CE311S Lab 6
Analyzing Column Reliability Using Multiple Variable Models

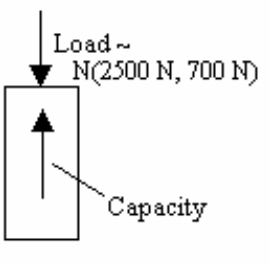
Purpose

In this laboratory you will investigate how the reliability of a column is affected by two random variables: the capacity of the column and the load acting on the column.

Introduction

You have been asked by a structural engineering firm to analyze the reliability of different column designs for a particular building. According to the firm, the load that the column will be subjected to is normally distributed with a mean of 2500 Newtons (N) and a standard deviation of 700 N. Using the provided computer program, you will explore how the mean capacity, the uncertainty in this capacity, and the correlation between load and capacity affect the performance and cost of the column. The following notation will be used throughout the laboratory:

L = Load
C = Capacity
$\rho_{C,L}$ = Correlation coefficient between capacity and load
M = Margin of Safety = C - L
F.S. = Factor of Safety = C / L
μ_i = Mean (e.g., μ_L = mean load)
σ_i = Standard deviation (e.g., σ_L = standard deviation of load)



***Procedure*:**

1. Run the program "Column.exe."
2. Click on the continuous-run button ( ) on the program toolbar.
3. Perform a series of experiments using the input values shown in the following table. Record the output data in the table. (10 pts)

Trial No.	μ_C	σ_C	$\rho_{C,L}$	Probability that Column Fails $P(M \leq 0)$	Mean F.S.	Construction Cost ($)
1	5300	200	0			
2	4000	200	0			
3	2700	200	0			
4	1100	200	0			
5	2700	50	0			
6	2700	125	0			
7	2700	330	0			
8	2700	560	0			
9	2700	200	-0.30			
10	2700	200	0.30			
11	2700	200	0.65			
12	2700	200	1.0			

4. Building codes of the city where the new building will be constructed specify that the probability of failure for columns must be less than or equal to 0.1%. You are asked to propose a design for the column in accordance with this requirement and assuming that both the load and the capacity are normally distributed and statistically independent. Use the program to determine your column design. Record your trials in the table below and circle your choice for the column design. (Hint: What is the correlation coefficient between two statistically independent random variables?) (10 pts)

Trial No.	μ_C	σ_C	$\rho_{C,L}$	Probability that Column Fails $P(M \leq 0)$	Mean F.S.	Construction Cost ($)
1						
2						
3						
4						
5						
6						
7						

***Questions*:**

1. The margin of safety is defined as the difference between the capacity and the load ($M = C - L$). Assuming that C and L are both normally distributed, derive equations for μ_M and σ_M in terms of μ_C, σ_C, μ_L, σ_L, $\rho_{C,L}$. Assume that $\rho_{C,L} \neq 0$. Show your work or explain your answer. (15 pts)

2. Failure of the column occurs when the load is greater than the capacity, i.e., when the margin of safety, M, is less than zero. What values of the factor of safety (F.S.) would define the event of failure? Show your work or explain your answer.(10 pts)

3. The reliability of a column depends on two random variables - the capacity of the column and the load acting on the column. However, you will notice that there are no input dials to control the expected load and the variability of the load. Why are you, as the engineer, unable to control these load values? (10 pts)

4. a) For a constant load, how is the probability that the column will fail affected by uncertainty (variance) in the capacity? (15 pts)

   b) How could you increase the factor of safety? (15 pts)

5. The structural engineering firm wants you to support your proposed column design (from Step 4 in the Procedure) with your own hand-calculations. You are asked to present calculations to demonstrate that the proposed design meets the building code requirements for the maximum allowable probability of failure. You should also calculate the factor of safety for the column. (In other words, you should prove the computer/support output with your own calculations.)

   Typically, calculations such as these would be included in an appendix of a design report and would be presented on engineering paper. You will prepare these calculations with your partner, and they must contain the following (in this order):

   I. Problem statement (What was the problem analyzed?)
   II. Known values (What variables were known?)
   III. Assumptions (What had to be assumed to solve the problem?)
   IV. Calculations
   V. Results (What are the answers to the calculations?)
   VI. Conclusion (What conclusion can be made about the design?)

   For this problem, you do not need to write essays, paragraphs, or even whole sentences for each point. Rather, succinctly state what you did, how you did it, and/or what conclusion you made from this. (15 pts)