Covenant Journal of Engineering Technology (CJET)Vol. 2, No. 2, Dec.. 2018

An Open Access Journal Available Online

Analysis of Ship Operation Safety within the Harbor under the Effect of Wave

Samson Nitonye[1] & Thaddeus C. Nwaoha[2]

[1]Department of Marine Engineering,
Rivers State University,
Nkpolu, Port Harcourt. Nigeria
[2]Department of Marine Engineering,
Federal University of Petroleum Resources,
Delta State Nigeria

Abstract: This research present the wave impart analysis on the operational safety of cargo ship in harbor and it effect on a mooring line system. From the analysis using MATLAB program the wave formed velocity in horizontal direction show a 1% decrease from (0.1 to 8m) of the water depth and the velocity in vertical direction show 2% increase from (0.1 to 8m) of the water depth. The acceleration in horizontal direction show 2% increase from (0.1 to 8m) of the water depth and the acceleration in vertical direction show 2% decrease with from (0.1 to 8m) of the water depth. The wave load on the mooring line between two anchors (A and B) of 1059m suspended length (Ls) is 200KN with horizontal restoring force at the Fairland (TH) of 1200KN which increase the tension by 250KN and causes the Fairland shift by 0.54m. This resulted to a reduction in mooring anchor XB to 498.96m and XA to 500.04m. The analysis also shows that the rate of water particle velocity and acceleration due to wave effects decrease with increase water depth, and the combined effect will cause damage to the catenary mooring line in extreme significant waves height and period. Sudden and critical tension on the chain and anchor A and B may set under this environmental load. The stability and dynamic positioning of any floating vessel is essential during offshore activities in the harbor. Therefore, it is necessary to carryout mooring system analysis and monitoring for safe ship operation under environmental wave load in the Harbor.

Keywords –SWATH, Resistance, Propulsion, Catamarans, Hull, Velocity and Vessel

1. Introduction

The function of a harbour is to provide safe anchorage for vessels and to facilitate smooth transfer of cargo between ship and adjoined land. Assured harbour tranquility is not on essential for safe anchorage, but it is also important for efficient port operation. Essentially, harbor tranquility reduces to the excitation of ships moored at anchorage or along a wharf and optimizes the mooring forces. Larger ships may not experience wave agitation to the wind-waves, whereas a small boat may be violently swung by the same wave [1].

In the viewpoint of port operation, the relationship between ship motion and cargo handling works as well falls in the judgment of harbor tranquility. Hence the use of constant tension winches and the stiffness and friction of the fenders, can have a very large influence on the resulting ships motions, the surge motion external forces from wind, waves and or currents [2].

2. Description of ship behavior at berth.

The movement of a moored ship at berth can be described by the three translator movements, namely surge, sway and heave, and the three movement of rotation, known as pitch, roll and yaw. This project is to determine the effective waves forces acting on the ship mooring line during anchorage at harbor; to determine the various load on ship at Harbor; to determine mooring effect on ship at harbor and to determine safety precautions for ship under wave.

2.1. Basic definitions of forces acting on a vessel at Harbor

Some forces act on a vessel at harbor. The forces are berthing forces, current force, seismic force, active earth pressure, mooring forces. The forces are described as follows:

2.1.1. Berthing Force

Horizontal forces act on the berth, whenever a vessel impacts on the berth anytime of the year. The strength of this force wholly depends on the energy in motion that can be absorbed by the fender system. The design vessel will be contacting the fenders at an approach angle of 100. Therefore, the impact as a result of berthing of the ship is at quarter point. When the berthing takes place, the fender system absorbs energy in motion and converts it into strain energy, thereby passing on a reaction force to the structure and the reaction force for which the berth is to be designed can be revealed from this process and deflection-reaction diagrams of the fender system selected [3].

2.1.2. Current Force

Currents can be described as the relatively constant motion of water caused by tidal action, wind drag, or river discharge. The most common currents considered in offshore structural analysis are tidal currents and wind drift currents. The later is generated from the drag of local wind on the surface of the water. The tidal and wind drift currents are regarded as horizontal and varying with depth. When vessel is fully loaded, pressure usually applies to the part of the vessel below the waterline dues to currents. The part of the vessel covered is approximately equal to wv2/2g per square meter of the part, where v is the velocity in m/s and w is unit weight of water in t/m2. The vessels usually berths parallel to the current. On harbor parallel to the direction of the water current, there are two types of ocean current, the surface circulation current and the deep circulation current [4].

