34
16.80	12	10	11	17	38
18.40	14	12	12	18	42
19.90	14	13	14	19	46
21.50	13	14	15	21	50
23.00	18	16	17	23	56



Sample No	Depth of sample (m)
1	1.50-1.95
2	3.10-3.55
3	4.60-5.05
4	5.90-6.35
5	7.50-7.95
6	9.20-9.65
7	11.50-12.10
8	13.10-13.70
9	16.20-16.80
10	17.80-18.40
11	20.90-21.50
12	22.40-23.00
13	24.20-24.80

Sand(fine to medium)	⁘	Disturbed Sample	•
Sandy Clay	▨	Undisturbed Sample	▮
Clay	▨		
Mud	~		
Shell	°		

Figure 4.8.6(1) Soil Profile and Standard Penetration Test DQ_1-97

BOREHOLE No: DQ_{2-97}

Depth (m): 24.10

Coordinate (m): N = 1705250

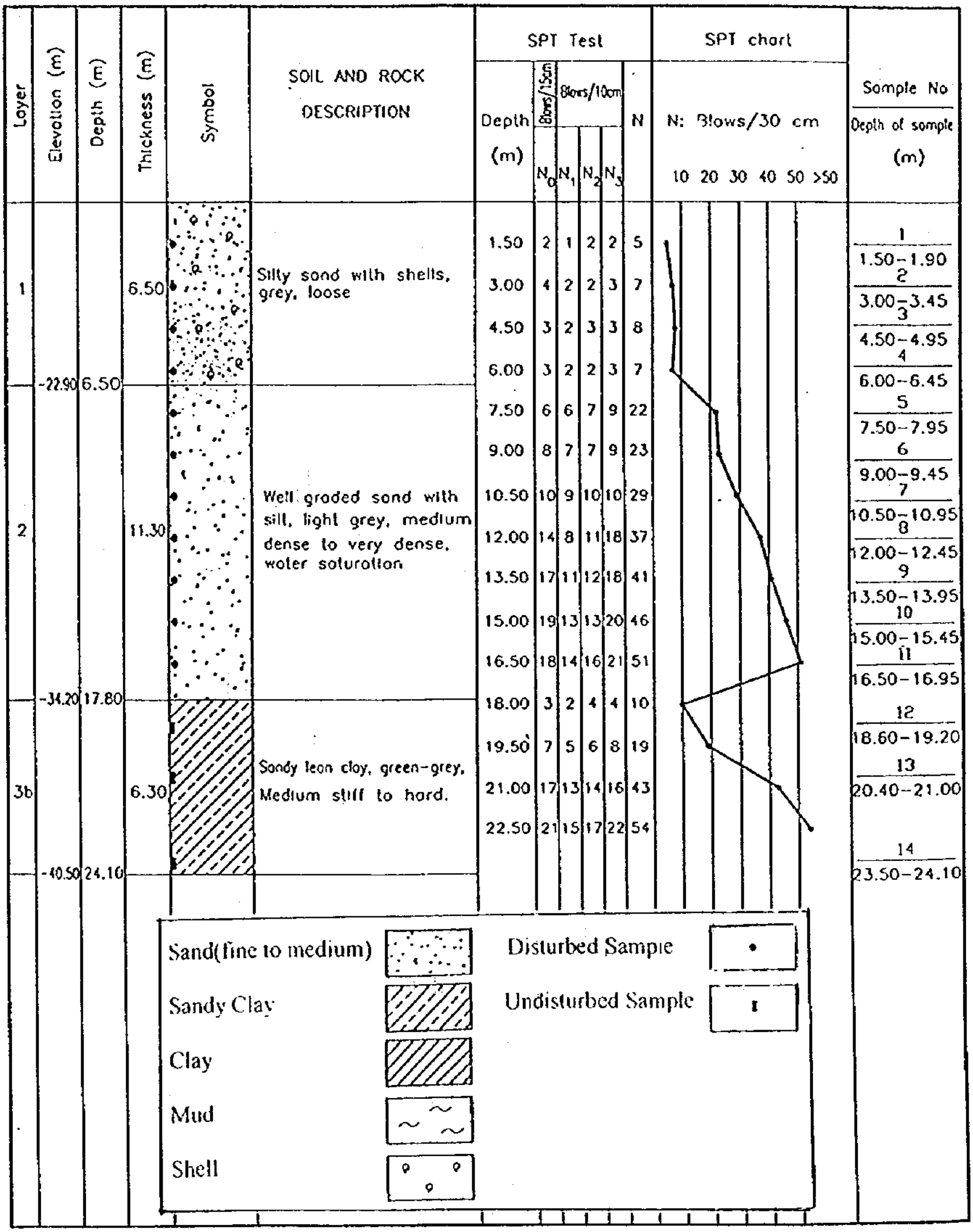
E = 584660

Elevation (m): −16.40

Location: Binh Thuan – Binh Son – Quang Ngai

Date commenced: 04-09-1997

Date completed: 04-09-1997



Layer	Elevation (m)	Depth (m)	Thickness (m)	SOIL AND ROCK DESCRIPTION
1	-22.90	6.50	6.50	Silty sand with shells, grey, loose
2	-34.20	17.80	11.30	Well graded sand with silt, light grey, medium dense to very dense, water saturation
3b	-40.50	24.10	6.30	Sandy lean clay, green-grey, Medium stiff to hard.

SPT Test Depth (m)	Blows/15cm N_0	Blows/10cm N_1	N_2	N_3	N	Sample No	Depth of sample (m)
1.50	2	1	2	2	5	1	1.50-1.90
3.00	4	2	2	3	7	2	3.00-3.45
4.50	3	2	3	3	8	3	4.50-4.95
6.00	3	2	2	3	7	4	6.00-6.45
7.50	6	6	7	9	22	5	7.50-7.95
9.00	8	7	7	9	23	6	9.00-9.45
10.50	10	9	10	10	29	7	10.50-10.95
12.00	14	8	11	18	37	8	12.00-12.45
13.50	17	11	12	18	41	9	13.50-13.95
15.00	19	13	13	20	46	10	15.00-15.45
16.50	18	14	16	21	51	11	16.50-16.95
18.00	3	2	4	4	10	12	18.60-19.20
19.50	7	5	6	8	19	13	20.40-21.00
21.00	17	13	14	16	43	14	23.50-24.10
22.50	21	15	17	22	54		

Sand(fine to medium)	⁘	Disturbed Sample	●
Sandy Clay	▨	Undisturbed Sample	▮
Clay	▨		
Mud	~		
Shell	°		

