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Port Operational Studies for Busan Container Port Expansion

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CONTENTS

1 . Introduction

Economic forces over the past years of shipping recession have led to a range of larger, faster container ships being introduced, which are desingned to serve the main container ports of the world. These ships, although they may be operated economically, can be below standard in their manoeuvrability characteristics. Their size and windage can impose limitations on the design of a container port if it to handle the ships effectively and safely.

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For many years, it was rarely necessary to consider the manoeuvrability of a ship using a port, as the available space was usually large compared with the size of the ship. With smaller ships, the consequences of errors in berthing or manoeuvring are often not too severe, and berthing errors can often be corrected by the judicious use of fenders. With a 60,000 dwt container vessel however, the consequences of grounding or berthing incidents are nearly always severe, and as this type of ship can have a turning cicle diameter of around one nautical mile, the manoeuvring space for the unaided vessel needs to be very large.

This paper examines the growth in container movements in the port of Buasn, and considers new design procedures which may give some indication of the optimum layout of jetties and channels, and of navigational procedures in this and other container ports. The manoeuvring behaviour of container vessels in this port is being considered as an academic exercise at the University of Wales Institute of Science & Technology, and the scope of this study will be outlined.

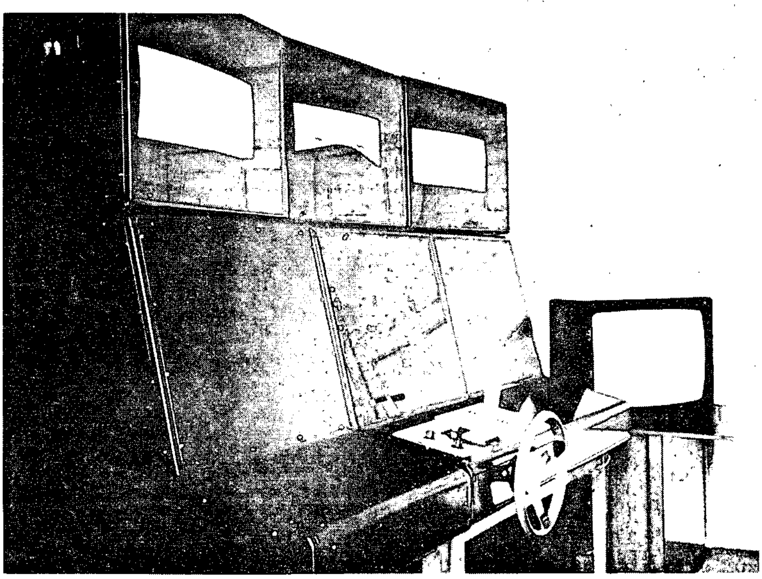
2. Port Design Methodology

Traditionally, the layout of the seaward side of a port is designed using very empirical criteria. Channel widths, the radius of bends, and the provision of navigational aids are usually considered on the basis of established principle, and by and large the practice works reasonably well. However, when we consider the amount of money which is invested in a port for civil engineering works and for the provision of cargo handling services, it may be legitimate to consider whether some more precise design criteria may be appropriate.

For example, channel widths and depths will usually be decided, after careful examination of the port's plans, on a basis of well esablished guidelines. If however a channel width ends up too large, there will be a continual dredging requirement to maintain the channel; if it is too narrow, the risk of collision or grounding will be increased. The main problem existing to date is that there has been no effective way of determining what is the "correct" or "optimum" channel width. Not only are there no well established figures of merit for a ship entering a port, in terms of such quantifiable criteria as distance off track, number of helm and engine orders etc., but there has until the past decade been no effective design tools with which proposed designs can be tested, in a realistic and quantifiable manner.

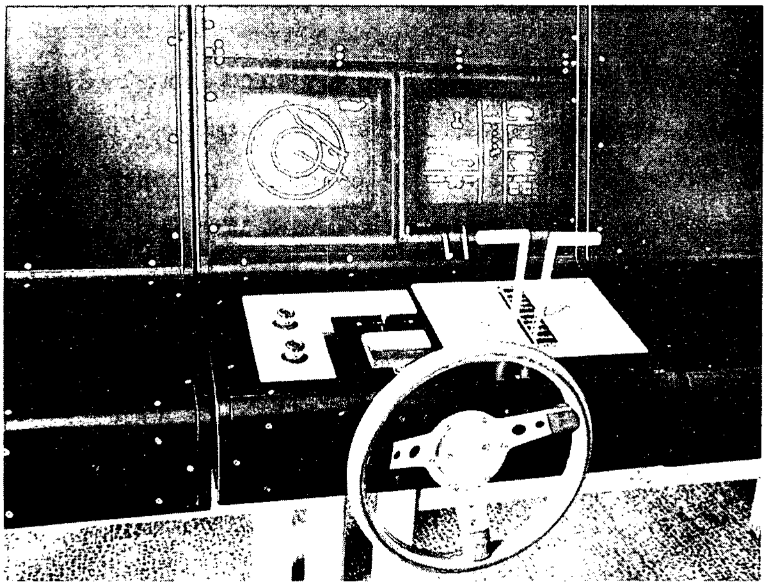
Recent developments in simulation technology have however now enabled the second if these problems to be satisfactorily addressed. It is now possible, within the design budgets of most port authorities, to examine, in simulation, the effects of proposed changes to a port's layout and operational characteristics as part of the design process. These changes have been made possible largely in consequence of the ready availability of small, powerful microcomputers, enabling the necessary large computing power required for effective simulation to be provided within a physically small device.

