

Original Manuscript ID: IIOAB-2016-035

Original Article Title: "Oscillating Water Column (OWC) Building Performance Analysis As Beach Abrasion Reducing"

To: author

Reviewer: 1

Recommendation: Accept with revision

Comments:

The subject of the manuscript is interesting but it is not well organized and needs to be revised thoroughly before the publication. In what follows there are some comments on this version of manuscript:

1. In "Abstract" section, some information is not suitable, like mentioning the Abrasion.
2. Abstract must be revised completely with providing the information about the experiments which is not mentioned in this version.
3. The language of the article needs to be modified and a complete revision is needed.
4. The "Introduction" must be revised. There is no policy for writing this section in spite of the importance of that. It is expected that the authors review the relevant works concisely and then demonstrate the innovation of this work clearly. Also, the main contribution of this work is not conspicuously presented at the end of the introduction. The literature review is poor.
5. In the last paragraph of the "Introduction" section, after mentioning the contribution of the work, the authors should provide the information about the next sections briefly and in one short paragraph.
6. The arrangement of the article needs to be modified based on this order in the section of "Materials and Methods": A. Experimental Setup, B. Data Acquisition, C. Governing Equations of Numerical Simulation, D. Geometry and generated grid.

Additional Questions:

1) Does the paper contribute to the body of knowledge?: The manuscript requires a significant revision before being resubmitted to **IIOAB Journals** since it is not properly organized however I find the information to be fascinating. Since the novelty of the work is now unclear, its novelty will rely on this revision.

2) Is the paper technically sound?: This manuscript needs to be modified, and I have some suggestions that could be useful.

3) Is the subject matter presented in a comprehensive manner?: The data is sufficient, however it has to be stated with greater technicality and precision.

4) Are the references provided applicable and sufficient?: This was one of the key issues that prevented me from seeing the importance of this work. The introduction needs to be substantially revised because the literature review is poor.

5) Are there references that are not appropriate for the topic being discussed?: No

5a) If yes, then please indicate which references should be removed.:

Reviewer: 2

Recommendation: Accept with revision

Comments:

1. The introduction still needs to be improved.

2. In the results and discussion section, people always looking for some discussion between the present findings and the previous related works. I am seeing you have done a few, however, if you can this part needs to be improved to somehow show how other people get similar or contrary results for some cases you studied! Especially if you refer back to experiments, that would strengthen the results and discussions part.

3. I think, in papers, the novelty is always very important to be defined very clearly. One way to highlight the novelty comes from very critical analysis of the previous works. I am still thinking the introduction needs to be improved. It's alright to briefly explain the previous works and what they concluded. Now, if you take one step forward and try to show how studies tried to cover the gaps and they were complement of each other, in that way you will end up with a better flow of introduction and finally you can highlight the gap and novelty more clearly.

Additional Questions:

- 1) Does the paper contribute to the body of knowledge?: actually, does not make a meaningful contribution to knowledge
- 2) Is the paper technically sound?: Needs major technical contribution
- 3) Is the subject matter presented in a comprehensive manner?: The presentation isn't comprehensive it needs to better organize
- 4) Are the references provided applicable and sufficient?: in terms of the novelty aspect? NO
- 5) Are there references that are not appropriate for the topic being discussed?: No
- 5a) If yes, then please indicate which references should be removed.:

