Zagazig University
Faculty of Engineering
Water Engineering Department

Harbor & Coastal Lab
Guide Book

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Harbor & Coastal Lab.

The laboratory includes small wave flume, two large wave flumes and wave basin as shown in the figure (1).

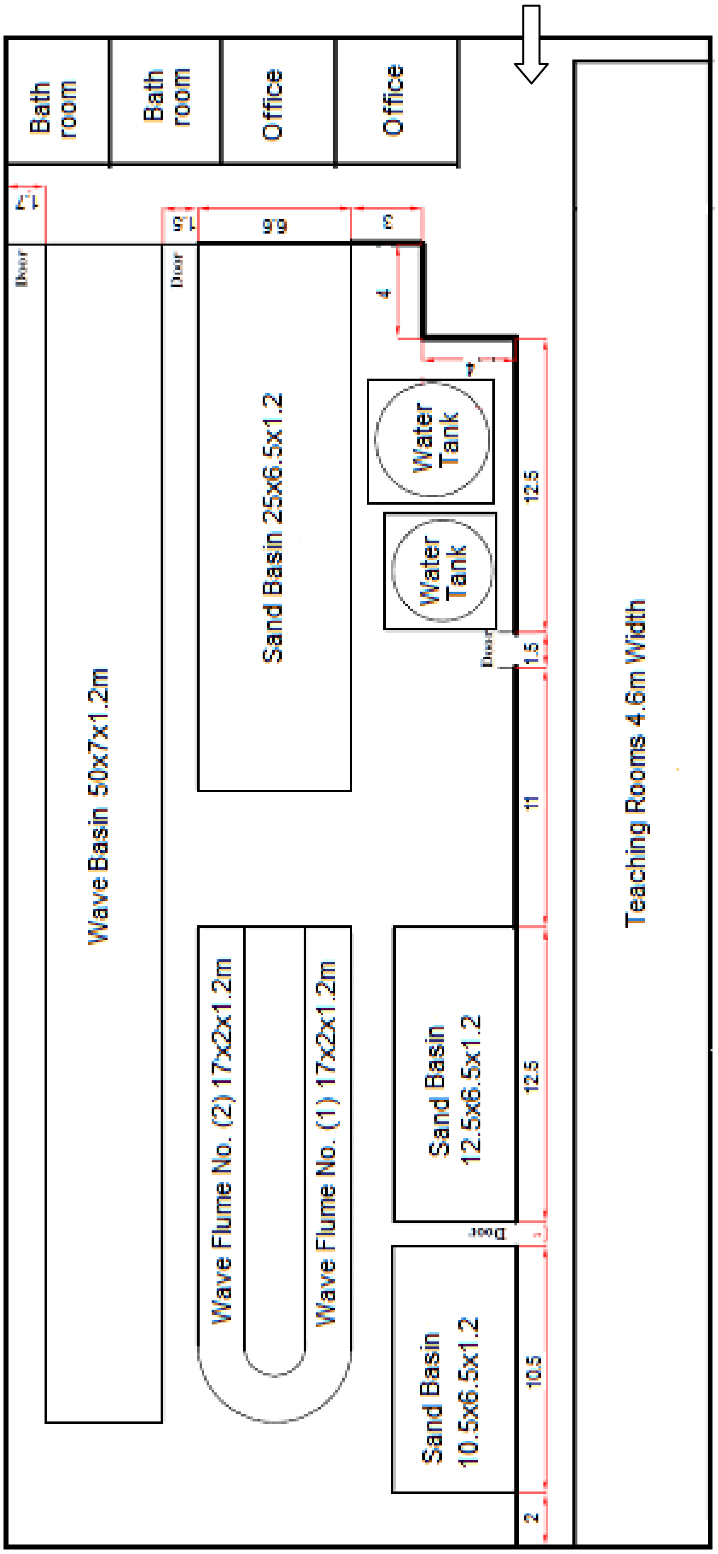


Figure (1) Plan of the lab.

Wave Basins and Flumes

Wave basin is a wave tank which has a width and length of comparable magnitude, often used for testing ships, offshore structures and three-dimensional models of harbors (and their breakwaters).

Wave flume (or **wave channel**) is a special sort of wave tank: the width of the flume is much less than its length. The generated waves are therefore – more or less – two-dimensional in a vertical plane (2DV), meaning that the orbital flow velocity component in the direction perpendicular to the flume side wall is much smaller than the other two components of the three-dimensional velocity vector. This makes a wave flume a well-suited facility to study near-2DV structures, like cross-sections of a breakwater. Also (3D) constructions providing little blockage to the flow may be tested, e.g. measuring wave forces on vertical cylinders with a diameter much less than the flume width.

Wave flumes may be used to study the effects of water waves on coastal structures, offshore structures, sediment transport and other transport phenomena.

The waves are most often generated with a mechanical wavemaker, although there is also wind–wave flumes with (additional) wave generation by an air flow over the water – with the flume closed above by a roof above the free surface.

The wavemaker frequently consists of a translating or rotating rigid wave board. Modern wavemakers are computer controlled, and can generate besides periodic waves also random waves, solitary waves, wave groups or even tsunami-like wave motion. The wavemaker is at one end of the wave flume, and at the other end is the construction being tested, or a wave absorber (a beach or special wave absorbing constructions). Often, the side walls contain glass windows, or are completely made of glass, allowing for a clear visual observation of the experiment, and the easy deployment of optical instruments.

Wave Flume (1)

Description:

- The wave flume dimensions are: 2m width, 1.2m height and 17m total length.
- The wave flume divides into three parts: wave generator part (1.5m length), wave absorber part (2.5m length) and the working section part (13m length).
- The vertical sides and bed of the flume are made from reinforced concrete of 0.25 m thickness and covered with ceramic.
- A gravel wave absorber with slope 3:1 is installed at the end part of the flume to absorb the transmitted waves.
- The general views of the wave flume and the end absorber part are shown in Photos (1) and (2).

