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REPORT OF THE PORT AND
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1 . The Allowable Ship Motions for Cargo Handling at Wharves

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Synopsis

This Paper discusses ship motions moored at a quay wall as the harbour calmness index. Cargo handling at a wharf may occasionally be interrupted and/or suspended if ship motions exceed the allowable ones. The wharf operation efficiency, then, should be defined based on the allowable ship motions for cargo handling in terms of the type and size of a ship and a cargo handling equipment. There are such several factors which affect ship motions as waves, wind, current, types of quay walls, mooring ropes, fenders and properties of a ship. Effect of waves is most remarkable above all. Large ship motions are often observed when a ship is subjected to long period waves though the wave height in front of a is 50cm or so, while the target of wave height as harbour calmness index is about 50cm currently in Japan.

In this paper, we show instances of interruption and suspension of cargo handling due to ship motions. The allowable ship motions were estimated in terms of the type and size of a ship through executing numerical simulations not only for each instance of interruption and suspension of cargo handling which might be caused due to ship motions butalso for execution of cargo handling. These values were also evaluated and revised respecting opinions of cargo handling operators. Then the Allowable Ship Motions for cargo handling at wharves are proposed.

Key Words: Allowable Ship Motions, Calmness Index, Calmness of Harbour, Cargo Handling, Port, Harbour, Wharf Operation Eficiency.

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1. 港湾荷役における係岸船舶の許容動揺量

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要 旨

本論文は，港内の静穏度の指標としての係岸船舶の動揺に着目して論ずる。係岸船舶が荷役の許容動揺量を超えて動揺する場合には，荷役が中断または延期されることがある。したがって，港湾荷役の稼働率は荷役可能な船舶の動揺量に基づき，船種，船型，および荷役の方法に従って定義されなければならない。係岸船舶の動揺に及ぼす要因としては，波・風・流れなどの外力，係船岸の種類・係留索・防げん材などの係船岸の特性，そして船舶それ自身の諸元などがある。なかでも外力のうち，波の影響が最も大きい。港内の静穏度の目安は係船岸前面波高が 50cm 以下とされているが，船舶が長周期波の作用を受けると，たとえ波高が 50cm 程度であったとしても，大きな動揺を起こすことがある。

本論文においては，係岸船舶の動揺が原因となって荷役に支障をきたした事例を例示する。また，個々の事例について数値シミュレーションを行って係岸船舶の許容動揺量（暫定値）を求め，この許容動揺量の暫定値について港湾荷役関係業者に意見照会をした。それらの結果に基づいて修正して得た許容動揺量を提示する。

本論文の成果を活用することにより，係岸船舶の許容動揺量に基づいて港湾荷役の稼働率を計算する手法を確立し，港湾の施設整備計画における港湾荷役の稼働率を合理的かつ厳密に把握することができる。また，港湾の施設の利用に関しても，適切な措置を講じることができる。

キーワード：係岸船舶の許容動揺量，静穏性指標，港内静穏度，港湾荷役，港湾，荷役稼働率

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CONTENTS

1. Introduction

One of the authors has suggested that the wharf operation efficiency has to be calculated based on the **Allowable Ship Motions** in terms of the type and size of a ship and a cargo handling equipment[1]. He introduced some instances of interruption and/or suspension as well as execution of cargo handling which were investigated at several Japanese ports in Ref.[1]. It has been suggested that the wharf operation efficiency calculated based on the allowable ship motions for cargo handling might be smaller than that calculated based solely on the wave height in front of a berth when a ship is exposed to long period waves.

He has also presented an initial attempt to establish an alternative method for calculating the wharf operation efficiency. **Figure. 1** shows a block chart for a calculation of the wharf operation efficiency in that manner. There are such several items which must be cleared for the calculation as ①ship motions in terms of the type and size of a ship, wave direction, wave period and wave height, ② the allowable ship motions for cargo handling, ③ joint distribution of the wave height and period in each wave direction, ④ wave height ratio in front of a berth to deep water for each wave period and wave direction.

It is said that the allowable ship motions for cargo handling are the most important items for a calculation of the wharf operation efficiency, however, there have been a few studies in Japan on that point. As introduced in Ref.[1], studies on the allowable ship motions for cargo handling have been done by Bratteland[2], Bruun[3], Bloom and Posch[4], and Vigosson[5]. The results of these studies have been obtained through interviews with cargo handling operators and summarizing the previous studies.

Some calculation of the wharf operation efficiency according to the manner above

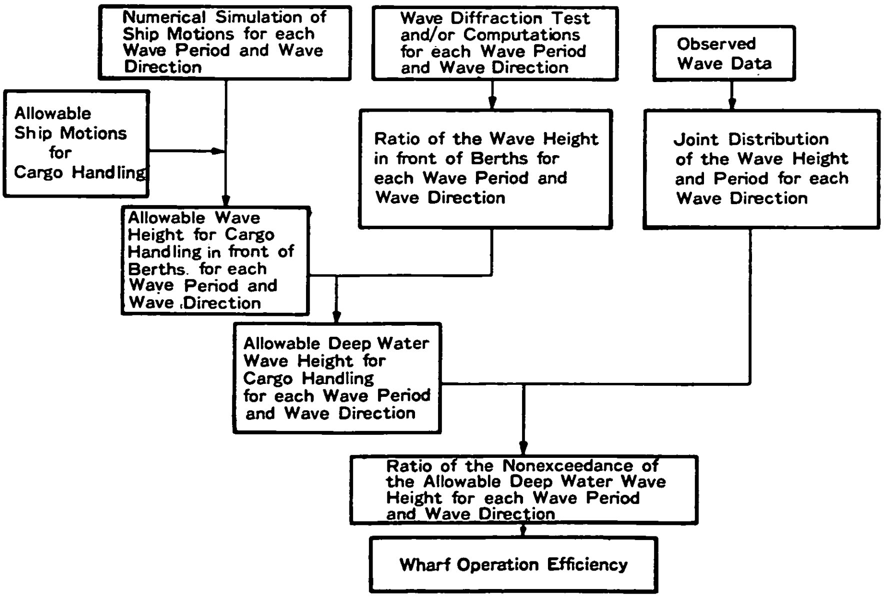

Fig. 1 Block Chart for the Calculation of the Wharf Operation Efficiency

mentioned were made by one of the authors referring to the allowable ship motions proposed by Bruun [3]. The First District Port Construction Bureau (hereafter the 1st DPCB) [6, 7] carried out some investigations on interruption and suspension of cargo handling in connection with wave and wind conditions. It is noted, however, that they presented the criteria for the harbour calmness index solely in terms of wave height. The wave period measured in the investigations were in the range of 3 to 6s. And considering the wave directions against each wharf, major components of ship motions which affected cargo handling to be suspended are thought surging and heaving accordingly. When a ship is exposed to long period waves, ship motions become larger than in short period waves. Or when a ship is exposed to waves of which direction closes to perpendicular to a quay line, other components of ship motions such as swaying and rolling become distinguished.

Recently, the Second District Port Construction Bureau (hereafter the 2nd DPCB) [8] with an assistant of the Association for the Promotion of Study on Civil Engineering has analysed data obtained from 403 collected out of 3,000 inquiries which were sent to captains through Japanese shipping companies. They have summarized values of data obtained from the inquiries and determined the critical ship motions for cargo handling by taking the mean of the data. But, there is an appreciable depreciation of data obtained from the inquiries. And it is a question to take the mean of data as the critical ship motions for cargo handling. It is thought that the large depreciation depends on the person replied to the inquiry whether he had experienced troubles of cargo handling due to ship motions or not.

Though, there were several contributions in foreign countries, the authors considered that it had to be needed to determine the allowable ship motions for cargo handling in order to establish the revised calculation method for the wharf oreration efficiency with due regard to not only the present state of performance of cargo handling but also opinions of cargo handling operators in Japan. These contributions have been referred to establish the **Allowable Ship Motions** for cargo handling in this paper.

Then investigation on the performance of cargo handling was carried out at several ports located at the coast of the Pacific Ocean. Data were classified into such several categories as ① excuted without interruption, ② interrupted, ③ suspended, ④ stood off a berth due to occupation of the former ship, ⑤ stood off a berth due to rough weather condition, ⑥ stood off a berth due to out of order of pilotage. However, these were roughly classified into two categories for the purpose of the investigation. One is the category that cargo handling is executed. And the other is the category that cargo handling is interrupted and/or suspended due to ship motions. Those instances which might not be related were omitted. Against all the instances of cargo handling belonging to above mentioned two categories, ship motions were calculated by means of the numerical simulation method [9].

Then the results of the calculation of ship motions were statistically analysed and the allowable ship motions for cargo handling were obtained. These figures are called the **Provisional Figures.** Because the **Povisional Figures** were estimated from the limited data obtained at a few ports above mentioned, the **Provisional Figures** must be evaluated by cargo handling operators at all the ports in Japan. This evaluation was carried out by means of the inquiry. In the inquiry, major questions are ① existence of troubles on cargo handling due to ship motions, and ② opinion against the **Provisional Figures** of allowable ship motions for cargo handling. Analysing the data obtained from the inquiry, it was found that some revision was needed. Then, the revised allowable ship motions for cargo handling is to be proposed.

Furthermore, some consideration for the practical use is made. For the practical use the procedures shown in **Fig. 1** must be more simplified. Because, comparing with the current method for a calculation of the wharf operation efficiency, the proposed attempt method is so complicated that it must be needed to consult ship motions at each berth for various types and sizes of ships subjected to various wave conditions. It is obvious that the procedure is simple and takes less load for the culculation if the criteria are defined in terms of wave height and wave period for various types and sizes of ships. For this purpose, establishment of the data base of ship motions must be needed though a quite lot of computation must be executed.

2. Instauces of Interruption and Suspension of Cargo Handling

2.1 Previous Studies

Several investigations were done in some of the District Port Construction Bureaus, Ministry of Transport[3), 4), 8)], Kubo et al.[10)], Monji and Fujiwara[11)] on interruption and suspension of cargo handling relating to wave and wind conditions. Those results were summarized in Ref.[1)]. Among them, the investigations done in the 1st DPCB[3), 4)] have so much contributed to give a relation between execution of cargo handling and wind and wave conditions. The critical wind speed in ten minutes average and the significant wave height for cargo handling have been summarized in **Table. 1** after the investigation. Most of ships which had to be interrupted and/or suspended of cargo handling were subjected to both strong wind and waves. The wave period measured in the investigations were in the range of 3 to 6s. And considering to the wave directions against each wharf, the major components of ship motions affecting cargo handling to be suspended are thought surging and heaving accordingly.

When a ship is exposed to long period waves, ship motions become larger than in a short period waves. Or when a ship is exposed to waves of which direction closes to perpendicular to a quay line, other components of ship motions such as swaying and rolling become distinguished. Consequently it is recommended for a port planner to consider ship motions when calculating the wharf operation efficiency. For this purpose, the allowable wave height must be established in combination with wave period in terms of the type and size of a ship.

As already mentioned, the 2nd DPCB have summarized values of data obtained from the inquiries and determined the critical ship motions for cargo handling by taking the mean of the data. But, there is appreciable depreciation of data obtained from the inquiries. And it is a question to take the mean of data as the critical ship motions for cargo handling. It is thought that the large depreciation depends on the person replied to the inquiry whether he had experienced troubles of cargo handling due to ship motions or not.

The manner of application for port planning is as follows. At first, motions of a vessel moored at a berth and subjected to a certain wind and wave conditions are estimated. Then these are compared with the allowable ship motions for cargo handling. Finally, the probability of occurrence is calculated when ship motions are less than the allowable ones.

Table 1 Causes of interruption of Cargo Handling and the Critical Wave Height and Wind Speed

Causes & Reason / Kind of goods	Wave		Wind and Rain (Snow)		
	Critical Wave Height	Conditions	Critical Wind Speed	Conditions (Wind)	Conditions (Rain)
Bulk cargo coal, coke, ore, phosphate pattassium chloride	0.5~1.0m	• Ship motions	10m/s	• Scatteren (Wind) • Crane Operation on a wharf difficult • Ship motions	• Wet in the rain and snow (70%)
Packed fertilizer, rice, grains	0.5~1.0m	• Ship motions	15m/s	• Ship motions (60%) • Crane operation on a wharf difficult	• Wet in the rain and snow
Heavy machines	0. 5m	• Ship motions	10m/s	• Cargo motions (35%) • Ship motions (35%) • Crane Operation on a wharf difficult (25%)	• Wet in the rain and snow (35%) • Poor visibility • Slippery (50%)
Timbers (on the wharf)	0.5~1.0m	• Ship motions	10m/s	• Ship motions (50%) • Cargo motions (50%) • Crane operation on a wharf difficult (20%)	• Deep Snow (40%) • Poor visibility
Oil	0.5~1.0m	• Ship motions	10m/s	• Ship motions	
Stone material Sulfaric acid	—	—	15m/s 25m/s	• Crane Operation on a wharf difficult	• Wires become slippery

2. 2 Investigation and Results

(1) Outline of the Investigation

The investigation of interruption and suspension of cargo handling due to ship motions was carried out at the Sendai Port, the Onahama Port and the Kashima Port (hereafter, the S Port, the O Port and the K Port respectively), where it had been considered that cargo handling was influenced by ship motions due to the action of long period waves. These ports are located at the coast of the Pacific Ocean as shown in **Figs. 2, 5 and 7.** Interruption and suspension of cargo handling was investigated by use of work diaries of operators. Items for investigation are date and time of interruption and/or suspension of cargo handling, the berth, properties of a ship, waves and wind conditions, kind of goods handled, method of cargo handling, structures of mooring facilities, the type and size of fenders, and the arrangement and type of mooring ropes.

Wave meters are set outside the breakwaters in those ports, but nothing are placed inside the basin. The wave height in the basin was estimated according to the results of wave diffraction computation. At the S port, the wave diffraction test and the visual observation by the berth master were made as well. There were depreciations on those values of wave height ratio in front of a berth to deep water. Ship motions are to be computed for each case of interruption, suspension and execution of cargo handling by means of the computer program developed in the Port and Harbour Research Institute[9].

Interruption and/or suspension of cargo handling are defined in this report such that cargo handling operation was interrupted and/or suspended due to ship motions. Interruption includes stopping of cargo handling along side a quay wall. Suspension of cargo handling includes standing off a berth in a basin or the outside the harbour breakwaters mainly due to rough weather conditions and waiting for cargo handling to commence after mooring to a berth. Instances in which cargo handling was obviously interrupted and/or suspended due to strong wind were excluded. For all the incidents of suspension of cargo handling investigated in above mensioned three ports, ships were standing off a berth outside the harbour breakwaters.

(2) Incidents of Interruption and Suspension of Cargo Handling Operation at the S port

The investigation was made for two berths in the S Port. They are the P2 and the P3 berths indicated in **Fig.** 2. Data were obtained over two years in 1983 and 1984. Data were analysed and instances of suspension of mooring berth due to increase of wave height, and interruption of cargo handling due to large ship motions were obtained. **Table.** 2 summarizes the number of ships calling and the occurrences of interruption and/or suspension of cargo handling which might have been due to large ship motions during the two years. This shows 11.5 and 3.1% respectively.

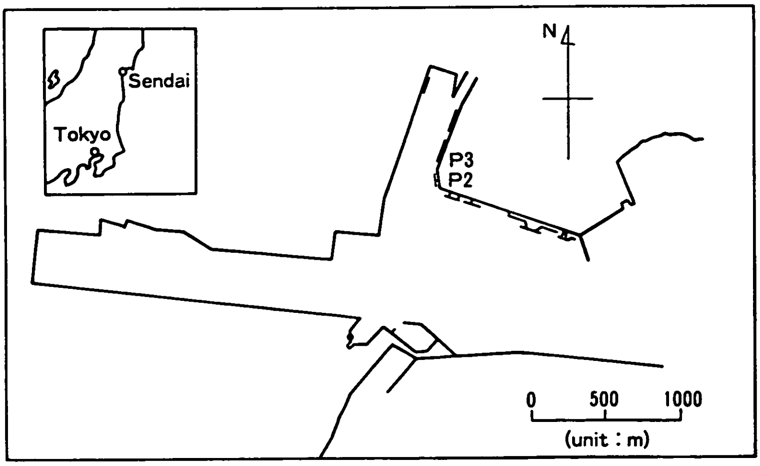

Fig. 2 Plan View of the S Port

Table 2 Number of Ships Calling and Interruption and/or Suspension of Cargo Handling Operations (S. Port)

Name of Pier	Year	Number of Ships Calling	Number of Suspension	Number of Interruption
P 2	1983	53	7	2
	1984	62	11	1
P 3-C	1983	178	15	3
	1984	133	15	9
P 3-D	1983	188	17	4
	1984	159	24	5
Total	1983	419	39	9
	1984	353	50	15
1983 ~ 1984		773	89	24

Figures 3-(a), (b) show the relation between gross tonnage (GT) of those ships for which cargo handling operations were interrupted with the significant wave height or the significant wave periods. **Figures** 4-(a), (b) show the relation between gross tonnage (GT) of those ships which stood off a berth outside the harbour breakwaters with the significant wave height and the significant wave period. It can be said that the smaller the ship, the higher the wave height and the longer the wave period was, the more frequently cargo handling were interrupted and/or suspended. In any event, there were many cases in which the wave height in front of a berth was less than 30cm when cargo handling being interrupted and/or suspended. The critical wave height may be smaller for a ship subjected to long period waves and/or waves in the direction close to 90 degrees, because ship motions depends on the wave direction and wave period.

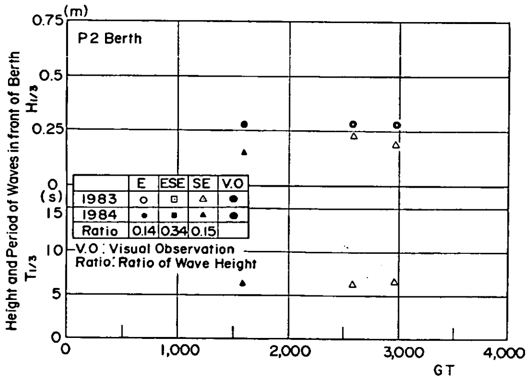

Fig. 3(a) Relation of Wave Height and Period vs GT when Cargo Handling was Interrupted and/or Suspended (S Port, P2 Berth)

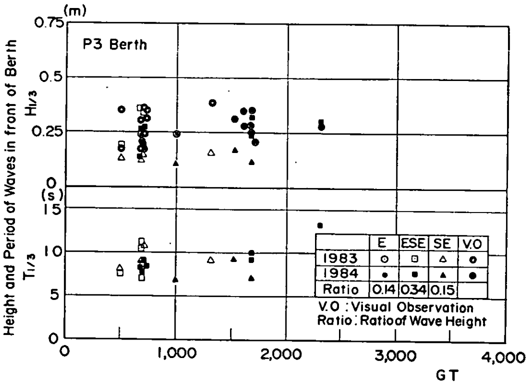

Fig. 3(b) Relation of Wave Height and Period vs GT when Cargo Handling was Interrupted and/or Suspended (S Port, P3 Berth)

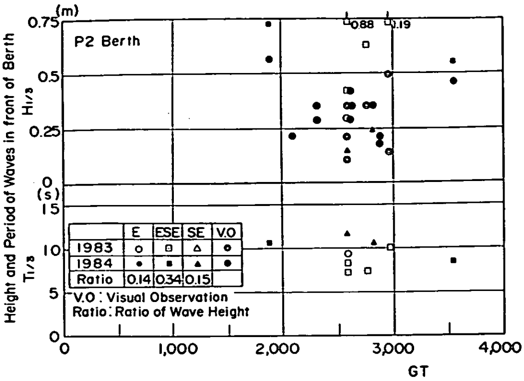

Fig. 4(a) Relation of Wave Height and Period vs GT when Ships stood off a Berth Outside Harbour Breakwater (S Port, P2 Berth)

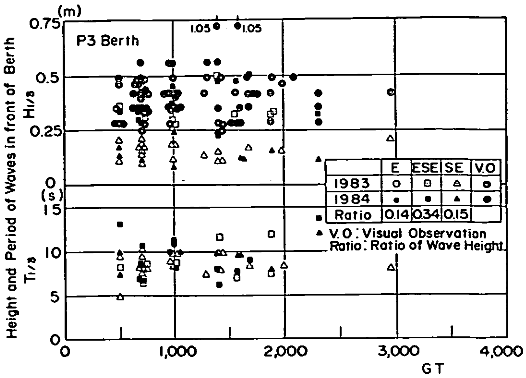

Fig. 4(b) Relation of Wave Height and Period vs GT when Ships stood off a Berth Outside Harbour Breakwater (S Port, P3 Berth)

(3) Instances of Interruption and Suspension of Cargo Handling Operation at the O port

The investigation was made for several berths at the O Port. They are the P1, the P2, the P3, the P4, the P7, the F and the O berths indicated in the plan view of the O Port (**Fig.** 5). Data were obtained from October 1979 to December 1984. Data were analysed and instances of suspension of mooring a berth due to increase of wave height, and interruption of cargo handling due to large ship motions. **Table 3** summarizes the number of ships calling and the occurrences of interruption and/or suspension of cargo handling which might have been due to large ship motions during the 5 years. This shows 0.28 and 0.14% respectivery. Interruption and suspension of cargo handling occurred rather frequently at those berths of the P1, the

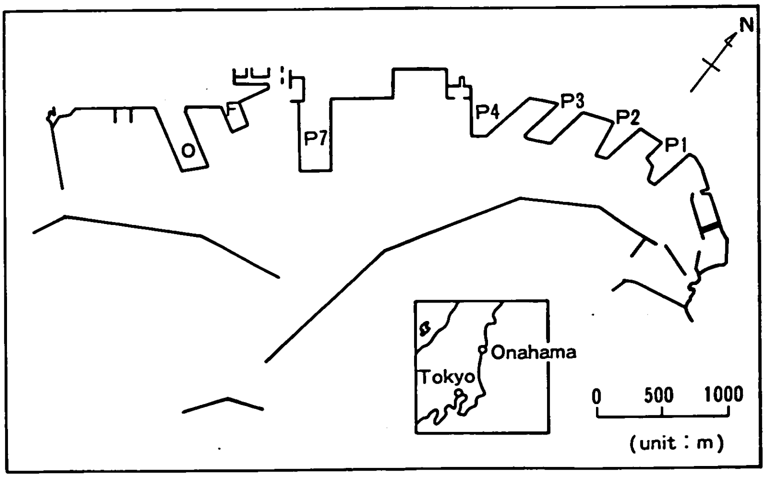

Fig. 5 Plan View of the O Port

Table 3 Number of Ships Calling and Interruption and/or Suspension of Cargo Handlling Operations (O Port)

Name of Pier	Number of Ships Calling	Number of Suspension	Number of Interruption
P 1	2825	16	2
P 2	2317	6	1
P 3	3544	24	11
P 4	5188	5	3
P 7	932	5	2
F	935	13	9
O	5383	12	0

P3, and the F. It seems that the occurances of interruption and suspension of cargo handling at the O Port is not so large compared to those at the S Port. This is owing to the effect of the harbour breakwaters which protect the harbour from waves in the East to South direction.

