

(3) Terms of Reference

REPUBLICA DE CHILE  
Ministerio de Transporte y Telecomunicaciones  
Oficina de Planificacion

PORT DEVELOPMENT PLANNING  
FOR SAN ANTONIO AND VALPARAISO

Terms of Reference

May 30, 1985

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## I. BACKGROUND

The earthquake of March 3, 1985, which affected the central zone of Chile, caused important damage to infrastructure and equipment in the ports of San Antonio and Valparaiso, including various levels of deterioration to major civil works, some of which were totally destroyed. These ports, together with Quintero (which did not suffer damages from this earthquake) constitute the terminals that serve maritime commerce destined for or originating in the principal centers of production and consumption of the Fifth Region, the Metropolitan area of Santiago, and important parts of the Fourth, Sixth and Seventh Regions of the country.

San Antonio and Valparaiso handled four million tons of cargo in 1984, which represents an important part of all cargo handled in the country's ports, and constitutes in value % of all cargo in foreign trade. Because of their importance to the economy of the country, it is imperative that these ports be provided with the capacity to satisfy the requirements of maritime commerce as soon as possible. To meet these short term needs, it has been decided to seek solutions that will impose a minimum of constraints on the various options that should be considered in selecting the best long term solution for these ports.

The long term solution, in turn, should be supported by a general development plan for both ports, covering the

rehabilitation, expansion and, possibly, reassignments of capacities between the ports, which are to be defined in a manner that will allow implementation in accordance with the development of transportation needs.

General development plans for these ports should reflect the basic need to minimize the socio-economic costs<sup>\*</sup> of cargo transfer and transport through both ports. Investments in port infrastructure and equipment should therefore be defined with the objective of overall socio-economic efficiency. With the objective of socio-economic efficiency, port infrastructure and equipment should be defined in a manner that will best serve maritime and land transport modes, including the road and rail access serving the principal cargo flows in the ports' hinterland. Future vessel size and cargo handling technology in maritime transport will affect these ports and the alternatives for development that should be considered. Conversely, the physical constraints for port development in Valparaiso and San Antonio will have a bearing on the introduction of technological change. Equipment used in land transport and the availability and efficiency of road and rail services must also be incorporated in this analysis.

The close proximity (80 kms) of the two ports is another aspect of importance. Developments in one port can affect the

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<sup>\*</sup> In these terms of reference, socio-economic costs mean all outlays, both public and private.

share of cargo handled by the other. Thus the two ports must be considered as one from the point of view of international maritime trade. Duplication of specialized terminal capabilities should be avoided and complementarity among facilities should be sought, except to the extent redundancy may be justified to reduce risks of earthquake damage. In the country's present situation, competition would lead to dispersion of scarce public and private resources.

Both Valparaiso and San Antonio have harbor basins and berthing space for ocean carriers that are sheltered by man-made breakwaters. There is a consensus that it is not technically and economically feasible to extend these breakwaters; therefore the alternatives for port development must be limited to space within existing harbor areas. This is believed to be practical since the trend towards containers and unitized cargo reduces the space requirements for berthing. This factor should encourage the modernization of Chilean ports and is likely to permit capacity increases to meet operational needs without extension of breakwaters.

Future port investments at San Antonio and Valparaiso should be planned with an understanding of the causes of recent earthquake damage in both ports, taking into account the possibility of future earthquakes and applying the lessons learned from observed structural and foundation conditions and their effects on existing port infrastructure.

Finally, the port development plan should consider

opportunities for public/private investments in waterfrontage and areas adjacent to the ports. Commercial waterfront facilities such as restaurants, retail shopping, hotels, housing, and waterfront parks may offer some socio-economic benefits to the ports and their cities. Industrial development in other nearby locations may also offer significant economic benefits to communities and ports, including greater employment.

