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MOTION CHARACTERISTICS OF A RESEARCH VESSEL FOR SHORT-TERM VOYAGE

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ABSTRACT

All floating bodies are subjected to 6 degree of freedom due to various encountering forces. The design challenge lies in reducing the excessive ship behaviour and design a comfort class ships. Research vessel in specific to be design to best comfort since they can have used by non-seafarers. This paper shows the study on motion characteristics of the vessel where the real-time data measured from the newly built coastal research vessel. The data is obtained from the ships Motion Response Unit for the entire duration of the voyage which is approx. 6 hr. 30 mins. The results obtained indicate a peak roll amplitude of 12.03 Degree and average of 6.0 degree. The peak heave motion obtained 1.8m, pitch of 4.39 degree, surge of 3.9 and, sway of 7.6m. The results obtained indicate that the vessel behaved in a normal condition within the acceptable criteria in the sea state 3 which favourable for carrying out scientific activities. The dampening devices like the bilge keel, Anti-roll tank and other devices helped in improving the vessel performance.

Keywords: Research vessel, sea state, roll, pitch, heave, acceptable criteria.

for short term voyage is analysed.

2 INTRODUCTION

The International Maritime Organization (IMO) decided to revise its intact stability criteria because the current criterion is not applicable to the current ships topology. The present criterion was statistically developed based on the ships topology four decades ago. The criterion is also very difficult to revise because it's prescriptive nature. Therefore, some delegations in IMO proposed that the new generation of the criteria should be developed in performance based one [1].

The 6 degree of freedom is the most important factor for the safe voyage of all types of ships in terms of sea condition [2]. To determine the motion characteristics of a ship. It is necessary to know the characteristics of each term relating to hydrodynamic and hydrostatic force.

In all the 6 degree of motions, the roll motion will play a very important role for large amplitude roll motion in resonance causes capsizing of a ship. When it comes to heave, pitch, sway and yaw, the wave damping is dominant and the viscous damping components can be usually ignored [3]. The theoretical calculation is difficult to predict the roll damping.

From the stability point of view it's very important to determine all 6 degrees of motion and its effects on the ship at the different sea states and weather condition [4].

In the present paper, the response or motion characteristics of a newly built coastal research vessel

1.1 SHIP PARTICULARS

Table- 1: Ship particulars

Length	43 m
Length BP	39 m
Beam Mld	9.6 m
Depth up to main deck	3700 mm abl
Draft (Moulded)	2.5 m
Draft (Scantling)	2.65 m
GRT	< 500
Endurance	15 days
Fuel Capacity	66.16 m ³
Fresh water Capacity	20.8 m ³
Lube Oil Capacity	2.4 m ³
Classification	IRS
Officers and Crew onboard	12
Scientists on board	8
IMO No	9867205
Official No	4580
Call Sign	VTAQ
MMSI	419001421

2. Motion Reference Unit:

Operating the vessel at sea is highly challenging activity, because of the various encountering forces and weather conditions. So, it is necessary to measure the roll, pitch, heave, surge and sway motion. Where the motion reference unit (MRU) provides the accurate determination of roll, pitch and heave for any vessel on which it is mounted. The data on which study is carried out is obtained from the "CRV Sagar Tara"



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ships motion reference unit for the entire duration of the voyage on 13/September/2019. When she is taken for the voyage to carry out the tests Such as vibration measurement, Air born noise measurement, etc

2.1 Visakhapatnam Port limits :

Visakhapatnam port trust situated at east coast of India at the latitude of 17° 41' 25.7064" N, Longitude of 83° 13' 51.7764" E. Established in 1933. The Port was opened to ocean traffic with the arrival of a passenger vessel S.S. JALADURGA of the Scindia Steam Navigation Co., on the 7th October, 1933. The Port was formally inaugurated by His Excellency Lord Willingdon, the then Viceroy and Governor General of India on 19th December 1933.