Figure 6 shows the relation of gross tonnage (GT) with the significant wave height or the significant wave period of deepwater wave when cargo handling wsa interrupted and/or suspended. Though the harbour breakwaters are constructed north to south to protect almost all the berths from the waves in the East direction, there are several instances of interruption and suspension of cargo handling operation when the wave direction is around East. It is difficult to say, because of lack of the wave data measured inside the harbour breakwaters, whether there are still some disturbances due to waves in the East direction or not. If so, these disturbances may be caused by overtopping and/or permeating waves through the rubble mound of composite breakwaters.

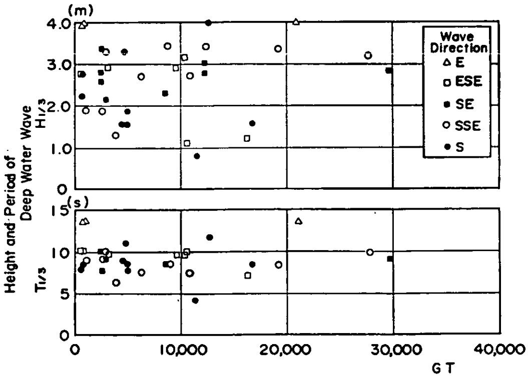

Fig. 6 Relation of Deep Water Wave Height and Period vs GT when Cargo Handling was Interrupted and/or Suspended (O Port)

(4) Instances of Interruption and Suspension of Cargo Handling Operation at the K port

The investigation was made for several berths at the K Port. They are the TD,

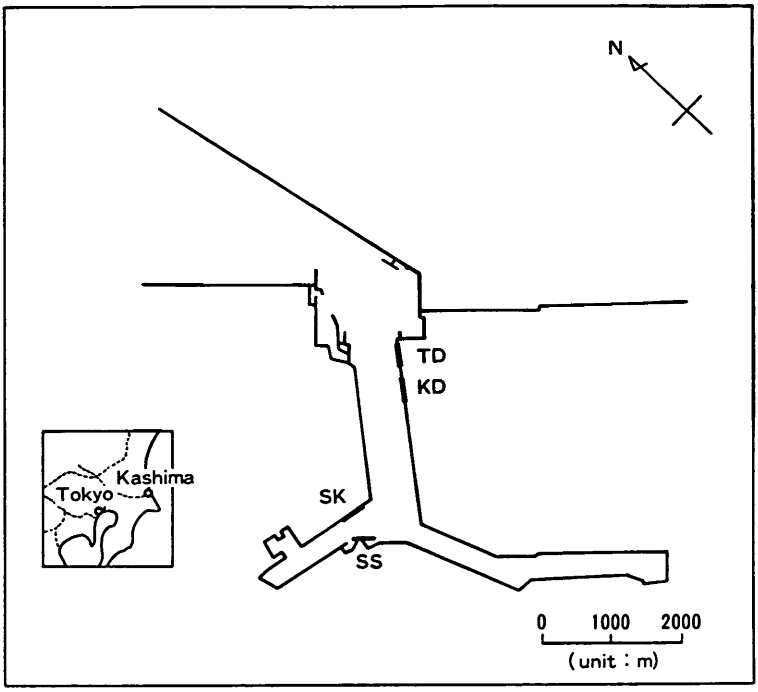

Fig. 7 Plan View of the K Port

Table 4 Number of Ships Calling and Interruption and/or Suspension of Cargo Handling (K Port)

Name of Berth	Number of Ships Calling	Number of Suspension	Number of Interruption	Period
TD Berth	D : 2,886	24	26*	1982-10 1985- 9
KD Berth	F : 680	7	12	1979- 4 1986-10
SS Berth	F : 712	7	15	1978-12 1986- 5
SK Berth	F : 1,464	5	44	1983- 2 1986- 8
	D : 375	5	30	1986- 5 1986- 9

* leave a berth without executing cargo handling

D: Domestic Cargo

F: Foreign Cargo

the KD, the SS and the SK berths indicated in the plan view of the K Port (**Fig. 7**). Data were obtained from April 1979 to October 1986. Data were analysed and instances of suspension of mooring berth due to increase of the wave height, and interruption of cargo handling due to large ship motions. **Table 4** summarizes the number of ships calling and the occurrences of interruption and/or suspension of cargo handling which might have been due to large ship motions during the 7 years. This shows 2.0 and 0.78% respectively. Interruption and suspension of cargo handling occurred rather frequently at those berths of the SS and the SK. The occurances of interruption and suspension of cargo handling in the K Port is not so large compared to those at the S Port, but larger than those at the O Port. This is owing to the effect of the harbour breakwaters which protect the harbour from the waves in the East to South direction.

Figures 8 (a) **to** (d) show the relation of gross tonnage (GT) with the significant wave height or the significant wave period of deepwater wave when cargo handling was interrupted and/or suspended.

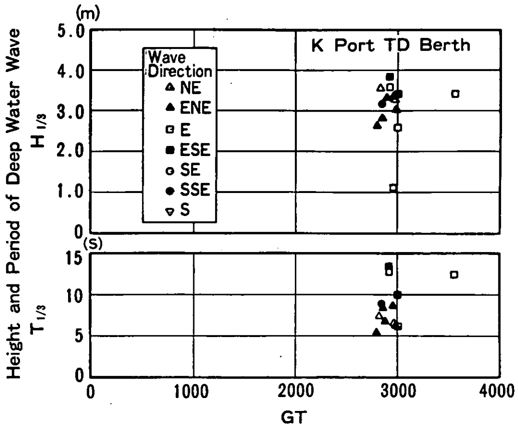

Fig. 8(a) Relation of Deep Water Wave Height and Period vs GT when Cargo Handling was Interrupted and/or Suspended (K Port, TD Berth)

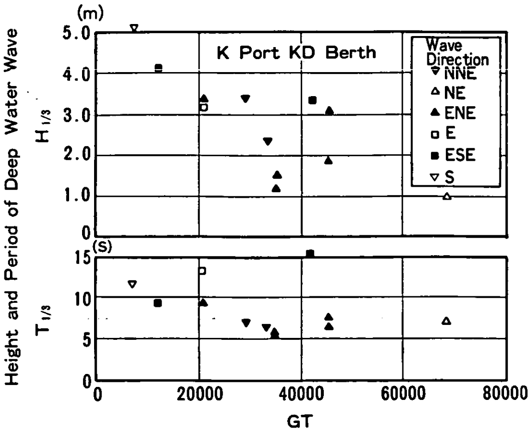

Fig. 8(b) Relation of Deep Water Wave Height and Period vs GT when Cargo Handling was Interrupted and/or Suspended (K Port, KD Berth)

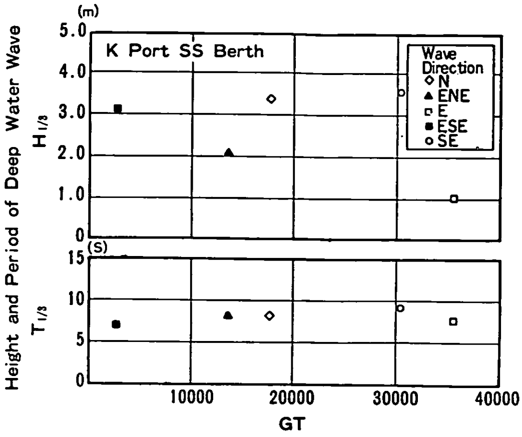

Fig. 8(c) Relation of Deep Water Wave Height and Period vs GT when Cargo Handling was Interrupted and/or Suspended (K Port, SS Berth)

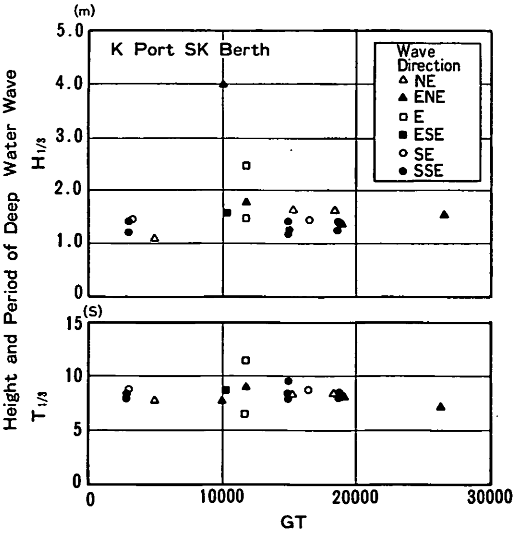

Fig. 8(d) Relation of Deep Water Wave Height and Period vs GT when Cargo Handling was Interrupted and/or Suspended (K Port, SK Berth)

3. Provisional Figures of the Allowable Ship Motions for Cargo Handling

3.1 Numerical Simulation

Numerical simulation was executed for thoes cases of both the S Port and the K Port as tabulated in **Tables 5 and 6.** The total number of cases of the numerical

Table 5 Number of Cases of Numerical Simulation (S Port)

Name of Berth	Ship Size	Interruption	Suspension	Execution	Total
All the Berths	500-3600	23	77	55	155
	500-1000	12	36	43	91
	1000-2000	9	26	7	42
	2000-3600	2	15	5	22
P2-B	1600-3600	2	13	6	21
	1600-2000	1	2	2	5
	2000-3600	1	11	4	16
P3-C	500-3000	10	26	19	55
	500-1000	3	10	17	30
	1000-2000	6	12	1	19
	2000-3000	1	4	1	6
P3-D	500-2000	11	38	30	79
	500-1000	9	26	26	61
	1000-2000	2	12	4	18

Table 6 Number of Cases of Numerical Simulation (K Port)

Name of Berth	Ship Size	Interruption	Suspension	Execution	Total
All the Berths	2800-70000	39	24	31	94
	2800- 5000	19	13	6	38
	5000-10000	5	0	5	10
	10000-30000	13	7	16	36
	30000-50000	1	3	2	6
	50000-70000	1	1	2	4
TD Berth	2800- 3600	14	11	0	25
KD Berth	5000-70000	3	3	6	12
	5000-10000	1	2	2	5
	10000-30000	1	0	2	3
	30000-50000	0	0	0	0
	50000-70000	1	1	2	4
SS Berth	10000-40000	3	6	6	15
	10000-30000	2	3	4	9
	30000-40000	1	3	2	6
SK Berth	3000-25000	19	4	19	42
	3000- 5000	4	0	4	8
	5000-10000	5	0	5	10
	10000-25000	10	4	10	24

simulation for the S Port and the K Port were 155 and 94 respectively. In detail, 23, 77, and 55 out of the 155 cases for the S Port and 39, 24 and 31 out of the 94 cases for the K port are corresponding to interruption, suspension and execution of cargo handling respectively. Regarding to the O Port no numerical simulation was executed due to the small number of instances of interruption and suspention of cargo handling.

The wave height in each case of numerical simulation was determined from the deepwater wave height multiplied by the wave height ratio in front of a berth taking account of reflected waves. **Figures 9 and 10** show the relation between the wave height ratio and wave period at both the P2 and the P3 berths. As formerly mentioned, both tests and computations were carried out on wave diffraction in the basin of the S Port. Furthermore, visual observations of wave height (denoted V. O. in the figures) were carried out at the berthing dolphin of each berth for every occasion of berthing and mooring by a berth master. Open Symbols and closed symbols correspond to the computations and the visual observations respectively. And double open circles and squares correspond to the tests. The wave diffraction tests were carried out on the condition that the wave dissipation works at the opposite revetment had been completed, while the wave diffraction computations were carried out on the condition that there had been no wave dissipation works. The execution of the wave dissipation works had begun in 1984, however, the effect of the wave dissipation works did not appear so much during the term when the visual observations described in this paper were made. As a result, it is read from these figures that the wave height ratio obtained from the computations is rather larger than the others. Though there was appreciable depreciation of data, the wave height ratio was determined 0.4 and 0. 3 in front of the P2 and the P3 berths respectively. Regard to the K Port, the wave height ratio was determined as summarized in **Table 7** according to computations.

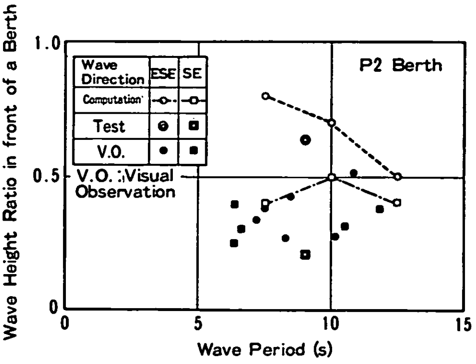

Fig. 9 Relation between the Wave Height Ratio and Wave Period (S Port, P2 Berth)

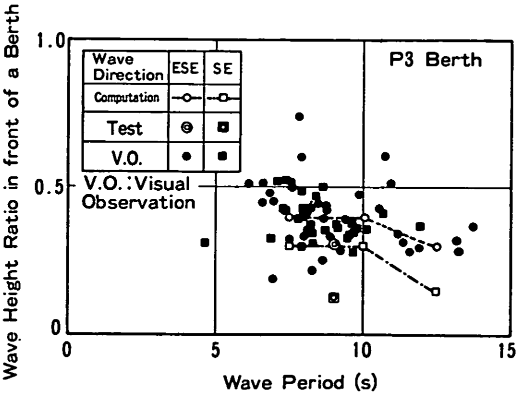

Fig. 10 Relation between the Wave Height Ratio and Wave Period (S Port, P3 Berth)

Table 7 Wave Height Ratio in front of a Berth to Deep Water Wave Height adopted in a Numerical Simulation (K Port)

Name of Berth	Wave Direction		
	N	NNE	NE
TD	0.49	0.38	0.23
KD	0.46	0.34	0.20
SS	0.25	0.19	0.09
SK	0.11	0.11	0.05

Typical arrangements of ropes and fenders of mooring ships at each berth which were adopted for computations are shown in **Figs. 11 to 17**. In these figures, wave direction, the type of ropes and the type of fenders are shown. The numerals shown beside ropes in some of these figures are number of ropes respectively.

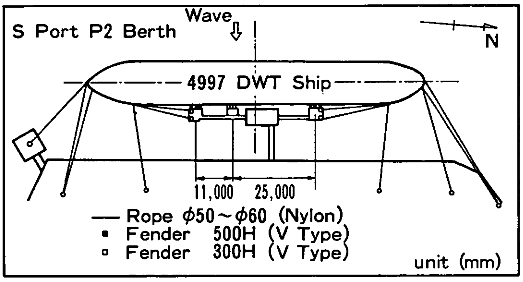

Fig. 11 Arrangements of Mooring Systems (S Port, P2 Berth)

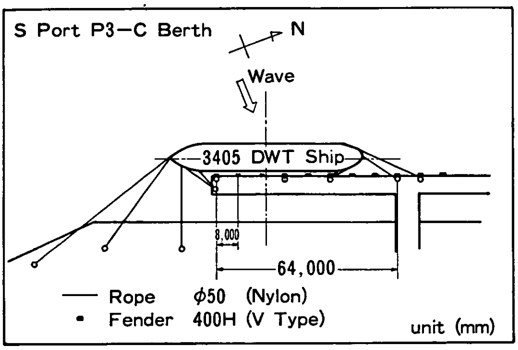

Fig. 12 Arrangements of Mooring Systems (S Port, P3-C Berth)

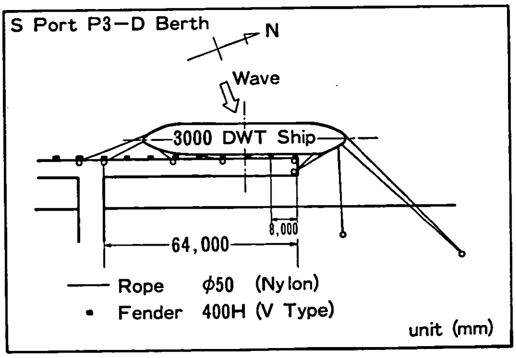

Fig. 13 Arrangements of Mooring Systems (S Port, P3-D Berth)

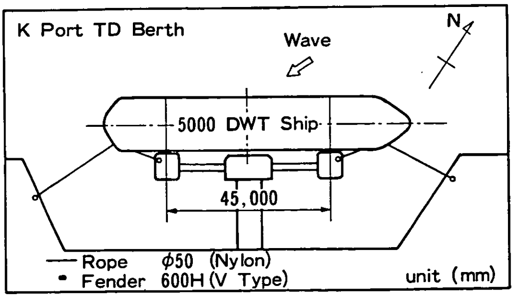

Fig. 14 Arrangements of Mooring Systems (K Port, TD Berth)

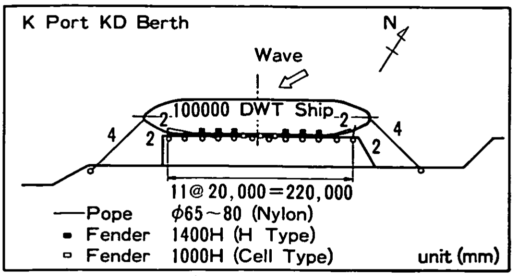

Fig. 15 Arrangements of Mooring Systems (K Port, KD Berth)

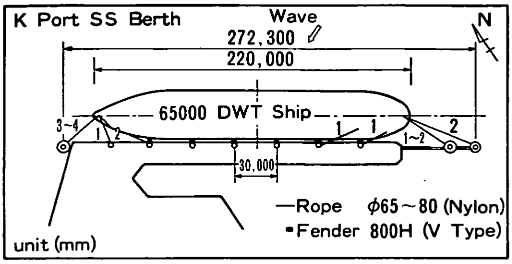

Fig. 16 Arrangements of Mooring Systems (K Port, SS Berth)

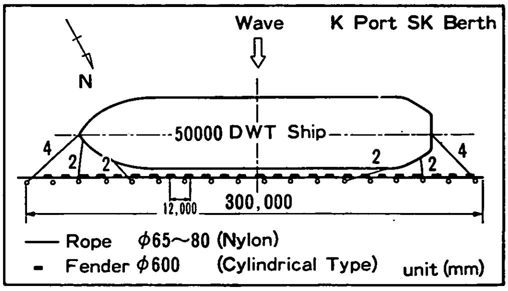

Fig. 17 Arrangements of Mooring Systems (K Port, SK Berth)

The interval of the time step and the number of steps of the numerical simulation are 0.25s and 6,000 respectively. On the statistical anlyses, date obtained up to 1,000 steps were omitted.

3.2 Statistical Analyses

The out put of the numerical simulation was put into the statistical analysis to get the maximum amplitude of each component of ship motions. The maximum amplitude is defined as the absolute value of either positive or negative movement from the neutral position. Then the cumulative distribution of the maximum amplitude for each component of ship motions were obtained as shown in **Figs. 18 to 22.** In these figures, bold line, dashed line and dash-dot line correspond to interruption, execution and suspension of cargo handling respectively. The figure denoted as N=23 for instance is the number of data obtained through the numerical simulation.

