Analysis of Stability Criteria and Characteristics of Passenger Ships

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Abstract

This thesis presents an in-depth analysis of stability criteria and characteristics specific to passenger ships, focusing on their vital role in ensuring the safety and comfort of passengers at sea. The study examines international regulations, codes, and rules related to passenger ship stability. Through a systematic analysis of stability requirements and calculations, this research investigates the factors influencing passenger ship stability, including hull form, weight distribution, and stability-enhancing measures. The findings of this research contribute to a comprehensive understanding of stability principles and their practical application in the design, operation, and maintenance of passenger ships. As a conclusion, a table made to show main differences between stability operations at passenger ships and at cargo ships is presented.

Keywords: Stability, Passenger ship, IMO regulations

Content

Chapter 1. Introduction

A passenger ships is usually defined as a ship carrying more than 12 passengers - on international voyages must comply with all relevant IMO regulations, including those in the SOLAS and Load Lines Conventions. A vessel type known as a passenger ship is one that is created and utilized primarily for the transportation of passengers. Both short- and long-distance travelers can utilize it, and it often provides amenities and facilities for them to use while traveling, such as cabins or rooms, dining spaces, recreation areas, and occasionally even stores or theaters. From little ferries and riverboats to enormous ocean liners that can carry thousands of passengers, there are many various types and sizes of passenger ships. They can operate on various bodies of water, including rivers, lakes, and seas, and can be used for a variety of reasons, such as conveying visitors, commuters, or laborers.

Passenger ships could be divided into three such as cruise ships, ferries and ocean liners. Since the 1980s, when Knut Kloster, the director of Norwegian Caribbean Lines, purchased one of the largest remaining liners, the SS France, and converted her into a massive cruise ship that he renamed the SS Norway, cruise ships have become larger than the previous generation of ocean liners. Her success proved there was a demand for substantial cruise ships. Following orders for successive classes of larger and larger ships, the Cunard liner Queen Elizabeth's 56-year reign as the largest passenger ship ever built came to an end. This dethronement paved the way for countless other dethronements from the same position. Large passenger ships known as cruise ships are employed mostly for leisure travel. Contrary to ocean liners, which are employed for transportation, cruise ships usually set sail on round-trip cruises to a number of ports of call, where guests may take part in "shore excursions" such as tours. Some cruise ships make two- to three-night round excursions on "cruises to nowhere" or "nowhere voyages" without stopping at any ports of call. In comparison to ocean liners, modern cruise ships typically have less hull strength, speed, and agility. Recent vessels, nevertheless, have been referred to as "balcony-laden floating condominiums" because of the facilities they have incorporated to cater to aquatic tourists.

With a total passenger capacity of 581,200, there were 323 cruise ships in operation as of December 2021. With an estimated market of $29.4 billion and more than 19 million passengers transported globally each year as of 2011, cruising has grown to be a significant component of the tourism industry. Every year since 2001, nine or more freshly built ships serving a North American clientele have been added to the sector, along with others serving a European clientele. However, the COVID-19 pandemic in 2020 caused the entire industry to all but collapse. Royal Caribbean's

Wonder of the Seas, which overtook its predecessor, Symphony of the Seas, is the largest passenger ship as of 2023 (Wikipedia).

A ferry is a type of boat that crosses a body of water carrying people, occasionally also carrying automobiles and freight. Sometimes referred to as a water bus or water taxi, a small passenger ferry with numerous stops, such in Venice, Italy, is also known as one. Ferries offer direct access between sites at a capital cost significantly cheaper than bridges or tunnels, and they are an integral feature of the public transportation systems of many waterside cities and islands. Ferry services are another name for ship connections that span much greater distances, and many of them transport automobiles (for example, across lengthy distances in water bodies like the Mediterranean Sea). The roll-on, roll-off (ro-ro) ferry Leviathan began service between Granton, near Edinburgh, and Burntisland in Fife in 1850. It was built to efficiently transport freight wagons over the Firth of Forth in Scotland. The ro-ro ferry was transformed from an experimental and marginal ship type into one of central importance in the transportation of goods and passengers thanks to the vessel's highly innovative design and the ability to move freight in great quantities and with little labor.

The first ferry ship in history was built in Istanbul in 1871. The Bosporus Steam Navigation Company's general manager, Giritli Hüseyin Haki Bey, planned the iron steamship Suhulet, which translates to "ease" or "convenience," and a British shipyard constructed it. It was 157 tons heavy. It had dimensions of 155 feet (47 meters) long, 27 feet (8.2 meters) broad, and 9 feet (2.7 meters) of draft. With the side wheel being turned by its 450 horsepower, single-cylinder, two-cycle steam engine, it could travel at speeds of up to 6 knots. When Suhulet was first built in 1872, its distinctive characteristics included a dual hatchway system and a symmetrical entrance and exit for horse-drawn vehicles. The boat ran on a route between Üsküdar and Kabatas that is still traveled by modern ferries today.

The length of the trip, the required vehicle or passenger capacity, the required speed, and the water conditions the ship must navigate all affect ferry designs. There are different type of ferries such as double-ended ferries, hydrofoils, hovercrafts, catamaran, roll-on/roll-of, cruiseferry / RoPax, fast RoPax ferry, turntable ferry, pontoon ferry, train ferry, foot ferry, cable ferry and air ferry. Double-ended ferries may travel back and forth between two terminals without turning around thanks to their replaceable bows and sterns. The BC Ferries, Staten Island Ferry, Washington State Ferries, Star Ferry, a number of ferries on the North Carolina Ferry System, and the Lake Champlain Transportation Company are well-known double-ended ferry systems. The majority of the coastal and fjord ferries in Norway are double-ended boats. The southern Prince Edward Island to the Canadian mainland ferries were all double-ended. Upon the Confederation Bridge's completion, this service was halted. Additionally, there are some double-ended ferries in Sydney, Australia and British Columbia. The first of the Coastal-class ferries, which at the time were the largest double enders in the world, was launched by BC Ferries in 2008. These were surpassed as the world's largest double-enders when P&O Ferries launched their first double-ender, called the P&O Pioneer, which is due to enter service in September 2022. On some English Channel routes, where the ferries now compete against the Eurotunnel and Eurostar trains that use the Channel Tunnel, hydrofoils succeeded hovercraft due to their higher cruising speeds. In the Canary Islands, passenger-only hydrofoils also proved to be a workable, quick, and reasonably priced alternative; however, they have lately been replaced with faster catamaran "high speed" ferries that can transport cars. Given that the new vessels consume significantly more fuel and encourage the improper use of cars in islands already suffering from the effects of heavy tourism, many view their replacement by the larger craft as a step backward. To transport cars, hovercraft were created in the 1960s and 1970s. The largest was the enormous SR.N4, which traveled between England and France carrying automobiles in its center part with ramps at the bow and stern. Catamarans have nearly as much speed as hovercraft and are less susceptible to sea and weather conditions. There is currently only one service left, a foot passenger service provided by Hovertravel between Portsmouth and the Isle of Wight. Since 1990, high-speed catamarans have completely changed the ferry industry, taking the place of hovercrafts, hydrofoils, and standard monohull ferries. There were many builders in the 1990s, but the market has since consolidated to just two manufacturers of huge vehicular ferries that are between 60 and 120 meters in length. For a comfortable ride, Incat of Hobart, Tasmania, prefers a Wave-piercing hull, whereas Austal of Perth, Western Australia, constructs ships using SWATH designs. Both of these businesses compete with various other ship manufacturers in the smaller river ferry sector. Large conventional ferries called ROROs are named for how simple it is for cars to board and disembark. A cruiseferry is a vessel that combines roll-on/roll-off ferry functionality with that of a cruise liner. Because of their combined Roll on/Roll Off and passenger design, they are often referred to as RoPax. Fast RoPax ships are regular ferries with a sizable garage intake and a sizable passenger capacity. They are powered by regular diesel engines and have propellers that can reach speeds of above 25 knots (46 km/h; 29 mph). Turntable ferry allows vehicles to load from the "side". The vehicle platform can be turned. When loading, the platform is turned sideways to allow sideways loading of vehicles. Then the platform is turned back, in line with the vessel, and the journey across water is made. Pontoon ferries transport cars across rivers and lakes and are extensively utilized in developing nations with vast rivers where bridge construction is prohibitively expensive. A pontoon is used to transport one or more vehicles, with ramps at either end for cars to drive on and off. Cable ferries are normally pontoon ferries, although on larger rivers, pontoon ferries are motorized and can be steered independently like a boat. A train ferry is a ship that transports railway vehicles. Typically, one deck of the ship is equipped with railway tracks, and the vessel has a door to the wharves at either or both the front and aft. Foot ferries are small ships that transport pedestrians and bikes over rivers. These are either self-propelled or cable-powered vessels. Such ferries can be seen, for example, on the lower Scheldt River in Belgium and, more specifically, the Netherlands. Regular foot ferry service is also available in Prague, the Czech Republic's capital, and across the Yarra River in Melbourne, Australia, at Newport. The restored and enlarged ferry service in the Port of New York and New Jersey solely transports pedestrians. A cable or chain ferry, which is usually a pontoon ferry (see above), can cross very short distances since it is pushed and steered by cables connected to each shore. The cable ferry is sometimes propelled by someone aboard the boat. Reaction ferries are cable ferries that generate power by using the perpendicular force of the river. The four Rhine ferries in Basel, Switzerland, are examples of modern powered ferries. Cable ferries can be used to travel short distances across fast-flowing rivers. The cable ferry between Vancouver Island and Denman Island in British Columbia is the world's longest, with an ocean traverse of roughly 1900 meters. Free ferries are available in certain regions of the world, including Woolwich in London, England (over the River Thames), Amsterdam, Netherlands (across the IJ canal), South Australia's Murray River, and many lakes in British Columbia. Many cable ferries operate on lakes and rivers in Canada, including one that charges a toll on the Rivière des Prairies in Quebec, Canada, between Laval-sur-le-Lac and Île Bizard. In 2009, Finland had 40 road ferries (cable ferries) operating on lakes, rivers, and at sea between islands. Traveling by "air ferry" was available in the 1950s and 1960s—airplanes, generally ex-military, specially outfitted to carry a small number of cars in addition to foot passengers. These ran on a variety of routes, including those between the United Kingdom and Continental Europe. Channel Air Bridge, Silver City Airways, and Corsair were among the companies that provided such services. The word also refers to any "ferrying" via air and is frequently used in reference to airborne military operations.

