NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2011-2012

CV4251 – CIVIL ENGINEERING CONSTRUCTION TECHNOLOGY

April/May 2012 **Time Allowed: 2½ hours**

INSTRUCTIONS

1. This paper contains **SIX (6)** questions and comprises **FOUR (4)** pages.
2. Answer **ALL** questions.
3. This is a Closed-Book Examination.
4. The questions do not carry equal marks.

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1. (a) A building structure is made up of numerous subsystems, briefly discuss any five of the key subsystems.

(5 Marks)

Wrote all 8 for revision purpose

(b) In general, the manufacturing industry seems to enjoy a higher rate of success in adopting automation and robotics (A & R) in work processes, as compared to the construction industry. Identify the main features of these two industries and give your comments and support with reasons on any four major factors that might have caused this disparity.

(10 Marks)

feels like repeat

2. (a) (i) It is frequently stated that by using more Prefabrication/Pre-casting in construction industry, it can contribute to shorter construction periods without increase in construction labor. Explain how this is made possible by means of Prefabrication/Pre-casting.

(ii) In employing Prefabrication/Pre-casting in the construction project, it requires special design considerations. State these special design considerations and elaborate on each of them.

(10 Marks)

(b) A scraper is required to load, haul and discharge some soil in a project. The scraper has to travel three sections of path A, B and C before discharging of soil. The capacity of the scraper, in loose volume is 30 m^3. The time required for loading, accelerating, turning and dumping is 3.0 min. The scraper also has a rolling resistance of 300 N per tonne of vehicle weight, which translates into an equivalent grade of 3%. (Note: Effective Grade = Actual + Equivalent)

The swell factor of the soil is 1.25 and the estimated total volume of soil to be handled is 1,300 m^3 (bank volume). Other details concerning the haul path and the variation of speed of scraper with effective grade are summarized in Table Q2(a) and Table Q2(b).

Table Q2(a): Details of the Haul Path

Section	Distance (m)	Actual Grade (%)
A	600	-3
B	500	-1
C	300	-3

Table Q2(b): Variation of Average Speed with Effective Grade

Effective Grade (%)	0	2	4	6	8
Hauling Speed (km/h)	40	35	28	22	18
Returning Speed (km/h)	40	40	35	30	25

(i) Based on the information given above, estimate the cycle time of the scraper.

(ii) If the job needs to be completed within 8.5 hours, estimate the minimum required rate of the scraper in m^3/h (in loose volume).

(iii) Using your answers in parts (i) and (ii), estimate the minimum required operating efficiency of the scraper so that it could finish the job in 8.5 hours. (You may express the operating efficiency either as a % or as working minutes per hour).

(10 Marks)

CV

3. (a) The Buildable Design Appraisal System was developed by the Buildir Construction Authority as a means to measure the potential impact o building design on the use of site labor.

(i) In the above stated appraisal system, what are the objectives of having the buildable score?

(ii) What are the basis and three principles of a buildable design? Elaborate on each of the three principles of buildable design.

(iii) In the above stated appraisal system, explain briefly the three main components of the design that must be considered.

(iv) In a case that when two contractors have attained the same buildable score in their own building projects, explain briefly what does it mean in term of their productivity?

(12 Marks)

(b) Table Q3 shows the labour saving indices, S_w, for different types of wall systems as outlined in the Buildable Design Appraisal System (BDAS) guidelines.

Table Q3: Labour Saving Indices for Wall Systems- S_w value

Wall System	Labor Saving Index S_w	
Curtain wall/full height glass partition/dry partition wall/prefabricated railing	0.7	1.00
Precast concrete panel/wall	0.8	0.9
PC formwork	0.5	0.75
Cast-in-situ RC wall	0.5	0.7
Cast-in-situ wall with prefabricated reinforcement	0.54	0.74
Precision block wall (internal wall)	0.4	0.45
Precision block wall (external wall)	0.3	
Brickwall	0.3	

(i) Explain briefly why there are two different labor saving indices for certain types of wall systems as shown in the above Table Q3.

(ii) The wall system of a condominium project is made up of 55% of brickwall (in terms of total length) and 45% of cast-in-situ RC wall (with prefabricated reinforcement). Using the contents of Table Q3, estimate the difference in Buildable Score that would have resulted from using the two different labor saving indices for the cast-in-situ RC wall (with prefabricated reinforcement). Under what situation would you consider such a difference significant?

(8 Marks)

just the wall
x40 or not?

→ Definition

Notes one sketch only
no steps

4. (a) A tunnel of 5.5 m in inner diameter uses a precast segmental lining to protect the excavation through soft sandy clay layers. The depth of the tunnel is 17 m from the ground level. The groundwater level is found at 8 m from the ground level. With the aid of sketches briefly describe the steps how to advance the tunnel by the earth pressure balance tunnelling method.

