TANTAUNIVERSITY
FACULTY OF ENGINEERING
DEPARTMENT OF STRUCTURAL ENGINEERING
FINAL EXAM – SECOND SEMESTER 2022/2023
(STUDENTS OF STRUCTURAL AND CIVIL ENGINEERING)

| COURSE TITLE: SPECIAL TOPICS IN THE DESIGN OF REINFORCED CONCRETE | | CORSE CODE: CSE 4218 AND CSE 4247 |
|---|---|---|
| DATE: 15 JUNE, 2023 | FINAL TERM EXAM (TOTAL MARKS 70) | TIME ALLOWED: 3 HOURS (10:00-13:00) |

**For design problems: assume that; concrete characteristic strength $f_{cu}$=25 MPa and steel yield strength is $f_y$=400 MPa.**

## Question No. 1 (Total marks is 20 Marks)

**a)** Figure (1) shows a plan of an orthotropic RC slab, considering hinged edges, **it is required to carry out the followings:**

1. Calculate the ultimate uniform load acting on the shown slab.
2. Make a complete design for the shown slab using the yield line theory by the virtual work method.
3. Draw neat sketches for the reinforcement detailing.

Consider slab thickness = 160 mm, flooring cover = 2.0 kN/m$^2$, live load = 5.0 kN/m$^2$.

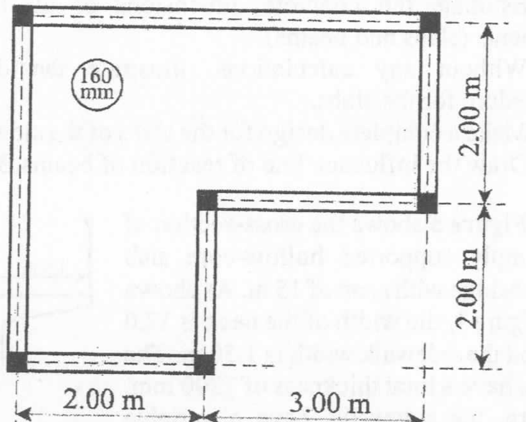

**Fig. 1**

## Question No. 2 (Total marks is 20 Marks)

a) ***State*** the expected failure modes at beam-column connections. ***Which*** of them are more dangerous and ***why***? ***explain*** the philosophy of **strong column weak girder**. ***How*** the Egyptian Code ensure this philosophy?

b) **Fig. 2** shows insufficient reinforcement of closed beam-to-column joint. It is required to ***carry out*** a complete design (design + drawing) the lack reinforcement at the joint zone. ***Why*** the main reinforcement must be curved at the corner marked A.

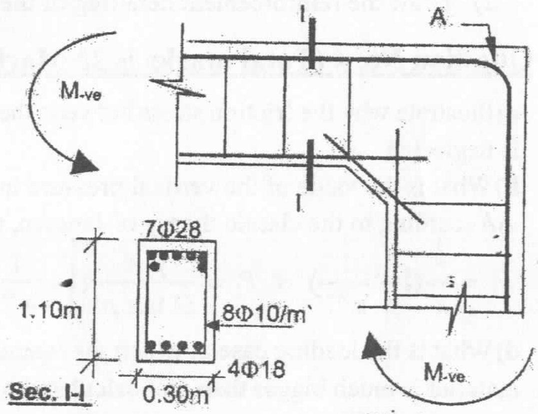

**Fig. 2**

c) ***Design*** a hinged base for the same column shown in **Fig. 2** (dowels + neoprene plate + reinforcement) subjected to normal force of 1200 kN and horizontal force of 120 kN. ***State*** the advantage of neoprene plate under loading.

d) For the joint in earthquake zone shown in **Fig. 3**, it is required to: ***calculate*** the shear capacity of the column shown in Fig. 2 if the longitudinal steel is 6 D 18, and floor height is 3.0 m. ***calculate*** the maximum shear acting in the joint if the beams tension steel is 4 D 16 and the compression steel is 2 D 12, Then ***calculate*** the joint shear capacity, and the steel needed in the joint according to ECP-203/2018 code. ***Draw*** the reinforcement details.

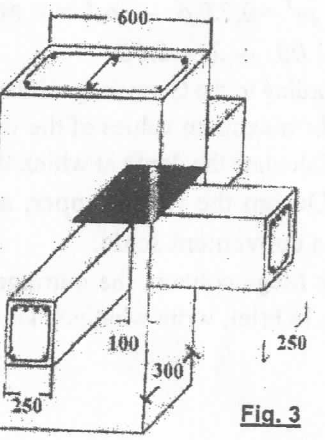

**Fig. 3**

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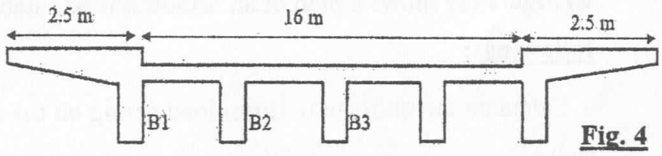
## Question No. 3 (Total marks is 20 Marks)

**a)** For the given RC girder type road-way bridge with a span of 25 m as shown in **Fig. 4.** The total width of the bridge is 21 m, and the sidewalk width is 2.5 m. The main girders are used at 4.0 m centerline-to- centerline spacing. While the cross girders are used at 5.0 m spacing. It is required to carry out the following;

1) Estimate the concrete dimensions of all bridge elements (slabs and beams).
2) Without any calculations, illustrate the design procedure for the slabs.
3) Make a complete design for the slabs of the sidewalk.
4) Draw the influence line of reaction of beams B1, B2 and B3.

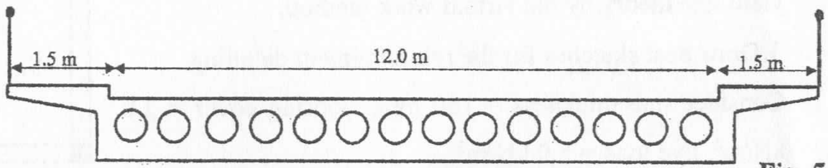


Cross section of the bridge

**Fig. 4**

**b) Figure 5** shows the cross-section of a simply supported hollow-core slab type bridge with span of 15 m. As shown in Figure 1, the width of the deck is 12.0 m and the sidewalk width is 1.50 m. The slabs have a total thickness of 1200 mm, where, the sidewalks have a variable thickness of 200/400 mm. It is required to carry out the following;

1) Calculate the maximum shearing force and bending moment of the slab.
2) Draw the reinforcement detailing of the slabs in a plan and longitudinal section.



Cross section of the bridge

**Fig. 5**

## Question No. 4 (Total marks is 20 Marks)

**a)** Illustrate why the friction stress between the filling material and the walls of a bunker is neglected.

**b)** What is the value of the vertical pressure in a bunker at a vertical depth = h.

**c)** According to the classic theory of Janssen, prove that:

$$P_1 = \frac{\gamma}{k}\left(1 - \frac{1}{e^{kx}}\right) \quad \& \quad P_2 = \frac{\gamma A}{O \tan \rho'}\left(1 - \frac{1}{e^{kx}}\right) \quad \text{Where;} \quad K = \frac{O}{A} \tan \rho' \tan^2\left(45 - \frac{\rho}{2}\right)$$

**d)** What is the loading case at which the lateral horizontal pressure caused by the filling material is much bigger than that calculated by the classic theory of Janssen?

**e)** As shown in **Fig.6**, a silo-cell with circular cross section having a 7.00 m diameter and 42 m height and rested on 8 columns will be utilized for storing wheat (قمح), consider that; $\rho_f' = 0.75\ \rho$ – $\rho_e' = 0.60\ \rho$ – $\rho = 30°$ – $\gamma = 0.80\ t/m^3$ – $\mu = \tan \rho'$ $\lambda_e = 1.00$ – $\lambda_f = 0.50$.