Photo (1) General view of the wave flume (1)

Photo (2) General view of the wave absorber

Wave Generator Description:

- The wave generator is from a flap type and installed at the beginning of flume.
- It consists of a hinged steel gate supported with the flume bed and connected to two steel flywheels with 0.36 m diameter by two steel rods of 1.5cm diameter and 1.5m long.
- The whole system is connected with a 5HP variable speed motor of 1400 rpm.
- A gearbox is used to reduce the number of revolution to range between 20 and 120 rpm which produce a wave period range between 0.8 and 3s.
- Electronic digital inventor is used to control the generator velocity.
- General views of the different parts of the generator and the calibration of the wave generator are presented in photos (3) to (5) and figure (2).

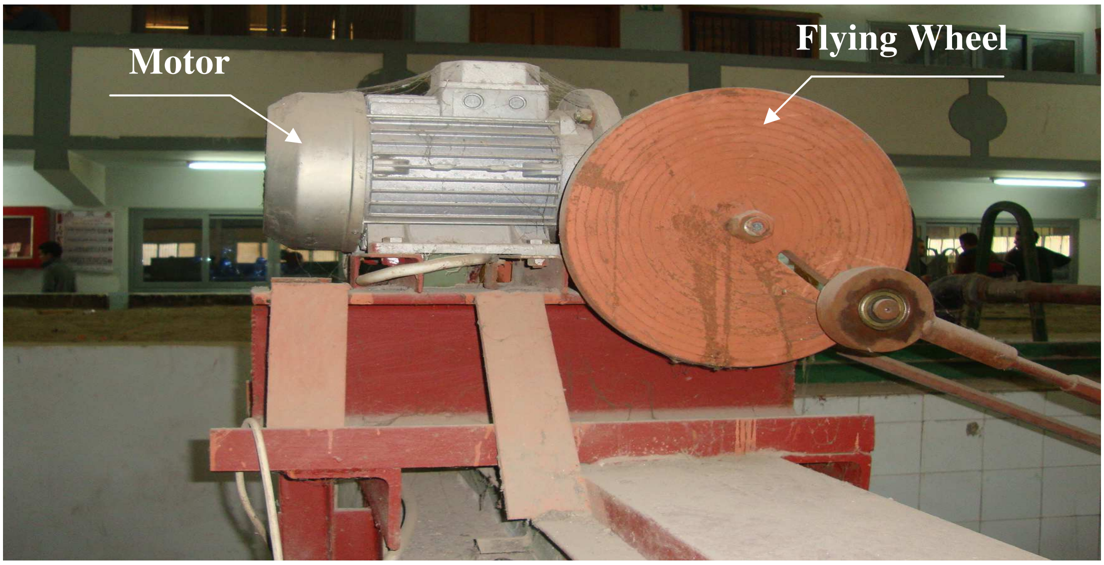


Photo (3) Side view of the wave generator

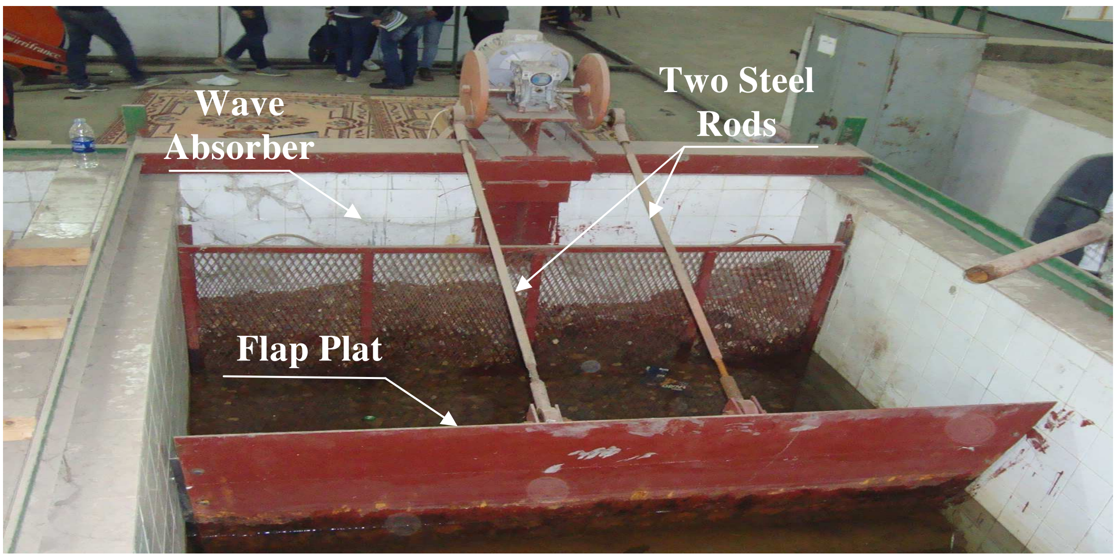
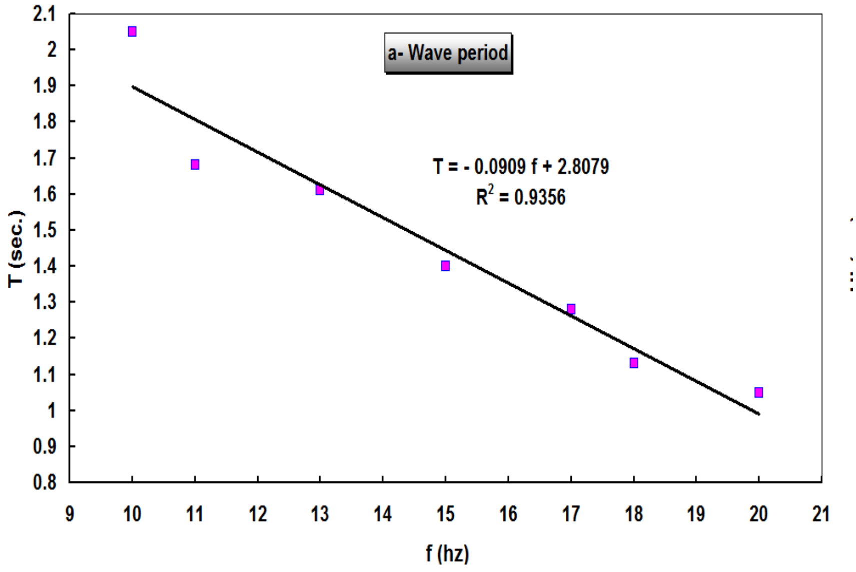
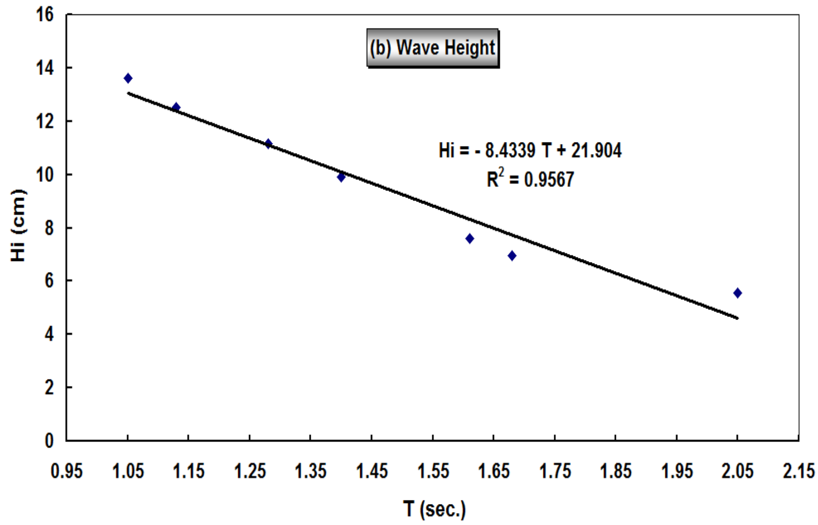


