Study of Wave Induced hydrodynamic Motion of Floating Pontoon with Prismoidal and Box Shape

[1]Aridhip Jana, [2]Ronak Pithwa, [3]Shankar Sharma, [4]Harshali Dodia, [5]Yuvraj Chavda

[1,2,3,4]Universal Collage of Engineering

[5]Department of civil engineering. Saraswati College of Engineering.

Abstract -The concept of floating bridge takes advantage of natural law of buoyancy of water to support dead load and live loads. There is no need of conventional piers or foundations. However, an anchoring or structural system is needed to maintain transverse and longitudinal alignment of the bridge. Modern floating bridges generally consist of concrete pontoons. Pontoons are basically hollow floating structures. In order to reduce total weight and height of floating structures, it is important to reduce the hydraulic pressure subjected to bottom of floating structures and limit acceleration within a certain range to make men's ordinary work possible. The above two condition depends on the geometry of the pontoon. With the results from the experiment performed it is found that Prismoidal Shaped pontoon with waffle base gives more satisfactory result

I. INTRODUCTION

After the first step toward sea with creation of a ship, mankind has been paying insatiable effort to develop vast ocean. With those efforts, nowadays the size and usage of marine structures are beyond our imagination. Huge cruise ships, containers or oil carriers, FPSOs (Floating Production and Storage Offloading) are the clear examples. Recent floating structures different from a ship shape for transportation, having a marine ground concept for creating marine space aregathering interest like floating harbor, floating airport, and drilling rigs. On these structures, men can work at sea feelinglike doing that at land. In civil engineering field, even though two-third of this planet is cover with water, it has been true that most structures werebuilt on the earth. One of the reasons is that structures basically require firm foundation. Of course there are so many structures built on the sea bed but it has some limitation to the various application of sea. Due to the recent issues of green energy, shortage of land by NIMBY, safe oil storage sites, the ocean is under development for expanding the territory and those make the civil engineers have much interest in floating structures.

Large floating offshore structures such as LNG terminals, storage vessels, and container terminals are exposed to severe offshore environment conditions such as waves, water pressure, and impact loads. Therefore, these floating offshore structures must satisfy particular design requirements. Floating structural systems should withstand the severe offshore environment and not allow permanent structural damage during service life. Also, structural members should absorb external impacts and deformation energy to prevent structural collapses. To satisfy these design requirements, floating offshore structures are constructed for high structural performance in bending and shear to support wave-induced bending moment and impact loads.

In order to reduce total weight and height of floating structures, it is important to reduce the hydraulic pressure subjected to bottom of floating structures and limit acceleration within a certain range to make men's ordinary work possible.

In this study, experimental studies are to be conducted on pontoon-type floating structures in order to investigate wave-induced hydrodynamic motion. A series of small-scale tests with various wave cases to be performed on the pontoonmodels and the wave-induced hydraulic pressure on the bottom and acceleration on the top of pontoon models to be measured. Finally, the hydraulic pressures subjected to the bottom and acceleration of pontoon models need to be compared each other.

II. TYPES OF FLOATING STRUCTURE

Modern floating bridges generally consist of concrete pontoons. Pontoons are basically hollow floating structures. Types of floating structure are

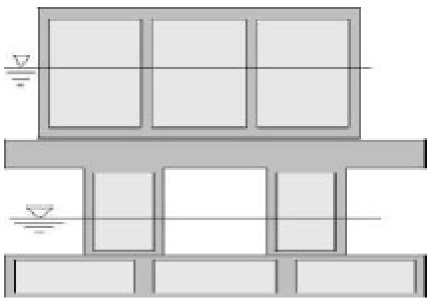

Fig. 1) Pontoon Type

Fig. 2) Semi- Submerge Type

Pontoon type

A floating structure is generally made into the form of pontoon. Pontoon has the shape of a box as shown in the Fig.

(1). In the case of constructing large size floating structure, a target structure is composed with many pontoons connected with each other by welding or beam-connecting. This type has been widely applied with many advantages such as maximized submerged volume for securing buoyancy, practical use of inner space for storage or machinery room, simple details and so on. However, this system is unable to absorb wave impact energy because the sides face up to the wave action. The wave-induced impact energy is delivered entirely to the structure and it increases motion and bending moment of pontoon. Consequently, this system is vulnerable to wave-induced bending moment and hydrodynamic motion so in order to satisfy design criteria for strength of floating structures, it should be required to have a large cross section and depth. These disadvantages limit the application of floating structures of this type to only nearly-still waterconditions and constrain the multi-purpose application of floating structures to wild offshore conditions.

Semi-submersible Type

For this type, pontoon for buoyancy is located at the bottom of a structure and submerged entirely. Some columns are placed on the pontoon and support deck which is working area. Deck is entirely above the water surface as shown in the Fig. (2). Waves flow through the columns so the semi-submersible is less affected by the waves than a pontoon type. Therefore this type is of advantage in wild sea and generally used for oil drilling rig located at deep sea.

However this type has relative disadvantages over the pontoon type that it requires its own pontoon for buoyancy while entire structure contributes to the buoyancy in pontoon type. Furthermore there should be much more complex considerations such as squeeze/pry loads those make the columns move within and without repeatedly for successive waves.