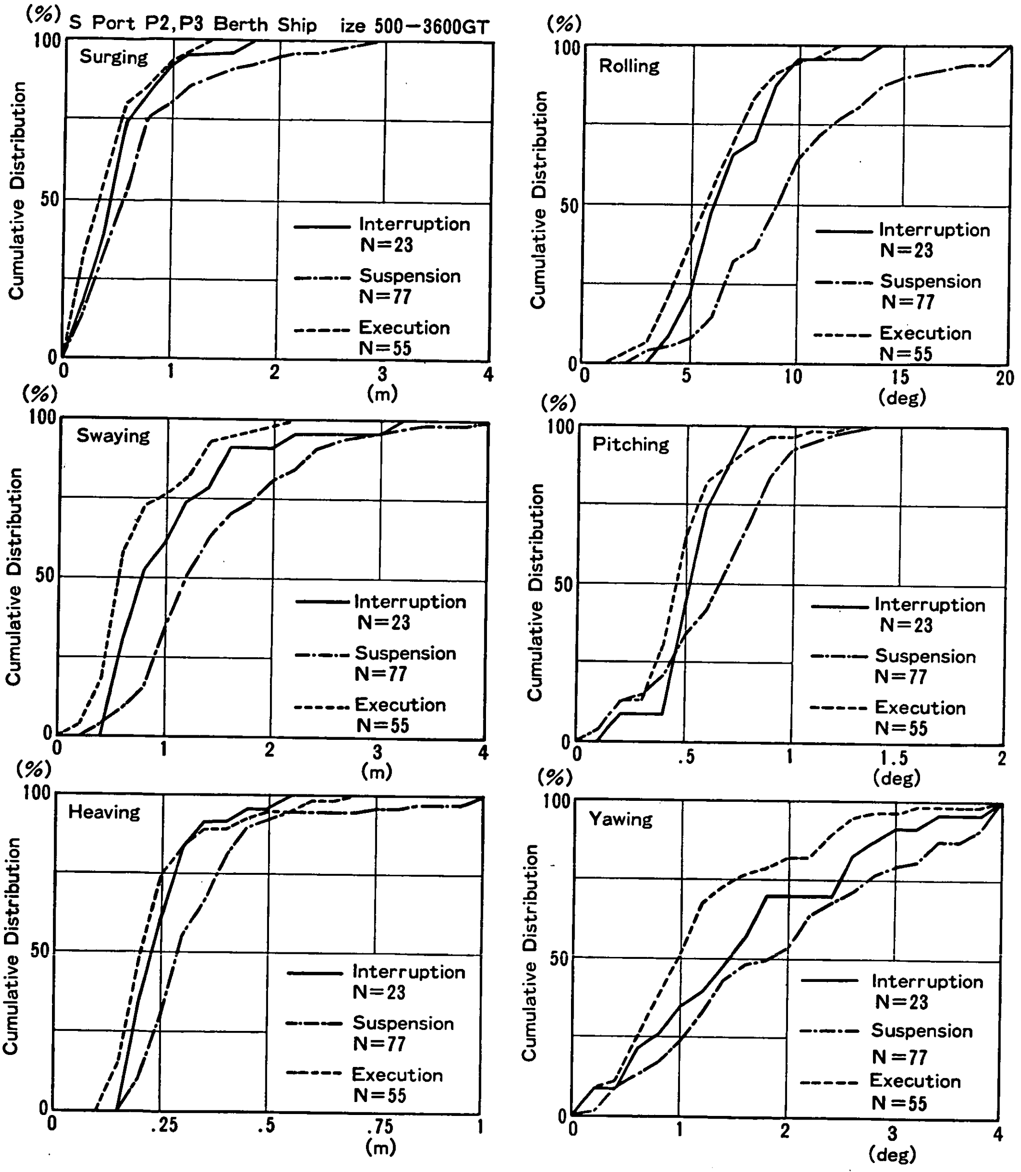

Fig. 18 Cumulative Distributions of the Maximum Amplitude of Ship Motions (S Port, P2 and P3 Berth)

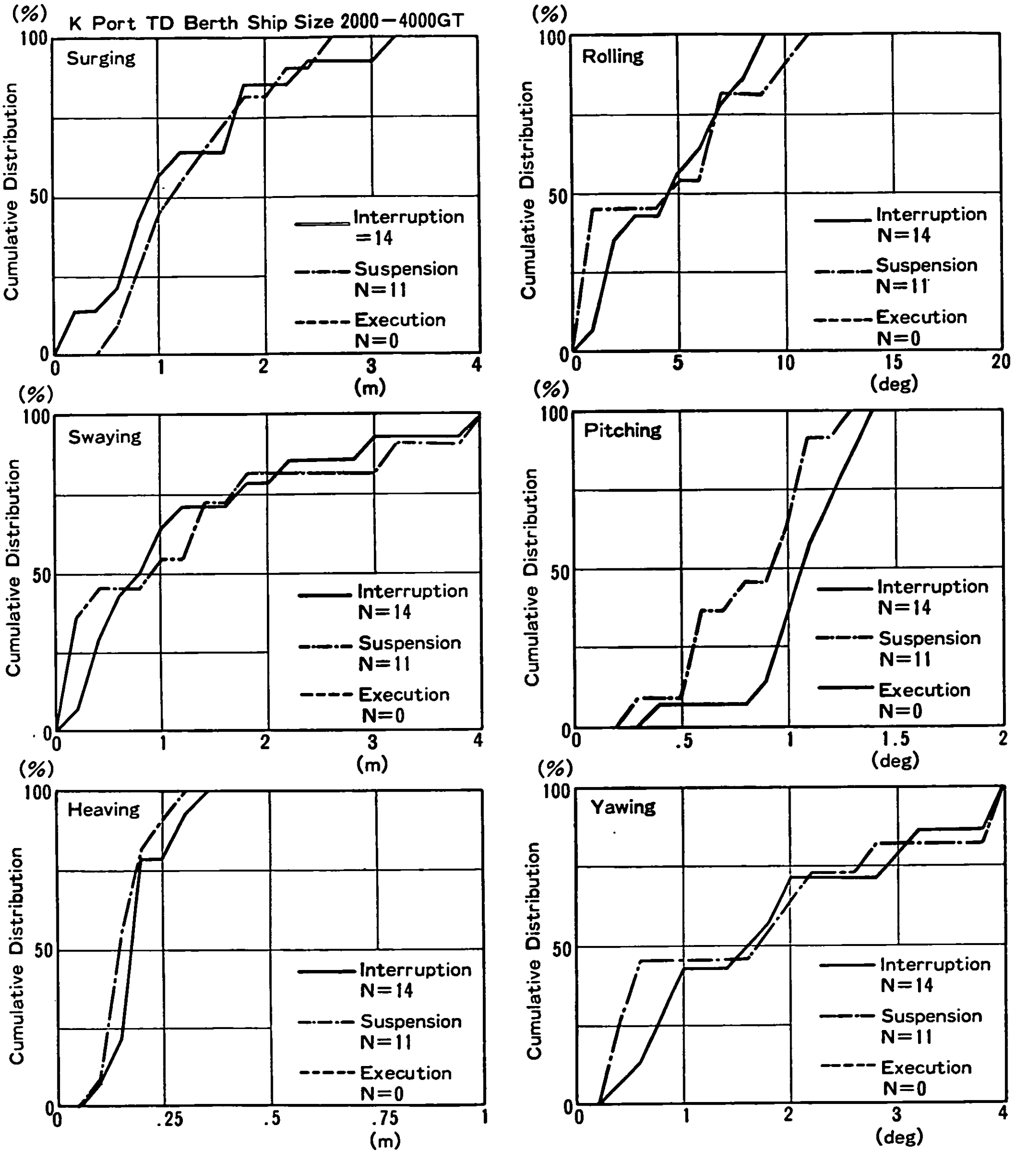

Fig. 19 Cumulative Distributions of the Maximum Amplitude of Ship Motions (K Port, TD Berth)

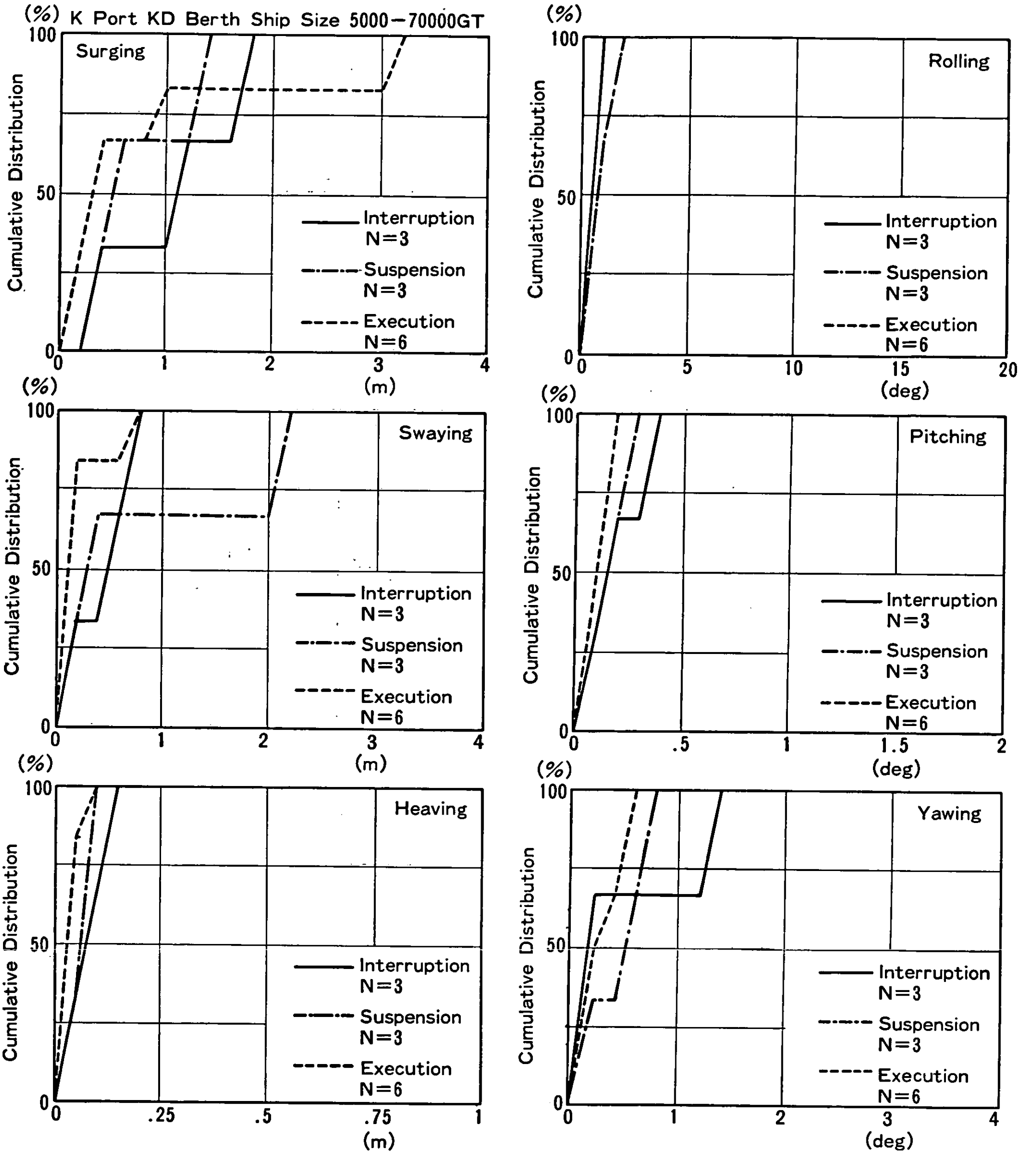

Fig. 20 Cumulative Distributions of the Maximum Amplitude of Ship Motions (K Port, KD Berth)

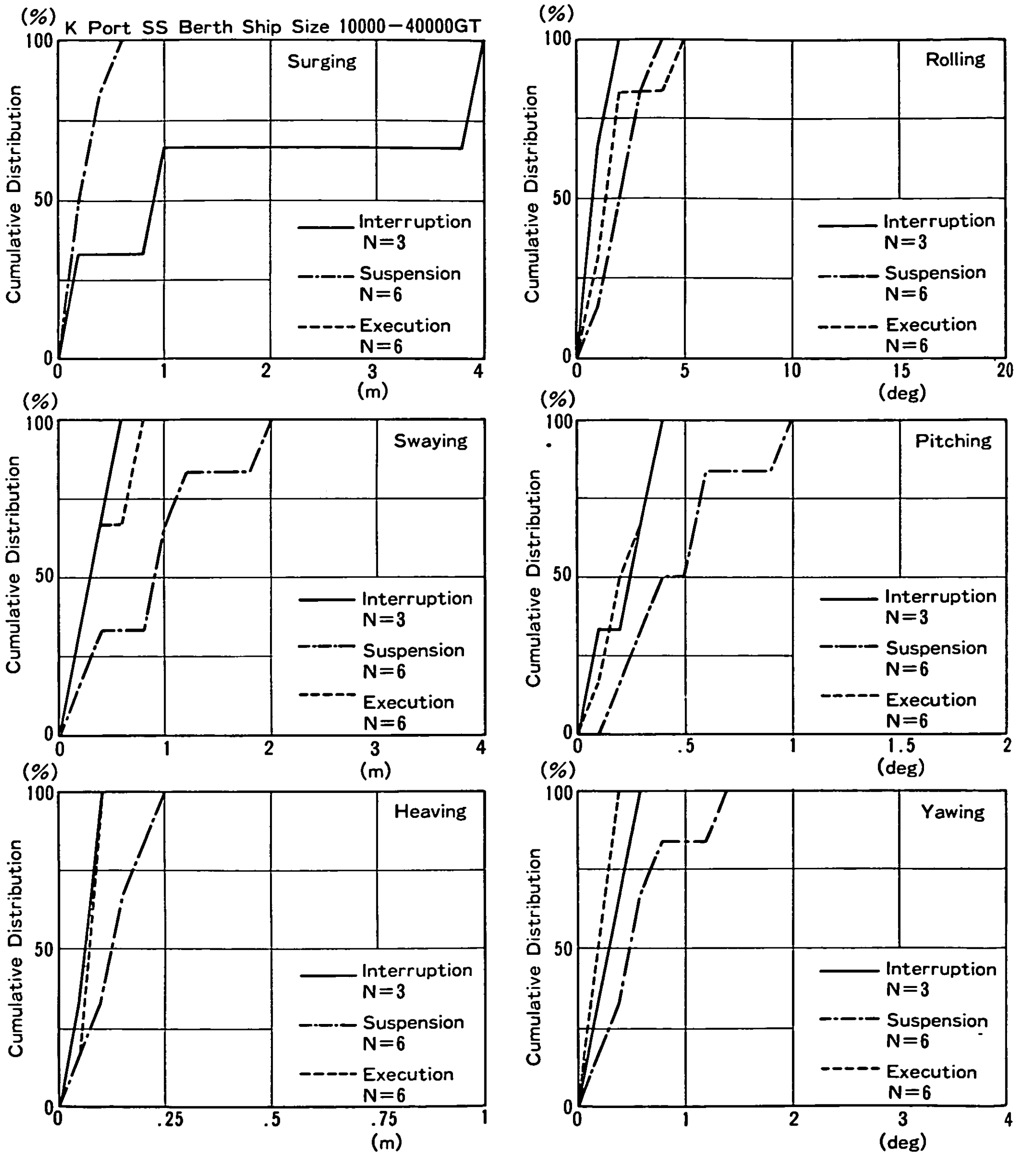

Fig. 21 Cumulative Distributions of the Maximum Amplitude of Ship Motions (K Port, SS Berth)

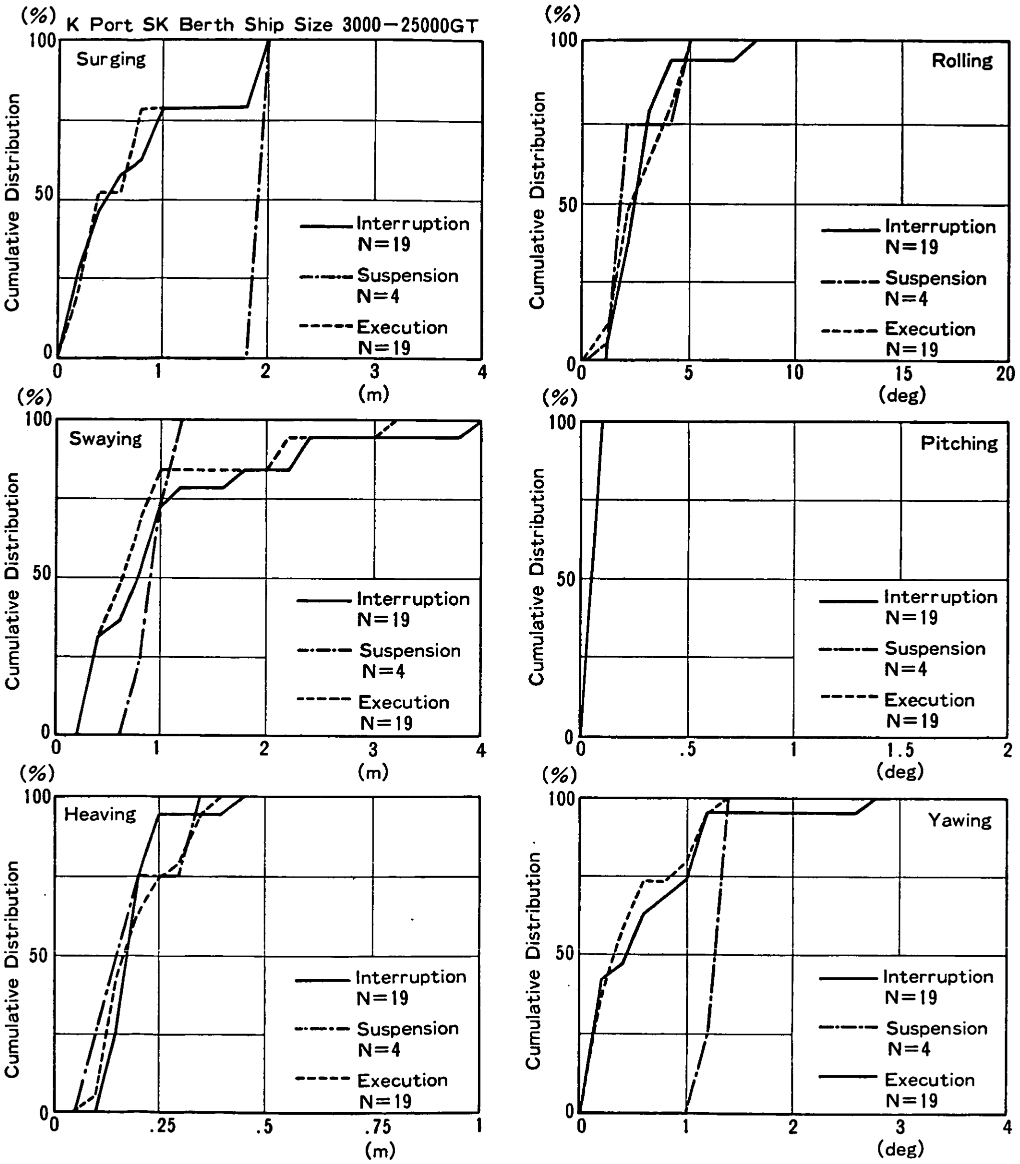

Fig. 22 Cumulative Distributions of the Maximum Amplitude of Ship Motions (K Port, SK Berth)

It can be seen that the cumulative distribution for interruption lies between those for the remaining two occasions. From these figures, the values corresponding 50% of the cumulative distribution were obtained and summarized in **Table** 8. The values were obtained for each berth in terms of the type of a ship. In **Table** 8, the **Provisional Figures** of the allowable ship motions for cargo handling as well as those proposed by Bruun³⁾ and the 2nd DPCB⁶⁾. Figures with superscript * are those components of ship motions which might not govern cargo handling at each berth relating the wave direction.

Bruun summarized them through both literatures and interviews wirh cargo handling operators.

Table 8 Ship Motions correspond to 50% of the Cumulative Distribution and the Provisional Figures of the Allowable Ship Motions

Kind of Ship	Investigated Berth	Component of Ship Motions					
		Surging (m)	Swaying (m)	Heaving (m)	Rolling (deg)	Pitching (deg)	Yawing (deg)
Oil Carriers	S Port P2 Berth	0.28*	0.50	0.48	4.1	0.15*	0.11*
	P3-C Berth	0.39*	0.80	0.19*	5.7	0.50*	1.40*
	P3-D Berth	0.65*	0.89	0.24*	7.6	0.55*	2.43
	Total	0.46*	0.78	0.23*	6.1	0.52*	1.44*
	K Port TD Berth	0.86	0.80	0.17*	4.5	1.06*	1.58*
	Provisional Figures	± 1.0	+ 0.75	± 0.5	± 6.0	± 2.5	± 2.5
	Bruun	2.3	1.0	0.5	4.0	—	3.0
	2nd DPCB	1.20	1.08	0.80	6.91	7.67	7.49
Ore Carriers	K Port KD Berth	1.1	0.5	0.07*	0.4*	0.15*	0.5*
	Provisional Figures	± 1.0	+ 0.5	± 0.5	± 4.0	± 1.0	± 1.0
	Bruun	1.5	0.5	0.5	4.0	—	2.0
Grain Carriers	K Port SS Berth	0.9	0.3	0.07*	1.0	0.25*	0.30*
	Provisional Figures	± 1.0	+ 0.5	± 0.5	± 1.0	± 1.0	± 1.0
	Bruun	0.5	0.5	0.5	1.0	—	1.0
General Cargo Ships	K Port SK Berth	0.4*	0.75	0.17*	2.3	0.05*	0.45*
	Provisional Figures	± 1.0	+ 0.75	± 0.5	± 2.5	± 1.0	± 1.5
	Bruun	1.0	0.5	0.5	3.0	—	2.0
	2nd DPCB	0.96	0.74	0.69	4.58	3.27	2.67

1) The figures by the 2nd DPCB are averages of the average values of loading and unloading for each ship kind.