Photo (4) Front view of the generator

Photo (5) Wave generator control unit (Inverter circuit)



(a) Relationship between the wave period and the frequency



(b) Relationship between the wave height and the wave period

Figure (2): Calibration of wave generator

Wave Flume (2)

Description:

- The wave flume dimensions are: 2.0m width, 1.20m height, and 17m total length.
- The wave flume divides into three parts: wave generator part (1.5m length), wave absorber part (2.5m length) and the working section part (13m length).
- The vertical sides and bed of the flume are made from reinforced concrete of 0.25m thickness and covered with ceramic.
- A gravel wave absorber with slope 3:1 is installed at end part of the flume to absorb the transmitted waves.
- The general views of the wave flume and the end wave absorber are shown in Photos (6) and (7).

Photo (6) General view of the wave flume (2)

Photo (7) General view of the end wave absorber

Wave Generator Description:

- Flap type wave generator is used and installed at the up wave end of flume.
- It consists of a 1x1x0.005m steel gate hinged with the bed by 2 stainless steel hinges, and connects with a 0.30m circular flywheel by a connecting rode with 0.025m diameter and 0.9m long.
- The whole system is derived by a 3.0 HP motor with 1400 RPM.
- A gearbox is used to reduce the number of revolution to 140 RPM.
- An inverter circuit is used to change the motor speed to produce a wave period ranging from 0.8 to 2s.
- General views of the different parts of the generator and the calibration of the wave generator are presented in photos (8) to (10) and figure (3).