2.1.3. Seismic Force

In areas susceptible to seismic disturbance horizontal force equal to a friction of the acceleration of gravity times the weight applied as its centre of gravity should be taken. The fraction will depend upon the likely seismic intensity of the area and shall be taken in accordance with IS: 1893-2002. The weight to be used is the total dead load plus one half of the live load [5].

2.1.4. Active Earth Pressure

This type of force is applicable only if the berth has a retaining wall at the landside, thus retains the earth. Active earth pressure is experienced in situations where the wall moves sufficiently away from the backfill by translatory motion, rotation about the base or their combination, which reduces lateral pressure of the backfill. Active earth pressure does not occur in jetty or pier.

2.1.5. Mooring Force

The mooring loads are the lateral loads caused by the mooring lines when they pull the ship into or along the dock or hold it against the forces of wind or current. The load on ropes caused by winds or currents, acting on the ship during berthing cannot be estimated with accuracy. Factors such as tensioning of the rope and its angle to the berthing line are considered during such estimation exercise. Thus, mooring force will be two types; Wind force and Current force [6]. Ships are moored at berth, when the followings below are available.

- Mooring lines connecting ships to berths
- Bollards and storm bitts on shore
- Mooring hooks on mooring and breasting dolphins.
- Fenders between ship and berth
- Mooring winches and bollards that is onboard the vessels to be moored.

2.1.6. Wave force

The periodic undulation of the sea surface is known as waves. The complexity of motion of the waves is a major challenge to workers in the ocean environment. Waves cause fatigue type of loading on offshore and exposed coastal structures. They adversely affect coastlines and harbor facilities and induce violent motions in moored ships and floating structure [7].

2.2. Criteria and Framework of Vessels at Harbor

In analysis of ship operations at harbor, port and harbor risk assessment criteria, frequency criteria, defining the framework for marine risk assessment

2.2.1. Port and Harbor Risk Assessment Criteria

The risk assessment criteria for port and harbor need to be known, so as to provide guidance for the assessment exercise. They are recommended because they provide a consistency of standard for all ports and harbors. However, consideration should be given to modification of one scale should circumstances at a particular harbor or port demonstrate the need [8].

2.2.2. Frequency Criteria

The frequency component of risk is usually considered based on per-movement basis or a simple per-annum basis. Where ports or harbors have a larger number of movements, a per-movement scale can be considered as this provides a simple set of criteria for reporting safety performance once the safety management system is established. Risk and safety management software can be used to detect a per-movement and a per-annum frequency scale at any stage.

2.2.3. Defining the Framework for Marine Risk Assessment

The framework for any marine risk assessment logically needs to follow the established Formal Safety Assessment (FSA) marine incident categories that are relevant to assessment in a port or harbour. These are Collision, Contact (which can include a sub-category of Berthing Contact), Grounding, Loss of Hull Integrity, Fire/Explosion, Equipment Failure (Often a cause of other accident categories) and Personal Injury.

Collision and contact differentiation as incident categories is vital. The definition of collision is obvious. Contact is associated with incidents involving the vessel striking something fixed, such as a navigation aid or heavy landing on a berth, or a bar harbor, or a bridge structure or deck.

The port or harbor then needs to be categorized into appropriate areas for the risk assessment. Areas are selected partly around natural topographical features, such as channel extents, but also very much around the marine activities associated with an area. Selection of areas is important if the Port and Harbor Safety Management System is considered. Under the Port and Harbor Safety Management System, risk can be expressed by area if wanted and risk management can also be targeted by area. Areas are depicted on the chart as Area A; Area B, etc, and for a key categorization for the hazard identification process.

Vessel types then need to be defined associated with the trades of the port or harbor. It is appropriate to consider primary and secondary types during such definition exercise. For example, a primary category of “Tankers” can have sub-categories of LNG; Chemical (MARPOL Annex II); Product.. Passenger vessels can also be categorized in the same way, as can leisure craft in a harbor with different leisure activities ongoing [9].

2.3. Hazard Identification Process

Hazard identification is the most important step of risk assessment process. An overlooked hazard is more likely to introduce error into the overall risk assessment of a port or harbor, than an inaccurate assessment of frequency or consequence identified hazards. Errors made in assessing consequence and frequency of hazards can cancel each other out over the full spectrum of incidents The omission of a hazard can result in an underestimation of the overall risk profile. Moreover, important risk control may not be introduced to properly manage the risk, resulting in an accident waiting to happen [10].

2.4. The Port and Harbor Safety Management System

The successful introduction of a working Port and Harbor Safety Management System is not a small task and the time-scales needed to achieve this should not be underestimated. From experience of harbors and ports generally, the process often involves organizational change which will only occur if undertaken in a measured and planned way [11].