The typical type of passenger ship is an ocean liner. Once upon a time, such liners made scheduled line voyages to every inhabited part of the globe. Line journeys have almost vanished with the introduction of passenger airliners and specialized cargo vessels conveying freight. However, as they declined, there was an increase in sea trips for pleasure and fun, and by the late twentieth century, ocean liners had given way to cruise ships as the dominant type of large passenger ship containing hundreds to thousands of people, with the main area of activity changing from the North Atlantic Ocean to the Caribbean Sea. They are primarily used for transportation across seas or oceans. The category does not include ferries or other vessels engaged in short-sea trading, nor dedicated cruise ships where the voyage itself, and not transportation, is the primary purpose of the trip. Nor does it include tramp steamers, even those equipped to handle limited numbers of passengers. Some shipping companies refer to themselves as "lines" and their container ships, which often operate over set routes according to established schedules, as "liners". Though ocean liners and cruise ships have certain similarities, they must be able to sail between continents on a fixed timetable, thus they must be faster and equipped to resist the rough seas and poor conditions found on long voyages over the open ocean. They normally have a higher hull and promenade deck with higher positioning of lifeboats (the height above water called the freeboard), as well as a longer bow than a cruise ship to protect against severe waves. Furthermore, for additional strength, they are frequently designed with thicker hull armor than cruise ships, as well as a deeper draft for increased stability, and have vast capacities for fuel, food, and other consumables during lengthy trips. The bridge aboard an ocean liner is normally located on the upper deck for better sight. The first ocean liners were constructed in the mid-nineteenth century. Technological advancements like as the steam engine, diesel engine, and steel hull enabled the construction of larger and faster liners, resulting in competition amongst world powers of the time, particularly the United Kingdom, the German Empire, and, to a lesser extent, France. Ocean liners, once the main mode of intercontinental travel, were rendered completely obsolete by the advent of long-distance aircraft following World War II. Automobile and railway technical advancements also played an impact.

After the retirement of the Queen Elizabeth 2, the only ship currently in service as an ocean liner is the RMS Queen Mary 2.

There are some specific differences between cruise ships and ocean liners. Although some ships exhibit traits of both types, the design priorities of the two types differ: ocean liners prioritize speed and conventional luxury, whereas cruise ships prioritize amenities (swimming pools, theaters, ballrooms, casinos, sports facilities, and so on) over speed. Different designs result from these priorities. Furthermore, ocean liners were often built to cross the Atlantic Ocean between Europe and the United States, or to sail even further to South America or Asia, whereas cruise ships service shorter routes with numerous stops along coastlines or among various islands. Both the Queen Elizabeth 2 (QE2) (1969) and her successor as Cunard's flagship RMS Queen Mary 2 (QM2), which entered service in 2004, are of hybrid construction. Like transatlantic ocean liners, they are fast ships and strongly built to withstand the rigors of the North Atlantic in line voyage service but both ships are also designed to operate as cruise ships, with the amenities expected in that trade.

Stability operations are of great importance for passenger ships. There have been many accidents for these reasons in the past. There are also some examples from the recent past such as the grounding in Washington, falling over in dry dock in Cape Town and the rogue wave incident on board the Viking Polaris according to recent news. The Walla Walla ferry, operated by Washington State Ferries, ran aground due to a generator failure caused by contaminated fuel. However, there were no injuries or pollution. An investigation revealed that the contaminated fuel led to a loss of propulsion and steering, impacting backup systems as well. The ferry has since returned to service after testing the onboard fuel and installing upgraded generator monitoring gauges. The incident involving the Walla Walla ferry highlights the importance of fuel quality and its impact on the vessel's operation. The presence of contaminated fuel led to significant consequences, including generator failure and the grounding of the ferry.

The historic tall ship Bark EUROPA suffered damages and fell over in dry dock during an attempt to put it back into the water in Cape Town, South Africa on 20th May of 2023. One crew member sustained minor injuries. The operator is assessing the extent of the damage, and it is unclear when sailing operations can resume. The EUROPA has a rich history dating back to its construction in 1911 and underwent significant renovations over the years. It currently serves as a Sail Training Vessel and can accommodate trainees and crew members. The operator is committed to restoring the ship to full operational capacity. The incident involving the Bark EUROPA highlights the challenges and risks associated with maritime operations, even during routine maintenance activities like placing a ship back into the water. The safety of crew members is of utmost importance, and it is fortunate that the injuries sustained were minor. Assessing the extent of the damages is crucial for determining the necessary repairs and ensuring the ship's seaworthiness. The EUROPA's rich history and significant renovations make it an important vessel with cultural and historical value. Its role as a Sail Training Vessel provides valuable opportunities for trainees to learn about sailing and actively participate in deck activities. The operator's commitment to restoring the ship to full operational capacity reflects their dedication to preserving this historic vessel and continuing its voyages.

