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EFFECT OF SLOPE, SIZE, AND ARRANGEMENT OF ROUGHNESS OF SEA WALL ON OVERTOPPING OF RANDOM WAVES

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ABSTRACT

The present study investigated the effect of upstream slope and roughness height on the amount of overtopping of sea walls by waves. The slopes of the sea walls tested were 45°, 51°, 56°, and 61°. Sea walls with roughness heights of 20 and 30 cm were examined for 4 arrangements of roughness. The results were analyzed for the effect of slope and roughness on overtopping by waves. The results show that increasing the slope increased the overtopping. The amount of overtopping was directly related to the slope and increasing the height of the Roughness on a steep surface decreased overtopping. Increasing the height of the Roughness on a steep surface of the wall decreased the water height on the corona. In all tests, the best type of arrangement was type 3, which showed the least overtopping. The change in roughness height for this type for all slopes showed the least effect or no effect. The effect of overtopping was investigated in relation to the geometrical arrangement at the level of the sea wall and the results are presented.

Keywords: Overtopping of waves, Slope, Sea wall, Height of roughness

INTRODUCTION

The increase in population in coastal areas increases the importance of protection of the coasts and ports. Iran has several thousand kilometers of coastline and must provide accurate and scientific designs for the construction and operation of offshore structures to protect coasts and ports. One type of marine protection structure is a sea wall, which acts as a protective barrier and is constructed parallel to the coastline. Sea walls are fully self-reliant and are used to protect the coast from the effects of waves.

Unlike the protective coatings that are built on the coastal slopes, sea walls are usually built in areas that lack coastal slopes. From the practical point of view, the primary purpose of construction of a sea wall is to protect the surface behind it from the damaging effects of waves. Depending on the type of sea wall, these structures are built to withstand the force of waves or change the wave direction and absorb the force of the waves.

The ruling parameters in the design of coastal structures include hydraulic, geotechnical, and structural parameters. The amount by which waves overtop the wall is a crucial hydraulic factor in the design of sea walls and was examined in the present study. The amount of overtopping of marine structures by waves determines the amount of damage caused to the structures and facilities behind the wall. It is an important hydraulic factor in the design of such structures and the geometric features of the structure, such as the corona level can be identified using it.

Overtopping is the amount of water passing per unit time; in this case, it is cubic meters per second (m^3/s). Often, the amount of water overtopped is the same for the length of the structure, so overtopping can be defined as the value per unit length ($m^3/s/m$). Wave overtopping occurs when waves of water rise from the seaward side of the structure (sea walls or breakwaters) and passing over the corona of the structure.

Research History

Several studies have focused on waves overtopping marine structures. These methods have consistently correctly predicted overtopping of structures to protect the coast against sea waves. By 2002, nearly 6,500 tests had been conducted; physical models of regular waves have also been carried out in the USA. The most complete set of random waves was completed by Owen (1980). Owen carried out a number of physical model tests to study overtopping and the relationship between the height of the sea wall and degree of overtopping. He showed that the degree of overtopping depends on environmental conditions such as wave height and wave period, as well as on the geometry and type of structural material. The combination of these factors should be investigated. Von Meyer and Duval (1992) carried out another series of studies.

Investigated parameters

The current study examined the effects of type and slope of Roughness on the degree of overtopping of a sea wall. A total of 36 tests were designed on sea walls using 4 slopes (45°, 51°, 56°, and 61°); in addition, 4 roughness arrangements and roughness heights of 20 and 30 cm were considered. Figure 1 shows the variables for 4 walls with different slopes and dimensions located on a steep surface. They featured 4 arrangements of Roughness with different shapes at heights of 20 and 30 cm. The slopes are denoted by letters E, F, G, and H and the Roughness are denoted by numbers 1, 2, 3 and 4 (the number of steps). Table 1 lists the variables for each type and Table 2 lists the modes of review.

