JFMSE, 30(1), pp. 109~115, 2018.
수산해양교육연구, 제30권 제1호, 통권91호, 2018.
www.ksfme.or.kr
https://doi.org/10.13000/JFMSE.2018.02.30.1.109

Evaluation Model of Cruise Terminal on Berthing Capability
: The Case of Busan Cruise Terminal

Nam-Kyu PARK† · Sang-Cheol SUH

(†Tongmyong University · Port & Logistics Institute of Tongmyong University)

크루즈 터미널의 선박 접안능력 평가 모델에 관한 연구
- 부산항 크루즈 터미널을 대상으로-

박남규† · 서상철

(†동명대학교 · 동명대학교 항만물류연구소)

Abstract

The calling of cruiser ship to Korean port is increasing recently for 141callings in 2010 to 593 calling in 2015. The unexpected callings makes the Port Authority be confused because they cannot provide proper facility of cruiser ship at the time and right location. The unbalance of demand and supply of cruiser ship drop the service level, in a result the cruiser shipping company makes to leave the port. This paper deals with the procedure and model to estimate the dedicated facility of cruiser ship for the purpose of providing the facility which is not short of until 2025 of the target year in consideration of the size, number and location. The estimation of terminal facility depends on demand forecasts in the targeted area and the service level including ship waiting ratio, berth occupancy ratio, the size of cruiser ship etc. This paper suggests practical method and procedure to estimate the cruiser ship facility for ten years including forecasting, simulation estimation, ship waiting ratio, and berth occupancy ratio. As a result of calculating the number of berths of the Port of Busan, it was found that Dongsam-dong and North Port which has 1 berth of 220,000 ton and 1 berth of 100,000 ton are enough to accommodate the cruise ships in peak season of 2020 year.

Key word : Cruiser, Demand forecasts, Service level, Ship waiting ratio, Berth occupancy ratio, Cruiser ship, Mother port, Visiting port

Ⅰ. Introduction

According to UN WTO, 46% of cruiser earn an average yearly income of $75,000, which indicates that most cruiser ship travel product consumers are in higher income groups. Approximately 82% of cruiser of North America look for long-distance cruising products such as a cruise to Asia which is one of the fastest growing markets as a cruise destination (Tan, 2011). As the Asian cruise markets are developing, cruise ports are pressed to improve their service quality and to construct more terminals for customers (Mc Carthy, 2003).

The number of cruise ships calling at Korean

† Corresponding author : 051-629-1861, nkpark@tu.ac.kr
※ This search was supported by the Tongmyong University of Research Grants 2017F056.

ports greatly increased from 141 in 2010 to 593 in 2015. The authorities could not predict the right place at the right time nor provide appropriate services for cruise users. The purpose of this study is to establish a methodology to calculate the number of berths of a cruise terminal and to estimate the number of cruise berths in the Port of Busan empirically. To this end, port call data of the Port of Busan from 2010 to 2015 was analyzed and the required berths were predicted. In addition, the number of expected port calls in the peak season of 2020 was predicted. Finally, a simulation model was developed to calculate the number of berths's requirement based on appropriate occupancy rate and waiting rate.

Ⅱ. Research Methodology

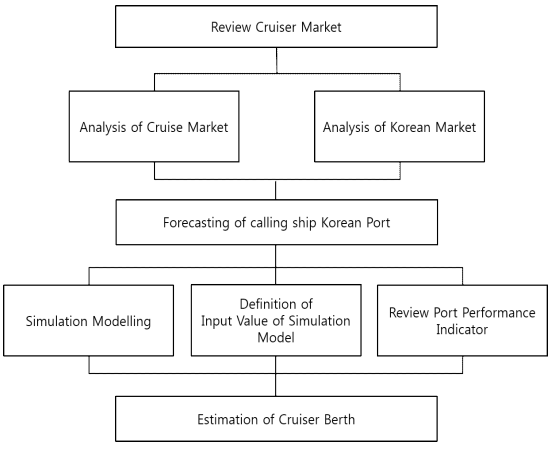
The simulation modelling in order to evaluate the capacity of berth has been consistent with the growth of information technology and the increasing demand for quick and reliable solutions for designing cruise terminal. Since Steer and Page (1961) and Beattie et al. (1971) did two pioneering studies based on Monte Carlo statistics. Port simulation models, Lawrence (1973), experienced a continuous improvement and by the end of the 1980s PSM became sector which facilitated the rapid expansion of simulation modelling in port development. During the last decade, the accelerated use of simulation models (SM) in port development and particularly in cruise terminals (CT) became a trend.

The first stage of research is to survey the cruise markets by analyzing the trends and number of cruise calls in the target markets.

