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Statistics of storm surges in Hong Kong

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सार — हाँगकाँग की तटीय अवसंरचना के डिजाइन के लिए वहाँ की तूफानी लहरों के आँकड़ों का होना नितांत आवश्यक है । इस शोध पत्र में हाँगकाँग के तट पर उठने वाली तूफानी लहरों की कुछ विशेषताओं तथा लहरों से संबंधित आँकड़ों के बारे में जानकारी प्रस्तुत की गई है ।

ABSTRACT. Storm surge statistics are essential for the design of coastal structures in Hong Kong. This research note describes some of the characteristics and statistics of storm surges in Hong Kong.

Key words — Storm surge, Storm tide, Extreme storm tide analysis, Return period and chart datum.

1. Introduction

A major response of the ocean to tropical cyclones is the rise of sea water level due to the fall of atmospheric pressure and more importantly the strengthening of winds as tropical cyclones approach the coastal areas (Pugh 1987). This phenomenon is described as storm surge, generally defined as the difference between recorded and predicted sea levels. The total sea level, consisting of both normal astronomical tide and storm surge is called storm tide (WMO 1993). A detailed description of storm surges can be found in Bretschneider (1967) and Murty (1984) and storm surge modelling in Jelenianski *et al*. (1992) and Guo and Wang (1994) amongst others.

The Hong Kong observatory has long been concerned with the study of storm surge for operating storm surge warnings and for providing inputs for infrastructure projects. The purpose of this paper is to describe some of the storm surge statistics obtained in Hong Kong.

2. Tide data for storm surge estimation in Hong Kong

Early observations of tide levels in Hong Kong were made by reading tide poles. A recording tide gauge was installed at North Point in 1950 and relocated to Quarry Bay, about half a kilometre to the east of North Point in 1985. Hong Kong's tide gauge network has expanded gradually throughout the years and there is now a network of 9 tide gauges (Fig. 1). This allows storm surges in different parts of Hong Kong to be characterized.

3. Storm surges in Hong Kong

On an average, Hong Kong is affected by about six tropical cyclones a year. Statistics show that storm surges are the highest for tropical cyclones making landfall to the west of Hong Kong. Historically, the maximum storm surge recorded in Hong Kong was about 4 metres. This occurred in Tolo Harbour (refer to Fig. 1 for geographical locations) during the passage of a typhoon on 2 September 1937. The narrow inlets at the head of Tolo Harbour provided conditions favourable for the amplification of surges and during