Figure 4.8.6(2) Soil Profile and Standard Penetration Test DQ_2-97

BOREHOLE No: DQ_{3-97}

Depth (m): 20.90

Coordinate (m): N = 1704670

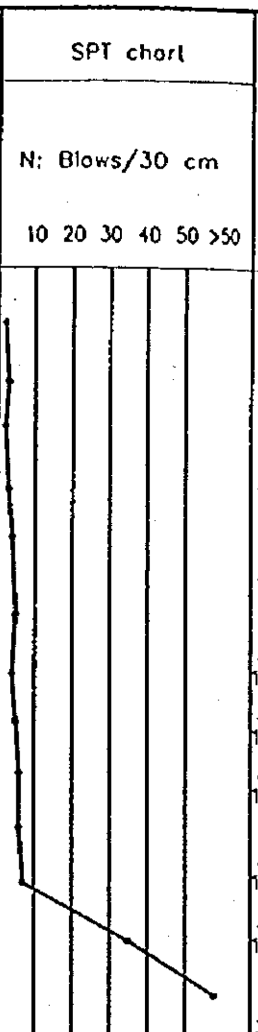
E = 585720

Elevation (m): -4.40

Location: Binh Thuan -- Binh Son - Quang Ngai

Date commenced: 05-09-1997

Date completed: 05-09-1997



Layer	Elevation (m)	Depth (m)	Thickness (m)	Symbol	SOIL AND ROCK DESCRIPTION	SPT Test Depth (m)	Blows/15cm N_0	Blows/10cm N_1	Blows/10cm N_2	Blows/10cm N_3	N	Sample No / Depth of sample (m)
3a	-21.60	17.20	17.20	▨	Lean clay, dark grey, very soft to medium stiff	1.50	0	0	1	1	2	
