CORRELATIONS BETWEEN WIND SPEEDS AND CONSTRUCTION INCIDENTS

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ABSTRACT Preventing wind-related accidents is an important safety concern for construction projects in dense urban environments. In this study, the vulnerability of construction practice to high wind levels was investigated by examining the correlation between wind level and related construction incidents and accidents. Statistical analysis was performed in order to explore potential trends in wind-related complaints and construction incidents, and to identify geospatial risk. Wind-related risk zones were identified in a geographic information system (GIS) platform. Wind data and construction-related complaints over a period from January 2010 to October 2015 in New York City were used for this study. The results were presented in the form of GIS maps of complaint distribution. These maps may be used in assessments including of wind-related hazards due to construction activities in a given region of a dense urban environment. It was found that complaints data strongly correlates with wind data in New York City for the period studied. Based on analysis of the data, a methodology was presented to identify risk zones when a high-level wind is anticipated.

1. Introduction

An important safety concern during construction activities in dense urban areas involves wind related accidents resulting from dislodgment of construction materials and components, tools, and debris from buildings under construction. In order to evaluate the consequences of wind-related hazards at construction sites, there is a need to understand the relationship between the quantity and severity of wind-related incidents on the one hand, and the level or intensity of wind on the other hand. There have been limited attempts to investigate the data on wind-related incidents and accidents. Two examples of such studies include statistical analysis of construction accidents reported to New York Department of Buildings (DOB) from 2006 to 2009 (Eschenasy 2010) and the correlation of wind data and the number of falling trees during high-intensity wind events in Lisbon for the period of 1990-2005 (Lopes et al. 2009). The intent of this paper is to understand the vulnerability of construction practice to wind level by examining the correlation between wind intensity level and related incidents at construction sites. Analysis of historical wind data in New York City and reported complaints that emanate from construction sites to the Department of Building (DOB) are used as input data. It is shown that civilian complaints and concerns can provide valuable information for assessing potential projected risks, since complaints often point to a situation that can endanger civilians. Study of complaint details may lead to an improved understanding of wind-related hazards in dense urban environments. It is hypothesized that high wind events lead to greater number of wind-related complaints. A statistical analysis is performed in

order to explore potential trends in wind-related complaints in New York City. Several specific patterns and trends in the data are explored, including association of the complaints data and wind data, relationship between type of complaints and wind data, and spatial distribution of complaints. Strong winds were considered as wind speed levels with an intensity of 20 mph or greater. Windy days were categorized as follows: days with wind speeds of 20 mph or greater, days with wind speeds of 25 mph or greater, and days with wind speeds of 30 mph or greater. Correlation analysis was then performed to probe relationships between wind intensity levels and various complaints files to the DOB during each of the aforementioned windy events.

The current New York Building Code states that when the wind level reaches 30 mph construction activities should be halted (Gholitabar 2017). OSHA (Occupational Safety and Health Administration) states that when the wind level is above 20 mph, a qualified construction authority must determine if, in light of the wind conditions, it is not safe to lift personnel. This research also aims to investigate the appropriateness of said wind limits in construction work using the above mentioned data.

2. Data Collection

In order to examine the correlation between wind speed and construction-related incidents, two sets of data were used including construction complaints¹ and weather data² for New York City. It was assumed that complaints or incidents are recorded on the same day that the complaint or incident occurs.

¹ (<https://data.cityofnewyork.us>)

² (www.weatherunderground.com)

The study covers wind data and construction-related complaints over a period from January 2010 to October 2015 in New York City.

2.1 Data on Construction-Related Complaints

The construction-related complaints data were used for this study was obtained from the 311 Database of New York City DOB³. The data consisted of 43,826 construction-related complaints. Every complaint registered had a unique ID name, date, type, descriptor, zip code, address, and borough. The data signifies whether the complaint has a possibility of causing incident and injury. Only data with such potential was selected for subsequent analysis.

2.2 Wind Data

Wind data from local weather stations were used for the analysis. Data from Central Park (CP) weather station was used. The wind data used for analysis covered the same period as the available construction-related complaints.

3. Analysis of Data

Preliminary analysis of the data included correlation of the type of complaints with the level of wind. The overall spatial distribution of all the construction complaints (including non-windy days) for each category of data over the course of all years considered are presented herein. Figure 1 shows the geographic distribution of the 43,826 complaints in New York City for the aforementioned period within the five boroughs of New York City. It can be seen that the greatest number of complaints originated in Manhattan, followed by Brooklyn, Queens, the Bronx, and Staten Island. It is noteworthy that the number of ongoing construction projects in the five boroughs follows a similar trend, although other factors may influence the recorded number of complaints. The percentage of complaints in each category during the same period is shown in Figure 2. It can be seen that the three categories with the greatest number of involved are site conditions that endangered workers, inadequate or defective scaffolding conditions, and debris falling or in danger of falling. Data analysis for each of the studied year can be found in Gholitabar 2017, which demonstrate a similar general trend to the data presented.

3.1 Analysis of complaints during windy days

The percentage of each type of complaint during windy days in New York showed the majority of complaints during windy days with wind speed greater than 25 mph refer to conditions where debris was reported to be falling from the construction site or was in danger of falling.

The wind and complaints data were used to compile geographic information system (GIS) maps for geospatial analysis of the data. The spatial mapping was carried out using ArcGIS spatial analysis. The five boroughs were divided into census tracts (CT), and each complaint was mapped to the CT to which it belonged (Gholitabar and Griffis 2017).

Figure 1 Percentage of total construction-related complaints in each borough of NYC.

Figure 2 Percentage of construction-related complaints in each complaint category.

