PAST WINDSTORM OCCURRENCE TREND, DAMAGE, AND LOSSES IN PENANG, MALAYSIA


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Abstract

Windstorm occurrence in several parts of Malaysia, particularly in the northern region, has severely affected humans, causing damage to property as well as fatality. This study aims to investigate the past windstorm occurrence trend, including damage and losses, in Penang districts from 2010 to 2013. Data on windstorm occurrence and on damages and losses from districts were collected from the Land and District office and Social Welfare Department of Malaysia, Penang, Malaysia. The monthly windstorm occurrences in the districts were compared. Windstorm likely occurs in during March, May, and November annually. This windstorm occurrence indirectly contributes to the damage and losses in that particular area. Therefore, this phenomenon must not be neglected in Malaysia. The negative effects of this phenomenon become more severe with increasing incidence. Therefore, disaster mitigation efforts should be exerted to reduce the disastrous consequences of windstorm.

Keywords: natural disaster; windstorm; damage and losses; disaster mitigation.

1. Introduction

Henderson and Ginger [1] classified windstorm as a tropical cyclone, thunderstorm, tornadoes, monsoons, and gale. Windstorm occurrence increases annually, leading to increased property damages and local economic disruptions. EM-DAT [2] reported that the total damage caused by natural disasters from 2012 to 2014 is higher in Asia than in other regions in the globe. The Malaysian Meteorological Department (MET) is instrumental in delivering early warning sign alerts on upcoming windstorm events through their website and social media. This proactive approach creates and increases awareness.
among Malaysians and minimizes windstorm impact. Majid et al. [3] reported that windstorm predominantly damages houses in the northern region of Peninsular Malaysia.

As reported in previous studies, data were collected from newspaper articles and published reports. A complete database on previous wind storm occurrence in Malaysia remains unavailable. Eiser et al. [4] found that the quality of available data to allow integrated risk assessments is uneven because of several factors, such as lack of monitoring technologies, insufficient funding, and suppression data and delay. The development of such a database is crucial to provide information on windstorm distribution and damage level. This study aims to assist weather forecasters, state authorities, manufacturers, insurance companies, and the public toward disaster preparedness and mitigation.

This study focuses on windstorm occurrences and on number of houses, damages, and losses in Penang, Malaysia. Windstorms in Malaysia must not be neglected because the occurrence has initiated damage and losses to structures and human life.

2. Methodology

Malaysia is situated in Southeast Asia and is divided by the South China Sea into peninsular Malaysia and east Malaysia, Fig. 1(a). Peninsular Malaysia shares a land and maritime border with Thailand and maritime borders with Thailand, Vietnam, and Indonesia. East Malaysia shares land and maritime borders with Brunei and Indonesia and a maritime border with the Philippines. Penang is located in the northern peninsular Malaysia; the island portion is separated by the Straits of Malacca adjoining the mainland. Penang has five districts, two [Northeast Penang Island (TL) and Southwest Penang Island (BD)] in the island portion and three [Northern Seberang Perai (SPU), Central Seberang Perai (SPT) and Southern Seberang Perai (SPS) on the mainland Fig. 1(b). The Land and District Office and Social Welfare Department of Malaysia developed a database Appendix A.

Descriptive statistics was adopted in this research to analyze data on the (a) cumulative monthly windstorm occurrence from year 2010 to 2013 (b) total house damage and percentage from year 2010 to 2013 and (c) yearly number of occurrence, house damage and losses.

Cumulative windstorm occurrence which referring to Figs. 2(a) and (b), is the total sum of windstorm event takes place in every month that also represents each district in Penang. Total house and damage and percentage represents house damage addition for each district which reflects the total number of house damage and plotted in percentage (Fig. 3). Meanwhile, for yearly number of occurrence, house damage and losses shows the cumulative number of windstorm occurrence related to house damage and losses yearly.
3. Result and Discussion

3.1. Windstorm occurrences

The graph was plotted to determine the monthly cumulative windstorm occurrences for five districts in Penang from 2010 to 2013 (Figs. 2(a) and 2(b)). The monthly frequency of windstorm occurrences was monitored. Windstorm occurrence shows an increasing trend from January to March, with March having the highest occurrence for each district. Windstorm occurrences gradually decrease from May to August. The trends increase from September and peak in October. The highest number of windstorm occurs in March, which
predominantly affects SPU and SPT. Meanwhile, the windstorm occurrences in October mostly affect SPU, followed by SPT and SPS. These findings are also in line to the statement of MET that windstorm can occur throughout the year but most likely predominate inter-monsoon periods, namely April to May and October to November. Over land, windstorm frequently develops in the afternoon and evening hours; over the sea, windstorm is more frequent at night.

