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Case Studies of the Effect of Loading and Unloading Cargo in Ship

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Abstract:

Stability is the main factor or is very essential especially for safety of crew members as it is for commercial purpose. In Eritrea there are so many people living in coastal areas which their economic activities depend up on sea related works like fishing and a kind of some businesses like trading through the seas and other work .But, although their economic activities fully depends on this kind of risky field of work ,most of them are always found to be unaware and not skilled of the needy sea life terms ,safety matters and basic concepts like stability of ship and how it is affected during maneuvering ,loading & unloading ,ballasting and other techniques. So it has been a reason for creating a massive financial & economical destruction, life losses and hardly affecting the sea living organisms in a way we regret. Everyone might have confused saying "In this modern world how can these great consequences are still not minimized and kept at their higher state having qualitatively & quantitatively unsatisfying reasons to their occurrence? "we will leave the question for the reader .But, in general, it clearly teaches us that showing even a small negligence or irresponsibility and being unskilled in such things comes up with a mass of losses and gigantic destructions .So to overcome these problems, its time to do a deep research that finds the root fountains of its reasons out so everyone in the circle of marine society will have enough skills and so backwards will be at its lowest level. In this project important terms of stability and factors that affect it are discussed that helps to improve safe ship working and bring awareness to the unskilled people.

Introduction:

It is necessary to maintain a stability of ship with the certain safety covering which can maintain the life of crew members, avoid damage of cargoes; the stability of ship differs during loading and unloading condition.

Need for the Project Work:

Ship"s stability is a very important term for safety of the crew members, the ship and the cargo. Many ship accidents and different kinds of losses have been taking place, so lack of stability is found to be a vital and one of the vast reasons that have been causing a mass of destruction and great losses. The need of this project research paper is therefore to have a general idea of the ship stability, factors affecting the stability and to minimize its consequences.

Statement of the Problem:

Ship stability has been very much interesting since its lack started to lead into great disastrous consequences. The problem is that the people in the marine society (specially, crew members, stevedores, fishers) are found to be not enough skilled of the ship stability and factors affecting it, however, their safety and work depend this very important title. And the second problem is that the term ship"s stability is found to be a little complex term which is not easy to understand.

Objective of the Project:

- To determine the meta centric height of ship when it is fully loaded with cargo and it is unloaded
- To determine the time period of oscillation when ship is fully loaded with cargo and it is unloaded
- To determine effect of loading cargo in proper way and in not proper way to the ships stability
- To determine the importance of ballasting and unballasting and when it should be done

1.6 Significance:

The significance of this research paper is that:

- To increase the consciousness of the marine people on the ship"s stability
- To readymade the mind of the poor people about avoiding taking of dangerous actions that may result great destruction.
- To higher the knowledge of how does this stability affects our financial, economic and human life issues.
- To understand international standards toward the ship"s stability.

Hypothesis: Ship stability is very important and relevant to every vessel that sails in the waters.

Litrature Review:

Erika Buchari et al. [1]have done a research on a title, " Analysis of Model Loading and Unloading Time of Ships at Boom Baru Port, Palembang, Indonesia." It concerns, during loading and unloading condition time and speed are some of the main problems that happen in container terminal ports in Indonesia. This is mainly caused by longer loading and unloading time. Loading and unloading time depends on some factors that are ship size, limitation of equipment and stacking yard, shallow port basin, trial period and tidal magnitude. Dwelling time is accumulated time from loading and unloading containers, until the container leave the terminal. The speed of unloading process is affected by many factors, such as ship size, performance of the equipment, number of handling equipment, qualifications from the operator, and the depth of post basin.

Carlos F. Daganzo et al. [2] have done research concerning "Crane Double Cycling in Container Ports:

Effect on Ship Dwell Time." Department of Civil and Environmental Engineering, at University of California, Berkeley. In this study Double-cycling is a technique that can be used to improve the utilization of quay cranes by converting empty crane moves into productive ones. Instead of using the current method, where all relevant containers are unloaded before any are loaded (single-cycling), containers are loaded and unloaded simultaneously. This allows the crane to carry a container while moving from the apron to the ship (one move) as well as from the ship to the apron; doubling the number of containers transported in a cycle (or two moves). The crane efficiency improvement can be used to reduce ship turn-around time and therefore improve port throughput, and address the capacity problem.