In the second stage, as Busan port is visiting port, we need to survey the conditions of home port in order to estimate the number of calling. On the case of the Port of Busan, the Port of Shanghai is deemed to be the home port. Generally speaking the size and number of outgoing vessels of the home port used to influence the size and number of cruise ships of the Port of Busan. Since air draught or draught is determined depending on the size of cruise ships which influence berthing facilities, the markets and facilities of a home port need to be thoroughly investigated.

The third stage is to estimate the number of calls of cruise ships. Generally, the prediction of the required berths is conducted for five years in the future. In order to verify the suitability of a prediction model, MSE(Mean Square Error) should be comparatively analyzed with other models. In particular, the size of ships should be divided into two groups based on 100,000 tons during peak months.

The last stage is to construct a simulation model for estimating the number of required berths. The required berths should be calculated according to proper standards in considering berth occupancy and waiting rate based on the simulation model(Refer to [Fig. 1]).



[Fig. 1] Research Process

Ⅲ. Analysis on Cruise Market

The number and size of required berths of a cruise terminal is influenced by the size, length, and the number of calls of cruise ships. Precedent analyses on the global cruise markets are good materials to use for estimating cruise requirement and investigating berth development trends. The number of tourists in the global cruise markets is expected to increase by 4% every year from 2005 to 2020 and is estimated to be approximately 25 million in 2020. Specially, the number of Asian cruise tourists is expected to increase by 14.3% every year and to reach approximately 3.8 million in 2020. These numbers imply that the number of cruise tourists and demands of the North American markets will slowly decrease after 2010 and the market share of the Asian cruise markets will increase whereas the growth of the European markets will slow down (CLIA, 2014 State of the Cruise Industry Report). This statistical data suggests how rapidly increasing demands of cruise tourists need to reflected in a prediction model when calculating the number of berths in a targeted country. The length and capacity of cruise ships greatly changed in the last 25 years. 'Carnival Holiday' launched in 1985 has a length of 222 meters and capacity of 46,000 tons. However, 'Royal Caribbean' launched in 2010 has a length of 362 meters and capacity of 230,000 tons. Its length and tons increased by 60% and 500%, respectively (The New York Times, 2014). The size of cruise ships is rapidly enlarged compared to 25 years ago, and the size of berths should be redefined considering the size of incoming vessels.

1. Trends of Chinese Cruise Markets

According to the China Cruise Industry Development Report, international cruise terminals of China's three cruise ports of Shanghai, Tianjin, and Sanya handled 377 calls, and around 1,168,000 tourists entered in 2013. Among them, 65% of tourists entered via the Port of Shanghai. The important point which demands our attention is that 91.7% of the tourists are Chinese tourists who are expected to visit Busan in the future. This is due to the fact that the cruise route for visiting the Port of Busan is Shanghai-Busan-Fukuoka-Kagoshima-Shanghai which takes seven days (China Cruise & Yacht Industry Association, 2014)

2. Cruise Calls of the Port of Shanghai of China

Shipping lines that operate ships in relation with China as a home port are Costa Cruises, Royal Caribbean, Princess, and Star Cruises. Royal Caribbean is operating the Oasis of the Seas with a capacity of 200,000 tons, length of 361 meters, and ship draught of 9.3 meter with Shanghai as its home port (China Cruise Industry Development Report, 2014)

3. Cruise Facilities of the Port of Shanghai of China

The cruise terminals of the Port of Shanghai are composed of Shanghai Port International Cruise Terminal and Shanghai Wusongkou International Cruise Terminal. Shanghai Port International Cruise Terminal located on the western part of Huangpu River in Shanghai is the China's first international cruise terminal opened in 2008. Its current specification of four berths with a depth of water of 9m to 13m and berth length of 1,200 meters will be remodeled to three berths with a berth

length of 832 meters and capacity of 70,000 tons. Because of Nampu Bridge, Yangpu Bridge, and shallow sea levels, 100,000-ton or larger vessels use Shanghai Wusongkou International Cruise Terminal. As of 2015, Shanghai Wusongkou International Cruise Terminal has two 200,000-ton berths with a length of 774 meters and width of 34 meters (available for 220,000-ton vessels) and is able to accommodate the world's largest cruises.