Fig. 1. Port Design Simulator



A typical small simulator, specially designed for port simulation, is shown in Fig. 1. The key visual cues required to enable the pilot to identify the ship position are shown on three screens. The position of the visual scene, or the "Look Angle" can be varied by the pilot to give all round vision. This is particularly important for port approach simulation, as the ship's position and velocity are gauged by the pilot by referring to transits ahead, abeam and astern. Additional cues are given by the radar and instrumentation screens, (Fig. 2). The pilot's responses are fed into the Motion Computer, which calculates the ship position in response to both the commands and to the environment.

Fig. 2. Radar and Instrumentation Screens of Port Design Simulator.



It is this ability of the simulator to reliably predict the behaviour of the ship in a wide range of environmental conditions which enables it to be used as a design tool. A range of design options can be tested in the simulator, and the most suitable one evaluated, using the port's pilots to assess the effectiveness of the options. They may be assisted by the use of a range of Steering Quality Indices, which are quantitative measures of the effectivencess of the entry. Once a design has been decided upon, a range of operational strategies can be practised by the pilots, or by ship's officers, to determine for example the most effective approach strategies in a range of conditions.

The simulator can also be used to evaluate appropriate strategies to be used in the event of failure of ship equipment or of tugs. Several serious accidents have been caused in recent years by the failure of tugs at a critical point in a manoeuvre, and the simulator can be used both to assist in the decision on numbers and types of tugs to deploy in given conditions, and also to work out ways in which the effects of a tug failure can best be minimised.

3 . Busan Container Terminal Developments

3.1. Busan container Terminal Developments and its Operational Method

The Busan Container Terminal consists of 4 berths of 50,000 ton vessels. It was constructed under the 1st and 2nd Busan port development projects financed by the IBRD in 1974 and 1979 respectively. The purpose of this container terminial was to cope with the increasing maritime transportation of container cargo in the international shipping market since 1960.

The Busan Container Teminal Operation Company(BCTOC) which was inaugurated on March 10, 1978, to operate and maintain this terminal, has handled an increasing quantity of containerized cargo since September 30, 1978. This cargo has been increasing at an astounding annual rate of 20%.

In 1979, the first full year of operation, the Busan Container Terminal handled a throughput of 264,300 TEU, which comprised about 44% of the container volume that passed through the port of Busan in that year.

Upon completion of Pier 6, in the Spring of 1983, two more large berths were added to the Busan Container Terminal and the backup area of the overall facility was more than doubled in size. The new operation was a combination stacking system using straddle cariers and transfer cranes(transtainers), supplemented by yard tractors and chassis which handled the horizontal container movements between the quay cranes and the stacking area, as well as the movements between the stacking area and the CFS and rail facility.

1984 was the first full year of operation of the total Piers 5&6 facility, and the container throughput was 661,500 TEU, comprising about 63% of the container volume passing through the port of Busan in that year. Busan Container Terminal, which uses both straddle carriers and transfer cranes, is an example of combination system. With its combination system, import containers are handled by the transtainers and export containers are handled by straddle carriers; and the terminal is zoned accordingly.

At Busan it was decided that the system of off-dock facilities would be continued(in fact, they were expanded), with most import containers going directly to off-dock facilities and vice versa for export containers. In a very real sense, the off-dock CY/CFS facilities in various locations around Busan are an extension of the container terminal stacking area, as much of the dwell time of containers in Busan takes place off dock. CFS services also are provided off dock for the foreign shipping lines.
(The three CFS buildings at the BCT are used exclusively for the Korean national carriers).

The off-dock facilities consists of 31 locations with accumulative container yard area of about 2.95 million square meters, which is about 4.7 times the total land area of the Buasn Container Terminal. All but two of the off-dock locations also have the container freight stations, with accumulative CFS floor area of 339,000 square meters, which is about 13.2 times the total floor area of the three CFS buildings at the Piers 5&6 Busan Container Terminal. Korean flag carriers are subject to different terminal rules than other containership operators at BCT. Korean flag operators are allowed free time of 15 days on both import and export containers on the terminal while other flag operators are allowed only 4 days for export and 5 days for import containers. Korean flag operators have unlimited storage time for empty containers while other flag operators are not allowed any such storage. CFS facilities on the terminal are for the exclusive use of Korean flag operators; all other operators must use off-terminal facilities.