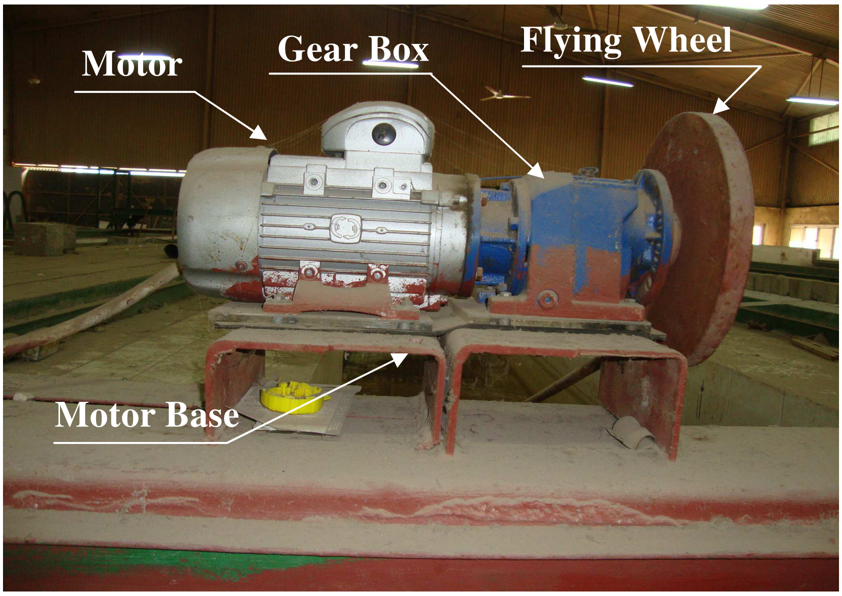


Photo (8) Different components of the wave generator

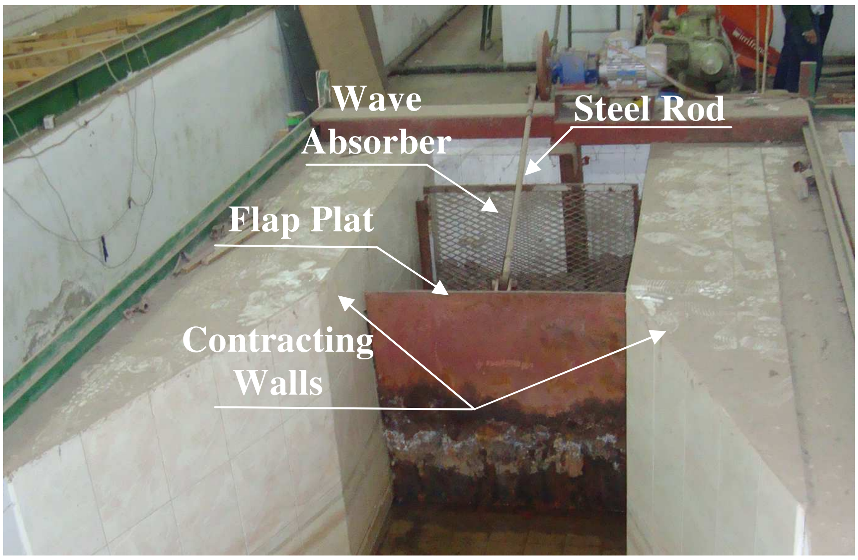


Photo (9) Front view of the wave generator

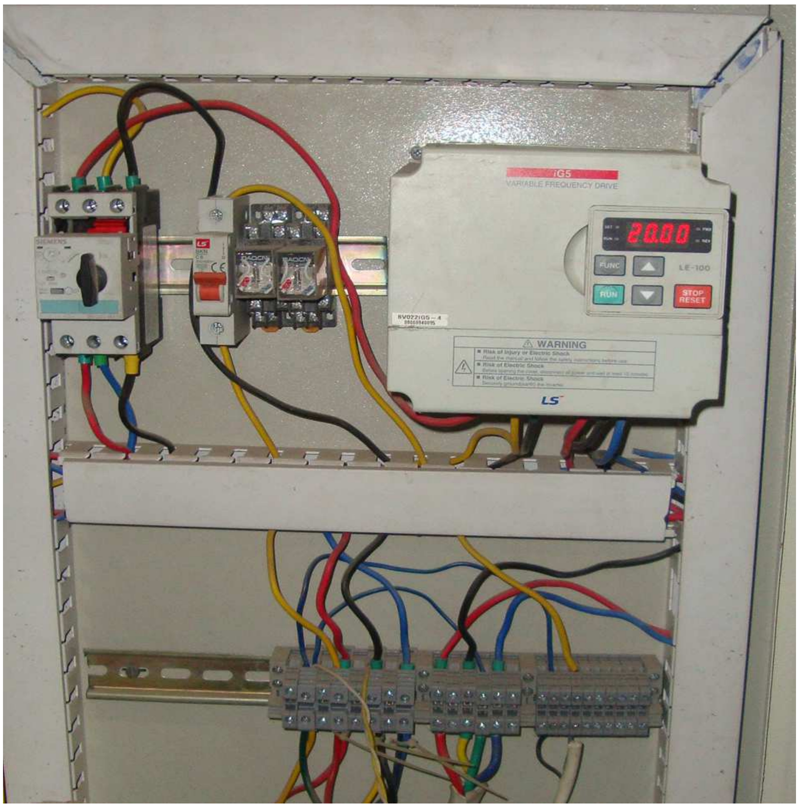
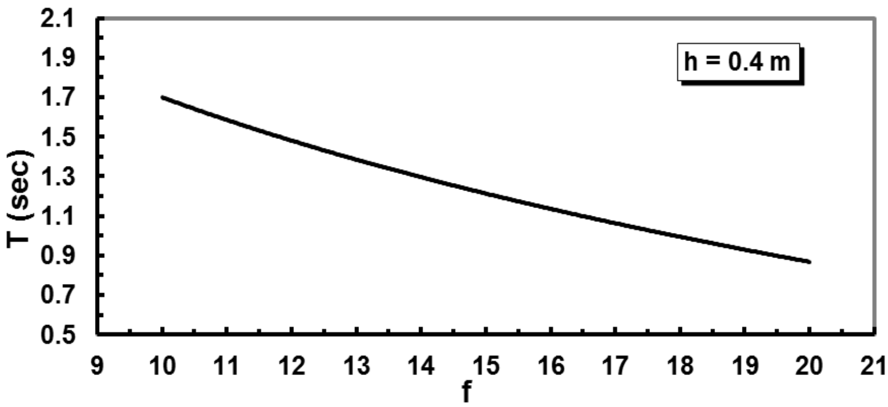
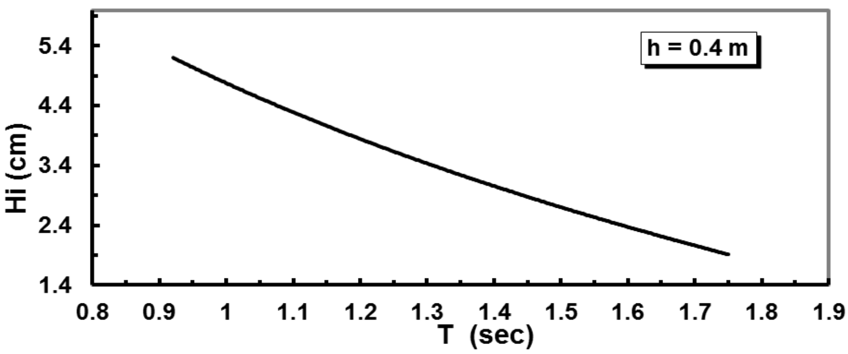


Photo (10) Wave generator control unit (Inverter circuit)



(a) Relationship between the wave period and the frequency



(b) Relationship between the wave height and the wave period

Figure (3): Calibration of wave generator

Wave Basin

Description:

- The wave basin dimensions are: 7m width, 1.20m height, and 50m length.
- The wave basin divides into three parts: wave generator part (5m length), wave absorber part (5m length) and the working section part (40m length).
- The vertical sides and bed of the basin are made from reinforced concrete of 0.25m thickness and covered with ceramic.
- A crushed stone wave absorber with slope 4:1 is installed at end part of the basin to absorb the transmitted waves.
- The general views of the wave basin and the end wave absorber are shown in Photos (11) and (12).

Photo (11) General view of the wave flume (2)

Photo (12) General view of the end wave absorber

Wave Generator Description:

- Flap type wave generator is used and installed at the up wave of the basin.
- It consists of a 5x0.75x0.01m steel gate hinged with the bed by 3 stainless steel hinges, and connects with two 0.35m circular flywheels by two connecting rods with 0.025m diameter and 1.25m long.
- The whole system is derived by a 10.5 HP motor with 1400 RPM.
- A gearbox is used to reduce the number of revolution to 140 RPM.
- An inverter circuit is used to change the motor speed to produce a wave period ranging from 0.8 to 2s.
- General views of the different parts of the generator and the flap system are presented in photos (13) and (14).