2.2 Ship Trajectory Map:

The figure:1 shows the trajectory followed by the ship in arrow mark direction path during the tests were conducted. The ship was taken to almost 10 nautical miles from the fishing harbour where the initial depth is 13 m and while conducting the experiments for newly built ship the depth reached around 60 m. where the under-water acoustics measurement tests were conducted. During the experiments, the sea condition werestate 3. The ship was experienced all 6 degree of freedom. The sea states according to wave heights are given in the table.

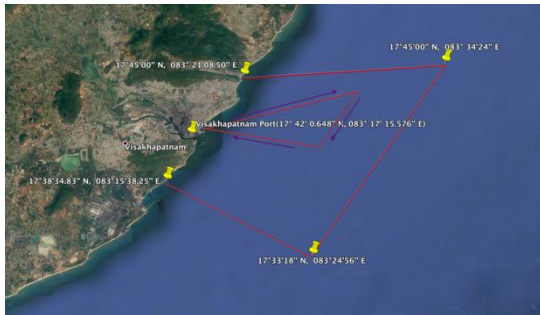


Fig-3: ship trajectory Map

Table-2:Scientific Equipment on-board ship

Sl.No	Item Name	Supplier Name
1.	BOD Incubator	Lab Kits
2.	Oven	H.L. Scientific Industries
3.	Laboratory Water purification system	Milipore
4.	Refrigerator-2 Nos(-15°C)	LAB Kit
5.	Deep Freezers-Nos(-80°C)	LAB Freez

6.	Double beam UV-VISIBLE Spectrophotometer	Shimadzu
7.	Zoom Stereo Microscope	Leica
8.	Auto Salinometer	OSIL
9.	Thermosalinometer	Sea Bird
10.	Gravity corner 3m length	Norinco
11.	Motion Reference Unit	IX BLUE
12.	USBL	IX BLUE
13.	Sediment Sampler (VAN VEEN Grab)	Nornico
14.	Multibeam Eco-Sounder up to 1000 m	Kongsberg
15.	Automatic weather station	Benson Marine
16.	Scientific winches and handling system -4 Nos	Kley France
17.	CTD	SEA-BIRD
18.	Auto clave	Astell and bio Gene
19.	Centrifuge	Lab kit
20.	Portable Nutrient System	Clean grow
21.	Underway data logging System	Teledyne Ocean Science
22.	Single beam Eco-Sounder	Kongberg
23.	Niskin water samplers with go devil messenger 10 Nos	NORNICO
24.	Zooplankton net with flowmeter	Aishwarya Engineering
25.	Dosimat	Metrohom
26.	Vaccum pump with filtration unit -2 Nos	Merck Milipopre
27.	Bacteriological Incubator	Next Era Technologies
28.	Laminar Flow	NexT Era Technologies
29.	UV Cabinet	Next Era Technologies
30.	Fume Hood Explosion proof	iGene Labserve Pvt.Ltd
31.	Texture Analyser	Horiba
32.	Auto Analyser	Skalar
33.	Carbon Dioxide Analyser	Elron instrument/Licor
34.	Ultrasonic Scientific Anemometer	Electrotek International/Metek

3. INCOIS Data:



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The weather condition (sea state) and significant wave heights for the day, when ship have been taken to carry out scientific tests, data were collected from the Wide rider buoy(vizag) which were deployed by National Institute of Ocean Technology, Chennai. At the location of latitude :17.63 N,Longitude:83.27 E in Bay of Bengal.

For the obtained data, graphs were plotted to get the maximum wave period and significant wave height for the particular region (Visakhapatnam port Limits).

