Analysis of the Causes of Ship Stress Due to Incorrect Cargo Placement on the MV. Kanal Mas

Defnico Eka Arvenda Garfiosa[1*], Anak Agung Ngurah Ade Dwi Putra Yuda[2], Jaka Septian Kustanto[3], Fazri Hermanto[4]

[1,2,3,4]Program Studi Teknologi Rekayasa Operasi Kapal, Politeknik Pelayaran Surabaya, Indonesia
[*]Corresponding author:
E-mail:defekarag74@gmail.com

Abstract.
This research is motivated by the increasing risk of ship stress on container ships due to imbalanced cargo distribution that can trigger hogging and sagging conditions. The purpose of this study is to analyze the causes of ship stress due to incorrect cargo placement on board the MV. Kanal Mas and to identify efforts to optimize cargo distribution. This study uses a descriptive qualitative approach. The study population includes all officers and crew, with samples selected using purposive sampling consisting of the Captain, First Officer, Second Officer, Third Officer, and related crew. The research instrument is the researcher himself with data collection techniques through observation, interviews, and documentation. Data analysis uses the interactive model of Miles, Huberman, and Saldaña which includes data reduction, data presentation, and conclusion drawing. The results of the study indicate that ship stress is mainly caused by port operational limitations, out-of-sequence conditions, and uneven cargo distribution. The conclusion of the study shows that ship stress on the MV. Kanal Mas is more influenced by operational factors than technical errors in the preparation of the bay plan, so that it is necessary to strengthen coordination and continuous supervision of cargo distribution.

Keywords: *Ballast Adjustment, Container Stowage, Ship Stress, Stability and Stowage Plan.*

I. INTRODUCTION

Maritime transportation plays a crucial role in global trade, as the majority of international goods distribution still relies on container ships. In recent years, increased global logistics activity has driven the use of large-capacity container ships with high operational complexity. This situation has made ship structural safety increasingly important, particularly regarding load distribution, which can affect ship stability and strength (Bilican et al., 2024; Silva-Campillo & Pérez-Arribas, 2022).

In Indonesia, sea transportation is the backbone of inter-island goods distribution due to the archipelagic nature of the region. However, increased shipping activity also increases the risk of ship stress due to unbalanced cargo distribution. Conditions such as sagging and hogging can arise when cargo placement is not planned, potentially compromising the safety and structural integrity of the ship (Lang et al., 2021).

Previous research has shown that cargo distribution significantly influences the structural stress of container ships. Silva-Campillo and Pérez-Arribas (2022) explain that the configuration of cargo and ship structure can increase the ship's longitudinal stress. Furthermore, Bilican et al. (2024) emphasize the importance of a proper stowage plan to maintain ship balance and reduce the risk of structural damage during navigation.

However, most previous research has focused on numerical simulations and the technical aspects of ship structures. Studies of operational factors in the field, such as cargo misplacement by ship operators and the actual implementation of stowage plans, are still limited. Yet, suboptimal operational conditions can be a major cause of ship stress in container ships.

Based on these conditions, there is a research gap regarding empirical analysis of the causes of ship stress due to cargo misplacement during container ship operations. Therefore, this research focuses on analyzing the causes of ship stress on board the MV Kanal Mas and efforts to optimize cargo placement to reduce the risk of sagging and hogging during shipping.

This research aims to identify factors causing ship stress, analyze preventive measures, and evaluate the optimization of cargo placement on container ships. The research's novelty lies in its empirical approach, using direct observation during sea practice, thus providing a concrete picture of the relationship between cargo placement and ship structural safety. Practically, this research is expected to provide input for ship officers and shipping companies in improving ship operational safety and efficiency.

II. METHODS

This study uses a qualitative approach with descriptive methods to analyze the causes of ship stress due to incorrect cargo placement on the MV. Kanal Mas. This approach was chosen because it can describe ship operational phenomena in depth based on real-world conditions. According to (Creswell and Creswell, 2023) (Sugiyono,2022), qualitative research aims to comprehensively understand social phenomena through direct observation and interpretation of field data. The research was conducted during approximately one year of marine practice (Prala) activities on the MV. Kanal Mas.

The study population included all crew and officers involved in cargo management and navigation activities. The sample was determined using a purposive sampling technique, selecting informants deemed knowledgeable about cargo placement and ship stability control, such as the captain, first officer, second officer, third officer, and several crew members. Explain that purposive sampling is used to obtain in-depth and relevant data in line with the research focus (Emzir,2021) (Sudaryono (2021).

The primary research instrument was the researcher herself, using data collection techniques such as observation, in-depth interviews, and documentation. Observations were conducted during the loading and shipping processes to assess cargo distribution and potential ship stress. Interviews were conducted with ship officers and crew, while documentation was used to supplement the data, including stowage plans, cargo manifests, and shipping reports. Stated that this combination of techniques can increase data validity through triangulation.