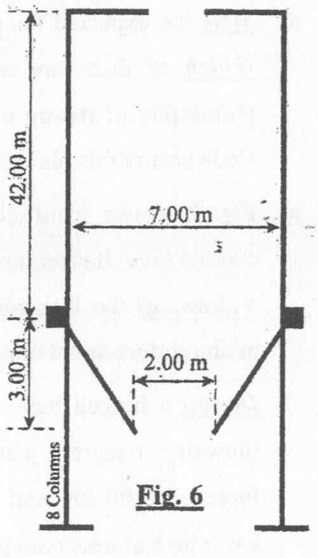


**Fig.6**

According to the German specification **DIN 1055**, it is required to carry out the following:

i) The maximum values of the vertical, horizontal and friction stresses.

ii) Calculate the depth at which the lateral pressure $P_2$ equals to 85% of the maximum lateral pressure ($P_2 = 0.85\ P_{2\,max}$).

iii) Design the wall, hopper, and belt beam then draw reinforcement details on sectional elevation and plan by a convenient scale.

**f)** The Mega column, the outrigger, and tube systems are commonly used in supper tall buildings to resist the lateral loads. In brief, write what you know about these systems.

**With our best wishes**
**Examiners committee**
**Prof. Dr. Emad Etman – Dr. Mahmoud abdelaziz – Dr. Ali hassan – Dr. Mohamed Ellithy**

**Question (4) (10Marks)**

Figure 4 shows a bar element subjected to a concentrated load with value (5 ton) at point (B). The Reactions at points (A) and (D) are shown in the Figure.

If EA= 10000 ton , it is required to:

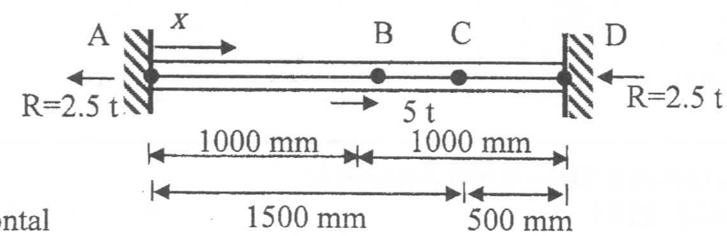



**Figure 4**

- find the exact value of the horizontal displacement and the strain at points (C) located at $x=1500$ mm.

  ( Hint: $\epsilon_x = \frac{\partial u}{\partial x}$ )
- find the horizontal displacement and strain at Point (C), then compute the amount of error for point (C) using the finite element method in each of the following cases :
  - a) The bar is modeled using a single 2-node uniform bar element.
  - b) The bar is modeled using two 2-node uniform bar element of equal length.
- draw clear sketches for the displacement and strain along the bar for case (a), (b) and the exact solution, and comment on the results

**Question (5) (8 Marks)**

For the simple beam element shown in Figure 5, the assumed displacement function is

$w(x) = \mathbf{a1} + \mathbf{a2}\, x + \mathbf{a3}\, x^2 + \mathbf{a4}\, x^3$.

It is required to:

1- Find the constants **a1, a2, a3, and a4** in terms of w1, θ1, w2, and θ2. Then, show that the shape functions of that element are

$$\mathbf{n_1(x)} = 1 - 3(x/L)^2 + 2(x/L)^3$$
$$\mathbf{n_2(x)} = x\,(1 - 2(x/L) + (x/L)^2)$$
$$\mathbf{n_3(x)} = 3(x/L)^2 - 2(x/L)^3$$
$$\mathbf{n_4(x)} = x\,(-(x/L) + (x/L)^2)$$

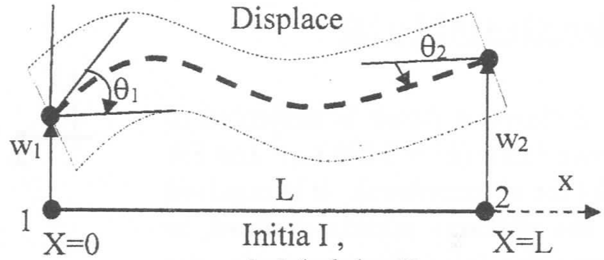



**Figure 5**

2- Draw clear sketches for the shape functions.

3- Write the displacement function in terms of shape function. At the middle point of beam element (x=L/2), if the depth of the beam is H and w1= w2 = θ1= 0.0 and $\theta 2 = 4L^2/EI$, find the deflection, the strain and the stress at the outer upper fiber of the beam y=H/2.

4- If a tapered beam element of length L is to be used to model a beam whose second moment of area varies along its length. The second moment of area I(x) varies linearly from I1 at node 1 to I2 at node 2. Show that the elements K11 of the element stiffness matrix is $6E(I1+I2)/L^3$ . (Hints: Put I(x) =I1+ ((x/L) (I2-I1)).

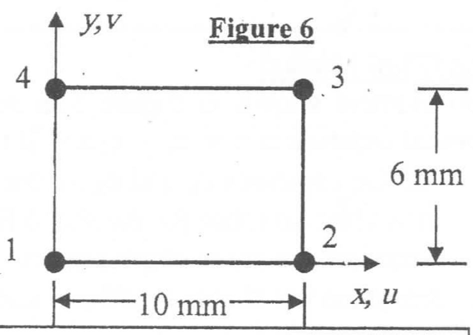
**Question (6) (7 Marks)**

A linear quadrilateral element used for plane stress formulation is shown in Figure 6. the assumed displacement functions is $u = c_1 + c_2x + c_3y + c_4xy$ and $v = c_5 + c_6x + c_7y + c_8xy$. The nodal displacements at the four nodes of the element are known and are given below. It is required to:

(a) find the displacements ($u$ and $v$) at the center.

(b) calculate the strain and stress components at center.

**Figure 6**




***Given:*** E=2100 t/cm$^2$ , ν = 0.30, t = 1 cm , *Nodal Displacements*

| | | | |
|---|---|---|---|
| $u_1 = 0.0 \times 10^{-3}$ mm | $v_1 = 0.0 \times 10^{-3}$ mm | $u_2 = 2.0 \times 10^{-3}$ mm | $v_2 = -2.0 \times 10^{-3}$ mm |
| $u_3 = 1.0 \times 10^{-3}$ mm | $v_3 = 0.0 \times 10^{-3}$ mm | $u_4 = 0.0 \times 10^{-3}$ mm | $v_4 = -1.0 \times 10^{-3}$ mm |

TANTA UNIVERSITY

01 June 2023

FACULTY OF ENGINNERIN

**Computerized Structural Analysis**
**Year 2022-2023**
**Allowed time: 3 hrs**

**Total Marks: 60 Marks**

**Course Code: CSE4245 Fourth**
**June 2023 (Second Term)**
**No. of Pages: (3) + Data sheet**

## Question (1) (8 Marks)

Figure 1 shows a plane truss subjected to concentrated loads. It is required to use **the stiffness matrix method**, to determine the joint displacements and the forces in members 1 and 2.