## II. OBJECTIVES

The objectives of port development planning for San Antonio and Valparaiso are to provide a physical plan and strategic framework for modernizing, expanding, and replacing terminal installations through a phased program of investments over the next two decades; that program should permit the ports to meet service needs of their hinterland efficiently, conforming to the following basic criteria:

- a. optimal utilization of the existing physical assets in each port;
- b. promotion of maritime commerce and of other appropriate uses of the waterfront;
- c. compatibility of proposed developments with the urban and social environment of each port; and
- d. facilitation of private sector participation in the proposed port investments.

To this end, the port planning work defined herein shall provide the following principal outputs:

- (1) a diagnosis of the causes of earthquake damage to terminal installations at San Antonio and Valparaiso, together with an assessment of the remaining useful life of the principal existing facilities in each port;
- (2) determination of required port service and terminal capacities in the Fifth Region;
- (3) an evaluation of alternative development schemes to meet the port service needs of the Fifth Region;
- (4) proposed port development plans for the ports of San Antonio and Valparaiso, in the period 1988 through 2007, with:
  - a. recommendations on the uses and regulation of land and water areas within each port;
  - b. access and circulation plans for maritime, road, and rail traffic;
  - c. outlines of the principal port installations proposed, with recommendations on the type of construction and level of earthquake resistance;
  - d. an implementation program for recommended developments to 1997 that will ensure adequate port capacity and economy in the contracting of construction for new facilities;
  - e. a detailed investment program for the years 1988-1997 and estimates of investments required in the following decade; and
  - f. a program for use of waterfront lands not required for maritime activity such as commercial waterfront developments and industrial plant locations;
- (5) recommendations on the short term measures to be adopted for expediting port services during implementation of the proposed port developments; and
- (6) terms of reference comprising definitions of the objectives, scope, budget, and time frame for professional services needed to expedite the next steps in implementation of the recommended program.

### III. SCOPE OF SERVICES

#### A. General

The Consultants shall perform all field investigations, economic and environmental studies, engineering analyses, and other work specified herein, as required, to attain the objectives given in Part II hereof. In the conduct of these tasks, the Consultants shall work closely with the Ministry of Transport and Telecommunications (MTT), the Ministry of Public Works (MOP), and EMPORCHI, which will assign counterparts to work with the Consultants and will provide the data, services, and facilities outlined in Part IV hereof. The Consultants shall be solely responsible, however, for the interpretation of all data and services received and for the findings and recommendations in their reports.

The geographic area to be covered by physical port development planning to be conducted by the Consultants shall be the land and water areas under the jurisdiction of EMPORCHI in the ports of San Antonion and Valparaiso, the immediate surroundings that constitute the terminal environment, and the arterial access connections (road and rail) on which the functioning of terminals within the port will depend. The geographic area to be covered by traffic and the socio-economic analyses to be conducted by the Consultants shall be the tributary area of the two ports, including the metropolitan area of Santiago and other inland origins and destinations of maritime commerce served by the ports.



Basic information on inland transport related to the ports and forecasts of maritime trade through San Antonio and Valparaiso will be provided to the Consultants from results of the "Intermodal Corridor Study" being conducted under separate contract by MTT. These results may require revision to take account of changes in trade or terminal conditions which may affect the distribution of freight among the ports; the Consultants shall be responsible for revising and extending the forecasts as appropriate.

#### B. Field Investigations

##### 1. Data Review and Work Program

The Consultants shall review the available records on physical conditions in the ports of San Antonio and Valparaiso (see Part IV hereof) and compile all material necessary to make a detailed analysis of earthquake damage. This shall include compilation of combined bathymetry and topography maps of the ports and surrounding areas, surveyed structural damage, and surface deformations. These maps should be compared to pre-existing plans of the ports, and any pre-existing level lines in the coastal area between San Antonio should be resurveyed for evidence of regional subsidence or uplift.

The Consultants shall also make a preliminary assessment of all seismic sources, covering both interplate and intraplate faults significant to the ports. This shall comprise a review of

historical seismicity and analysis of data compiled by the University of Chile's seismic network, an assessment of the "seismic gap" concept, of field work on terrestrial faults (intraplate), and an assessment of the tsunami potential. The results of this investigation shall be an assessment of probable maximum earthquake, recurrence of large events from various sources, expected ground accelerations in future events from various sources, and estimates on frequency of damaging tsunamis.

