# Tripos IIB/IIA
# 4D16 CONSTRUCTION MANAGEMENT

## Q1

(a)
This solution can be largely taken from the notes:

**Step 1: develop the brief**
- Determine factors that will govern scheme layout
- Identify site ownership, access limitations, etc…
- Desired commencement and completion dates
- Establish the budget and a preliminary cost estimate
- For present situation, client will need to appoint designer

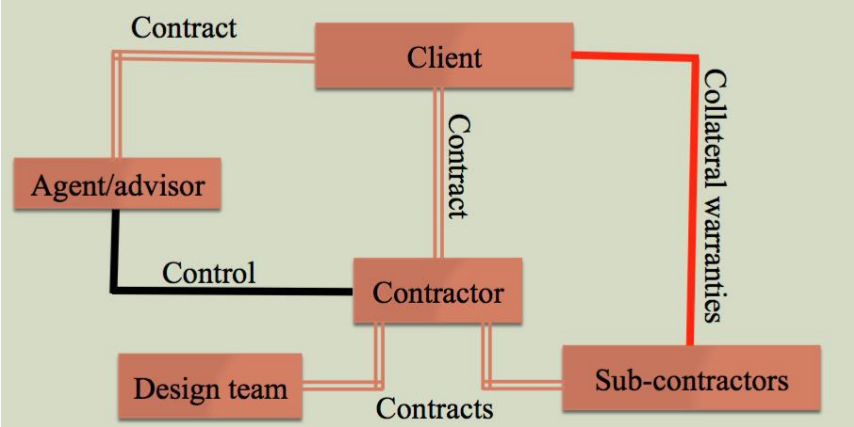
**Step 2: feasibility stage**
Assess whether the project is feasible technically and financially.
**Step 3: Draft scheme sketching**
The designer puts on paper preliminary response to the brief
**Step 4: Cost estimates**
- Quantity surveyor prepares an initial cost estimate.
- Client will expect a reasonably indicative estimate
- Costs can be revised as design develops
- Revised cost > client's budget => adjustments
- Once within budget, cost estimate = cost control document

**Step 5: Choose procurement route**
**Step 6: Detailed design stage**
**Step 7: Apply for planning.**

Tender documents: (1) formal invitation, (2) bill of quantities, (3) drawings, (4) form of tender, (5) health and safety file.

(b)
The students are expected to use the information given in the question to explain that:
1. The client is not an experienced client which means that consultants will need to be appointed early.
2. That time and quality take priority over cost; the academic year will have to start on a specific date and the building will house academics and technical staff who will have very specific requirements for their new building.
3. Estate Management will be keen to ensure the project does not overrun in terms of cost as the budget gets fixed upfront.

Taking the points above into consideration a traditional route of procurement is appropriate – an example is shown in the figure below. The client appoints consultants for design, cost control, and contract administration, and appoints a contractor responsible for carrying out the construction work. A lump sum (fixed price) or target cost contract is agreed at the start but it will be crucial for the client to get expert advice in evaluating price estimates.




(c)

| Item | Quantity | Unit cost (£) | Total (£) |
|---|---|---|---|
| **MATERIALS** | | | |
| Excavation, Grading, and Foundation | 500 | 7.50 | 3750 |
| Construction of Frame and Shell | | | |
| Reinforced Concrete | 80 | 150 | 12000 |
| Structural steel | 20 | 800 | 16000 |
| Roofing | | | |
| Roofing material with insulation | 300 | 40 | 12000 |
| Exterior Walls, Windows, and Doors | | | |
| Brick Walls | 200 | 120 | 24000 |
| Glass Curtain Walls | 200 | 400 | 80000 |
| Aluminum Windows | 20 | 480 | 9600 |
| Steel Doors | 5 | 800 | 4000 |
| Flooring, Walls, Ceiling | | | |
| Ceramic Tile Flooring | 150 | 24 | 3600 |
| Gypsum Wallboard | 200 | 16 | 3200 |
| Acoustic Ceiling Tiles | 100 | 12 | 1200 |
| **Total (today)** | | | 169350 |
| Total as at July 2025 (8%) | | | 182898 |
| Total as at July 2026 (8%) | | | 197529.84 |
| Total as at July 2027 (8%) | | | 213332.2272 |
| **Take cost to be average over project duration** | | | **205431.0336** |
| **PLANT & EQUIPMENT** | | | |
| Lumped total | 1600 | 150 | 240000 |
| **Total including inflation at 2%** | | | **249696** |
| **LABOUR** | | | |
| Possible working hours | 41600 | | |