Findings also shown that the least windstorm occurrence affected TL and BD, respectively. According to MS1553: 2002, Penang island is classified under Category 4 with numerous large and high terrains (10.0 m to 30.0m high) and closely spaced obstruction. Meanwhile, for mainland is an example of suburban area included in Category 3. Severe windstorm associated with hail and wind gusts may result in strong wind and can cause severe damages to extensive area. Low-rise non-engineered structures are prone to destruction due to strong wind. Keul et al. [5] stated that the probability of windstorm occurrence is affected by many factors, such as topographic effects, sea land area contrasts and climatic background, population density, and observational possibility.

Fig. 2. Cumulative monthly windstorm occurrence from year 2010 to 2013.
3.2. Number of houses damaged

Figure 3 shows that the number of houses damaged during windstorm events from 2010 to 2013 in SPU, SPT, SPS, TL, and BD. The number of houses damaged was defined by the quantity of houses damaged in that particular district per windstorm event and converted into percentage of the total number of houses damaged. During this period, the highest number of houses damaged among the five districts was recorded in SPU, with 538 (47%) of the total number of houses damaged, followed by SPS, TL, SPT, and BD, with 226 (20%), 137 (12%), 126 (11%), and 111 (10%) of the total number of houses damaged, respectively.

Windstorm severely affect rural non-engineered buildings. Figure 4 shows that the number of houses damaged by windstorm events annually increases throughout the four-year data period. The number decreased in 2013 because the data recorded were cut off by August. The majority of the houses damaged were low-rise buildings. Figure 5 shows an image of the damage on the roofing system on-site after a windstorm occurrence, i.e., roofs being blown-off and broken trusses. The most common damages include roofing system failure, damage due to flying debris, damage to building components, uprooted trees, power failure, and fatalities. Building codes are important in decreasing the physical vulnerability of houses and buildings [1, 6]. Henderson and Ginger [1] observed that failure is caused by missing or poorly installed fasteners, poor roofing structure, insufficient fasteners, and sub-standard roof sheathing, fasteners, and nails. The loss of function of roof structures is often attributed to inadequate nailing and connecting spacing. In cases where complete structural failure does not occur, failure of the building envelope often allows wind-driven rain to penetrate the building, leading to unserviceable conditions. For commonly used range of roof pitches for residential structures, wind forces oriented normally to the ridge of the roof cause wind uplift forces Simiu and Scanlan [7].

![Fig. 3. Total of house damage and percentage from year 2010 to 2013.](image3)

![Fig. 4. Yearly numbers of occurrence and house damage.](image4)
Fig. 5. Failure of the roofing system due to windstorm.
3.3. Damage and losses

As shown in Fig. 6, the damage cost increases with increasing number of houses involved during the windstorm for SPU, SPT, and SPS. For BD and TL, the numbers of houses damaged are higher but the damage cost is lower compared with those for the other districts. Low-rise buildings were predominantly damaged by windstorm occurrences. Approximately 80% of the cases that incurred damages to the roofing systems were caused by thunderstorms in Peninsular Malaysia. Damage breakdown shows that 47% damage targeted the steel sheet roofing, 30% the truss system, 13% the roof tiles, and 20% other related components [3]. Windstorm occurrence in Malaysia must be taken seriously, and building codes and guidelines in Malaysia need to be revised.