Within the first month of these investigations, the Consultants shall prepare a program and budget for fieldwork remaining to be undertaken in order to provide a basis for the analyses outlined in Sections III-C, -E, and -F below. The program and budget shall comprise subsurface explorations and structural investigations, as outlined in 2 and 3 of this Section, and any other fieldwork deemed necessary by the Consultants. The Consultants shall submit this program for comment and approval by the Client and shall then proceed with execution of the program as approved.

## 2. Subsurface Explorations

The Consultants shall undertake borings in the land and water areas of each port so that the data collected, in combination with subsurface information available from previous investigations, will provide a sound basis for evaluating general foundation conditions for port development planning. This shall include selected borings and both refraction and reflection

geophysical surveys of the ports.

These investigations shall provide information on bedrock configuration and depth, thickness of unconsolidated deposits, and samples for evaluating the properties of foundation and embankment materials. During these investigations samples shall also be collected for determining the dynamic properties of the foundation and embankment materials.

### 3. Structural Investigations

Investigations of the structural condition of all principal installations in the ports (e.g. berths and breakwaters) shall be undertaken to determine the strengths of structural materials and to make an assessment of the state and rate of deterioration in critical areas. The Consultants shall take core samples of concrete and masonry at typical locations, conduct inspections by divers, plot underwater surface deformations, and conduct such sample tests as may be deemed necessary by the Consultants for the analyses required.

#### C. Analysis of Structural Damage and Options

##### 1. Diagnosis of Damage Causes

The Consultants shall analyze all data obtained from the field investigations outlined in Section III-B above and from drawings and design information available on existing port facilities, to diagnose the causes of structural damage and, in

particular, the conditions and factors responsible for differences in the level of damage sustained by different port structures. This shall include evaluation of such aspects as original structural design loads and assumptions, physical condition of key structural elements, characteristics of underlying rock, soil, and embankment materials, distance from earthquake source, direction of strong motions, etc.

The results of this analysis shall be presented in detail in the Consultants' Interim Report, giving their diagnostic findings on each major structure in the ports.

## 2. Life Expectancy of Structures

Based on the foregoing, the Consultants shall assess the possibility of remedial measures or repairs that could be undertaken to extend the useful life of damaged port facilities. The Consultants shall also investigate the effects on the existing port structures of tidal movements, currents, wave action, possible future earth tremors, vessel and cargo operations, truck and rail traffic, and other factors that may contribute to the progressive deterioration of port installations.

The above investigations shall be used by the Consultants in a determination of the remaining useful life (with and without repair work, where appropriate) for each berth and for all other major structures within the two ports. The principal factors considered in this analysis and the reasoning that has been employed in reaching conclusions shall be presented in detail for

every structure estimated by the Consultants to have a useful life expectancy of less than ten years.

### 3. Structural Alternatives and Risks

The information obtained on site conditions and existing facilities within the two ports shall be used by the Consultants in preliminary engineering analyses for typical future port installations, for three purposes:

- (a) to develop seismic design criteria for aseismic design of selected port facilities;
- (b) to define the design configuration(s) of wharves and related structures best suited for terminal installations in typical locations where future development may be considered in each port; and
- (c) to provide a basis for estimating the structure costs of alternative development schemes to be evaluated under Section III-E below.

These engineering analyses shall include review of available strong motion data, evaluation of response spectra and dynamic analyses, to be used in a review of alternative structural solutions associated with various levels of resistance to seismic exposure. Previous analyses have suggested that it may be appropriate to consider more than one level of resistance to earthquake shock in the future design of port facilities, as this may offer an economical alternative to extremely high costs of structures if all were to be designed to resist maximum expected earthquakes. The concept of "high aseismic berth(s)" should be further explored, in order to provide assured operational

capacity of a certain level in each of the ports, while other facilities may be designed against smaller earthquake ground motions.