| | | | |
|---|---|---|---|
| Time off | 4800 | | |
| Sick time | 1280 | | |
| Actual working hours | 35520 | 25 | 888000 |
| **Actual working cost including inflation at 4%** | | | 979670.016 |
| **National insurance @13.8%** | | | 122544 |
| Paid annual leave/holidays | 24000 | 25 | 600000 |
| **Paid a/l including inflation at 4%** | | | 661939.2 |
| **Total labour cost** | | | **1764153.216** |

**Total** 2219280.25 £

Contingency of 10% seems appropriate because of lack of expertise in the Estate Management team, high interest rates and uncertainty, a focus on quality for the project and the possibility of a donor coming in later

**Q2**

(a)

Health and safety is regulated by the Health and Safety at Work Act 1974. This is an Enabling Act, which allows the Secretary of State to make further laws (regulations) without the need to pass another Act of Parliament. The Health & Safety Executive, established in 2008, performs the function of regulation and enforcement of the Health and Safety at Work act. It serves improvement notices, prohibition notices and can also prosecute offenders. It oversees over 200 regulations and also the Approved Code of Practice (ACOP).

(b)

Clients' duties include:

- •Appoint a CDM co-ordinator
- •Appoint a principal contractor
- •Provide pre-construction information to CDM co-ordinator
- •Make sure that the construction phase does not start unless there are suitablewelfare facilities and a construction phase plan in place

Principal Contractors' duties include:

- •Plan, manage and monitor construction phase
- •Prepare, develop and implement a written plan and site rules before constructionbegins)
- •Give sub-contractors relevant parts of the plan
- •Make sure suitable welfare facilities are provided throughout construction
- •Ensure all workers have site inductions and required training
- •Secure the site

(c)

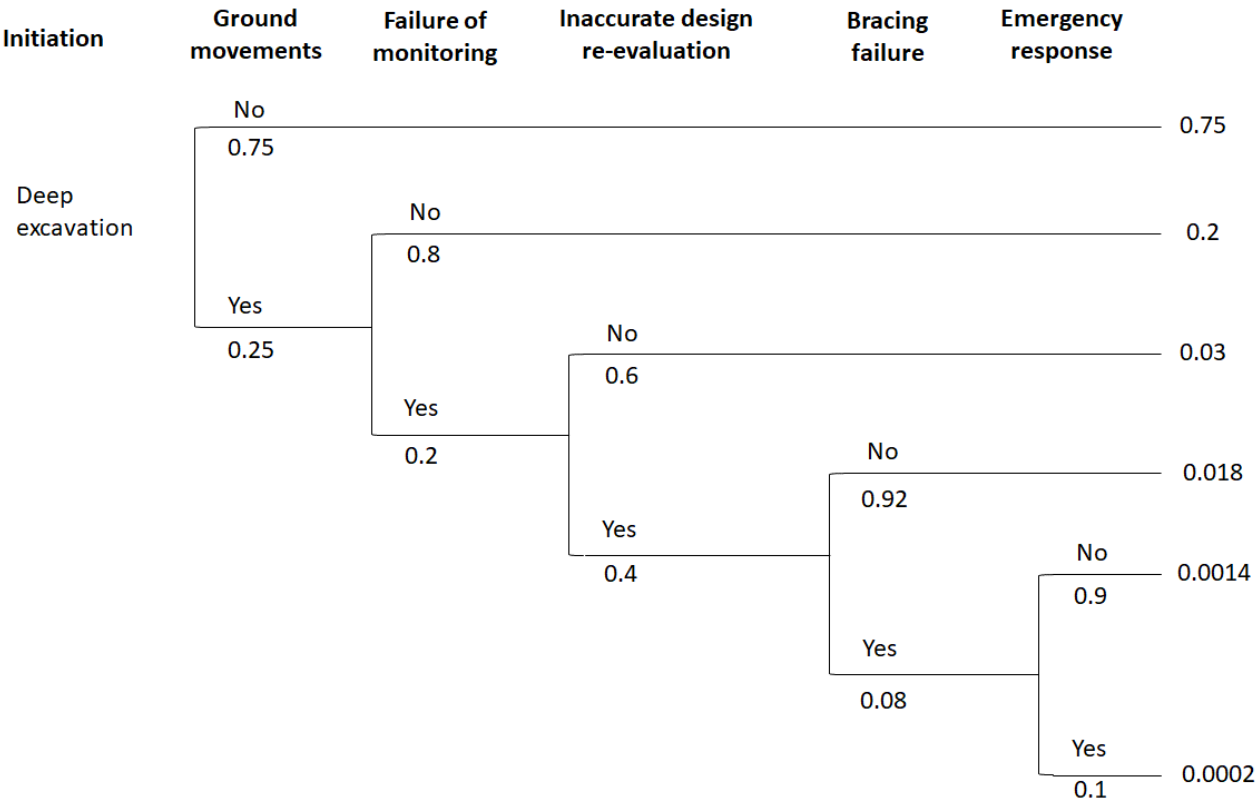
The MS describes the sequences of operations for safe working that will ensure health and safety during the performance of a task.