**EA= 1000t for all members**

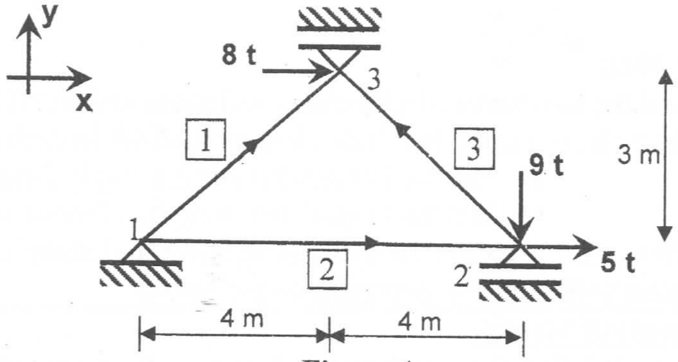



**Figure 1**

## Question (2) (10 Marks)

Figure 2 shows a frame is subjected to the shown loads (EI = 3000 t.m$^2$ and EA = 7500 t for all members). It is required to use **the stiffness matrix method**, to determine the joint displacements, the axial force in the link member c-d and draw the bending moment diagram.

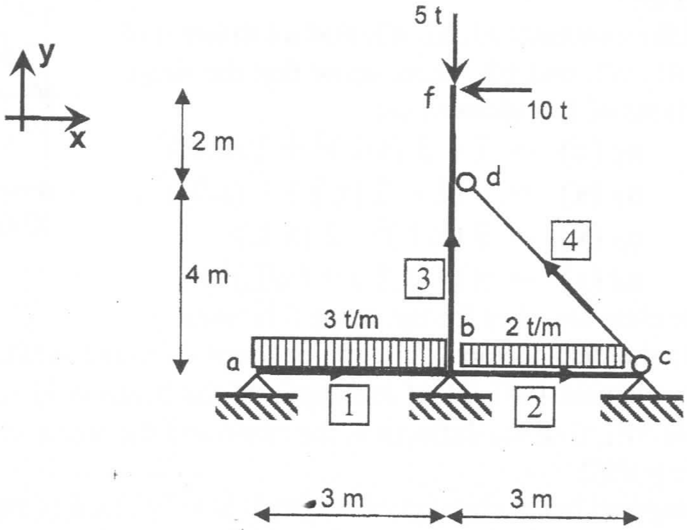



**Figure 2**

## Question (3) (6 Marks)

The truss element shown in Figure 3 is prismatic and has two nodes 1 and 2. The assumed axial displacement function is $u = c_1 + c_2x^2$. It is required to:

- find the constants $c_1$ and $c_2$ in terms of $u_1$ and $u_2$.
- draw clear sketches for the shape functions.
- determine the strain-displacement matrix [B].
- determine the element stiffness matrix $[k_{11}]$ in terms of E, A, and L.


**Figure 3**

**Question (7) (4Marks)**

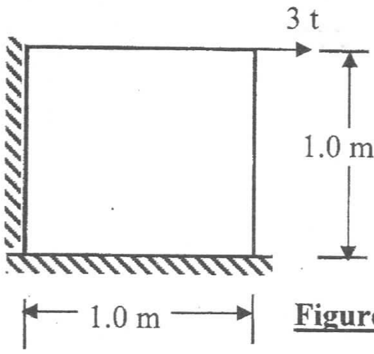



**Figure. 7.a**

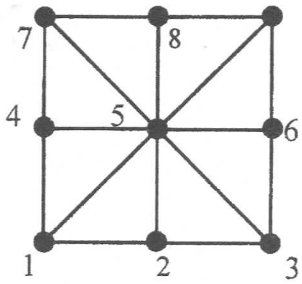



**Figure. 7.b**

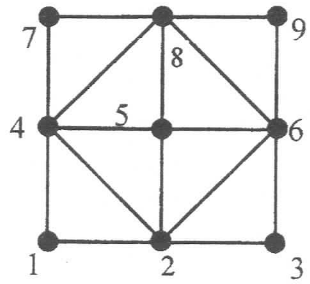



**Figure. 7.c**

Figure. 7.a shows a 1×1 m steel plate with a thickness of 1.0cm. The plate is fixed against a rigid floor and wall. The plate needs to be analyzed to calculate deformations and stresses using the 2D finite element mesh shown in Figure. 7.b or in Figure. 7.c. The mesh consists of 8 elements

It is required to:

a. mention the type of analysis required for obtaining the required results (plane stress or plane strain)? Explain your answer.

b. sketch the mesh shown in Figure. 7.b showing the appropriate boundary conditions at all nodes.

c. explain which mesh in Figure. 7.b or Figure. 7.c gives more accurate results.

If the 2D-wall shown in Figure. 7.a is modeled three times using the same number of square plane elements but with variable element dimensions L*9L, 3L*3L, and 2L*4.5L. What is the most accurate case? Why?

**Question (8) (7Marks )**

Consider the two-dimensional 2-element system shown in Figure 8. Element 1 is constant-strain triangle while element 2 is a spring. The structure is hinged at nodes A, and B. The stiffness matrix of element 1 is given below.

1. Assemble the global system stiffness matrix, $K$.
2. Solve for the displacement matrix.
3. Find the force in element 2.
4. Find the stress and strain in center of element 1

$$k^{(1)} = \begin{bmatrix} 75 & 0 & 0 & -75 & -75 & 75 \\ 0 & 200 & -50 & 0 & 50 & -200 \\ 0 & -50 & 200 & 0 & -200 & 50 \\ -75 & 0 & 0 & 75 & 75 & -75 \\ -75 & 50 & -200 & 75 & 275 & -125 \\ 75 & -200 & 50 & -75 & -125 & 275 \end{bmatrix} \text{t/m}$$

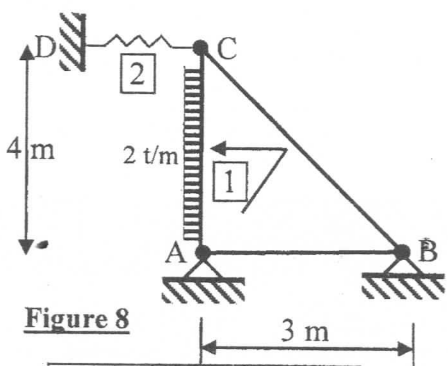



**Figure 8**

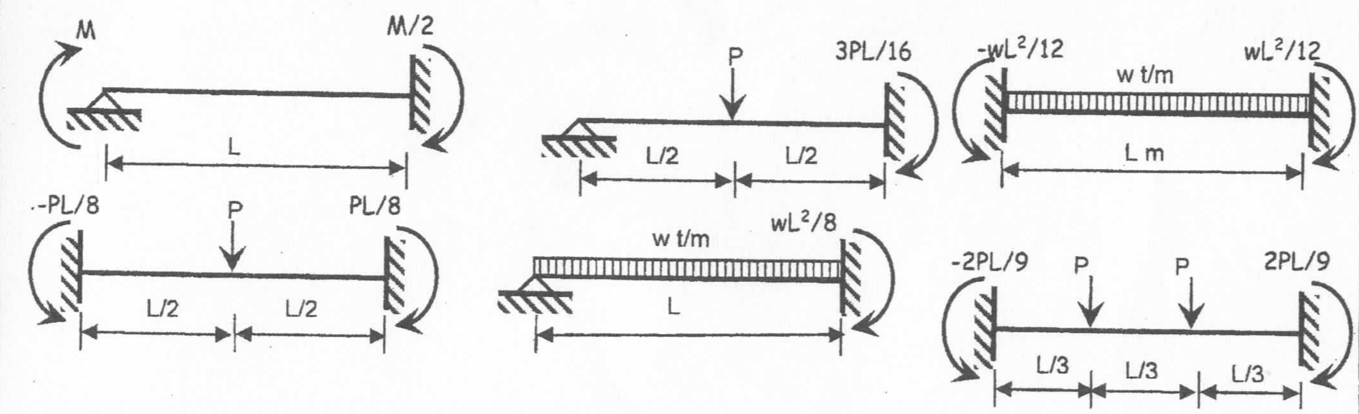
**Given:**

For spring
K = 80 t/m

For CST
E = 250 t/cm$^2$
t = 1.5 cm
ν = 0.25

Connectivity Table

| Element | i | j | k |
|---|---|---|---|
| 1 | A | B | C |




***The Global Stiffness Matrix of a Truss Element***

$$K = \frac{EA}{L}\begin{bmatrix} c^2 & cs & -c^2 & -cs \\ cs & s^2 & -cs & -s^2 \\ -c^2 & -cs & c^2 & cs \\ -cs & -s^2 & cs & s^2 \end{bmatrix}$$