Policy is set at the top of the organization, with identified roles and responsibilities to discharge the policy being designed next. The new or changed risk control options and procedures originating out of the risk assessment process then follow. A key component is intelligence, which is kept refreshed by ongoing consultation with users and from the results of audit or review. Feedback from users of the safety management system significantly enhances intelligence, but only if the climate within or between organizations facilitates the information flow. If the feedback information flow is good, then the safety management system can provide an open and proactive feed-forward flow of information to all [12].

2.5. Navigation safety policy A D V I

This section takes the form of a declaration of the overall navigational safety policy objectives. Typical stated objectives are [11]:

i. Comply with all legal duties and responsibilities for the regulation of vessel traffic and the safety of navigation.
ii. Develop and maintain an effective Safety Management System based on the continuing assessment and mitigation of risk.
iii. Maintain access to port services, by ensuring the provision of appropriate pilotage, traffic management, towage, and berthing services.
iv. Develop a consensus for safe navigation through stakeholder input.
v. Ensure that suitable anchorages, mooring locations and the best channels for navigation, are determined, marked, monitored and maintained.
vi. Sustain its harbour management functions in respect of hydrographic surveying, navigation, dredging, and the provision and maintenance of navigation aids.
vii. Remove sunken vessels and other obstructions that are, or may become, an impediment to safe navigation
viii. Promulgate relevant navigational, tidal and weather information to all port users as determined by the risk assessment.
ix. Facilitate the leisure use of the port, maintaining and protecting the rights of the public to access its waters for leisure use, whilst complying with the various navigational safety measures that may be in force.
x. Create awareness and motivation of all port users with respect to safety and the protection of the environment.
xi. Publish and maintain contingency plans to cover emergency situations relating to the safety of life, property or the environment.

xii. Maintain appropriate emergency and oil spill response capabilities.
xiii. Ensure that all port or harbor operational staffs are trained to recognized standards and have appropriate experience for their roles and duties.
xiv. Ensure that working craft, including tugs, pilot boats and work boats are fit for their purpose and operated to appropriate safety standards.
xv. Review regularly duties and powers required to support and maintain an up-to-date set of bylaws in respect of navigational safety and enforce them so as to effectively regulate and facilitate harbor use.
xvi. Keep under review the cost effectiveness of modern

3. Material and Methods

This research will focus on methods use in the analysis of waves acting on ship within the harbor. Mooring equation will also be utilized in calculation of the forces and tension acting on mooring line. Such exercise will be facilitated using a MATLAB software.

3.1. Wave Theory

There are many wave theories that are useful in the design of offshore structures such as linear/airy wave theory, second-order stroke wave theory, fifth-order stroke wave theory and the stream function theory. This research is focus on linear/airy wave theory [13]. The parameters that are needed in describing any wave theory are:

i. Period (T), which is the time taken for two successive crests to pass a stationary point [14].
ii. Height (H), which is the vertical distance between the crest and the following trough [14].. For a linear wave, the crest amplitude is equal to the trough amplitude, while they are unequal for a non-linear wave [14].
iii. Water depth (d), which represents the vertical distance from the mean water level to the mean ocean floor [14]. For wave theories, the floor is assumed horizontal and flat [14].
iv. Wavelength (L), which is the horizontal distance between successive crests [14].
v. Wave celerity or phase speed (c), which represents the propagation speed of the wave crest [14].
vi. Frequency (f), w which is the reciprocal of the period [14].
vii. Wave elevation (β) which represents the instantaneous elevation of the wave from the still water level (SWL) or the mean water level (MWL) [15].
viii. Horizontal water particle velocity (u), which is the instantaneous velocity along x of a water particle [14].
ix. Vertical water particle acceleration (G), which is the instantaneous acceleration along x of a water particle [14].
x. Vertical water particle acceleration (G), which is the instantaneous acceleration along y of a water particle [14].
xi. For the linear wave theory, the wave has the form of a sine curve and the free surface profile is written in the following simple form: $\mu = a\sin(kx - wt)$ [14].
xii. Crest the top of the wave [14].

3.2. Linear/Airy Wave Theory

The simplest, but very useful wave theory is the linear or small amplitude wave theory, which assumes that the wave amplitude is small compared to the wavelength [16].

The linear wave theory is also called the first-order theory because one can neglect terms that are above first order when expanding the solution in a perturbation series. The wave profile are then assumed to be expanded in power series of a non-dimensional perturbation parameter, £, in terms of the wave slope at the zero-down crossing of the wave [17].

