Nearshore Wave Propagation Characteristics in Steep Slope Zone of South Java Sea

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Abstract. NCEP provided the ocean wave long term data, one year nearshore wave surveyed at -20m water depth of South Java coast, the relation between two series synchronous data were analyzed, the wave direction are all prevailing from S to SSW. The wave in India Ocean is mostly swell, the significant wave height and period changed obviously and disorder while it is propagating on steep slope from deep water to shallow water. The wave spectrum were calculated, \( H_0 \) and \( T_p \) were adopted for analyzing wave propagation characteristics from global wave position to survey position. The survey wave \( H_0 \) and \( T_p \) have good relation with global wave. The reason of statistic \( H_s \) and \( T_s \) decreasing is dispersion on shallow water, which is shown from water surface elevation process.

1. Introduction

Wave is a major ocean hydrodynamic factor for coastal engineering. To obtain the wave condition, long term offshore global wave data and short term nearshore wave survey data would be used. The relationship of these two series would be analyzed including wave height, wave period and wave direction [1]. Based on the rule between two series data, the long term data would be adopted to calculate different return period wave condition for design and verification.

In order to improve the accuracy, wave numerical model would be performed to simulate the wave propagating from the global wave data point to survey point, the model always consider wave breaking, refraction, diffraction, dissipation and so on, SWAN wave model is extensive used [2]. Some constant rules were regard as primary analysis before numerical model, including, serious wave comes from offshore, wave period is tiny changed before breaking.

This paper will try to find the difference between global wave data and survey data, which including wave height and wave period. A new methodology is recommended based on the characteristic of wave propagation from deep water to shallow water sharply.

2. Wave data

The global wave data were download from NCEP, 6 hours interval, from Feb.2010 to Feb. 2011, including significant wave height, significant wave period, wave direction, wind velocity and wind direction [3][4]. The location is in the southern coast of East Java, far away from Capital Pacitan and faces Indian Ocean. The survey wave data were measured by DEC, 1 hour interval, from Feb.2010 to Feb.2011, including significant wave height, significant wave period, wave direction, maximum wave
height, total energy and so on. The depth is -20m. The locations showed as following figure1. The distant from global wave location to survey location is 34km.

Figure 1. The location of global wave position and survey position

3. Primary analysis of wave height, wave period and wave direction
The wave was propagated from offshore to nearshore, the wave at survey position is delayed from global wave position, the delayed time was estimated by distant, wave period, wave direction and water depth \[^5\]. Considered the delayed time difference, the synchronous time series data of survey wave were adopted for comparison to global wave data. In following figure 2, the correlation of wave height between global data and survey data is weak.

![Wave height comparison between Global data and Survey data](image)

\[ y = 0.1598x + 1.3014 \]
\[ R^2 = 0.0284 \]

Figure 2. Wave height comparison between Global wave height $H_s$ and Survey wave height $H_s$

In following figure3, the correlation of wave period between global data and survey data is weak, because the waves had less broken at survey location, the relation characteristic is beyond evaluation.
Figure 3. Wave period comparison between Global wave $T_s$ and Survey wave $T_s$

In following figure 4, the correlation of wave direction between global data and survey data is reasonable, the wave direction concentrated in S and SSW direction.

4. Further analysis of time process, wave height and wave period

Learned from the figure of wave height comparison, sometimes the global wave height is 2~3 times of survey wave height, sometimes the survey wave height is 2 times of global wave height. In order to analyze the difference, the wave height process is compared as following figure 5. Figure 5 shows the whole year significant wave height process, two interesting durations were captured, one is in which global wave height is larger, one is in which survey wave height is quite similar with global wave height. The two fragments were zoomed up in figure 6 and figure 7.

Figure 5. The time process comparison between global wave $H_s$ and survey wave $H_s$

Figure 6 is 14-July-2010, Global wave: $H_s=3.37m, T_s=12.64s, 188.23^\circ$; Global wind: $v=2.41m/s, 74.54^\circ$ Survey wave: $H_s=1.22m, T_s=11.46s, 160^\circ$, Energy = 1034KJ

Here, there are about 5 small waves in each big wave.

Figure 6. Water surface elevation of 14-Jul-10 6:25

Figure 7 is 17-Nov-2010, Global wave: $H_s=2.08m, T_s=11.07s, 195.04^\circ$;
Global wind: $v=3.06\text{m/s}$, $237.04^\circ$
Survey wave: $H_s=2.33\text{m}$, $T_s=11.1\text{s}$, $220^\circ$, Energy = $3621\text{KJ}$

Here, the survey wave height quite equals to global wave height.

5. Analysis of wave energy and wave spectrum
The wave spectrum were calculated, as following figure 8, the spectrum have two peaks, one frequency is swell wave, another is dispersion wave, related with short period wave\textsuperscript{[6][7]}.

Based on wave energy, $H_0$ instead of $H_s$, were adopted for comparison with Global wave.

Based on wave spectrum, $T_p$ instead of $T_s$, were adopted for comparison with Global wave period.

6. The propagation characteristic from global wave to survey wave
The average wave period is about 12s, so $d/L_0$ equals to $1/11$, the wave dispersion into several series short period wave, the statistic wave height decreased, meanwhile the statistic wave period is shorter
than incident wave. The wave dispersion and concentration is random, the wave energy keep constant, it means an higher wave would occurred as calculated by wave energy. So it is feasible that adopted $H_0$, instead of $H_s$, and it would be more reasonable for coastal engineering [8] [9].

The wave propagated from deep water to nearshore, dissipation, shoaling, wind influence should be included, so as to, help for analysis of diffraction, reflection and refraction. A practiced formula for wave dissipation were adopted here as:

$$K_f = [1 + 64\pi^2 fH\Delta x \frac{K^2}{3g^2T^2sh(\frac{2\pi h}{L})^3}]^{-1}$$

$\Delta x$ is distance from Global wave location to survey location.

$f$ is wave dissipation parameter, about 0.01~0.1, here is 0.03.

$H$ is significant wave height.

$K_s$ is shoaling coefficient.

$T$ is significant wave period.

$h$ is water depth.

$L$ is wave length.

$A$ ratio by calculated is 0.94.

After verification, the wave height and wave period process showed as follows.

Figure 11. The process of global wave $H_s$ and survey wave $H_0$.

Figure 12. The process of global wave $T_s$ and survey wave $T_p$.

The relationship between wave height and wind velocity, the relationship between wave direction and wind direction, were analyzed as following figure13and figure 14. The results shows the wave is not related with local wind.
7. Main conclusions and outlooks

For swell in India Ocean, the wave dispersion in nearshore shallow water, wave height statistic decreased, wave period shorted, wave energy kept constant. Calculated the wave spectrum energy, obtained $H_0$ and $T_p$, there were good relation between global wave and survey wave. The wave dispersion and concentration is random, $H_0$ and $T_p$ is more reasonable from coastal engineering, instead of $H_s$ and $T_s$.

The statistic maximum wave height sometimes more than two times of significant wave height in survey data, and for structure safety, the maximum wave height is the most important parameter, it should be further study.

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