$c = \cos\theta$ and $s = \sin\theta$

***The Local Stiffness Matrix of a hinged fixed beam Element***

$$K = \begin{bmatrix} \frac{3EI}{L^3} & -\frac{3EI}{L^3} & \frac{3EI}{L^2} \\ -\frac{3EI}{L^3} & \frac{3EI}{L^3} & -\frac{3EI}{L^2} \\ \frac{3EI}{L^2} & -\frac{3EI}{L^2} & \frac{3EI}{L} \end{bmatrix}$$

***The Local Stiffness Matrix of a Fixed hinged beam Element***

$$K = \begin{bmatrix} \frac{3EI}{L^3} & \frac{3EI}{L^2} & -\frac{3EI}{L^3} \\ \frac{3EI}{L^2} & \frac{3EI}{L} & -\frac{3EI}{L^2} \\ -\frac{3EI}{L^3} & -\frac{3EI}{L^2} & \frac{3EI}{L^3} \end{bmatrix}$$

***The Global Stiffness Matrix for a Fixed-Hinged Frame Element***

$$K = \begin{bmatrix} a_1 & a_2 & -a_3 & -a_1 & -a_2 \\ & a_4 & a_5 & -a_2 & -a_4 \\ & & a_6 & a_3 & -a_5 \\ & & & a_1 & a_2 \\ & & & & a_4 \end{bmatrix}$$

$a_1 = (EA/L)\,c^2 + (3EI/L^3)\,s^2$

$a_2 = (EA/L - 3EI/L^3)\,cs$

$a_3 = (3EI/L^2)\,s$

$a_4 = (EA/L)\,s^2 + (3EI/L^3)\,c^2$

$a_5 = (3EI/L^2)\,c$

$a_6 = 3EI/L$

where $c = \cos\theta$ and $s = \sin\theta$

***The Local Stiffness Matrix of 2-noded Bar Element***

$$K = \begin{bmatrix} \frac{EA}{L} & -\frac{EA}{L} \\ -\frac{EA}{L} & \frac{EA}{L} \end{bmatrix}$$

***The Shape Function of 2-noded Bar Element***

$$n_x = \begin{bmatrix} 1 - \frac{x}{l} & \frac{x}{l} \end{bmatrix}$$

***For a CST*** (case of plane Stress) $\{\varepsilon\}=[B]\{d\}$ $\{\sigma\}=[D]\{\varepsilon\}$ $[K]= t\,A\,[B]^T[D]\,[B]$

$$[D] = \frac{E}{1-\nu^2}\begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & (1-\nu)/2 \end{bmatrix} \qquad [B] = \frac{1}{2A}\begin{bmatrix} \beta_1 & 0 & \beta_2 & 0 & \beta_3 & 0 \\ 0 & \gamma_1 & 0 & \gamma_2 & 0 & \gamma_3 \\ \gamma_1 & \beta_1 & \gamma_2 & \beta_2 & \gamma_3 & \beta_3 \end{bmatrix}$$

where $\beta_1 = y_2 - y_3$, $\beta_2 = y_3 - y_1$, $\beta_3 = y_1 - y_2$ and $\gamma_1 = x_3 - x_2$, $\gamma_2 = x_1 - x_3$, $\gamma_3 = x_2 - x_1$

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FINAL EXAM – SECOND SEMESTER 2022/2023
(STUDENTS OF STRUCTURAL ENGINEERING)

| COURSE TITLE: DESIGN OF REINFORCED CONCRETE STRUCTURES (3)B | | CORSE CODE: CSE 4237 |
|---|---|---|
| DATE: 5 JUNE, 2023 | FINAL TERM EXAM (TOTAL MARKS 85) | TIME ALLOWED: 4 HOURS (10:00-14:00) |

# Design aids

جدول (٤-١٣) الحد الأدنى لسمك الغطاء الخرساني

| قسم تعرض سطح الشد | سمك الغطاء الخرساني * (مم) عام لجميع العناصر عدا الحوائط والبلاطات المصمتة $f_{cu}$ ** ≤ 25 | عام لجميع العناصر عدا الحوائط والبلاطات المصمتة $f_{cu}$ ** > 25 | للحوائط والبلاطات المصمتة $f_{cu}$ ** ≤ 25 | للحوائط والبلاطات المصمتة $f_{cu}$ ** > 25 |
|---|---|---|---|---|
| الأول | 25 | 20 | 20 | 20 |
| الثاني | 30 | 25 | 25 | 20 |
| الثالث | 35 | 30 | 30 | 25 |
| الرابع | 45 | 40 | 40 | 35 |

- * يجب الا يقل سمك الغطاء الخرساني بأي حال عن قطر أكبر سيخ مستعمل في التسليح.
- ** بوحدات ن/مم٢

جدول (٤-١٦) قيم المعامل $\eta_1 \eta$

| السمك الافتراضي للقطاع $t_1$ (مم) | المعامل $\eta_1 \eta$ |
|---|---|
| $t_1 \le 100$ | 1.00 |
| $t_1 \le 200$ | 1.20 |
| $t_1 \le 400$ | 1.30 |
| $t_1 \ge 600$ | 1.40 |

جدول (٤-١٥) إجهادات تشغيل الصلب ومعاملات خفض إجهادات خضوع الصلب $\beta_{cr}$ التي تستوفى شروط حالة حد التشرخ للصلب عالي المقاومة ذي النتوءات

| إجهاد تشغيل الصلب ن/مم² | $\beta_{cr}$ صلب 350 | $\beta_{cr}$ صلب 420 | أسطح شد القسم الأول: قطر السيخ مم | أسطح شد القسم الثاني: قطر السيخ مم | أسطح شد القسمين الثالث والرابع: قطر السيخ مم |
|---|---|---|---|---|---|
| 220 | 1.00 | 0.92 | 18 | 16 | 10 |
| 200 | 0.93 | 0.83 | 22 | 18 | 12 |
| 180 | 0.85 | 0.75 | 25 | 22 | 18 |
| 160 | 0.75 | 0.67 | 32 | 25 | 22 |
| 140 | 0.65 | 0.58 | --- | 32 | 25 |
| 120 | 0.56 | 0.50 | ---- | ---- | 32 |

- $t_{\text{cylindrical walls}} = C_3 \cdot \gamma_w \cdot H \cdot R$

where H is the tank height
R is the tank radius.

| H/R2 | 1.4 | 1.2 | 1.0 | 0.8 | 0.6 | 0.4 | 0.2 | 0.1 | 0.08 | 0.06 | 0.04 | 0.02 | 0.01 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| n | 16.4 | 15.2 | 13.9 | 12.5 | 10.9 | 9.00 | 6..50 | 4.77 | 4.32 | 3.82 | 3.26 | 2.46 | 1.93 |
| C1 | 7.40 | 7.44 | 7.49 | 7.55 | 7.65 | 7.82 | 8.22 | 8.80 | 9.04 | 9.4 | 10.1 | 11.7 | 14.4 |
| C2 | .118 | .127 | .138 | .154 | .175 | .211 | .284 | .375 | .409 | .455 | .525 | .646 | .769 |
| C3 | .800 | .895 | .890 | .882 | .870 | .852 | .812 | .756 | .736 | .708 | .663 | .570 | .462 |

