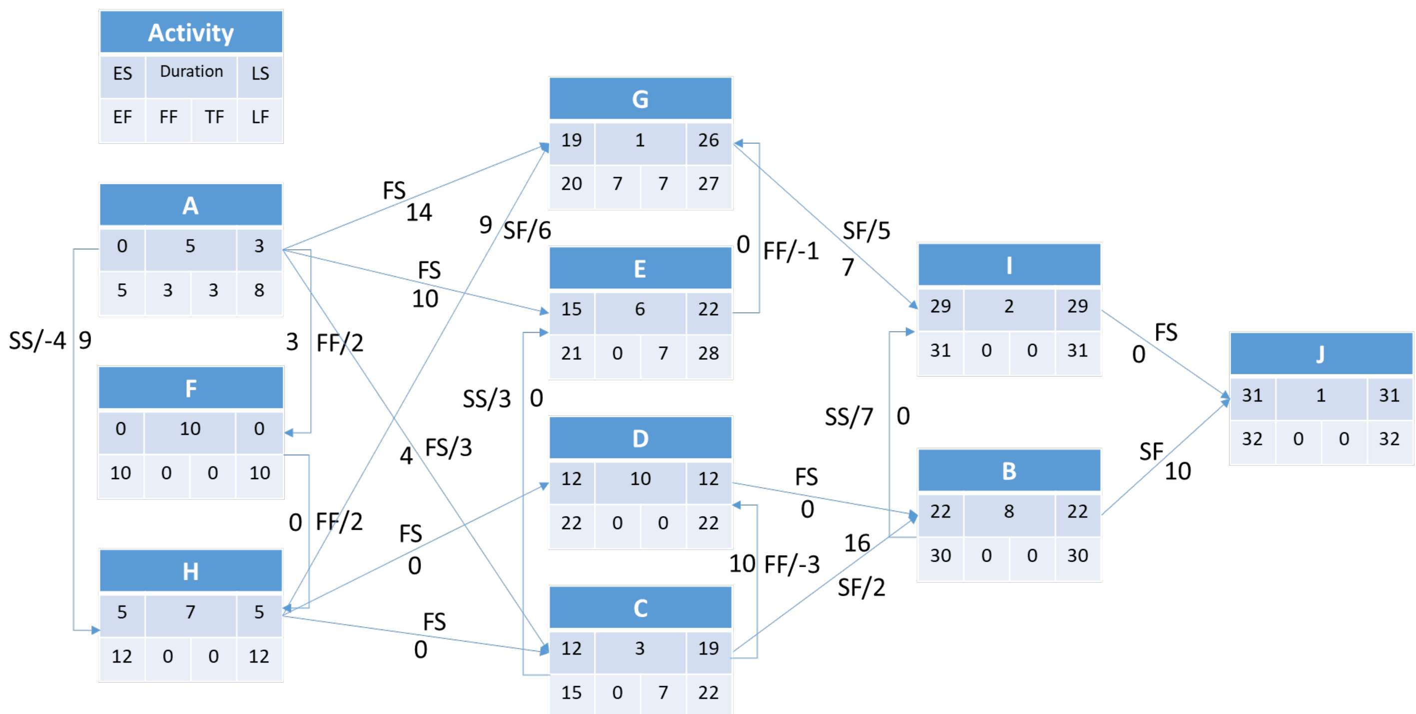
Tripos IIA
3D9 CONSTRUCTION AND MANAGEMENT

1 (a)

Difficult coordination
Weaker management/site communication
Difficult to mitigate disputes
Detrimental to job efficiency
Complicated scheduling of operations
Weaker GC, division of project authority
Fragmented responsibility

(b)



Critical path: F-H-D-B-I-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	29	30	31	32	33	34	35	36	37	38
A	5	6	3	3	X	6	6	6	6	6																																	
B	8	4	22	0	X																							4	4	4	4	4	4	4	4								
C	3	2	19	7	X													2	2	2																							
D	10	6	12	0	X													6	6	6	6	6	6	6	6	6	6																
E	6	4	22	7	X																							4	4	4	4	4	4										
F	10	2	0	0	X	2	2	2	2	2	2	2	2	2	2																												
G	1	6	26	7	X																															6							
H	7	4	5	0	X						4	4	4	4	4	4	4																										
I	2	2	29	0	X																																			2	2		
J	1	6	31	0	X																																					6	
Total Resources						8	8	8	8	8	6	6	6	6	6	4	4	8	8	8	6	6	6	6	6	6	6	8	8	8	8	8	8	4	4	6	0	0	0	2	2	6	0

The revised total project duration is 37 days.