ARTICLE

OSCILLATING WATER COLUMN (OWC) BUILDING PERFORMANCE ANALYSIS AS BEACH ABRASION REDUCING

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ABSTRACT

Ocean waves is a new renewable energy that is rarely explored. It has a great chance to reduce carbon pollution in the world. In spite of that, the ocean waves responsible for the beach abrasion that occurs in some county in the world. Using Oscillating Water Column (OWC) building reducing the impact of waves against abrasion become populer. In this research is to analyze the performance of OWC power conversion as water building for abrasion reducing and as well as electrical energy resource from ocean wave energy conversion. The OWC made in laboratory scale with 4-meter of length, 0.6-meter of width, and 0.6 m height. Wide of chamber in OWC is 0.24-meter square. The OWC has manual wave generator system and breakwater system for reduce wave feedback effect in chamber. High variation wavelength used is 10, 15, and 20 cm for the operation starting time of 0-20 seconds. The results from this study showed that energy conversion has linear relationship to wave characteristic, the higher the wave produced, the higher the power generated by OWC. In the wave height of 10 cm, power generated is 3.5563 watt. While the wave height of 20 cm, power generated is 5.586 watt.

INTRODUCTION

Breakwater designed for reducing the abrasion [1], reduce abrasion, but actually, many cases explained that the breakwater cause fishing vessels become damaged and cause fishermen trouble catching fish, because fishing nets snagged or damaged by the breakwater.

The magnitude of western Java sea waves brings serious problems of abrasion. However, efforts are needed to reduce coastal erosion or abrasion. There are two ways can be implemented. First way is to divide the wave energy into small waves, so the waves did not make coastal erosion or abrasion. The second way is to collect and gathering the wave energy, then convert it into another form of energy. The second way will give the double result. First reducing the abrasion and as well obtain the electrical energy. Ocean in western Java had the high waves and sustainable, provide an opportunity to transform wave energy into electrical energy, thus sea south western Java had the high sea waves and sustainable, provide an opportunity to transform wave energy into electrical energy, thus reducing abrasion [2], whereas the electrical power science believes that energy collecting received in OWC can be used fatherly rotating the turbine and then generate electrical energy.

OWC has a working principle gather to convert ocean wave energy into mechanical energy [3], the mechanical energy in OWC can then be converted into electrical energy [4]. OWC has a working principle gather to convert ocean wave energy into mechanical energy [3]. The mechanical energy can then be converted into electrical energy through a turbine [4].

The waves southern regions of western Java had high waves with a frequency of 0-10% [5], while the potential of ocean waves at Jimbaran of Bali has a potential of between 176 kW - 4 MW [6]. Some researchers believe that the global potential for electrical energy from sea waves at the beach estimated is 1TW [7]. The energy generated by ocean waves is 5 times of what is produced by wind energy at the same rate [8].

Wave Energy Converter (WEC)

There are many concepts of Wave Energy Converter (WEC) and more than 1000 patents on techniques WEC made in Japan, North America and Europe [9]. Despite having varied designs, WEC can be categorized based on the place and type. WEC Type Attenuator (A) by Salter [10], Point absorber and the type of Terminator [11], while according to [9]. WEC operating model can be divided into several, namely: Submerged pressure differential, Oscillating wave surge converter, Oscillating Water Column (OWC) and overtopping devices. According to [6]. OWC is one of the systems and equipment that can transform wave energy into electrical energy using oscillating column (chamber) as Fig 1 below.

The OWC technology concept in Fig. 1, the air pressure of the chamber air pressure to the turbine. The turbine will move the turbines which will produce electrical energy, as in Figure 1. The room's watertight be fixed with the bottom structure is open to the sea. The air pressure in the room's watertight caused by the movement of the rise and fall of the surface of the sea waves. The movement is a movement compresses and decompresses the motion that is on the level of water in the room. This resulted in the movement, generates an alternating high velocity stream of air. This air flow is driven through a pipe to a turbine generator that is used to generate electricity.