A Viking expedition cruise ship, the Viking Polaris, was struck by a rogue wave off the southern tip of South America, resulting in one passenger's death and injuries to four others. The incident occurred as the ship was sailing towards Ushuaia, Argentina. The ship sustained limited damage, including broken windows, and arrived in port in Ushuaia on November 30th 2022. The Drake Passage, known for extreme weather conditions and turbulent seas, was the location of the incident. Viking Cruises is investigating the incident and providing support to the authorities. The incident involving the Viking Polaris highlights the unpredictable nature of the sea and the potential dangers that can arise, even for well-equipped cruise ships. The impact of a rogue wave demonstrates the challenges posed by extreme weather conditions, particularly in areas notorious for rough seas like the Drake Passage. It is reassuring to see that Viking Cruises has promptly notified the affected passengers' families and is providing support during this difficult time. The safety and well-being of passengers and crew remain a top priority. The Viking Polaris, as a purpose-built "Polar Class" expedition ship, is designed to navigate challenging environments, including polar regions. However, this incident serves as a reminder that even well-designed vessels can encounter unexpected circumstances. It underscores the importance of preparedness, crew training, and adherence to safety protocols when operating in remote and challenging areas.

The main objectives of this bachelor degree thesis is to detect the differences between passenger ships and cargo ships on stability base and find out the differences about the stability operations on both ship types. In order to detect it, rules about passenger ships, international regulations, guidelines and circulars have been examined in depth. After the first Chapter (Introduction), second chapter detects differences about main characteristics, construction process and regulations have been examined. Stability operations on passenger ships are detailed at chapter 3. The stability rules that passenger ships must follow according to international rules are examined at chapter 4. Comparative analysis between stability operations at passenger ships and stability operations at cargo ships have been done at chapter 5. Finally, in Chapter 6, conclusions and final remarks are underlined.

Chapter 2. Main Characteristics and Regulations

2.1. Differences between passenger ships and other ships

Unlike other ships, which are normally built to move cargo or carry out other specialized jobs, passenger ships are built solely to convey people. These are some significant distinctions between passenger ships and other ship types:

- Design: Comfort and safety are top priorities when building passenger ships. Compared to other types of ships, they often feature additional amenities such dining establishments, bars, and entertainment venues. Some ships, like cargo ships, are built primarily to be effective at moving cargo.

- Capacity: While other ships normally have fewer crew members and may not have any passengers at all, passenger ships are built to carry a large number of people, frequently in the hundreds or even thousands.

- Safety features: To protect the passengers in an emergency, passenger ships must contain a number of safety features, including lifeboats, life rafts, and safety gear. There can be fewer safety features needed on other ships.

- Regulations: Due to the possible risk to human life, passenger ships are subject to stricter rules than other ships. These rules could cover things like requirements for crew training, safety standards, and passenger safety drills.

- Navigation: To ensure a safe and effective voyage, passenger ships frequently have cutting-edge navigational equipment. It's possible that other ships won't need as advanced navigational equipment.

Generally, the main distinction between passenger ships and other ships is their intended use: while other ships are made for other, more specialized uses, such as carrying cargo or conducting scientific research, passenger ships are made to transport people in comfort and safety.

2.2. Differences Between Passenger Ships and Other Ship Types According to International Codes

Based on their intended function, design, and mode of operation, many ship classes are distinguished by international maritime norms and conventions. According to international codes, the following are some of the main distinctions between passenger ships and other ship types:

- Safety requirements: Due to the presence of passengers on board, passenger ships are subject to stricter safety regulations than other ship types. Specific safety and training requirements are put out for passenger ships by international agreements like the International Convention for the Safety of Life at Sea (SOLAS) Chapter 1 / Regulation 7,12,14,18, Ch. II1 / Reg. 2, 8.1, 8.2, Ch. II2 / Reg. 5.3.3, 7.8, 8.3.4, 9.2.2.6, 9.5.2.5, 12.3 Ch. III / Reg. 6.5.1, 6.5.3, 21.1.1.1, 22.1.1, 23.1, 25.1, 27.1, 29.1, 30.2 and the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) Regulation V/2.

- Crew requirements: In order to ensure the safety and comfort of passengers, passenger ships need a larger and more varied crew than other ship types. The crew must receive training in topics like crowd control, emergency preparedness, and passenger care.

- Design features: Features of passenger ships include stabilizers to lessen motion sickness, common areas for entertainment and socializing, and safety equipment including lifeboats and evacuation systems. These elements promote passenger comfort and safety.

- Environmental regulations: The International Convention for the Prevention of Pollution from Ships (MARPOL), which establishes limitations on emissions and discharges from ships, is one example of an environmental law that regulates the influence that passenger ships have on the environment.

- Liability: Due to the potential for increased liability for passenger injuries or property damage, passenger ships are frequently required to carry liability insurance.

Generally, the regulations and codes that are applicable to passenger ships reflect the special operational and safety requirements of this type of ship.

Chapter 3. Stability Operations on Passenger Ships

According to Danish Maritime Authority's Order 1521 the actions taken to make sure the ship is stable and balanced when at sea and that it can safely endure the forces of the wind, waves, and other external variables are referred to as stability operations on passenger ships. The safety and comfort of passengers and crew, as well as the efficient operation of the ship's machinery, depend on the stability of the passenger ship.

On passenger ships, stability operations may be performed in the following ways:

- For the purpose of adjusting the ship's center of gravity and maintaining stability, ballasting and de-ballasting entail adding or removing water from the ballast tanks.

- Trim adjustment: This entails moving the ship's cargo, fuel, or water in order to correct the weight distribution and maintain balance.

- Heeling tests: In these tests, the ship is purposefully tilted to assess its stability and calculate the amount of ballast required for balance.

- Weather monitoring entails keeping an eye on the weather and modifying the ship's path or speed to lessen the effects of the wind and waves.

- Operational planning entails carefully organizing the ship's schedule, cargo loading, and passenger distribution to keep it balanced and stable during the navigation.

- Crew training: To guarantee that the crew is equipped to handle any stability-related difficulties that may develop, the crew is trained in stability protocols and emergency response.

The maintenance of passenger and crew safety and comfort, as well as the efficient operation of the ship's systems and equipment, depend on stability operations on passenger ships.

3.1 Ballasting and de-ballasting Operations at Passenger Ships

In passenger ships, ballasting and de-ballasting operations are performed to alter the ship's center of gravity and uphold its stability like operations at other ship types. These procedures entail filling or emptying the seawater-filled ballast tanks, which are found in the ship's lowest section. Ballasting operations are morely used to reduce the ship's center of gravity and increase stability once it has been loaded with passengers, cargo, and fuel, the crew will add seawater to the ballast tanks. Many techniques can be used for ballasting, including pumping seawater into the tanks, gravity filling, or a combination of the two while de-ballasting operations are used to maintain stability and elevate the ship's center of gravity when it is unloaded or has less weight aboard, the crew drains seawater from the ballast tanks. Similar techniques to ballasting, such as gravity discharge or pumping the seawater out of the tanks, can be used for de-ballasting. To make sure the ship is keeping correct balance and stability throughout ballasting and de-ballasting operations, the crew will use a variety of instruments, such as inclinometers and draft gauges for monitoring the operations. Ballasting and de-ballasting operations must be carried out properly and in accordance with established procedures to protect the safety of passengers and crew. While the operations is in progress the crew will adhere to stringent procedures for ballasting and de-ballasting, which include making sure the ship is level and free from risks and that the tanks are filled or emptied at a controlled rate to minimize any unexpected weight changes.

3.2 Trim Adjustment

The practice of altering the weight distribution on a ship to obtain the right balance and trim is known as trim adjustment in the context of passenger ships. The trim of a ship, which affects its speed, fuel consumption, and stability, is the difference between its bow and stern drafts (the depth of the ship below the waterline). After ship's present trim by measuring the draft at several spots along the ship's length is calculated by the crew before altering the trim. The crew will start moving weight around the ship to change the trim after determining the present trim. This may entail redistributing or relocating fuel, ballast, or cargo from one area of the ship to another. The crew will keep an eye on the ship's trim when weight is changed to make sure it is keeping a stable and proper balance. This could entail taking measurements of the draft at various points along the length of the ship, calculating the stability of the ship using computers, or measuring the ship's trim angle with inclinometers.