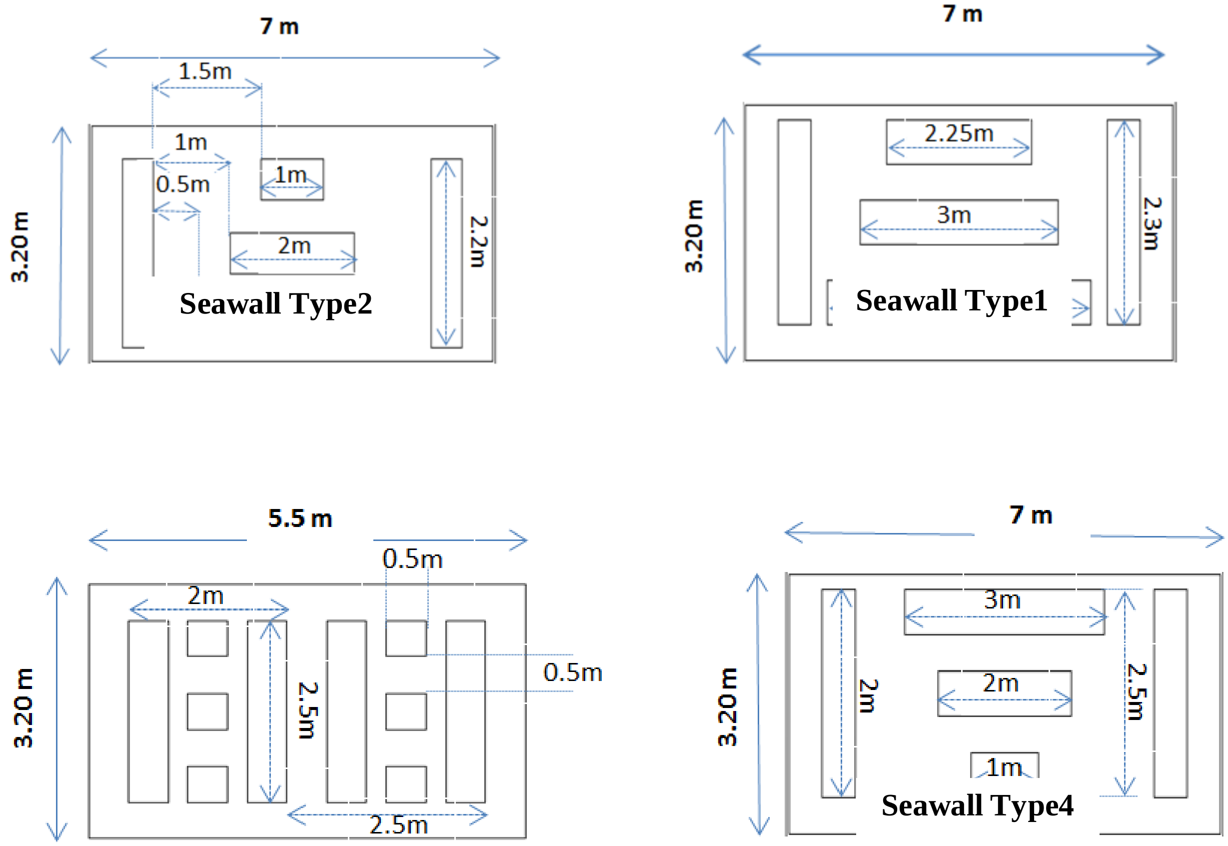

Figure 1: Schematics of wall types

Table 1: Designation of variables

Form	Roughness	Form of Roughness			
		1	2	3	4
E	Without Roughness	E1			
	20 cm	E2-1	E2-2	E2-3	E2-4
	30 cm	E3-1	E3-2	E3-3	E3-4
F	Without Roughness	F1			
	20 cm	F2-1	F2-2	F2-3	F2-4
	30 cm	F3-1	F3-2	F3-3	F3-4
G	Without Roughness	G1			
	20 cm	G2-1	G2-2	G2-3	G2-4
	30 cm	G3-1	G3-2	G3-3	G3-4
H	Without Roughness	H1			
	20 cm	H2-1	H2-2	H2-3	H2-4
	30 cm	H3-1	H3-2	H3-3	H3-4