3.2 Spatial maps of complaints in regular days and on windy days

The majority of the complaints and incidents occurred in the west and southwest parts of the city with the greater number of under construction projects. In order to analyze the correlation between wind intensity and construction-related complaints, a more local measure of wind speed is needed. Gholitabar and Griffis presented methods for geospatial prediction of local wind speed distribution in dense urban areas based on discrete weather station data (Gholitabar & Griffis 2017).

In this study, a correlation was established between the debris complaints data (discussed in previous sections) and localized wind speed for the borough of Manhattan (Gholitabar 2017) using GIS analysis. Wind patterns in urban local areas despond on several factors including neighborhood buildings configurat configuration. Gholitabar and Griffis proposed a method to estimate the urban local wind using semi analytical methods (Millward-Hopkins, J. T. et al. 2011 & 2012). They presented a map of local areas for Manhattan with local wind index (LWI). The higher the LWI is for a locality (census tract; CT), the higher the wind level impact will be. The methods presented above can be used to investigate the trends in wind debris related incidents in various localities in an urban environment.

³ (<https://data.cityofnewyork.us>).

In this section, the relationship between the number of wind-debris related incidents and the local wind index is investigated. To achieve this task, wind debris related incidents were extracted from New York City open data complaints. In order to relate the data to wind effects, each incident was compared against wind speed on the day of the incident, and only incidents corresponding to wind speeds of 20 mph or higher were retained for further analysis. Figures 4 shows the distribution of wind-debris related incidents overlaid on local wind index (LWI) maps (Gholitabar and Griffis 2017). The results are shown in Figure 3 (a,b,c,d) and Figure 4.

The number of complaints in each locality during windy days of the years was categorized into four groups, as follows:

- Fewer than 4 annual incidents during windy days
- 4 to 8 incidents during windy days
- Greater than 8 annual incidents during windy days
- Greater than 10 annual incidents during windy days

Results of the analysis are shown in Figure 3. It can be seen that there is a general correspondence between the number of wind debris-related incidents in the localities of Manhattan and the local wind index. In particular, it can be seen that localities with a local wind index (LWI) greater than one correspond to those with a greater number of wind-debris related incidents.

Results shown in Figure 4 reveal that 67% of the localities with more than eight wind-debris related incidents have an LWI above one. Moreover, all the localities having 10 or more incidents also have a local wind index greater than one. This correspondence indicates that it is important to quantify local winds in assessing wind debris-related hazard throughout the city. These results can also be used in prioritization of preventative actions in preparation for high wind events in the city. This can serve as a guideline for city planners to specify the localities within the borough of Manhattan, which are in high risk of wind-borne debris. A similar approach can be done of other urban areas.

3.3 Daily Complaints per day

In another approach to show the effect of the wind on construction activities and operations, the daily average of complaints on windy days and non-windy days for each level of wind are calculated based on CP data. The wind speed levels were not considered to be accumulative, instead, it was categorized as:

- Days with wind speed greater than 20 mph and less than 25 mph ($20 < \text{wind} < 25$ mph)
- Days with wind speed greater than 25 mph and less than 30 mph ($25 < \text{wind} < 30$ mph)
- Days with wind speed greater than 30 mph ($30 \text{ mph} < \text{wind}$)

Wind speed less than 20 mph considered a regular day.

Figure 3 (a) Distribution of debris complaints during windy days overlaid on local wind index map, size of the circles is proportional to the number of debris complaints - 2011. Darker colour corresponds to higher Local Wind Index.

Figure 3 (b) Distribution of debris complaints during windy days overlaid on local wind index map, size of the circles is proportional to the number of debris complaints – 2012. Darker colour corresponds to higher Local Wind Index.

Figure 3 (c) Distribution of debris complaints during windy days overlaid on local wind index map, size of the circles is proportional to the number of debris complaints - 2013. Darker colour corresponds to higher Local Wind Index.

Figure 3 (d) Distribution of debris complaints during windy days overlaid on local wind index map, size of the circles is proportional to the number of debris complaints - 2014. Darker colour corresponds to higher Local Wind Index.

Figure 4 Relationship between debris-related complaints on windy days and localized wind index (LWI) in Manhattan localities (100% of the localities with debris incidents more than 10 have LWI greater than 1).

Analysis of daily complaints per day shows that the number of complaints during windy days is greater than regular days and days with lower levels of wind, see Figure 5.

Figure 5: Frequency or number of complaints per day for each category of wind speed based on Central Park Data.

4. Conclusions

The statistical analysis in this study was conducted for all construction-related complaints reported in 311 NYC open data. This study presents strategies to evaluate complaints, by investigating the patterns and frequencies of complaints (spatially and temporally). It is important to mention that complaints can be caused by many factors such as engineering operation, how educated the complainers are, and how easy it is to contact and report the complaints.

Complaints were analyzed for the following characteristics:

- Percentage of each type of complaints during windy days
- Frequency of complaints per regular days and per windy days
- Spatial map of the complaints in the city and the correlation of local wind level with the number of complaints in each urban locality

The advantage of analysis of frequency is to quantify and provide context for typical versus unusual situations. Among the data considered, the largest number of complaints were concerned with objects that were falling or in danger of falling. The next most common types of complaints, which were also sensitive to wind level, were defective or cracking facades, signs in danger of fallings. These results can be used for geospatial risk analysis related to wind effects. For example, high frequency of complaints in a locality might show a higher risk of incidents, which can assist in the development of emergency planning. Moreover, it was clear from the data that the number of complaints per day during windy days is greater than regular days. Wind level also significantly affects the frequency of the construction complaints (higher wind level higher frequency). It is necessary to deepen our research and collect more detailed data about each type of complaints, with the purpose of understanding all the probable causes of fall or occurrence of incidents in the city during high wind days.

5. References

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