The data analysis technique used the interactive model of Miles, Huberman, and Saldaña, which includes data collection, data reduction, data presentation, and conclusion drawing. The obtained data was selected and focused on the factors causing ship stress, then presented narratively to facilitate analysis of the relationships between phenomena. This technique was chosen because it can systematically explain the relationship between load distribution and ship structural conditions (Miles et al., 2020).

The research procedure involved several stages: problem identification, literature review, field data collection, data analysis, and conclusion drawing. All stages were conducted systematically during the marine practice activities on the MV Kanal Mas to obtain a clear picture of the causes of ship stress and efforts to optimize cargo placement to reduce the risk of sagging and hogging on container ships.

III. RESULTS AND DISCUSSION

Data Presentation

1. Observation Results

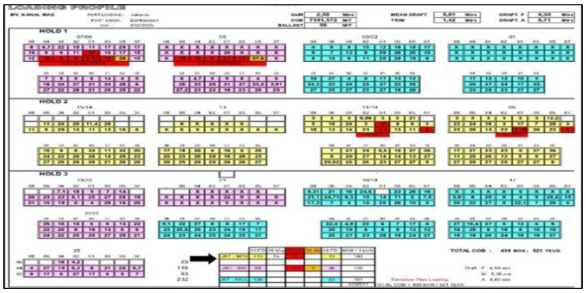

Fig. 1 Bayplan voyage 32

In the image, the cargo to be unloaded at Balikpapan Port is marked in yellow, specifically in hold 2. However, after unloading, the load is concentrated at the ends of the ship because ships often carry empty containers at Balikpapan Port, although some contain only a small amount. This can cause the ship to experience hogging. The following is the bay plan for voyage 33 Balikpapan-Samarinda:

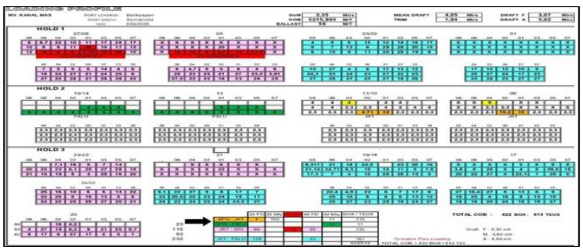

Fig. 2 Bayplan voyage 33

After the unloading process in Balikpapan was completed, it was apparent that the remaining load on the ship was concentrated at the ends of the ship, as holds 1 and 3 still contained cargo destined for subsequent ports, such as Samarinda and Pantoloan. This situation was reinforced by the operational fact that on the Balikpapan route, ships frequently received empty containers, while the number of containers containing cargo was relatively small.

Fig. 3 Bayplan voyage 43

According to the bay plan for voyage 44, the MV. Kanal Mas was carrying only empty containers, most of which were placed in holds 1 and 3. The loading process in Pontianak was irregular due to limited high tides in the Kapuas River, resulting in uneven cargo distribution. After unloading at Tg. Tapa, the remaining cargo was concentrated in hold 2, or the center of the ship.

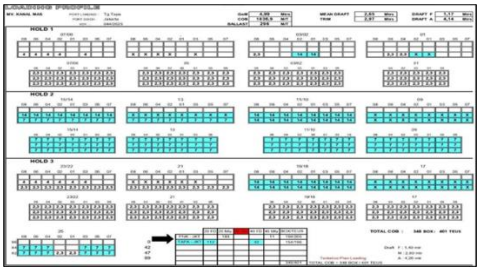

Fig 4 Bayplan voyage 43

The bay plan shows that the cargo from Tg. Tapa Port, marked in blue, is concentrated in hold 2, or the center of the ship, while holds 1 and 3 are nearly empty. This condition causes uneven load distribution and increases the risk of sagging. If this continues, stress on the ship's midship structure could increase, potentially compromising the ship's strength and safety. Therefore, careful consideration is needed in the bay plan preparation and loading process.

2. Interview Results

a. The results of the information obtained from the answers of source 1 (Captain) as contained in the attachment:

According to Captain Ratten, the captain of the MV. Kanal Mas, cargo management relies heavily on accurate bayplan preparation and strict supervision during the loading and unloading process. Bayplans serve as the primary guideline for maintaining the ship's balance, stability, and safety. Therefore, even small errors in container placement can affect the ship's condition and trigger ship stress.

