Tripos IIB/IIA

4D16 CONSTRUCTION AND MANAGEMENT - Solution

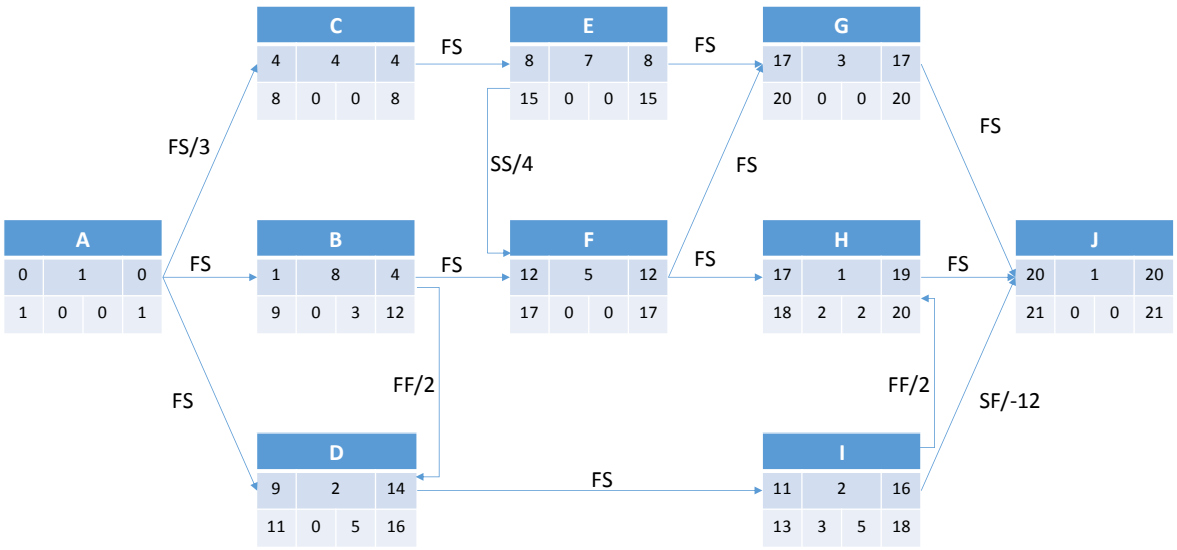
1

(a) **Finish-to-start (FS)—** the start of each activity depends on the completion of its preceding activity

Start-to-finish (SF) – each activity's completion time depends on the start of its preceding activity

Scenarios: pre-installation inspections; material delivery times.

(b)



Critical path: A-C-E-F-G-J

(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	25	26	27	28
A	1	3	0	0	X	3																											
B	8	4	4	3	X								4	4	4	4	4	4	4	4													
C	4	3	4	0	X				3	3	3	3																					
D	2	2	14	5	X																2	2											
E	7	3	8	0	X																3	3	3	3	3	3	3						
F	5	2	12	0	X																				2	2	2	2	2				
G	3	3	17	0	X																									3	3	3	
H	1	2	19	2	X																									2			
I	2	1	16	5	X																		1	1									
J	1	4	20	0	X																												4
Total Resources						3	0	0	3	3	3	3	4	4	4	4	4	4	4	4	5	5	4	4	5	5	5	2	2	5	3	3	4

The revised total project duration is 28 days.

1 extra labourer would bring the total duration to under 22 days.

Assessor's Comments:
Attempts 22 (egt2) + 39 (egt3) + 3 (FIBE) + 1 (NUC) + 1 (EGT6), Average mark 12.24(egt2) + 12.9 (egt3) + 11 (FIBE) + 9 (NUC) + 10 (EGT6)
This was the most popular question. Most candidates' answers were average. Part (a) asked them to provide 3 short answers and help set out their thinking process for part (b); the definition of FS and SF relationships was answered well by most students. A few were unable to provide good scenarios to explain the concepts. Part (b) asked them to lay out a network diagram and calculate its parameters. Over half the students made mistakes on this one; some were due to lack of understanding of free float, and some due to lack of understanding of the relationships between activities. Part (c) asked students to allocate resources. A few did not remember how to do this at all, and some only partially remembered the process. Some got it 100% right. A few run out of time.

2

(a) An outflow delay is the time between a general contractor receiving a service or product and the time he/she is liable to pay for it. It occurs when material suppliers deliver construction materials or when subcontractors complete a portion of the work. General contractors should use it when early payment discounts are not provided to minimise negative peaks in their cash flow.