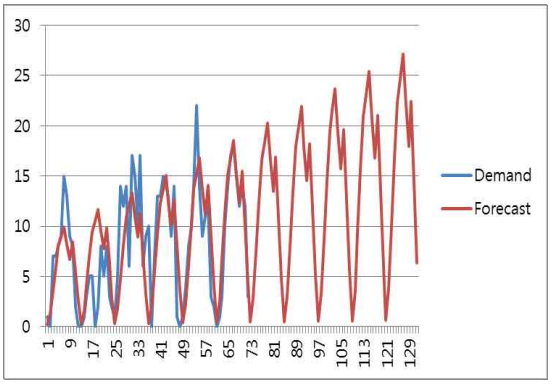
Ⅳ. Trends of Korean Cruise Market

The monthly number of calls of cruise ships of Busan Port from 2016 to 2020 is predicted based on time series for 5 years. The prediction model applied for this study is the decomposition of time series which is known to be useful for a long-term prediction (Barlow and Tippett, 2004). As a result of verifying the effectiveness of the time-series model, its effectiveness is confirmed with the coefficient of determination of 0.372, standard error of 1.878, and significance probability of 0.000. Prediction model Y= 5.033+ 0.081*T. These indexes represent the accuracy of the prediction model and is found to be MAPE of 57, MSE of 13 and MAD of 3. As a result of the prediction, the number of calls in 2020 is estimated to be 188 in 2020, and its peak season is expected to be July with 27 port calls.

Recently, THADD is a big thread of cruise tourism industry since March of 2017. According to the BPA report in 2017, the cruise tourists are declining to approximate 240,000 and the number of calling ship will be also expected to be 116. However, the paper deals with proper berth facility in response to the cruiser demand regardless of the unexpected occurrence.

<Table 1> Forecasting Calling Number of Busan Port in 2020

Cruiser Tonnage	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Sum
Below 100,000	0	2	5	8	10	11	12	10	8	10	6	3	85
Over 100,000	1	2	5	9	12	14	15	12	10	12	8	3	103
Sum	1	4	10	17	22	25	27	22	18	22	14	6	188



[Fig. 2] Forecasting of Calling of Busan Port from 2016 to 2020

Ⅴ. Simulation Model for The Required Berths

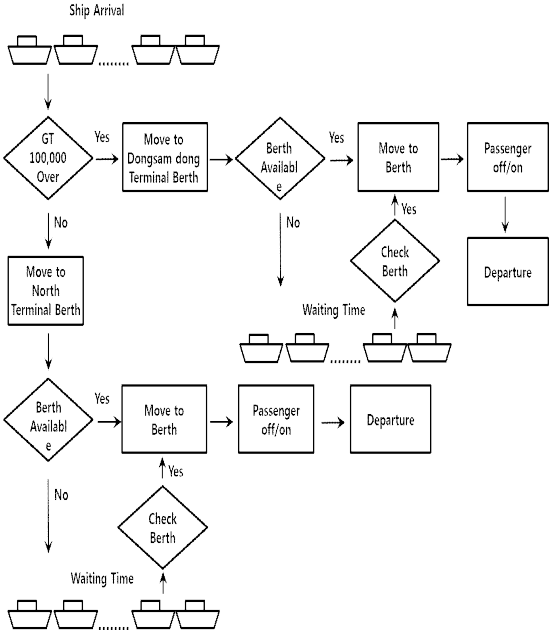
The dedicated terminal for cruise ships is an important factor when shipping lines determine destinations. The Port of Busan has 2 dedicated berths with more than 100,000-ton for cruise ships. If a port does not have facilities exclusive for cruise ships, they enter a port through an international passenger wharf or terminal.

<Table 2> Cruise Terminal Berths of the Ports of Busan

Port		Berth Capacity	Berth Length(meters)	Operation Time
Busan	North Port	100,000 x 1 berth	360	2015.7
	Dong-Samdong	220,000 x 1 berth	400	2014.6

Model structure - Ship-berth link is complex due to different inter-arrival times of ships, multiple quays and berths. The modeling of these systems must be divided into several segments, each of which has its own specific input parameters. These segments are closely connected with the stages in ship service([Fig. 3]).

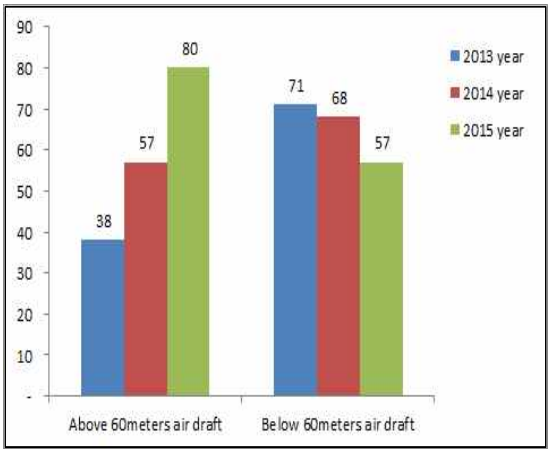
In order to build a cruise ship entry, berth, and depart process model, the vessel entry distribution should be analyzed by region and capacity. A simulation model was constructed based on the Port of Busan. Incoming vessels in 2020 were divided into two groups based on their size. The Port of Busan has a 100,000-ton cruise terminal in North Port and 220,000-ton cruise terminal in Dongsam-dong.



