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FREQUENCIES OF STORM SURGES IN THE WESTERN HARBOR OF ALEXANDRIA, EGYPT.

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ABSTRACT

Frequencies of storm surge days at Alexandria are investigated, the research covered storm surge data for winter months of the two periods (1964 - 1969) and (1974 - 1983).

The possible occurrence of storm surge days are deduced as well as the number of these days per year. The frequency of the abnormalsurges which exceed ± 30 cm above or below the predicted tide level is determined from an empirical relations for the frequency of occurrence of surges and the surge va[illegible]

INTRODUCTION

During the year, Alexandria is exposed to number of storms which are usually during the gale season. Gales being most frequent between December and February. In Alexandria, the gale starts when the wind speed reaches 12 m /s or more. These winds with low barometric pressure are naturally influence the sea level producing storm surges which are determined from the difference between the observed and the predicted sea level.

Since the knowledge of the frequency with which storm surges may be expected to occur in future is of great importance for navigations and for warning purposes, the aim of this study is to get a better evaluation of forecasting of these storm surges at Alexandria harbour.

Special attention is paid to the forecasting of the unusual storm surges which may be expected once in hundreds of years.

Data and methods of analysis

During the periods (1964-1969) and (1974-1983) the storm surge days are determined as that days where the difference between the predicted and the observed sea level exceed 10 cm. For determining the frequency of their occurrence , these days are divided into groups with time interval 5 days. The number of cases of each interval are determined and expressed as a percentage of the total frequency.

For each month (From November to March), the number of storm surge days per year are obtained over the investigated period.

The abnormal surge conditions are considered as that surges which exceed $\pm$ 30 cm. The possible occurrence of these surges for hundreds of years are estimated by applying the logarithmic statistical treatment used by Lennon , 1963. An empirical relations have been derived for the frequency of occurrence of storm surges at Alexandria and the surge values.

RESULTS

Frequency distribution of storm surge days

During each winter from about the middle of November to the end of March, the storm surges may be expected. From the work on surges at Alexandria, it is noted that the duration of a single storm surge lies between a few hours and three or four days. In some cases two or more single storm surge join together inducing large surges with duration of several days.

The days of occurrence of storm surges during winter months of the investigated period are determined and the frequency distribution of these days are calculated. Detailed knowledge of these frequencies are shown in Fig. 1 for the months from November to March.

It can be seen from the figure that the possible occurrence of storm surge days during November are expected to be at the last half of the month. During this period the frequency gave values between 18.27 % to 21.15 % of the total frequency.