(b)

Activities	Cost		Duration (days)		Crash cost/Unit Time (£/day)	Maximum Crash Allowed (days)
	Crash	Normal	Crash	Normal		
A	£2,400	£2,000	2	6	£100	4
B	£3,200	£2,800	3	7	£100	4
C	£4,500	£4,100	1	3	£200	2
D	£4,300	£3,600	2	4	£350	2
E	£5,400	£3,400	6	8	£1,000	2
F	£1,200	£1,000	2	3	£200	1
Sum		**£16,900**				

Step	Paths	Duration	Activities Crashed	Project Duration after Crash	Crash Cost (£)	Cumulative Direct Cost (£)	Corresponding Indirect Cost (£)	Cumulative Total Cost (£)
0	A-C-F	15		15	0	£16,900	£5,000	£21,900
	A-D-E-F	25		25				
	A-B-F	16		16				
	A-B-C-F	18		18				
	A-B-D-E-F	24		24				
1	A-C-F	15	A by 4 days	11	400	£17,300	4200	£21,500
	A-D-E-F	25		21				
	A-B-F	16		12				
	A-B-C-F	18		14				
	A-B-D-E-F	24		20				
2	A-C-F	11	D by 1 day	11	350	£17,650	£4,000	£21,650
	A-D-E-F	21		20				
	A-B-F	12		12				
	A-B-C-F	14		14				
	A-B-D-E-F	20		20				

When the overall project duration is 21 days, the minimum overall cost is £21,500.

Assessor's Comments:

Attempts 21 (egt2) + 38 (egt3) + 3 (FIBE) + 1 (NUC) + 1 (EGT6), Average mark 13.6 (egt2) + 14.76 (egt3) + 13 (FIBE) + 4 (NUC) + 9 (EGT6)

Question 2 had 2 parts. It was a popular question, and when answered, it was answered well. The first part was theory questions that expected the students to show an understanding of cash flow analysis, the reasons it is conducted, and the factors that affect it. A few answers showed superficial understanding of the subject. The 2nd part asked candidates to perform a time-cost trade-off analysis. By far most attempts were almost right with a few logic or numerical mistakes.

3 (a) Risk can be defined as the combination of the probability of an event and its consequences. The reasons why projects have a tendency to exceed target cost projections are below:

(i) Political expedience

Politicians favour megaprojects – they resuscitate depressed economies, create jobs and win elections – so much, so that most Megaprojects fail before they have even started. Political expedience drives project approval without robust feasibility studies/business cases being established and inadequate due diligence being performed. Many projects are therefore destined to fail. Political decision makers when approving ill-conceived Megaprojects for construction often implicitly refer to Hirschman's 'Hiding Hand'. Hirschman offered that, even though economic

forecasters are likely to get the true cost of a Megaproject wrong at the project onset, it is highly likely that the benefits to society will also be underestimated. In time these two opposing forces, underestimated cost and underestimated benefit will balance each other out to help a Megaproject achieve a form of viability in the future. Published evidence does not support this view. In fact, as with the Eurotunnel project, economic forecasters not only demonstrate a tendency to underestimate project cost but also to overestimate project benefits. The Eurotunnel's final cost was double what has anticipated at the onset and realised annual revenue has only been 50% of what was originally forecasted.

(ii) Wicked risks (risks due to complexity)

Project environments are non-linear and dynamic and persons within them tend to behave irrationally. All of these factors contribute to the generation of unpredictable or 'wicked' risks. Our current application of risk management processes to project environments fails to grapple with the system complexity that is characteristic of most project environments. We need to expand our lens of inquiry and focus on identifying the hidden interdependencies that often drive complexity. Managing risk exclusively in the discrete spaces of projects or programmes conceals and therefore increases the negative impacts of complexity. If we want to improve the successful management of risk in a project then we need to get better at managing risks across an organisation.

(iii) Myopia (short sightedness)

Most Megaprojects have very long durations; between 4 to 10 years typically. On average, senior project leadership maintains a two-year tenure in role. This situation can drive the wrong behaviour on the project, one where short-term decision-making takes precedence over decisions that impact on the long-term success of the project.

(iv) Hubris (over confidence)

The prevailing ethos in the construction sector is one of overconfidence. Not enough attention is paid to lessons that have been learnt from past failures, which unfortunately increases the chances of these mistakes being made again.