Capt. Ratten also emphasized the importance of coordination between the ship's crew and port foreman. Misalignment of loading procedures with the bay plan can lead to uneven load distribution and increase the risk of hogging and sagging. Furthermore, port operational conditions, such as time constraints due to tidal fluctuations at Pontianak Port, often force the loading process to be carried out quickly, resulting

in less than optimal cargo placement. Therefore, monitoring the ship's draft before sailing is crucial to ensure balanced and safe load distribution throughout the voyage.

b. The results of the information obtained from the answers of source 2 (Chief Officer) as contained in the attachment

According to Jemmi Herliem, Chief Officer of the MV. Kanal Mas, the bay plan is a crucial document that determines the vessel's stability and therefore must be carefully prepared, taking into account container weight, port destination, and load distribution. Each voyage has different loading conditions, so planning must always be adapted to the situation on the ground.

A major frequent problem is mismatched container loading sequences (out of sequence), which causes foremen to make uncoordinated loading changes, resulting in unplanned cargo distribution. This can disrupt the ship's balance, as has happened on several previous voyages.

Loading irregularities can also lead to load concentrations, both amidships and at the ends of the ship, potentially causing sagging or hogging. For example, on voyage 44, the load was concentrated in hold 2, increasing the load amidships and requiring ballast adjustments.

The Chief Officer also emphasized the importance of deck crew supervision and good communication with port authorities to ensure loading is in accordance with the bay plan. Successful cargo management depends heavily on coordination between all parties to maintain the ship's stability.

c. The results of the information obtained from the answers of source 3 (Second Officer) as contained in the attachment:

MV. Kanal Mas's Second Officer, Reza Ibnu Hanif, explained that the bayplan implementation in the field does not always go according to plan due to the ship's operational conditions. On voyage 32 at Balikpapan Port, all loaded containers had to be placed in hold 2 because holds 1 and 3 still contained cargo for the next port, limiting loading flexibility.

This condition causes uneven load distribution, as the load is concentrated in certain areas of the ship, while others remain at the ends. This can potentially lead to ship stress in the form of hogging if it occurs repeatedly.

The Second Officer added that this imbalance can increase pressure on the bow and stern, causing the ship's centerline to experience a lighter load. Therefore, regular ballast adjustments and routine draft checks are essential to maintain the ship's stability and safety during navigation.

d. The results of the information obtained from the answers of source 4 (Third Officer) as contained in the attachment:

MV Kanal Mas' Third Officer, Riki Agus Pratama, explained that during the loading and unloading process, he assisted the Chief Officer in ensuring loading was in accordance with the bay plan and monitored the position of the containers on deck to ensure they remained under control through good communication with the foreman.

He also explained that loading and unloading at Balikpapan Port was carried out first because the channel conditions were deeper and safer for ships with full draft, while Samarinda Port had a shallower channel so that ships had to reduce their draft before they could enter safely.

This condition causes loading flexibility to be limited because some of the cargo for the next port is still in holds 1 and 3, so that after the unloading process in Balikpapan, the ship's load tends to be concentrated at the ends of the ship and has the potential to cause ship stress such as hogging.

Therefore, the Third Officer emphasized the importance of strict monitoring of the draft, trim, and stability of the vessel to ensure safe navigation despite operational limitations in the field.

Data analysis

Data analysis in this study was conducted by combining field observations and interview information to identify factors causing cargo misplacement that could potentially cause ship stress on the MV Kanal Mas. The analysis focused on cargo distribution, port operational conditions, and the implementation of bay plans and monitoring systems during the loading and unloading process.

Observations showed that loading activities did not always proceed according to the bay plan. On voyage 32, cargo from Balikpapan was concentrated in hold 2, while holds 1 and 3 could not be adjusted

because they still contained cargo for the next port. This resulted in an imbalance in the load after unloading, potentially leading to hogging. Meanwhile, on voyages 43–44, the cargo was concentrated more in hold 2, increasing the risk of sagging due to uneven load distribution longitudinally.

These findings are reinforced by interviews, which indicate that bayplan implementation is often hampered by operational factors in the field. The captain emphasized the importance of adhering to the bayplan, but in practice, obstacles occurred, such as out-of-sequence foreman decisions, time constraints due to high and low tides in Pontianak, and shipping lane restrictions in Balikpapan and Samarinda. Furthermore, the Second Officer explained that out-of-sequence conditions made loading adjustments unavoidable, while the Third Officer added that navigational safety factors also influenced loading patterns, particularly regarding the depth of the port channel.

Based on the combined findings of observations and interviews, it can be concluded that the misplacement of cargo was not caused by the negligence of the ship's crew, but was triggered by operational situations that could not be fully controlled by the ship, including:

a. Determination of the loading and unloading sequence based on the depth of the port channel.
b. Time limitations at certain ports due to tides.
c. Container loading sequence out of sequence.
d. *Foreman* who made loading decisions without optimal coordination with the ship's side.

As a result, the load distribution can deviate from the plan, resulting in load concentration at the ends or middle of the ship, which increases the risk of ship stress such as hogging and sagging, and has the potential to weaken the strength of the ship's structure in the long term.