This work should provide a basis for recommendations by the Consultants on the level of "acceptable risk" to seismic exposure, which will have important implications for determining overall cost and design of the program. Risk analysis methods shall be employed in these evaluations, which shall constitute the first cycle in a multi-phased approach; subsequent cycles shall be undertaken at later stages, during the design phase of individual components of the proposed development.

Preliminary engineering designs for wharves and related structures shall be based on analyses of subsurface and sea conditions, draft and size of typical vessels to be served, appropriate live loads for cargo transfer operations, and land transport requirements. The Consultants shall prepare typical cross sections of alternative wharf structures, defining principal dimensions and types of materials and components to be considered, taking into account construction methods and materials available locally as well as others that might be imported. In this analysis the Consultants shall consider the history of port construction in Chile over the past two decades and propose, where appropriate, the introduction of modern construction methods and materials that have been developed and tested elsewhere.

The foregoing preliminary engineering analysis shall result in the selection of one or more "typical section(s)" for berth construction, as considered most appropriate and economical by the Consultants for each general location at which new terminal construction may be considered in the development plan. These "typical sections" shall be used in the preparation of alternative layouts for port development schemes and in the estimating of quantities and costs for principal categories of construction materials and work, which shall be used as a basis for establishing unit costs in the evaluation of alternatives and in the preparation of the proposed investment program.

#### D. Determination of Operational Needs

##### 1. Maritime Transport Projections

The "Multimodal Corridor Study" (see Sections III-A and IV-A hereof) is expected to produce forecasts of maritime cargo generated in both domestic and foreign trade through the ports of San Antonio and Valparaiso. These forecasts, based on origin/destination data for 1984, will be for the calendar years 1990, 1995, 2000, and 2010.

The Consultants shall analyze the forecasts prepared in the "Multimodal Corridor Study", revise and extend them as appropriate, and adapt them to the needs of the Consultants' port development planning work. In addition, the Consultants shall collect and review all available data on existing and proposed

shipping services, with particular reference to proposed changes in the operating patterns of container lines in trade with the Southern Cone.

On the basis of this analysis, the Consultants shall prepare their own projections of vessel calls, likely sizes and operational characteristics of vessels, container movements, and terminal operating requirements for the years 1990, 1995, 2000, and 2010. These projections shall be presented in "ranges", taking into account the sensitivity of Chilean exports and imports to fluctuations in the price of copper, minerals, and other key commodities. The lower range shall reflect a conservative view of Chile's economic and foreign trade prospects and the upper range shall reflect an optimistic view, as defined by the responsible economic planning agencies of the Government of Chile.

## 2. Intermodal and Inland Access Options

The Consultants shall review and analyze the findings and recommendations of the "Multimodal Corridor Study" with regard to the land transport connections to each port, the access requirements by rail and road, and the options considered in assessing port terminal conditions. Clearly the Corridor study will have to be based on assumptions regarding physical conditions in each port which may no longer be valid at the time the Consultants begin the evaluation of alternative development schemes in accordance with Section III-E hereof. The Consultants



shall therefore review those assumptions and draw their own conclusions as to the ground transportation available to serve each of the two ports.

### 3. Phased Transfer to New Facilities

Interim measures by MOP and EMPORCHI are being taken at both San Antonio and Valparaiso to ensure the continuous and efficient servicing of maritime trade, despite the damage sustained by terminal facilities in the recent earthquake. These interim measures will be highly important for commercial port operations until new facilities have been installed and have become operational.

It is important that all planning for port development at San Antonio and Valparaiso take into account the operating requirements at existing port terminals and that the alternative schemes to be assessed envision a phased transfer of operations to new facilities. The Consultants shall make specific recommendations regarding the maintenance of port service capabilities and the transition from old to new facilities to minimize interference between on-going port operations and proposed construction and repair activities.

#### E. Alternative Port Development Schemes

##### 1. Preparation of Alternative Layouts

On the basis of findings resulting from the work described

under Sections III-B, -C, and -D above, the Consultants shall prepare alternative layouts for the physical development of terminal facilities and related installations in each of the two ports, taking into account the maximum projected cargo traffic for the year 2010 and resulting requirements for vessel berths, land areas for terminal operations, navigational access, circulation by land transport modes, and auxiliary facility needs.