They are not a requirement of the CDM Regulations but are identified by HSE as one way of satisfying the requirements of the regulations. The risk assessment is required under the construction phase health and safety plan.

(d)
(i) Suitable risk management process taken from lecture notes:
Step 1: Identify risks
e.g. hazard identification, HAZOP
Step 2: Assess risks
e.g. qualitative or quantitative approaches. Prioritise risks following assessment.
Step 3: Treat risks
Challenge controls. Take action: avoid, mitigate, accept, transfer or and/or insure.
Step 4: Monitor & report
e.g. risk register

(ii)

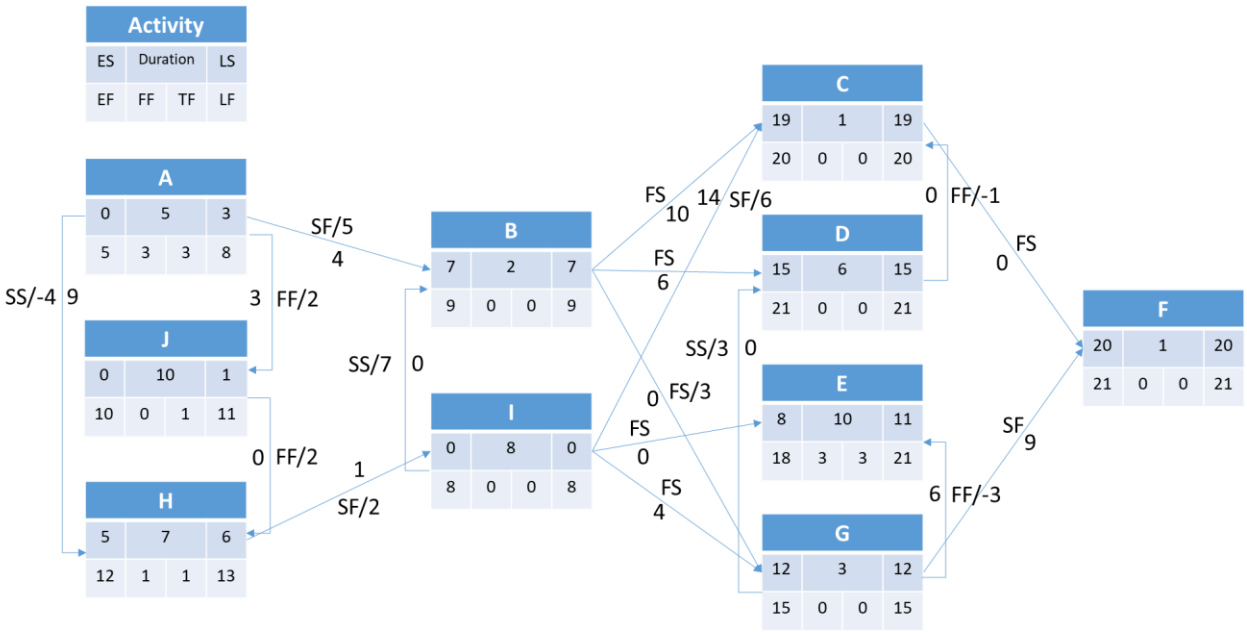
Likely chain of events: development of ground movements → failure of monitoring trigger thresholds → inaccurate re-evaluation of bracing support system design → failure of bracing support system → failure of emergency response and evacuation.