Table 2: Modes of review

Variable	Number	Size
Slope of sea wall	4	45°, 51°, 56°, 61°
Configuaration of Roughness	4	
Height of Roughness	2	20 cm and 30 cm

RESULTS AND DISCUSSION

The results are presented on the basis of change in the slope of the sea wall. Figure2 shows overtopping of the wall with no roughness and a 61° slope with roughness heights of 20 to 30 cm decreases overtopping up to 50%. The greatest overtopping occurred for sea wall type E, arrangement 4, at a roughness height of 20 cm. The least overtopping was for arrangement 1 at a roughness height of 30 cm.

Figure 3 shows a sea wall with a slope of 56° to 61°. When compared with type E, type F shows that the effect of slope and increasing the roughness height decreased overtopping.This diagram shows the similarity of the high rate of overtopping for arrangement 3 at roughness heights of 20 and 30 cm. The results indicate that arrangement 3 for this particular slope was not very effective.

Figure 4 shows sea wall type G has similar levels of overtopping at roughness heights of 20 and 30 cm. The full compliance of overtopping in arrangement 3 is important for this particular slope. Arrangement 3 does not influence the height difference; thus, a height of 20 cm can be used instead of 30 cm to produce the same level of overtopping and reduce the volume of operation.

Figure 5 for sea wall type H shows that a decrease in slope of 61° to 45° decreased in the amount of overtopping. This indicates that decreasing the slope decreased overtopping. Another significant point is the similarity of overtopping for both roughness heights for all arrangements. This shows that the roughness height had the least effect for a slope of 45°. Arrangements 5 to 7 resulted in better Roughness height changes on the sea wall and decreased the overtopping of waves.

Figure 6 shows the results of overtopping with a roughness of 20 cm and different slopes. A significant finding is that the increase in slope increased overtopping. A slope of 45° showed the least overtopping, and the slope of 61° had the greatest. The lowest level of overtopping was recorded to arrangements 1 and 3.

Figure 7 shows the results for the sea wall with roughness heights of 20 and 30 cm shows that an increase in slope increased overtopping. Figure 7 indicates that an increase in roughness from 20 to 30 cm decreased the effect of slope.

The results for slope and roughness height parameters shows that sea walls with a slope of 45° and a roughness height of 20 and 30 cm have the least overtopping and that overtopping increased as the slope increased. The maximum overtopping was recorded for the E2- 4 sea wall with a slope of 61°, roughness height of 20 cm, and arrangement 4. The least overtopping was recorded for the H3-1 mode sea wall with a 45° slope, roughness height of 30 cm, and arrangement of 1.

It can be concluded from Figure 8 is that there is a similarity of overtopping of the sea wall for a slope of 45° using arrangement 1 for roughness heights of 20 and 30 cm. In this case, a roughness height of 30 cm can be used to reduce the volume of operations at a 45° slope for arrangement 4. The gaps and differences in roughness at both 20 and 30 cm is greater and indicates that this arrangement is effective for the amount of overtopping. Figure 8 indicates that arrangements 1 and 3 are the best and arrangement 3 showed the least change. The difference in roughness height for the two states and had the lowest rate of overtopping than the other modes, making it the best type of arrangement.