The Korean flag lines currently account for about 16% of the ship calls and about 20% of the TEU at BCT.

3.2 The Growth Trends In Container Traffic In Busan Port

Since the mid-1970s, at about the time that almost all of the containerizable goods movements had completed the conversion from conventional, bulk handling system to containers, about 90% of the Korean container traffic(in TEU) has consistently been through Busan, and about 10% through Incheon.

Table 1. shows the trends in container traffic through the port of Busan.

Table 1. Trends in Container Traffic through the port of Busan

Year	Import	(000 TEU) Export	Total
1977	214.9	239.9	454.9
1978	234.0	272.5	506.5
1979	284.2	348.7	632.8
1980	256.1	376.7	632.9
1981	315.6	428.4	744.0
1982	348.5	438.2	786.7
1983	375.0	508.6	883.7
1984	423.9	630.4	1,054.3
1985	467.0	681.0	1,148.0
1986	571.0	698.0	1,269.0

*Sources : Containerization International Yearbook

Before the opening of Pier 5 of the Busan Container Terminal in 1978, all container movements through Busan Port was handled through conventional berths. In 1979, the first full year of operation, the Busan Container Terminal handled a volume of 264,300 TEU, which comprised about 44% of the container volume that passed through the port with four cranes. In 1983, Pier 6 was completed and the number of cranes were doubled. Currently, Busan Container Terminal primarily serves the large line-haul containerships which call regularly at Busan. On the other hand, small feeder ships and ships equipped with cranes are usually serviced through the conventional berths. In 1987, it is expected that 70% of the containers through Busan will be handled through Buasn Container Terminal, 30% through conventional berths.

Table 2 shows the trends in container traffic through the Busan Container Terminal.

Table 2. Trends in Container Traffic through the Busan Container Terminal.

Year	Import	Export	Total
	(000 TEU)		
1978	18.5	16.7	35.2
1979	133.1	131.2	264.3
1980	144.2	140.8	285.0
1981	179.8	184.5	364.3
1982	214.0	204.0	418.0
1983	230.9	270.4	501.3
1984	282.7	378.8	661.5
1985	322.2	394.7	716.9
1986	430.0	520.0	950.0

* Sources; from BCTOC

3.3. Third Stage Development Plan for new Container Terminal and Port Design Simulation.

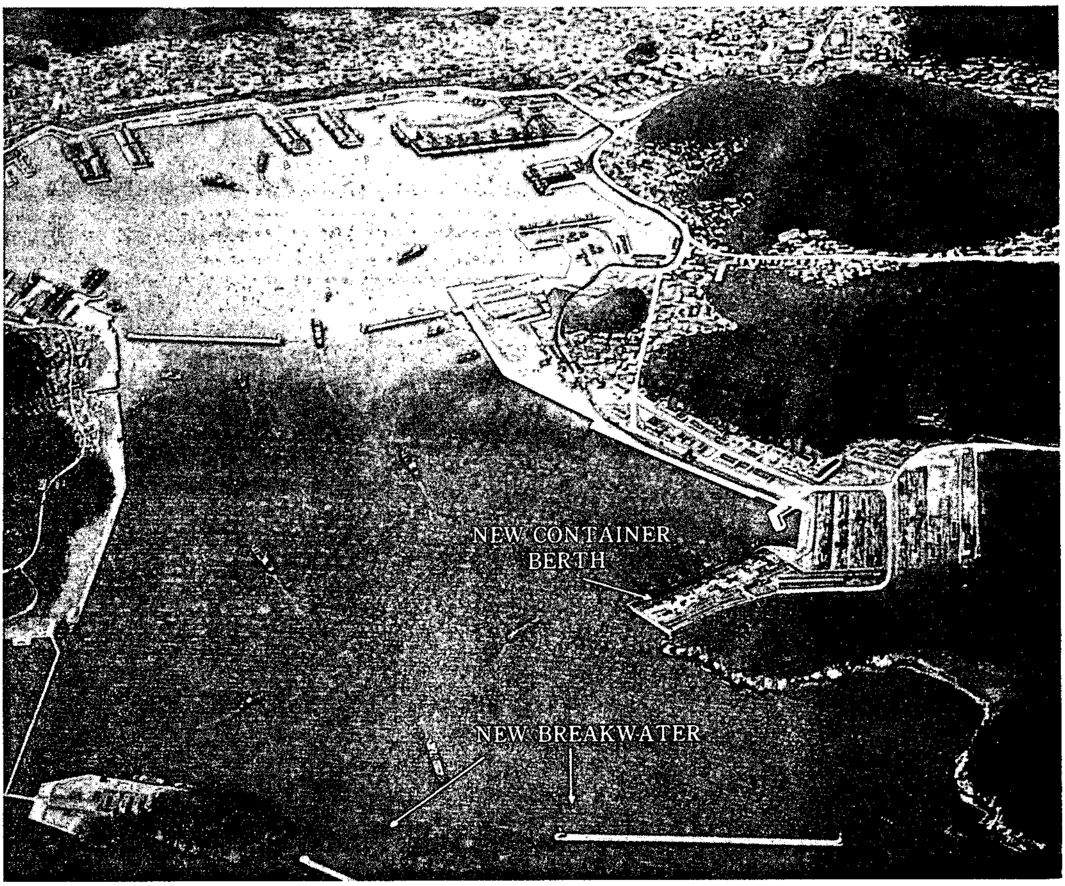
In 1986 about 950,000 TEUs were handled at this container terminial. This accounts for 66% of the total volume of containerized cargo import and export for Korea. It is anticipated that this growth trend will continue for years to come, causing increasing amount of strain on terminal operations.