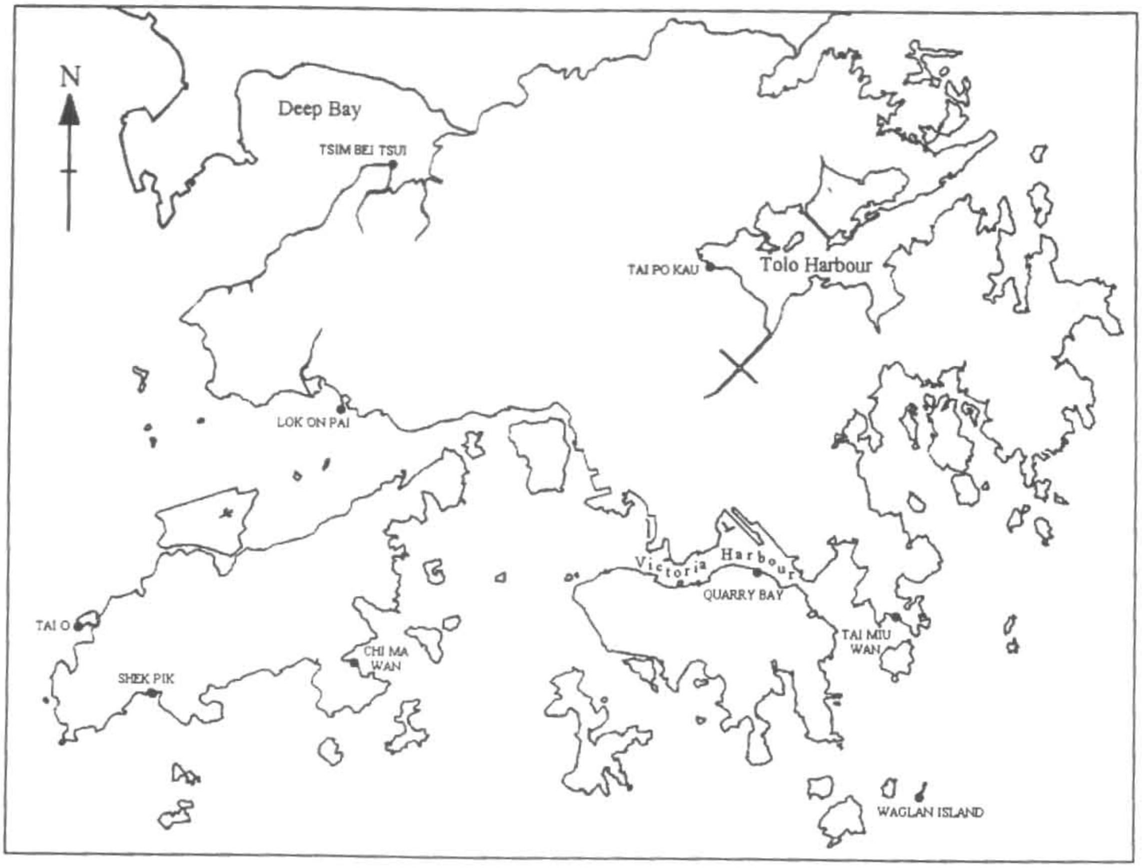

Fig. 1. Tide gauge network in Hong Kong • Tide station

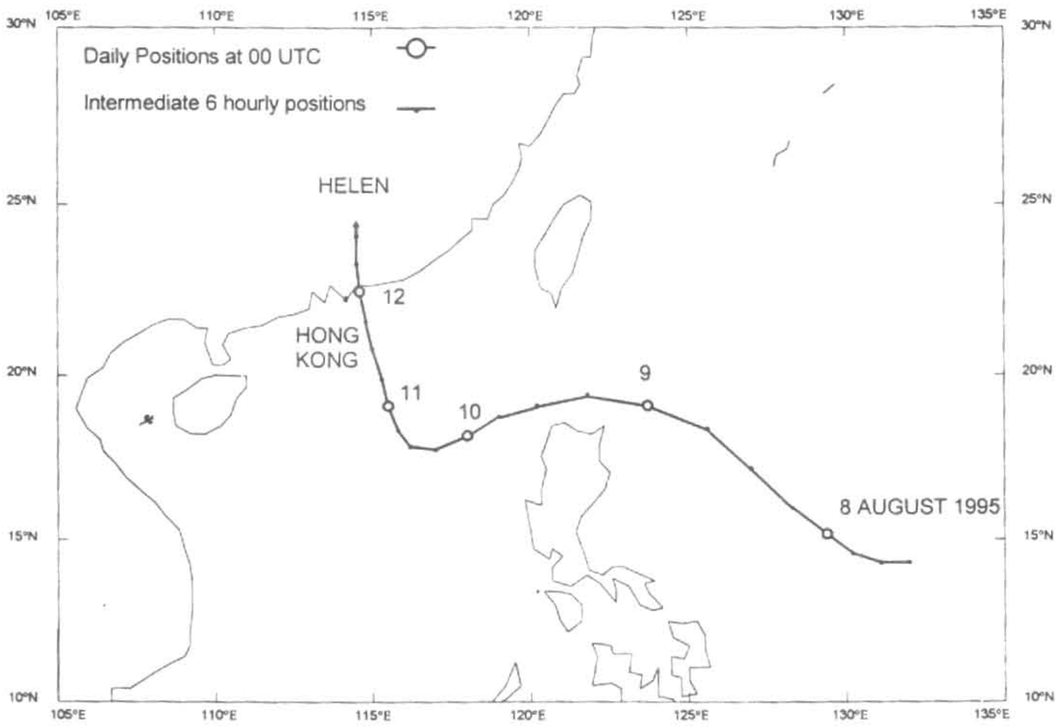

Fig. 2. Track of severe tropical storm Helen: 7-12 August 1995

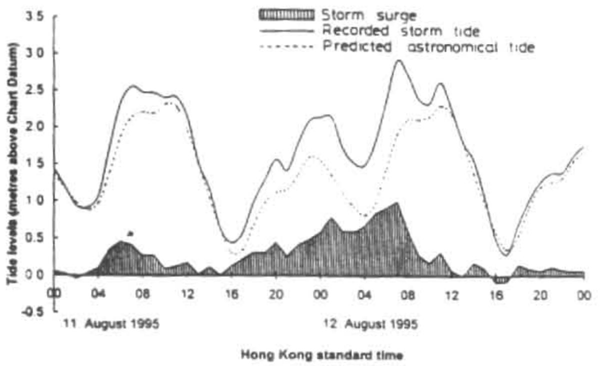

Fig. 3. Storm surge at Tolo Harbour during the passage of severe tropical storm Helen

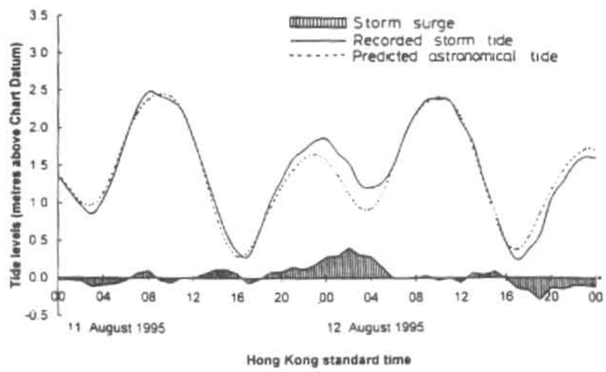

Fig. 4. Storm surge at Chi Ma Wan during the passage of severe tropical storm Helen

the above event, some 11,000 lives were lost and several villages around Tolo Harbour were destroyed. Elsewhere in Hong Kong, the maximum storm surges generally did not exceed 2 metres.

The different responses of different bays in Hong Kong can be illustrated by the storm surges in Chi Ma Wan and Tolo Harbour during the passage of severe tropical storm Helen in August 1995. Helen made landfall to the northeast of Hong Kong. It's track is shown in Fig. 2 (RO 1995).

Fig. 3 shows the recorded storm tide, the predicted astronomical tide, and the storm surge at Tolo Harbour during the event. A storm surge of about 0.5 metre was observable at Tolo Harbour beginning from the morning of 11 August 1995. It reached a maximum of about 1 metre between 7 a.m. to 8 a.m. the next day. However, the storm surge at Chi Ma Wan (Fig. 4) was short-lived and reached not more than 0.5 metre and there was even a weak persistent negative surge that evening due to offshore winds.

Details of storm surges in Hong Kong and/or its modelling can be found in Watts (1959), Cheng (19€7) and Lau (1980a).

4. Extreme storm tide analysis