3.3. Finite Water Depth

Velocity potential

$$\emptyset = \frac{g\zeta_a \cosh k(z+d)}{\omega \cosh kd}\cos(\omega t - kx) \quad (1)$$

Dispersion relation

$$\frac{\omega^2}{g} = k\tanh\, kd \quad (2)$$

Wave length $L_0[(\frac{2\pi d}{L_0})]^{1/2}$ (3)

Wave elevation $\zeta = \zeta_a \sin(wt - kx)$ (4)

Dynamic pressure

$$P_D = \frac{\mu y\zeta_a \cosh k(z+d)}{\cosh kd}\sin(\omega t - kx) \quad (5)$$

Velocity in x -

$$u = \omega\zeta_a \frac{\cosh k(z+d)}{\sinh kd}\sin(\omega t - kx) \quad (6)$$

Direction Velocity in z –

$$w = \omega\zeta_a \frac{\sinh k(z+d)}{\sinh kd}\cos(\omega t - kx)$$

(7)

Direction Acceleration in x–axis

$$a_x = w^2\zeta_a \frac{\cosh k(z+d)}{\sinh kd}\cos(\omega t - kx) \quad (8)$$

Acceleration in z- axis

$$a_z = -w^2\zeta_a \frac{\sinh k(z+d)}{\sinh kd}\sin(\omega t - kx)$$

(9)

Where; Angular wave ω = 2π/T, Wave number k = 2π/λ, Λ is the wave length, T = wave period, Ca = wave amplitude, g = acceleration of wave due to gravity, t = time, x = direction of wave propagation, z = vertical coordinate, d = water depth, Total pressure in the fluid $= p_d - pgz + p_o$ and p_0 = atmospheric pressure

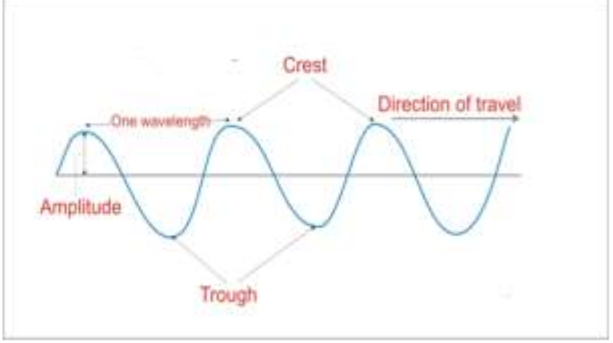


Figure 1: Transverse wave [17]

3.4. Catenary Mooring Line Equation

Catenary moorings are common in oceanographic, metrologic and offshore applications. These systems accommodate current, wind, tides, and wave induced deformations by lowering and lifting excess line to and from the sea floor. It can play an important role in the dynamic response of the system [20].

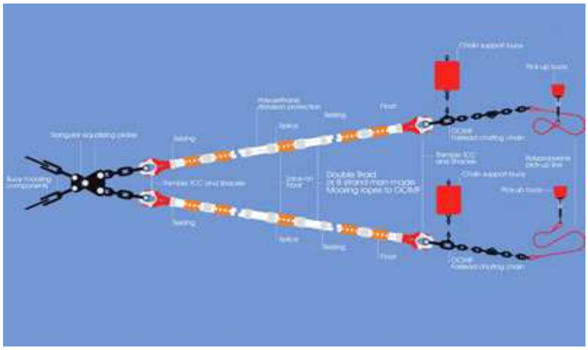


Figure 2: Single point mooring system [21].

A single point mooring system is used to connect all the lines to a single point. It links sub-sea manifolds connections and weather running tankers, which are free to rotate 360 degrees. A buoy, mooring and anchoring elements are the single point system. Tension acting on the mooring rope can be calculated using formulas as follow [22].

Suspended line length

$$Ls = a\,Sinh\left(\frac{x}{a}\right) \quad (10)$$

Vertical dimension (depth)

$$h = a\left\{cosh\left(\frac{x}{a}\right) - 1\right\} \quad (11)$$

Where parameter $a = \frac{T_H}{W}$

Using line tension at the platform

Tension at the top is

$$T = W\,\frac{(L^2 s + h^2)}{2h} = \sqrt{{T_H}^2 + {T_z}^2} \quad (12)$$

$$T_H = T\cos(\theta_w) \quad (13)$$

Maximum tension $T_{max} = T_H + wh$ (14)

We have the minimum limit length

$$L_{min} = \sqrt[n]{2\frac{T_{max}}{wh} - 1}$$

Requirement $T_{max} \leq T_{br}$ (15)