*Solid Circular Plates Subjecteed To Uniform Load :-*

$M = \text{coeff.} \times pR^2$

Positive sign indicates compression surface loaded

| at point | 0.00R | 0.10R | 0.20R | 0.30R | 0.40R | 0.50R | 0.60R | 0.70R | 0.80R | 0.90R | 1.00R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mr | +.075 | +.073 | +.067 | +.057 | +.043 | +.003 | +.003 | -.023 | -.053 | -.087 | -.125 |
| Mt | +.075 | +.074 | +.071 | +.066 | +.059 | +.050 | +.039 | +.026 | +.011 | -.006 | -.025 |

*Table XIX* : Stiffness of Circular Plate with Center Support
$k = \text{coeff.} \times Et^3/R$

| c/D | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 |
|---|---|---|---|---|---|
| Coeff. | 0.290 | 0.309 | 0.332 | 0.358 | 0.387 |
| Without Center Support : $k = 0.104\, Et^3/R$ | | | | | |

*Table XX* Stiffness of Cylindrical Wall, near edge hinged, far edge free :
$k = \text{coeff.} \times Et^3/H$

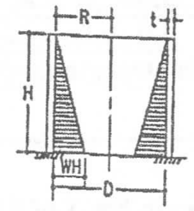
| $H^2/Dt$ | 5 | 6 | 8 | 10 | 12 | 14 | 16 | 20 |
|---|---|---|---|---|---|---|---|---|
| coeff. | .713 | .783 | .903 | 1.01 | 1.11 | 1.2 | 1.28 | 1.43 |



TANTAUNIVERSITY
FACULTY OF ENGINEERING
DEPARTMENT OF STRUCTURAL ENGINEERING
FINAL EXAM – SECOND SEMESTER 2022/2023
(STUDENTS OF STRUCTURAL ENGINEERING)

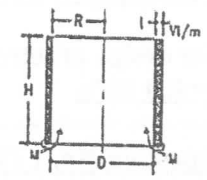
| COURSE TITLE: DESIGN OF REINFORCED CONCRETE STRUCTURES (3)B | | CORSE CODE: CSE 4237 |
|---|---|---|
| DATE: 5 JUNE, 2023 | FINAL TERM EXAM (TOTAL MARKS 85) | TIME ALLOWED: 4 HOURS (10:00-14:00) |

*Table VII* : Moments in cylindrical wall
Triangular Load
Fixed base, free top
Mom. = coeff. * $wH^3$
Positive sign indicates tension in the outside.



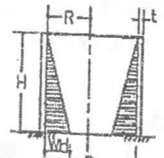
| $H^2/Dt$ | 0.1H | 0.21H | 0.3H | 0.4H | 0.5H | 0.6H | 0.7H | 0.8H | 0.9H | 1.0H |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.4 | +.0005 | +.0014 | +.0021 | +.0007 | -.0042 | -.0150 | -.0302 | -.0529 | -.0816 | -.1205 |
| 0.8 | +.0011 | +.0037 | +.0063 | +.0080 | +.0070 | +.0023 | -.0068 | -.0224 | -.0465 | -.0795 |
| 1.2 | +.0012 | +.0042 | +.0077 | +.0103 | +.0112 | +.0090 | +.0022 | -.0108 | -.0311 | -.0602 |
| 1.6 | +.0011 | +.0041 | +.0075 | +.0107 | +.0121 | +.0111 | +.0058 | -.0051 | -.0232 | -.0505 |
| 2.0 | +.0010 | +.0035 | +.0068 | +.0099 | +.0120 | +.0115 | +.0075 | -.0021 | -.0185 | -.0436 |
| 3.0 | +.0006 | +.0024 | +.0047 | +.0071 | +.0090 | +.0097 | +.0077 | +.0012 | -.0119 | -.0333 |
| 4.0 | +.0003 | +.0015 | +.0028 | +.0047 | +.0066 | +.0077 | +.0069 | +.0023 | -.0080 | -.0268 |
| 5.0 | +.0002 | +.0008 | +.0016 | +.0029 | +.0046 | +.0059 | +.0059 | +.0028 | -.0058 | -.0222 |
| 6.0 | +.0001 | +.0003 | +.0008 | +.0019 | +.0032 | +.0046 | +.0051 | +.0029 | -.0041 | -.0187 |
| 8.0 | .0000 | +.0001 | +.0002 | +.0008 | +.0016 | +.0028 | +.0038 | +.0029 | -.0022 | -.0146 |
| 10. | .0000 | .0000 | +.0001 | +.0004 | +.0007 | +.0019 | +.0029 | +.0028 | -.0012 | -.0122 |
| 12. | .0000 | .0001 | +.0001 | +.0002 | +.0003 | +.0013 | +.0023 | +.0026 | -.0005 | -.0104 |
| 14. | .0000 | .0000 | .0000 | .0000 | +.0001 | +.0008 | +.0019 | +.0023 | -.0001 | -.0090 |
| 16. | .0000 | .0000 | -.0001 | -.0002 | -.0001 | +.0004 | +.0013 | +.0019 | +.0001 | -.0079 |

*Table XI* : Moments in cylindrical wall
Moment Per m, M, applied at base
Hinged base, free top
Mom. = coeff. * M
Positive sign indicates tension
in outside



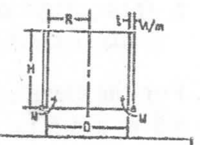
| $H^2/Dt$ | 0.1H | 0.21H | 0.3H | 0.4H | 0.5H | 0.6H | 0.7H | 0.8H | 0.9H | 1.0H |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.4 | +.013 | +.051 | +.109 | +.196 | +.296 | +.414 | +.547 | +.692 | +.843 | 1 |
| 0.8 | +.009 | +.040 | +.090 | +.164 | +.253 | +.375 | +.503 | +.659 | +.824 | 1 |
| 1.2 | +.006 | +.027 | +.063 | +.125 | +.206 | +.316 | +.454 | +.616 | +.802 | 1 |
| 1.6 | +.003 | +.011 | +.035 | +.078 | +.152 | +.253 | +.393 | +.570 | +.775 | 1 |
| 2.0 | -.002 | -.002 | +.012 | +.034 | +.096 | +.193 | +.340 | +.519 | +.748 | 1 |
| 3.0 | -.007 | -.022 | -.030 | -.029 | +.010 | +.087 | +.227 | +.426 | +.692 | 1 |
| 4.0 | -.008 | -.026 | -.044 | -.051 | -.034 | +.023 | +.150 | +.354 | +.645 | 1 |
| 5.0 | -.007 | -.024 | -.045 | -.061 | -.057 | -.015 | +.095 | +.296 | +.606 | 1 |
| 6.0 | -.005 | -.018 | -.040 | -.058 | -.065 | -.037 | +.057 | +.252 | +.572 | 1 |
| 8.0 | -.001 | -.009 | -.022 | -.044 | -.068 | -.062 | +.002 | +.178 | +.515 | 1 |
| 10. | 0 | -.002 | -.009 | -.028 | -.053 | -0.067 | -.031 | +.123 | +.467 | 1 |
| 12. | 0 | -.000 | -.003 | -.016 | -.040 | -.064 | -.049 | +.081 | +.424 | 1 |
| 14. | 0 | 0 | 0 | -.008 | -.029 | -.059 | -.060 | +.048 | +.387 | 1 |