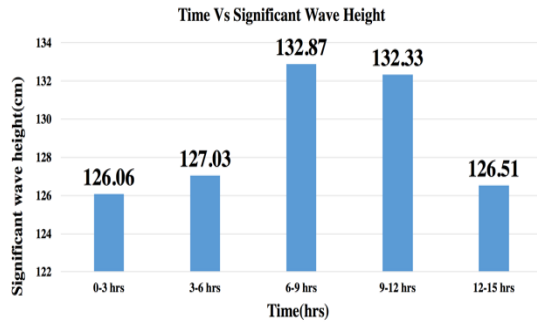


Fig-4: Time Vs Significant wave height

132.87 cm (1.32 m), Figure:4 shows the maximum significant wave height observed on that day.

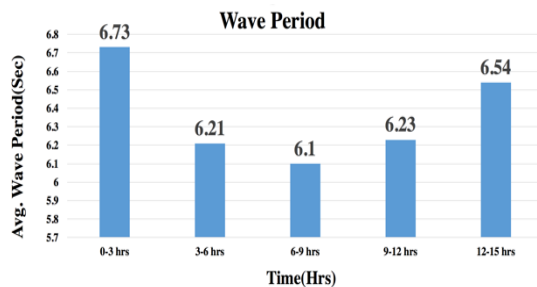


Fig-5: wave period for different time intervals

On that day, Figure: 5 shows the maximum wave period observed is 6.73 sec.

Sea State is general condition of the free surface on a large body of water with respect to wind waves and swell at certain location and moment. It is characterized by statistics, including the wave height, period and the power spectrum. The sea state varies with the time, as the wind condition or swell condition. The following table indicates the various sea states with respective wave heights.

Source: The World Metrological Organization Sea State Code (WMO Sea State Code)

0	Calm-glassy	0
1	Clam-rippled	0 to 0.1
2	Smooth-wavelets	0.1 to 0.5
3	Slight	0.5 to 1.25
4	Moderate	1.25 to 2.5
5	Rough	2.5 to 4
6	Very rough	4 to 6
7	High	6 to 9
8	Very high	9 to 14
9	Phenomenal	Over 14

3.1 Methodology:

The data were collected from the MRU (Motion Response Unit) which consists of the roll, pitch, heave, surge and sway values for each 1/5th second time intervals (i.e. for the 1 sec. of time it gives the 5 values). This data is then divided into several sets each of 15 minutes' interval. For the divided set of data, the graphs were plotted between time interval versus all 6 degrees of freedom and taken the maximum or peak values from the graphs.

The above collected data which were separated into several data sets, for each 15 minutes' data sets, graph were plotted between roll with respective time, as of we know that the roll motion will play a major role in among the pitch, heave, surge and sway motions of the vessel. As the obtained MRU data consists of the large quantity of data (i.e. for the 1 sec. of time, it gives the 5 values). The following graphs were plotted for 6 degree of freedom each 15 minutes' data.

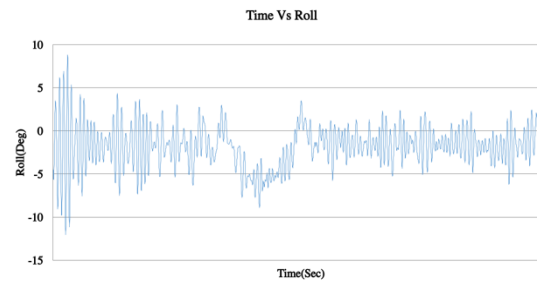


Figure-6: Time Vs roll

Figure: 6 shows the maximum roll amplitude was reached to 12.03 deg after 1 hr 45 min from the starting time of the voyage

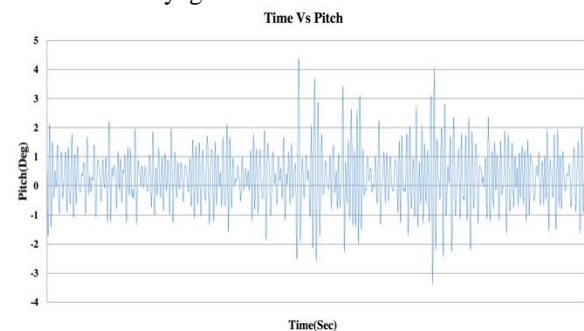


Table 5: sea states with corresponding wave heights

Sea State	Description	Wave Height (meters)