The layouts shall be prepared at a scale of 1:2000 (or such other scale as may be agreed upon with the Client), based on maps, charts, and aerial photography to be provided to the Consultants.

In the preparation of these layouts, the Consultants shall give due consideration to the general criteria given in Section II above and to the structural alternatives and risks defined in accordance with Section III-C-3. Efforts shall be made to devise terminal arrangements which take maximum advantage of the natural and man-made environment in each port, provide for safety and efficiency in port operation, and minimize adverse environmental impact on residential and recreational areas in the vicinity of the terminals.

The alternative port layouts for the year 2010 shall be analyzed and modified in accordance with Sections III-E-2 and -3 below.

## 2. Functional Analysis

For each major category of cargo operation in the ports, the Consultants shall prepare preliminary estimates of space requirements and sketch layouts of terminal configurations, to ensure efficiency of transfer operations and in-transit storage, provisions for medium to long-term storage where appropriate, speedy entry and exit for land transport modes, etc. These sketch layouts shall be adapted to the physical constraints of candidate sites in each port, providing a realistic basis for functional analyses of terminal installations in alternative locations.

In the study of alternatives for future container installations, particular attention shall be given to sea conditions affecting the motion of vessels while at berth and to the effects of such vessel motions on the efficiency/safety of loading and discharge operations using dock-mounted container cranes.

In the layout of proposed port terminal installations, the Consultants shall consider possibilities of much greater private sector participation in investments than has been customary in the past. Space allocations and terminal configurations shall be adapted to encourage such participation.

In the layout of access and circulation patterns for land transport modes, particular consideration shall be given to the relative share of movements by rail and by truck, possible

changes in these relationships over the next two decades, and appropriate space allocations for rail and truck operations (including waiting lines, parking areas, yard and switching areas, etc.)

While the focus of functional analyses to be conducted by the Consultants shall be on domestic and international maritime commerce, the space requirements for other operations within the ports of San Antonio and Valparaiso shall also be taken into account; these shall include (but not be limited to) operations of the Chilean Navy, commercial fishing, ship repair activities, and recreational craft.

### 3. Phasing and Costing

The alternative layouts prepared for projected traffic in the year 2010 shall then be analyzed by the Consultants for advantages and disadvantages in phased implementation and for relative construction costs.

Taking into account current operational needs and the useful life expectancy of existing structures, the Consultants shall determine the sequence of developments best suited for the principal alternative layouts under consideration, assessing the operational and technical problems that would be encountered during demolition, the repair of existing and/or construction of new facilities, as required for each scheme.

The Consultants shall also prepare preliminary estimates of construction and equipment costs, based on the structural

alternatives considered most appropriate for proposed installations at their specific locations within each port. These estimates shall include both permanent port installations and the interim or temporary structures required to maintain port traffic and transfer operations at minimum levels during the demolition, repair, or construction of facilities. In making these analyses, the Consultants shall draw upon estimates prepared in C-1 of probable damage from natural events; these probabilities shall be incorporated in the analysis of construction costs.

#### 4. Selection of Preferred Alternative

The Consultant shall compare the alternative schemes considered most efficient and appropriate for future development of the ports of San Antonio and Valparaiso on the basis of their socio-economic costs. This evaluation shall be performed first for all facilities required to be completed in the alternative schemes during the first ten years of the port development program, i.e. to satisfy traffic requirements to the year 2000. The evaluation shall then consider the schemes still under consideration for the program as envisioned during the first twenty years, i.e. to satisfy traffic requirements to the year 2010.

The Consultants shall determine the least cost solution (in socio-economic terms) to satisfy traffic requirements during each of the above two time-frames, taking into account capital costs, terminal operating and maintenance costs, the cost of ships'

time while waiting and while at berth, the cost of land transport vehicles while in the port area, and the costs associated with cargoes while in transit.