*Table I* : Tension in circular rings
Triangular Load
Fixed base, free top
T = coeff. * wHR
Positive sign indicates tension



| $H^2/Dt$ | 0.0H | 0.1H | 0.2H | 0.3H | 0.4H | 0.5H | 0.6H | 0.7H | 0.8H | 0.9H |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.4 | +0.149 | +0.134 | +0.120 | +0.101 | +0.082 | +0.066 | +0.049 | +0.029 | +0.014 | +0.004 |
| 0.8 | +0.263 | +0.239 | +0.215 | +0.190 | +0.160 | +0.130 | +0.096 | +0.063 | +0.034 | +0.010 |
| 1.2 | +0.283 | +0.271 | +0.254 | +0.234 | +0.209 | +0.180 | +0.142 | +0.099 | +0.054 | +0.016 |
| 1.6 | +0.265 | +0.268 | +0.268 | +0.266 | +0.250 | +0.226 | +0.185 | +0.134 | +0.075 | +0.023 |
| 2.0 | +0.234 | +0.251 | +0.273 | +0.285 | +0.285 | +0.274 | +0.232 | +0.172 | +0.104 | +0.031 |
| 3.0 | +0.134 | +0.203 | +0.267 | +0.322 | +0.357 | +0.362 | +0.330 | +0.262 | +0.157 | +0.052 |
| 4.0 | +0.067 | +0.164 | +0.256 | +0.339 | +0.403 | +0.429 | +0.409 | +0.334 | +0.210 | +0.073 |
| 5.0 | +0.025 | +0.137 | +0.245 | +0.346 | +0.428 | +0.477 | +0.469 | +0.398 | +0.259 | +0.092 |
| 6.0 | +0.018 | +0.119 | +0.234 | +0.344 | +0.441 | +0.504 | +0.514 | +0.447 | +0.301 | +0.112 |
| 8.0 | -0.011 | +0.104 | +0.218 | +0.335 | +0.443 | +0.534 | +0.575 | +0.530 | +0.381 | +0.151 |
| 10. | -0.011 | +0.098 | +0.208 | +0.323 | +0.437 | +0.542 | +0.608 | +0.589 | +0.440 | +0.179 |
| 12. | -0.005 | +0.097 | +0.202 | +0.312 | +0.429 | +0.543 | +0.628 | +0.633 | +0.494 | +0.211 |
| 14. | -0.002 | +0.098 | +0.200 | +0.306 | +0.420 | +0.539 | +0.639 | +0.666 | +0.541 | +0.241 |
| 16. | 0.000 | +0.099 | +0.199 | +0.304 | +0.412 | +0.531 | +0.641 | +0.687 | +0.582 | +0.265 |

*Table VI* Tension in circular rings
Moment Per m,M, applied at base
Hinged base, free top
T = coff. * $MR/H^2$
Positive sign indicates tension



| $H^2/Dt$ | 0.0H | 0.1H | 0.2H | 0.3H | 0.4H | 0.5H | 0.6H | 0.7H | 0.8H | 0.9H |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.4 | +2.70 | +2.50 | +2.30 | +2.12 | +1.91 | +1.69 | +1.41 | +1.13 | +0.80 | +0.44 |
| 0.8 | +2.02 | +2.06 | +2.10 | +2.14 | +2.10 | +2.02 | +1.95 | +1.75 | +1.39 | +0.80 |
| 1.2 | +1.06 | +1.42 | +1.79 | +2.03 | +2.46 | +2.65 | +2.80 | +2.60 | +2.22 | +1.37 |
| 1.6 | +0.12 | +0.79 | +1.43 | +2.04 | +2.72 | +3.25 | +3.56 | +3.59 | +3.13 | +2.01 |
| 2.0 | -0.68 | +0.22 | +1.10 | +2.02 | +2.90 | +3.69 | +4.30 | +4.54 | +4.08 | +2.75 |
| 3.0 | -1.78 | -0.71 | +0.43 | +1.60 | +2.95 | +4.29 | +5.66 | +6.58 | +6.55 | +4.73 |
| 4.0 | -1.87 | -1.00 | -0.08 | +1.04 | +2.47 | +4.31 | +6.34 | +8.19 | +8.82 | +6.81 |
| 5.0 | -1.54 | -1.03 | -0.42 | +0.45 | +1.86 | +3.93 | +6.60 | +9.41 | +11.0 | +9.02 |
| 6.0 | -1.04 | -0.86 | -0.59 | -0.05 | +1.21 | +3.34 | +6.54 | +10.2 | +13.0 | +11.4 |
| 8.0 | -0.24 | -0.53 | -0.73 | -0.67 | -0.02 | +2.05 | +5.87 | +11.3 | +16.5 | +6.06 |
| 10. | +0.21 | -0.23 | -0.64 | -0.94 | -0.73 | +0.82 | +4.79 | +11.6 | +19.4 | +20.8 |
| 12. | +0.32 | -0.05 | -0.46 | -0.96 | -1.15 | -0.18 | +3.52 | +11.2 | +21.8 | +25.7 |
| 14. | +0.26 | +0.04 | -0.28 | -0.76 | -1.29 | -0.87 | +2.29 | +10.5 | +23.5 | +30.3 |
| 16. | +0.22 | +0.07 | -0.08 | -0.64 | -1.28 | -1.30 | +1.12 | +9.67 | +24.5 | +34.6 |

*Table XII* : Shear at base of cylindrical wall

V = coef. * ( $wH^2$ (triangular) ; pH (rectangular) ; M/H (mom. at base) )

Positive sign indicates shear acting inward

| $H^2/Dt$ | Triangular Load, fixed base | Rectangular Load, fixed base | Triangular or Rectangular Load, hinged base | Moment at edge |
|---|---|---|---|---|
| 0.4 | +0.436 | +0.755 | +0.245 | -1.58 |
| 0.8 | +0.374 | +0.552 | +0.234 | -1.75 |
| 1.2 | +0.339 | +0.460 | +0.220 | -2.00 |
| 1.6 | +0.317 | +0.407 | +0.204 | -2.28 |
| 2.0 | +0.299 | +0.370 | +0.189 | -2.57 |
| 3.0 | +0.262 | +0.310 | +0.158 | -3.18 |
| 4.0 | +0.236 | +0.271 | +0.137 | -3.68 |
| 5.0 | +0.213 | +0.243 | +0.121 | -4.10 |
| 6.0 | +0.197 | +0.222 | +0.110 | -4.49 |
| 8.0 | +0.174 | +0.193 | +0.096 | -5.18 |
| 10 | +0.158 | +0.172 | +0.087 | -5.81 |
| 12 | +0.145 | +0.158 | +0.079 | -6.38 |
| 14 | +0.135 | +0.147 | +0.073 | -6.88 |
| 16 | +0.127 | +0.137 | +0.068 | -7.36 |

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| COURSE TITLE: DESIGN OF REINFORCED CONCRETE STRUCTURES (3)B | | CORSE CODE: CSE 4237 |
|---|---|---|
| DATE: 5 JUNE, 2023 | FINAL TERM EXAM (TOTAL MARKS 85) | TIME ALLOWED: 4 HOURS (10:00-14:00) |

الامتحان ورقة واحدة بمقاس ايه ثري، 4 صفحات كاملة، على الطلاب القيام بالحل والرسم في كراسة الإجابة المسطرة فقط ولن ينظر لاى أوراق أخرى. مسموح باستخدام مساعدات التصميم المسنمة في اللجان فقط.