Yihuai Hui et al. [3] studied "Sail Structure Design and Stability Calculation for Sail assisted Ships" at Marine collage Shanghai maritime University. Ship sail-assisting is a kind of integrated technology involved in fluent dynamic analysis, sail structure design, sail rotation control, ship stability and maneuverability. This paper systematically introduces several aspects of sail assisting technology. The paper firstly introduces sail type selection and experimental results of arc sail models. Thrust force coefficient, drifting force coefficient, lifting force coefficient, resistance coefficient and rotating torque coefficient of the sail model are discussed and optimal sail rotated angle is calculated in the paper. A control mechanism and the material of sail structure are designed for the sail operation of a ocean-going bulk carrier. Based on stability requirements of ocean-going ships, this paper proposes a stability criterion for sail-assisted ships and suggests a calculation method of stability parameter for the requirements. Comments and recommendations are finally discussed for the further application of the sail onboard ship.

Metin Taylan et al. [4] studied the "EFFECT OF FORWARD SPEED ON SHIP ROLLING AND STABILITY ." Istanbul University, faculty on naval architecture and ocean engineering. Most of the time this job shows that ship stability is evaluated at zero speed. Majority of the stability criteria is also based on the behavior of ship at stand still. However unlike fixed offshore platforms, shipper on the move due their nature of operation. Therefore, a ship's hydrostatic and hydrodynamic characteristic undergoes changes because of the varying under water volume, center of buoyancy and gravity and pressure distribution. This work deals with effect of forward speed on ship stability and motion, particularly on rolling motion in synchronous beam seas.

Research Methodology:

Research Procedure:

We collected all of the data that is needed for the research from Massawa port through questionnaire.

Data were taken from both foreign and national ships.

Graphic Representation of the Procedures:

Selection of the title (stability effect of ship) Collecting information from Massawa port

Calculations depending on the data collected that determines our objectives Theoretical analysis of every objective‟s calculations

Conclusion:

Sequence process of research collecting data from internet **The Questionnaire**

The questionnaire was consisting of 10 questions dealing with ten vital parameters for our research and they are listed below

Parameter 1

Metacentric height when fully unloaded with cargo

Parameter 2

Metacentric height when fully loaded with cargo

Parameter 3

Center of gravity when fully unloaded with cargo

Parameter 4

Center of gravity when fully loaded with cargo

Parameter 5

Weight of ship when fully unloaded with cargo

Parameter 6

Weight of ship when fully loaded with cargo

Parameter 7

Draught of ship when fully unloaded with cargo

Parameter 8

Draught of ship when fully loaded with cargo

Parameter 9 Width of the ship **Parameter 10** Length of the ship

Theoretical Analysis

Calcultion for Meta Centric Height

All calculations are done by assuming the ship is rectangular in shape.

M/V KOTA HANDAL:

Calcultion for Meta Centric Height:

All calculations are done by assuming the ship is rectangular in shape.

M/V Kota Handal:

Centre of gravity with no cargo =6.79m taken from ship. BM=I/V

$I=lb^3/12$.

l= Length of the ship b= width of the ship

I =Total moment of area of the ship. $I= (160\times25^3)/12$.

I=208333.33 m.

$V = LWD = (160\times25\times8.5)\ m^3$

$=34000m^3$ BM=208333.33/34000=6.12 m KB=8.5/2=4.25 m

KG=6.79m when it is unloaded taken from ship. GM=BM-BG

=5.64-(KG-KB)

=5.64-(6.79-4.25)

GM=3.1 m.........................GM=3.3 m taken from ship.

BM=I/V. BM=208333.33/36800=5.66m.