(Breaking strength/tension in mooring line).

$$X = L - Ls + x \quad (16)$$

$$X = L - h\sqrt{\left(+\frac{2a}{h} + \propto \cos^{-1}\left[1 + \frac{h}{a}\right]\right.} \quad (17)$$

$$X = L - h\sqrt{\left[1\,\frac{2T_H}{wh} + \frac{T_H}{w}\right] + \cosh^{-1}\left[1 + \frac{wh}{T_H}\right]} \quad (18)$$

$$X = cosh^{-1}\left[1 + \frac{h}{a}\right] \quad (19)$$

Definition of parameters

Ls = Suspended line length

h = Vertical dimension (depth)

T_H = Horizontal restoring force applied by the mooring lines

T_z = Vertical component of tension

T_{max} = Maximum tension

T = Tension at the top

W = Weight per unit length of cable in water

L_{min} = Minimum line length

a = Horizontal dimension

Sin h and Cos h are parabolic function

Wave parameters

Wave heights (H) - - - 2m

Water depth (d) - - 8m

Wave period - - - 6.5m

For shallow water 6.5x8.86

$L = {}^{T}/\sqrt{gd} = \frac{6.5}{\sqrt{9.81 \ x \ 8}} = 6.5x8.86 = 57.6$ m

Intermediate water depth

$I = L_o \left[\left(\frac{2\pi d}{L_o}\right)\right]^{1/2} = 67 \left[\left(\frac{2\pi \ x8}{67}\right)\right]^{1/2}$

= 58m

For deep water

$L_o = {gT^2}/{2\pi} = \frac{9.81 x (6.5)^2}{2 x \pi} = 65.97m = 67m$

Table 1 Wave parameters

Parameter	Formula	Calculation	Result
Wave frequency (w)	$\frac{2\pi}{T}$	$\frac{2 \ x \ 3.142}{6.5}$	$0.97 \ {}^{rad}/_{sec}$
Wave length (λ, L)	$L_o \left[\left(\frac{2\pi d}{L_o}\right)\right]^{1/2}$	$67 \left[\left(\frac{2 \ x3.142 \ x \ 8}{67}\right)\right]^{1/2}$	58m
Wave speed (c)	$\frac{L}{T}$	$\frac{58}{6.5}$	8.92m/s
Wave number (K)	$\frac{2\pi}{L}$	$\frac{2 \ x \ 3.142}{58}$	0.11
Amplitude (a)	$\frac{H}{2}$	${}^{2}/_{2}$	1
Time (t)	$\frac{3T}{4}$	$\frac{3 \ x6.5}{4}$	4.88(sec)
Frequency (f)	$\frac{1}{T}$	$\frac{1}{6.5}$	0.15 H_2
Wave length (L)	${}^{C}/_{F}$	$\frac{8.92}{0.15}$	59.47 = 60m

Table 2: Parameters of wave calculated

Parameters	Values	Units
Wind velocity	0	(m/s)
Wave length (λ, L)	58	(m)
Wave number (K)	0.11	
Wave length (L)	60	(m)
Amplitude (a)	1	(m)
Time (t)	4.88	(s)
Wave speed (C)	8.92	$(\frac{m^2}{s})$
Wave frequency (w)	0.97	(rad/sec)
Wave height (H), (x)	2	(m)
Water depth(d)	8	(m)
Wave period (T)	6.5	(s)
Density of water (e_s)	1.025	Kg/m^3
Frequency (f)	0.15	Hz
Design current speed U_C		

Velocity U_x Direction

$$U_x = w\zeta_a \frac{\cosh K(Z+d)}{simhkd} sim(wt-kx) = 1.08\ m/s$$

Velocity in Z Direction

$$U_z = w\zeta_q \frac{Simhk(Z+d)}{simhkd} \cos(wt-kx) = 1.76\ m/s$$

Acceleration in x Direction.

$$A_x = w^2\zeta_q \frac{\cosh K(z+d)}{simhkd} \cos(wt-kx) = 1.32\ m/s^2$$

Acceleration in Z Direction

$$A_z = w^2\zeta_q \frac{simhk(z+d)}{simhkd} sim(wt-kx) = 0.58\ m/s^2$$

Mooring Data

This mooring system lines are designed to stabilize the portion for the storage or fuel offshore with design specification of net Norske veriths.