[Fig. 3] Simulations Model from Entry to Departure of Cruise Ships

At the Port of Busan, 100,000-ton or smaller cruise ships should enter through North Port and cruise ships larger than 100,000 tons should access to Dongsam-dong, since the air draft of Busanhang Bridge is limited to 60 meters.

The number of calling ships in Busan Port for three years whose air draft is 60 meters above a nd below, are shown on [Fig 4].



[Fig. 4] The Number of Calling Ships on 60 Meters Above and Below Air Draft

1. Definition of Input Values of Simulation Model

Data collection - All input values of parameters within each segment are based on data collected during the study period. The main input data consist of ship inter-arrival times, tourists per ship,

Inter-arrival times of ships - The inter-arrival time distribution is basic input parameter that has to be assumed or inferred from the observed data. Many authors suggest various types of distributions for inter-arrival times of ships at ports.

The arrival time intervals of cruise ships accessing to the Port of Busan are a minimum of 0 hours, a maximum of 336 hours, and 55.7 hours on average. The distribution of arrival time intervals of cruise ships applied for the simulation model are as shown in <Table 3>.

<Table 3> Inter-Arrival Times of Ships Distribution, 2015

Distribution Expression	-0.001+ 336 *BETA(0.66, 3.32)
Square Error	0.002762
Number of Data Points	122
Min Data Value	0
Max Data Value	336
Sample Mean	55.7
Sample Std Dev	56
Chi-Square Test Statistic Corresponding p-value	4.71 0.096

The size of cruise ships - the Port of Busan has a minimum of 138 GT, a maximum of 168,000 GT, and 99,600 GT on average. The distribution of size of cruise ships applied for the simulation model are as shown in <Table 4>.

<Table 4> Calling Ships Data

Distribution Expression	138 +1.68e+005 * BETA(1.27, 0.868)
Square Error	0.049116
Number of Data Points	120
Min Data Value	138
Max Data Value	168,000
Sample Mean	99,600
Sample Std Dev	46,500

The berthing time - The Port of Busan has a minimum of 7 hours stay, a maximum of 16.5 hours stay, and 9.95 hours stay on average. However, it is assumed that a cruise ship stays at the pier until another cruise ship enters the next day because cruise ships do not enter a port at night in practice. The berthing time of cruise ships divided into two groups based on their capacity (smaller than 100,000 tons and 100,000 tons or larger) is as shown in <Table 5>.

<Table 5> Berthing Time Distribution

	Cruiser of over 100,000 tons	Cruiser of below 100,000 tons
Distribution Expression	NORM(9.95, 1.86)	NORM(9.26, 1.71)
Square Error	0.070384	0.130265
Number of Data Points	64	54
Min Data Value	7	6
Max Data Value	16.5	15
Sample Mean	9.95	9.26
Sample Std Dev	1.88	1.73

Ⅵ. Estimating the Cruise Berths

When calculating the number of berths required, the simulation model operates based on the number of port calls in the peak month. For example, the monthly number of port calls of Dongsam-dong of the Port of Busan was found to be 15 with the occupancy rate of 42% and waiting rate of 33% during the peak season. Therefore, the Port of Busan was not found to need additional berths. The standards of berth development demand are based on the occupancy rate of 40% and waiting rate of 20% for two berths (UNCTAD, 1986).

<Table 6> Additional Number of Berths of the Port of Busan -in 2015 to 2020

Terminal	Capacit-y	Numb-er of Calling per Year	Number of Calling per Peak Month	Berth Occupancy Rate per Year (%)	Ship Waiting Ration (%)	Additional Number of Berth (2015~2020)
Dong Samdong	Over 220,000	103	15	42	10.3	nil
Nort Port	Below 100,00	85	12	33	7.7	nil
Total		188	27			

Ⅶ. Conclusion

This study was conducted to estimate the number of required berths based on a simulation model by predicting the number of port calls of the Port of Busan in the peak season of 2020. According to Ministry of Ocean and Fishery Affairs, the number of berths required is generally calculated through comparing the demands and cargo handling capacity of berths. This study suggests which procedures and methods should be applied to calculate berth requirement of rapidly growing cruise terminals and tried to prove the validity of the procedures. As a result of calculating the number of berths of the Port of Busan, it was found that Dongsam-dong and North Port which has 1 berth of 220,000 ton and 1 berth of 100,000 ton are enough to accommodate the cruise ships in peak season of 2020 year.

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- Received : 17 October, 2017
- Revised : 26 December, 2017
- Accepted : 02 January, 2018