**For design problems: assume that; concrete characteristic strength $f_{cu}$=30 MPa and steel yield strength is $f_y$=400 MPa.**

## Question No. 1 (Total marks is 30 Marks)

**A. For the shown four U-shaped open conduit water tanks in Fig. 1 of 8.5 m width and 2.8 m height, it is required to:** *(15 marks)*

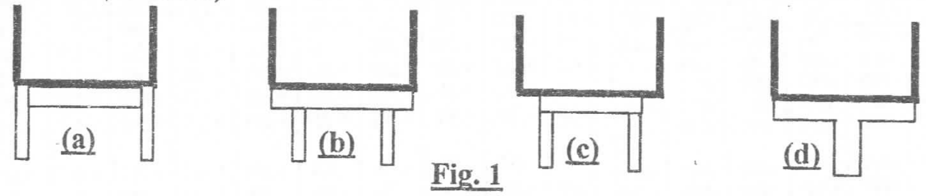


Fig. 1

1- ***Draw*** sectional elevation and plan indicating concrete dimensions of the fourth tank and all supporting elements. *(4Marks)*
2- ***Discuss*** the difference between the four cases from the point of view of straining actions. *(2Marks)*
3- ***Select*** the best choice from the structural and economic point of view, and ***comment***. *(1Marks)*
4- ***Carry out*** a complete design for the tank elements for case (d) and ***give*** full reinforcement details sectional elevation and plan (add any supporting element you needed). *(6Marks)*
5- ***If*** the height of the previously designed tank is increased to 4m, *is there a required change in the statical system, and* ***comment***. *(2Marks)*

**B. For the elevated rectangular tank shown in Fig. 2, with floor 6.5 m x 5.5 m and 4.5 m water depth, it is required to:** *(15 marks)*

1. ***Sketch*** the suitable statical system showing all necessary elements of the tank. *(1Marks)*
2. ***Carry out*** a complete design for the tank elements. *(7Marks)*
3. ***Give*** full reinforcement details on sectional elevation and plan. *(3Marks)*
4. If the height of the pervious designed tank is increased to 6m, with the same columns, ***suggest*** the suitable statical system for this case. *(2Marks)*
5. ***Calculate*** the load on the floor beam with span 6.5 m. *(2Marks)*

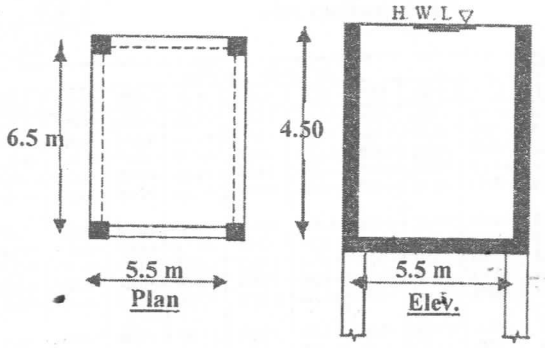
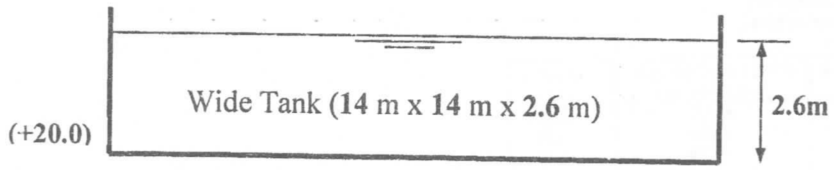


Fig. 2

## Question No. 2 (Total marks is 30 Marks)

**A. For the shown cross section of an elevated wide tank in Fig.3, it is required to carry out the following:** *(12 marks)*

Fig. 3




1. ***Suggest*** the suitable statical system (inner columns are permitted and don't use projected beams). *(1Marks)*
2. ***Estimate***, the concrete dimensions of all RC elements. *(2Marks)*
3. ***Calculate and draw*** the straining actions on both floor and wall and then ***design*** the critical sections of the tank. *(6Marks)*
4. ***Draw*** to a reasonably scale sectional elevation and plans showing all concrete dimensions and ***give*** full details of reinforcement for the tank. *(3Marks)*



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|---|---|---|
| DATE: 5 JUNE, 2023 | FINAL TERM EXAM (TOTAL MARKS 85) | TIME ALLOWED: 4 HOURS (10:00-14:00) |


**B. For the shown swimming pool (Fig. 4) which is constructed on medium clay with net bearing pressure equal to 150 kN/m², the pool width is 12 m. A pump room and storage area are required under the right side of the pool. two columns are used to support the floor on the right side. It is required to:** *(18 marks)*

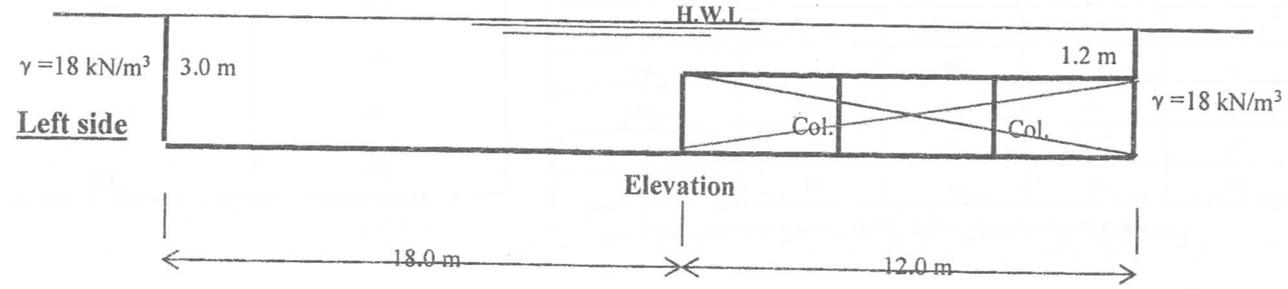


Fig. 4

1. ***Suggest*** the statical system and ***sketch*** the possible cases of loading for the given pool and the resulted straining actions. *(3Marks)*
2. ***Carry out*** a complete design for the critical sections of the left side. *(6Marks)*
3. ***Draw*** to a reasonable scale detail of reinforcement for the given sectional elevation and the plan of the right side. *(3Marks)*
4. ***Check uplift*** for the given structure considering that the high ground water level is -1.2 m and RC foundation level is -3.5 m. *(3Marks)*
5. ***Explain*** briefly the precautions that can be considered in the design of the pool concerning its safety due to the effect of raising the ground water level GWT after construction. *(3Marks)*

## Question No. 3 (Total marks is 25 Marks)

**A. For the elevated cylindrical tank shown with D=10 m and height 8.0 m, it is required to:** *(15 marks)*

1. ***Estimate***, the concrete dimensions of all RC elements. *(2Marks)*
2. ***Draw*** the straining action diagrams for the wall and the floor. *(7Marks)*
3. ***Carry out*** a complete design for all critical sections. *(3Marks)*
4. ***Draw*** to a reasonable scale detail of reinforcement. *(3Marks)*

**B. For the shown cross section of an elevated surface of revolution tank in Fig. 6, it is required to carry out the following:** *(10 marks)*

1. Without any calculation ***sketch*** the load transfer, the straining actions on all elements, and all needed and supporting elements including foundation. *(4Marks)*
2. ***Make*** the necessary adjustments to the shape of the tank to match the design materials and R.C elements. ***Explain*** your point of view. *(3Marks)*
3. ***Give*** full details of reinforcement for a section elevation of the tank. *(3Marks)*

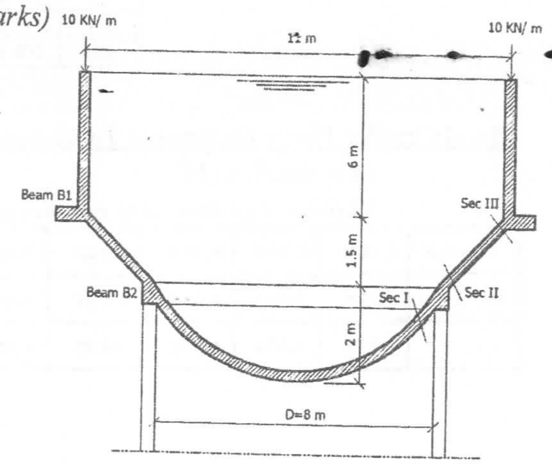


Fig. 5

**End of questions ….. (Wishing you best of luck)**

Prof. Dr. Mohamed Hussein Mahmoud    Prof. Dr. Dr Nesreen Mohamed Kassem
Assis. Prof. Dr. Mahmoud Ahmed Abdelaziz