Under the assumptions that 1) the close correlation between average annual changes in Korean GNP and TEU through all Korean ports which existed in the period of 1976 to 1985 will continue till 1990 2) Korean GNP will increase by an average of 8% in the period of 1986 to 1990, and TEU by 12% per year, the numbers of containers through BCT is expected to increase from 950,000 TEUs in 1986 to about 1,538,000 TEUs in 1990.

To cope with this situation, the government has undertaken a 3rd stage of the Busan Port Development Project, initiated in December 1985. This will include a 3-berth container pier in the Busan outer harbor area and is scheduled to be completed by 1990.

The third stage development plan is aimed at the construction of a port facility in the outer harbor for the increasing cargo growth of Busan Port, (Fig. 3). It will be managed by the 5-year program of the 6th Economic Social Development. With the implementation of this project from 1985 through 1990-with a total investment of 210 billion won-the stevedoring capacity could be increased to 38,830,000 tons from 28,020,000 tons and the berthing capacity could be increased from 79 to 82 vessels at one time.

Fig. 3. Third Stage Development Plan of Busan Harbour



The port designer of Busan port may have been or will probably be faced with the requirement to ensure that the layout and operational strategies in the new berths are adequate to cope with the new ship in all likely operational conditions. Traditional methods of port design are in the main based on empirical considerations. These are likely to be adequate when there are generous tolerances in the area of the harbour, or ships have an adequate manoeuvrability. In many present situations however, the ship is large compared with the available space in the port, and so the dynamic behavior of the ship becomes of great significance. It becomes sensible, therefore, to carry out the design based on the dynamic relationships between the port, the ship and the mariner, or pilot.

4. Research Applications

In Section 2, the difficulty of evaluating what constitutes an "Optimal" or "Best" port approach was mentioned. This particular problem is currently being addressed by the Authors in a study based in Busan, at the Korea Maritime University, and in Cardiff, UK, at the University of Wales Institute of Science and Technology. A simulation of the port is being made, using the simulator shown in Figure 1, and this will be used to determine what features of an approach may be considered as being of most significance. Clearly, it is important that the ship stays within the dredged channel, but is it important that it stays exactly in the centre of the channel, or is some lattitude allowable? Other aspects of port entry strategy to be studied will include:

① How is the situation altered if two way traffic is allowed?

② Are the number and size of engine or helm orders significant?

③ What provision can be made for limited failures of ship or equipment?

④ Can improvements to safety or ease of approach be made by changes in the alignment of jetties or the better provision of navigation aids?

⑤ What provision can be made for ships to leave unaided in the event of emergencies ashore, such as fire at the jetty, or of the imminence of very severe winds?

The study will also examine the validity of the simulation approach. Simulators are currently widely used for this type of study, (Ref. 1), but to date little work has been carried out to test the relevance of the studies to actual ports, (Ref. 2, 3). The design parameters of the simulator, such as the visual fidelity, the scope of the mathematical model, and the face validity of the controls will be systematically examined and conclusions drawn on the suitability of this approach for real world port design problems.

Further papers in this series will be presented as the work progresses.

5. Conclusions

As ports continue to expand their capacity, safety margins are being eroded, and the reliance on empirical design methods for the port results frequently in less than optimal design.

It is now becoming common for large ports to consider their design and operational strategies in simulation before committing themselves to a large expenditure. Although the simulation will not tell the civil engineer or port authority how to design a port, it will provide quantitative, dynamic information on which to base design judgements.

For the port of Busan, with its rapid expansion plans, it is likely that such a simulation study could yield important design information to give the port safer, more effective operations. Such a study is being carried out by the authors as part of a wider investigation into the use of simulation techniques for this type of work.

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