2) Figures with superscript * are those components of ship motions which might not govern cargo handling at each berth relating the wave direction.

3) + of swaying means away from a berth.

The 2nd DPCB obtained them by means of inquiries sent to captains through Japanese shipping companies. The number of collected replies of the inquiries was 403 out of 3,000. Among them, effective ones were 346 which were classified broadly into data of cargo ships and oil carriers. Cargo ships include such ten types of ships as general cargo ships, grain carriers, ore carriers, car carriers and so on, while oil carriers include such three type of ships as oil carriers, LNG carriers, LPG carriers. The critical ship motions were presented by taking the mean of the data obtained from the inquiries. The number of the answers varies for the type of a ship as well as the component of ship motions. For instance, it is in the range of 25 to 94 out of 162 effective ones for cargo ships, and 15 to 71 out of 148 for oil carriers. But, it is not clear whether the values described in the inquiries are of double amplitude or amplitude of ship motions. If they were of the double amplitude, the critical ship motions for cargo handling might become rather small.

The 2nd DPCB also sent inquiries to cargo handling companies to ask wave and wind conditions when cargo handling were interrupted. The number of the collection was 118 out of 239. Among them, 51 described that cargo handling had been interrupted due to ship motions by wave action. The majority in the joint distribution of the type of a ship and the wave height is in range 3, 000 to 5, 999 and 1m respectively. The number of the answers in that range is 11. But, as formerly mentioned, the critical wave height for cargo handling varies depending on the wave directions and wave period as well as the type and size of a ship. Then, it is doubt to adopt the 1m of wave height as the critical wave height, because of a lack of detail examination relating those parameters of waves.

3. 3 The Provisional Figures

As summarized in **Table 8, the Provisional Figures** of allowable ship motions for cargo handling were determined. The determination was made based on the results of numerical simulations executed for those cases of interruption and suspension of cargo handling. And the proposal by Bruun[3] and the 2nd DPCB were also referred. Regarding the figures proposed by the 2nd DPCB, they were regarded as the amplitude of ship motions. The **Provisional Figures** were determined so that down to two places of decimals become a multiple of 0.25.

As above mentioned, figures with superscript * are those components of ship motions which might not govern the cargo handling at each berth relating the wave direction. For those components, it is thought that the maximum ship motions obtained by means of numerical simulations might be smaller than the allowable ship motions. Then, the **Provisional Figures** for those components were determined referring to those proposed by Bruun and/or the 2nd DPCB.

Regarding the **Provisional Figures** of pitching and yawing, the same values were determined except for general cargo ships, because the effect of these motions in terms of vertical or horizontal displacements at bow and stern are proportional to ship length. It seem that the **Provisional Figures** of pitching and yawing are smaller than those proposed by Bruun and the 2nd DPCB. In Particular, there is appreciable depreciation between the **Provisional Figures** and those proposed by the 2nd DPCB. Regarding oil carriers, the value of 2. 5 degrees was adopted according to the results of the numerical simulations. Though Bruun proposed 2. 0 degrees of yawing for such as ore carriers and general cargo ships and 1. 0 degree for grain carriers respectively, the horizontal displacement at bow and stern of a ship becomes about 2. 0 and 1. 0m respectively if the ship length were 120m which corresponds to 10, 000 DWT or so in size. It seems that the 2. 0m of displacement is a little larger comparing to the allowable ship motion in sway. As a result the value of 1.0 degree was adopted as the allowable ship motions in both pitch and yaw for such as ore carriers, grain carriers and general cargo ships. Regarding general cargo ships, the value of 1.5 degrees was adopted as the allowable ship motion in yaw, because the allowable ship motion in sway is 0.75m which is 0.25m as large as for the other two types of ships.

4. Inquiry to Cargo Handling Operators on the Provisional Figures

4.1 Form of Inquiry

The investigation by inquiry was carried out with cooperation of the Planning Division, Bureau of Ports and Harbours, Ministry of Transport. Inquiries were sent to almost all cargo handling companies registered in Japan. Details of the inquiry form is attached in Appendix

There are five questions. The No. 1 question is description on the port, that is name and prefecture belonging. The No. 2 question is description on the type and size of a ship, kind of goods handled, method of cargo handling. The type of a ship is classified into eight categories such as general cargo ship, grain carriers, ore carriers, oil carriers and so on. The size of a ship is classified into seven ranks. Kind of goods are such fifteen items as agricultural and dairy products, marine products, forest products, coal, ore and rock salt, oil kind and so on. The method of cargo handling corresponds to such equipments as gantry crane on a wharf, grab bucket or cramshell, shooter, belt conveyer, derrick on a ship, and so on.

The No. 3 question is on the occurrence of interruption and suspension of cargo handling due to weather conditions, Causes of troubles on cargo handling are waves, strong wind, rain or snow, mist or fog and so on. When there are troubles on cargo handling due to weather conditions, it is requested to describe detail of the interruption and the suspension as asked in No. 4 question.

The No. 5 question is the main one in the inquiry, that is asking opinions of cargo handling operators on the **Provisional Figures** of allowable ship motions for cargo handling. There are five ranks for evaluation such as −2, −1, 0, +1, +2. The rank +2 corresponds to the opinion that the allowable ship motion at the concerned port or the company is rather as large as and over 1.5 times of the **Provisional Figures.** The rank +1 corresponds to the opinion that the allowable ship motion at the concerned port or the company a little larger than the **Provisional Figures.** The rank 0 corresponds to the opinion that the allowable ship motion at the concerned port or the company is equivalent to the **Provisional Figures.** The rank −1 corresponds to the opinion that the allowable ship motion at the concerned port or the company a little smaller than the **Provisional Figures.** And the rank −2 corresponds to the opinion that the allowable ship motion at the concerned port or the company is as large as and under 0.7 times of the **Provisional Figures.** If opinions are in ranks of −2, −1, +1, and +2, it is requested to describe the allowable ship motion of the concerned port or the company.

The number of the inquiries was 400 and of which 198 were effective. However, it seems that the number of data concerning oil carriers was a slightly few. This may be caused from the destination of the inquiries. They were sent to cargo handling companies. The operation of oil berths is, however, performed under the supervision of a berth master concerned. Then, the inquiries were again sent to oil companies and/or oil terminal to fill up lack of data. The number of the inquiries sent to oil companies and/or oil berths was 300 of which 209 were effective.

4.2 Statistical Analyses

Data obtained from inquiries were analysed statistically. Two kind of analyses were made. One is summarization of opinions on the allowable ship motions corresponding to the ranks of opinion. The other is that on the allowable ship motions described by cargo handling operators in the inquiries. **Figures 23 to 27** show the frequency distribution of opinions corresponding to each rank, ship and component of ship motions. Generally speaking, the majority of opinions correspond to the rank 0 that is the **Provisional Figures** were equivalent to the allowable ship motions adopted by cargo handling operators or companies.

Excluding oil carriers, there are some numbers of opinions that the allowable ship motions adopted at the concerned port or the company is either larger or smaller than the **Provisional Figures.** But, regarding oil carriers, opinions of cargo handling operators seems that the **Provisional Figures** for both domestic and foreign oil carriers are a little larger than the allowable ship motions at the concerned ports or companies. However, the number of data for foreign oil carriers is still a few.

Figures 28 to 32 show frequency distributions of the allowable ship motions for each ship and component of ship motions described in the inquiries by cargo handling operators. Also, these data were analysed to get cumulative distributions as shown in **Figs. 33 to 37.** From these figures both values corresponding to 50% of cumulative distributions and the mean of data were obtained. These values are shown in **Figs. 38 to 42** comparing with the **Provisionai Figures** for cargo handling. These summarized information will be used for discussion on the revision of the **Provisional Pigures.**

Figures 43 and 44 show the location of ports where the troubles on cargo handling due to ship motions were described in the inquiries. Figures were made for ships under or over 10,000 GT in size. However, these were several answers which did not classify the ship size clearly. For instance, it was replied using the code number of ship size in the inquiry as 1, 2, 3, 4, or 4, 5, or 1 2, 3 and so on. As a result even if we classified a ship size in two classes as under or over 10,000GT, there are a few answers which include such small ships under 1,000GT in both classes. It is generally said that small ships are so sensitive to the action of waves that they make large motions even subjected to short period waves. Then, in these figures data which include small ships under 1,000 GT are remarked. Open symbols correspond to the answers concerning ships under 1,000 GT in size. Double open circles and squares correspond to answers concerning ships under 10,000GT, that is small ships under 1,000 DWT are included in this class. Closed symbols correspond to answers concerning ships in the range of 1,000 to 10,000 GT. On the other hand, answers which include timbers as the kind of goods handled are remarked, because small crafts are usually used for handling of timbers. This reads the results that the short period waves may affect cargo handling for such large ship as 10,000GT. These figures show rough information on the ports where ship motions affect cargo handling depending on the method. In Particular, regarding **Fig. 44,** it can be learned that these ports are located at the coast of northern part of the Japan Islands on both the Pacific Ocean and the Sea of Japan.

Table 9 shows the mean, maximum, minimum and standard deviation of the allowable ship motions described in the inquiries comparing with the **Provisional Figures.** This is tabulated taking account the occurrence of troubles on cargo handling due to ship motions by the action of waves. Those data where ship motions due to wave action are listed in top three of causes of troubles are summed up exclusive of data with no troubles on cargo handling. It shows that the maximum of the allowable ship motions described by cargo handling operators with no troubles on cargo handling is considerably larger than that of the allowable ship motions described by

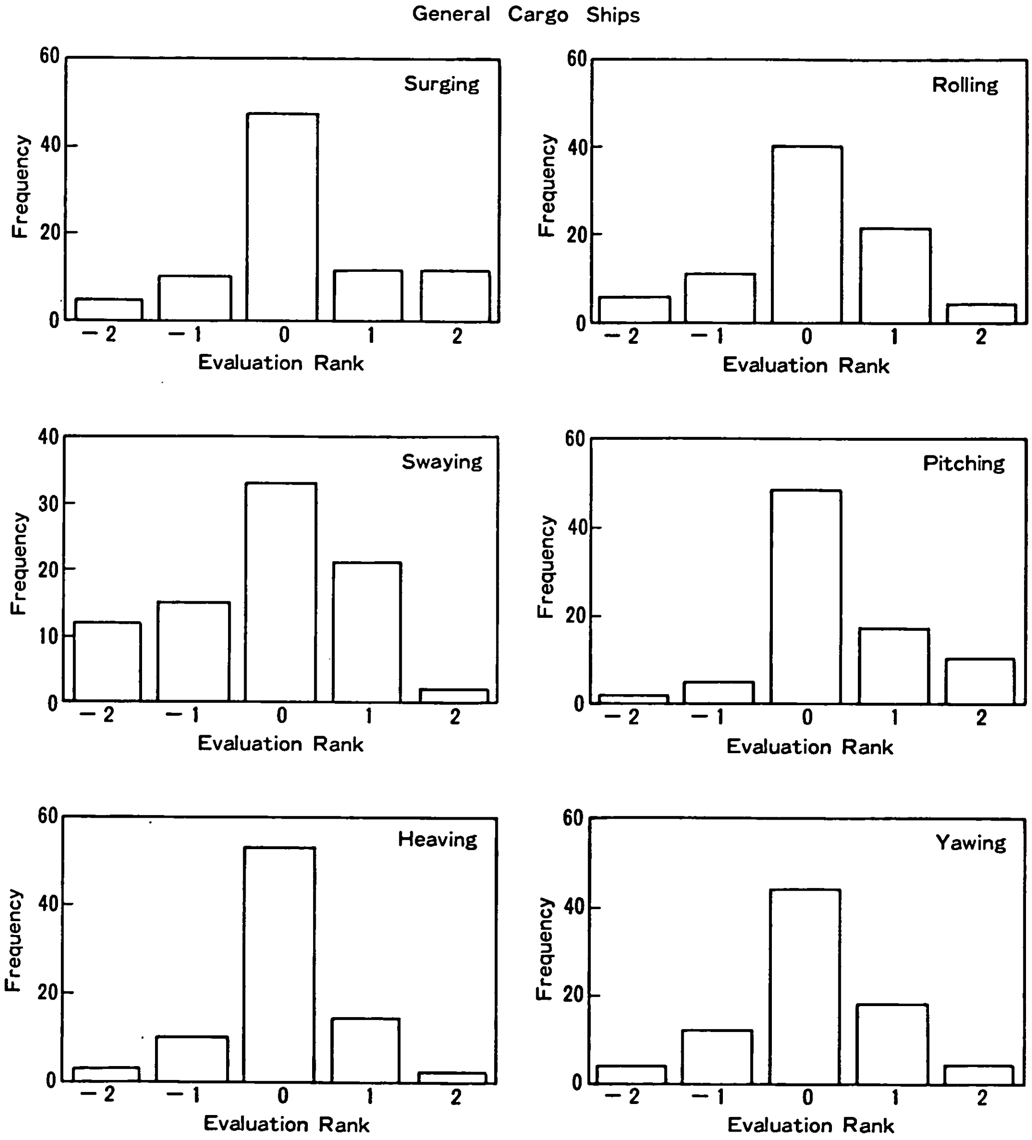

Fig. 23 Frequency Distributions of Opinions of Cargo Handling Operators Corresponding to each Rank (General Cargo Ships)

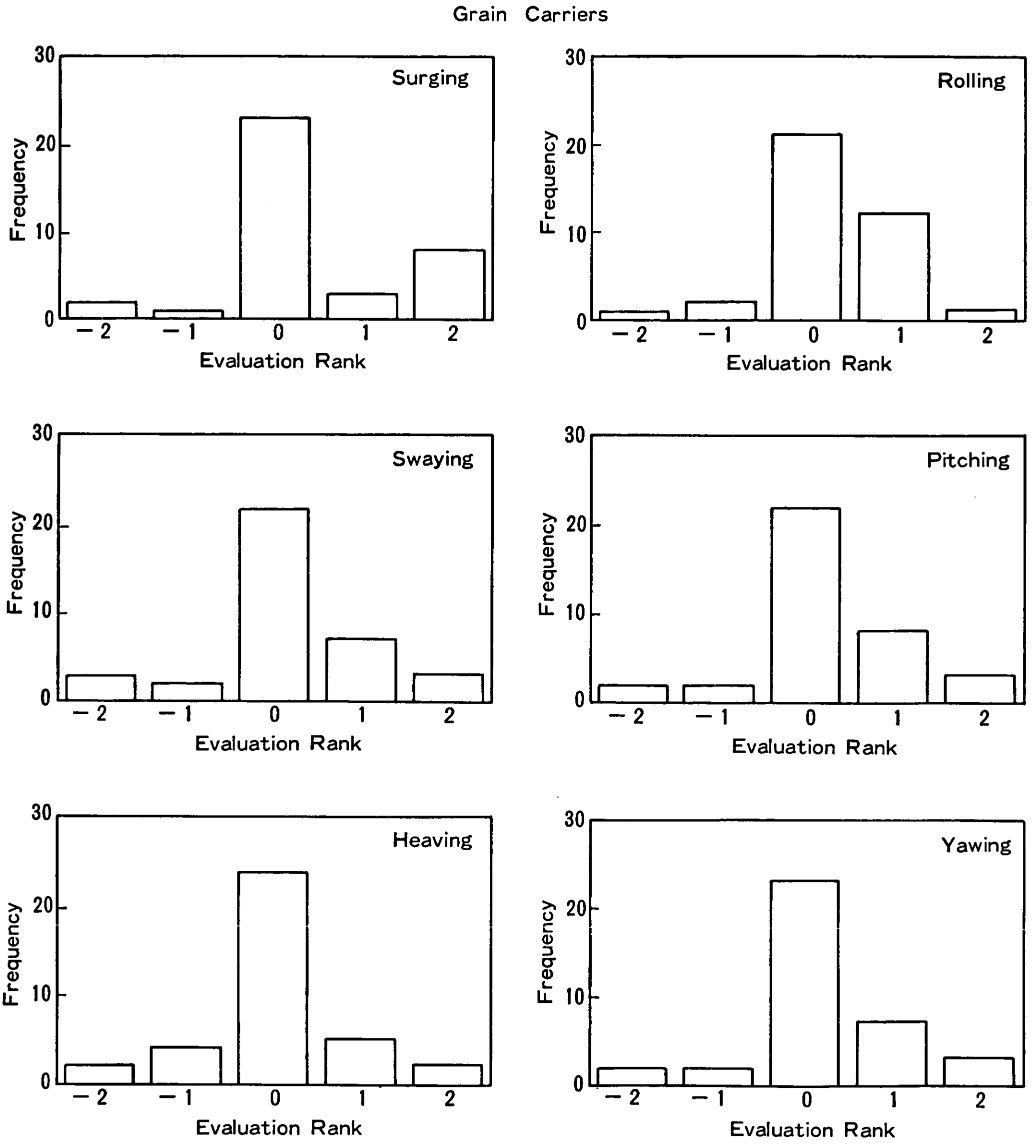

Fig. 24 Frequency Distributions of Opinions of Cargo Handling Operators Corresponding to each Rank (Grain Carriers)

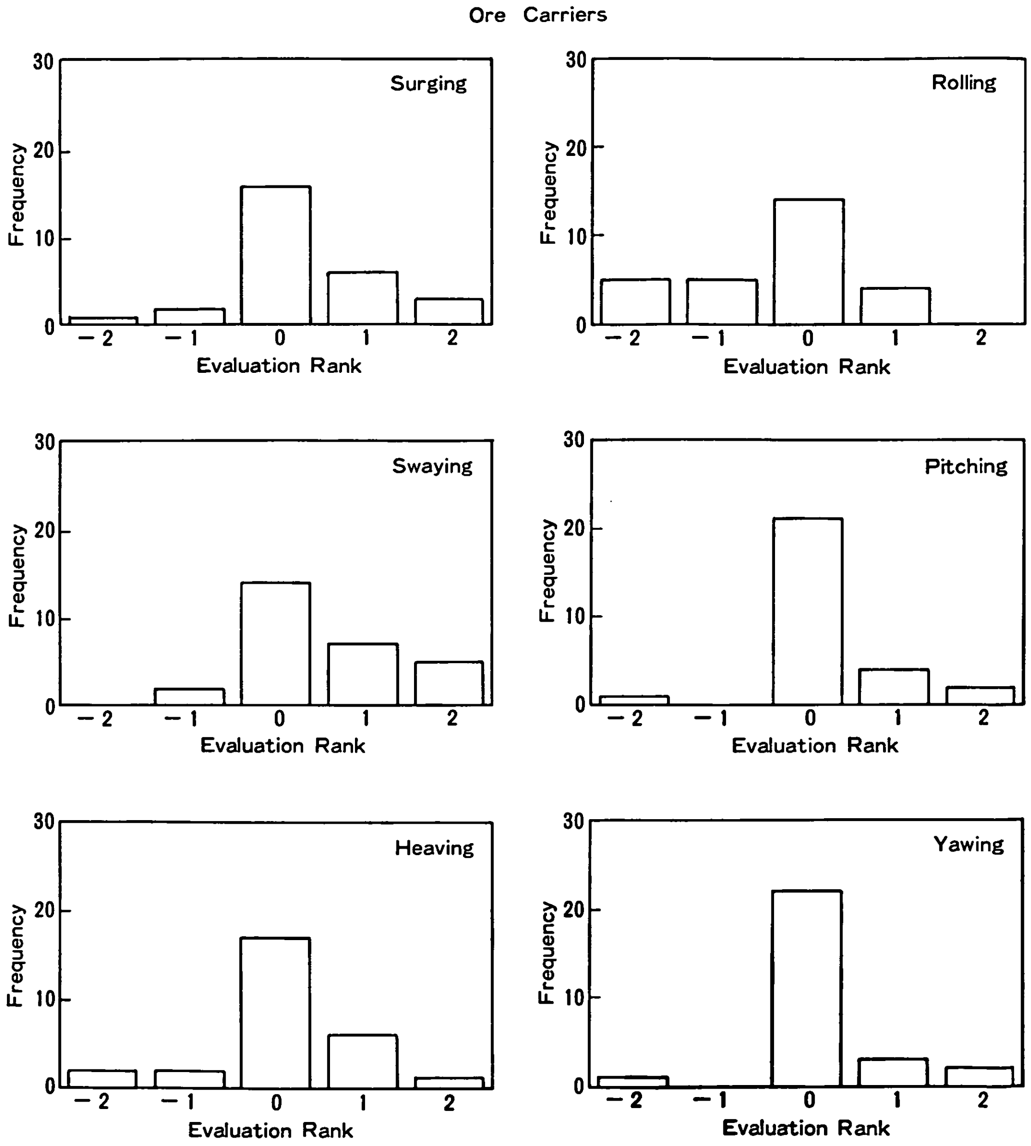

Fig. 25 Frequency Distributions of Opinions of Cargo Handling Operators Corresponding to each Rank (Ore Carriers)

Oil Carriers (Domestic)