KG=9.79 m taken from ship. GM=BM-BG

GM=BM-(KG-KB)

=5.66-(9.79-4.61)

=0.48 m

M=0.46m from stability booklet**.** Fig 4.1 M/V KOTA HANDAL

Fig 4.1 M/V KOTA HANDAL

M/V KAZIM GENC:

Fig 4.2 M/V KAZIM GENK

A. AT NO LOAD CONDITION

Area of the ship = 84.80m × 13.60m = 1153.28m2 volume = 1153.28 × 2.5 = 2883.2m3

I = 84.80 × 13.60m3

= 17775.88m GM = BM – BG

= 6.16 - BG BM = I/V

= 1775.88/2883.2

BM = 6.16m

GM = 6.16 - (KG – KB)

= 6.16 (2 - 1.25) GM = 5.4m

GM= 4.9m from the given booklet. B.AT FULLY LOADED CONDITION V= 1153.28 × 6 = 6919.68m3

BM = 17775.88/6919.68 BM=2.56

GM = BM - BG = BM – (KG - KB) = 2.56 – (4.8 - 3) GM = 0.76m

Fig 4.2 M/V KAZIM GENK

Fig 4.3.M/V TENGDA

M/V TENGDA:

BM= I/V

I= $lb^3/12$ = 179.9 x $30^3/12$

= 404775

V= l x B x D

= 179 x 30 x 60 V= 32382m^3

BM = 404775/32382 = 12.5 KB = 3 m

GM = BM - BG BG = KG - KB

= 12.5 - (7.4 - 3)

= 4.4 m

V= 179.9 x 30 x 10.6

= 57208.2m^3

BM= 404775 / 572082

= 7.07m

GM =7.07 - (11.99 – 5,3)

= 0.38 m

M/V IRIS OF THE SEA:

BM = I/V

I= $lb^3/12$ =108.9 ×$18.20^3/12$ = 54709.25

V= L×B×D = 108.9×18.20 × (2.20+5.20/2)m^3

= 7333.326 m^3 KG = 6.65m

BM = 54709.25/7333.326 = 7.46m

GM = BM - BG

= BM – (KG - KB)

= 2.66m when there is no cargo BM = I/V

I = $lb^3/12$ = 108.9 × 18.203/12

= 54209.25

V= l x B x D

= 108.9 × 18.20 × (7.20 + 8.10/2)m^3

= 15162.147 m^3

BM = 54709.25/15162.147 = 3.60m GM = BM - BG

=BM – (KG-KB) =1.825m when it is fully loaded

M\V ALAHMED

Fig 4.4 M/V ALAHMED

BM = I/V

I= $lb^3/12$

= 100.75× $(16)^3/12$

= 409,600/12

= 3.420 m

I = 34133.33m^4

BM =34133.33m^4/9978.28m^3 = 3.420m KB = 6.19/2

= 3.095 m

KG = 5.934 m, taken from ship GM = BM - BG

= 3.420 - (OG - OB)

= 3.420m - (5.934m - 3.095m)

= 3.420m - 2.839 m

= 0.581 m

Metacentric height when the ship is fully loaded with cargo=0.581metre.

When there is no cargo in the ship

(Weight of ship + store + machinery + crew)= 2064 tones Centre of gravity of ship when no cargo = 7.8 meter.

Height of ship when no cargo =7.95 meter. Volume of water displaced = Area × Draft

= (100.75m×16m)×2.1 metre

= 3385.2 m3

I = bd3/12 BM = I/V

= (100.75× (16)^3)/12 => 34389.33m^4/3385.2m^3

= 389.33m

BM = 10.158m KB=2.1/2

= 1.05 metre.

KG=7.8 meter when no cargo.

GM = BM – BG => 10.158 - (7.8m-1.05m)

= (10.158 - 6.75)

= 3.40 m

The metacentric height when no cargo= 3.40 meter.

When the ship is loaded in improper way the center of gravity comes to metacenter GG‟= (W × KG) / (W1 × KG1)

Where

W=weight of cargo

KG=Centre of gravity when there is cargo W1=Weight of ship

OG1=Centre of gravity when empty

M/V RECEP KURU

Fig 4.5 M/V RECEP KURU BM= I/V

I = bd^3/12 I = bd^3/12

= 100×14.5^3/12

= 25405.20m^4 BM=I/V

= 25405.20m^4/4060m^3

= 6.257m.