Length of anchor chain (L) = 500M

Number of anchors used = 2 anchors

Horizontal pretension TH = 150KN

Weight of anchor in water (W) = 1000 N/M

Height of water depth (h) = 100m

Length of work barge LP = 60m

Breadth of work barge B_p = 25m

Height of work barge HP = 4m

From the figure, the distance is (2x +Lp) in

Using expression

X = L – Ls + x

Where $L_2^2 = h^2 + 2ha$

$$a = \frac{TH}{W} = 150m$$

$$L_s^2 = (100)^2 + 2 x 100 x 150$$

Ls = 200m

Calculate for the value of x the suspended length

$$L_s = a\, smh\left(\frac{x}{a}\right)$$

X = 199.5m

X = L – Ls + X = 499.5m

Distance between two anchor A & B
(2x + Lp) m = 1059m
Hence
The distance from anchor A and B is
= 1059m
L_{min} = 0.00697m
Vertical force at the fairlead Tz = WLs
Tz = 1 x 200 = 200KN
Tension at the top

$$T = \sqrt{T_h^2 + L_s^2} = 250 \text{ KN}$$

:. Max tension at the top
Tmax = TH + Wh
Tmax 250 KN

$$a = L_s^2 = \frac{(L^2 - h^2}{2h} = 1200\text{m}$$

new a = 1200m
New Th = horizontal pretension
T_h = aw = 1200 KN
New X_a due to mo vena is from

$$\frac{L_s}{a} = 5m\,h\left(\frac{XA}{a}\right)$$

Xa = 500.04 m
Hence the Fairland moved a distance (500.04 – 499.5) m = 0.54m

The initial pretension
TH = 1200 KN
X = 300.54m
This movement causes reduction in X_B by 499.5 – 0.54, XB = 498.96m
New X_B for anchor B the effective environmental force on the anchor A that will cause this now X_B = 499m on anchor B.

4. Results and Discussions

The water particle velocity and acceleration are calculated using a MATLAB program.

Table 3: Combined wave and current velocity

Water depth	Velocity x direction ux	current velocity uc	Total Velocity Ut = Ux + Uc
0	1.74	17.40	19.14
-1	1.72	17.40	19.12
-2	1.69	17.40	19.09
-3	1.63	17.40	19.03
-4	1.55	17.40	18.95
-5	1.46	17.40	18.86
-6	1.35	17.40	18.75
-7	1.22	17.40	18.62
-8	1.08	17.40	18.48

Table 4: Velocity and acceleration values

Water depth	Horizontal Velocity Ux	Vertical velocity Uz	Horizontal acceleration Ax	Vertical acceleration Az
0	1.74	0.02	-0.04	0.94
-1	1.72	0.13	-0.22	0.93
-2	1.69	0.23	-0.40	0.91
-3	1.63	0.33	-0.58	0.88
-4	1.55	0.43	-0.75	0.84
-5	1.46	0.52	-0.91	0.79
-6	1.35	0.61	-1.06	0.73
-7	1.22	0.69	-1.20	0.66
-8	1.08	0.76	-1.32	0.58

Table 5: Horizontal restoring force and draft

Draft d/L (m)	Horizontal restoring force applied by the mooring line tension T_H (KN)
100	240
200	480
300	720
400	960
500	1200

Figure 3: Graph showing increase in total velocity and increase in water depth

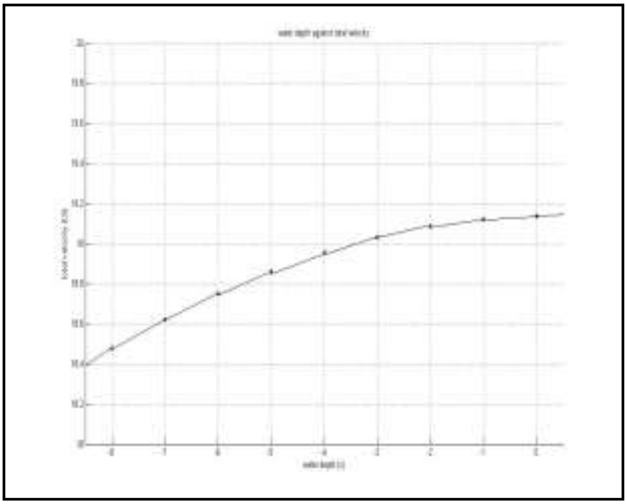


Figure 4: Graph showing increase in horizontal and vertical acceleration with increase in depth