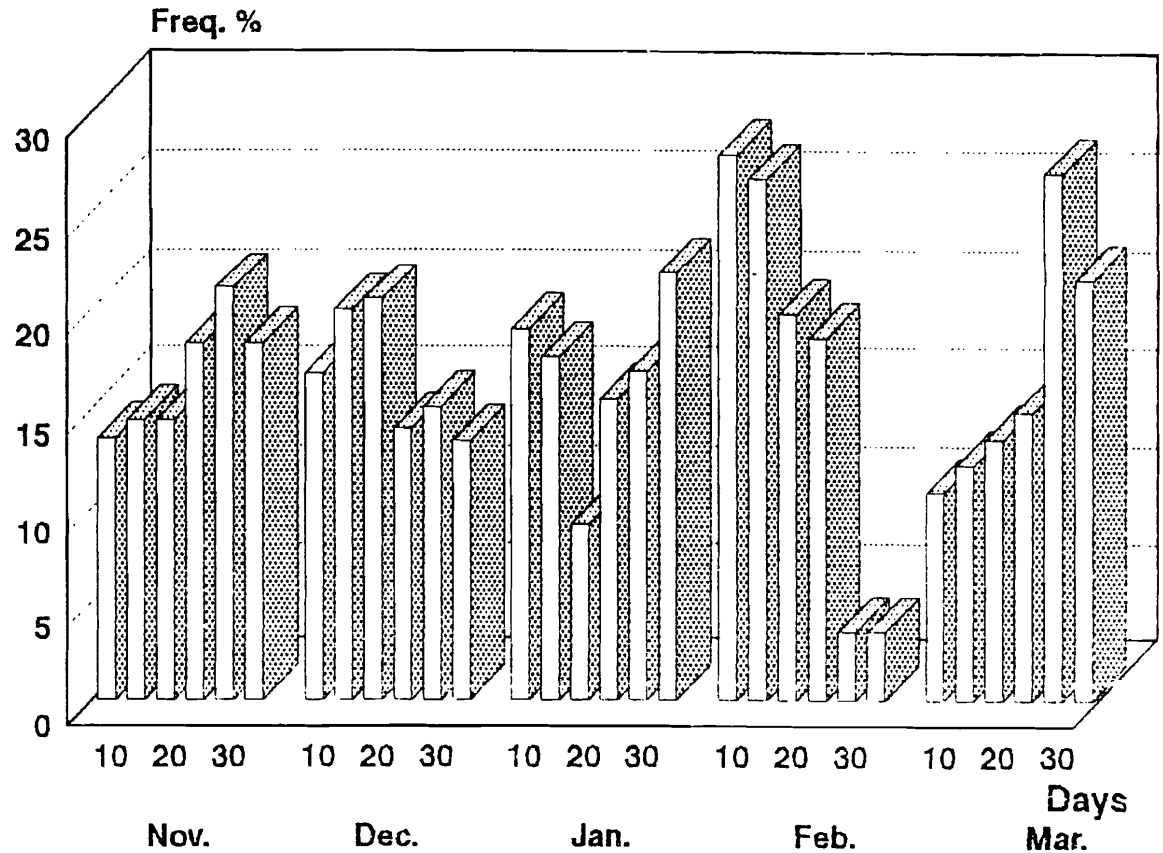

Figure 1: Frequency distribution of storm surge days during the months (Nov.-Mar).

For December, it shows that storm surges have to be expected at the first half of the month, which gave frequencies ranging between 16.76% to 20.54 % . The graph for January illustrates that the first and last five days of the month are almost time of storm surges. The frequencies of their occurrence are between 18.31 % to 19.01 %.

It is noted from the two diagrams of February and March that the most pronounced frequencies are shown at the first ten days of February ,it is between 26.74 % to 27.91 % ,and decreases towards the end of the month, then starts to increase again during March, it reaches its maximum at the end of March with frequencies ranging between 21.62 % to 27.00 % during the last 10 days.

The number of storm surge days during the investigated period are given in Table (1). It can be noted that December has the most pronounced frequency of the number of storm surge days (31.3%) which is about 12 days per year. The frequency of the number of storm surge days during November is about 17.6 % which is nearly 7 days per year, while it is 24.0 % in January , it corresponds to 9 days per year . The frequency is about 14.6 % in February and represents 5.4 days per year. The lowest frequency observed was in March, it is equal 12.5 % which is nearly 5 days per year.

The average number of hours per year of surge heights at different levels, based on 10 years period (1974 - 1983) are given in Table (2) . This table shows decreases in surge hours towards the higher surge levels. It is noted that December and January have some hours of surges at levels more than 35 cm while November has the highest number of hours per year at low levels (Less than 10 cm). The lowest recorded number of hours are found in March (End of winter season) .

Abnormal sea level at Alexandria

The abnormal sea level is the case when the difference between the observed and the predicted sea level heights exceed $\pm$ 30 cm , it is denoted by high positive surges or low negative surges .

On basis of the 10 years period (1974 - 1983), the frequency distribution of these surges have been estimated by Moursy , 1989. Since these frequencies are of greatest technical significance for coastal constructions, special attention has been paid to the abnormal cases of sea levels. The percentage of their occurrence are given in table 3. The table shows that the frequency of the lowest negative surge does not exceed 0.72 % and the greatest frequency for the highest positive surge is 0.25 %, which means

Table (1): Frequency distribution of the number of storm surge days for the periods (1964 - 1969) and (1974 - 1983).