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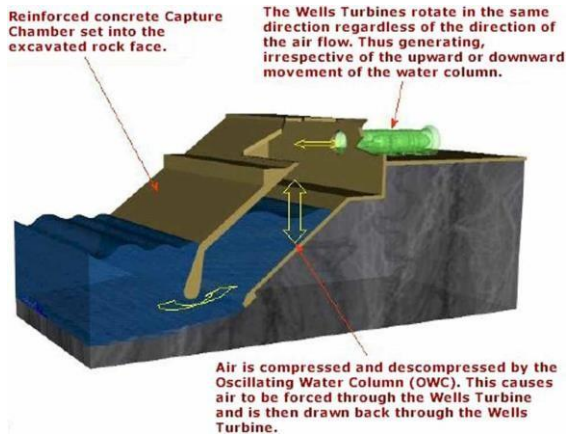


Fig 1. OWC [10]

Wind Effect

Fig 2. Shows the relationships between wave speed and period for various depths (left), and wave length and period (right), for periodic, progressive surface waves [12]. Higher wind speed and deeper the ocean, lower wave period. Note that the term phase velocity is more precise than wave speed.

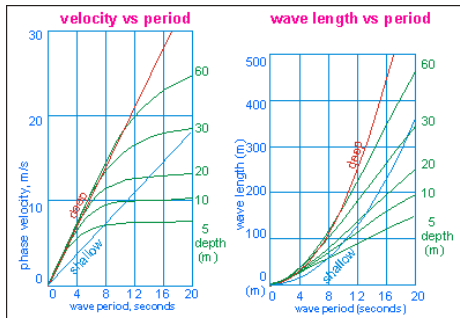


Fig 2. The spectrum of the wave period for different wind speeds [12]

Oscillation water column Conversion

Calculation of the wave energy from OWC. The amount of potential energy of ocean waves can be calculated by (1)

$$P.E. = mg \frac{y(x,t)}{2} (J) \quad (1)$$

Equation (1) can be write to the other form that involve densities value as (2).

$$P.E. = w\rho g \frac{y^2}{2}. \quad (2)$$

$$PE = w\rho g \frac{a^2}{2} \sin^2(kx - \omega t) \quad (3)$$

The magnitude of the potential energy of the wave, it is assumed that the wave is a function of "x" with respect to time, so we get the equation $y(x, t) = y(x)$.

$$dP.E. = 0,5 w\rho g a^2 \sin^2(kx - \omega t) dx(J) \quad (4)$$

The other form of $k = 2\pi/\lambda$ and $\omega = 2\pi/T$, so the simple form of (3) is represented by (5).

$$P.E. = \frac{1}{4} w\rho g a^2 \lambda \quad (Joule) \quad (5)$$

The kinetic energy that produce from wave for one period of wave is represented by (6) and total energy of wave (7) is sum of potential energy and kinetic energy.

$$K.E. = \frac{1}{4} w\rho g a^2 \lambda \quad (6)$$

$$Ew. = P.E. + K.E. = \frac{1}{2} w\rho g a^2 \lambda \quad (7)$$

Substitution from (6) and (7) to find the energy density (EWD) of wave as (8) and energy in electrical (PW) can be find out by (9). The power density (PWD) is power of wave in watt per meter square (10).

$$E_{WD} = \frac{E_W}{\lambda_W} = \frac{1}{2} \rho g a^2 \quad (J/m^2) \quad (8)$$

$$P_W = \frac{E_W}{T} \quad (Watt) \quad (9)$$

$$P_{WD} = \frac{P_W}{\lambda_W} = \frac{1}{2T} \rho g a^2 \quad (Watt/m^2) \quad (10)$$

Where the “ ρ ” is water density (kg/m³), “ w ” is wave width in meter (assumed equal to chamber of OWC).

“ a ” is Wave amplitud (h/2), “ h ” is wave high in meter, “ k ” is wave constanta $\frac{2\pi}{\lambda}$, “ λ ” is wave lenght in meter, “ ω ” is wave frequency in rad/s represented by $\frac{2\pi}{T}$ divide by periode (T).

MATERIALS AND METHODS

In this research, OWC designed in small scale with 4 meters of length, 0.6 meters of high and 0.6 meter width as Fig. 3, While Fig. 4 is chamber of OWC with 0.48 meter of length and 0.5 meter of width, so the chamber is 0.24 m² of wide. Water wave generated by manual wave generator system. Air speed in chamber measured by mini electrical generator with tubin. This anemometer will sense the air flow through the chamber that representing the speed of electrical generator turbin.