3.3 Heeling Tests

On passenger ships, heeling tests are used to assess stability and determine how much ballast is required to maintain balance. In these tests, the ship is purposefully heeled while being tilted, and the ship's reaction to the tilt is then measured. Before the heeling test, the ship's crew will get it ready by securing any loose things and making sure there are no risks on board. Also, the personnel will let passengers know about the test and make sure they are secure and comfortable. The crew will then add ballast on the opposing side to tilt the ship to one side. The amount of ballast added will vary depending on the size and weight of the ship as well as the desired degree of heel. To regulate the amount of ballast injected and gauge the heel angle, the crew may utilize a heeling tank or other tools. The crew will use inclinometers, draft gauges, and other tools to determine how the ship is responding to the tilt as it heels. They can use this information to compute the ship's stability and calculate how much ballast is required to maintain the right balance.

3.4 Weather Monitoring

In passenger ships, weather monitoring is a crucial component of safe navigation and operation. To decide on the ship's path, speed, and operation, it entails gathering and examining information regarding weather conditions. A number of sources, such as weather forecasts, satellite images, and observations from other ships, will be used by the ship's crew to acquire meteorological data. This data is used to paint a picture of the weather as it is right now and to forecast any potential changes. The crew will utilize computers and other technology to assess the weather information and spot any potential dangers, such as strong winds, rough seas, or storms. The optimal path and speed for the ship to take to avoid these dangers will also be determined using this data. Possible decisions include modifying the ship's path, slowing down, or changing its route to avoid dangerous weather.

3.5 Operational Planning

The elements that affect the ship's stability during routine operation must be identified and managed as part of operational planning for stability on passenger ships. This covers elements like the allocation of fuel and cargo, the mobility of passengers and personnel, and the environment. Taking into account the ship's size, weight, and cargo capacity, the crew will make the stability calculations according to specific stability requirements. The crew will create stability plans that describe how the ship's stability will be preserved throughout routine operation based on the assessment. To do this, safe loading and unloading processes may need to be established, along with the optimal locations for fuel and cargo, and protocols for crew and passenger movement. The crew will keep an eye on the stability of the ship while it is underway, utilizing computers and other tools to keep tabs on things like weight distribution, draft, and heel. In order to ensure stability, they will also keep an eye on the weather and change the ship's operation as necessary.

3.6 Crew Training

On passenger ships, stability operations are normally taught to crew members through a combination of classroom and practical training. Crew members receive classroom instruction in ship stability principles and the variables that can affect them. Learning about the many stability issues, such as initial, static, and dynamic stability, as well as the various elements that might affect a ship's stability, like weight distribution, environmental factors, and cargo loading, are all part of this. Crew members participate in simulated exercises to gain practical stability operations abilities. To mimic various stability scenarios and hone problem-solving abilities, this may entail computer simulations. Under the supervision of more seasoned crew members, crew members receive practical training while on the ship. They could be responsible for activities including loading and unloading cargo, keeping an eye on the ship's draft and heel, and managing ballast operations.

3.7 Stabilizer

Active fin stabilizers reduce roll experienced by a vessel while underway or, more recently, while at rest. They extend below the waterline beyond the vessel's hull and change their angle of attack in response to heel angle and rate of roll, similar to aviation ailerons. This type of stabilizing device is commonly used on cruise ships and yachts. Ship stabilizers are fins or rotors that are installed beneath the waterline and emerge laterally from the hull to decrease the roll of a ship caused by wind or waves. A gyroscopic control mechanism governs the active fins. When the gyroscope detects a ship roll, it alters the angle of attack of the fins such that the ship's forward motion exerts force to counteract the roll. Fixed fins and bilge keels do not move; they reduce roll by absorbing hydrodynamic drag as the ship rolls. Stabilizers are typically found in ocean-going ships. When the vessel is moving, fins produce lift or downforce. The lift produced by the fins should operate against the vessel's roll moment. To do this, two wings, one on each side of the ship, are installed underwater. Stabilizers can be retractable or non-retractable. While non-retractable type is mostly used on small vessels such as yachts, retractable type lets all medium and large cruise and ferry ships have the ability to retract the fins into a space inside the hull in order to avoid extra fuel consumption and reduce the required hull clearance when the fins are not needed.

The movement of a stabilizer is comparable to that of an aircraft's ailerons. Some fins, particularly those put on bigger ships, are equipped with flaps that improve fin lift by roughly 15%. Stabilizer control must take into account several variables that change rapidly, such as wind, waves, ship motion, draft, and so on. Fin stabilizers are substantially more efficient at greater speeds and lose efficiency when the ship is traveling at a slow pace. Actively operated fins (such as Rolls-Royce's stabilisation at rest system, which oscillates to counteract wave motion) and rotary cylinders using the Magnus effect are two ways for stabilization at anchor or at low speed. The latter two systems are retractable, providing for a narrower vessel profile when docking and less drag while traveling.

The process of increasing roll reduction for a vessel that is not ongoing is referred to as stabilisation while not underway, stabilisation at rest, zero-speed stabilisation, or on-anchor stabilisation. In some circumstances, this operation may be carried out using equipment systems that are simultaneously utilized for roll stabilisation while on the move. Similar to the forces that influence vessels underway, roll and pitch generating forces are applied to vessels at anchor, at moorings, adrift, or keeping station. Different tactics have been used to lessen the consequences of these pressures. The lifting force of a variable system that utilizes "active fins" made specifically for roll attenuation of a vessel while underway is produced by the flow of water over the surface of the fin. A maximum lift force can be produced for hull stabilization by extending the fin's angle of attack to its maximum operating angle. The lift force provided by the water flow over the fin when the vessel is moving is not present when these same devices are utilized to roll stabilize stationary ships. The amount of water that can be moved when stroking the fins in one direction at a specific moment in time and any powered fin movements can provide a lifting force (also known as a roll-resisting force) for a stationary vessel. Active fin systems can offer incrementally more stability for boats at rest, although these systems often have larger actuators and fins and may need a different kind of power source than systems made for stability when underway. A variety of commercial manufacturers make stabilization devices that can be employed while stationary, anchored, or moving at zero speed.

Chapter 4. The Stability Rules That Passenger Ships Must Follow According to International Rules

International bodies like the International Maritime Organization (IMO) and the International Convention for the Safety of Life at Sea have set forth a variety of stability standards and regulations that passenger ships must abide by (SOLAS). The following are some of the main stability regulations that apply to passenger ships:

- Initial stability: The capacity of the ship to retain an upright position in calm water is an essential condition for passenger ships. This includes making sure the ship is built to withstand the effects of wind and waves as well as meeting minimal stability parameters based on the ship's size and weight.

- Dynamic stability: Passenger ships must also adhere to rules for dynamic stability, or the ship's capacity to retain stability in rough seas and throughout maneuvers. This includes adhering to regulations on the maximum permitted angles of heel and making sure the ship is built to withstand capsizes or other stability-related disasters.

- Ballast operations: In order to maintain stability, ballast operations, which entail altering the weight distribution on the ship, must be adhered to by passenger ships. This entails adhering to regulations regarding the permitted volume and location of ballast water as well as making sure that ballast tanks are correctly maintained and operated.

Information on stability: Passenger ships are required to give the crew stability information, such as documentation of the ship's stability characteristics and guidelines for maintaining stability while in operation. Crew members who are in charge of stability operations must have easy access to this information.

Regular inspections: Passenger ships must go through routine inspections to make sure they adhere to stability rules and regulations. The documentation for the ship's stability, the use of ballast, and other stability-related issues may all be examined during these inspections, which are normally conducted by flag state authorities or other authorized bodies.

Therefore, keeping stability standards and regulations requires constant attention and upkeep from ship owners and operators in order to preserve passenger ship safety and performance.

4.1 Initial stability requirements for passenger ships

Initial stability standards for passenger ships are determined by a variety of elements, including as the ship's size, weight, and design. There are some general guidelines that apply to the majority of passenger ships, while the specific regulations may vary depending on the vessel.