Photo (13) Different components of the wave generator

Photo (14) Wave generator control unit (Inverter circuit)

Measuring Devices

- There are two wave gauges in the laboratory. It is of a standard conductivity type wave probe. It is used to measure the wave elevations.
- The wave probe comprises of two thin parallel stainless steel electrodes. The probe consists of two 0.0015m diameter stainless steel wires spaced 0.0125m and are 0.30m long.
- The probe is connected to a wave monitor module in the electronic console by a twin core flexible cable.
- This monitor provides output signals in form of voltage data.
- An electronic converter is used for converting the analogue signals to digital voltage data.
- These data are collected by the personal computer and converted to the wave elevation by a simple computer program. Where the water surface variation could be drawn.
- A general view of the Standard conductivity type wave probe instrument is presented in photo (15).

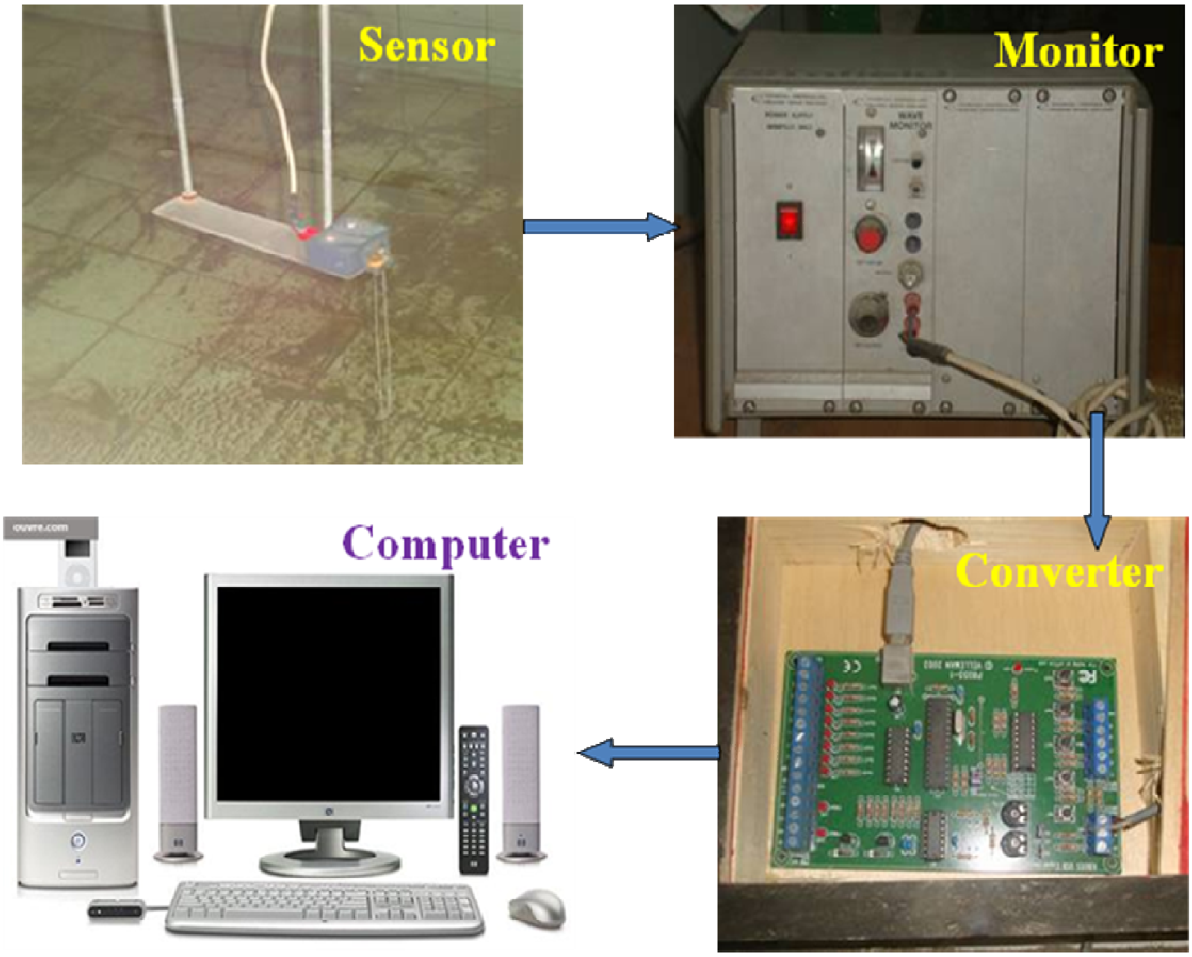


Photo (15) General view of the Standard conductivity type wave probe

4- Wave Flume 3

Description:

- The wave flume dimensions are: 0.3m bed width, 0.45m height, and 15.6m overall length.
- The flume is divided into three parts: wave generator part (1.5m length), wave absorber part (1.5m length) and working section (12m length).
- The vertical sides are made from toughened glass of 1.2cm thickness.
- The bed is made of cold-rolled steel sheets that are welded to each other by a watertight agent and is painted with anti-corrosive paint.
- At the top of the working section there are steel angles (5cmx5cmx0.6cm) which are used to hold the measuring instruments carriage over two aluminum rails fixed at the top of those angles.
- A steel screen wave absorber with slope 3:1 is installed at the end of the flume to absorb the transmitted waves.
- A general view of the flume and the different its important parts are shown in Photos (16) to (19).

