LEARNING MEDIA OF RUBBLE-MOUND BREAKWATER DESIGN FOR EDUCATIONAL PURPOSE

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Introduction

The rapid development of science and technology today, has brought very rapid changes in various aspects of life. The work and way work changes, many jobs are lost, while various types of work just popped up. Economic, social, and cultural changes are also occurring at a rapid rate high. In this very dynamic time, higher educations must respond quickly and right. Learning transformation is needed to be able to equip and prepare higher education graduates to become a superior generation. The responsive generation and ready to face the challenges of his time, without being uprooted from his nation's cultural roots. Nowadays creativity and innovation are important keywords to ensure development sustainable Indonesia. Students currently studying at the higher educations, must be prepared to become a true learner who is skilled, flexible and tenacious (agile learner).

Merdeka Belajar – Kampus Merdeka (MBKM) or Independent Learning – Independent Campus Policy launched by the Minister of Education and Culture, Republic of Indonesia is a framework to prepare students to become graduates who tough, relevant to the needs of the times, and ready to be a leader with passion high nationality (Directorate General of Higher Education, Ministry of Education and Culture, 2020). Minister of Education and Culture Regulation Number 3 of 2020 concerning National Higher Education Standards, gives students the right for three semesters of study outside the study program. Through this program, opportunities are opened broad area for students to enrich and improve their insight and competence in the real world according to their passions and ideals. Learning can happens anywhere, the universe of learning is limitless, not only in classrooms, libraries and laboratories, but also in villages, industry, workplaces, places service, research centers, and in the community. Through close interaction between higher educations with the world of work, with the real world, then the higher education will be presented as a springs for the progress and development of the nation, also coloring culture and civilization nation directly.

One way to support the MBKM program for lecturers is to develop innovative and creative learning methods. One of the learning methods used is by developing the application of computational techniques. The learning media is focused on the coastal protection structure, namely rubble mound breakwaters use structural voids to dissipate the wave energy. Rubble mound breakwaters consist of piles of stones sorted according to their unit weight: smaller stones for the core and larger stones as an armour layer protecting the core from wave attack. In designing a rubble mound breakwater structure, several variables are using graphs and tables to get the value. The high possibility of making mistakes when reading graphs and tables can be affected to the result which can make the rubble mound breakwater becomes unstable and not strong enough. To avoid errors in the calculation and reading graphs or tables, it is needed a program that can automatically calculate in designing the structure of the rubble mound breakwater. This learning media can save the time, can avoid the errors in calculation and reading graphs or tables, and can be used as a learning media for the educational purpose.

Discussion

1. Rubble Mound Breakwater

A breakwater built as a rubble mound is constructed by placing material of various sizes layer by layer (or unit by unit) until the desired cross-section shape is achieved. A rubble mound breakwater on Glagah beach, Kulon Progo, Indonesia is shown in Figure 1.

Figure 1. A rubble mound breakwater on Glagah beach, Kulon Progo, Indonesia.

Figure 2 shows a typical cross section of a rubble mound breakwater. The core, shown in the cross section is usually composed of sand fill, and the armour layers are made up of more rock or the concrete armour units (Palmer and Christian, 1998).