Distance of the center of buoyancy B from the base point K KB = 2.8/2

=1.4 meter.

KM = KB+BM

= 1.4metre+6.257metre

= 7.657 meter.

Distance of gravity from the base point K KB = 2.8/2

= 1.4 meter.

KM = KB+BM

=1.4 meter + 6.257 meter

KM= 7.657 meter.

Distance of center of gravity from the base point KG = 4.5 meter. KG = 4.5 metre.

BG = KG-KB

= 4.5 metre-1.4 metre

= 3.1 metre. Metacentric height GM = BM-BG

= 6.257 meter- 3.1 meter

= 3.157 meter.

Theoretical Analysis for Time Period of Oscillation:

M/V. Recep Kuru

$T=2\pi\sqrt{(k^2/g \quad GM)}$

$=2\pi\sqrt{(3.5^2/(9.81\times0.925))}$

$=2\pi\sqrt{(3.5^2/(9.074))}$

$=2\pi\sqrt{(7.1350)}$

$=2\pi \times 1.1619$

= 7.30 seconds.

From here we conclude that time period of oscillation is less when there is no cargo so more sagging and hogging takes place when there is no cargo crew member working in ship will fill uncomfortable.

Time period of oscillation $T=2\pi\sqrt{(k^2/g \quad GM)}$ We assume the radius of gyration = 3.5 meter.

Time period of oscillation $T= 2\pi\sqrt{(3.5)^2/(9.81\times 3.157)}$

Time period of oscillation $T=2\pi\sqrt{(12.25/30.97)}= 2\pi\sqrt{0.0395} =1.248$ seconds. Volume of water displaced= Area ×Draft.

Volume of water displaced= 100×14.5×6.29= 9120.5 m^3

Distance of the center of buoyancy B and the metacenter M is given by $BM=I/V=25405.20m^4/9120.5m^3=$ 2.78 meter.

Distance of the center of buoyancy B from the base point O KB= 6.29/2 metre = 3.145 meter.

KM=KB+BM= 3.145metre+2.78 meter= 5.930 meter. Distance of center of gravity from the base point O= 5 meter. KG= 5 meter.

BG=KG-KB= (5-3.145) meter=1.855m

Metacentric height

GM= (BM-BG) m = (2.78-1.855)m=0.925m.

From here we conclude that metacentric height gets reduced when the ship is loaded with full cargo.

4.3 Theoretical Analysis For Drag Force M/V Kota Handal:

It is assumed that the sea is smooth and the ship hull is also smooth. The flow of sea water is assumed to be laminar

Re=ρ×Velocity×length/ (Dynamic viscosity) Density = 1025 kg/m^3 assumed

Dynamic viscosity=0.001(assumed) Re=inertia force / viscous force Re= (1025x2m/s x160)/0.001= CD=0.455/(log10Re)$^{2.58}$-(1700/Re)

CD =0.455/(log10Re)$^{2.58}$-(1700/Re)=0.455/(log10328000000)2.58-(1700/328000000)=0.00181 FD= DRAG FORCE

FD= CD × ½ × ρ × velocity^2 × area FD= 0.00181 × 0.5 ×1025 × 2 × 800

=1484.2 N when it is unloaded drag force FD=CD × ½ × ρ × velocity^2× area

FD= 0.00181 × 0.5 ×1025 × 2 × 1520

FD = 2819.98 N when it is fully loaded

- Percentage increase in drag force of fully loaded condition compared to unloaded condition= (2819.98 - 1484.2)/1484.2
- % drag force increase=0.9 x 100
- % drag force increase =90%

M/V KAZIM GENC:

We assume the sea is smooth and the ship hull is also smooth. The flow of sea water is assumed to be laminar