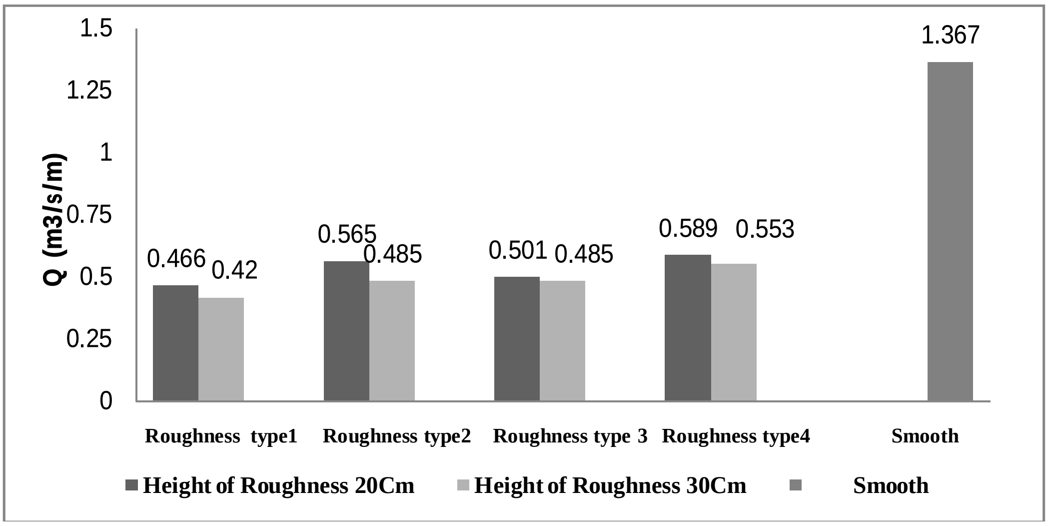

Figure 2: Overtopping of seawall type E (61° slope)

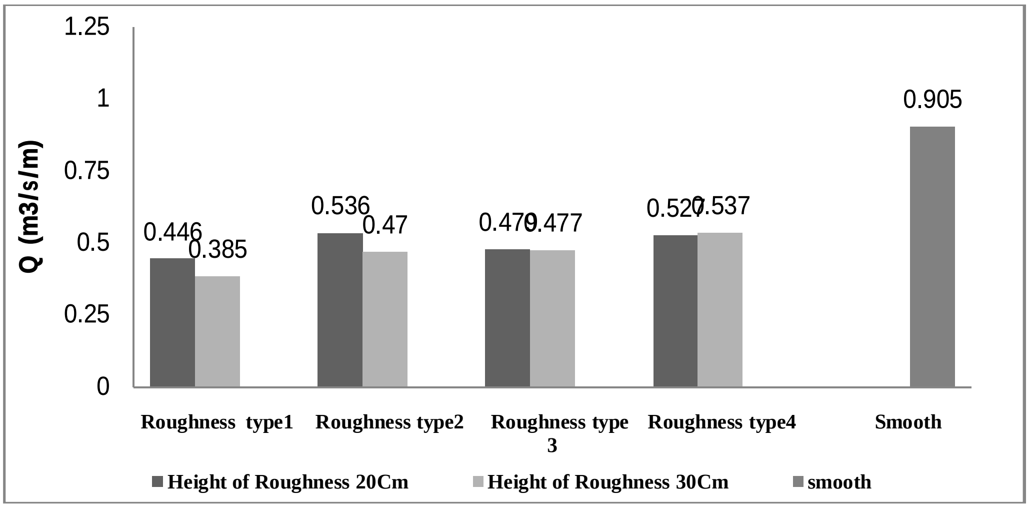

Figure 3: Overtopping of seawall type F (56° slope)