						3.10	0	1	1	1	3	1 2.10-2.70
						4.30	0	0	1	1	2	2 3.70-4.30
						6.00	0	1	1	1	3	3 5.40-6.00
						7.30	0	1	1	2	4	
						9.40	0	1	2	2	5	4 8.80-9.40
						11.00	1	1	1	2	4	5 10.40-11.00
						12.30	1	1	2	2	5	6 11.70-12.30
						13.70	1	1	2	3	6	7 13.10-13.70
						15.20	1	1	2	3	6	
						16.70	1	2	2	3	7	8 16.10-16.70
3b	-25.30	20.90	3.70	▨	Sandy lean clay, brownish yellow, light grey, hard.	18.30	7	9	11	15	35	9 17.70-18.30
						19.80	14	13	18	27	58	
												10 20.30-20.90

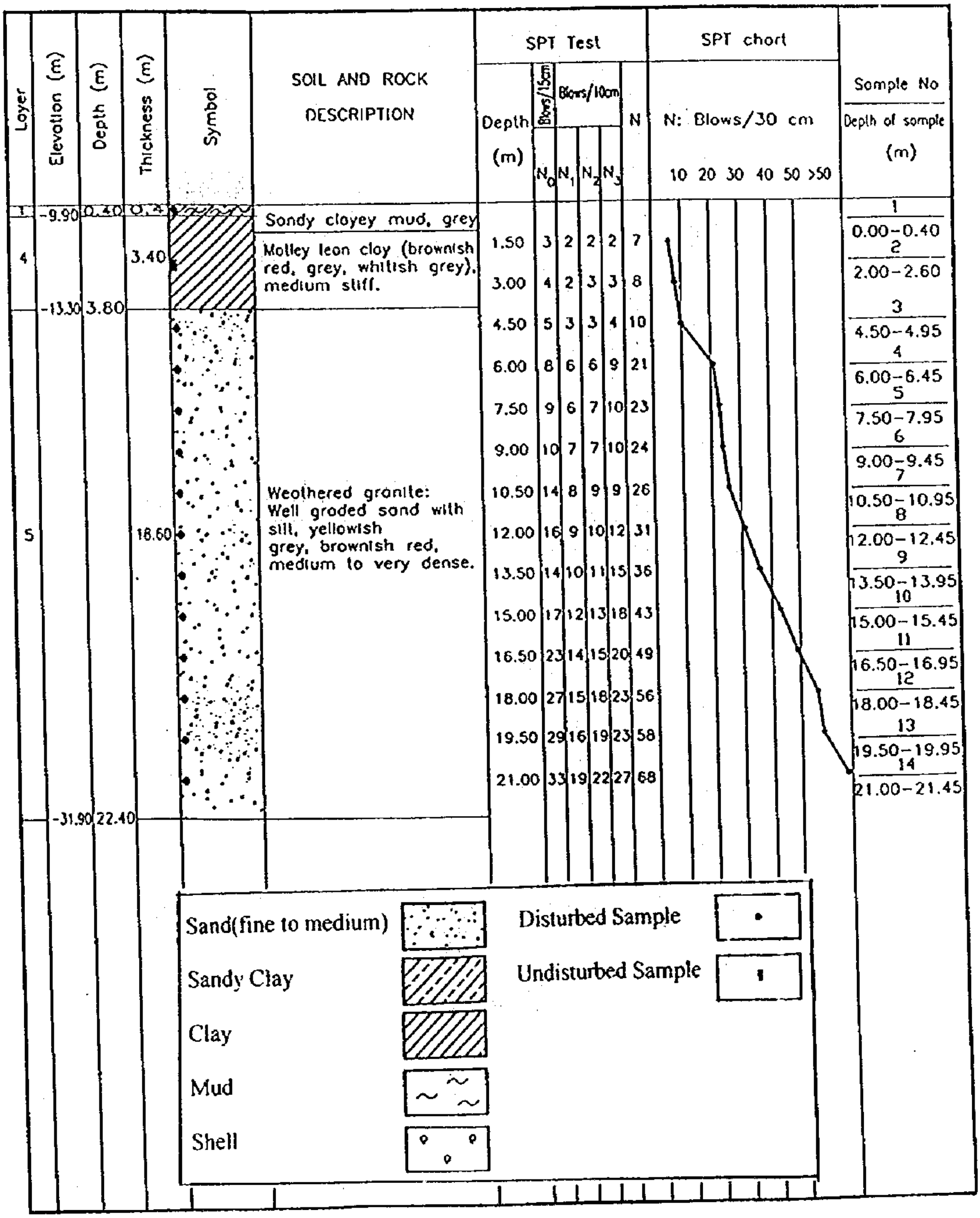
Sand(fine to medium)	⁙	Disturbed Sample	•
Sandy Clay	▨	Undisturbed Sample	▮
Clay	▨		
Mud	~		
Shell	°		