Photo (16): General view of the wave flume

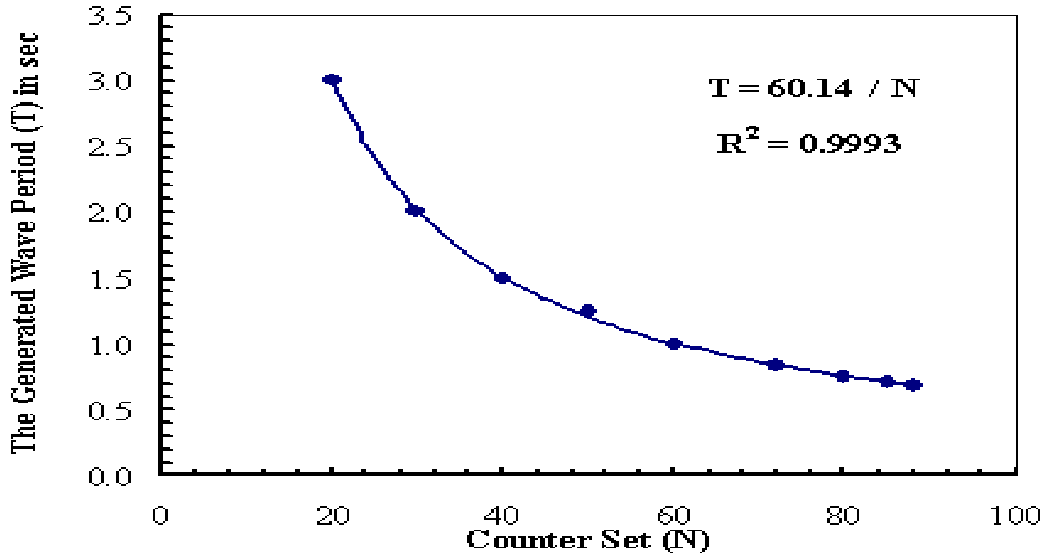
Photo (17): Wave Absorber at the end of the flume

Photo (18): Changing flume bed slope part

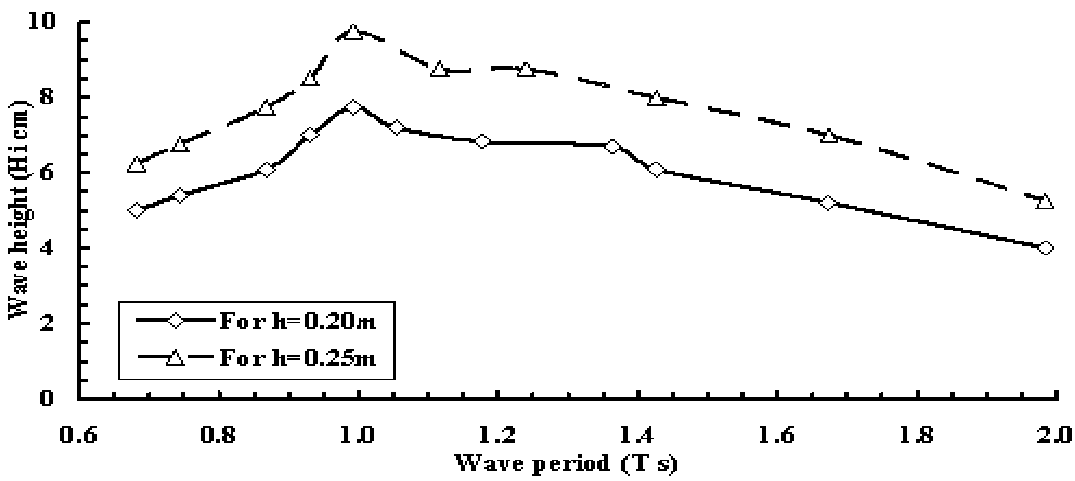
Photo (19): Wave generator control box

Wave Generator Description:

- Flap type wave generator is used and installed at the up wave end of the flume.
- It consists of a hinged steel gate hinged with the flume bed and connected with 22cm diameter flywheel by a connecting steel rod of 1cm diameter and 56cm long.
- The whole system is derived by a 0.75HP variable speed motor of 1410RPM.
- A gearbox is used to reduce the number of revolution to range from 15 to 90RPM, which in turn produces a wave period ranging from 0.67 to 4s.
- The calibrations, the different parts, and the general view of the wave generator are shown in Figure (4) and (5), and Photo (20).



(a) Relationship between the wave period and the counter set



(b) Relationship between the wave height and the wave period

Figure (4): Wave Generator Calibration.

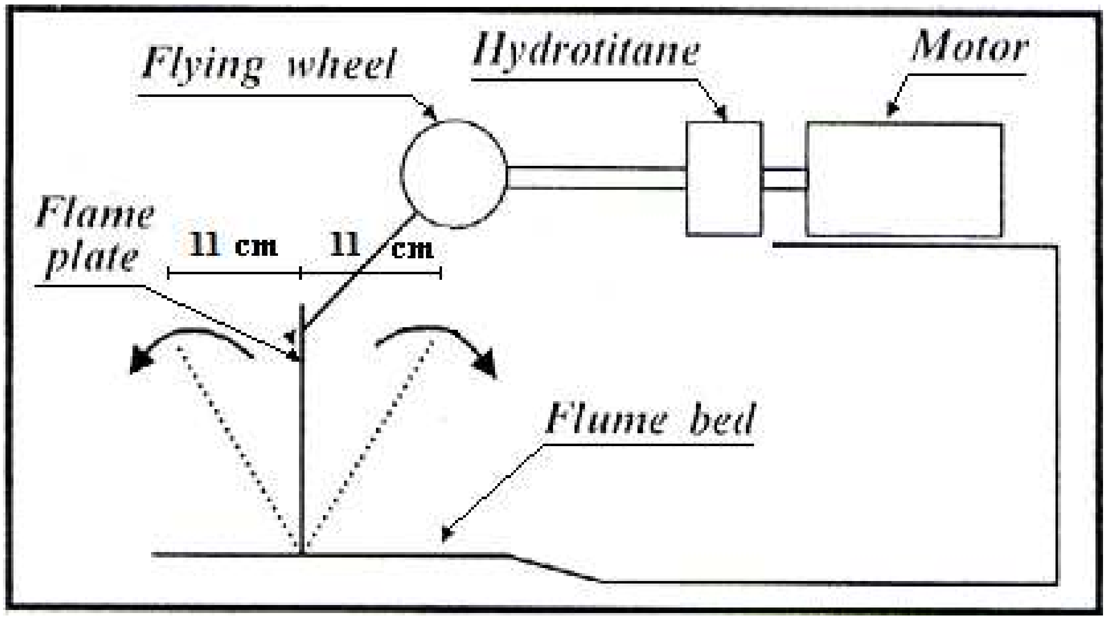


Figure (5): Different Parts of Wave Generator.