On the basis of these cost analyses and an evaluation of environmental, urban, and social impacts, both positive and negative, the Consultants shall make recommendations as to the alternative (or alternatives) considered most advantageous for port developments at San Antonio and at Valparaiso. These recommendations shall be presented in the Consultants' Interim Report.

The port development recommendations shall be reviewed and discussed at meetings to be attended by the Consultants during which all Government agencies concerned, affected municipalities, and transportation interests will be invited to participate and comment. On the basis of subsequent discussions, the Consultants will be advised of the Government's decision regarding the selected alternative for each port.

#### 5. Scope and Budget for Next Steps

The Consultants shall define the scope of feasibility studies and detailed engineering tasks required for the next steps in preparation of the proposed first stage development in the ports of San Antonio and Valparaiso. To the extent possible, these tasks shall be dovetailed to minimize the total time required before contracts for construction of new port installations can be awarded. Particular attention shall be given to the required level of engineering definition and

economic analysis, to conform to the requirements of international lending agencies.

These scope definitions shall be presented by the Consultants in the form of draft terms of reference (comprising sections on background, objectives, and scope of services) suitable for use in the solicitation of proposals from consulting firms and subsequent incorporation into the contract with the selected consulting firm.

Based on these draft terms of reference, the Consultants shall prepare man-power charts and cost estimates, assuming price levels for professional services that correspond to international scales, with appropriate provisions for contingencies. The Consultants shall also present a time schedule for the next steps in consultant selection and contract award for professional services needed.

#### F. Recommended Port Developments

##### 1. General Development Plans

For the selected alternative at each port, the Consultants shall prepare the following plans at 1:2000 scale:

- (a) a general "land-use plan", indicating the areas to be allocated to principal terminal activities, auxiliary port services, port related industries, commercial fisheries, maintenance and repair facilities, other urban uses, etc;

- (b) a "traffic circulation plan", indicating the right-of-way dimensions to be reserved for principal access roads, railroad trackage, public parking and yard facilities, port entry and egress controls, and internal traffic management;
- (c) a "First Stage Development Plan", indicating the principal port facilities recommended to be constructed by 1992; and
- (d) a "Second Stage Development Plan", indicating the principal port facilities recommended to be constructed by 1997.

Plans for the two stages of proposed development shall indicate key dimensions of major terminal installations and shall be accompanied by supplementary drawings showing typical cross sections for proposed wharves and other major installations. The two stages of development shall reflect the Consultants' recommendations regarding the program of implementation, discussed in the following subsection.

## 2. Program of Implementation

The damaged condition of existing port installations at San Antonio and Valparaiso and the continuing process of deterioration caused by sea action and terminal operations, taken together with the possibility of further earthquake activity in the port region, make it imperative that special care be taken in the programming of port improvements to minimize impairment of maritime transport through the two ports. The Consultants shall therefore prepare a detailed program for the implementation of proposed first stage developments, outlining safety precautions and



transitional arrangements (including detours, temporary structures, and related operating procedures) recommended to reduce costs and hazards during the demolition, repair, and construction of facilities.

A similar program shall be outlined, in less detail, for the implementation of the proposed second stage developments in each port.

### 3. Investment Requirements

The Consultants shall prepare an investment program showing the estimated capital costs of all stages of the proposed development, with breakdowns for each port showing major facility and equipment components, foreign exchange and local currency requirements, and provisions for physical and price contingencies. The estimates shall include costs of engineering, construction supervision, and other consulting services required for program implementation. The Consultants shall indicate the components of the investment program considered most appropriate or suitable for private sector participation.

### 4. Operational Recommendations

Taking into account ongoing port operational needs as defined earlier and the first stage program of implementation mentioned above, the Consultants shall make specific recommendations to adapt terminal activities to the needs of demolition, repair, and construction activities, minimizing

interference and, to the extent possible, related cost increases in both terminal operations and port development.

G. Time Schedule and Reports

The Consultants shall mobilize their team in Chile within one month of the Starting Date.