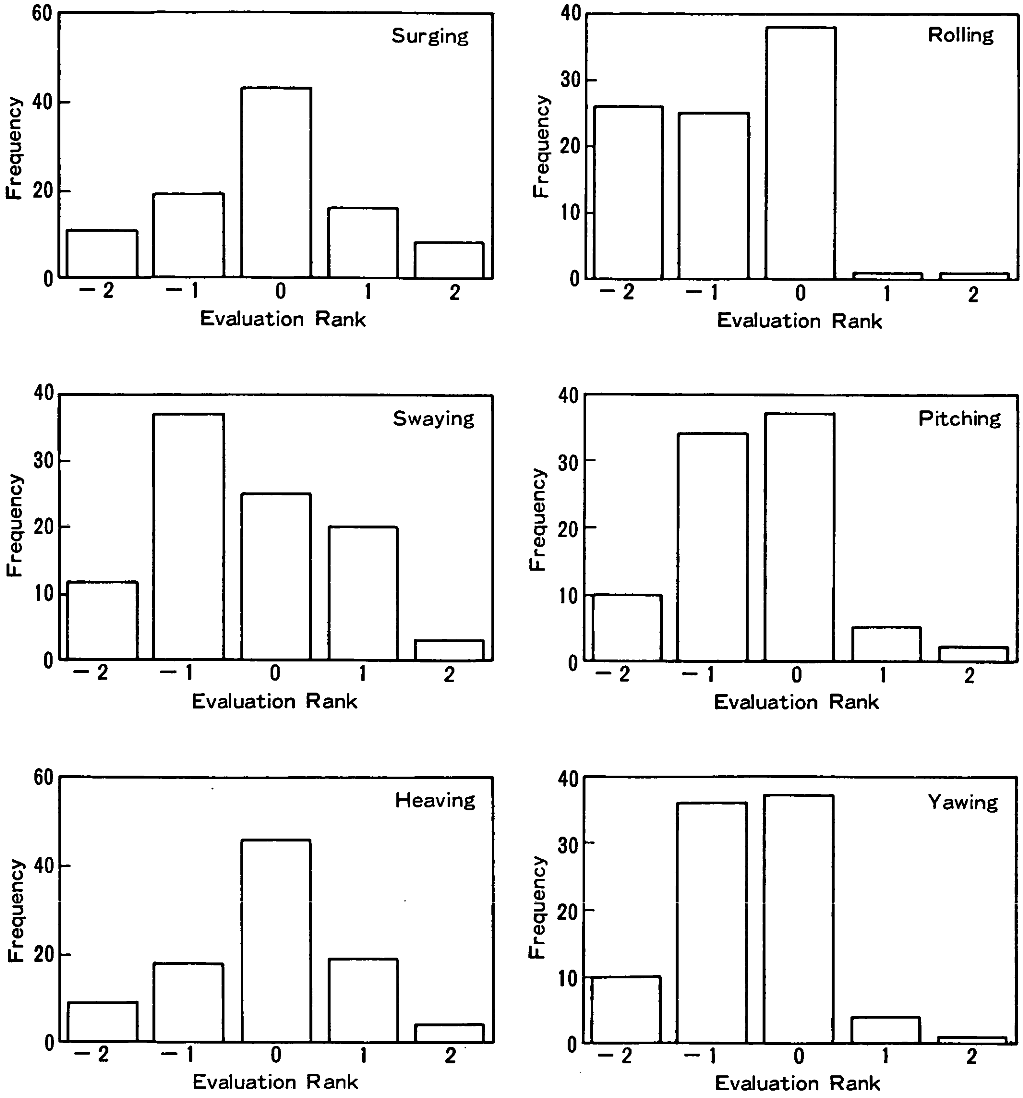

Fig. 26 Frequency Distributions of Opinions of Cargo Handling Operators Corresponding to each Rank (Oil Carriers, Domestic)

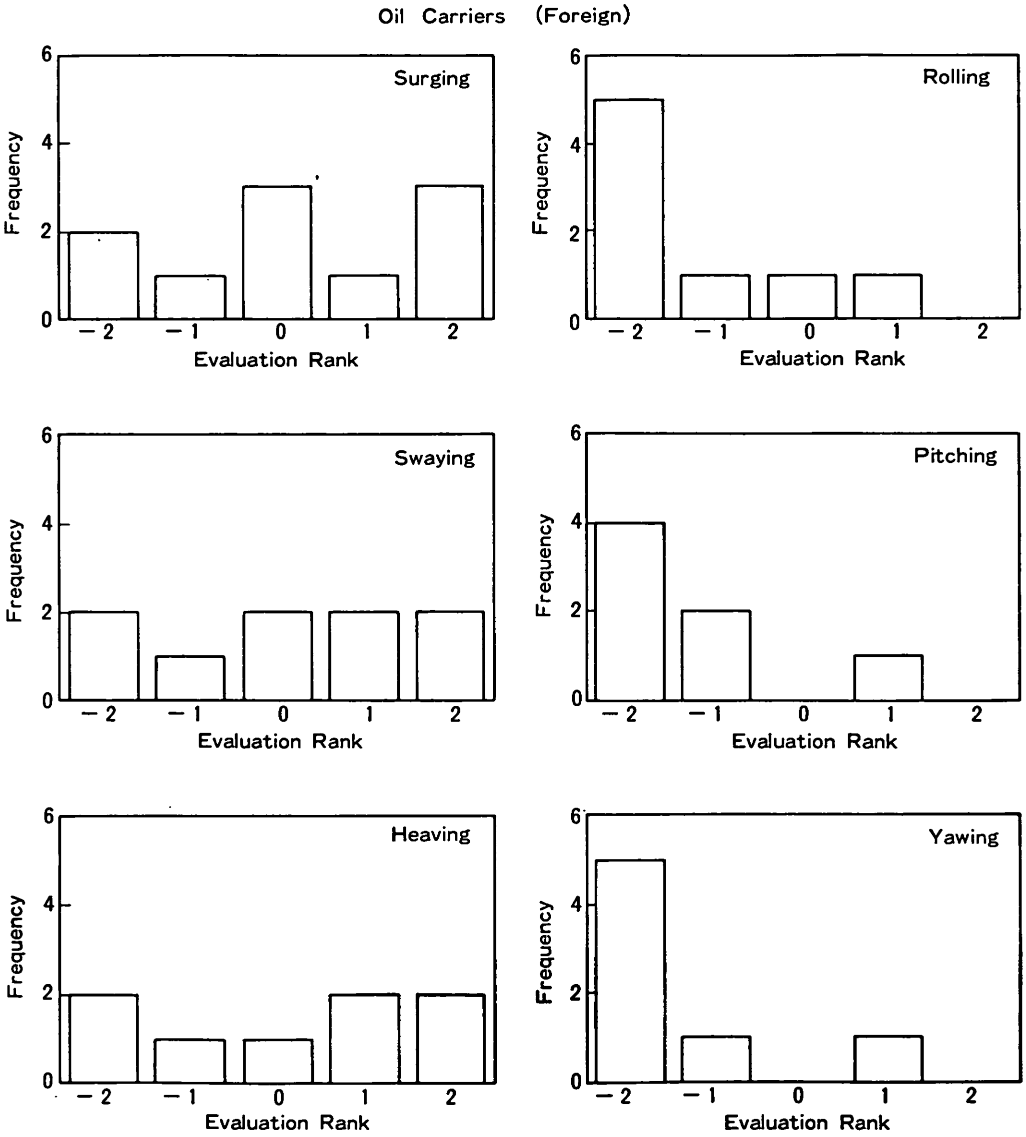

Fig. 27 Frequency Distributions of Opinions of Cargo Handling Operators Corresponding to each Rank (Oil Carriers, Foreign)

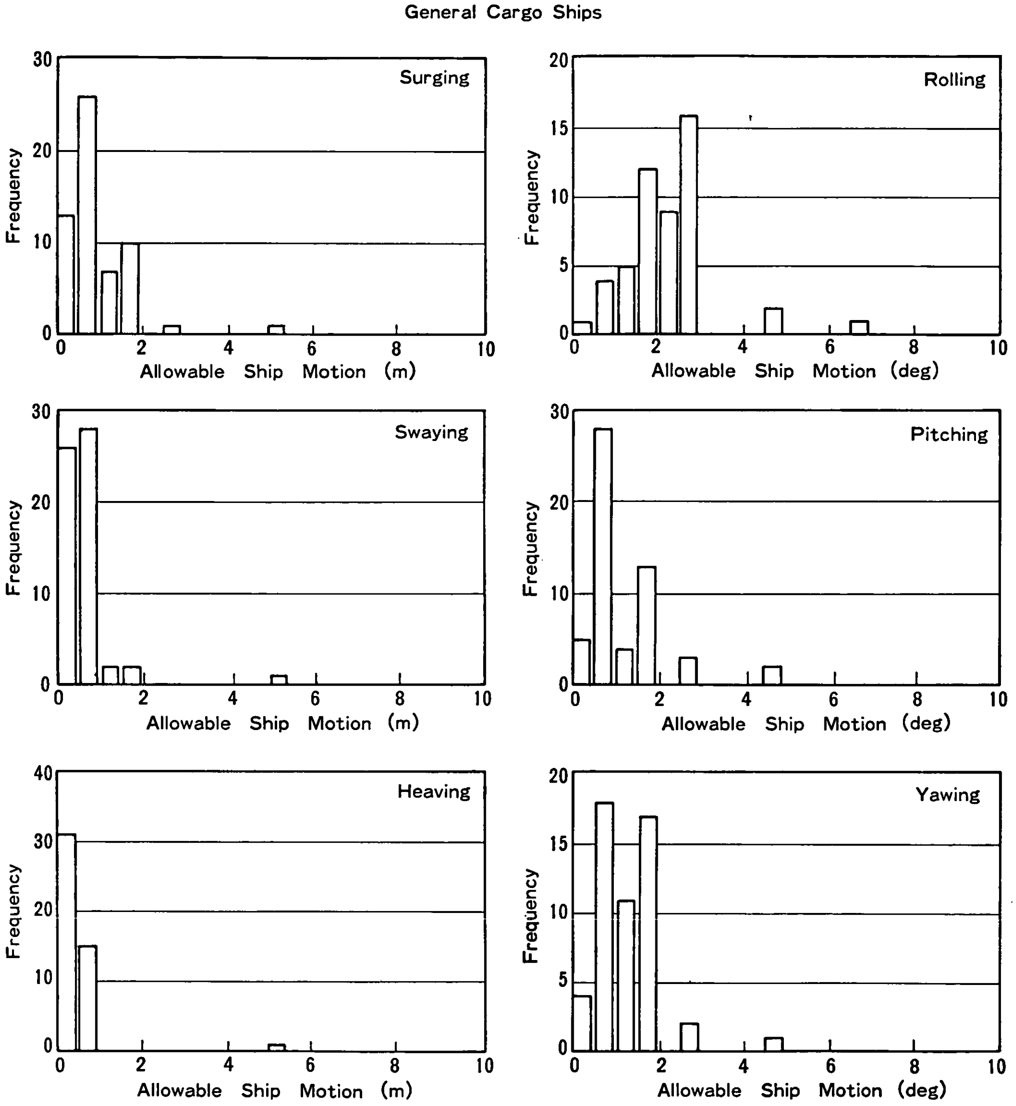

Fig. 28 Frequency Distributions of the Allowable Ship Motions described in the Inquiries (General Cargo Ships)

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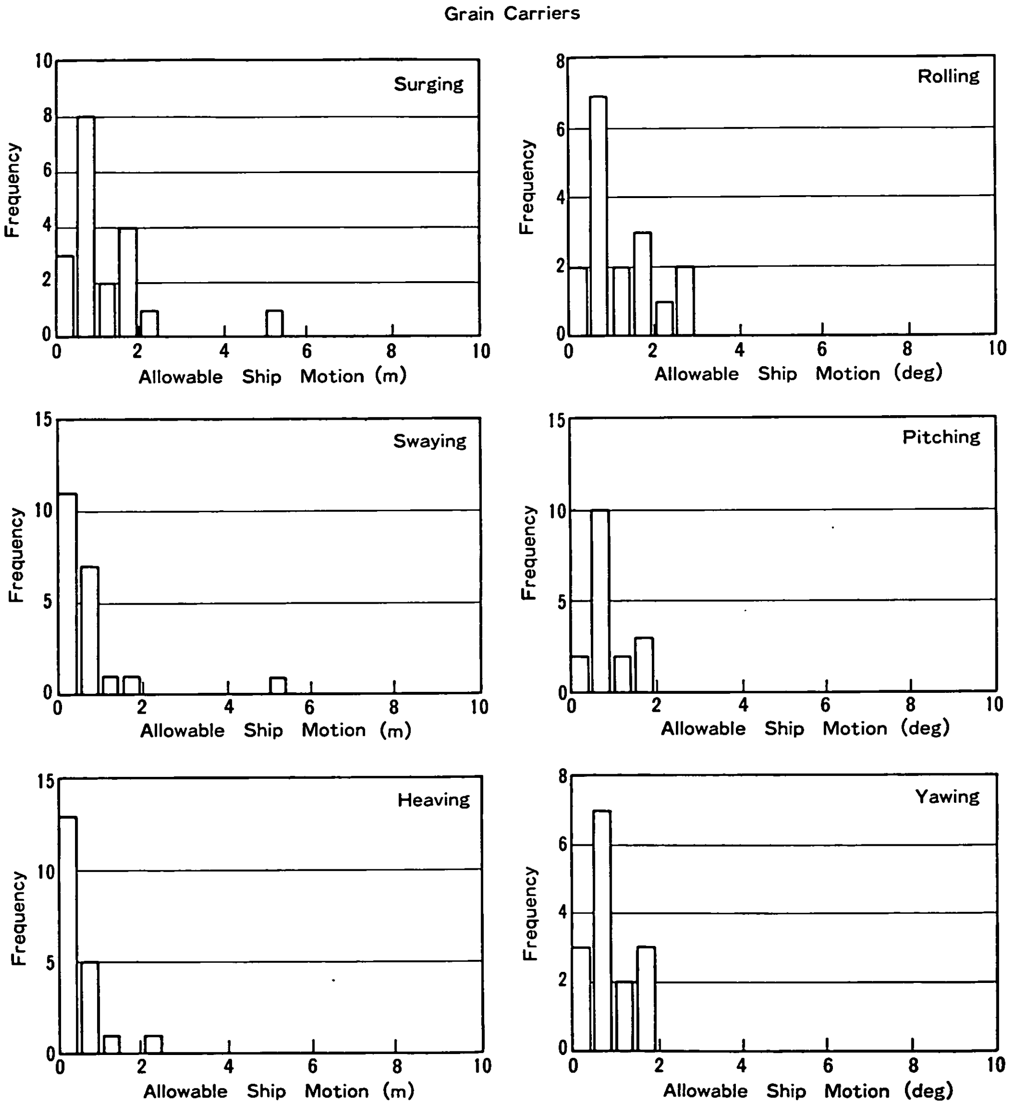

Fig. 29 Frequency Distributions of the Allowable Ship Motions described in the Inquiries (Grain Carriers)

Ore Carriers

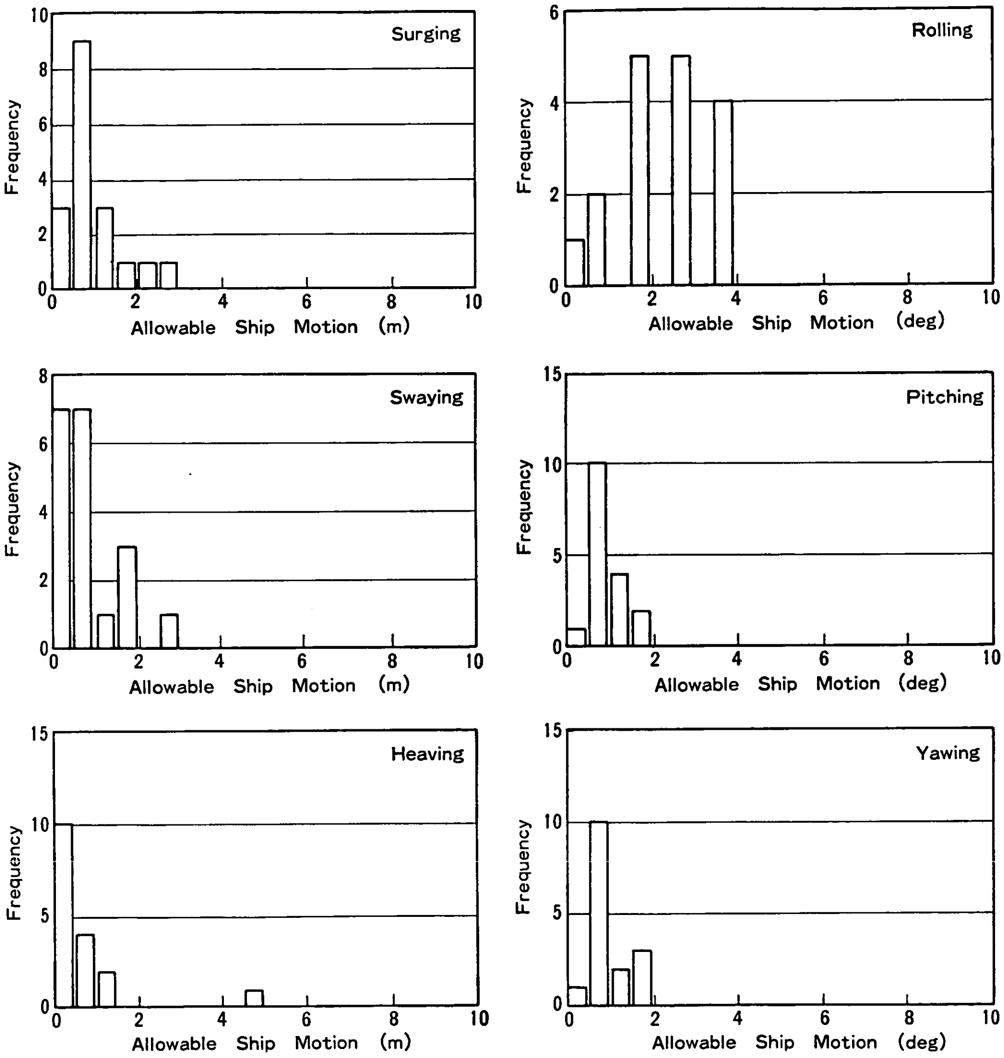

Fig. 30 Frequency Distributions of the Allowable Ship Motions described in the Inquiries (Ore Carriers)

Oil Carriers (Domestic)

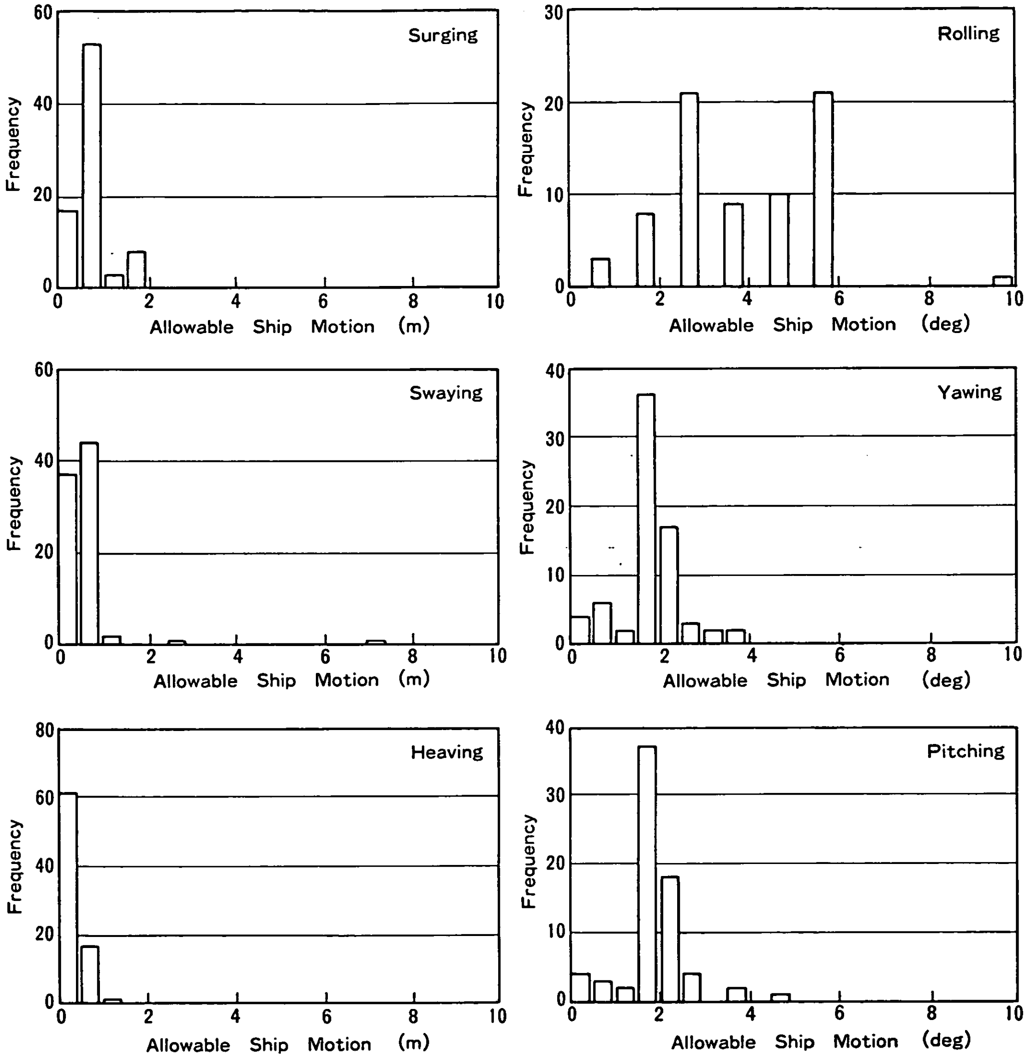

Fig. 31 Frequency Distributions of the Allowable Ship Motions described in the Inquiries (Oil Carriers, Domestic)