**Q3**

(a) (i) Performance also includes safety, timeliness, quality. Productivity is cost effectiveness.
(ii) (1) Timeliness of information or feedback; (2) Cost of collecting data; (3) Doesn't pinpoint the root of the problem; (4) Human error in estimating input & output; (5) City to city labour cost hard to compare.

(b)




Critical path: I-B-G-D-C-F

(c)

| Act. | Dur. | Res. | LS | TF | / | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 5 | 5 | 3 | 3 | X | 5 | 5 | 5 | 5 | 5 | | | | | | | | | | | | | | | | | | | |
| B | 2 | 4 | 7 | 0 | X | | | | | | | | | | | 4 | 4 | | | | | | | | | | | | |
| C | 1 | 2 | 19 | 0 | X | | | | | | | | | | | | | | | | | | | | | | | 2 | |
| D | 6 | 2 | 15 | 0 | X | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 |
| E | 10 | 1 | 11 | 3 | X | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | |
| F | 1 | 1 | 20 | 0 | X | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| G | 3 | 3 | 12 | 0 | X | | | | | | | | | | | | | | | | 3 | 3 | 3 | | | | | | |
| H | 7 | 3 | 6 | 1 | X | | | | | | 3 | 3 | 3 | 3 | 3 | 3 | 3 | | | | | | | | | | | | |
| I | 8 | 1 | 0 | 0 | X | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | |
| J | 10 | 4 | 1 | 1 | X | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | | | | | | | | | | | | |
| Total Resources | | | | | | 10 | 10 | 10 | 10 | 10 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 1 | 1 | 1 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 4 | 3 |

The revised total project duration is 24 days.
2 extra labourers would bring the total duration to under 21 days.

**Q4**

(a)

(i)

**Value:** In lean construction, value is defined from the customer's perspective. It involves identifying and delivering what the customer truly values while eliminating activities that do not contribute to that value.

**Waste elimination:** Lean construction aims to minimise or eliminate waste in all forms, including time, materials, and resources. Common types of waste include overproduction, waiting time, unnecessary transportation, excess inventory, unnecessary motion, defects, and underutilisation of talent.

**Continuous improvement (Kaizen):** Lean construction emphasises a culture of continuous improvement, where teams regularly assess their processes and strive to make incremental enhancements over time.

(ii)

The value principle aligns with sustainability by focusing on delivering features that enhance the building's environmental performance. Waste elimination reduces resource consumption and aligns with energy efficiency goals. Continuous improvement ensures that sustainable practices are continuously integrated into construction processes.

(b)

(i)

Value Stream Mapping is a lean construction technique used to visualise, analyse, and improve the flow of materials and information throughout a construction process. It is a visual representation that helps identify waste, streamline processes, and enhance overall project efficiency.

Key components of a Value Stream Map include:

1. **Process box:** Represents a specific construction process or activity.
2. **Material flow:** Indicates the movement of materials through various process steps.
3. **Information flow:** Shows how information is communicated between stakeholders.
4. **Lead time:** Highlights the time it takes to complete each process.
5. **Value-adding and non-value-adding activities:** Distinguishes between activities that add value to the project and those that do not.

(ii)

Process Steps:

1. Structural Framing
2. Concrete Pouring
3. Quality Inspections

Material Flow:

- Structural framing materials move from the supplier to the framing process.
- Concrete is delivered to the construction site and poured during the concrete pouring phase.
- Quality inspections involve the movement of inspection reports and approvals.

Information Flow:

- Project plans and specifications are communicated to the framing team.
- Inspection results and quality approvals are communicated to relevant stakeholders.

Lead Time:

- Identify the time taken for each process step and the overall lead time for the superstructure construction phase.

Value-adding and non-value-adding activities:

- Value-Adding: Structural framing, concrete pouring, and quality inspections.
- Non-Value-Adding: Waiting times, delays, and excess inventory.

**Waste Identification:**

- Waiting times during structural framing or concrete pouring.
- Excess inventory of materials on-site.
- Delays in communication between quality inspections and subsequent construction steps.

