

**ORDRE DES INGÉNIEURS DU QUÉBEC**  
**May 2019 SESSION**

All documentation is permitted  
Calculators: allowed models only  
Exam duration: 3 hours

**14-CI-A7 Construction Project Management**

**Question 1 (5 points)**

What is the utility of the Earned Value method? Use curves and formulas to explain this method.

**Question 2 (20 points)**

Using the data in Table 1, draw the AOA diagram (Activity On Arrow) and indicate the critical path.

Indicate, for each activity, the Early Start (ES), the Early Finish (EF), the Late Start (LS), the Late Finish (LF), the total Float (TF), and the Free Float (FF).

**Table 1**

Activity	Duration	Predecessor
N	10	none
P	4	Q
Q	4	N
R	5	Q
S	5	P
T	12	N
U	8	P, T
V	3	R
W	7	U, S, V
X	5	R
Y	5	U
Z	8	S, U, V, X

### Question 3 (20 points)

Resolve the resource conflicts for the following project, knowing that you can use up to 6 resources at the same time. The activities must be carried out on an ongoing basis (no interruption of work is permitted).

Figure 1, indicates the network, critical path and for each activity, the Early Start (ES), the Early Finish (EF), the Late Start (LS), the Late Finish (LF), the total Float (TF), and the Free Float (FF).

The **calculation steps must be demonstrated**. This means that you have to redraw the network and make a new Gantt chart every time an activity is delayed because of a conflict. New resource links must also be demonstrated (this means new constraints between activities to resolve resource conflicts).

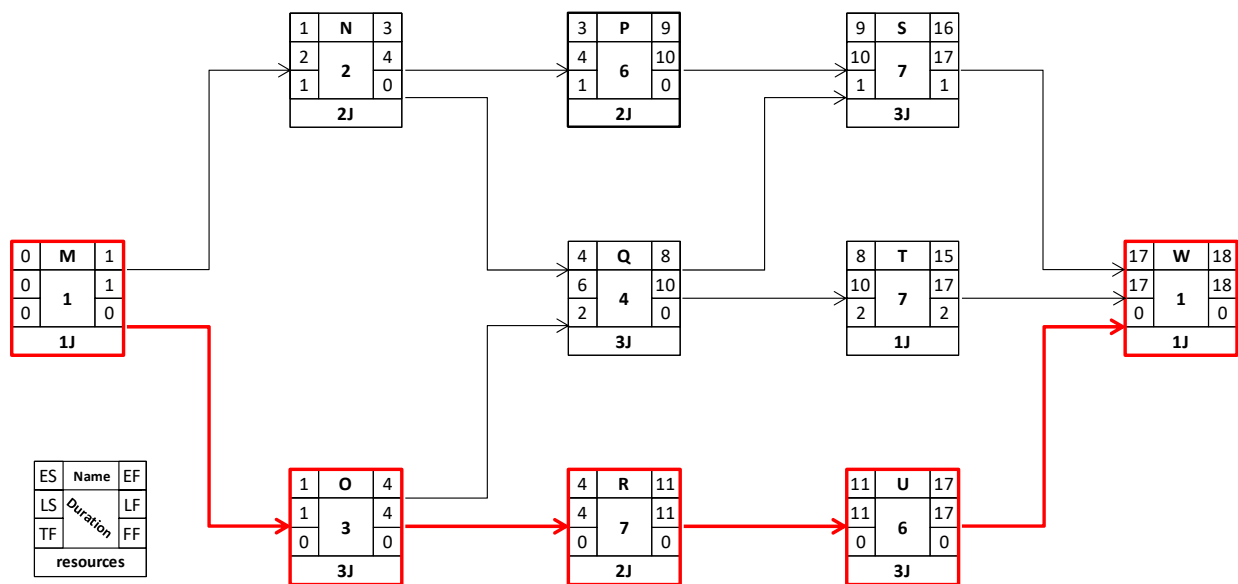


Figure 1 – Resource conflicts

### Question 4 (20 points)

Using the two following tables (2 and 3), please:

- 1 - Calculate the planned, actual / revised costs and the earned value and draw the Planned, the Actual and the Earned Value progress curves.
- 2 - Calculate the variances and draw a histogram to show the cost and the schedule variances.
- 3 - Calculate the performance indexes and draw curves to show the cost and the schedule performance indexes.

**Table 2**

Planning													
Item	Unit Price	Unit	Total	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	
			Quantity										
Structure													
Excavation	20 \$ / U	m³	300	300									
Reinforced Concrete for foundation	500 \$ / U	m³	40	30	10								
Reinforced Concrete for Floor Slab	800 \$ / U	m³	250		200	50							
Reinforced Concrete for Last Floor	750 \$ / U	m³	50			50							
	Quantity	Unit	Amount in \$										
Finishing													
Partitions and Finishes	1	lump sum	120 000			10 000	20 000	40 000	30 000	20 000			
Plumbing	1	lump sum	45 000				10 000	20 000	10 000	5 000			
Ventilation	1	lump sum	80 000				40 000	20 000		20 000			
Fire Protection	1	lump sum	25 000				10 000	10 000		5 000			
Electricity	1	lump sum	60 000		5 000	5 000	10 000	20 000	10 000	10 000			
Communication	1	lump sum	19 000		2 000	2 000				15 000			