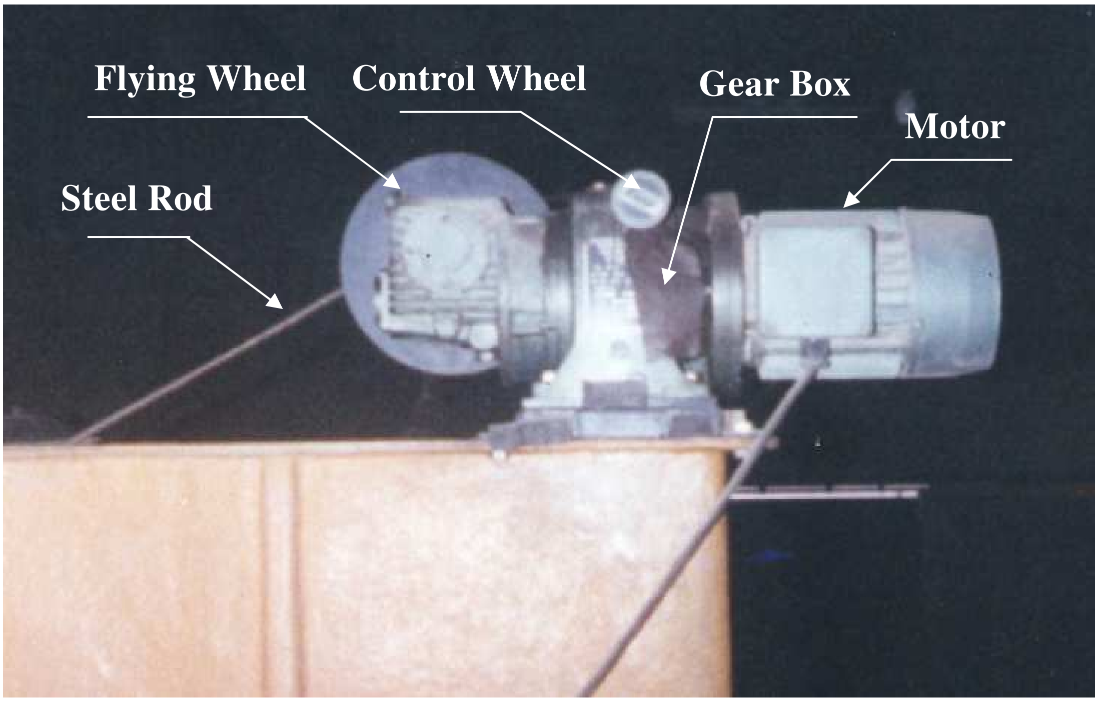


Photo (20): General View of the Wave Generator

Some Applications

Wave Flume 3

Koraim, A. S. and Salem, T. N. (2012) "The hydrodynamic characteristics of a single suspended row of half pipes under regular waves" Ocean Engineering, Vol. (50), Issue (1), pp: 1-9.

ABSTRACT

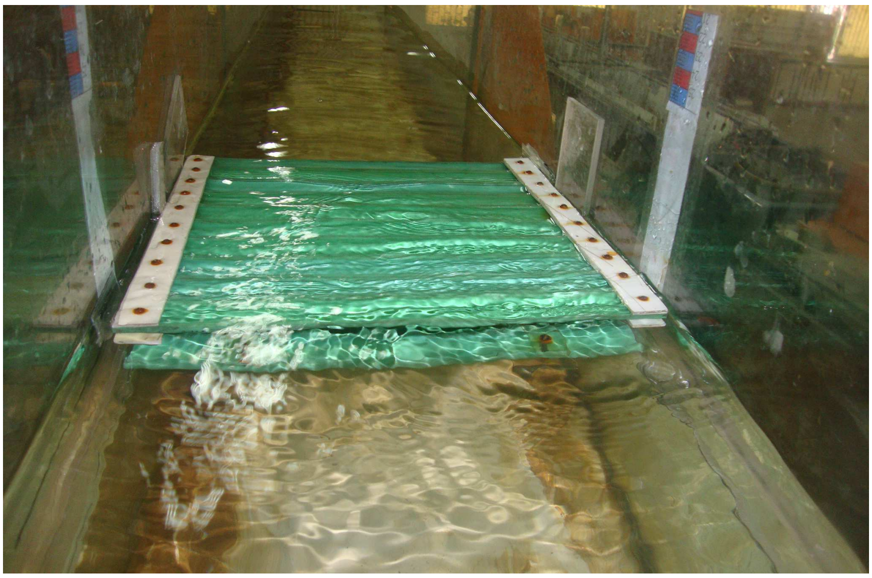
In this paper, the hydrodynamic performance of a new type breakwater is studied using physical models. The breakwater consists of one row of half pipes suspended on supporting piles. The transmission, the reflection, and the wave energy dissipation coefficients are presented for different wave and structure parameters. The results indicate that the performance of the proposed breakwater becomes efficient increases when: (1) the half pipes are horizontal; (2) the diameter of the half pipes is increased; (3) the breakwater inclination angle is 45^{o}; (4) the breakwater draft is greater than the half of the water depth; (5) the wave length is more than two times the water depth. In addition, the proposed breakwater type gives high performance when compared with the other similar breakwater systems, e.g. suspended vertical or horizontal pipes and slots, by about 5 to 40%.

Vertical half pipes breakwater model.

Koraim, A. S. (2013) "Hydrodynamic efficiency of suspended horizontal rows of half pipes used as a new type breakwater" Ocean Engineering, Vol. (64), pp 1-22.

