CE 703-CONSTRUCTION RISK MANAGEMENT
TAKE-HOME EXAM
(Submission is due on 5/5/2021-Wednesday till 13:30)

An investor wants to analyze the feasibility of a ready-mix concrete plant. For this purpose, a risk analysis based on Monte Carlo simulation will be carried out to find the "no-return payback period" of the investment. Please note that the no-return payback period is the time it will take for estimated revenues and other economic benefits to recover the initial investment.

The investment period is composed of design, taking necessary permissions, and construction activities. The design and taking permissions activities are carried out in parallel and both should be completed in order to start the construction process. Duration of Design (DD), Duration of Taking Permissions (DP), and Duration of Construction (DC) are estimated as 4, 3, and 8 months, respectively. However, these values are subject to change due to various risk factors.

Cost of Design (CD) is calculated by multiplying Duration of Design (DD) with Monthly Design Cost (MDC), as given below:

$$CD = DD \times MDC$$

Cost of Construction (CC) is estimated by using 2 variables: Duration of Investment (DI) and Construction Cost Factor (CCF). Duration of Investment (DI) is the total duration to complete design, permissions, and construction activities. Construction Cost Factor (CCF), on the other hand, is a statistical data obtained from previous projects. Cost of Construction (CC) is formulated by using these 2 variables, as given below:

$$CC = \begin{cases} 1.1 \times CCF & \text{IF } DI \leq 12 \\ 1.2 \times CCF & \text{IF } 12 < DI \leq 14 \\ 1.3 \times CCF & \text{IF } 14 < DI \leq 16 \end{cases}$$

Monthly Design Cost (MDC) and Construction Cost Factor (CCF) are estimated as 400,000 TL and 30,000,000 TL, respectively, but they are also expected to change due to some risk factors. As there is no cost of getting permissions, the Investment Cost (IC) of the project is equal to the summation of cost of design (CD) and cost of construction (CC), as given below:

$$IC = CD + CC$$

For the operation period, Hourly Production (HP), Yearly Working Hours (YWH), Unit Cost of Cement (UCC), Unit Cost of Aggregate (UCA), Unit Cost of Water (UCW), Unit Cost of Chemical Additives (UCCA), and Operational Cost Percentage (OCP) are the parameters that affect total operating costs.

The best estimate values of these variables are given below:

- Hourly Production (HP) = 75 m^3/hour
- Yearly Working Hours (YWH) = 2000 hours
- Unit Cost of the Cement (UCC) = 0.3 TL/kg
- Unit Cost of the Aggregate (UCA) = 50 TL/ton
- Unit Cost of the Water (UCW) = 0.013 TL/liter
- Unit Cost of the Chemical Additive (UCCA) = 3.5 TL/liter
- Operational Cost Percentage (OCP) = 8% of total material cost

Total Material Cost (TMC) is the summation of the costs of cement, aggregate, water, and chemical additive. The cost of each material is calculated by multiplying the total amount of the material with its unit cost. For this purpose, the amount of each material in a 1 m^3 concrete is given below (They are fixed values):

- Amount of the Cement = 330 kg/m^3
- Amount of the Aggregate = 1150 kg/m^3
- Amount of the Water = 215 $liter/m^3$
- Amount of the Chemical Additive = 5 $liter/m^3$

Total Operational Cost (TOC) is calculated by multiplying Total Material Cost (TMC) with Operational Cost Percentage (OCP), as given below:

TOC = TMC x OCP

Total Workmanship Cost (TWC) is calculated by multiplying Yearly Working Hours (YWH) with a fixed coefficient, as given below:

TWC = 320 x YWH

Selling Price of the Concrete (SPC) is estimated according to Hourly Production (HP), as formulated below:

SPC = 240 – 0.15 x HP

By considering all of these parameters, the Yearly Profit (YP) of the ready-mix concrete plant is calculated with the following formula:

YP = HP x YWH x SPC – TWC – TOC – TMC

No-return payback period of the investment is calculated by dividing Investment Cost (IC) to Yearly Profit (YP), as given below:

Payback Period = IC/YP

Table 1 shows the parameters subject to risk, their best estimates, probability distributions, and correlations.

Risk analysis should be carried out based on this data. You should assume that the variables other than those given in the above table are constant.

Table 1. Data for Monte Carlo Simulation

Parameter	Best estimate	Risk	Distribution	Correlation
Duration of Design (DD)	4 months	Vagueness of design, unfamiliarity with design standards	Triangular (3, 4, 5)	None
Duration of Taking Permissions (DP)	3 months	Administrative delays, high bureaucracy	Triangular (2, 3, 5)	None
Duration of Construction (DC)	8 months	Unexpected weather conditions, low productivity	Uniform (7, 11)	None
Monthly Design Cost (MDC)	400,000 TL	Change in design	Trapezoidal Minimum: 300,000 Most likely range: 350,000-450,000 Maximum: 550,000	None
Construction Cost Factor (CCF)	30,000,000 TL	Change in resource costs (material, equipment etc.)	Normal Mean = 30,000,000 TL Std. dev. = 1,000,000 TL	None
Hourly Production (HP)	75 m^3	Change in productivity	Uniform (70, 82)	1. YWH (-0.80)
Yearly Working Hours (YWH)	2000 hours	Change in demand, low productivity	Trapezoidal Minimum: 1800 hours Most likely range: 1900-2200 Maximum: 2400	1. HP (-0.80) 2. OCP (+1.00)
Unit Cost of the Cement (UCC)	0.3 TL/kg	Market fluctuations	Triangular (0.28, 0.30, 0.31)	1. UCA (+0.90)
Unit Cost of the Aggregate (UCA)	50 TL/ton	Market fluctuations	Uniform (47, 52)	1. UCC (+0.90)
Unit Cost of the Water (UCW)	0.013 TL/liter	Market fluctuations	Triangular (0.011, 0.013, 0.014)	None
Unit Cost of the Chemical Additive (UCCA)	3.5 TL/liter	Market fluctuations	Triangular (3.3, 3.5, 3.8)	None
Operational Cost Percentage (OCP)	8 percent	Changes in operational cost items	Singular 7 percent: 10% 8 percent: 40% 9 percent: 30% 10 percent: 20%	1. YWH (+1.00)

By using the information given in Table 1, you are required to:

Task 1: Calculate the no-return payback period of this investment using the best estimate values (base case)

Task 2: Carry out a Monte Carlo simulation using @Risk (100,000 iterations) and prepare a report (statistics, percentiles, Tornado graph etc.) showing results of simulation.

Please refer to your Monte Carlo Simulation results to answer the following questions:

a) Payback period for the base case:……..
Mean payback period value at the end of 100,000 iterations: ……

b) Is the base case scenario optimistic or pessimistic? What is the probability (approximately) that payback period is higher than the base case payback period?

c) Compare the attractiveness of the "ready-mix concrete plant" with an alternative investment option having the same mean value but a COV of 0.75. Which one would you choose?

d) Based on the findings of sensitivity analysis, propose at least 3 risk mitigation strategies that can be utilized for the ready mix concrete plant investment project.

e) Propose a method to incorporate "political risk" (unfavorable events due to instability of political conditions such as change of government, change in international relations etc.) in this analysis. How would you reflect the adverse consequences of political risk ?