2 extra labourers would bring the total duration to under 33 days.

(a)

Dry common earth: Table 2-5: unit weight: 1,471 $\frac{kg}{LCM}$, swell=25%, shrinkage=10%, LF=0.8, SF=0.9. AoR = 32 degrees (Table 2-6). Soil must be cut in a trapezoidal section shape in both directions.

Cut: A to B: $L = \frac{560\ m}{2} = 280\ m;\ h = 20\ m$

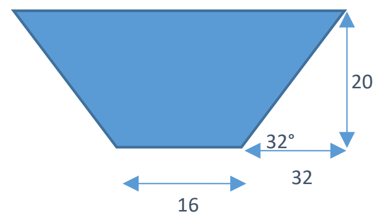
We split the shape into 4 simpler shapes: a) a triangular section in the middle (ADB) with depth equal to the road width, b) two pyramids (left and right of the width), with ADA' as the base and B as the tip at the top, c) one triangular section left of AD with ADA' as the base and road width as the height, and d) two pyramids at the corners of ADA', with ADA' as the base and AA' as the height.

Volume of (a): $\frac{(20\ m)\times(280\ m)}{2} \times (16\ m) = 44{,}800\ BCM$

Volume of (b): $\frac{\frac{20\ m \times 32\ m}{2}\times(280\ m)}{3} = 29{,}867\ BCM$

Volume of (c): $\frac{(20\ m)\times(32\ m)}{2} \times (16\ m) = 5{,}120\ BCM$

Volume of (d): $\frac{\frac{20\ m \times 32\ m}{2}\times(32\ m)}{3} = 3{,}413\ BCM$



Total vol.: $a + c + 2 \times (b + d) = \mathbf{116{,}479\ BCM}$

$$= \frac{116{,}479}{0.8} LCM = 145{,}599\ LCM$$
$$= 116{,}479 \times 0.9 = 104{,}831\ CCM$$

Fill: B to C: $L = 280\ m;\ h = 20\ m$

Calculation is the same. Total vol.: $\mathbf{116{,}479\ CCM} > 104{,}831\ CCM$ hence soil in ADB is not enough to fill BEC. We will need to get extra $116{,}479 - 104{,}831 = \mathbf{11{,}648\ CCM}$ from the pit = 16,178 LCM

(b)

Route 1: Rolling resistance factor = 75 kg/t (soft rutted dirt, Table 4-1). Traction coefficient = 0.6 (dry earth, Table 4-2)

Route 2: Rolling resistance factor = 50 kg/t (rutted dirt roadway, Table 4-1). Traction coefficient = 0.6 (dry earth, Table 4-2)

We calculate the maximum grade that a truck can ascend/descend. Note that, when descending, the use of brakes makes the vehicle all-wheel drive. Two-wheel drive is only for ascending. Also note that weight has no effect in this equation for AWD, as shown below. We then compare this grade with the slopes of both routes.

$$useable\ rimpull > total\ resistance$$
$$useable\ rimpull = coefficient\ of\ traction(\%) \times weight\ on\ drivers\ (kg)$$
$$total\ resistance = grade\ resistance + rolling\ resistance$$
$$= Weight\ (kg) \times Grade(\%) + RRfactor\ (kg/t) \times Weight\ (kg)/1000$$

For truck to ascend the slope:
$\therefore FWD, i.e. weight\ on\ drivers \neq total\ weight, then$:
$Grade(\%) \leq Traction(\%) \times Weight\ on\ drivers\ (\%) - RRfactor/1000$
For truck to descend the slope:
$\therefore AWD, i.e. weight\ on\ drivers = total\ weight, then$:
$Grade(\%) \leq Traction(\%) -\ RRfactor/1000$