Figure 4.8.6(3) Soil Profile and Standard Penetration Test DQ_3-97

BOREHOLE No: DQ_{4-97}

Depth (m): 22.40
Coordinate (m): N = 1704000
E = 584000
Elevation (m): -9.50

Location: Binh Thuan - Binh Son - Quang Ngai
Date commenced: 01-09-1997
Date completed: 02-09-1997



Layer	Elevation (m)	Depth (m)	Thickness (m)	SOIL AND ROCK DESCRIPTION	SPT Test Depth (m)	Blows/15cm N_0	Blows/10cm N_1	N_2	N_3	N	Sample No Depth of sample (m)
1	-9.90	0.40	0.4	Sandy clayey mud, grey							1 0.00-0.40
4	-13.30	3.80	3.40	Motley lean clay (brownish red, grey, whitish grey), medium stiff.	1.50	3	2	2	2	7	2 2.00-2.60
					3.00	4	2	3	3	8	
5	-31.90	22.40	18.60	Weathered granite: Well graded sand with silt, yellowish grey, brownish red, medium to very dense.	4.50	5	3	3	4	10	3 4.50-4.95
					6.00	8	6	6	9	21	4 6.00-6.45
					7.50	9	6	7	10	23	5 7.50-7.95
					9.00	10	7	7	10	24	6 9.00-9.45
					10.50	14	8	9	9	26	7 10.50-10.95
					12.00	16	9	10	12	31	8 12.00-12.45
					13.50	14	10	11	15	36	9 13.50-13.95
					15.00	17	12	13	18	43	10 15.00-15.45
					16.50	23	14	15	20	49	11 16.50-16.95
					18.00	27	15	18	23	56	12 18.00-18.45
					19.50	29	16	19	23	58	13 19.50-19.95
					21.00	33	19	22	27	68	14 21.00-21.45

Sand(fine to medium)	⁘	Disturbed Sample	•
Sandy Clay	▨	Undisturbed Sample	▮
Clay	▨		
Mud	～		
Shell	°		