↓ how does the numbers affect the ~~g~~ steps

(9 Marks)

7. (b) Briefly describe, with the aid of sketches, the steps on how to construct a 22 m long secant-pile-type concrete bored piles using a casing method through a soil deposit consisting of 7 m of stiff clay from the ground level, 5 m of loose sand layer, 8 m of stiff clay, and 10 m of hard soil stratum. The diameter of the secant piles is 1,000 mm and the ground-water table is not found in the project site.

so deep

(9 Marks)

5. (a) With the aid of sketches, briefly describe the steps of a bottom-up basement construction method supported internally in a relatively soft clay deposit. A three-layer strut system is used to support the sheetpile as a temporary retaining wall during the excavation. The depth of the excavation is 14 m and the ground-water table is at 7 m below the ground surface.

How affect?

(9 Marks)

(b) A 230 ha reclamation of land is built to site an industrial area. The scope of work includes dredging 10 million m^3 of sand from the adjoining seabed, and then transporting the sand by barges to reclaimed the land. The subsoil conditions in the area designated for dredging consist of dense sand layer of 5 m in thickness. Some areas of the seabed are lined with soft clay. The depth of water in such dredging areas is 10 m. Identity the type of dredger(s) that you consider the most suitable for the above operations. State the reason(s).

(10 Marks)

?

soft clay is not sticky soil?

6. You are the project manager of a building project. The project is a 6 blocks of 16 storey housing development with 2 basements and communal facilities. The construction is at the super-structure stage. Currently, there are about 200 site staff and workers working on the site. Work out a **fire emergency response procedure** in a flow chart format by considering the following points: response procedure of site staff and workers; roles of emergency response team, fire fighting team and first aid team; and hotlines of police and SCDF.

(8 Marks)

END OF PAPER

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1(a) Foundation: supports the building & carries the live & dead loads of superstructure (simple footing, driven pile, bored piles, raft)
Framing: consists of columns, beams, slabs & shear walls. Framing serves to frame up the building soundly.
Building envelope: consists of everything outside the frame (exterior walls, roo
Interior walls: may or may not form part of the structural frame of the building (eg. partition walls in high-rise commercial building are completely seperate from the frame)
Utilities: include electricity, water, gas, telephone, television cable
Environmental control systems: Heating, lighting, ventilation
Transportation systems: includes vertical (eg. stairs, elevators) & horizontal (travellators, shuttle trains in airport terminals)
Fire suppression: Fire sprinklers, smoke detectors, wet & dry risers

(b) Manufacturing
- All the work performed at one permanent location
- Short to medium service life of a typical product
- High degree of repetition & standardisation
- Workplace carefully adjusted to human needs

Construction
- Work dispersed among many temporary locations
- Long service life of a typical product
- Large no. of tasks requiring a high degree of manual skills
- Small extend of standardisation, each project has distinctive features
- Harsh work environment

• The dispersion of activities in constructions means robots need to be more mobile as compared to manufacturing where fixed production line allows stationary robots.
• Construction projects differ from one to another, hence requiring an additiona dimension of flexibility.
• Tasks in construction are more complex. Design that integrates complexity requires high talents & costs.
• Authority is divided among sponsors, designers, contractors & subcontra

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Hence, it is more difficult to push for a unified trend for AfR in construction.

2(a)(i) Construction can proceed within a shorter period as the construction is broken up into manufacturing activities & installation works, done concurrently / in advance.
Prefabrication of several same type components in a controlled environment increases the productivity (standardisation.)
The construction process involves mainly simple assembly of precast components.

(ii) Handling
Consideration of stresses (eg. shear, bursting, tensile) during handling
Standardisation
Components to be standardised in shape & size to reduce production cost
Method of manufacture
- Ensure simple dismantling & re-assembling within acceptable tolerance limits
- Ensure stiffness of mould to control dimensional accuracy.
Transportation
- Stacking on vehicle either horizontally / vertically
- Check height, width & load restrictions on public roads
Erection
- Consider stability of precast components during erection
(eg. temporary adjustable fixing until permanent connection is complete)

(b)(i)

Section	Effective Grade for Hauling (%)	Effective grade for returning (%)
A	0	6
B	2	4
C	0	6

Hauling: $\left(\frac{0.6}{40} + \frac{0.5}{35} + \frac{0.3}{40}\right) \times 60 = 2.207$ min
Returning: $\left(\frac{0.6}{30} + \frac{0.5}{35} + \frac{0.3}{30}\right) \times 60 = 2.657$ min
Fixed time = 3.0 min
Cycle time = $2.207 + 2.657 + 3.0 = 7.864 \approx 7.86$ min

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(ii) Total volume of loose soil = $1.25 \times 1300 = 1625\ m^3$

Min required rate = $1625/8.5 = 191.176\ m^3/hr \approx 191\ m^3/h$

(iii) Let Y be the min operating efficiency.