ABSTRACT

The hydrodynamic efficiency (effect of structure on incident wave attenuation) of a new type breakwater was studied using physical models under regular waves. The breakwater was consisted of one or more horizontal rows of half pipes suspended on supporting piles. The hydrodynamic efficiency of the breakwater was validated through calculation of the wave transmission, reflection and energy dissipation coefficients for different wave and structural parameters. Results indicated that the transmission coefficient decreases with increasing the relative wavelengths (h/L and B/L), wave steepness (H_i/L) and relative breakwater width (B/d), and it increases with decreasing the relative draft (D/h). The reflection and dissipation coefficients take the opposite trend. The proposed breakwater system is more efficient than the smooth plate type by about 5 to 25%. The use of a second row improves the breakwater efficiency by about 20 to 50% and the use of the third row improves the efficiency by about 5 to 15% more than the two rows system. Empirical equations were developed for estimating the transmission and reflection coefficients. The results of these equations were compared with other experimental and theoretical results giving a reasonable agreement. The proposed breakwater type was efficient when compared with other breakwater systems.



Horizontal half pipes breakwater model.

Wave Flume 2

Koraim, A. S., Heikal, E. M. and Abo Zaid, A. A. (2014) "Hydrodynamic characteristics of porous seawall protected by submerged breakwater" Applied Ocean Research, Vol. (46), pp 1-14.

ABSTRACT

In this paper, the hydrodynamic efficiency of a new type porous seawall is experimentally studied by using physical models. The seawall consists of front steel screen, back solid wall and filled rock-core. A submerged breakwater with different parameters is installed in front of the seawall. The wave run-up on the seawall and the wave reflection due to the seawall with or without the submerged breakwater are investigated. The wave transmission due to the submerged breakwater is investigated also. The results indicate that; the run-up and reflection coefficients due to the seawall only decrease with increasing of: the relative water depth (h/L); the wave steepness (H_i/L); the relative seawall width (b/h); and the seawall porosity (n). The submerged breakwater decreases the run-up on the seawall and the wave reflection by about 20 to 60% and less than 70% respectively. In addition, the submerged breakwater is achieving low transmission coefficients with increasing of the relative breakwater height (D/h) and the relative breakwater width (B/h).

Porous seawall model

Vertical submerged breakwater model

Koraim, A. S. (2014) "Hydraulic characteristics of pile-supported L-shaped bars used as a screen breakwater" Ocean Engineering Vol. (83), 36–51.

ABSTRACT

The hydrodynamic performance of horizontal L-shaped bars suspending on sporting piles was experimentally and theoretically studied under normal regular waves. The effect of different wave and structural parameters was investigated e.g. the wave length, the horizontal L-shaped bars draft and spacing, the supporting piles diameter and spacing. The theoretical model based on an Eigen Function Expansion Method and a Least Square Technique was developed to determine the hydrodynamic performance of such structures. In order to examine the validity of the theoretical model, the theoretical results were compared with the present experimental results and with the results obtained from different previous studies. Comparison between experiments and predictions showed that the theoretical model provides a good estimate of the wave transmission, reflection, and energy dissipation coefficients when the upper and lower friction factors are f_U=1.25 and f_L=0.75. The proposed theoretical model gives a reasonable performance when compared with the theoretical and experimental results of other similar breakwater models.

Pile-supported L-shaped bars

Koraim, A. S. (2015) "Mathematical study for analyzing caisson breakwater supported by two rows of piles" Ocean Engineering, Vol. (104), August, 89–106.

ABSTRACT:

The hydrodynamic characteristics of the semi immersed caissons suspending by two rows of piles is experimentally and mathematically studied under normal regular waves. The effect of different wave and structural parameters is investigated e.g. the incident wave length and height, the caisson width and draft and the supporting piles diameter and spacing. The mathematical model based on an eigenfunction expansion method is developed to determine the hydrodynamic characteristics of such structures. In order to examine the validity of the mathematical model, the mathematical results are compared with different experimental and mathematical results. Comparison between experiments and predictions shows that the mathematical model provides a good estimate of the wave transmission, reflection, and energy dissipation coefficients when the lower pile part friction factor is f_p=1.0. The proposed mathematical model gives a reasonable efficiency when compared with the mathematical and experimental results of other similar breakwater models.

Caisson breakwater supported by two rows of piles

Wave Flume 1

Heikal, E. M., Koraim, A. S. and Elbagory, I. A. (2014) "Efficiency of vertical suspended breakwater supported on piles" The Egyptian International Journal of Engineering and Technology, Vol. (17), No. (1), January, pp. 1793-1811.

ABSTRACT:

The efficiency of purposed breakwater, which consists of caissons sheets supported on two or three rows of piles, was studied using physical and numerical models. The breakwater efficiency was analyzed using the Flow-3D package under normal regular waves. The efficiency of the breakwater was presented as a function of the wave transmission and reflection coefficients for different breakwater and waves characteristics. It was found that, the proposed Flow-3D numerical model underestimates the transmission and the reflection coefficients by about 5-10%. The transmission coefficient (k_t) decreases with increasing the relative caisson draft (D_1/h), the relative plate depth (D_2/h and D_3/h), the relative breakwater width (B/h), the distance between piles (S) and piles diameters (d) and with decreasing the piles gap-diameter ratio (G/d). The study shows that values less than 0.25 for k_t and more than 0.9 for k_r are possible when $D_1/h \geq 0.5$ and also when D_2/h, $D_3/h \geq 0.4$ at $D_1/h=0.1$.

Vertical suspended breakwater supported on piles

New Subjects under Studying

Koraim, A. S. Heikal, E. M., and Abo Zaid, A. A. " Wave Transmission Characteristics of Gabions Filled With Rubble Used as Submerged Breakwater" wave flume 2

Gabions Filled With Rubble Used As Submerged Breakwater

Koraim, A. S. And Heikal, E. M." Wave Transmission Characteristics of Two Rows of Piles Suspending Large Half Pipes "wave flume 2

Two Rows of Piles Suspending Large Half Pipes

Heikal, E. M., Koraim, A. S. and Elbagory, I. A. "Wave Transmission Characteristics of One Row of Piles Suspending Hydraulic Jets" wave flume 2

Heikal, E. M., Koraim, A. S. and Elbagory, I. A. "Wave Transmission Characteristics of One or Two Rows of Piles Suspending Plastic Screens" wave flume 2