Test of OWC is applied by different In the wave height of 10 cm, 15 cm and 20 cm. Measurment of testing is Wind speed of oscillation in chamber, Wind Power in Chamber, electrical power of turbin. These results will be the conclusion of the OWC performance in reducing the wave energy.

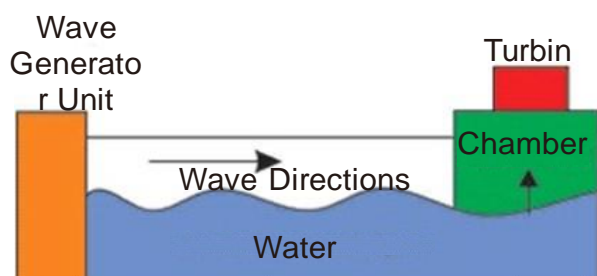


Fig 3. OWC Model with wave small scale

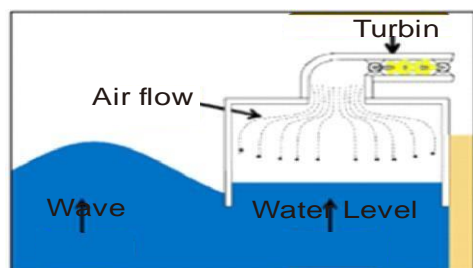


Fig 4. Chamber model with electrical generator system

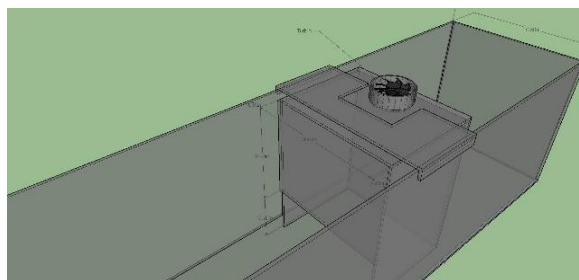


Fig 5. Design of Chamber in OWC system

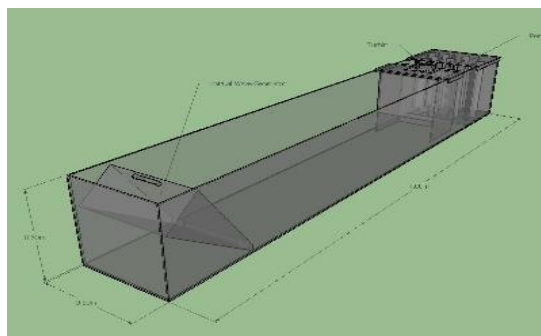


Fig 6. Design of Laboratory scale OWC

RESULTS

Fig 7 shows relation between oscillation of wind speed in chamber at different wave height. The chamber applied with various wave high 10 cm, 15 cm and 20 cm. Higher wave applied in OWC, more rapid the frequency of chamber oscillation. Particularly at in the wave height of 10 cm, the wind speed graphic sinusoidal form. The air speed in the chamber on the different wave height, it is known that the waves can be mitigated by changing the wave potential energy into kinetic energy in the turbine and chamber. The speed of the wave height of the water outside the OWC change linearly with the speed of air in the chamber to variations in wave height. The air fluctuations pressure has the ability to rotate the turbine generator. This change has potential reducing or even eliminate the abrasion.