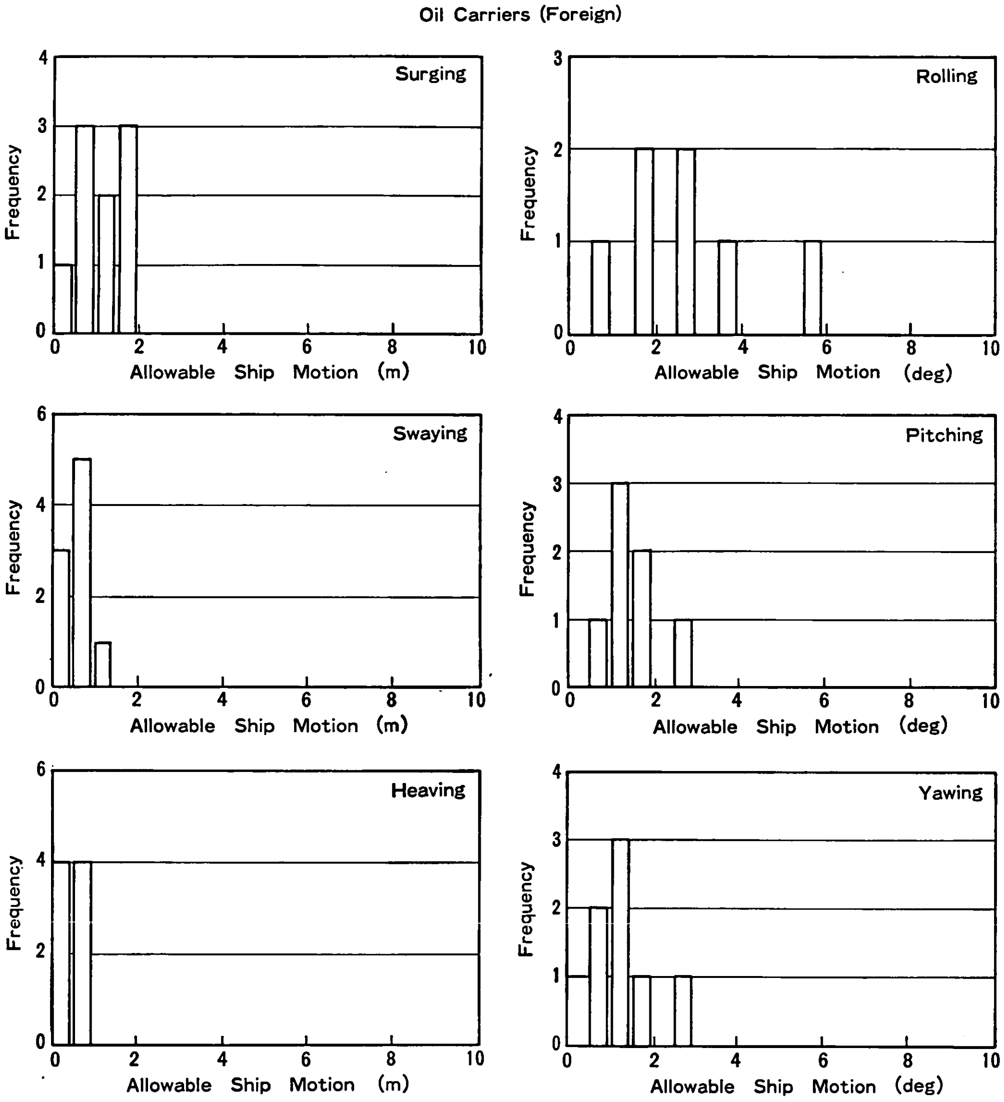

Fig. 32 Frequency Distributions of the Allowable Ship Motions described in the Inquiries (Oil Carriers, Foreign)

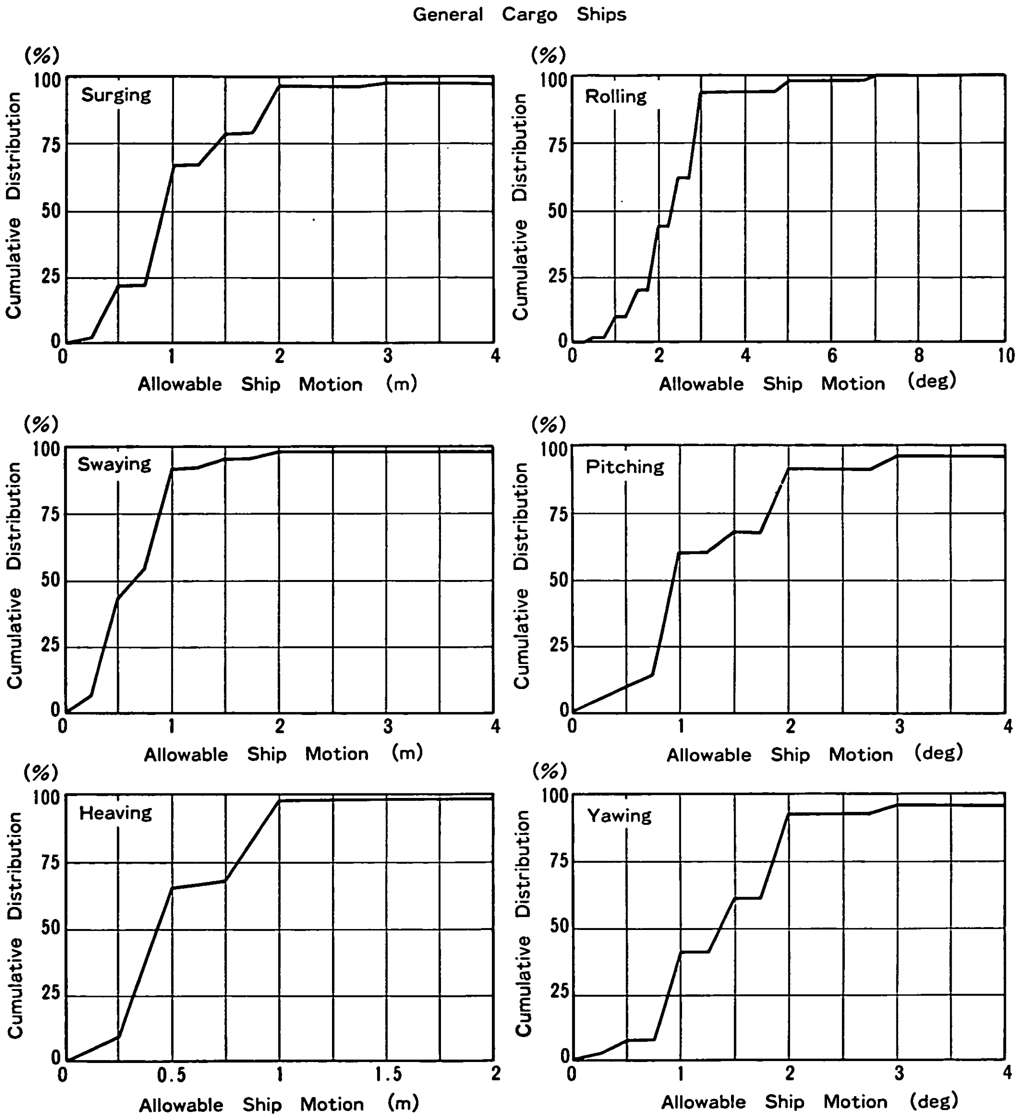

Fig. 33 Cumulative Distributions of the Allowable Ship Motions described in the Inquiries (General Cargo Ships)

Grain Carriers

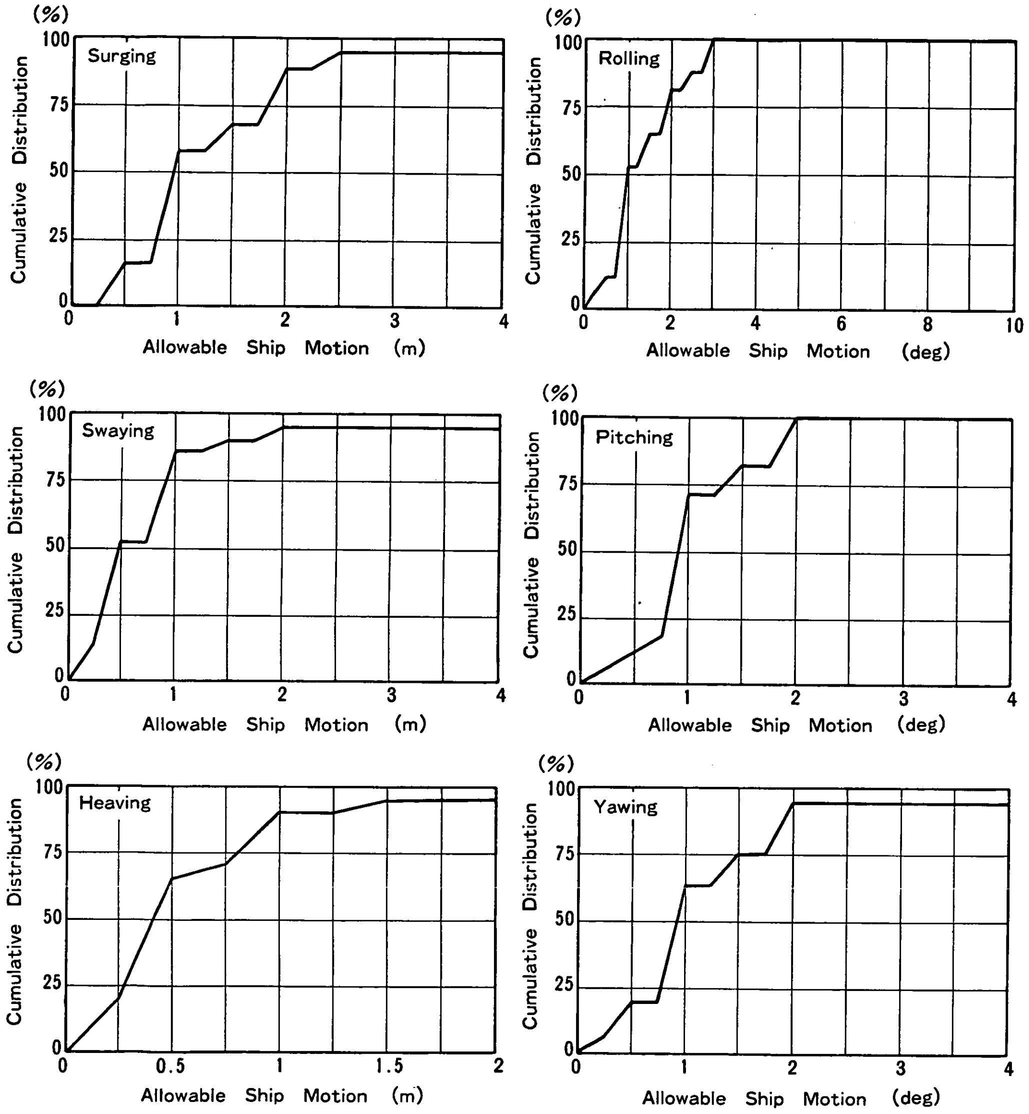

Fig. 34 Cumulative Distributions of the Allowable Ship Motions described in the Inquiries (Grain Carriers)

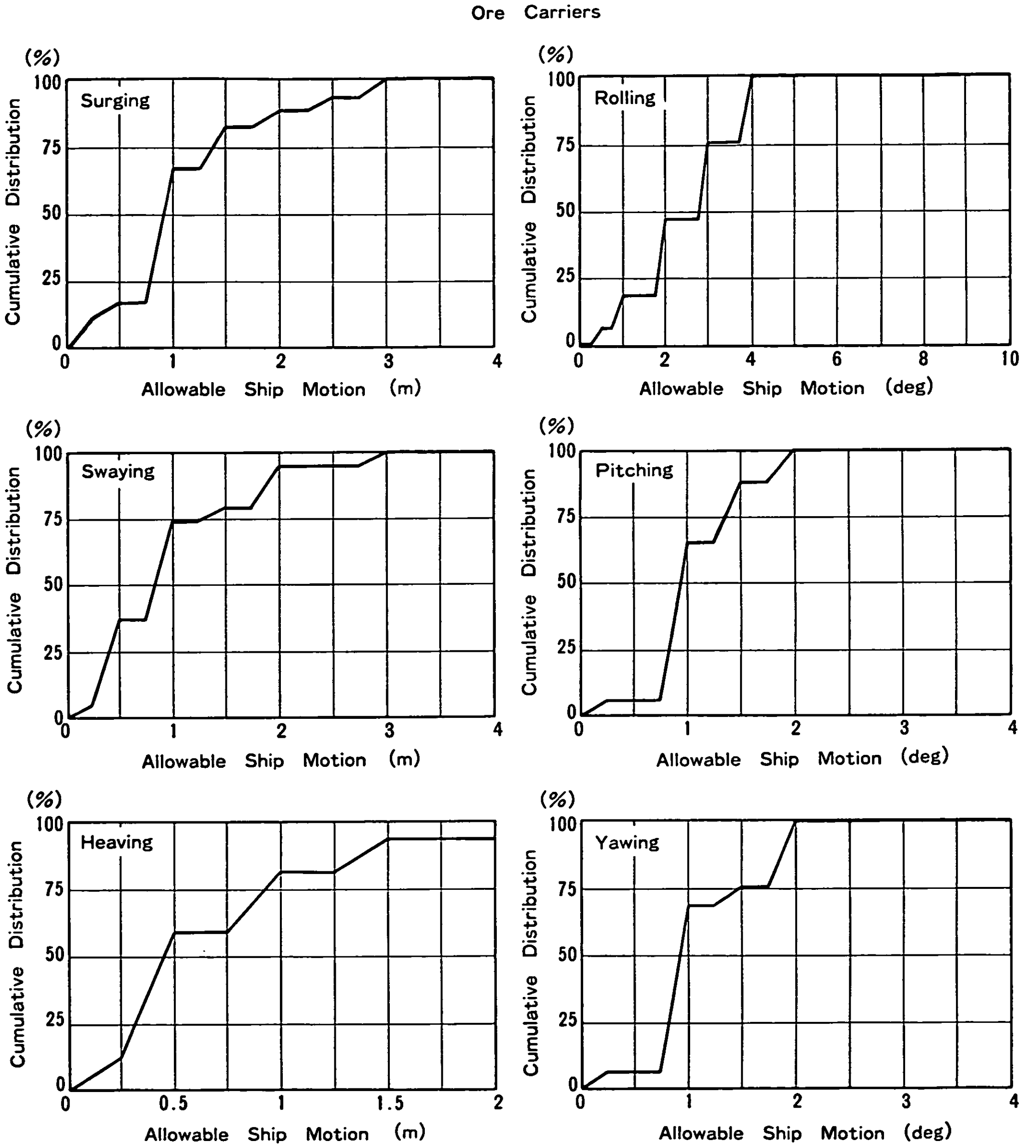

Fig. 35 Cumulative Distributions of the Allowable Ship Motions described in the Inquiries (Ore Carriers)

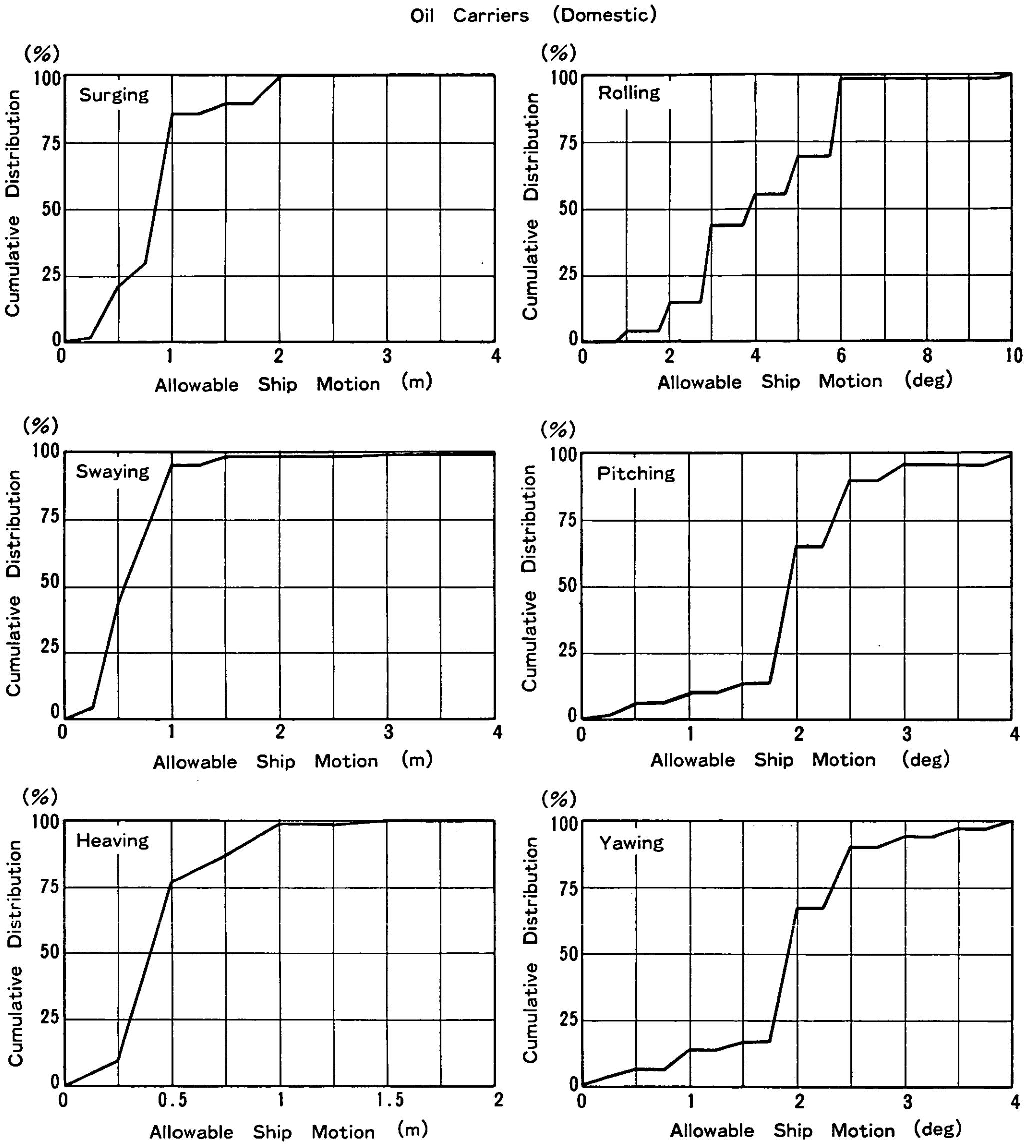

Fig 36 Cumulative Distributions of the Allowable Ship Motions described in the Inquiries (Oil Carriers, Domestic)

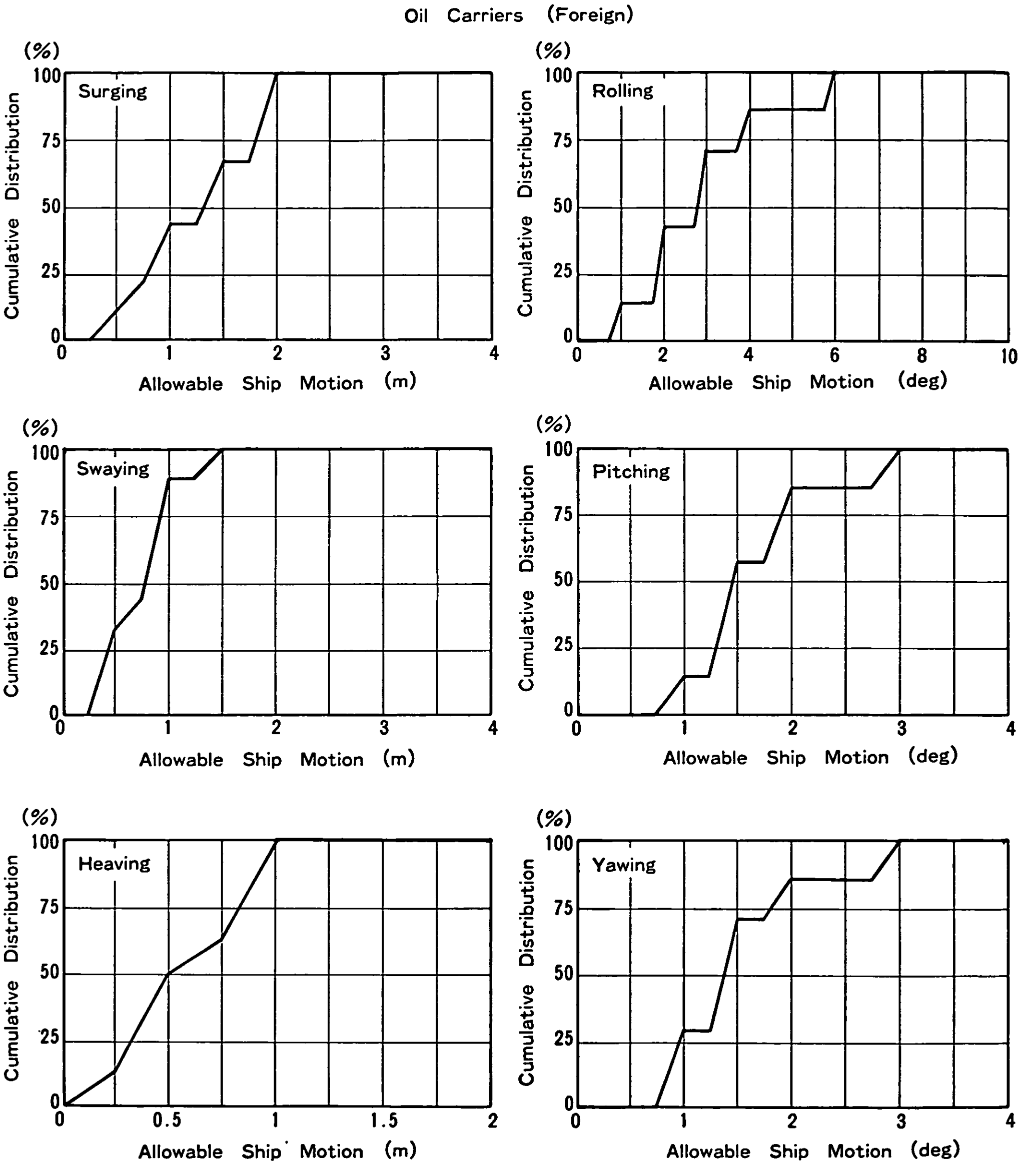

Fig. 37 Cumulative Distributions of the Allowable Ship Motions described in the Inquiries (Oil Carriers, Foreign)