Month	Nov.	Dec.	Jan.	Feb.	Mar.
Number of storm surge days of the periods (1964-1969) and (1974-1983)	104	185	142	86	74
Frequency %	17.6%	31.3%	24.0%	14.6%	12.5%
Number of storm surge days per year	6.5	11.6	8.9	5.4	4.6

Table (2): The number of hours per year of surge heights at different levels in Alexandria.

Surge height (cm)	Nov.	Dec.	Jan.	Feb.	Mar.
0 - 5	127.6	96.4	108.5	91.6	71.5
5 - 10	111.0	94.6	84.3	67.2	43.8
10 - 15	77.0	92.8	60.6	46.1	16.9
15 - 20	52.0	75.8	39.6	25.5	9.7
20 - 25	24.1	50.8	22.5	16.1	6.2
25 - 30	10.1	25.0	6.9	7.2	3.3
30 - 35	2.3	11.6	3.1	2.1	0.5
35 - 40	0.4	3.0	0.7	0.4	0.1
40 - 45	-	2.0	0.6	0.1	-
45 - 50	-	1.1	0.1	0.1	-

Table (3): Frequency distribution of highest and lowest surges at Alexandria.

Positive surge (cm)	Frequency %	Negative surge (cm)	Frequency %
30	0.25	-45	0.01
35	0.06	-40	0.02
40	0.03	-35	0.17
45	0.02	-30	0.72

Table (4): The frequency of occurrence of the abnormal surges at Alexandria.

Number of years	200	100	50	25	10	5	2
Positive surges (cm)	75.8	72.2	68.5	64.8	60.0	56.3	51.5
Negative surges (cm)	-67.6	-64.7	-61.7	-58.8	-54.9	-51.9	-48.0

that the surge heights of Alexandria may consider moderate. However, it still have an abnormal surge conditions on long period.

In order to extrapolate the trends of the frequencies necessary for determining the optimum height for sea coast protection, an empirical relation have been derived by Moursy 1989 for the frequency of occurrence of positive surge and the surge value

$$\text{Log } (n / N) = - 0.082 \, S + 3.92$$

Where S denotes the positive storm surge , n the number of cases during the period of the records for which the surge contributions have been exceeded and n/N the average number of cases per year of the surge contribution. The same technique is used for negative surges and the following equation is deduced

$$\text{Log } (n / N) = 0.102 \, S + 4.60$$

On the basis of the above two equations , the positive and negative surge contribution to be exceeded once in 200, 100, 50, 25, 10, 5, and 2 years are given in Table (4). The benefit of knowing these heights of surges is of great important that the protective structures which is adequate for storm surges that occur once in 10 years is not sufficient to protect the storm surges that occur once in 100 years.

CONCLUSION

Since the knowledge of the expected sea state is required for the design and for the safety of life at sea, attention has been paid to the forecasting of the storm surges. For making a better evaluation of the expected surges at Alexandria, the frequency distribution is applied for the past storm surge days. The results indicate that the possible occurrence of these surges are found to be at the last half of November, first half of December, first and last five days of January, first ten days of February and at the end of March.

Statistical treatment on the number of storm surge days showed that their probability are more pronounced in December and represents 31.3 % of the total frequency, which is about 12 days per year. The probability for November is 17.6 %, while for January and February is 24.0 % , 14.6 % respectively. The lowest probability observed was in March (12.5 %) which is nearly 5 days per year.

Special attention has been paid to the abnormal surge conditions where the surge heights exceed $\pm$ 30 cm. Although the frequency of their occurrence does not exceed 0.25 % for positive surges and 0.72 % for negative ones, for long period ,the surge may reach 72.2 cm for positive surge and -64.7 cm for negative surge once in 100 years and may reach 75.8 cm for positive surge and - 67.6 cm for negative surge once in 200 years. These results are of great interest in coastal engineering and navigational purposes.

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