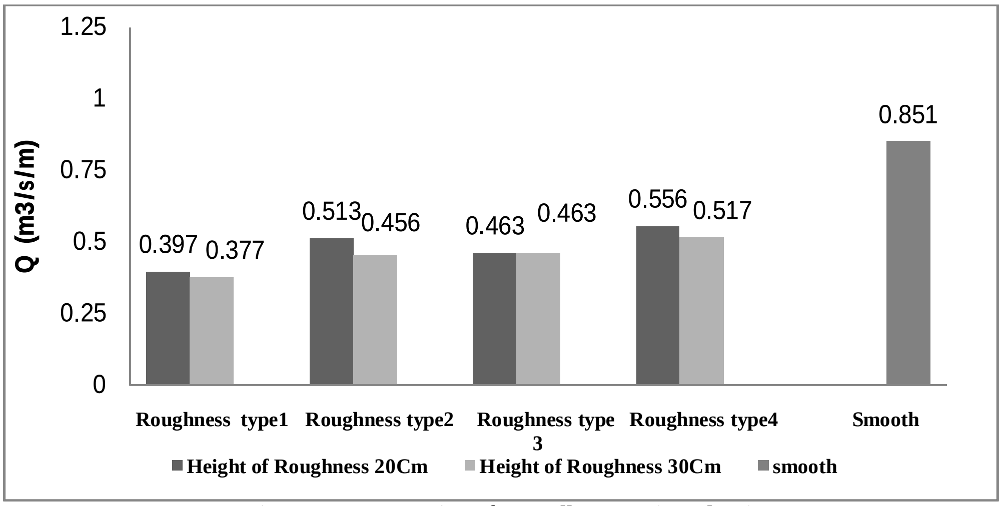

Figure 4: Overtopping of seawall type G (51° slope)

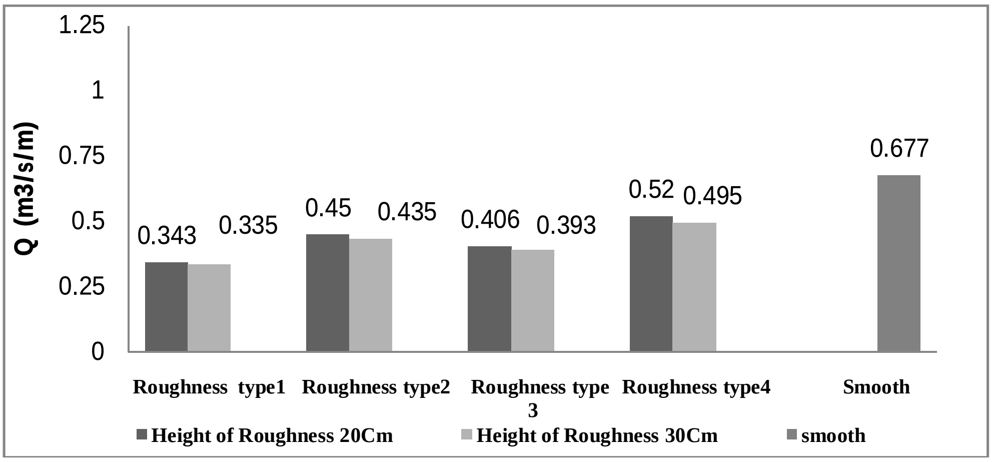

Figure 5: Overtopping of seawall type H (45° slope)