Re=ρ×Velocity×length/ (Dynamic viscosity Density = 1025kg/m3

Dynamic viscosity=0.001(assumed) Re=inertia force / viscous force

Re= (1025x2x93.2)/0.001=191060000 CD=0.455/(log10Re)2.58-(1700/Re)

Theoretical analysis of drag force

CD=0.455/(log10Re)2.58-(1700/Re)=0.455/(log10191060000)2.58-(1700/191060000)=0.001937 FD= DRAG FORCE

FD=CD × ½ × ρ × velocity2 × area FD= 0.00193 × 0.5 ×1025 × 2 × 800

=1589.13 N when it is unloaded (drag force) FD=CD× ½ × ρ × velocity2 × area

FD= 0.00193 × 0.5 ×1025 × 2 × 1520

FD= 3006.94 N when it is fully loaded

- Percentage increase in drag force of fully loaded condition compared to unloaded condition= =(3006.94 – 1589.13)/1589.13
- % drag force increase=0.892 x 100
- % drag force increase =89.2%
- From here we concluded that the metacentric height gets reduced when it is fully loaded compared to when it is unloaded or no cargo. So there is direct effect of stability of ship when the ship is filled with cargo.

M/V TENGDA

We assume the sea is smooth and the ship hull is also smooth. The flow of sea water is assumed to be laminar

Re=ρ×Velocity×length/ (Dynamic viscosity) Density = 1025kg/m3

Dynamic viscosity=0.001(assumed) Re=inertia force / viscous force Re= (1025x2x180)/0.001

=369000000

$CD=0.455/(\log_{10}Re)^{2.58}-(1700/Re)$

$CD=0.455/(\log_{10}Re)^{2.58}-(1700/Re)=0.455/(\log_{10}369000000)^{2.58}-(1700/369000000)=$ 0.00178 FD = DRAG FORCE

FD=CD × ½ × ρ × velocity2 × area FD= 0.00178 × 0.5 ×1025 × 2 × 800

=1458.8 N when it is unloaded drag force FD =CD× ½ × ρ × velocity2 × area

FD= 0.00178 × 0.5 ×1025 × 2 × 1520

FD= 2771.7 N when it is fully loaded

Theoretical analysis of drag force Percentage increase in drag force of fully loaded condition compared to unloaded condition = (2771.7 –1458.8)/1458.8

- % drag force increase=0.8989 x 100
- % drag force increase =89.89%

From here we concluded that the metacentric height gets reduced when it is fully loaded compared to when it is unloaded or no cargo. So there is direct effect of stability of ship when the ship is filled with cargo.

M/V IRIS OF THE SEA:

We assume the sea is smooth and the ship hull is also smooth. The flow of sea water is assumed to be laminar

Re = ρ×Velocity×length/(Dynamic viscosity) Density = 1025kg/m^3

Dynamic viscosity=0.001(assumed) Re = inertia force / viscous force

Re = (1025x2m/s x108.9)/0.001 = 223245000 CD = $0.455/(\log 10Re)^{2.58}$ - (1700/Re)

CD = 0.455/(log10Re)2.58 - (1700/Re) = 0.455/(log10 223245000)2.58-(1700/223245000)

= 0.001906

FD = DRAG FORCE

FD = CD × ½ × ρ × velocity2 × area

FD = 0.001906 × 0.5 ×1025 × 2 × 800

=1484.2 N when it is unloaded drag force FD = CD × ½ × ρ × velocity2 × area

FD = 0.001906 × 0.5 ×1025 × 2 × 1520

FD = 2819.98 N when it is fully loaded

- Percentage increase in drag force of fully loaded condition compared to unloaded condition=(2819.98 - 1484.2)/1484.2
- % drag force increase=0.9 x 100
- % drag force increase =90%

4.3.5 M/V RECEP KURU

Effect of power produced due to drag force:

Since it is a Bulk carrier there is no wave and eddy drag force. When there is full cargo

Cd=1.41×10-3 for turbulent we assumed CD = Friction drag coefficient.

When the ship is fully loaded.

FD = CD× 1/2ρU0^{2}A = 1.41×10^{-3}×1/2×1.025×(10×0.5148)^2 ×100×6.29 = 12.045KN.