Fig-7: Time Vs pitch

The figure: 7 shows the maximum pitch angle was reached to 4.39 deg after 4 hr 45 min from the starting time of the voyage

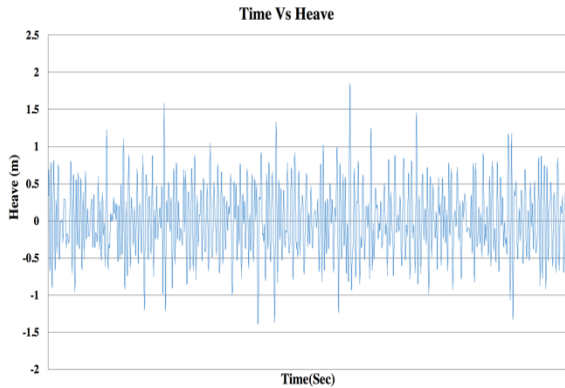


Figure-8: Time Vs heave

Figure:8 shows the maximum heave was reached to 1.842 m after 2 hr 45 min from the starting time of the voyage

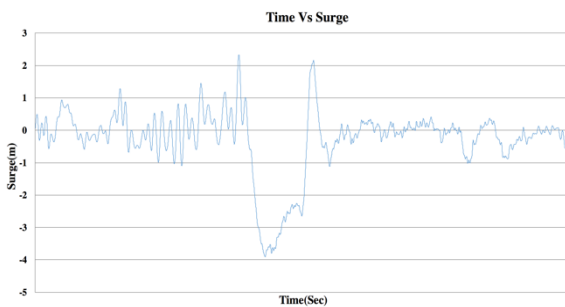


Figure-9: Time Vs surge

Figure: 9 shows the maximum surge was reached to 3.916 after 1 hr 45 min from the starting time of the voyage.

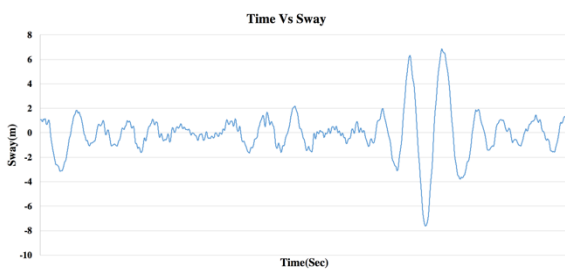


Fig-10: Time Vs sway

Figure: 10 shows the maximum sway was reached to 7.636 m after 3 hr 30min from the starting time of the voyage

4. RESULTS & DISCUSSION:

The results obtained for the study which is carried out

on data which is obtained from the MRU unit. The maximum roll angle was reached 12.03 deg in sea state condition 3. Below figure-11 shows the various roll angles for the full period of voyage.

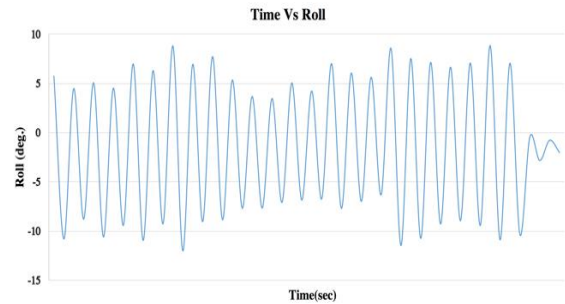


Fig-11: Time Vs roll for entire time duration of the voyage

The maximum pitch angle was reached 4.39 deg in sea state condition 3. Figure 12 shows the various Pitch angles for the full period of voyage.