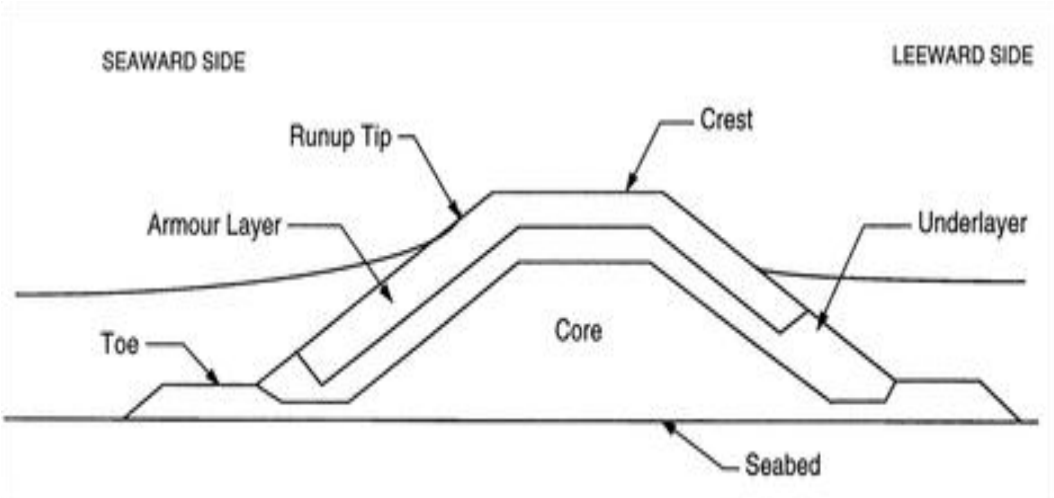

Figure 2. Cross section of a typical rubble mound breakwater.

Generally, the units are not structurally connected, so that the integrity of the rubble-mound depends on features such as the weight of the material, the interlocking nature of the material, and the cross section of the structure. The structure is usually built with material graded from smaller sizes in the core to larger material for armour layer against wave attack (Raichlen, 1975). The armour layer may be composed of quarry-stone if it is available in the required sizes and is economically feasible to use. When these conditions are not met, specially designed concrete units for armour layer of the rubble-mound have been developed that tend to interlock better than rock when properly placed; hence, it may be possible to use armor units lighter than the required quarry-stone. Over the years numerous geometric shapes have been developed for such armour units, with each shape generally introduced to improve on the interlocking characteristics of its predecessors. To mention only a few, various names used for different units: tribars, tetrapods, quadripods, and dolos.

2. Design of Rubble Mound Breakwater

Various studies related to rubble-mound breakwater have been carried out and it is very useful to obtain a stable rubble mound breakwater before it is constructed at the specified location

(Carrasco, et.al, 2014; Contestabilea, et.al., 2017; Iuppa, et.al., 2016). Research in the laboratory is carried out to ensure the condition of the rubble mound breakwater is safe, stable and survive for a long time (Pattipawaej, Dani and Samskerta, 2015; Pattipawaej and Dani, 2016 and 2017).

The initial action required is the calculation for stability of the rubble mound breakwater. Initial input data that is required are HWL (Height Water Level), MWL (Mean Water Level), LWL (Low Water Level), wave height, wav eperiod, depth of the sea, slope of the sea bed, and slope of the rubble mound breakwater, refraction coefficient, also specific gravity of rubble/broken stone. The calculations process (Triatmodjo, 2014) as follows:

- location water depth of breakwater structure based on HWL, MWL, and LWL (d_{HWL}, d_{MWL}, and d_{LWL})
- determination of the wave condition in the location breakwater planned, such as the height of breaking wave (see Figure 3) and the water depth at the location of the breaking wave (see Figure 4)

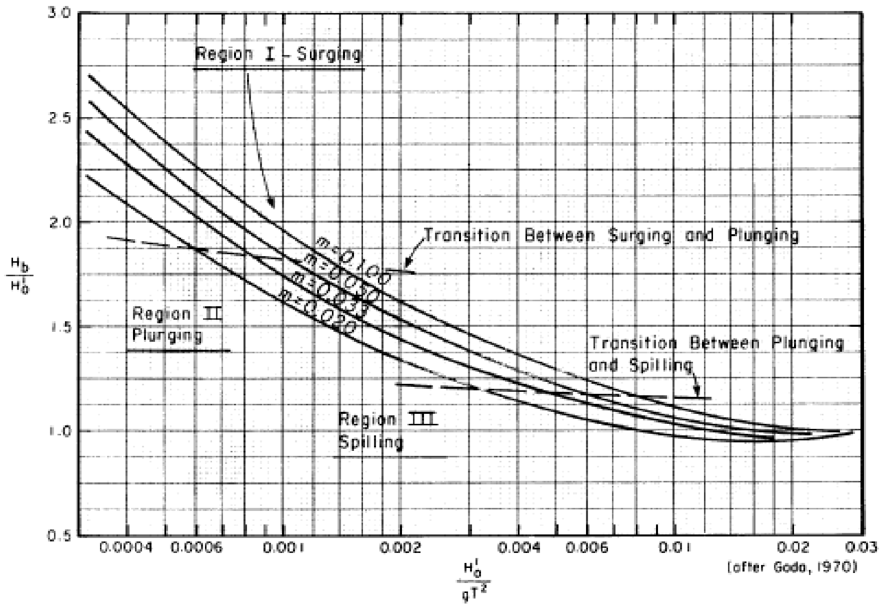

Figure 3. Breaker wave heigth index versus deepwater water steepness (Shore Protection Manual, 1984)