However, the ship's crew has taken mitigation measures such as regular draft monitoring, increased communication with the foreman, ballast adjustments, and recording bayplan discrepancies for correction at the next port.

Thus, ship stress on the MV. Kanal Mas was more due to dynamic field operational conditions than technical errors in the bay plan preparation.

IV. DISCUSSION

1. What factors can cause ship stress on a ship?

From the analysis of data obtained from observation, interviews, and documentation during the research on board, one of the causes of ship stress on the MV. Kanal Mas is port operational constraints. On voyage 32, the ship had to carry out its first loading and unloading at Balikpapan Port because the channel depth is sufficient to allow the ship to dock with a high draft, while Samarinda Port has a shallower channel.

This caused all cargo from Balikpapan to be placed in hold 2 while holds 1 and 3 still contained cargo for the next port, so that after the next unloading, there was a buildup of load at the end of the ship. This condition has the potential to cause hogging, which is when the middle of the ship is pushed up due to the heavier load at both ends. Conversely, on voyages 43–44, all cargo from Tanjung Tapa Port was focused on hold 2.

This was triggered by limited loading time at Pontianak Port due to the influence of the Kapuas River tide, causing the placement of empty cargo on the deck to be random. After unloading at the next port, only hold 2 still contained cargo so that the load was concentrated in the middle of the ship. This condition increases the risk of sagging, a condition where the center of the ship bends downward due to the weight of the load concentrated in the middle of the ship.

This is in line with research by Suci, Sukarno, and Alie (2025), which explains that hogging conditions cause a maximum tensile stress on the deck of 410.28 N/mm², while in sagging conditions the deck experiences a compressive stress of 279.91 N/mm². These results indicate that uneven load distribution can affect the longitudinal strength of the ship and increase the risk of structural failure.

2. What efforts can be made to reduce the occurrence of ship stress?

Efforts that can be made to reduce the occurrence of ship stress on the MV. Kanal Mas include two loading scenarios that show that ship stress on the MV. Kanal Mas was not caused by errors in the preparation of the bay plan, but arose from adjustments to field conditions that were unavoidable due to technical and oper-

ational limitations of the port. Interview findings support this, where the Captain, Chief Officer, and officer on duty stated that loading discrepancies were usually influenced by foreman decisions, loading and unloading time pressures, and limited port facilities. Nevertheless, the ship's crew has implemented various mitigation measures to reduce the risk of ship stress, including:

a. Continuously monitor the ship's draft during loading and unloading,
b. Making ballast adjustments to maintain the trim and stability of the vessel,
c. Increase direct communication with foreman if errors in cargo placement are found,
d. Document out of sequence containers for correction at the next port.

3. How can cargo placement be optimized to reduce ship stress?

Proper cargo placement must adhere to the principle of equitable load distribution, both longitudinally, transversely, and vertically. Cargo arrangement must follow the stowage plan (bayplan) that was planned before the loading process. Placing containers according to the port sequence is crucial to avoid overstowage and overcarriage, which can hinder the loading and unloading process and cause an imbalance in load distribution. Some important principles for proper cargo placement on a ship, based on research findings, are:

a. Place heavy containers proportionally to avoid concentrating the load at one particular point.
b. Follow the order of the destination port in arranging the cargo to support smooth loading and unloading.
c. Conduct strict supervision during the loading and unloading process to ensure it is in accordance with the bay plan.
d. Maintain the balance of the ship by periodically monitoring draft, trim and stability.
e. Make ballast adjustments if there is an imbalance in the load distribution.

V. CONCLUSION

This study shows that the occurrence of ship stress on the MV. Kanal Mas is primarily influenced by operational conditions in the field that cause an imbalance in load distribution, both in the form of load concentration at the ends of the ship that can potentially cause hogging and in the middle of the ship that triggers sagging. The main factors found include the limitations of the port channel, the influence of tides, out-of-sequence conditions in container picking, and loading adjustments made without optimal coordination between the ship and the foreman. Although the bay plan has been prepared systematically, its implementation often experiences deviations due to dynamic operational conditions. The limitation of this study lies in the focus of the analysis which is only carried out on one ship and a certain period during sea practice, so it does not fully represent the full variation of container ship operational conditions. Therefore, further research is recommended to expand the research object to several types of ships and different shipping routes to obtain a more comprehensive picture of the factors causing ship stress.

Practically, this study emphasizes the importance of strengthening coordination between ship crews and port authorities in implementing bay plans, as well as the need for stricter oversight of cargo distribution, draft, trim, and ship stability during loading and unloading. The results also imply that mitigation measures such as ballast adjustments, regular monitoring, and documentation of containers that do not conform to the plan must be carried out consistently to minimize the risk of ship stress. Therefore, this study is expected to serve as a reference for ship officers and shipping companies in improving operational safety and efficiency of container ship cargo management, especially in port conditions with operational limitations.

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