$Y\left(\frac{60}{7.864}\right) \times 30 = 191.176$

$Y = 83.5\%$

3(a)(i)
- To promote more buildable designs upstream and constructability downstream to the industry through objective assessment
- It is not the intention to promote buildable score at the expense of good architectural design
- It is not solely to promote prefabrication

(ii) 1) Standardisation

Repetition of grids, sizes of components and connection details (eg. repeated floor layout, column size)

2) Simplicity

Uncomplicated building construction systems & installation details (eg. flat plate/slab system will ease formwork construction)

3) Single integrated elements

Combine related components together into a single element that may be prefabricated in factory, (eg. prefabricated toilet)

(iii) 1) Structural systems

The buildable score for a particular structural system is the product of percentage area covered by the system & the corresponding labour saving indices of table 1.

(Max 50 points inclusive of 5 bonus points)

2) Wall systems (Max 45 points)

The buildable score for a particular wall system is computed by multiplying the percentage wall length covered by the wall system and the labour saving indices of table 2.

3) Other buildable features (max. 10 points)

The use of certain buildable design features are awarded with points directly

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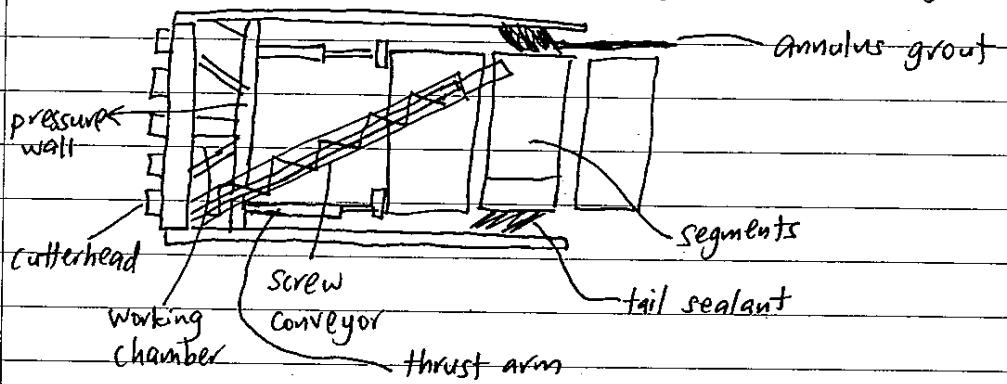
according to table 3. (standardisation of beams, columns, windows, door)

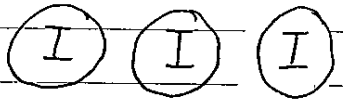
(iv) The designs during the upstream design process show the same extend of labour saving for the construction methods.
However, downstream construction methods may differ (eg. technology), leading to different productivity.

(b)(ii) Difference in BS = $40[0.45(0.7-0.5)] = 3.6$

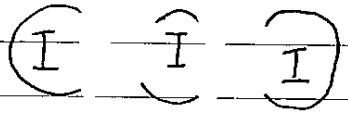
4(a)
- Convert the excavated soil & water into high density slurry
- Stabilise the tunnel face by pressurising the excavated soil & water as the support medium for the tunnel face to counterbalance the earth & water pressures
- Rotating cutter head cuts & thrusts into the tunnel face
- Transport the excavated material by a screw conveyor



(b)
① Excavate through the stiff ground to a depth of 22m
② Construct the alternate piles.



③ Cut & remove small arc of the alternate piles.



④ Add intermediate piles to provide interlocking.

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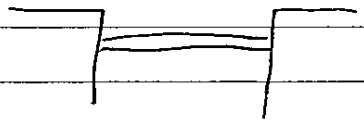
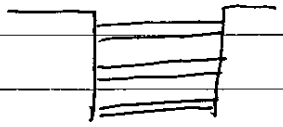
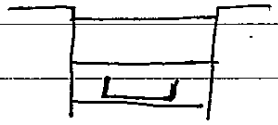
5(a) ① Drive the sheet piles 14m deep into ground, with some length exposed, out of ground.
② Excavate 1m and struct.

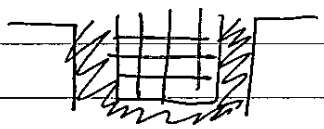


③ Excavate further & strut, repeat for one more layer.



④ Construct bottom-up.



⑤  Backfill.