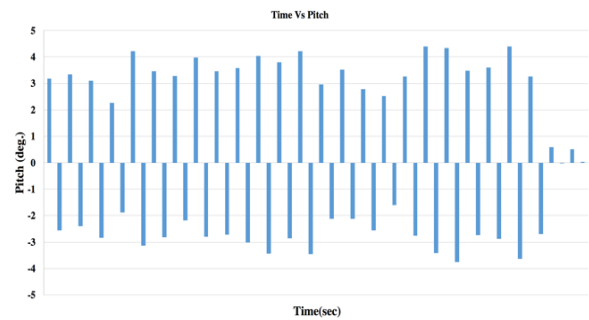


Fig-12: Time Vs Pitch for entire time duration of the voyage

The maximum Heave was reached 1.82 m in sea state condition 3. Figure-13 shows the various Heave motion for the full period of voyage.

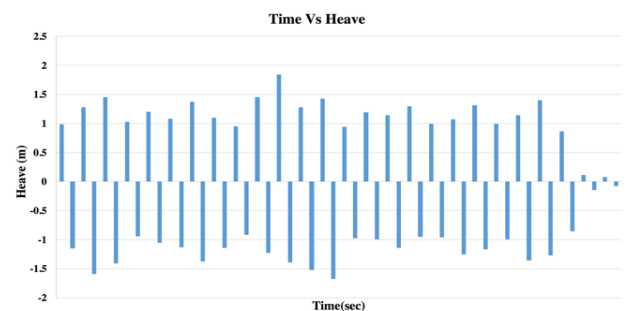


Fig-13: Time Vs Heave for entire time duration of the voyage

The maximum Surge was reached upto 3.91 m in sea state condition 3. Figure-14 shows the various surge motions for the full period of voyage.



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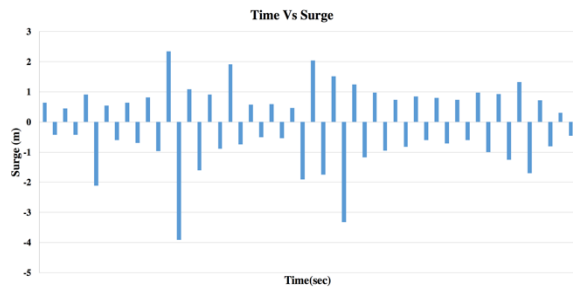


Fig-14: Time Vs Surge for entire time duration of the voyage

The maximum sway was reached upto 7.64 m in sea state condition 3. Figure-15 shows the various sway motions for the full period of voyage.

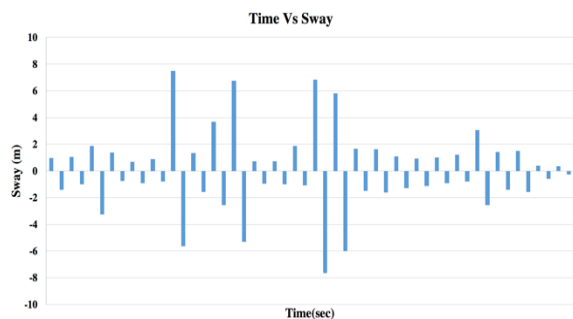


Fig-15: Time Vs Sway for entire time duration of the voyage

5. CONCLUSION

The results obtained indicate that the vessel behaved in a normal condition within the acceptable criteria in the sea state 3 which favourable for carrying out scientific activities.

The Roll angle significantly depends on the alteration of the waterline characteristic when the ship position relative to the wave in sagging and hogging conditions. When the difference of waterline area between sagging and hogging condition increases the roll angle tends to increase because the restoring arm variation as the main factor induce roll motion in following seas also increases.

Roll angle depends on the period of righting arm variation. The restoring arm tends to be constant on the time spent by the ship in a certain position in waves

The results obtained indicate that the vessel behaved in a normal condition in the sea state 3 which favourable for carrying out scientific activities.

As per the regulations standards, the peak roll angle achieved by the ship which was within the standard limits and rest of the motions which were achieved by the calculations also in favourable condition.

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