The Consultants shall prepare and submit the following reports, in the languages and within the time periods indicated below:

<u>Report</u>	<u>Number of Copies</u>				<u>Calendar Months from Starting Date</u>
	<u>to MTT</u>		<u>to World Bank</u>		
	<u>Span.</u>	<u>Eng.</u>	<u>Span.</u>	<u>Eng.</u>	
Inception	6	-	4	-	2
Progress	6	-	4	-	4, 6, 8
Interim	20	5	-	5	7
Draft Final	20	5	-	5	9
Final	60	20	2	5	(*)

(\*) 30 days after receipt of comments on Draft Final Report.

The Inception Report shall contain the Consultants' proposed program and budget for field investigations (see Section III-B above).

Progress Reports shall summarize all work completed during the preceding two months, highlighting any unusual problems encountered, and outline the work scheduled for the next two-month period.

The Interim Report shall cover all work performed under Sections III-B, -C, -D, and -E hereof and shall contain a detailed description of the recommended development plan, together with background material required for the program's justification.

The Draft Final Report shall cover all work performed under this assignment and shall be complete and edited, including all graphics, so that printing of the Final Report can proceed without delay.

The Final Report shall reflect the revisions deemed appropriate by the Consultants in response to comments received from the Government and the World Bank on the Draft Final Report.

#### IV. DATA, SERVICES, AND FACILITIES FOR THE CONSULTANTS

(to be completed by MTT/MOP/EMPORCHI)

#### 参考資料4.

##### その他関係資料

- (1) 地震の概要と Japanese Expert Mission 報告書要約
- (2) Japanese Expert Mission 報告書
- (3) IMO 専門家の報告書

(I) 地震の概要と Japanese Expert Mission の報告書の要約

(1) 地震の概要

地震の諸元は以下のとおりである。

発震年月日時刻 : 1985年3月3日19時46分 (現地時刻)

震源 : (緯度)  $33^{\circ}14'24''S$ , (経度)  $72^{\circ}02'24''W$ ,  
(深さ) 15 km

マグニチュード : 7.7 (Richter)