Power required to propel the ship.

P = FDU0 = 12.045×(10×0.5148) = 62.00766KN.

When there is empty CD = 1.41×10^{-3}

FD = CD×1/2 ρU0

2A=1.41×10^{-3}×1/2×1.025×(10×0.5148)^2×(100×2.8)=5.362KN.

P = FD U0 = 5.362×(10×0.5148) = 27.60KN.

In both the cases if we compare when the ship is empty (no cargo) there is less drag compared to when it is fully loaded so here more fuel cost is required.

Effects on drag force produced in container ship:

The ship is fully loaded with cargo

FD = CD×1/2 ρU0^{2}A = 1.41×10^{-3}×1/2×1.025×(10×0.5148)^2×(100. 75 ×6.19) = 11.943KN.

Power required to propel the ship when it is fully loaded with cargo = 11.943×(10×0.5148)

= 61.482KN.

The ship is empty without cargo

FD = CD×1/2 ρ$U0^2$A=1.41×10^{-3}×1/2×1.025×$(10×0.5148)^2$×(100. 75 ×2.1) = 4.051KN.

Power required to propel the ship when it is empty without cargo P = FDU0 = 4.051×(10×0.5148) = 20.8545KN.

In both the cases if we compare when the ship is empty (no container) there is less drag compared to when it is fully loaded so here more fuel cost is required.

Weight of The Ship When There Is No Cargo & Ballast Iris Of Sea

With cargo and ballast when it is fully loaded

- Weight increased due to ballast condition = 10512mt – 9100 ton

  =1412 ton

- Weight of the ship when there is cargo and ballast condition

  = 8000 +1412ton

  =9412ton

- Volume = 108.9×18.20×900

  =17837.82m^3

- BM =3.067m
- GM =3.067 – (6.5884 – 4.5)

  =0.9786m so the ship became stable **EFFECT OF FUEL CONSUMPTION M/V IRIS OF THE SEA**

- FUEL CONSUMPTION when there is no cargo = 5.0 tons
- FUEL CONSUMPTION when it is fully loaded with cargo= 5.5 tons
- These are the fuel consumed for the same distance taken from visited ship
- Extra fuel is consumed when it is fully loaded with cargo=0.5 tons
- Cost of fuel increased due to more consumption of fuel %=10 % nakfa

EFFECT OF IMPROPER WAY OF LOADING CARGOES M/V ALAHMED

- When the ship is loaded in improper way the center of gravity comes to metacenter
- GG‘‘= (W×OG)/(W1×OG1)

When

W=weight of cargo

OG=Centre of gravity when there is cargo W1=Weight of ship

OG1=Centre of gravity when empty

- GG‘‘= (5151×5.934)/(2064×7.8) metre=1.89 metre.
- The metacentric height due to improper loading
- **G’M=GM-GG’**=3.40 metre-1.89 meter=1.51 meter.
- From here we find that metacentric height gets reduced to 1.51 so this is the main cause of ship

becoming unstable if ship is loaded in improper manner

Conclusion and Recommendation:

Conclusion:

It has been concluded that ship should not be fully loaded with cargo because

company can face disastrous consequence of ship becoming unstable. Ship should not be fully unloaded with cargo the crew members working in ship can feel uncomfortable due to reduction of time period of oscillation in bad weather condition which can also effect the stability of ship. Ballasting should not be done when the ship is fully loaded with cargo as it can reduce the stability of ship. It has been surveyed and found out that all crew members working in ship are not having proper knowledge of the stability effect of ship under various loaded condition. Many ships are not having stability booklet where metacentric height at various loaded conditions are written. There should be proper surveyor to check whether ships are having stability booklet at which metacentric height at various loaded conditions are written. Awareness in marine society should be given of the effects of stability of ship under various conditions.

Recommendation:

1. Give idea to the unskilled people of marine society about ship stability and how it affects ship structure.
2. How the ship stability does affects engine performance.
3. Study of design of ship which is best suited in adverse weather condition.

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