In Hong Kong, extreme storm tides are estimated from tide gauge records. Where records are not available or not of sufficient duration, the modelling approach has also been used. Previous work in extreme storm tide analysis for Hong Kong had been carried out by Cheng (1967), Peterson (1975), Lau (1980b) and Chan (1983). Tam (1996) has provided a storm surge risk assessment for Hong Kong.

TABLE 1

Extreme storm tides at different tide stations for various return periods

Tide station	North Point/ Quarry Bay	Tai Po Kau	Chi Ma Wan	Waglan Island
Period of tidal records used	(1954-1994)	(1962-1994)	(1963-1994)	(1976-1994)
Return period (year)	Extreme storm tide (metres above Chart Datum)			
2	2.8	3.1	2.9	2.6
5	3.1	3.5	3.1	2.9
10	3.2	3.8	3.3	3.0
20	3.3	4.0	3.4	3.2
50	3.5	4.3	3.6	3.4
100	3.6	4.6	3.7	3.6
200	3.8	4.8	3.8	3.7

The most updated values of extreme storm tides corresponding to different return periods can be found in the Hong Kong's Port Works Manual (CED 1994). This is shown in Table 1. The extreme storm tides are obtained by fitting a Gumbel distribution (Gumbel Type 1 distribution) to the annual extreme storm tides and using the method of moments in parameter estimation. Descriptions of the methodology can be found in texts such as Herbich (1990). For all return periods, Table 1 shows that the extreme storm tides at Tolo Harbour are the largest while that at Waglan island are smallest. This is a typical contrast between storm tide at inlet bay areas and at open coast environment with small topographic influence.

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