Route 1 (ascending, empty): $Grade \leq 0.6 \times 0.585 - 75/1000\ = 0.28$. *Max grade is 28% < 34%*

Route 1 (descending, full): $Grade \leq 0.6 - 75/1000\ = 0.525$. *Max grade is 52% > 34%*

Route 2 (ascending, empty): $Grade \leq 0.6 \times 0.585 - 50/1000\ = 0.30$. *Max grade is 30% > 8%*

Route 2 (descending, full): $Grade \leq 0.6 - 50/1000\ = 0.55$. *Max grade is 55% > 8%*

Hence, route 1 is not suitable for this truck type. However, route 2 is feasible.

(c)

$$Section\ D - E: Required\ \#\ of\ trucks = \frac{Haul\ unit\ cycle\ time}{load\ time} = \frac{4\ min}{2\ min} = 2\ trucks$$

$$Cut\ and\ fill\ time = \frac{145{,}599\ LCM}{580\ LCM/hr} = 251 hrs = 31\ days$$

$$Pit\ to\ site: Required\ \#\ of\ trucks = \frac{1.7\ hrs \times 60\ min/hr}{2\ min} = 51\ trucks$$

$$Pit\ Production = \frac{20\ LCM}{1.7\ hrs} \times 13\ trucks = 153\ LCM/hr$$

$$Pit\ to\ site\ time = \frac{16{,}178\ LCM}{153\ LCM/hr} = 106\ hrs = 13\ days$$

Total system time = **31 days**. For the first 13 days, 2 trucks will support the shovel, and 13 trucks will bring borrowed soil. The rest of the time, the 13 trucks will be idle.

3

(a)

Hazard: A source of potential harm or a situation with potential for harm (e.g., failure of bracing system).
Risk: The combination of the likelihood of a hazard occurring and the severity of its consequences.
Harm: Actual injury, damage to health, property, or the environment resulting from a hazard.

(b)

1. Identification: Recognize hazards, several approaches: (i) previous experience, (ii) individual consultation, (iii) group discussions, (iv) HAZOP (HAZard and Operability Study).

2. Assessment: via Impact and Likelihood. Risks can be assessed using two main ways (i) qualitative (usually done first) or (ii) quantitative (i.e. in a numerical format).

3. Mitigation: taking actions to reduce either the likelihood or the impact of a risk to an acceptable level. Type of actions: (i) avoid, (ii) mitigate, (iii) accept, (iv) transfer, (v) insure.

4. Monitoring risks: Track risks, update controls, maintain a risk register.

(c)

Risk score = Probability × Impact

Event	**Probability**	**Impact (1–5)**	**Risk Score (P × I)**	**Mitigation (**examples**,** student can pick one and it can be something different**)**	**Residual Score** (examples, it can be different score)
Delay in delivery of long-lead power-generation equipment (turbines, generators, boilers, HV gear)	0.5	5	2.5	Early procurement, supplier monitoring, dual sourcing, expedite logistics.	1.0
Quality defects in civil works requiring rework (foundations for heavy rotating equipment)	0. 5	4	2.0	Strong QA/QC controls, increased supervision, subcontractor training, pre-qualification.	1.0
Interface issues between Civil works and MEP installation (misaligned openings, wrong embedments, out-of-sequence work)	0.33	4	1.32	BIM coordination, interface workshops, joint scheduling, tolerance checks.	0.8

(d)

For a large, complex power-station project in the Middle East, the EPC/Turnkey procurement model is generally the most appropriate option. Power-station construction involves extensive civil works, long-lead mechanical and electrical equipment, and tightly integrated control systems. These characteristics make coordination critical, and the client—who is inexperienced in major construction—would benefit from having a single point of responsibility for engineering, procurement, and construction. EPC/Turnkey offers time and cost certainty, clearer risk allocation, and reduced interface risk compared with Traditional or Design & Build models. In contrast, the Traditional (Design–Bid–Build) route separates design from construction, often leading to disputes, slower delivery, and substantial coordination challenges. Design & Build improves integration but still leaves more design responsibility with the client than is ideal for a highly specialised industrial facility.