Figure 4.8.6(4) Soil Profile and Standard Penetration Test DQ_4-97

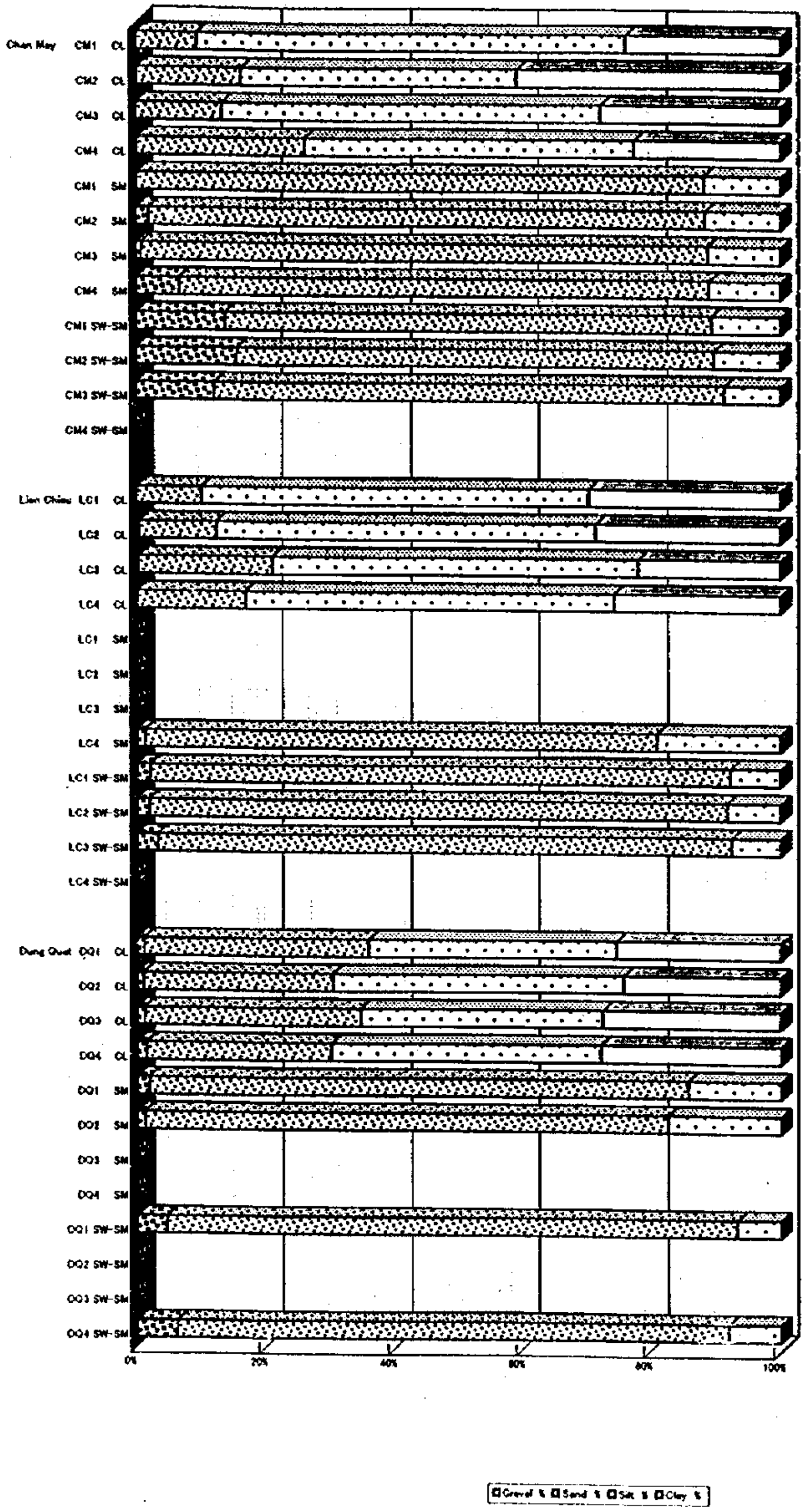


Figure 4.8.7 Result of Particle Size Analysis

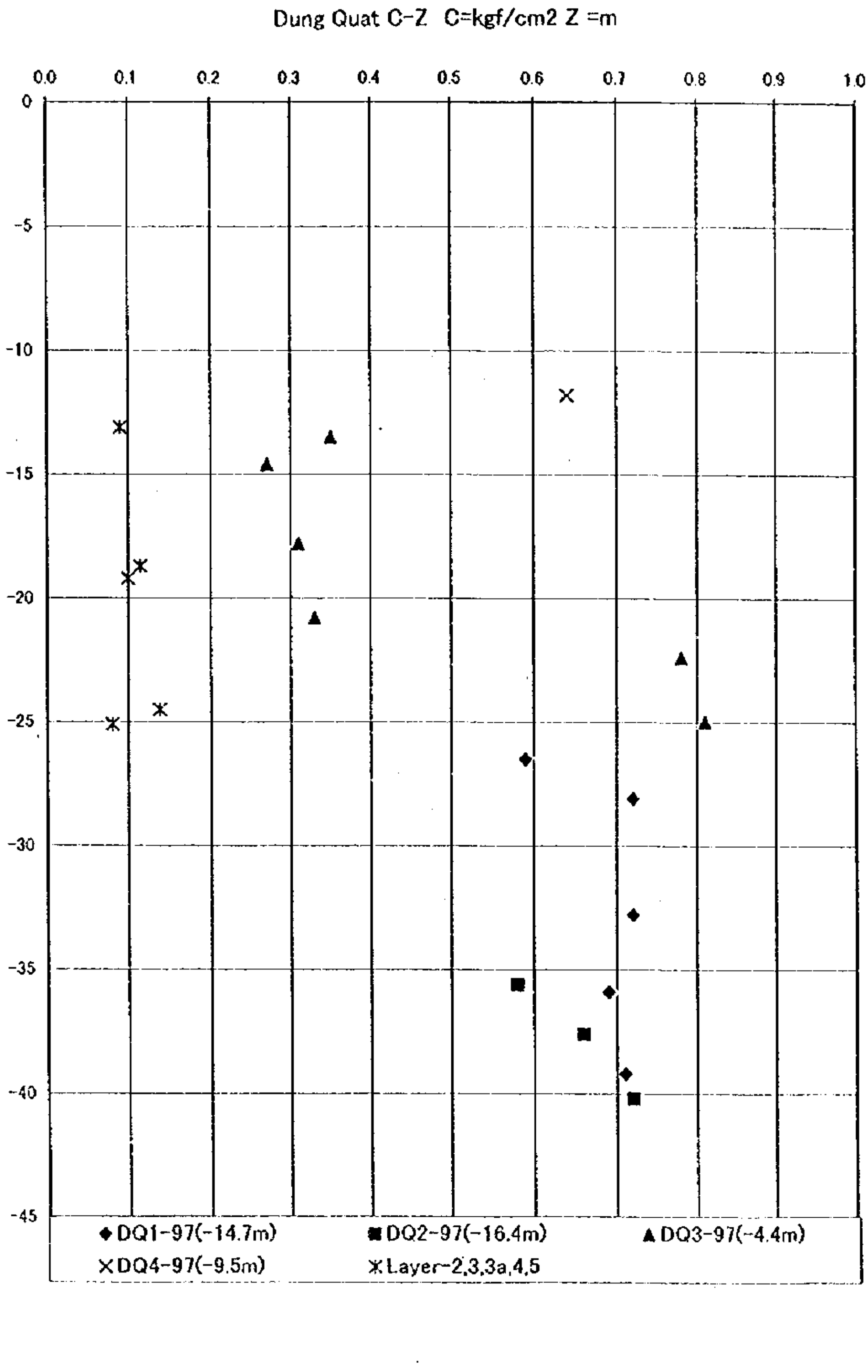


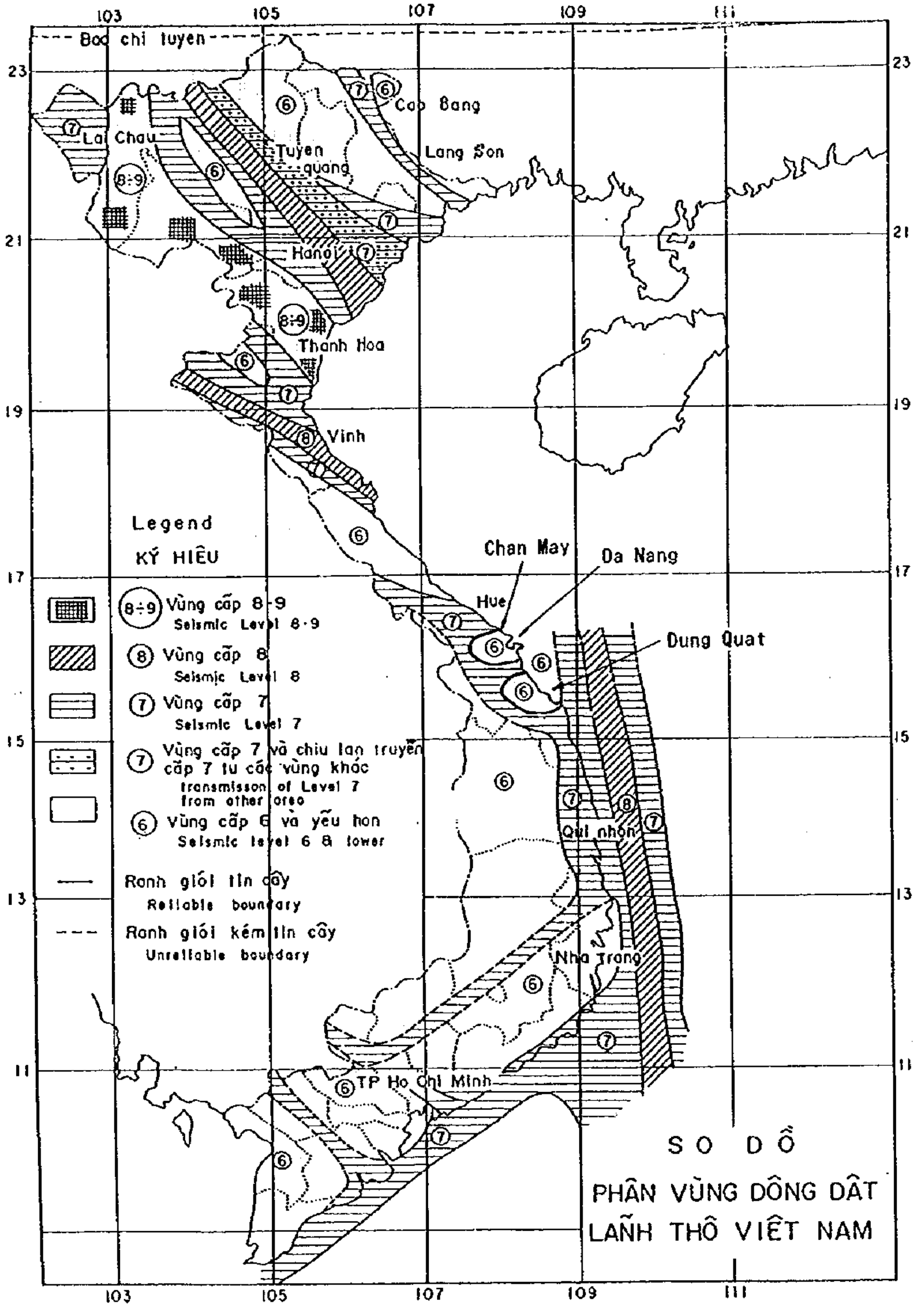
Figure 4.8.8 Relation between Cohesion and Depth in Dung Quat

4.9 Seismic Conditions

Earthquake intensity is an important factor for designing port facilities. Internationally, the level of earthquake intensity is divided 12 degrees for easy judging of earthquake intensity just after suffering an earthquake. Therefore this intensity level can be decided by man-feeling of shaking degree of ground and movement of furniture or extent of damage to buildings etc.

While for engineering purposes, we have to decide seismic force in compliance with seismic acceleration on the ground surface when an earthquake attack and the seismic coefficient method is prevailing to be used for determination of seismic force. Now, in Japan, the accelerations at ground surface in case of strong earthquake can be observed by measuring instrument installed at fixed points. Analyzing the data obtained from these observation points network and damage of quaywalls or structure, the relation between seismic coefficient and seismic acceleration on the ground surface gradually becomes clear.

Figure 4.9.1 shows the zoning map of seismic level in Vietnamese territory and it is used to determine the coefficient on materials and subsoil conditions. Concerning with port facilities, TCCV 4116-85 (Vietnamese technical standard for port construction promulgated by Ministry of transport in 1985) regulates a procedure how to calculate seismic force. According to this zoning map, seismic intensity in central region is classified as 6 to 7 degree which correspond to seismic coefficient of 0.05.



Source: TEDI

Figure 4.9.1 Zoning Map of Seismic Intensity Level