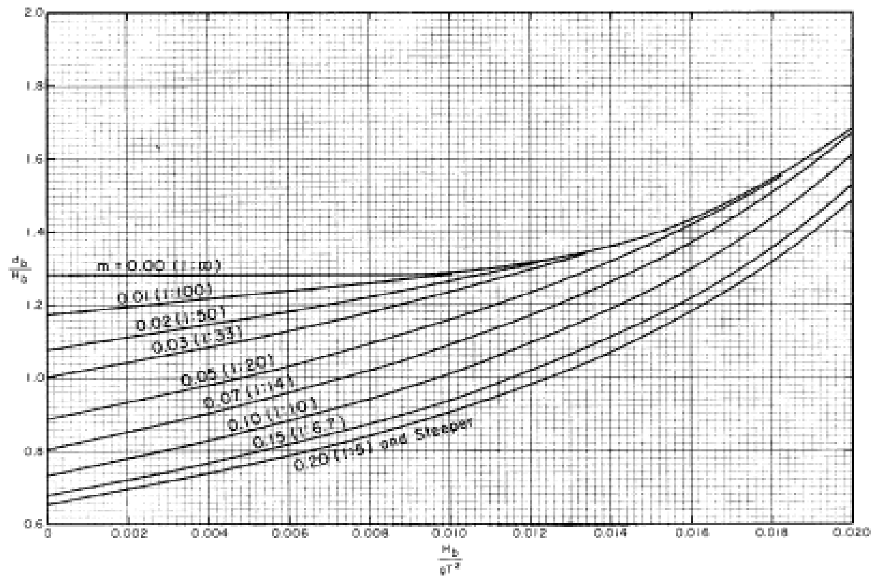

Figure 4. Water depth at the location of breaking wave (Shore Protection Manual, 1984)

- determination of top elevation of breakwater, i.e., the height of wave in deep water (H), Irribaren number:

$$I_r = \frac{\tan\theta}{(H/L_0)^{1/2}}, \quad (1)$$

where L_0 is offshore wave length, θ is slope angle of the stucture, and wave run-up (see Figure 5)

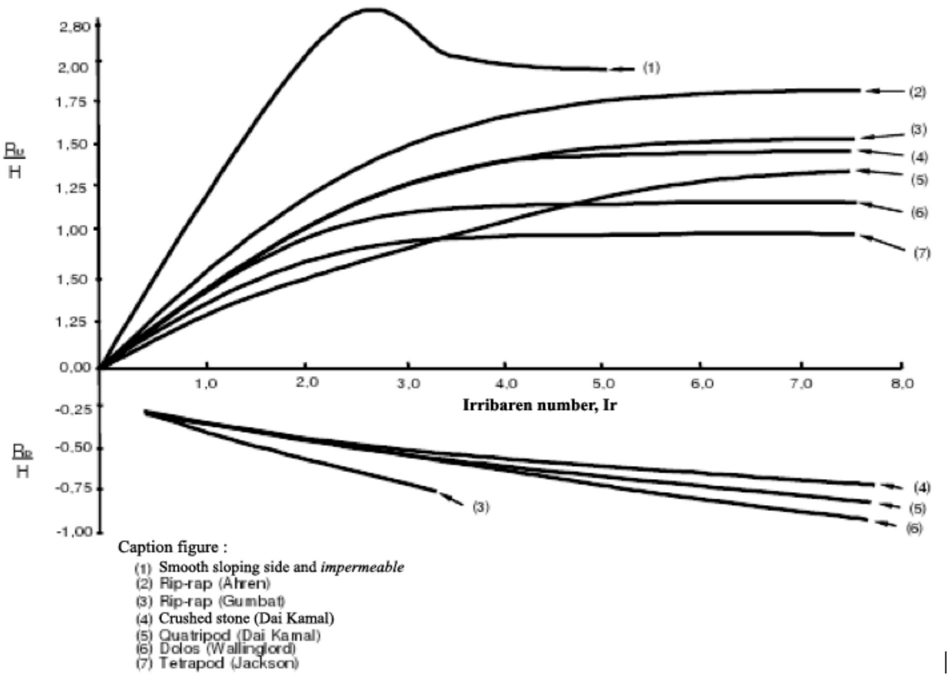

Figure 5. Wave run up (Shore Protection Manual, 1984)