The ship's metacentric height (GM), which is a measurement of the separation between the ship's center of gravity (G) and its metacenter, is one of the most important factors for initial stability (M). The distance between the G and M is crucial in evaluating a ship's initial stability since the metacenter is where a ship's buoyancy force acts when it is heeled over.

The maximum permitted angles of heel, which establish the point at which a ship is at risk of capsizing, are guidelines that passenger ships must also abide by. The maximum permitted angle of heel is usually determined by the size, weight, and design of the ship and is meant to keep the ship stable even in rough seas or while maneuvering.

Ultimately, ensuring the safety and performance of passenger ships depends on achieving initial stability requirements, which calls for careful consideration of elements including hull design, weight distribution, and ballast operations.

4.1.1 Why should passengers be included while calculating Light service draught at passenger ships?

Since they represent a significant weight that affects the stability and safety of the ship, passengers should be taken into account while determining the light service draught of a passenger ship.

The least amount of water required for a ship to function safely without cargo or people on board is called the light service draught. Yet, when more people board a ship, the weight of the vessel increases, which can lower the center of gravity and damage the ship's stability.

Also, the quantity and distribution of passengers may have an impact on the ship's list and trim. These elements can significantly affect the ship's maneuverability and handling abilities, especially in rough seas or under bad weather conditions.

In order to ensure that a passenger ship functions safely within its design parameters, it is crucial to take people into account while calculating the light service draught.

4.1.2 The formula to calculate Light service draught

The formula to calculate the light service draught of a ship depends on its specific characteristics, such as its displacement, waterline length, and draft.

One common formula for calculating the light service draught is:

Light service draught = (Light displacement / (LBP x B x CB)) + T

Where:

Light displacement is the weight of the ship when empty, including its hull, machinery, and equipment but excluding any cargo, fuel, or passengers.

LBP is the waterline length of the ship, measured between the forward and aft perpendiculars.

B is the beam of the ship, measured at its widest point.

CB is the block coefficient of the ship, which is the ratio of its underwater volume to its total volume.

T is the draft of the ship at the light displacement.

This formula takes into account the ship's weight and dimensions to determine the minimum amount of water needed to maintain its stability and manoeuvrability without cargo or passengers on board.

However, it's important to note that there may be variations in the formula depending on the specific design and characteristics of the ship, and it's always best to consult the ship's technical documentation or naval architects for accurate calculations.

4.2 How is dynamic stability handled at passenger ships?

The ability of the ship to maintain stability in rough seas and during maneuvers is known as dynamic stability, and it is an important factor to take into account when designing passenger ships. Passenger ships that handle dynamic stability must adhere to a number of rules and regulations as well as put in place a number of procedures and systems to maintain stability and prevent capsizing.

Making sure the ship's center of gravity stays as low as feasible is one of the important components of sustaining dynamic stability. This may entail paying close attention to how weight is distributed throughout the ship and using ballast water as necessary to change the center of gravity. Regulations governing ballast operations, such as those governing the size of ballast tanks, the volume of ballast that may be transported, and the placement of ballast tanks on passenger ships, must be adhered to.

Regulations governing the highest permitted angles of heel, which establish the point at which a ship is at risk of capsizing, must also be followed by passenger ships. The maximum permitted angle of heel is normally determined by the size, weight, and construction of the ship and may change in response to variables like the sea state and wind conditions. Passenger ships may employ a number of strategies, such as slowing down, altering course, or redistributing weight across the vessel, to minimize severe heeling.

Moreover, passenger ships need to have stability monitoring and maintenance systems in place at all times. The use of sensors to gauge the ship's angle of heel and other stability-related metrics, as well as protocols for handling instability or other emergency circumstances, may fall under this category. The crew must receive training in stability operations and emergency procedures, and they must be prepared to act promptly in the event that the ship's stability changes or if other problems arise that could jeopardize safety.

In general, managing dynamic stability on passenger ships necessitates continuous focus on elements including weight distribution, ballast operations, and monitoring and reaction systems. Passenger ships can guarantee the safety and wellbeing of passengers and crew in a variety of sea conditions by abiding by rules and putting best practices for stability operations into practice.

4.3 International Code On Intact Stability About Passenger Ships

The International Maritime Organization (IMO) created the International Code on Intact Stability (IS Code), which outlines the minimal requirements for intact stability of ships, including passenger ships.

The stability standards for the design and operation of passenger ships are among the stability-related topics covered by the IS Code. The code specifies the minimal standards for unbroken stability while taking into account the size, kind, and planned purpose of the ship.

The IS Code, in example, lays forth specific specifications for passenger ships to make sure they have enough stability to transport passengers safely in a variety of operating scenarios, including bad weather.

The IS Code also gives guidance for passenger ship construction and operation to make sure they have enough stability in case of damage, like a flooding incident. This covers the conditions for the ship's division, the placement of watertight bulkheads, and the availability of damage stability standards.

Generally, the IS Code is a crucial set of rules for the design and operation of passenger ships to guarantee that they have appropriate structural stability, especially in bad weather and in the event of damage. All ships covered by the International Convention on the Safety of Life at Sea are required to abide by the code, which is continually updated to reflect new technologies and safety concerns (SOLAS).

4.3.1 IS Code Part A / Mandatory Criteria -3.1.1

Protection from structural fire: Passenger ships must be built with components and designs that offer sufficient defense against the spread of fire. Using fire-resistant materials and installing fire detection and suppression systems fall under this category.

Lifesaving devices: To ensure the protection of passengers and crew in the case of an emergency, passenger ships must be outfitted with the proper lifesaving devices, such as lifeboats, liferafts, and lifebuoys.

Navigation and communication equipment: In order to provide safe navigation and emergency communication with shore-based authorities, passenger ships must be equipped with the proper navigation and communication technology, such as radar, GPS, and radio.

Passenger ships must be designed and built to offer sufficient stability and watertight integrity in order to prevent capsizing and flooding.

The overall goal of the requirements outlined in PART A / MANDATORY CRITERIA-3.1.1 is to protect the safety of the crew and passengers on board passenger ships, as well as to reduce the likelihood of accidents and other maritime crises.

4.3.2 The Structural Fire Protection For Passenger Ships Mentioned in IS Code Part A

The specifications for passenger ships' structural fire prevention include the following:

Fire-resistant materials: Materials that offer suitable protection against the spread of fire must be used in the construction of passenger ships. These substances must be able to endure high temperatures and keep smoke and flames from spreading.

Fire detection systems: In order to locate a fire on board a passenger ship rapidly, fire detection systems must be installed. These systems must have manual alarm points, heat detectors, and smoke detectors.

Fire suppression systems: Passenger ships must be equipped with automatic fire suppression systems, like sprinklers, as well as easily available, properly maintained portable fire extinguishers.

The overall goal of the structural fire protection regulations for passenger ships is to reduce the possibility of fire onboard and to make sure that any fires that do start can be rapidly found and put out to ensure the safety of both passengers and crew.

4.3.3 The fire suppression system requirements for passenger ships

The fire suppression system requirements for passenger ships include:

Automatic sprinkler systems: Passenger ships must be equipped with automatic sprinkler systems in accommodation spaces and service spaces, such as machinery rooms and cargo spaces. These systems must be designed and installed in accordance with SOLAS standards and must be capable of suppressing fires in their early stages.

Fire detection systems: In order to locate a fire on board a passenger ship rapidly, fire detection systems must be installed. These systems must have manual alarm points, heat detectors, and smoke detectors.

Fixed fire extinguishing systems: In specific high-risk sections including engine rooms, cargo holds, and galleys, passenger ships are required to have fixed fire extinguishing systems. These systems must be built and installed in accordance with SOLAS requirements, and they must be able to put out fires even when they are just starting.

Portable fire extinguishers: Passenger ships are required to have sufficient portable fire extinguishers on board so that crew members can put out flames when they are still in the early stages. In case of an emergency, these extinguishers must be kept in good condition and be easily accessible.