Figures 7(a) to 7(e) represent data on windstorm damages and losses in the Penang from 2010 to 2013. Damage costs increased with increasing windstorm occurrence rates. In SPU, 2011 incurred the largest damage cost, with approximately 40% (RM 656,750) of the total damage estimation cost of RM 1,659,450. The total damages increased by 22% from 2010 to 2011. However, only 36% (RM 598, 500) of the total damage cost was recorded in 2012. In 2013, a small damage cost was recorded for SPU. This result may be attributed to the cutoff data for 2013 being at the end of July. The damage cost increased in the last quarter of the year because previous trends of windstorm showed that the phenomenon occurs during November. SPU was the worst affected district during windstorm because many damaged houses were involved in the event Fig. 7(a).

As shown in Fig. 7(b), the slightest damage and lowest damage cost were recorded in 2010. In April, the total damage cost was hampered by 46% (RM 265,500) and indicated the highest damage and cost imposed compared with those recorded in 2012 and 2013. A slight increase of 26% (RM 158,520) to 28% (RM 158,500) was observed from 2011 to 2012.

The total damage to SPS was approximately RM 696,000 throughout the three-year data period Fig. 7(c). The second highest frequency of windstorm occurrence was recorded in SPS among the five districts. The damage cost in 2010 (RM 103,500, 15%) was lower than that in 2011 (RM 209,000, 30%) and 2012 (RM 279,000, 40%). The damage cost increased in 2013 because the availability of the existing data only cover up to August when this study was conducted.

Figure 7(d) illustrates the lowest damage cost in TL among other districts in Penang. The major damage cost, i.e., 83% of the total damage cost, was recorded in 2010. A sudden drop of damage cost to only 17% (RM 4,000) was observed in 2011. No damage cost was revealed in 2012 and 2013. Figure 7(e) shows that the major contributor to damage cost was 2011, with RM 568,410 (68%) of the total damage cost of RM 829,410. A small damage cost (RM 65,000, 8%) was recorded in 2012. The damage cost in 2013 increased by approximately 24% (RM 196,000).
Fig. 6. Damages, losses and house damages represent for each district.

Fig. 7. Damages and loss due to windstorm occurrences at (a) SPU, (b) SPT, (c) SPS, (d) TL and (e) BD district from year 2010 to 2013.
4. Conclusion

Past windstorm occurrences are important to prepare for disasters and mitigate their effects.

4.1. Windstorm occurrences

Windstorm predominantly occurs during April, May, and October, which cover the inter-monsoon period. SPU suffered the highest windstorm intensity as compared with other districts in Penang. Meanwhile, the lowest windstorm occurrences were recorded throughout the three-year data period. However, improvement of windstorm database remains a priority to further investigate windstorm characteristics.

4.2. Number of houses damaged

The highest and lowest numbers of houses damaged were recorded in SPU and SPT, representing 47% and 11% of the total houses damaged in Penang, respectively. Compulsory use of building codes to the non-engineered rural houses should be implemented, and the Malaysian code of building MS 1553:2002 [8] needs to be revised.

4.3. Damage and losses

An increase in severe windstorm events increases damage, losses, and even mortality. Damage, losses, and social problems are related to this natural disaster. Extensive damage was observed in rural non-engineered buildings in Penang. In line with this finding, Henderson and Ginger [1] found that failure is influenced by several factors, such as missing or poorly installed fasteners, insufficient fasteners, and sub-standard roof sheathing, fasteners, and nails. Kousky [9] classified damage to homes and contents as direct impacts of the disaster.

Future works are encouraged to conduct a survey by distributing questionnaires to practitioners regarding the current implementation of building codes in Malaysia. A post disaster survey also needs to be conducted to gather information on the type and level of damages. Thus, efforts on mitigation and other prevention measures need to be exerted to minimize human damage and economic losses, as well as prevent recurrence. Although Malaysia is not in the cyclone-prone region, a good awareness should be taken to reduce the negative impacts of windstorm.

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References


Appendix A

Methodology Flowchart

- Wind Disaster
  - Data Collection
    - Date of Event
    - Location
    - Damage cost
  - Trend of windstorm occurrence
  - Yearly damage estimation
  - Damage and losses

*Land and District office*
*National Security Council*
*Department of Welfare Malaysia*