Version BBS/2

EGT3/EGT2
ENGINEERING TRIPOS PART IIB
ENGINEERING TRIPOS PART IIA

Wednesday 1 May 2024 14.00 to 15.40

Module 4D16

CONSTRUCTION MANAGEMENT

*Answer not more than **three** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed.
Engineering Data Book.

10 minutes reading time is allowed for this paper at the start of the exam.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

You may not remove any stationery from the Examination Room.

1 You have just been appointed to advise the Estate Management Department at the University of Cambridge on the construction of a new building in West Cambridge. The University does not undertake a large number of developments and hence advisors are appointed to provide specific expertise when needed. As a world-leading higher education organisation and to increase the possibility of securing donor funding, Estate Management wants a particularly high-quality building. The new building needs to be ready for the start of the 2027/2028 academic year.

(a) What would you describe as the early steps to be followed in the tendering process? List five of the most important tender documents likely to be required for this project. [20%]

(b) Suggest a procurement route for Estate Management and explain the reasons behind your choice. [20%]

(c) Prepare an initial cost estimate for 'work package 6' of the project involving the construction of a state-of-the-art medium-sized lecture theatre with a seating capacity of 150. Use the following information to develop the costing:

- Construction of work package 6 will begin in July 2026 and is expected to last 12 months.
- The bill of quantities and unit costs as at today (1 May 2024) are provided in Table 1 below.
- Plant and equipment are all lumped together into an average hire rate of £150 per hour with a total hire time for the work package of 1600 hours.
- 20 workers will be required for work package 6. Total possible working hours in the year per worker is 2080 hours assuming 40 hours per 5-day week. Assume 8 sick days per year per worker. Holidays and annual leave are to be 30 days per year per worker. Take the labour rate to be £25 per hour and employer's contribution to national insurance to be 13.8%.
- You should assume a conservative price index increase of 8% for all construction materials and 2% for plant hire. Labour rate inflation can be taken as 4%. [50%]

(d) Suggest an appropriate contingency to use on the final estimate and provide a brief justification for this value. [10%]

(Cont.

Table 1: Bill of Quantities & Material Costs

Item	Quantity	Units	Unit cost (£)
Excavation, Grading, and Foundation	500	m^3	7.50 /m^3
Construction of Frame and Shell			
Reinforced Concrete	80	T	150 /T
Structural Steel	20	T	800 /T
Roofing			
Roofing Material with Insulation	300	m^2	40 /m^2
Exterior Walls, Windows, and Doors			
Brick Walls	200	m²	120 /m^2
Glass Curtain Walls	200	m²	400 /m^2
Aluminium Windows	20	units	480 /unit
Steel Doors	5	units	800 /unit
Flooring, Walls, Ceiling			
Ceramic Tile Flooring	150	m²	24 /m^2
Gypsum Wallboard	200	m²	16 /m^2
Acoustic Ceiling Tiles	100	m²	12 /m^2

2 (a) How is health and safety regulated in the UK? What is the role of the HSE in the UK? [10%]

(b) What are the duties of the client and the principal contractor under the CDM Regulations (2015)? [20%]

(c) How do Method Statements contribute to ensuring health and safety during the performance of a task in construction projects? Explain any differences in regulatory requirements between a Method Statement and Risk Assessment. [30%]

(d) Consider a scenario on a construction site involving a deep excavation which is supported by steel bracing. Four possible example events are listed in the Table 2 below (in no particular order).

(i) Describe a suitable risk management process. [10%]

(ii) Identify a likely chain of events for this scenario. [10%]

(iii) Perform an event tree analysis to identify the probability of each outcome. [20%]

Table 2: List of events

Event	**Probability**
Failure of emergency response & evacuation	0.10
Failure of bracing support system	0.08
Re-evaluation of bracing support system design either doesn't happen or is inaccurate	0.40
Development of ground movements	0.25
Failure of monitoring trigger thresholds	0.20

3 (a) Please answer the following questions:

(i) What is the difference between performance and productivity in construction? [10%]

(ii) Name four disadvantages of cost reporting and control systems. [10%]

(b) Use the project activities information provided in Table 3 below to:

(i) Draw the Activity-on-Node (A-on-N) diagram. Perform forward pass calculations to determine for each activity the early start time and early finish time. [20%]