In general, the PART A / MANDATORY CRITERIA-3.1.1 fire suppression system standards are meant to make sure that passenger ships are outfitted with efficient fire suppression systems to ensure the safety of passengers and crew in the case of a fire.

4.3.4 The structural fire protection plan requirements for passenger ships

Systems for detecting and extinguishing fires: Passenger ships are required to have fire detection and extinguishing systems that have been fitted in compliance with SOLAS specifications. The structural fire prevention plan must include these systems as well as steps for their testing, upkeep, and repair.

Firefighting supplies: Passenger ships are required to carry enough firefighting supplies, such as portable fire extinguishers, fire hoses, and other instruments. The location of this equipment and the protocols for using it must be specified in the structural fire protection plan.

Evacuation procedures: Passenger ships must have thorough evacuation plans in place to make sure that passengers and crew can leave the vessel safely and quickly in the case of a fire. These steps must be included in the structural fire prevention plan, along with those for doing exercises and instructing crew members on how to evacuate.

Communication and alarm systems: Passenger ships must be outfitted with communication and alarm systems that enable crew members to react to fires swiftly and efficiently. Procedures for evaluating and maintaining these systems, as well as instructions for utilizing them in an emergency, must be included in the structural fire protection plan.

4.3.5 The stability and listing requirements for passenger ships

Damage stability requirements: Passenger ships must be built so that, in the case of flooding or other damage, they stay afloat and stable. This comprises specifications for bulkheads, watertight subdivisions, and other structures created to stop floods and lessen its impacts.

Stability requirements: Passenger ships must be constructed to ensure that they have enough stability in both normal operation conditions and emergency situations. These specifications address how to determine and maintain stability margins as well as how to make sure the ship can recover from a sudden list or heel.

Listing requirements: Passenger ships must be designed and operated in a way that minimizes the risk of listing or capsizing. This comprises specifications for restricting the weight and distribution of cargo, making sure that people are dispersed evenly throughout the ship, and making sure the ship isn't overloaded.

4.3.6 Inclination limits due to the gathering of the passengers to one side according to IS CODE

Guidelines and specifications for the intact stability of all types of ships, including passenger ships, are provided by the IS Code.

The IS Code states that for ships transporting more than 200 people, the maximum angle of inclination owing to passenger movement should not exceed 15 degrees, and 10 degrees for ships carrying fewer than 200 passengers. This restriction is meant to guarantee that even if all of the passengers are congregated on one side of the ship, it will still be stable and secure.

The IS Code mandates that the ship's stability be evaluated and validated during the design and building phases in addition to the maximum degree of inclination, to make sure it satisfies the stability requirements for a variety of loading circumstances, including passenger movement.

It is crucial to remember that the IS Code only sets forth these minimal requirements, and ship designers and operators are urged to take additional safety precautions to protect passengers and personnel on board.

4.3.7 How to calculate the passengers' center of gravity

Calculating the center of gravity (CG) of passengers on a ship is an important step in assessing the stability of the ship. To determine the CG of passengers the following steps can be used:

Determine the weight of each passenger: This can be done by using an average weight value or by weighing each passenger separately.

Determine the location of each passenger: This can be done by measuring the distance from a reference point, such as the ship's centerline or a fixed point on the ship's structure, to the position where each passenger is located.

Multiply the weight of each passenger by the distance of their location from the reference point: This will give the moment of each passenger.

Sum the moments of all passengers: This will give you the total moment of the passengers.

Divide the total moment by the total weight of the passengers: This will give you the CG of the passengers.

The formula for calculating the CG of passengers is:

$$CG = \Sigma (W \times d) / \Sigma W$$

where:

CG = center of gravity of passengers

W = weight of each passenger

d = distance of each passenger from the reference point

Σ = sum of all passengers

In order to maintain the stability and safety of the ship, it is crucial to keep in mind that the location and weight of passengers can change over time. As a result, the CG of passengers should be updated on a frequent basis.

4.4 How does center of gravity of passengers affect center of gravity of the ship?

A ship's overall center of gravity may be impacted by the center of gravity of its passengers. A ship's center of gravity is where all of its weight is equally distributed. A ship's center of gravity can change as people board since they contribute weight to the vessel.

The center of gravity of the ship won't be significantly affected by the weight of the passengers provided they are dispersed evenly throughout the ship. The center of gravity of the ship, however, may be shifted by the weight of the passengers if they are all concentrated in one region of the ship.

For instance, if a ship's upper deck fills up with a lot of people, this may cause the center of gravity to move upward, making the ship less stable. This poses a risk of capsize or loss of stability, which can be hazardous in rough seas or during an emergency.

4.4.1 Center of gravity of seated passengers

According to Part A / Mandatory Criteria 3.1.1.2 of International Code on Intact Stability the center of gravity of seated passengers is assumed to be at a height of 0.3 meters above the seat. The average height of a person's center of gravity when seated, which is normally between the waist and the chest, is used to determine this height.

However, it's crucial to remember that this is merely a supposition and that individual passengers' actual centers of gravity may differ based on things like weight, height, and seating position. Based on the unique characteristics of the ship and passengers, more exact measurements and calculations may be necessary to assure the correctness of the center of gravity estimates.

4.4.2 Center of gravity of standing passengers

Because it is a conservative estimate that takes into account the typical height of a standing person as well as the potential movement and shifting of weight that can occur in a standing position, the center of gravity of passengers who are standing is frequently calculated as one meter above the deck they are on.

A person's center of gravity is higher when they are standing than when they are seated. A standing person's center of gravity normally sits around 1 meter or so above the deck they are on. The designers and operators of ships can make sure that the ship is stable and safe even in rough sea conditions by assuming that the center of gravity of standing passengers is at this height.

Also, presuming that standing passengers have a larger center of gravity gives the ship a safety margin in case passengers move around or alter their weight, which could make the ship unsteady. This cautious attitude promotes safety for both the crew and passengers by preventing mishaps.

4.5 The maximum heeling angle during maneuvers for passenger ships according to IS code

The International Code on Intact Stability specifies the maximum heeling angle for passenger ships during maneuvers (IS Code). According to the IS Code, passenger ships should not heel more than 10 degrees due to the gathering of passengers to one side.

The maximum heeling angle is restricted in order to protect the ship's stability and the safety of its passengers under typical operating circumstances. Exceeding this limit can cause the ship to become unstable, leading to a risk of capsizing or loss of stability, which can be dangerous or even fatal for passengers and crew.

It is significant to remember that the maximum heeling angle might change based on the unique characteristics of the ship, such as its size, shape, and weight distribution. Consequently, when defining the maximum heeling angle for a certain ship, ship designers and operators must take into account the pertinent elements. Moreover, laws and norms may differ from one nation or region to another, and adherence to local laws is crucial for maintaining the safety of passenger ships.

4.6 The effect of freeboard on stability

The amount of freeboard a ship has has a significant impact on its stability at large and moderate angles of inclination. Freeboard determines the angle of deck edge immersion which determines in turn the maximum values of stability. There is no impact of freeboard on initial stability. Due to its small freeboard, a tanker ship requires a very large amount of initial stability to give it an adequate maximum arm and an adequate range. On the other hand, a passenger ship can afford to operate with small initial stability since its large freeboard offers it a large maximum arm and a long range.

4.7 Lightship displacement of a passenger ship

A passenger ship's lightship displacement can change, but doing so usually involves making changes to the ship that alter its weight or weight distribution.

The displacement of a lightship is its weight when it is empty of all people, goods, and fuel. It takes into account the structural, machinery, and equipment weight of the ship. Any modifications to the ship's design or weight distribution, such as the addition or removal of equipment, may alter the lightship displacement. A cruise ship's weight would grow, for instance, if additional machinery or equipment were added, or if the ship underwent structural changes, increasing the lightship displacement. On the other hand, the weight of the ship would fall if it removed machinery or equipment, which would reduce the lightship displacement.