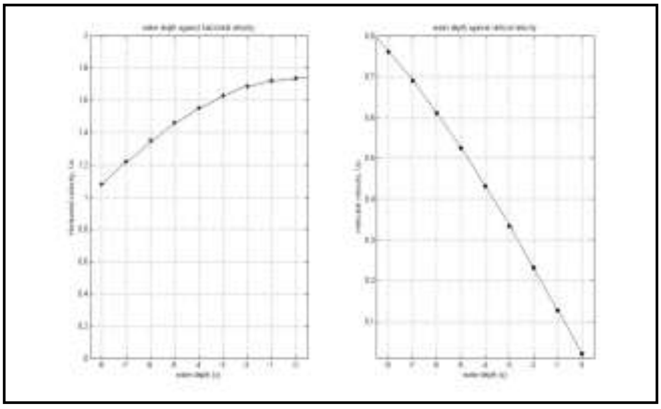
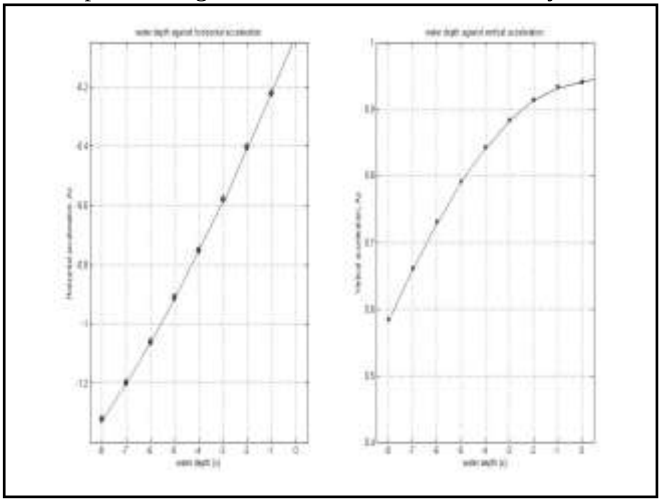
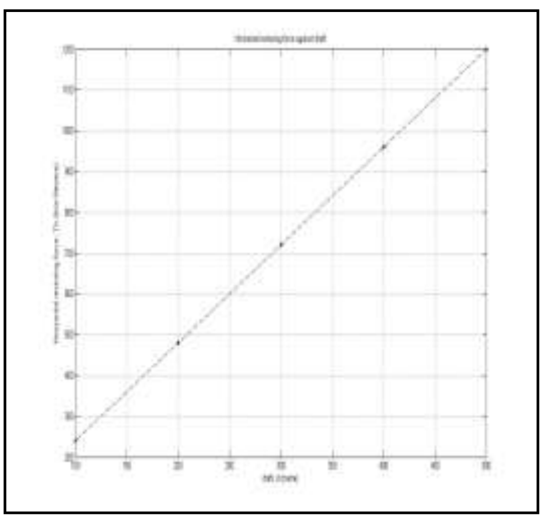


Figure 5: Graph showing horizontal and vertical velocity



The graph above shows the vertical and horizontal change in velocity against the water depth, however if the water depth started increase gradually it will result to increase in the horizontal velocity of the wave particles

Figure 6: Graph showing tension forces against draft of a mooring line



From the result on table (4) and (3) shows that the water particles velocity and acceleration values decrease with increased in water depth. Therefore, any vessel in deeper water will suffer higher velocity an acceleration of water particles compared to that in low water surface therefore vessel in low water depth will experienced higher wave the water particles, velocity and acceleration in low water surface, therefore vessel in low water depth will experienced higher wave.

The water particles, velocity and acceleration in low water depth will result to increase in wave frequency, period and wave celerity with respect to the vessel.

Table (5) shows horizontal restoring force applied by the mooring lines system and the suspended line length (draft).

There will be linear increase of the tension force with respect to increase in draft the wave forces acting on a vessel with connected chain to sea bed by mooring line will increase the tension on the chain.

The figure (3), (4), (5), (6) will help to detect the effect of wave forces and tension acting on each mooring line. This project will help to deduce tension, stiffness and provide stability to the vessel in harbour.

Acknowledgement

The authors acknowledged the contribution of Stanley Atausen Dan and Sidum Adumene in this research.

4. Conclusion

The analysis of wave effect on ship and its safety operation in the harbor are mostly ignored due to lack of equipment or may be lack of expertise to carryout designing test or collection of data. This research provides an understanding of the effect of waves acting loads on the ship, the mooring line and how it should be integrated in the analysis of the mooring system. The analysis presented here shows that catenary system is not best suitable for deep waters application, especially in swell waves scenario. Turret mooring system provide an alternative to deep and ultra-deep-water mooring system. The effect of wave acting on a vessel in anchorage and operation at harbor are mostly ignore by the harbor masters. This research provide insight into wave effect on ship at harbor and careful monitoring of the wave formation, the heading angle and the effect on the mooring line is necessary for the stability of the vessel. In extreme waves, cargo offloading, and transfer may be hindered, therefore an operational risk analysis is presented here to understand the effect of wave on ship operation in the harbor.