- the height of breakwater according to the selected armor unit material on each layer
- the weight of an individual armor unit in the primary cover layer (W) using Hudson equation:

$$W = \frac{w_r H^3}{K_D (S_r - 1) \cot\theta} \quad (2)$$

where K_D is an empirical stability coefficient, w_r is unit of weight of the armor material, H is the design wave height, and S_r is the specific gravity of the armor unit

- the width at the top breakwater:

$$B = nk_\Delta \left(\frac{W}{w_a}\right)^{1/3} \quad (3)$$

where n is number of stone, k_Δ is the layer coefficient (Triatmojo, 2010), and w_a is the specific weight of armor unit material

- the thickness of armor unit:

$$r = nk_\Delta \left(\frac{W}{w_a}\right)^{1/3} \quad (4)$$

2. Learning Media of Rubble Mound Breakwater Model

Figure 6 shows the initial display when the program starts. When the program is started, the user is prompted to the login. This login is intended to distinguish between users who have access right to users and who do not have access right, and user who have access right as the administrator and user who have access right as a guest. After the user login, then the application will present the main view. The main view can be seen in Figure 7.

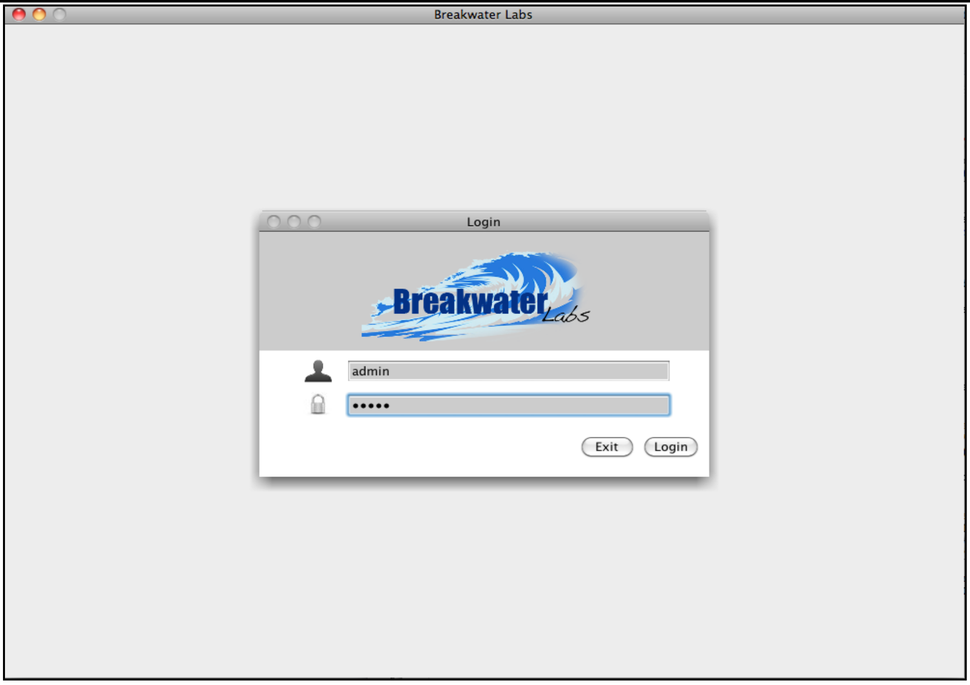

Figure 6. Initial Program

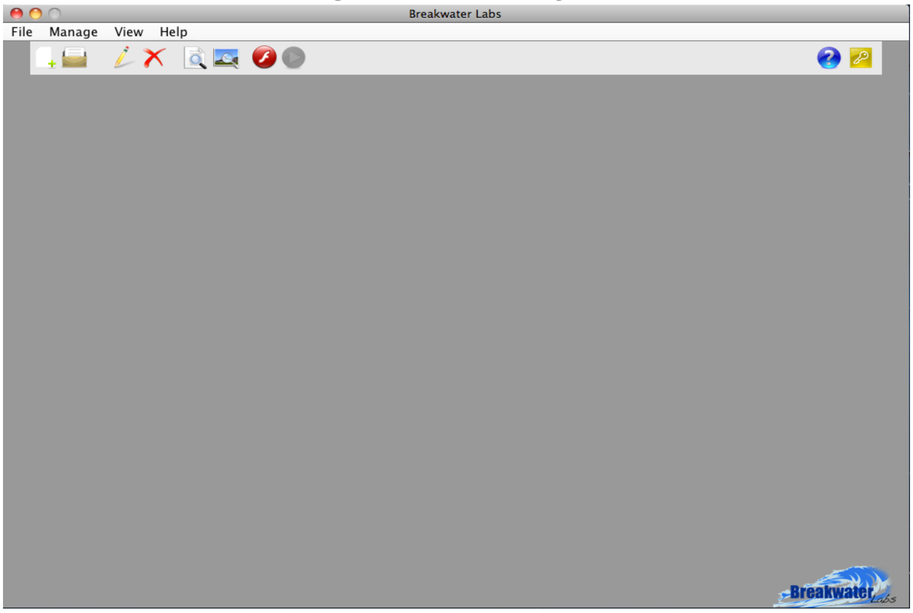

Figure 7. Main view

To create a new project, the user must push the New Project button. Afterward the system will show the first phrase of the new project view which allows the user to insert a project name. The first phrase new project view can be seen in Figure 8.

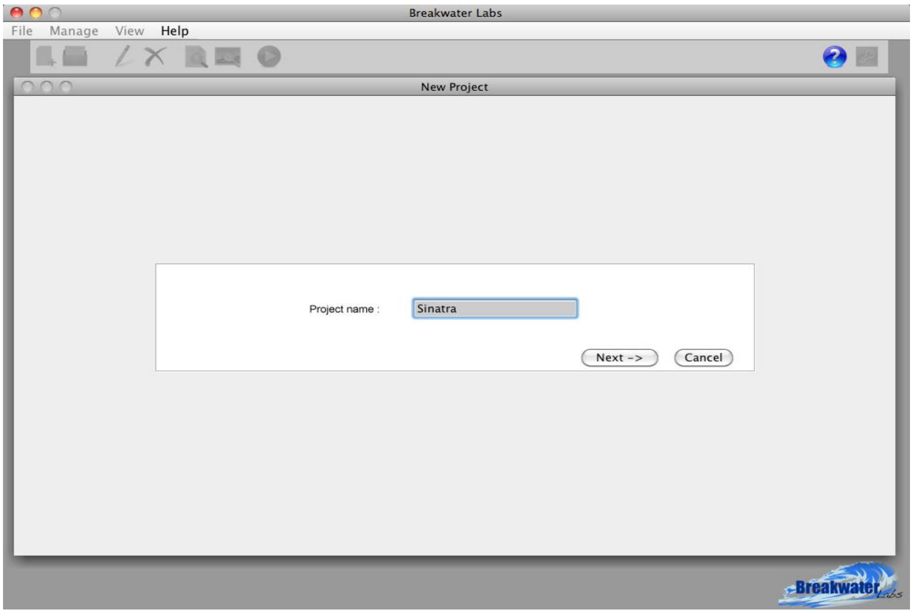

Figure 8. The first phrase new project view.

When the user had already inserted a project name, the learning media system will display the second phrase new project view which allow user to insert an initial data project. The second phrase new project view can be seen in Figure 9.