Changes in the lightship displacement may have an impact on the ship's stability and necessitate adjusting the ballast or other systems to keep the ship functioning in a safe manner. In order to ensure safe and stable operation, any changes to the ship that affect the lightship displacement must be carefully assessed and taken into consideration in the ship's design and operation.

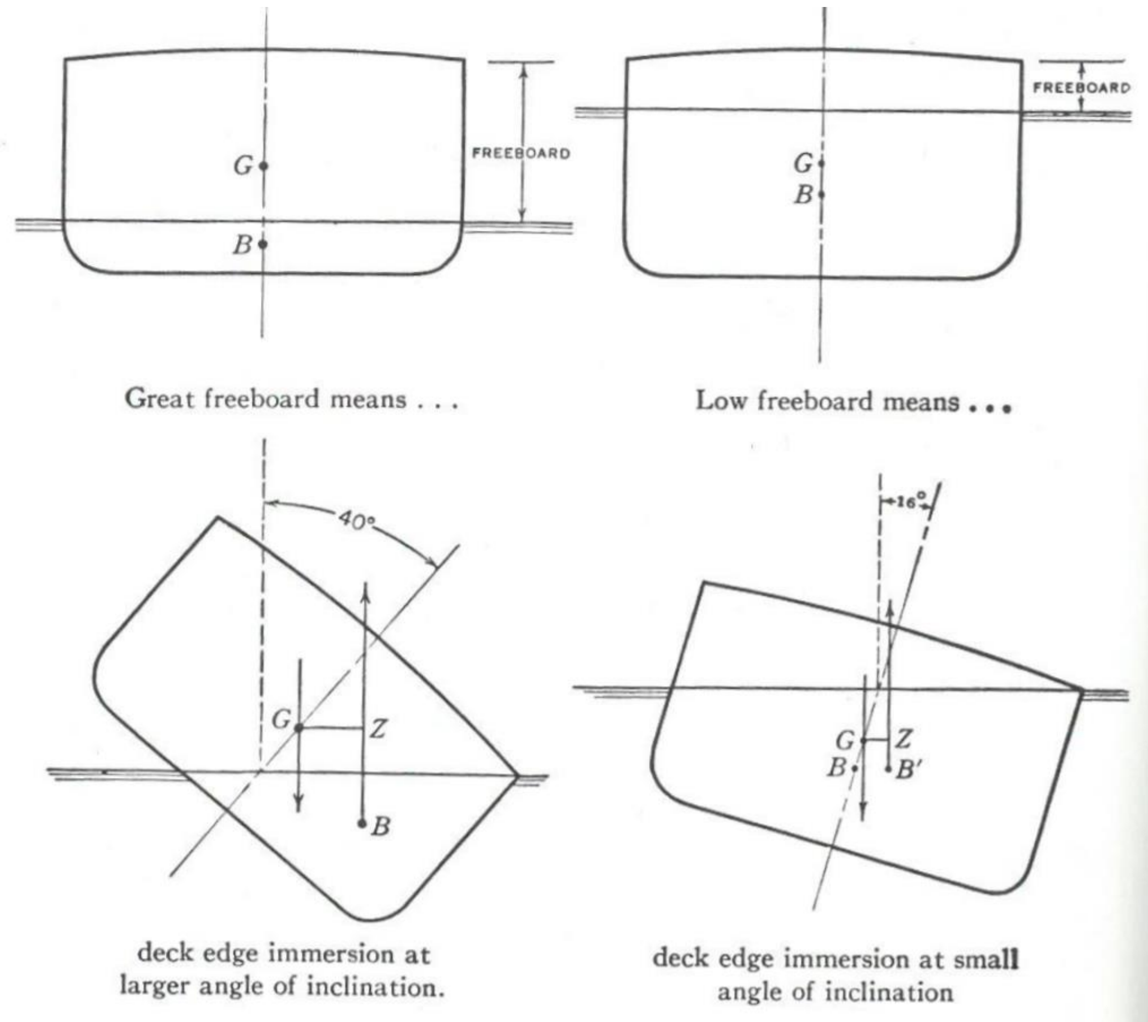

Figure 1: The effect of freeboard on stability at large angles of inclination

(Stability and Trim for the Ship's Officer – John La Dage and Lee Van Gemert (Original Edition) / Edited by William E. George)

Chapter 5. Comparative analysis between stability operations at passenger ships and stability operations at cargo ships

At this chapter some differences between stability operations at passenger ships and stability operations at cargo ships will be mentioned. For cargo and passenger ships, stabilization operations serve diverse purposes. Stability operations for passenger ships concentrate on keeping a stable platform in all operational circumstances, including rough seas and sudden maneuvers. On the other hand, stability operations for cargo ships are primarily concerned with keeping a stable platform and preventing cargo from shifting while being transported. Although passenger numbers, weight, and location might vary from voyage to voyage, the weight and center of gravity of passenger ships are often more erratic than those of cargo ships. Thus, more regular estimations of the ship's center of gravity and ballast requirements are required for passenger ship stability operations. While cargo is often pre-loaded and secured, the weight and center of gravity of cargo ships are more predictable because stability calculations can be made in advance. Calculations for stability are more difficult for passenger ships than for cargo ships. For passenger ships, there are additional factors to take into account, such as the number and distribution of passengers, luggage, fuel, and water, as well as the stability qualities of the ship. Contrarily, cargo ships have a more predictable weight distribution, which simplifies stability calculations.

5.1 Purpose of Stability Operations

For cargo and passenger ships, stabilization operations serve diverse purposes. Because passenger ships are built to carry people, the emphasis is on guaranteeing their safety and comfort. The safety of the passengers and crew in both routine and emergency scenarios, as well as the comfort of passengers throughout the navigation, are the primary considerations for passenger ship stability standards.

On the other hand, stability operations aboard cargo ships, which are built to deliver goods, are concentrated on preventing cargo shift and maintaining the crew's safety. The safety of the crew and the cargo, as well as the ship's capacity to maintain stability throughout loading, unloading, and transport of the cargo, are the primary considerations for the stability requirements for cargo ships.

In conclusion, while maintaining stability during operation is a requirement for both passenger ships and cargo ships, the emphasis of stability operations varies depending on the purpose of the vessel. Although cargo ships prioritize crew safety and cargo safety, passenger ships prioritize passenger comfort and safety.

5.2 Weight distribution

Both passenger ships and cargo ships must operate with stability procedures that take weight distribution into consideration. Yet, there are some variations in how the two types of vessels distribute weight:

Weight Distribution of Passengers:

For stability operations on passenger ships, the weight distribution of passengers is a crucial factor. The number, weight, and placement of passengers might vary from journey to voyage, complicating stability estimates. Also, the distribution of people throughout the ship and passenger movements while at sea can both have an impact on the stability of the ship.

Weight Distribution of Cargo:

For stability operations on cargo ships, the weight distribution of the cargo is a crucial factor. Because the cargo is pre-loaded and secured, cargo ships often have a more predictable weight distribution than passenger ships. It is crucial to make sure that the cargo is distributed equally to prevent cargo shift and preserve stability during loading, unloading, and transport of the cargo since the weight and position of the cargo might affect the ship's stability.

Ballast Weight:

Both passenger ships and cargo ships must take the weight of their ballast into account when conducting stability operations. To ensure that the ship maintains the desired stability, the draft and trim are adjusted using ballast. Typically, passenger ships utilize seawater to ballast and have a permanent ballast system. Contrarily, cargo ships have a more adaptable ballast system, and ballasting procedures can change based on the cargo carried and the needs of the ship for stability.

Other Factors:

The weight and position of fuel, water, and supplies are other elements that may affect weight distribution on both passenger ships and cargo ships. To guarantee that the ship maintains stability and safety throughout the journey, these elements must be taken into account during stability calculations.