(ii) Perform backward pass calculations to determine for each activity the total float and free float. Indicate which activities belong to the critical path. [30%]

Table 3: Project activities

Activity #	Durations (days)	Predecessor Activities: Relationships	Resource Demands (Labourers)
A	5	-	5
B	2	A:SF/5, I:SS/7	4
C	1	B:FS, I:SF/6, D:FF/-1	2
D	6	B:FS, G:SS/3	2
E	10	I:FS, G:FF/-3	1
F	1	C:FS, G:SF	1
G	3	B:FS/3, I:FS	3
H	7	A:SS/-4, J:FF/2	3
I	8	H:SF/2	1
J	10	A:FF/2	4

(c) You have ten available labourers. Perform resource allocation for the above project. What is the revised total project duration? How many extra labourers are needed to finish the project in fewer than 22 days? [30%]

4 You are part of a project management team tasked with the construction of a new sustainable building in Cambridge. The stakeholders are keen on implementing lean construction practices. The building design emphasises sustainability, energy efficiency, and a collaborative workspace environment.

(a) Identify and explain the following:

(i) Three core principles of lean construction. [15%]

(ii) How each of these principles aligns with the goals of sustainability and energy efficiency in construction. [15%]

(b) (i) Explain the concept of Value Stream Mapping in the context of lean construction. Highlight the key components of a value stream map and how it serves as a visual tool for analysing and improving processes. [20%]

(ii) For the construction of the superstructure for the sustainable office building project, consider three key processes: (1) structural framing, (2) concrete pouring and (3) quality inspections. Identify the key steps, information flow, and potential areas of waste. Discuss how the value stream map can be used to identify opportunities for improvement and enhance overall project efficiency. [30%]

(c) (i) Identify two common types of waste in construction projects. [10%]

(ii) Propose specific strategies to minimise or eliminate these wastes in the context of the sustainable office building project. [10%]

5 (a) (i) What is the optimum amount to bid in a lump sum job? [10%]

(ii) Will decreasing markup increase or decrease company profitability? Explain why. [5%]

(b) The cost and schedule data for a small project are given in Table 4 and Figure 1 below. Perform a time-cost trade-off analysis to determine the following. Assume an indirect cost of £2,100/day. Stop crashing activities when the cumulative cost starts increasing.

(i) What is the project's total duration, direct and indirect costs without crashing any activities? [25%]

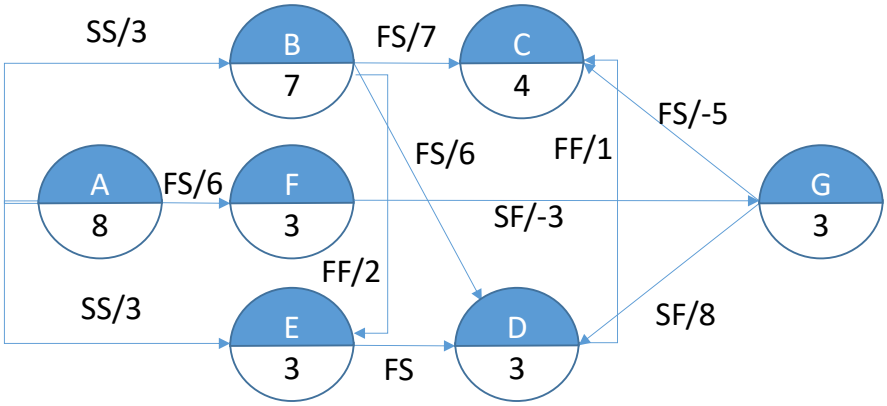
(ii) Determine the minimum overall cost of the project and its associated duration. [60%]

Hint: Calculate for the project the cumulative total cost for every cycle of crashing.

Table 4: Cost and schedule data

Activities	Cost		Duration (days)	
	Crash	Normal	Crash	Normal
A	£2,400	£1,600	4	8
B	£3,200	£1,600	3	7
C	£5,000	£1,400	1	4
D	£3,800	£3,400	1	3
E	£5,000	£1,000	2	3
F	£2,600	£1,000	1	3
G	£4,000	£800	2	3

Figure 1: Activity relationships



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