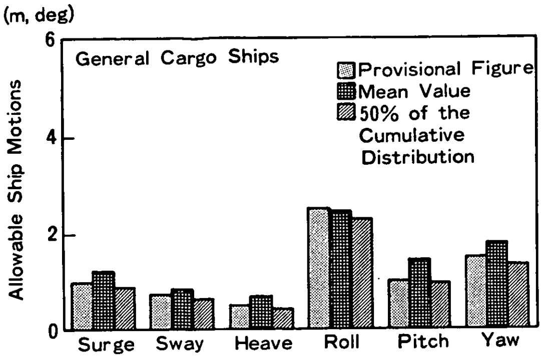

Fig. 38 Comparison of the Provisional Figures with the Mean and 50% of the Cumulative Distributions of data from the Inquiries (General Cargo Ships)

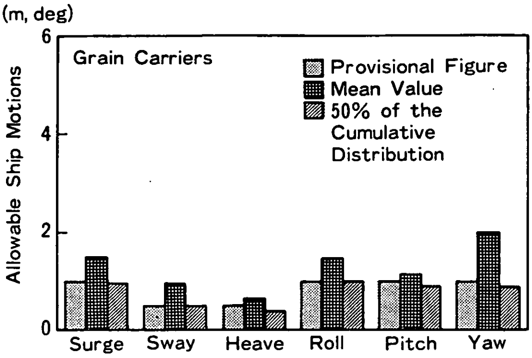

Fig. 39 Comparison of the Provisional Figures with the Mean and 50% of the Cumulative Distributions of data from the Inquiries (Grain Carriers)

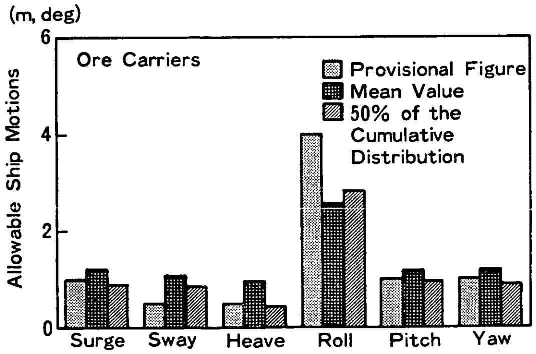

Fig. 40 Comparison of the Provisional Figures with the Mean and 50% of the Cumulative Distributions of data from the Inquiries (Ore Carriers)

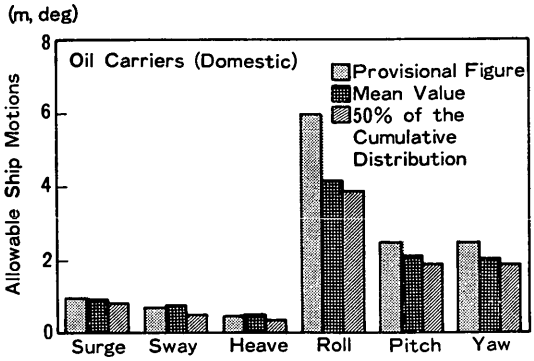

Fig. 41 Comparison of the Provisional Figures with the Mean and 50% of the Cumulative Distributions of data from the Inquiries (Oil Carriers, Domestic)

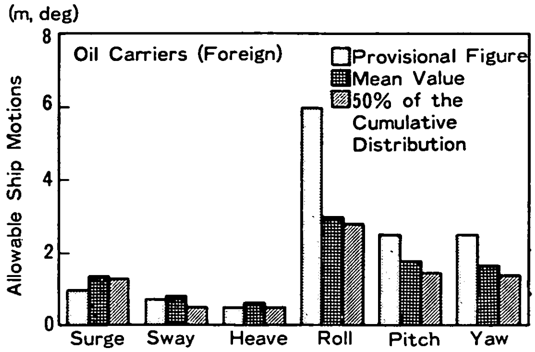

Fig. 42 Comparison of the Provisional Figures with the Mean and 50% of the Cumulative Distributions of data from the Inquiries (Oil Carriers)

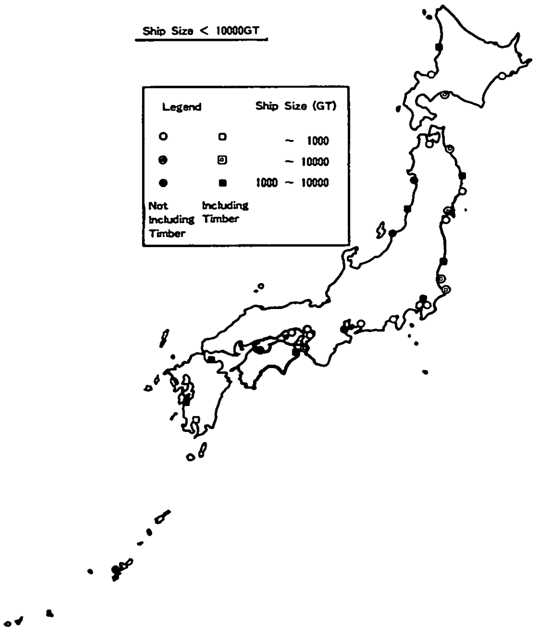

Fig. 43 Location of Ports where Troubles on Cargo Handling due to Ship Motions are described in the Inquiries (Ships under 10,000 GT)

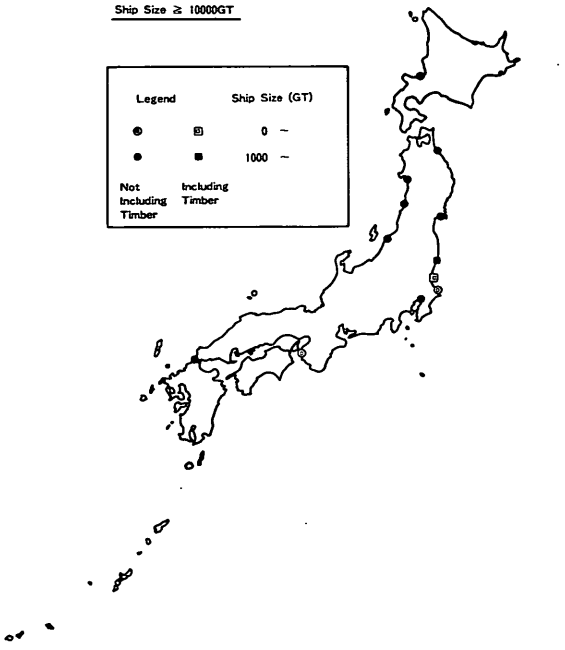

Fig. 44 Location of Ports where Troubles on Cargo Handling due to Ship Motions are described in the Inquiries (Ships over 10,000 GT)

those who have troubles on cargo handling due to ship motions by the action of waves. Then, on the discussion for the revision of the allowable ship motions for cargo handling, these data should be omitted which were obtained from such operators who have no troubles on cargo handling due to ship motions by the action of waves.

Regarding cargo handling equipment, the authors thought there should be some depreciation of the allowable ship motions. At least, we thought there was some difference between those cargo handling methods such as cranes mounted on a berth or on a ship, but the difference was not so obvious among each cargo handling method.

Table 9(a) Summary of the Allowable Ship Motions described in the Inquiries (General Cargo Ships)

Component of Ship Motions	Troubles on Cargo Handling due to Ship Motions by Wave Action	Number of Answers	**Provisional Figures**	Result of the Inquiry			
				Mean	Standard Deviation	Maximum	Minimum
Surging	No.1 Reason	2	**± 1.0m**	1.50	0.50	2.0	1.0
	No.2 Reason	18		1.19	0.53	2.0	0.5
	No.3 Reason	11		1.07	0.57	2.0	0.4
	Sub Total	31		1.17*	0.55	2.0	0.4
	No Troubles	27		1.25	1.03	5.5	0
	Grand Total	58		1.21*	0.81	5.5	0
Swaying	No.1 Reason	2	**+ 0.75m**	1.50	0.50	2.0	1.0
	No.2 Reason	17		0.79	0.27	1.0	0.2
	No.3 Reason	10		0.91	0.48	2.0	0.4
	Sub Total	29		0.88*	0.41	2.0	0.2
	No Troubles	30		0.87	0.95	5.5	0
	Grand Total	59		0.85*	0.72	5.5	0
Heaving	No.1 Reason	2	**± 0.5m**	0.75	0.25	1.0	0.5
	No.2 Reason	15		0.64	0.31	1.0	0.2
	No.3 Reason	8		0.64	0.29	1.0	0.3
	Sub Total	25		0.65*	0.30	1.0	0.2
	No Troubles	22		0.78	1.06	5.5	0
	Grand Total	47		0.71*	0.76	5.5	0
Rolling	No.1 Reason	2	**± 2.5deg**	2.75	0.25	3.0	2.5
	No.2 Reason	14		2.25	0.62	3.0	1.0
	No.3 Reason	8		2.25	0.66	3.0	1.5
	Sub Total	24		2.29*	0.63	3.0	1.0
	No Troubles	26		2.63	1.34	7.0	0.5
	Grand Total	50		2.47*	1.07	7.0	0.5
Pitching	No.1 Reason	2	**± 1.0deg**	1.50	0.50	2.0	1.0
	No.2 Reason	16		1.31	0.70	3.0	0
	No.3 Reason	10		1.48	0.85	3.0	0.5
	Sub Total	28		1.38*	0.75	3.0	0
	No Troubles	27		1.53	1.11	5.0	0
	Grand Total	55		1.45*	0.95	5.0	0
Yawing	No.1 Reason	2	**± 1.5deg**	1.75	0.25	2.0	1.5
	No.2 Reason	17		1.50	0.59	2.0	0
	No.3 Reason	9		1.44	0.72	3.0	0.5
	Sub Total	28		1.50*	0.62	3.0	0
	No Troubles	26		2.08	2.73	15.0	0.5
	Grand Total	54		1.78*	1.97	15.0	0

1) * Figures which are referred in Table 10
2) + of swaying means away from a berth

Table 9(b) Summary of the Allowable Ship Motions described in the Inpuiries (Grain Carriers)

Component of Ship Motions	Troubles on Cargo Handling due to Ship Motions by Wave Action	Number of Answers	Provisional Figures	Result of the Inquiry			
				Mean	Standard Deviation	Maximum	Minimum
Surging	No.1 Reason	0	± 1.0m	—	—	—	—
	No.2 Reason	6		1.75	0.48	2.5	1.0
	No.3 Reason	5		1.10	0.49	2.0	0.5
	Sub Total	11		1.45*	0.58	2.5	0.5
	No Troubles	8		1.56	1.54	5.5	0.5
	Grand Total	19		1.50*	1.10	5.5	0.5
Swaying	No.1 Reason	0	+ 0.75m	—	—	—	—
	No.2 Reason	8		0.88	0.41	1.5	0
	No.3 Reason	4		0.63	0.22	1.0	0
	Sub Total	12		0.80*	0.38	1.5	0
	No Troubles	9		1.19	1.62	5.5	0
	Grand Total	21		0.96*	1.11	5.5	0
Heaving	No.1 Reason	0	± 0.5m	—	—	—	—
	No.2 Reason	8		0.76	0.44	1.5	0
	No.3 Reason	4		0.62	0.22	1.0	0.5
	Sub Total	12		0.71*	0.39	1.5	0
	No Troubles	8		0.56	0.76	2.5	0
	Grand Total	20		0.65*	0.57	2.5	0
Rolling	No.1 Reason	0	± 1.0deg	—	—	—	—
	No.2 Reason	5		1.50	0.44	1.5	0
	No.3 Reason	5		1.80	0.98	3.0	1.0
	Sub Total	10		1.65*	0.77	3.0	0
	No Troubles	7		1.21	0.80	2.5	0
	Grand Total	17		1.47*	0.81	3.0	0
Pitching	No.1 Reason	0	± 1.0deg	—	—	—	—
	No.2 Reason	6		1.28	0.59	3.0	1.0
	No.3 Reason	4		1.00	0	1.0	0
	Sub Total	10		1.17*	0.48	3.0	0
	No Troubles	7		1.07	0.56	2.0	0
	Grand Total	17		1.13*	0.52	2.0	0
Yawing	No.1 Reason	0	± 1.5deg	—	—	—	—
	No.2 Reason	5		1.40	0.58	2.0	0.5
	No.3 Reason	4		1.25	0.43	2.0	1.0
	Sub Total	9		1.33*	0.52	2.0	0.5
	No Troubles	7		2.86	4.98	15.0	0
	Grand Total	16		2.00*	3.40	15.0	0

1) * Figures which are referred in Table 10
2) + of swaying means away from a berth

Table 9(c) Summary of the Allowable Ship Motions described in the Inquiries (Ore Carriers)

Component of Ship Motions	Troubles on Cargo Handling due to Ship Motions by Wave Action	Number of Answers	**Provisional Figures**	Result of the Inquiry			
				Mean	Standard Deviation	Maximum	Minimum
Surging	No.1 Reason	1	± **1.0m**	1.00	—	1.0	1.0
	No.2 Reason	3		1.17	0.47	1.5	0.5
	No.3 Reason	6		1.50	0.76	3.0	1.0
	Sub Total	10		1.35*	0.67	3.0	0.5
	No Troubles	8		1.03	0.72	2.5	0
	Grand Total	18		1.21*	0.71	3.0	0
Swaying	No.1 Reason	1	+ **0.75m**	1.00	—	1.0	1.0
	No.2 Reason	3		1.17	0.62	2.0	0.5
	No.3 Reason	6		1.33	0.90	3.0	0.5
	Sub Total	10		1.25*	0.78	3.0	0.5
	No Troubles	9		0.91	0.53	2.0	0.2
	Grand Total	19		1.09*	0.69	3.0	0
Heaving	No.1 Reason	0	± **0.5m**	—	—	—	—
	No.2 Reason	3		1.00	0.41	1.5	0.5
	No.3 Reason	6		1.42	1.62	5.0	0.5
	Sub Total	9		1.28*	1.36	5.0	0.5
	No Troubles	8		0.59	0.43	1.5	0.1
	Grand Total	17		0.95*	1.09	5.0	0.1
Rolling	No.1 Reason	1	± **4.0deg**	3.00	—	3.0	3.0
	No.2 Reason	2		2.50	1.50	4.0	0
	No.3 Reason	5		3.40	0.49	4.0	3.0
	Sub Total	8		3.13*	0.93	4.0	0
	No Troubles	9		2.06	0.96	4.0	0.5
	Grand Total	17		2.56*	1.08	4.0	0.5
Pitching	No.1 Reason	1	± **1.0deg**	2.00	—	2.0	2.0
	No.2 Reason	3		1.03	0.66	1.5	0.1
	No.3 Reason	5		1.10	0.20	1.5	1.0
	Sub Total	9		1.18*	0.50	2.0	0.1
	No Troubles	8		1.19	0.35	2.0	1.0
	Grand Total	17		1.18*	0.44	2.0	0.1
Yawing	No.1 Reason	1	± **1.0deg**	2.00	—	2.0	2.0
	No.2 Reason	3		1.03	0.66	1.5	0.1
	No.3 Reason	5		1.20	0.40	2.0	1.0
	Sub Total	9		1.23*	0.56	2.0	0.1
	No Troubles	7		1.42	0.35	2.0	1.0
	Grand Total	16		1.19*	0.48	2.0	0.1

1) * Figures which are referred in Table 10
2) + of swaying means away from a berth

Table 9(d) Summary of the Allowable Ship Motions described in the Inquiries (Oil Carriers, Domestic Cargo)

Component of Ship Motions	Troubles on Cargo Handling due to Ship Motions by Wave Action	Number of Answers	**Provisional Figures**	Result of the Inquiry			
				Mean	Standard Deviation	Maximum	Minimum
Surging	No.1 Reason	30	± **1.0m**	1.10	0.41	2.0	0.5
	No.2 Reason	4		1.50	0.05	2.0	1.0
	No.3 Reason	0		—	—	—	—
	Sub Total	34		1.15*	0.44	2.0	0.5
	No Troubles	47		0.85	0.37	2.0	0.15
	Grand Total	81		0.97*	0.43	2.0	0.15
Swaying	No.1 Reason	32	+ **0.75m**	1.11	1.24	7.5	0.3
	No.2 Reason	4		0.79	0.14	1.0	0.6
	No.3 Reason	0		—	—	—	—
	Sub Total	36		1.07*	1.17	7.5	0.3
	No Troubles	49		0.56	0.23	1.0	0.1
	Grand Total	85		0.78*	0.82	7.5	0.1
Heaving	No.1 Reason	30	± **0.5m**	0.52	0.19	1.0	0
	No.2 Reason	5		0.96	0.33	1.5	0.5
	No.3 Reason	0		—	—	—	—
	Sub Total	35		0.58*	0.26	1.5	0
	No Troubles	44		0.46	0.20	1.0	0.1
	Grand Total	79		0.51*	0.24	1.5	0
Rolling	No.1 Reason	26	± **6.0deg**	4.58	1.76	10.0	2.0
	No.2 Reason	4		4.25	1.09	6.0	3.0
	No.3 Reason	0		—	—	—	—
	Sub Total	30		4.54*	1.69	10.0	2.0
	No Troubles	43		3.91	1.64	6.0	1.0
	Grand Total	73		4.16*	1.69	10.0	1.0
Pitching	No.1 Reason	26	± **2.5deg**	2.17	0.39	3.0	1.0
	No.2 Reason	4		3.00	1.22	5.0	2.0
	No.3 Reason	0		—	—	—	—
	Sub Total	30		2.28*	0.64	5.0	1.0
	No Troubles	41		2.02	0.78	4.0	0
	Grand Total	71		2.13*	0.74	5.0	0
Yawing	No.1 Reason	26	± **2.5deg**	2.23	0.46	3.5	1.0
	No.2 Reason	4		2.25	0.43	3.0	2.0
	No 3 Reason	0		—	—	—	—
	Sub Total	30		2.23*	0.46	3.5	1.0
	No Troubles	42		1.95	0.84	4.0	0
	Grand Total	72		2.07*	0.72	4.0	0

1) * Figures which are referred in Table 10
2) + of swaying means away from a berth

Table 9(e) Summary of the Allowable Ship Motions described in the Inquiries (Oil Carriers, Foreign Cargo)

Component of Ship Motions	Troubles on Cargo Handling due to Ship Motions by Wave Action	Number of Answers	**Provisional Figures**	Result of the Inquiry			
				Mean	Standard Deviation	Maximum	Minimum
Surging	No.1 Reason	5	± **1.0m**	1.50	0.45	2.0	1.0
	No.2 Reason	0		—	—	—	—
	No.3 Reason	0		—	—	—	—
	Sub Total	5		1.50*	0.45	2.0	1.0
	No Troubles	4		1.19	0.60	2.0	0.5
	Grand Total	9		1.36*	0.54	2.0	0.5
Swaying	No.1 Reason	5	+ **0.75m**	1.04	0.26	1.5	0.7
	No.2 Reason	0		—	—	—	—
	No.3 Reason	0		—	—	—	—
	Sub Total	5		1.04*	0.26	1.5	0.7
	No Troubles	4		0.58	0.26	1.0	0.3
	Grand Total	9		0.83*	0.35	1.5	0.3
Heaving	No.1 Reason	4	± **0.5m**	0.83	0.20	1.0	0.5
	No.2 Reason	0		—	—	—	—
	No.3 Reason	0		—	—	—	—
	Sub Total	4		0.83*	0.20	1.0	0.5
	No. Troubles	4		0.39	0.19	0.7	0.2
	Grand Total	8		0.60*	0.29	1.0	0.2
Rolling	No.1 Reason	3	± **6.0deg**	3.67	1.70	6.0	2.0
	No.2 Reason	0		—	—	—	—
	No.3 Reason	0		—	—	—	—
	Sub Total	3		3.67*	1.70	6.0	2.0
	No Troubles	4		2.50	1.12	4.0	1.0
	Grand Total	7		3.00*	1.51	6.0	1.0
Pitching	No.1 Reason	3	± **2.5deg**	2.17	0.62	3.0	1.5
	No.2 Reason	0		—	—	—	—
	No.3 Reason	0		—	—	—	—
	Sub Total	3		2.17*	0.62	3.0	1.5
	No Troubles	4		1.50	0.35	2.0	1.0
	Grand Total	7		1.79*	0.59	3.0	1.0
Yawing	No.1 Reason	3	± **2.5deg**	1.83	0.85	3.0	1.0
	No.2 Reason	0		—	—	—	—
	No.3 Reason	0		—	—	—	—
	Sub Total	3		1.83*	0.85	3.0	1.0
	No Troubles	4		1.50	0.35	2.0	1.0
	Grand Total	7		1.64*	0.64	3.0	1.0