In conclusion, weight distribution is an important factor to take into account for both passenger ships and cargo ships during stability operations, but the weight distribution on passenger ships is more variable due to the changing number and position of passengers, whereas the weight distribution on cargo ships has a more predictable weight distribution due to pre-loading and securing of the cargo.

5.3 Regulations and Guidelines

As mentioned earlier there are variances in the regulations and guidelines about stability between passenger ships and cargo ships. The standards for stability for passenger ships and cargo ships are very different. In order to protect the crew and passengers, passenger ships must adhere to tight stability standards, especially in crises like collisions, high winds, and rough seas. On the other hand, cargo ships are mostly focused on the secure transportation of cargo as well as maintaining the stability of the ship during the loading, unloading, and transportation of the cargo. Due to the fluctuating number and positioning of people, load estimates for passenger ships are more difficult than for cargo ships. The stability of passenger ships must be considered together with the weight and distribution of the passengers as well as the effects of fuel, water, and supplies. Due to the weight and distribution of the cargo typically being known in advance, the load calculation process for cargo ships is more predictable. Compared to cargo ships, passenger ships must meet stricter stability standards. For instance, passenger ships need to have enough reserve buoyancy to ensure that the ship can stay upright even if some of its compartments are submerged. Moreover, they must have sufficient stability margins to stop overly high heels or rolling. Contrarily, stability requirements for cargo ships are primarily concerned with preventing cargo shift and assuring the crew's safety while loading and unloading.

In conclusion, there are substantial differences between passenger ships and cargo ships in the regulations and guidelines for stability operations as mentioned earlier. Due to the fluctuating quantity and positioning of passengers, passenger ships are subject to stronger stability rules and more complicated load calculations than cargo ships, which have stability criteria that are largely focused on the safety of the crew and cargo during loading and unloading.

5.4 Ballasting Operations

Compared to passenger ships, cargo ships often have larger ballast tanks and more advanced ballast systems. This is so that during loading and unloading operations, when cargo ships must maintain stability while carrying higher loads, they can do so. In contrast, passenger ships feature smaller ballast tanks and more adaptable ballast systems that can adjust when the quantity and positioning of passengers vary. The distribution criteria for ballast on passenger and cargo ships are different. Typically, ballast is distributed on cargo ships to maximize stability and lessen the possibility of cargo shifting during delivery. Yet, passenger ships must alter the distribution of their ballast to keep the ship stable regardless of changes in passenger position or number. For instance, the ballast may need to be changed to counterbalance a high number of passengers moving to one side of the ship.

5.5 Heeling Limits

Due to their various designs and operating demands, passenger ships and cargo ships have varying heeling limitations, which relate to the greatest angle of heel that a ship can withstand without losing stability.

5.5.1 Passenger ships

In comparison to cargo ships, passenger ships often have a lower heeling restriction. The reason for this is that extreme heel angles can make passengers uncomfortable, anxious, and even hurt themselves. Passenger ships are made to provide a comfortable and safe experience for passengers. Moreover, passenger ships are built with several decks, which raises the possibility of capsizing in the event of an abrupt and extreme heel.

5.5.2 Cargo ships

Comparatively speaking, cargo ships can heel more than passenger ships can. This is so that cargo ships can retain their stability when loading and unloading activities. Cargo ships are made to handle heavy, occasionally unsteady cargo. Cargo ships are more stable at higher heel angles since they also have a lower center of gravity than passenger ships.

It is vital to keep in mind that these heeling restrictions are not fixed and may change based on a number of variables, including the ship's stability qualities, weather, and the conditions in which it is loaded. To guarantee that the ship stays within the safe heeling limitations, stability calculations and heeling tests are conducted often.

5.6 Why do stability calculations for passenger ships are typically more complex than those for cargo ships?

Due to a number of considerations, including the following, stability calculations for passenger ships are often more complicated than those for cargo ships:

Distribution of passengers: Comparing the distribution of cargo between two ships, the distribution of people on a passenger ship is more complicated. Because passengers move throughout the ship, their weight is continuously shifting. The amount of passengers, how they are distributed throughout the ship, and how their movement affects stability must all be considered in the stability calculations.

Several decks: Passenger ships frequently have numerous decks, which makes stability calculations more difficult. It is important to consider the distribution of passengers and their belongings on each deck as well as how each deck affects the overall stability of the ship.

Comfort and safety requirements: Passenger ships must be able to withstand a variety of sea conditions while maintaining the safety and comfort of the passengers. This is because passenger ships are designed to offer a safe and comfortable experience for passengers. This entails taking into consideration the ship's motions, such as rolling and pitching, and making sure the ship doesn't go beyond safe heeling limits.

Passenger ships are bound by strict stability rules and regulations, which might complicate the calculations for stability. These rules may call for additional calculations and safety precautions in order to safeguard the safety of the crew and passengers.

To sum up, the need to ensure the safety and comfort of passengers in a complicated and dynamic environment has led to the complexity of stability calculations for passenger ships, whereas cargo ships are designed primarily for the transportation of cargo and do not have the same requirements for passenger safety and comfort.

Chapter 6. Conclusion

As a conclusion a table has been made to show differences between stability operations at passenger ships and at cargo ships at one place.

Aspect	Passenger Ships	Cargo Ships
Stability Considerations	Emphasis on passenger comfort, minimizing ship motions, and ensuring a smooth ride for passengers during normal and extreme conditions	Emphasis on cargo stability, proper weight distribution, and maintaining vessel stability during cargo loading/unloading
Stability Calculations	Calculations consider passenger distribution, passenger-related loads, and their effect on ship stability	Calculations focus on cargo distribution, weight distribution, and their effect on ship stability
Stability Criteria	Stability criteria based on passenger comfort, limiting heeling angles, and maintaining a stable platform for onboard activities	Stability criteria focus on cargo weight limits, cargo securing, and maintaining a safe stability margin for cargo operations
Ballast Operations	Ballast operations primarily for trim and draft adjustments, ensuring proper vessel trim and draft for passenger comfort and safety	Ballast operations primarily for maintaining proper stability during cargo loading/unloading, optimizing vessel trim and draft
Stability Documentation	Stability booklets and stability data for passenger ships, including information for the ship's officers to ensure safe operations	Stability booklets and loading manuals for cargo ships, providing guidelines for cargo loading, securing, and maintaining stability
Stability Monitoring and Control	Continuous stability monitoring systems to track heeling angles, listing, and stability conditions in real-time	Continuous stability monitoring systems to track stability parameters during cargo loading/unloading operations
Stability Training and Procedures	Crew members receive training on stability principles, stability-related emergency procedures, and damage control	Crew members receive training on cargo stability, cargo securing techniques, and ensuring proper weight distribution

Passenger Safety Considerations	Stability operations aim to ensure passenger safety during normal and extreme conditions, minimizing risks of falls and injuries	Stability operations aim to ensure cargo and crew safety, minimizing risks of cargo shifts, structural damage, and accidents
Stability in Emergency Situations	Stability procedures and plans include emergency scenarios, such as damage control, evacuation, and maintaining stability during emergències	Stability procedures focus on cargo-related emergency scenarios, including salvage operations, damaged cargo, and stability during emergencies

Table 1 : Differences Between Passenger Ships and Cargo Ships In Terms Of Their Stability Operation

It has been seen that passenger ships and cargo ships have some different stability rules. Distinctine rules for passenger ships have generally came in force in order to create more safety standarts for passengers and crew. It has seen that actions of passengers taken into account to specify distinctive rules for passenger ships while stability rules for cargo ships generally consider about movement of the cargoes. Some of the most notable distinguishing rules for passenger ships are those about the movements of the passengers. It was observed that observations and operations were also carried out to ensure the balance of the ship in line with the movements of the passengers. In addition, while the effect of passengers on the center of weight was investigated, it was observed that the passengers were divided into two parts as sitting passengers and standing passengers. Comfort of the passengers during sail has been ensured by setting a limit to the list that will occur as a result of the movements of the passengers. As all the rules show, the safety and comfort of passengers and crew are guaranteed.

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