**Opportunities for Improvement:**

- Reduce waiting times through better coordination of work schedules.
- Implement just-in-time delivery to minimise excess material inventory.
- Improve communication channels between quality inspections and subsequent construction steps.

**Enhance Overall Project Efficiency:**

- Implement a synchronised schedule for structural framing and concrete pouring.
- Establish a communication protocol to ensure timely quality approvals.
- Introduce visual management tools to monitor and control inventory levels.

**(c)**

**(i)**

Students are free to select 2 out of the 7 wastes covered in the lectures.

An example two wastes:

1. **Overprocessing:** Producing more than what is needed can lead to excess inventory, storage costs, and increased chances of defects.
2. **Transportation waste:** Unnecessary movement of materials or equipment can result in increased costs and time inefficiencies.

**(ii)**

Strategies may include:

1. **For the overprocessing waste:** Implementing a demand-driven production approach, adjusting production based on real-time demand.
2. **For transportation waste:** Optimising transportation routes, consolidating shipments, and using just-in-time delivery to minimise unnecessary movements.

5

(a) (i) Optimum bid amount = amount that gives the maximum expected profit.

(ii) Decreasing markup will increase company profitability if lowering it improves expected profit and vice versa.

(b)

| Activities | Cost | | Duration (days) | | Crash cost/Unit Time | Maximum Crash Allowed (days) |
|---|---|---|---|---|---|---|
| | Crash | Normal | Crash | Normal | (£/day) | |
| A | £2,400 | £1,600 | 4 | 8 | £200 | 4 |
| B | £3,200 | £1,600 | 3 | 7 | £400 | 4 |
| C | £5,000 | £1,400 | 1 | 4 | £1,200 | 3 |
| D | £3,800 | £3,400 | 1 | 3 | £200 | 2 |
| E | £5,000 | £1,000 | 2 | 3 | £4,000 | 1 |
| F | £2,600 | £1,000 | 1 | 3 | £800 | 2 |
| G | £4,000 | £800 | 2 | 3 | £3,200 | 1 |
| **Sum** | | **£10,800** | | | | |

| Step | Paths | Duration | Activities Crashed | Project Duration after Crash | Crash Cost (£) | Cumulative Direct Cost (£) | Corresponding Indirect Cost (£) | Cumulative Total Cost (£) |
|---|---|---|---|---|---|---|---|---|
| 0 | A-B-C | 21 | | **21** | £0 | £10,800 | £44,100 | £54,900 |
| | A-B-D-C | 20 | | 20 | | | | |
| | A-B-E-D-C | 16 | | 16 | | | | |
| | A-F-G-C | 17 | | 17 | | | | |
| | A-F-G-D-C | 17 | | 17 | | | | |
| | A-E-D-C | 10 | | 10 | | | | |
| 1 | A-B-C | **21** | B by 4 days | **17** | £1,600 | £12,400 | £35,700 | £48,100 |
| | A-B-D-C | 20 | | 16 | | | | |
| | A-B-E-D-C | 16 | | 12 | | | | |
| | A-F-G-C | 17 | | **17** | | | | |
| | A-F-G-D-C | 17 | | **17** | | | | |
| | A-E-D-C | 10 | | 10 | | | | |
| 3 | A-B-C | **17** | C by 1, F by 1 days | **16** | £2,000 | £14,400 | £33,600 | £48,000 |
| | A-B-D-C | 16 | | **16** | | | | |
| | A-B-E-D-C | 12 | | 12 | | | | |
| | A-F-G-C | **17** | | **16** | | | | |
| | A-F-G-D-C | **17** | | **16** | | | | |
| | A-E-D-C | 10 | | 10 | | | | |
| 4 | A-B-C | **16** | C by 1, D by 1, F by 1 days | **15** | £2,200 | £16,600 | £31,500 | £48,100 |
| | A-B-D-C | 16 | | **15** | | | | |
| | A-B-E-D-C | 12 | | 11 | | | | |
| | A-F-G-C | **16** | | **15** | | | | |
| | A-F-G-D-C | **16** | | **15** | | | | |
| | A-E-D-C | 10 | | 9 | | | | |

When the overall project duration is 16 days, the minimum overall cost is £48,000.