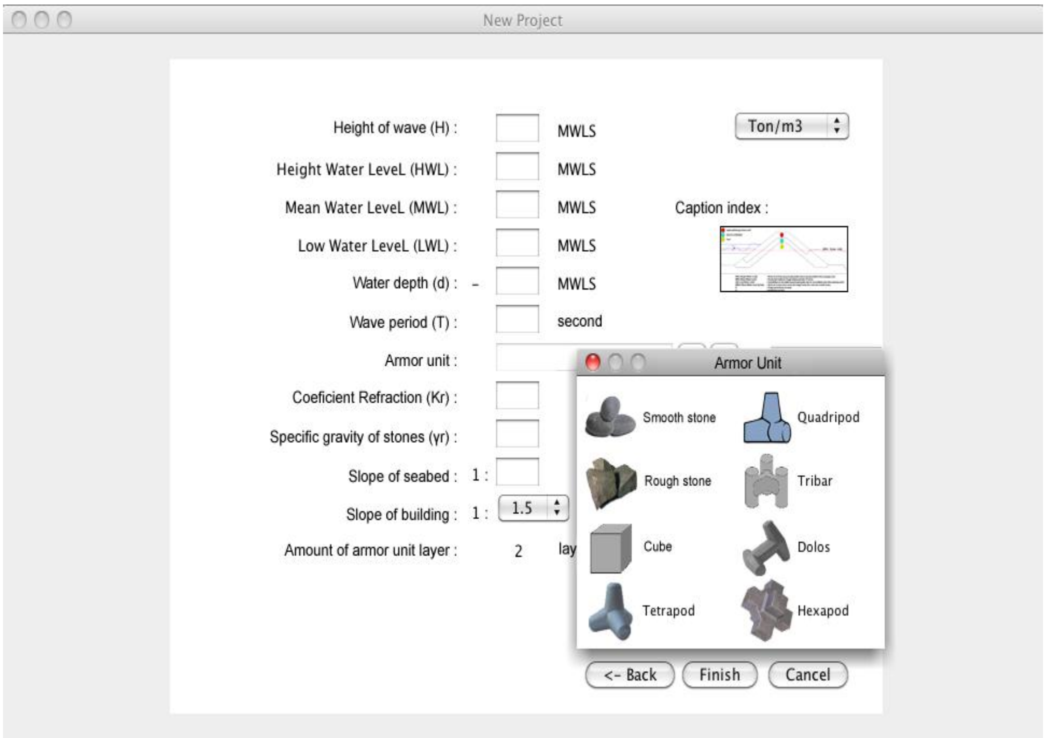

Figure 9. The second phrase new project view

Figure 10 shows the cross-sectional image of the output program. The drawing project is created automatically by the learning media program based on the initial data and computational results.