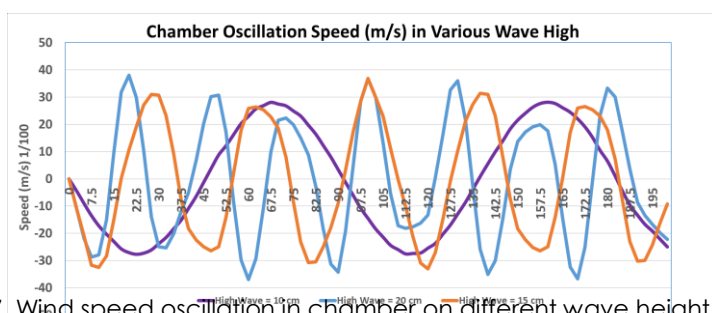


Fig 7. Wind speed oscillation in chamber on different wave height

Fig.7 shows the testing result of wave into wind speed oscillation in chamber. On the 10 cm of wave height produce the wind speed maximum is 0.282 m/s while on the 15 cm of wave height create the wind speed maximum is 0.3684 m/s and 20 cm wave height result the maximum wind speed 0.3811 m/s.

Fig. 8 is result energy conversion from wave of OWC into wind power that create from oscillation in chamber. On the 10 cm of wave height produces the wind power maximum is 13.755 watt, while on the 15 cm of high wave create the wind speed maximum is 24.029 watt and 20 cm wave height result the maximum wind speed 37.743 watt.

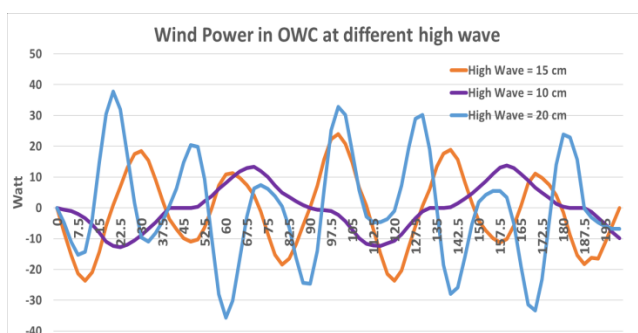


Fig 8. Wind Power of OWC on different wave height

Fig. 9 show the electrical power of OWC on different wave height. 10 cm of wave height produces the electrical power as 2.0357 watt, 15 cm of wave height produce the electrical power as 3.5563 watt, while

on the 20 cm high wave produce 5.586 watt. From Fig. 8 And Fig. 9 can be concluded that the smaller waves in OWC, the less energy is generated and the slower the frequency of oscillation in the chamber.

From Fig. 8 And Fig. 9 can be concluded that the smaller waves on OWC, the less energy is generated. Otherwise if the higher waves heading to OWC, the energy generated increasingly large. This condition is the advantage of OWC in overcoming the abrasion caused by the ocean waves.

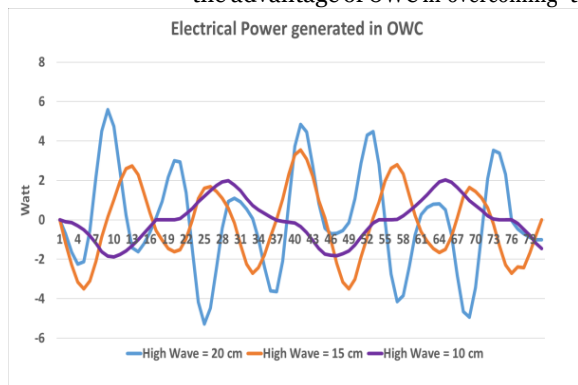


Fig 9. Electrical power generated in owc with on different high wave

CONCLUSION

The conclusion from this research that the oscillation model of water column (OWC) showed the potential for abrasion reducing by conversion the energy of ocean wave into electrical energy. OWC has a dual function, in addition to reducing abrasion and also be used as an alternative energy resources. High waves that heading in OWC has linearity relationship to the electrical energy generated. The higher the ocean waves in OWC, higher electrical energy will be produced. Result of OWC test is by OWC, the 10 cm of high wave produce the electrical power as 2.0357 watt, 15 cm of high wave produce the electrical power as 3.5563 watt, while on the 20-cm high wave produce 5.586 watt

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