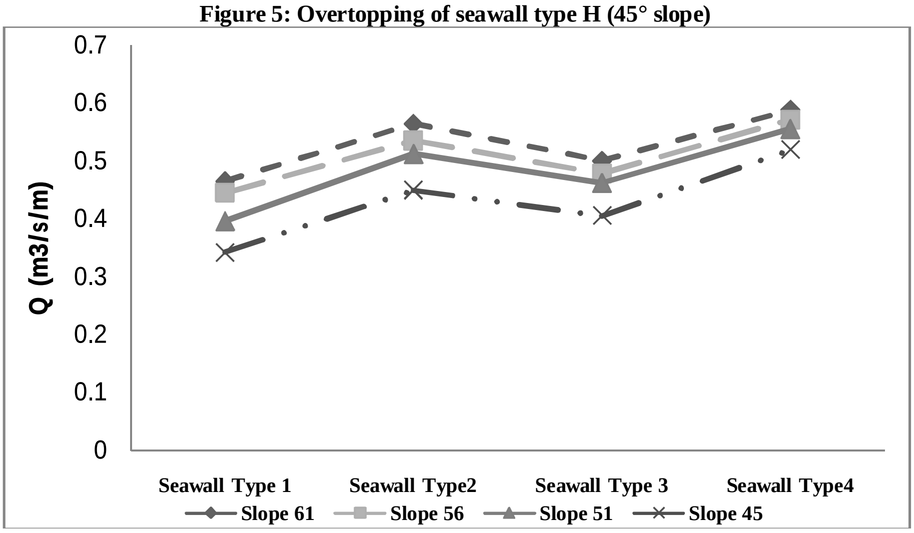

Figure 6: Roughness height of 20 cm versus slope

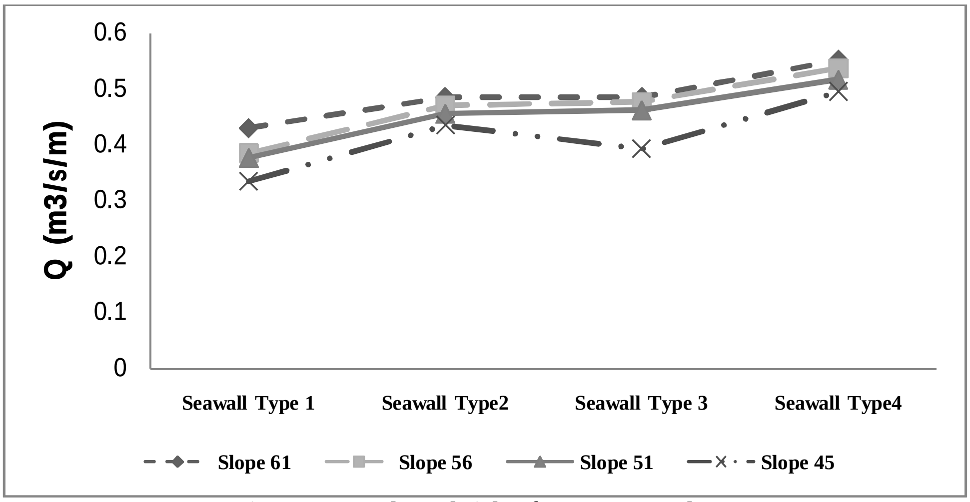

Figure 7: Roughness height of 30 cm versus slope.

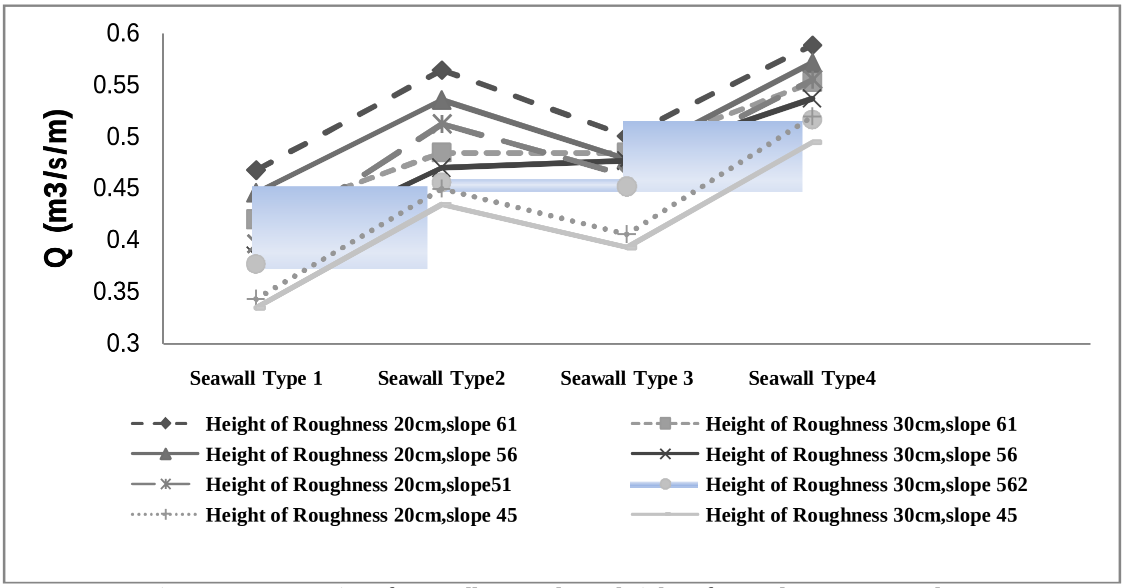

Figure 8: Overtopping of sea wall at roughness heights of 20 and 30 cm versus slope

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