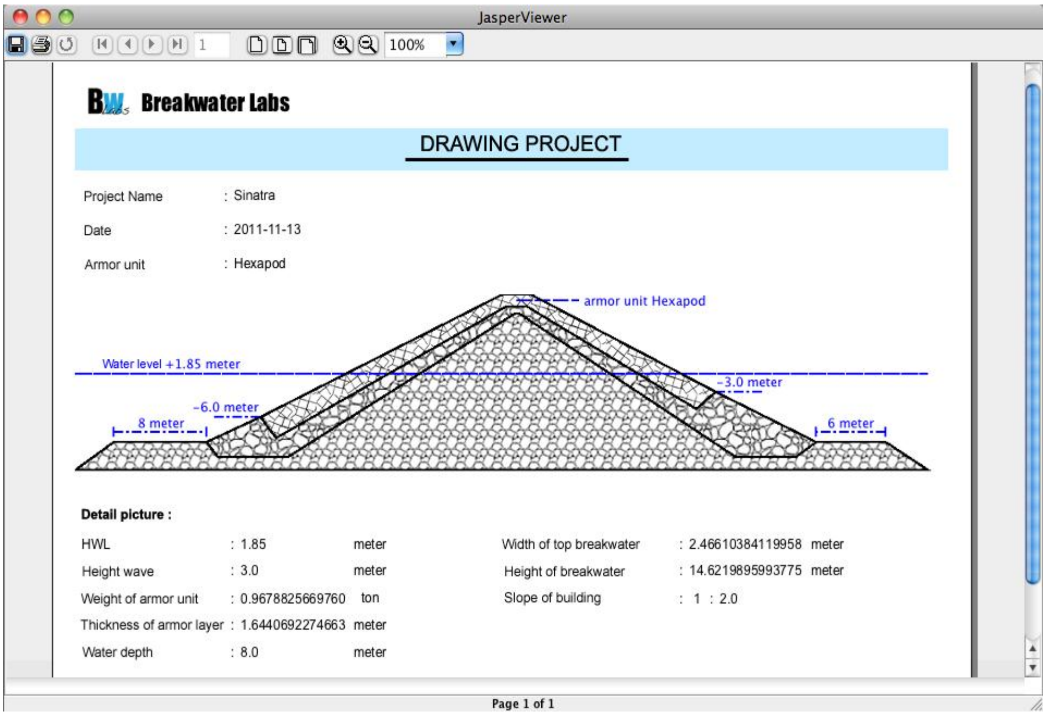

Figure 10. The cross-sectional image based on the initial data and computational result

3. Numerical Example using the Application

First, the input data is required and can be seen in Table 1. Based on the input data from Table 1, Table 2 shows the result of the manual computation on the design of the rubble mound breakwater.

Tabel 1 Initial Data

Input Parameter	
HWL	1.85 m
MWL	1.05 m
LWL	0.3 m
Height of wave	3 m
Water depth	- 8 m
Specific gravity of stone	2.65 ton/m3
Armor unit	Hexapod
Wave period	10 second
Slope of sea-bed	1:50
Slope of structure	1:2
Coefficient.refraction	0.95

Tabel 2 Manual calculation results

Output	
Height of breaking wave	0.00291 m
Depth of breaking wave	4.0 m
Wave condition	nonbreaking wave
Runup wave (Ru/H)	1.4
Elevation of breakwater	6.55 m
Height of breakwater	14.55 m
Weight of armor unit	0.967 m
Width of top breakwater	2.5 m
Thickness of armor layer	1.67 m

The result of numerical calculations can be seen in Figure 9. Table 3 shows the comparison results between the manual and the numerical calculations. The average difference of the results obtained is 0.73 %. These results demonstrate the accuracy of the results of numerical calculation with the highly efficient.

Calculation results :

Data	Value
Height of breaking wave	0.00290519877675841
Depth of breaking wave	4.132832665092
Wave condition	Unbreaking wave
Runup wave (Ru/H)	1.42399653312583
Elevation of bulding	6.62198959937749
Height of bulding	14.6219895993775
Coef.Stability (KD)	9.5
Weight of armor unit	0.967882566976045
Coef. Layer (KΔ)	1.15
Width top breakwater	2.46610384119958
Thickness of armor layer	1.64406922746639

Figure 11. Output of the numerical computation

Table 3 Comparison results between manual and numerical computation

Output	Manual computation	Numerical computation	Difference (%)
Height of breaking wave	0.00291	0.00290519877675841	0.16
Depth of breaking wave	4.1	4.132832665092	0.79
Wave condition	nonbreaking wave	nonbreaking wave	-
Runup wave (Ru/H)	1.4	1.42399653312583	0.36
Elevation of breakwater	6.55	6.62198959937749	1.08
Height of breakwater	14.55	14.6219895993775	0.49
Weight of armor unit	0.967	0.967882566976045	0.09
Width of top breakwater	2.5	2.46610384119958	1.35
Thickness of armor layer	1.67	1.64406922746639	1.55
Average difference			0.73

Conclusion

The rubbble-mound breakwater design is focused to provide coastal protection from the excessive wave action. Furthermore, the learning media of rubble-mound breakwater design is intentionally made for the educational purpose. The armor units form the primary cover layers of protection that exist in this application program consists of some variation among tetrapod, quadripod, hexapod, cube, dolos, tribar, smooth natural stone and rough natural stone. The numerical example shows that the average difference between the manual and the numerical computation for all form of protected items in primary cover layer obtained is equal to approximately 0.73 %. The result makes obvious that this learning media is satisfactory to design the rubble-mound breakwaters accurately and efficiently in the execution time.

The future research will include the determination of toe beam and first underlayer, second underlayer, and core and bedding layer. On the other hand, the simulation of this rubble-mound breakwater design will use the flash animation that supports simulation process to be more close to reality.

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