(v) Elephant in the room (corruption)

Megaprojects require fantastical sums of money to progress and this together with their uniqueness, numerous contractual interfaces and organisational complexity make them fertile beds for all manner of corruption – nepotism, bribery, conflict of interest, fraud, extortion and embezzlement. Corruption, although rarely addressed in publications, is a key contributor to Megaproject underperformance.

(b) Advantages of a Project Insurance:

(i) Avoids the need for the members of the design team to each have to take out and maintain high Limits of Indemnity under their PI Insurance. This avoids the twin perils of either a party being under-insured or the crippling cost of

purchasing high limits of indemnity for 15 years. They would not need to declare the fees in respect of this project under their own PI insurance hence there would be a real saving.

(ii) Hence facilitating the appointment of smaller niche forms for whom the prospect of a large limit of indemnity would act as an effective barrier to entry

(iii) Easier dispute resolution – only one insurer covering all the design team would avoid 'demarcation disputes' saving time and cost when claims do arise and avoiding or at very least mitigating associated legal costs. Also the focus of investigations would not be on attaching blame but rather on finding a solution and would eradicate the 'blame and claim' culture common in most construction contracts

(iv) Easier appointment documentation - no wrangles over each member of design team having to get their insurers to approve the appointment documents - these are instead approved by the one project insurer on behalf of all members of the design team

Potential disadvantages:

(i) The fact that liabilities are insured under a pooled arrangement may induce some firms to be more lax when carrying out their design role. Solution: the project insurers will almost certainly wish to put in place a system of independent checking and peer review. There are also very good professional commercial and reputational reasons why firms want to continue to do a top class job.

(ii) Cost – project insurance may possibly work out more expensive than traditional individual arrangements however this is in fact very unlikely when taking into account the 'hidden' costs associated with normal PI insurance and the claims resolution process

(c) Answers:

(i)
- Appoint the right people at the right time (ie Designer, Contractor)
- Provide pre-construction information to your Designer and Contractor (e.g. asbestos surveys) as soon as possible
- Make suitable arrangements, including the allocation of sufficient time and resources to ensure that the construction work can be carried out, so far as is reasonably practicable, without risks to health and safety

- Ensure that a contractor has drawn up a construction phase health and safety plan (even where there is only one contractor)
- Where there is more than one contractor involved, appoint a principal designer and a principal contractor.
- Ensure a Construction Phase Plan is in place (This should be proportionate to the scale of the work and associated risks and you should not allow work to start on site until there is a Plan.)
- Retain the H&S File (At the end of the project you should be given a H&S File.)
- Notify HSE as soon as possible before construction work starts.

(ii) The Principal Designer.

(iii) The Regulations require that it is the Client who appoints the Principal Designer (PD), so if all the designers have been novated to the D&B contractor, the Client must appoint a new PD. One obvious choice will be the D&B contractor himself. Even if he has no designers working for him in-house, the D&B contractor could fulfil the role as PD by appointing one of the novated designers to carry out those functions.

Assessor's Comments:

Attempts 10 (egt2) + 16 (egt3) + 2 (FIBE) + 1 (EGT6), Average mark 8 (egt2) + 9.56 (egt3) + 11 (FIBE) + 6 (EGT6)

Parts a and b were not answered reasonably well by most candidates. Part a asked students to define risk in a certain context and why project exceed cost projections. Many students chose instead to talk about risk in general. Part b asked about advantages and limitations of project insurance. Many attempts misunderstood this to be equal to personal professional insurance. I hypothesize that students chose not to give this chapter much importance as it did not have numerical examples like other chapters did.