References

[1] Jitendra K. Panigrahi, C.P. Padhy, A.S.N. Murty. "Inner harbour wave agitation using boussinesq wave model", International Journal of Naval Architecture and Ocean Engineering, 2015

[2] Nitonye, S., and Ofanson Uyi (2018) Analysis of Marine Pollution of Ports and Jetties in Rivers State, Nigeria, Open Journal of Marine Science, 8, 1, 114-135.https://doi.org/10.4236/ojms.2018.81006 http://www.scirp.org/journal/ojms

[3] Bruun, P., Marine terminal technology. Winch berthing and mooring. Recent developments. Advances in berthing and Mooring of Ships and offshore structures, NATO ASI Series E: Applied Sciences vol.146, 1988.

[4] Chakarabati, S. Mooring Design: Fit-for-purpose mooring systems. Newcastly University, Pp. 2, 9, 14, 12, 25, 26, 46, 47, 54, 54.

[5] Sakpaya, T., Isaacson, M. (1981). Mechanics of wave force on offshore structure. New York: Van Nostrad Reinhold.

[6] Inegiyemiema, M., **Nitonye, S.**, Dick, I. F. & Erekosima, A. (2014). Design of a mooring system for an offshore structure (A case Study of 5000-tonnes Offshore Work Barge [WB]). *International Journal of Engineering and Technology*, 4 (12), 683 – 692. (http://www.ijet.journal.org)

[7] Himesh B. Chopra and Patal P.G. (2015) Application of Forces Acting on Jetty Structure, International Journal of Science Technology & Engineering 01, 11, www.ijste.org

[8] Venice (2012), SAFE ADRIA Project (Action-Plan) http://www.cfli.it/venezia

[9] Umo Iduk and **Nitonye Samson**, (2015). Effects and Solutions of Marine Pollution from Ships in Nigerian Waterways, *International Journal of Scientific and Engineering Research, (IJSER) India* Vol.6 No: 9, pp 782 - 792 http://www.ijser.org

[10] Soares, C.G and Carvalho, A. (2003). Probability distributions of wave height and periods in measured combined sea-states from the Portuguese coast. Journal of Offshore mechanics and Arctic Engineering, 125(3):198-204.

[11] Kia Maanu Kia Ora (2004) Port & Harbor Risk Assessment and Safety Management Systems in New Zealand (Maritime Safety Authority of New Zealand) available online www.maritimenz.govt.nz

[12] Maritime Resolve (2015) Operations Plan and Safety Management System, available online http://www.weymouth-harbour.co.uk 01/06/2018

[13] Hussein, K, A Hussein, E Hegazy, and An Amin. (2013) "Structural design of a floating foundation for offshore wind turbines in red sea", Analysis and Design of Marine Structures.

[14] CHAKRABARTI S. (2005) "Ocean Environment", Handbook of Offshore Engineering.

[15] Thomas, T.J. and Dwarakish, G. (2015). Numerical wave modeling-a review. Aquatic procedia, 4:443-448.

[16] Yinglong Zhang (1994). "New solutions for the propagation of long water waves over variable depth", Journal of Fluid Mechanics.

[17] Jonas Anderson (2011) Simulation of Wave Induced Forces on Semi Submerged Horizontal Cylinders Using OpenFOAM, Department of Shipping and Marine Technology *Division of Sustainable Ship Propulsion* CHALMERS UNIVERSITY OF TECHNOLOGY Göteborg, Sweden 2011 http://publications.lib.chalmers.se/records/fulltext/151295.pdf

[18] Subhabrata Gangopadhyay, Uma Basu (2013), Scattering of Water Waves in an Ocean of Finite Depth having a Surface Discontinuity with an Icecover on One Half and Free Surface Subject to Surface Tension on the Other. International Journal of Scientific & Engineering

Research Volume 4, Issue3 https://www.ijser.org

[19] Kreuzer. E."Nonlinear dynamics of ship oscillations", 2000 2nd International Conference

[20] Rickson Viahul Rayan (2016) Calculation for Mooring Systems, Available online https://www.scribd.com/doc/84643736/DDS-582-1-Calculations-for-Mooring-Systems-1

[21] Rigzone (2017) How do Mooring System work, available online www.rigzone.com/training/insight 01/06/2018

[22] LI, R., ZHANG, S., and ZHANG, Y. (2005). Comparison between characteristics of mild slope equations and boussinesq equations.