Given the project type and the advantages of the EPC model, the client should adopt a standard form contract, with the FIDIC Silver Book being the most suitable. It is specifically designed for EPC/Turnkey arrangements, widely used in international power-generation projects, and clearly allocates design, performance, and time risks to the contractor. This reduces ambiguity and lowers the likelihood of contract disputes. A bespoke contract would introduce unnecessary complexity, require extensive legal drafting, and pose higher risks for a client without deep experience in managing major engineering contracts. A recognised standard form provides greater clarity, balanced obligations, and industry-accepted mechanisms for programme management, variations, and dispute resolution.

4

(a)

In Table 3, mean ratio = $\left(\frac{Act}{Est}\right)$ ≈ 1.03, On average, Actual ≈ 3.02% higher than estimated, so the GC has historically underestimated direct costs by about 3%.

Corrected direct cost=$21.0 \times 1.0302 \approx 21.63$ million

(b)

Calculate the probability of winning P, for different markups considering competitors A, B, C.

8%: $P = 0.82 \times 0.77 \times 0.84 = 0.530$

10%: $P = 0.80 \times 0.74 \times 0.82 = 0.485$

12%: $P = 0.533 \times 0.493 \times 0.547 = 0.144$

Calculate the probability of winning P, for different markups considering competitors A, B, C, and three unknown competitors.

8%: $P = 0.82 \times 0.77 \times 0.84 \times (0.81)^3 \approx 0.282$

10%: $P = 0.80 \times 0.74 \times 0.82 \times (0.7867)^3 \approx 0.236$

12%: $P = 0.5333 \times 0.4933 \times 0.8467 \times (0.5244)^3 \approx 0.021$

Markup	PA	PB	PC	PU	P(win)
8%	0.82	0.77	0.84	0.8100	0.282
10%	0.80	0.74	0.82	0.7867	0.236
12%	0.5333	0.4933	0.5467	0.5244	0.021

$$E = P(win) \times (m \times D)$$

8%: $E = 0.282 \times (0.08 \times 21.63) \approx £0.49m$

10%: $E = 0.236 \times (0.10 \times 21.63) \approx £0.51m$

12%: $E = 0.021 \times (0.12 \times 21.63) \approx £0.05m$

Expected profit is highest at 10%.

Markup	Profit if win	P(win)	Expected profit
8%	£1.73m	0.282	≈ £0.49m
10%	£1.66m	0.236	≈ £0.51m
12%	£1.99m	0.021	≈ £0.05m

(c)

$SPI = \frac{BCWP}{BCWS}$, $BCWP = CPI \times ACWP = 0.81 \times 6.1 = £4.941\ million,$

$SPI = \frac{BCWS}{BCWP} = \frac{4.941}{6.0} = 0.82$

$CV = BCWP - ACWP = 4.941 - 6.1 = -1.159\ million$

$$\%CV = \frac{CV}{BCWP} \times 100 = \frac{-1.159}{4.941} \times 100 \approx -23.5\%$$

$$SV = BCWP - BCWS = 4.941 - 6.0 = -1.059\, million$$

$$\%SV = \frac{SV}{BCWS} \times 100 = \frac{-1.059}{6.0} \times 100 \approx -17.7\%$$

At the end of the first year, the contractor's project is performing poorly in both cost and schedule terms. The CPI of 0.81 and a cost variance of approximately −23.5% indicate significant cost overruns, with actual expenditure substantially exceeding the budgeted value of work completed.

In addition, the SPI of approximately 0.82 and a schedule variance of −17.7% show that the project is behind schedule, having completed considerably less work than originally planned for the first year.

Overall, the project exhibits both cost and schedule underperformance at an early stage of a four-year programme. This represents a serious warning signal, indicating the need for immediate corrective actions in cost control, productivity improvement, and programme management to prevent further deterioration in performance.