1) * Figures which are referred in Table 10
2) + of swaying means away from a berth

4.3 Revision of the Allowable Ship Motions for Cargo Handling

As mentioned in the previous section, the **Provisional Figures** for cargo hadnling should be revised with consulting the results of the inquiry. For this purpose, all the information for the allowable ship motions are summarized in **Table 10**. In this table,

Table 10 Summary of the Invetigation on the Allowable Ship Motions

Type of Ship	Component of Ship Motions	Allowable Ship Motions	Provisional Figures	Mean of the Data in the Inquiries***	Cumulative Distribution of the Data in the Inquiries			Bruun	2nd DPCB
					25%	50%	75%		
General Cargo Ships	Surging	±1.0m	±1.0m	1.21 (1.17)	0.75	0.90	1.40	1.0	0.96
	Swaying	+0.75	+0.75	0.85 (0.88)	0.35	0.65	0.90	0.5	0.74
	Heaving	±0.5	±0.5	0.71 (0.65)	0.30	0.45	0.80	0.5	0.69
	Rolling	±2.5 deg	±2.5 deg	2.47 (2.29)	1.80	2.30	2.85	3.0	4.58
	Pitching	±1.0	±1.0	1.45 (1.38)	0.80	0.95	1.85	—	3.27
	Yawing	±1.5	±1.5	1.78 (1.50)	0.90	1.35	1.85	2.0	2.67
Grain Carriers	Surging	±1.0m	±1.0m	1.50 (1.45)	0.80	0.95	1.80	0.5	
	Swaying	+0.5	+0.5	0.96 (0.80)	0.30	0.50	0.90	0.5	
	Heaving	±0.5	±0.5	0.65 (0.71)	0.30	0.40	0.80	0.5	
	Rolling	±1.0 deg	±1.0 deg	1.47 (1.65)	0.80	1.00	1.90	1.0	
	Pitching	±1.0	±1.0	1.13 (1.17)	0.75	0.90	1.35	—	
	Yawing	±1.0	±1.0	2.00 (1.33)	0.80	0.90	1.50	1.0	
Ore Carriers	Surging	±1.0m	±1.0m	1.21 (1.35)	0.80	0.90	1.40	1.5	
	Swaying	+1.0*	+0.5	1.09 (1.25)	0.55	0.85	1.30	0.5	
	Heaving	±0.5	±0.5	0.95 (1.28)	0.30	0.45	0.90	0.5	
	Rolling	±3.0**deg	±4.0 deg	2.56 (3.13)	1.80	2.80	3.00	4.0	
	Pitching	±1.0	±1.0	1.18 (1.18)	0.85	0.95	1.35	—	
	Yawing	±1.0	±1.0	1.19 (1.23)	0.80	0.90	1.50	2.0	
Oil Carriers (Domestic)	Surging	±1.0m	±1.0m	0.97 (1.15)	0.60	0.85	0.95		1.20
	Swaying	+0.75	+0.75	0.78 (1.07)	0.35	0.55	0.80		1.08
	Heaving	±0.5	±0.5	0.51 (0.58)	0.30	0.40	0.50		0.80
	Rolling	±4.0**deg	±6.0 deg	4.16 (4.54)	2.80	3.85	5.75		6.91
	Pitching	±2.0**	±2.5	2.13 (2.28)	1.80	1.90	2.35		7.67
	Yawing	±2.0**	±2.5	2.07 (2.23)	1.80	1.90	2.35		7.49
Oil Carriers (Foriegn)	Surging	±1.5*m	±1.0m	1.36 (1.50)	0.75	1.30	1.80	2.3	
	Swaying	+0.75	+0.75	0.83 (1.04)	0.45	0.55	0.90	1.0	
	Heaving	±0.5	±0.5	0.60 (0.83)	0.30	0.50	0.80	0.5	
	Rolling	±3.0**deg	±6.0 deg	3.00 (3.67)	1.80	2.80	3.80	4.0	
	Pitching	±1.5**	±2.5	1.79 (2.17)	1.30	1.45	1.90	—	
	Yawing	±1.5**	±2.5	1.64 (1.83)	0.95	1.40	1.80	3.0	

1) Figures with superscript * is larger than the Provisional Figures
2) Figures with superscript ** is smaller than the Provisional Figures
3) Figures correspond to means for each items of Sub Total and Grand Total in Table 9(a) to (e)
4) + of swaying mean away from a berth

the **Provisional Figures,** mean of the data in the inquiries, 25%, 50% and 75% of the cumulative distributions of the data in the inquiries, revised **Allowable Ship Motions** are shown. Additionally, the allowable ship motions proposed by Bruun and the 2nd DPCB are also shown in the table. Regarding values in the column of the mean of the data in the inquiries, the values in parentheses are those for the cases where the occurrences of troubles on cargo handling were described in the inquiries.

The revision was made consulting especially to the 50% of the cumulative distributions of the data in the inquiries. The revised **Allowable Ship Motions** were determined so that down to two places of decimals become a multiple of 0.25 as well as the **Provisional Figures.** The **Provisional Figures** of allowable ship motions for cargo handling for both ore carriers and oil carriers were revised. As shown in the table, figures with superscript * are revised ones.

5. Proposal of the Allowable Ship Motions for Cargo Handling and Practical Use

5.1 The Allowable Ship Motions for Cargo Handling

As above mentioned the **Allowable Ship Motions** for cargo handling are proposed for such ships as general cargo ships, grain carriers, ore carriers and oil carriers. The **Allowable Ship Motions** were determined for each component of ship motions. **Table 11** is the summarize of the **Allowable Ship Motions** proposed in this paper.

Table 11 Allowable Ship Motions

Type of Ship	Component of Ship Motions					
	Surging (m)	Swaying (m)	Heaving (m)	Rolling (deg)	Pitchnig (deg)	Yawing (deg)
General Cargo Ships	± 1.0	+ 0.75	± 0.5	± 2.5	± 1.0	± 1.5
Grain Carriers	± 1.0	+ 0.5	± 0.5	± 1.0	± 1.0	± 1.0
Ore Carriers	± 1.0	+ 1.0	± 0.5	± 3.0	± 1.0	± 1.0
Oil Carriers (D)	± 1.0	+ 0.75	± 0.5	± 4.0	± 2.0	± 2.0
Oil Carriers (F)	± 1.0	+ 0.75	± 0.5	± 3.0	± 1.5	± 1.5

1) D : Domestic F : Foreign
2) + of swaying means away from a berth

5.2 Practical Use

One of the authors has already presented an initial attempt to establish an alternative method for calculating the wharf operation efficiency. However, for the practical use, procedures shown in Fig. 1 must become more simplified. Because, comparing with the current method for the calculation of the wharf operation efficiency, the proposed attempt method is so complicated that it must be needed to consult ship motions at each berth for various types and sizes of ships subjected to various wave conditions. It is obvious that the procedure is simple and take less load for calculation if the criteria were defined in terms of the wave height and wave period for various types and sizes of ships. A quite lot of computation must be executed for this purpose. However, the data base of ship motions must be established. The data base of the ship motions will be utilized not only for calculation of the wharf operation efficiency but also for design of the mooring facilities where ship motions affect the determination of either the fendering systems or the dimension of the mooring facilities 12).

6. Conclusion

In this paper, ship motions were discussed as the harbour calmness index, and, the **Allowable Ship Motions** for cargo handling were proposed for such ships as general cargo ships, grain carriers, ore carriers and oil carriers. The results of this paper should contribute port planning and construction in calculating the wharf operation efficiency and determination of layout of breakwaters and wharves and so on.

(*Received on Sept. 30, 1988*)

Acknowledgment

The authors express their sincere appreciation to the Director and members of the Planning Division, Bureau of Ports and Habours, for cooperation for the performance of the inquiry, and cargo handling companies, oil companies, oil terminals and persons concerning the inquiry, and the First and the Second District Port Construction Bureaus for quotation of the results of investigations on the allowable ship motions from the internal reports though they were not published.

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March, 1988

Re. Investigation on the Allowable Ship Motions for Cargo Handling in a Port

(Request)

Dear Sirs:

Bureau of the Ports and Harbours, Ministry of Transport is Proceeding the work of the revision of the Technical Standard for Port and Harbour Facilities in Japan. The investigation on the critical condition for cargo handling in a port has been carried out in 1986 fiscal year, however, it was decided to carry on the supplemental investigation on the allowable ship motions for cargo handling in this year.

The purpose of this investigation is to get the opinion on the Allowable Ship Motions which has been obtained through the studies in the Port and Harbour Research Institute. The results of the investigation will be utilized for planning and construction of a port.

It is the appreciation that you could cooperate the investigation with a full understanding the purpose of the investigation.

With good regard

Director
Planning Division
Bureau of Ports and Harbours
Ministry of Transport

Note for Filling in

(1) Some questions request to fill in while the others request to select matters concerns listed in a form.
(2) Use code number tabulated to fill in for such questions as Q2, Q4 and Q5.
(3) Send back the inquiry form to the Port and Harbour Research Institute before 28th of April. Use the envelope enclosed.
(4) If you need more information, do not hesitate to contact us.

Shigeru Ueda
Chief of the Offshore Structures Laboratory
Structures Division
Port and Harbour Research Institute
Ministry of Transport

Address: 3-1-1, Nagase, Yokosuka, Kanagawa, Japan
Phone: 0468-41-5410 Ext. 305

Investigation on the Allowable Ship Motions for Cargo Handling

Q1. Fill in the name of the port and the prefecture concerns.

Prefecture		Port	

Q2. Regarding to cargo handling, fill in the type and the size of a ship, kind of goods handled and cargo handling method. Use the code numbers tabulated in the right hand side on this page. Plural filling is allowed. Do not fill in the form anything if the type of a ship does not concern to your company.

Type of a Ship	Ship Size	Kind of Goods	Equipment for Cargo Handling
1 : General Cargo Ships			
2 : Grain Carriers			
3 : Ore Carriers			
4 : Container Ships			
5 : Oil Carriers (Crude Oil, LPG, LNG)			
6 : Car Carriers			
7 : Ferry Boats			
8 : Others (Passenger Boats, Fishing Boats, Mixed Boats, Working Crafts, etc.)			
Instance : General Cargo Ships	2, 3	13, 14	6, 7

Q3. If you have such troubles on cargo handling due to the environmental conditions such as interruption and or suspension, fill in the causes, order and the frequency of the occurrence. Approximate value is allowed. Use the code numbers of causes tabulated below.

Order	Causes for suspension of cargo handling	Frequency of suspension of cargo handling	Number of ships calling and executed cargo handling
1			
2			
3			
4			
5			

Code Number of Causes of Troubles on Cargo Handling
1 : Waves
2 : Strong Wind
3 : Rain and/or Snow
4 : Fog
5 : The Others (Please fill in)

Code Number (Use for Q2, Q4, Q5)

Code Number of the Size of a Ship

Code Number	Ship Size
1	– 999 GT
2	1,000 – 2,999 GT
3	3,000 – 9,999 GT
4	10,000 – 29,999 GT
5	30,000 – 49,999 GT
6	50,000 – 99,999 GT
7	100,000 –

Code Number of the Kind of Goods Handled

Code Number	Kind of Goods
1	Agricultural Products
2	Aquatic Products
3	Forest Products
4	Coal
5	Ore and Rock Salt
6	Gravel, Sand, Rock
7	Crude Oil
8	Metals
9	Machines
10	Ceramics
11	Petroleum Industrial Products
12	Chemical Industrial Products
13	Light Industrial Products
14	Miscellaneous Industrial Products
15	Others

Code Number of the Equipment for Cargo Handling

Code Number	Equipment
1	Gantry Crane (on a Wharf)
2	Grab Bucket
3	Shooter
4	Belt Conveyer
5	Chikusan Joint (Pipe)
6	Derrick installed on a Ship
7	Crane installed on a Ship
8	Gangway at Bow and Stern
9	Pneumatic unloader
10	Others

Q4. Who replied the occurrences of troubles on cargo handling due to environmental conditions in Q3, fill in the form below. If there is no trouble due to wave conditions, skip to Q5.

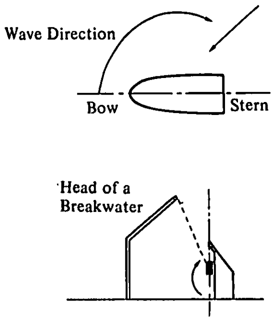
Fill in such items as name of a berth, wave height in front of a berth, wind speed, the type and the size of a ship, kind of goods handled, method of cargo handling.

a. due to wind generated waves (short period waves) (use the code numbers tabulated in p.1 of this form)

Berth	Wave Height	Wave Period	Wave Direction	Mean Wind Speed	Type of a Ship	Size of a Ship	Kind of Goods	Equipment of Handling
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				
	C. cm	C. sec.	C. °	C. m/s				

b. due to swell (long period waves) (use the code numbers tabulated in p.1 of this form)

Berth	Wave Height	Wave Period	Wave Direction	Type of a Ship	Size of a Ship	Kind of Goods	Equipment of Handling
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				
	C. cm	C. sec.	C. °				



Definition of the Wave Direction Acting to a Moored Ship

Wave direction is defined so as to measure clockwise from the bow. If the wave direction is not clearly defined at the berth concerned, make the angle between the bow and stern axis and the straight line links the head of the breakwater and the center of a ship.

Q5. Provisional Figures of the Allowable Ship Motions for cargo handling was established according to analyses of data of interruption and/or suspension of cargo handling at several ports in Japan. Fill in the form with the comparison between the **Provisional Figures** and the state of cargo handling at the berth concerned. Questions are made for each type of a ship (4 types which are general cargo ships, grain carriers, oil carriers, ore carriers). If a relevant ship is not present, check applicable box, and skip to the next. In the column of the opinion of yours, select and put circle a relevant among the code of opinions. Excluding the reply 1 selecting "0", fill in the form the allowable ship motions adopted in your company. Refer an instance below.

Type of a Ship	Ship Motions						Ships concerned in Analyses		
	Surging (m)	Swaying (m)	Heaving (m)	Rolling (deg)	Pitching (deg)	Yawing (deg)	Ship Size	Type of Mooring Facilities	Equipment for Cargo Handling
General Cargo Ships	±1.0	+0.75	±0.5	±2.5	±1.0	±1.5	5000 ~ 25000 GT	Fixed Type Berth such as Piers	Crane on a Wharf
Grain Carriers	±1.0	+0.5	±0.5	±1.0	±1.0	±1.0	10000 ~ 40000 GT	Fixed Type Berth such as Piers	Pnuematic Unloader
Oil Carriers	±1.0	+0.75	±0.5	±6.0	±2.5	±2.5	500 ~ 4000 GT	Fixed Type Berth such as Piers	Chikusan Joint
Ore Carriers	±1.0	+0.5	±0.5	±4.0	±1.0	±1.0	5000 ~ 70000 GT	Fixed Type Berth such as Piers	Grab

Note: Regard to swaying, the figure corresponds to the motion apart from the berth, while regarding to the others, figures correspond to amplitude of motions.

Instance: Heaving ±0.5 means ship motions in range from +0.5m to −0.5m, that is the double amplitude is 1.0m.

Instance of Filling Up

(1) General Cargo Ship

Presence of the relevant ship, check appropriate box. yes ☐ no ☐

If checked no, skip to the next ship.

Fill in the typical size of a ship, kind of goods handled, equipment for cargo handling by use of the code number in p. 1.

Size of a Ship	4	Kind of Goods Handled	13	Equipment for Cargo Handling	7

Ship Motions	Provisional Figures	Your Opinion					Allowable Ship Motions adopted in your Company
		−2	−1	0	+1	+2	
Surging	±1.0 m					[✓]	±2.0 m
Swaying	+0.75 m	[✓]					±0.5 m
Heaving	±0.5 m			[✓]			± m
Rolling	±2.5°				[✓]		±3°
Pitching	±1°					[✓]	±2°
Yawing	±1.5°				[✓]		±2°
		put circle to appropriate code in right hand size					fill in figures

Code for the opinion

+2: the allowable ship motions at the concerned port or the company is rather as large as and over 1.5 times of the **Provisional Figures**

+1: the allowable ship motions at the concerned port or the company is a little larger than the **Provisional Figures**

0: the allowable ship motions at the concerned port or the company is equivalent to the **Provisional Figures**

−1: the allowable ship motions at the concerned port or the company is a little smaller than the **Provisional Figures**

−2: the allowable ship motions at the concerned port or the company is rather as large as and under 0.7 times of the **Provisional Figures**

Note: Component of ship motions

Surging : longitudinal motion

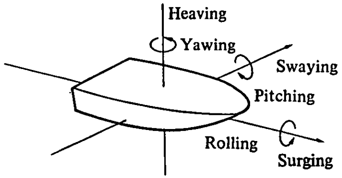
Swaying : transverse motion

Heaving : vertical motion

Rolling : rotating motion around longitudinal axis

Pitching : rotating motion around transverse axis

Yawing : rotating motion around vertical axis



(1) General Cargo Ship

Presence of the relevant ship, check appropriate box. yes ☐ no ☐

If checked no, skip to the next ship.

Fill in the typical size of ship, kind of goods handled, equipment for cargo handling by use of the code number in p. 1.

Size of a Ship		Kind of Goods Handled		Equipment for Cargo Handling	

Ship Motions	Provisional Figures	Your Opinion -2 -1 0 +1 +2	Allowable Ship Motions adopted in your Company	
Surging	±1.0 m	—+—+—+—+—+—	±	m
Swaying	+0.75 m	—+—+—+—+—+—	±	m
Heaving	±0.5 m	—+—+—+—+—+—	±	m
Rolling	±2.5°	—+—+—+—+—+—	±	°
Pitching	±1°	—+—+—+—+—+—	±	°
Yawing	±1.5°	—+—+—+—+—+—	±	°
		put circle to appropriate code in right hand size of p. 3.	fill in figures	

(2) Grain Carriers

Presence of the relevant ship, check appropriate box. yes ☐ no ☐

If checked no, skip to the next ship.

Fill in the typical size of ship, kind of goods handled, equipment for cargo handling by use of the code number in p. 1.

Size of a Ship		Kind of Goods Handled		Equipment for Cargo Handling	

Ship Motions	Provisional Figures	Your Opinion -2 -1 0 +1 +2	Allowable Ship Motions Adopted in your Company	
Surging	±1.0 m	—+—+—+—+—+—	±	m
Swaying	+0.5 m	—+—+—+—+—+—	±	m
Heaving	±0.5 m	—+—+—+—+—+—	±	m
Rolling	±1°	—+—+—+—+—+—	±	°
Pitching	±1°	—+—+—+—+—+—	±	°
Yawing	±1°	—+—+—+—+—+—	±	°
		put circle to appropriate code in right hand size of p. 3.	fill in figures	

(3) Oil Carriers

Presence of the relevant ship, check appropriate box. yes ☐ no ☐

If checked no, skip to the next ship.

Fill in the typical size of ship, kind of goods handled, equipment for cargo handling by use of the code number in p. 1.

Size of a Ship		Kind of Goods Handled		Equipment for Cargo Handling	

Ship Motions	Provisional Figures	Your Opinion -2 -1 0 +1 +2	Allowable Ship Motions adopted in your Company	
Surging	±1.0 m	—+—+—+—+—+—	±	m
Swaying	+0.75 m	—+—+—+—+—+—	±	m
Heaving	±0.5 m	—+—+—+—+—+—	±	m
Rolling	±6°	—+—+—+—+—+—	±	°
Pitching	±2.5°	—+—+—+—+—+—	±	°
Yawing	±2.5°	—+—+—+—+—+—	±	°
		put circle to appropriate code in right hand size of p. 3.	fill in figures	

(4) Ore Carries

Presence of the relevant ship, check appropriate box. yes ☐ no ☐

If checked no, skip to the next ship.

Fill in the typical size of ship, kind of goods handled, equipment for cargo handling by use of the code number in p. 1.

Size of a Ship		Kind of Goods Handled		Equipment for Cargo Handling	

Ship Motions	Provisional Figures	Your Opinion -2 -1 0 +1 +2	Allowable Ship Motions Adopted in your Company	
Surging	±1.0 m	—+—+—+—+—+—	±	m
Swaying	+0.5 m	—+—+—+—+—+—	±	m
Heaving	±0.5 m	—+—+—+—+—+—	±	m
Rolling	±4°	—+—+—+—+—+—	±	°
Pitching	±1°	—+—+—+—+—+—	±	°
Yawing	±1°	—+—+—+—+—+—	±	°
		put circle to appropriate code in right hand size of p. 3.	fill in figures	

Q.6 Fill in Name of your Company, name and affiliation of whom responsible to this inquiry.

Company		Affiliation		Name	

Thank you very much for your cooperation