**Table 3**

			Actual										
Item	Unit Price	Unit	Total	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	
			Quantity										
Structure													
Excavation	40 \$ / U	m³	350	250	100								
Reinforced Concrete for foundation	600 \$ / U	m³	40		20	20							
Reinforced Concrete for Floor Slab	750 \$ / U	m³	300			150	150						
Reinforced Concrete for Last Floor	750 \$ / U	m³	80				80						
	Quantity	Unit	Amount in \$										
Finition													
Partitions and Finishes	8	m²	125 000				10 000	20 000	30 000	30 000	20 000	15 000	
Plumbing	1	lump sum	50 000					10 000	20 000	10 000	5 000	5 000	
Ventillation	1	lump sum	85 000					40 000	10 000	10 000	5 000	20 000	
Fire Protection	1	lump sum	30 000					10 000	10 000		5 000	5 000	
Electricity	1	lump sum	65 000			5 000	5 000	10 000	15 000	10 000	10 000	10 000	
Communication	1	lump sum	24 000			2 000	2 000				10 000	10 000	
Change order 1	1	lump sum	20 000		20 000								
Change order 2	1	lump sum	60 000						30 000	20 000	10 000		

### Question 5 (15 points)

As estimator, your employer asks you to estimate the construction cost of the excavation of the existing soil, the backfill with clean stone, and the implementation of a slab on grade for the site shown in Figure 2

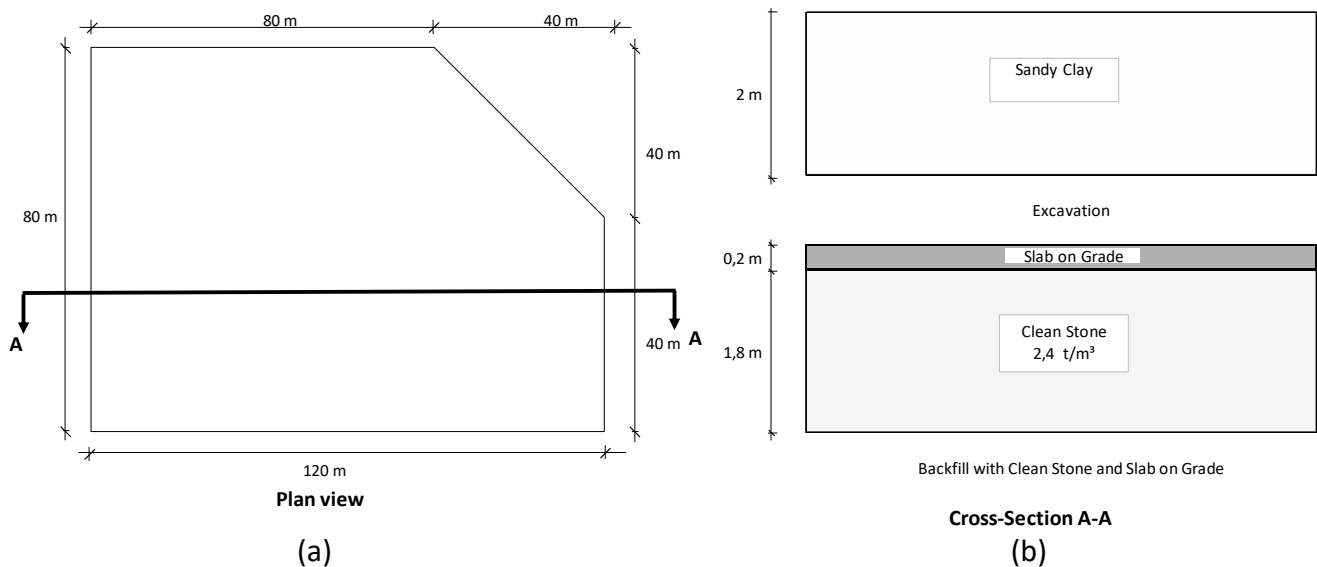


Figure 2. The project Plan and Cross-Sections views

Knowing that:

- The excavation total depth is 2 m ;
- Surveys show that the soil is sandy clay whose densities (bank state) is as shown in the figure 1 above ;
- The swell factor of the materials is 20% for the sandy clay soil ;
- The excavator production is 100 m<sup>3</sup>/ h for the sandy clay soil ;
- The excavator works 8 hours / day ;
- The hourly rate of the excavator (including the operator) is \$ 200 / hour (Minimum rental period is 4h00) ;
- The soil is loaded on trucks of 10 m<sup>3</sup>. Each truck make two (2) cycles per hour [ Loading + unloading + travel time (go + back) ] ;
- Trucks charge \$ 160 / hour (for the excavated soil). This rate includes the operator ;
- The cost of the clean stone, including the supply of materials, transport, placement and compaction, is \$ 50 / m<sup>3</sup> ;