III. OBJECTIVES

The present work aims to

1. To investigate wave induced hydrodynamic motion on six different prototypes of pontoon

a) Box pontoon with Flat base

b) Prismoidal Pontoon with Flat base

c) Box pontoon with Waffle base

d) Prismoidal Pontoon with Waffle base

e) Combination of box and prismoidal shape with Flat base

f) Combination of box and prismoidal shape with Waffle base

2. To study this prototypes for different wave case i.e. wave height and wave period.

3. To investigate Acceleration and Hydrodynamic pressure for different wave height

4. To investigate Acceleration and Hydrodynamic pressure for different wave length

5. To study the effect of bottom surface shape.

6. To compare different cases on basis of least acceleration and hydrodynamic pressure at the bottom of the pontoon

VI. METHODOLOGY

• In order to investigate wave-induced hydraulic pressure and acceleration by motion, experimental studies were conducted to the floating structures of pontoon type, as shown in figure below. Small-scale tests were conducted using self-made water tank at Universal College of Engineering. The dimensions of the tank are 44(L) × 18(W) × 18(H) inch and the small-scale pontoon models were placed in the transverse direction of the tank as shown in fig.(3)

Fig.(3)

• A mechanical frame was designed andfabricated to allow only heaving andPitching motion of pontoons with the minimum friction and to restrain other hydrodynamic motions of sway, rolling etc. as show in fig.(4)

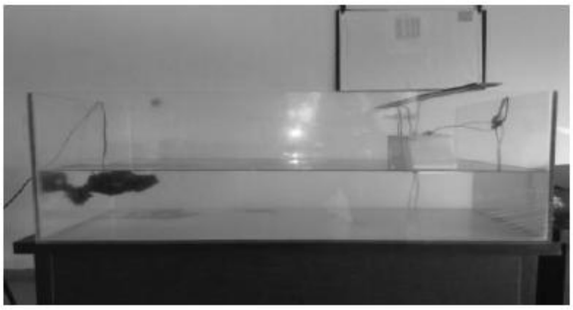

Fig.(4)

In order to generate wave, JVP-202 Wave maker, having output 12000L/h

And power of 24W was used shown in fig. (5).

Fig.(5)

Pressure gauge MPX5010DP having range 0-10 Kpa is placed at bottom centre of the pontoon prototype to measure and accelerometer of range 0.5g

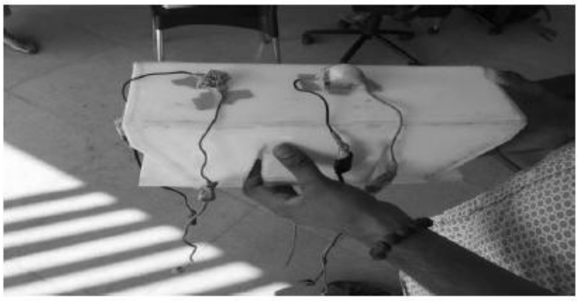

Fig.(6)

Pressure gauge MPX5010DP having range 0-10 Kpa is placed at bottom centre of the pontoon prototype to measure and accelerometer of range 0.5g. A Multistage amplifier was used to amplify the signal obtained from accelerometer. Arduinouno is used to make accelerometer compatible to obtain readings on CRO.

Fig.(7)

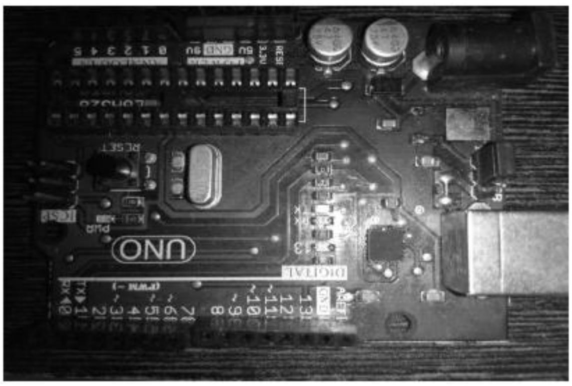

Fig.(8)

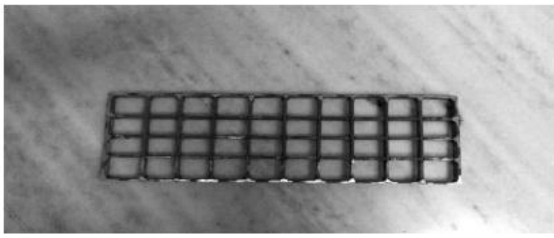

Fig.(9) – Waffle Base

IV. RESULTS

1) Variation of acceleration on base of wave height.

Table 1.

Height of wave	PB		PP		PBP		BPB	
	Accln (g)	Increased rate	Accln (g)	Increased rate	Accln (g)	Increased rate	Accln (g)	Increased rate
Low	0.0074	-	0.0053	-	0.0062	-	0.0082	-
Medium	0.0256	347%	0.0083	157%	0.0128	206%	0.0426	519%
High	0.0623	844%	0.0204	387%	0.0453	731%	0.086	1049%

2) Variation of acceleration on base of wave length.

Table 2.

Length of wave	PB		PP		PBP		BPB	
	Accln (g)	Increased rate	Accln (g)	Increased rate	Accln (g)	Increased rate	Accln (g)	Increased rate
0.5L	0.0122	-	0.0116	-	0.0134	-	0.0148	-
L	0.0256	211%	0.0083	72%	0.0342	255%	0.0395	266%
2L	0.1129	929%	0.0641	554%	0.1321	985%	0.1422	960%

V. FUTURE SCOPE

- Hydraulic pressure subjected to bottom of the pontoon prototypes for different wave length and different wave height.
- Comparison chart and graph of pontoon prototypes.
- Final discussion from the results.

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