Generation of Irregular Wave for Marine Application by Piston Type Wave Maker

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ABSTRACT

Present study, analyses the generation of irregular waves by the piston type wave maker for marine experimental analysis. Methodology is developed for the generation of irregular wave by the CFD for the given wave spectrum. Generated irregular wave is processed for FFT analysis and the wave spectrum is validated with original wave spectrum.

KEY WORDS: wave spectrum; irregular wave; numerical wave tank; CFD; FFT.

NOMENCLATURE

H_s – significant wave height (m)
T_z – the average zero-up – crossing wave period(s)
\omega - circular wave frequency (rad/s)
\zeta_an - amplitude component (m)
\omega_n - circular frequency component(rad/s)
 k_n - wave number component (rad/m)
\epsilon_n - random phase angle component (rad)
N – number of points taken for FFT analysis
\Delta – time interval taken for FFT analysis (s)
T – irregular wave time taken for FFT analysis(s)

INTRODUCTION

In the marine field, most of the ship structure or new marine operations are to undergo experimental verification and validations to avoid major loss because of unpredictable causes or structure failure in the real sea. It is becoming mandatory for the experimental analysis in the design stage itself for the new kind of ship structure. Initially potential theory was developed for the regular wave analysis which is based on the 2D strip theory. Here fluid is assumed to be in-viscous, irrotational and incompressible. Potential theory was quite improved by considering the 3D based theory like Green function method (Iwashita, et al 1989) and Rankine panel method (Jensen et al, 1986 and Iwashita, 1998). Though it is reliable for the analysis of standard structure and with a regular / irregular wave but the simulation of real sea state is still in developing stage.

Presently, due to the development of software technology and computational power, viscous solver is being used for marine application by many researchers (Park et al, 2001; Dong et al, 2001; Ducrozet et al, 2005; Taylor et al, Patrick et al; Joe Longo et al). In this research, ANSYS CFX has been used as a CFD solver and authors have made an effort to simulate the irregular wave for marine structure analysis. Generally, for the wave generation, three kinds of a mechanism are used in practical like a piston, flap and plunger type (Wang, 1974; Tommi Mikkola, 2007; Elangovan et al, 2008; ).

Generation of regular wave has been simulated by the piston type wave maker (Elangovan et al, 2009), and it was validated with theoretical & experimental data.

In continuation with the earlier work, wave generation process/methodology is developed for the generation of irregular wave by the CFD. Modeling of a wave maker is explained in details with wave maker tank size requirements. Simulated CFD irregular waves are carried for FFT analysis and the wave spectrum is compared with original wave spectrum. In the coming section, all the said task will be discussed in detail.

WAVE GENERATION PROCESS

For the design and analysis of ocean structure, the International Association of Classification Society (IACS, 2000) has recommended the Bretschneider wave spectrum for the wave data, which is available in that society website.

\[
S(\omega) = \frac{H_s^2}{4\pi} \left( \frac{2\pi}{T_z} \right)^4 \omega^{-5} \exp\left(-\frac{1}{\pi} \left( \frac{2\pi}{T_z} \right)^4 \omega^4 \right)
\]  

(1)

From the probability sea state diagram, maximum number of wave occurrence is noted 7738. For this maximum occurrence, significant wave height (H_s), 1.5 and the wave period (T_z), 7.5 are selected from that table. Now the wave spectrum shall be generated for the particular H_s and T_z (Dean et al, 1991; Daoud et al, 1995). It is the requirements to extract the regular wave keeping the frequency interval same and shall be plotted as frequency versus amplitude. Equation for the