

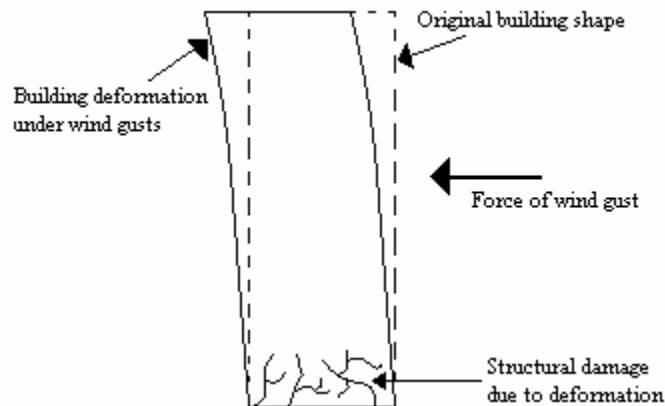
CE311S LAB 5

Investigating the Effects of Wind Gusts on a Building Design

Introduction

A certain architectural firm has won a design competition for a skyscraper in a city. The design is complex and there is a question as to whether or not new technology may have to be developed in order to make the building structurally sound. Tall buildings deform under the extreme forces exerted on them by gust of wind. This deformation can cause structural damage to the building which, if large enough, can be catastrophic. Your firm has been hired to determine whether or not current, state-of-the-art construction technology will allow the proposed building to survive large wind gusts without catastrophic damage.

Your firm has figured out what the structural properties of the building will be if it is built using current technology. Your firm has also analyzed the weather data for the city and determined the maximum wind gust (in miles per hour) for a given year (at the top of the building) to be given by a lognormal distribution with parameters $\mu = 4.2$ and $\sigma = 0.30$. The length of a maximum wind gust has been found to be distributed normally with a mean of 1 second and a standard deviation of 2.5 seconds. Given this information, a simulation has been developed to determine the effects of wind gusts on the structural stability of the proposed building design (given that it is built using current technology).



Procedure

- 1) Answer questions 1 – 3 located at the end of this report.
- 2) Unzip the file “structure.zip” found on the Lab web page and save the files to your desktop.
- 3) Run the file “structure.exe” Record the results in Table 1 located below. Repeat 30 times to simulate 30 years worth of data.
- 4) Answer questions 4 – 7 located at the end of this report.

Table 1

Trial #	Maximum Wind Gust Speed (m.p.h.)	Wind Gust Duration (s)	% of Building Structural Stability Lost	Cost to Reinforce Building from Structural Damages due to Wind Gusts
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
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25				
26				
27				
28				
29				
30				

(15 pts for above table)

Questions:

1) Given the distribution of the maximum wind gust speed, what is the mean and variance of the maximum wind gust? (10 pts)

2) Intuitively, what do you think the relationship between the wind gusts and the structural damage will be (include both the wind strength and its duration)? Do you think that it will be a linear relationship, or some other type? Elaborate in words or draw a graph for how you think the wind gust speed (ignore duration for this last part) will affect the structure of the building (the measure of structural stability will, for this lab, be given by the percentage of structural stability lost).(10 pts)

3) The building is considered to be a total loss (that is, it must be demolished) if its loss of structural stability exceeds 65%. According to the structural analysis of your firm, this will definitely happen when there is a wind gust of speed greater than 250 miles per hour (no matter the duration). Calculate the probability of this occurring. What important piece of information does this simple analysis leave out? (15 pts)

4) From the data you collected, what is the relationship between the wind gust speed and the *loss of structural stability* (not cost) of the building? How does the duration of the wind speed seem to affect this relationship? (10 pts)

5) The following are the “safe zones” for the building – that is, where the wind gusts will not produce a total loss in terms of structural stability:

Gust speed	Gust length
$\text{gust speed} < 75 \text{ mph}$	Any
$75 \leq \text{gust speed} < 100$	0 – 8 seconds
$100 \leq \text{gust speed} < 150$	0 – 5 seconds
$150 \leq \text{gust speed} < 190$	0 – 2.5 seconds
$190 \leq \text{gust speed}$	none

Calculate the probability that, in a given year, the gust speed will stay in one of these safe zones. Calculate the probability that the gust speed will stay in one of these safe zones over 30 years. Does this agree with your simulation data? If it does not, why do you think this discrepancy occurs? (15 pts)

6) From your data, calculate the average cost, per year, to reinforce the building due to structural losses incurred from wind gusts. Does this cost seem prohibitive? That is, given just this information, do you think that the building should be built using existing technology. (15 pts)

7) This analysis only considers the effects of a single wind gust on a building's structural strength. Smaller wind gusts (or, at least ones smaller than the largest one for a year) may, over time, also reduce the structural integrity of the building. Given your data and your answers to questions 4 and 5, make an educated guess as to whether or not this building will be stable over a period of 30 years when factoring in the cumulative effects of small wind gusts. Given this hypothesis, do you think the building should be built using existing technology? (10 pts)