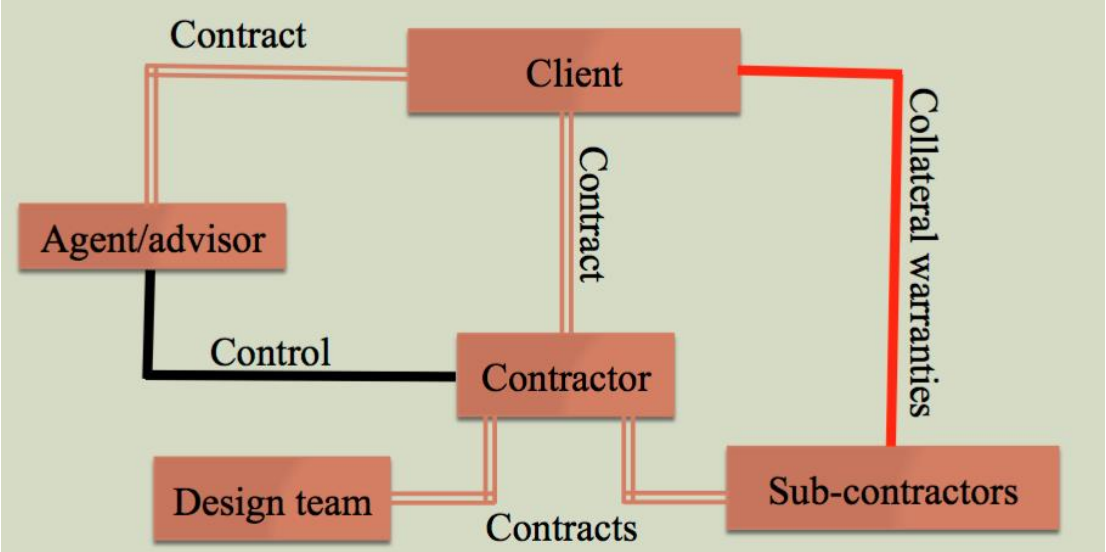
Part c is designed to test the students understanding of the CDM Regulations 2015 by using a hypothetical scenario in which the students need to provide advice for a client. The first two parts require the students to understand the clients' and designers' responsibilities and, in general, this was answered reasonably well. The third part requires more thinking where the students are given the opportunity to express their own thoughts for handling the novation process within CDM Regulations 2015. This part was answered very poorly by those who attempted it with only two candidates presenting a reasonable solution.

4 (a) Cost, time, quality and risk appetite.

(b) The students are expected to use the information given in question 4b 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) The client needs a particularly high quality building, which implies that the normal condition of reasonable skill and care is not suitable. Hence it would be prudent for the client to ensure that both the consultants and the contractors are held to the more stringent condition of fitness for purpose.

(d) Yes. More experienced clients might opt for the client-led procurement routes (Management route or the Construction Management route). These routes offer the flexibility for the client to divide the projects into packages that are then awarded to the most suitable sub-contractors.

Assessor's Comments:

Attempts 17 (egt2) + 21 (egt3) + 3 (FIBE) + 1 (NUC), Average mark 9.2 (egt2) + 10.33 (egt3) + 12.7 (FIBE) + 9 (NUC)

This question was reasonably popular. Part a was straightforward and answered very well by almost all those who attempted the question. Part b describes a scenario where the students needed to use the information presented in the question, in addition to the information presented in lectures, to suggest a suitable procurement route for a client. A large number of students suggested the 'Design and Build' procurement route overlooking that the client is particular about quality and hence more design control should be in the hands of the client. The last part of the question was poorly answered with the majority of the students demonstrating a lack of understanding of client-led procurement routes.

5 (a)

(i) Construction management is a procurement route in which the works are constructed by a number of different trade contractors. These trade contractors are contracted to the client but managed by a construction manager. The Construction Manager, acts as an agent for the client, administering and co-ordinating the works contracts. The construction manager is generally appointed early in the design process so their experience can be used to improve the buildability and packaging of proposals as they develop.

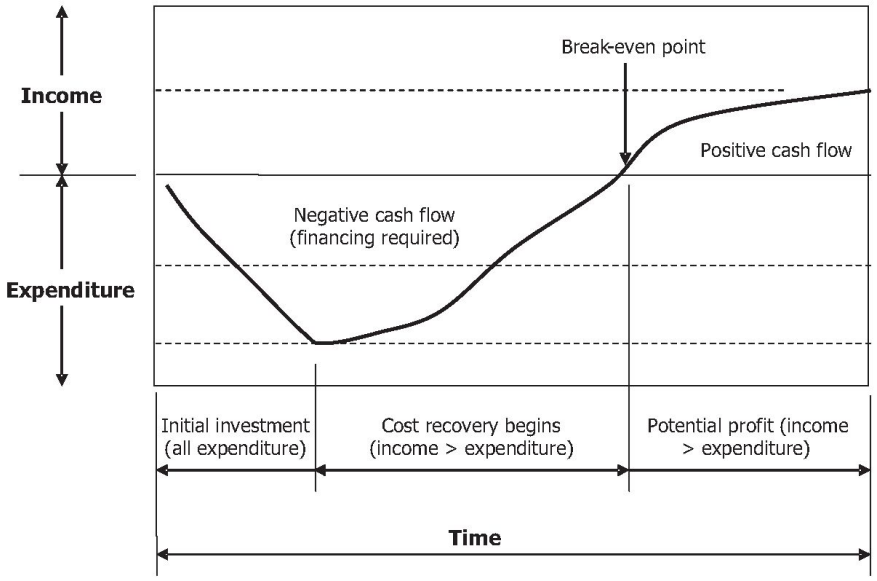
(ii) The duties include the following:

- Programming of design and construction activity, including information release programmes, approvals and reprogramming to meet overall completion dates.
- Advising on buildability construction methodologies and sequencing
- Commenting on and monitoring the progress of design development.
- Advising on requirements for preconstruction works and temporary works
- Packaging up the works into well-co-ordinated and clearly demarcated trade contracts, together with the definition of the transfer of design responsibility
- Preparing and collating pre-qualification and tender documentation together with the administration and negotiation of the tender process.
- Managing, planning and controlling the work of trade contractors, including the administration of design approvals and inspections.
- Monitoring and reporting on overall progress, advising on issues related to trade contractor performance and forecasting the impact of design changes or disruption to the progress of the works.
- Managing financial aspects of the project, including trade contract valuations, claims and administration of contra-charges.

- Initiating action by the client and project team to mitigate delays or cost overrun.

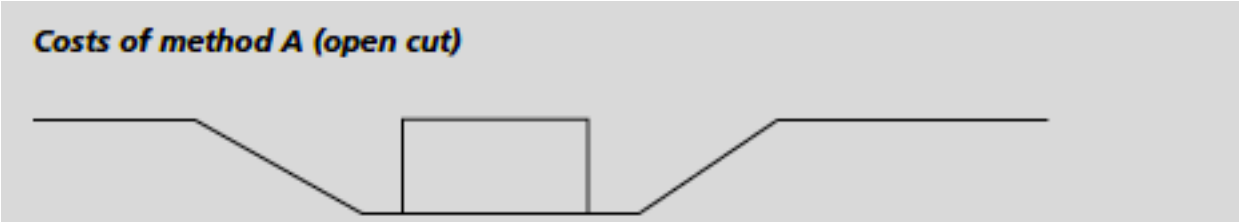
(iii) Yes. The Construction Manager is bound by the condition of reasonable skill and care duty.

(b)



(c) There are two solutions being considered:

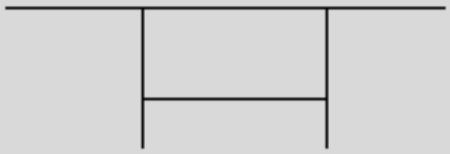
(1)



Excavating in open cut (18360+10800) X 2.5 = 72,900 m^3 @ £10/m^3 = £729,000
The students will need to make an assumption (this is an estimation problem) for the additional working space needed – a 2m wide space is assumed around the basement here.

Disposal on site 72,900m^3 @ £1/m^3 = £72,900
Bring back and fill 57,900 m^3 @ £2/m^3 = £115,800
Total net cost = £917,700

Costs of method B (steel cofferdam)



Sheet piling – mobilization/demob = 2 X £5,000 = £10,000
Sheet piling 160 X 15 = 2,400 m^2 @ £35/m^2 = £84,000
Excavate within cofferdam 15,000m^3 @ £25/m^3 = £375,000
Disposal on site = 15,000m^3 @ £1/m^3 = £15,000
Extract cofferdam = £5,000
Total net cost = £489,000

Thus, based on the above, the estimator would choose Method B. Adding site overheads (estimate 10%) and head office overheads and profit (12%), the rate = (1.22 X £489,900)/15,000m^3 = £40/m^3

Assessor's Comments:

Attempts 6 (egt2) + 9 (egt3) + 1 (FIBE), Average mark 10.5 (egt2) + 11 (egt3) + 10 (FIBE)
This is the least popular question. Parts a and b are straightforward and can be answered by going through the lecture notes. The last part asks the students to estimate the costs of a construction activity (using two different options). The question's aim is to assess the ability of the students to account for the necessary detail, which needs a detailed breakdown of the sub activities – those who tried this part made only some basic attempt – no demonstration of detailed thinking. In addition, the students needed to make some assumptions regarding overheads and profit – none of the students accounted for that.