(b) Transportation by barges gives the choice of only mechanical dredgers.
The large volume of sand implies backhoe dredger, grab pontoon dredger and front shovel dredger are not suitable due to low production rate.
This leaves us with only the bucket dredger that is able to dredge continuously with good control of dredging depth.
Also, there is no sticky soil that will cause discharge failure by the bucke

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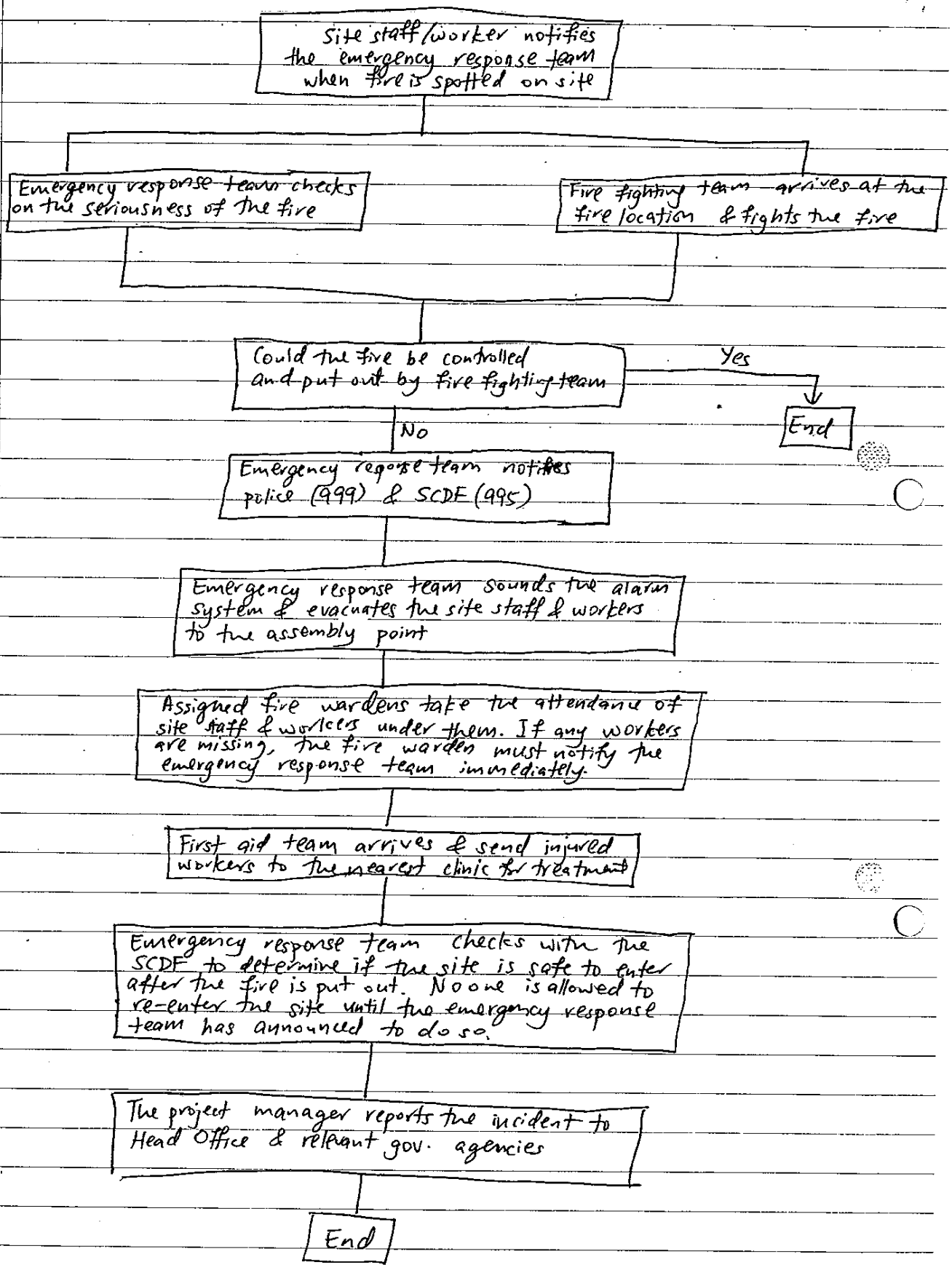
Site staff/worker notifies the emergency response team when fire is spotted on site
Emergency response team checks on the seriousness of the fire
Fire fighting team arrives at the fire location & fights the fire
Could the fire be controlled and put out by fire fighting team
Yes
End
No
Emergency response team notifies police (999) & SCDF (995)
Emergency response team sounds the alarm system & evacuates the site staff & workers to the assembly point
Assigned fire wardens take the attendance of site staff & workers under them. If any workers are missing, the fire warden must notify the emergency response team immediately.
First aid team arrives & send injured workers to the nearest clinic for treatment
Emergency response team checks with the SCDF to determine if the site is safe to enter after the fire is put out. No one is allowed to re-enter the site until the emergency response team has announced to do so.
The project manager reports the incident to Head Office & relevant gov. agencies
End