震度 (MM震度階) : バルパライソⅦ~Ⅷ, サンアントニオⅧ, サンチャゴⅦ

震央、余震震源分布範囲の概略、バルパライソ港・サンアントニオ港の位相、及びチリ中部に設置されている強震計の所在位置を図-1に示す。

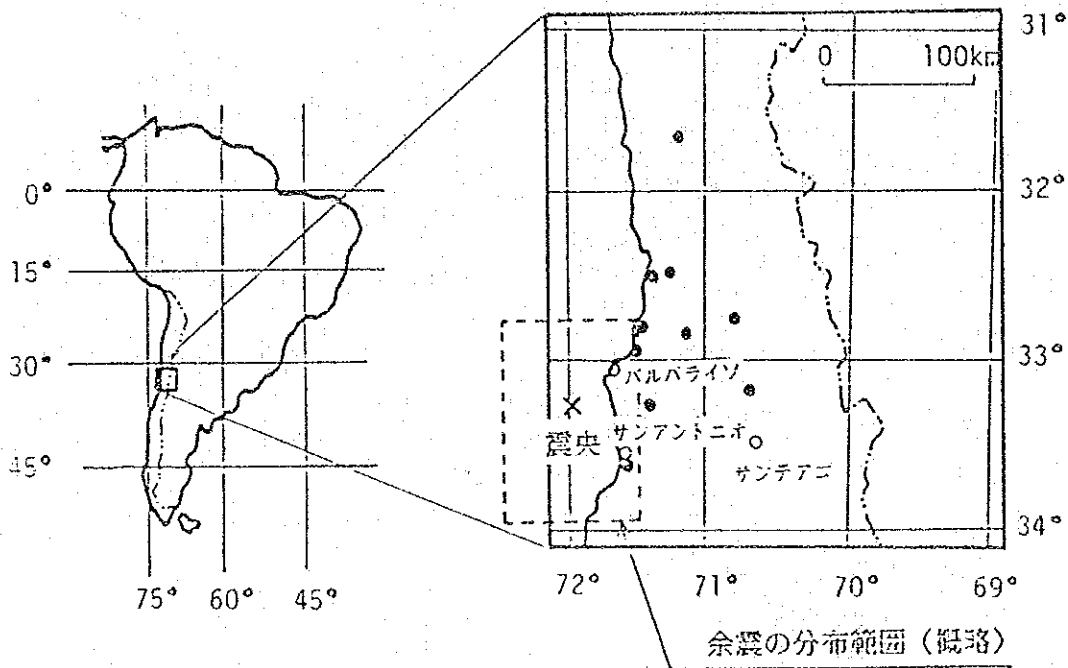


図-1 震央、余震の分布範囲、強震計設置地点 (黒丸)

(ii) Japanese expert mission 報告書の要約

題名 - REPORT ON DAMAGE TO PORT FACILITIES IN THE PORT OF VALPARAISO  
BY THE EARTHQUAKE ON MARCH 3 1985  
(APRIL 2, 1985 JAPANESE EXPERT MISSION)

1. はじめに

1985年3月の地震により、チリ国の主要な港であるバルパライソ港は被災を受けた。この件につきチリ政府より、港湾施設の被災調査の依頼を受けた我が国政府は、構成人員6名の専門家調査団を派遣した(派遣期間3月23日~4月1日)上記調査団の任務には、上記の他に、工学的見地より、被災した港湾施設の現時点での使用可能性、ならびに将来の復旧計画に関する計画案の作成も含まれていた。

2. バルパライソ港の概要

バルパライソ港は、チリ国最大の貿易港である。

施設として、10バース(総延長2005m)、31のクレーン、120,698 m<sup>2</sup>の上屋、5 haのコンテナ用地を有する港である。

貨物取り扱い量は、過去1時減少したこともあるが、将来は、チリ国の国民総生産の増加およびサンチャゴ地域の人口、果物等の生産量の増加に伴い増加することが予想される。また、世界的にコンテナ化の傾向があり、バルパライソ港は、この点で競争力を失いつつある。

このため、バルパライソ港は、貨物取り扱い能力の増強およびコンテナ化を計る必要がある。

3. 1985年3月地震の記録

地震発生時刻: 1985年3月3日 19:46'54" (チリ時間)

エピセンター: 南緯 33° 14' 24" 西経 72° 02' 24" 深度 15 km

マグニチュード 7.7

バルパライソ港の最大加速度は、以下のよう推定された。

岩盤上: バース 1~5 において、0.20 g, バース 6~9 において 0.25 g ; 地表面: バース 1~5 において 0.20 g, バース 6~9 において 0.30 g

バルパライソ港においては、液状化現象は観察されなかった。

4. 震災状況

パロン棧橋を除いた総ての施設になんらかの被害があった。岸壁の相当数は、前面が刷り出したり、傾斜しているのが観察された。

このような基本施設の被災と共に、道路、鉄道、エプロンおよび荷役機械に沈下、傾斜およびひびわれ等が観察された。

岸壁の傾斜および刷り出しの原因は、岸壁の安定性を上回る地震動によるものと考えられる。エプロンの沈下は、砂の抜け出しによるものと考えられ、クレーンの傾斜等は、基礎の異常な変形によるものと考えられる。

上記の調査結果に基づき、各施設の使用上の制限に関する提案を行なった。

#### 5. 復旧の基本概念

下記の事項をサンチャゴ地域の海の玄関という観点と2重投資を避けるという観点を重視しつつ実施することが望まれる。

- ① 3月3日地震による被害の復旧
- ② 港湾施設の耐震補強
- ③ 港湾施設の再開発
- ④ コンテナターミナルの開発

なお、設計震度として0.15～0.20を提案し、さらに、耐震バースも提案した。

#### 6. 提言

2000年を最終目標年とする開発プロジェクト調査に関して提言を行なった。

#### 7. おわりに

時間および資料の制限により定性的な報告にとどまったが、施設の復旧および開発に関してチリ側が本報告を参考とすることを期待する。