- The thickness of the slab on grade is 200mm ;
- The purchase cost of the ready mix concrete is \$ 200 / m<sup>3</sup> ;
- The cost of purchasing the wire mesh for the slab on grade is \$ 10 / m<sup>2</sup> ;
- The wire mesh is set up by two rodmen. The production rate for the installation is 20m<sup>2</sup>/hour ;
- The hourly rate for each rodman is \$ 60 / hour ;
- The cost for the cast in place for the concrete (labor only) is \$ 22 / m<sup>3</sup> ;
- The hourly rate of the pump (used for cast in place of concrete) is \$ 170 / hour (The minimum rental period is 4h00) ;
- The transportation cost of the pump is \$ 280 (for the round trip) ;
- The pump production is 25 m<sup>3</sup>/ hour ;
- The concrete finishing cost is \$ 5 / m<sup>2</sup> ;
- The formwork cost, Including materials and labor, is \$ 12 / ml ;
- The indirect costs of the site is \$ 30 000 ;
- Administrative expenses and profit are 20% of the total value ;
- Goods and Services Tax (GST) rate of 5% on the sale price ;
- Sales tax (QST) rate of 9.975% on the sale price excluding GST.

### Question 6 (20 points)

Using the method of parallelepipeds (méthode des parallélépipèdes), calculate the required volumes of excavation and backfill. The final level of the site (shown in Figure 3) should be 11 000.

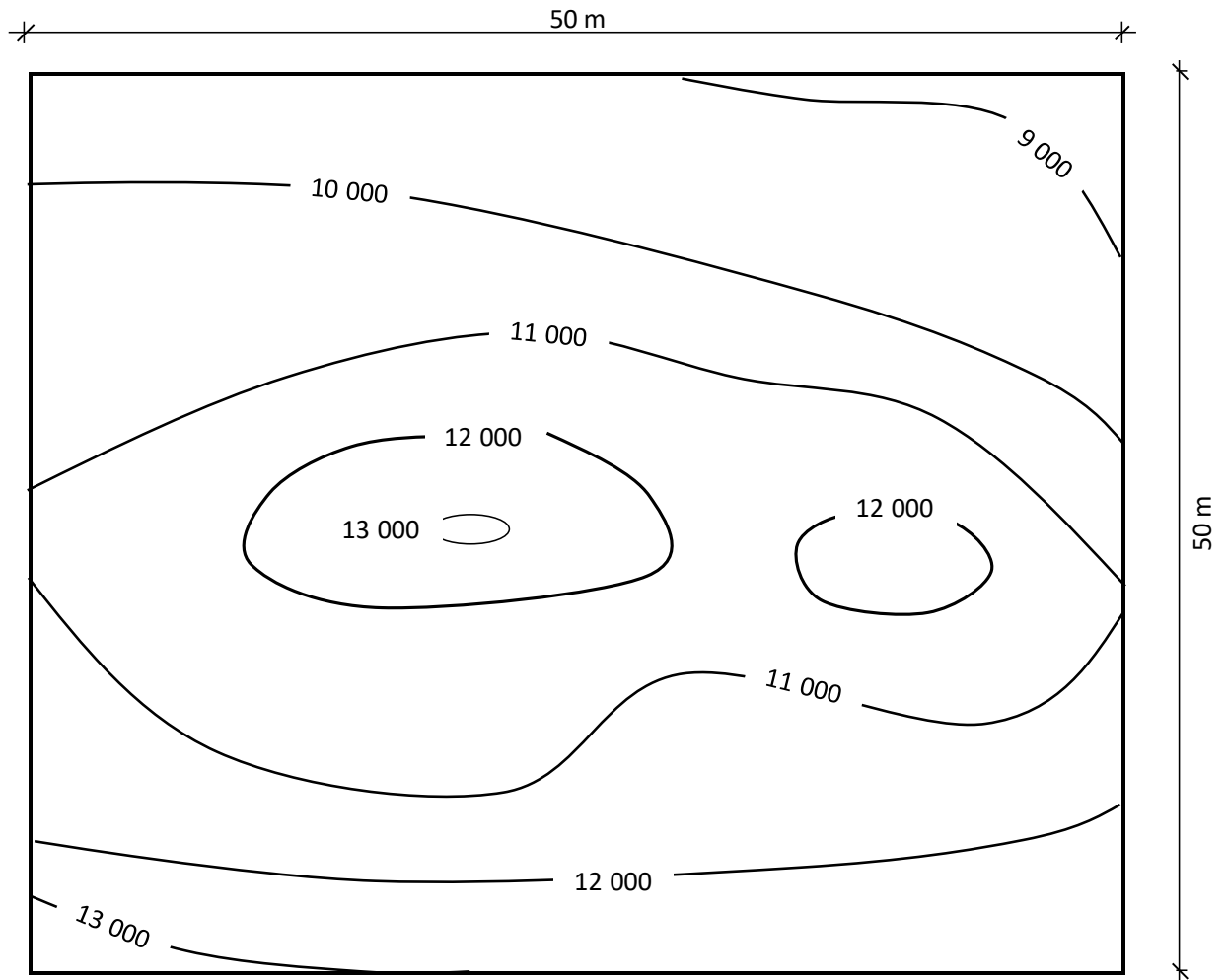


Figure 3 – The site map