Tanta University

Department: Structural Engineering

Faculty of Engineering

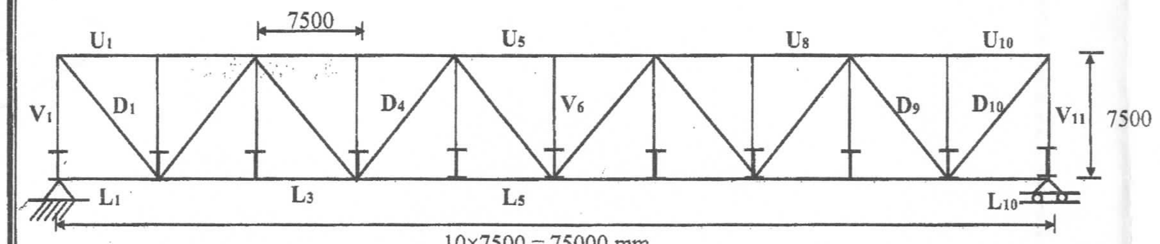
| Course Title | Design of Steel Bridges (b) | Academic Year 2022/2023 | Course Code | CSE4238 |
|---|---|---|---|---|
| Year/ Level | Fourth | Second- Semester Exam | | |
| Date | 8-6-2023 | No. of Pages (3) | Allowed time | 4 hrs |

**Remarks: The exam consists of eight questions in three pages;**
**Any missing data may be reasonably assumed.**

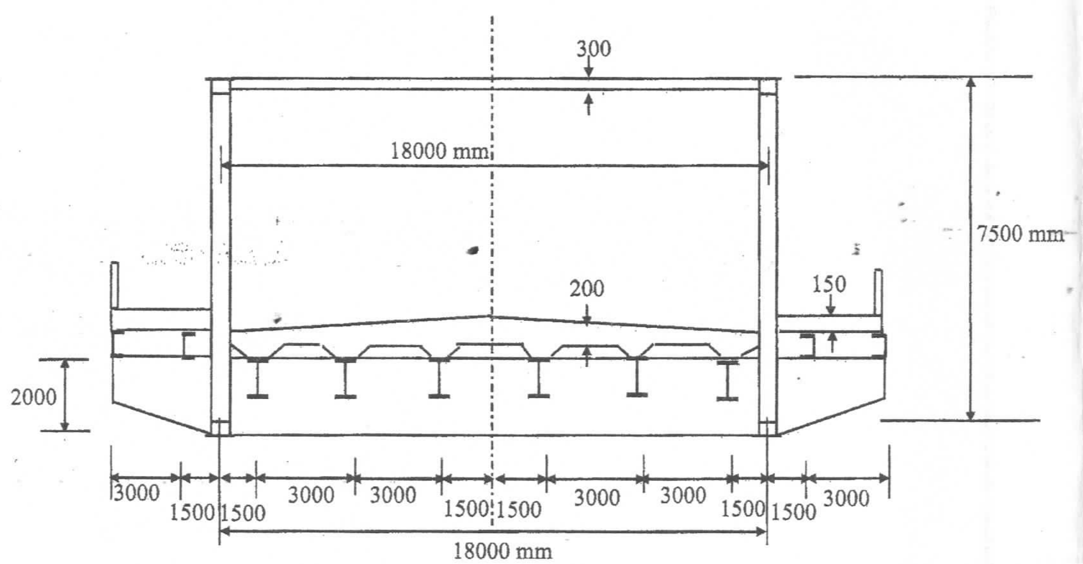
The main girders of a roadway through bridge are W-trusses having a span of 75 ms divided into 10 equal panels 7.5 ms each as shown below. The depth of main girder equals 7.5 ms. The spacing between the main trusses is 18 ms. The roadway consists of six traffic lanes 3 ms each and 2 side walks of 4.5 ms width each. The spacing between the stringers is 3 ms. The cross girder web height is equal to 2 ms. The spacing between gusset plates in the truss equals 0.5 ms. Steel used is St 44. The live load is shown in the figure below.

## DATA:

- Thickness of floor slab equals 200 mm besides 150 mm haunches.
- Weight of floor covering material = 175 kgs / m². Material of construction is st. 44.




**Elevation**

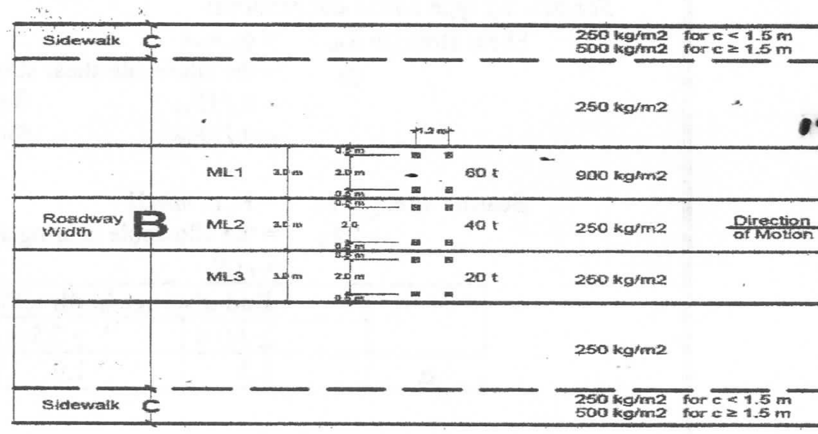



**Cross-section**



## REQUIRED:

1. **Draw** with a reasonable scale, in the answer booklet, elevation, cross-section and plans showing the arrangements of bracing systems of the bridge. **(20%)**
2. **Calculate** the maximum force in members U8 (Assume D.L. per main girder = 9.0 t/m). **(10%)**
3. **Calculate** the maximum force in members L5 (Assume D.L. per main girder = 9.0 t/m). **(10%)**
4. **Calculate** the maximum force in members D9 (Assume D.L. per main girder = 9.0 t/m). **(10%)**
5. **Calculate** the maximum force in members V11 (Assume D.L. per main girder = 9.0 t/m). **(10%)**
6. Design **a welded section** for the truss member U5 if the maximum force U5 = - 800 ton. Consider that the distance between gusset plates = 55 cm **(15%)**
7. Calculate the fatigue stress then **suggest a welded section's dimensions** for the truss member L3, if the maximum force $F3_{max}$ = 970 ton, $F3_{min}$ = 530 ton. Consider that the distance between gusset plate = 55 cm and $f_{sr}$ = 1.26 t/cm². **(10%)**
8. **Check the safety** of the diagonal member D4 if constructed using HEB 550 (A = 254 cm², $r_x$ = 23.2 cm and $r_y$ = 7.17 cm), knowing that the maximum force of D4 = - 170 ton. then **calculate the number of M24 bolts Grade 10.9** ($A_s$ = 3.53cm²) required for connecting the member to the gusset plates through a bearing type connection. **(15%)**




**Live Load For Roadway Bridges**

## Guide Equations:

The unsupported critical length $L_{u\,max} = \dfrac{1380 \cdot A_f \cdot C_b}{d \cdot F_y}$ or $\dfrac{20 \cdot b_f}{\sqrt{F_y}}$

$$f_{ltb1} = \frac{800 \cdot A_f \cdot C_b}{d \cdot L_u} \leq 0.58 F_y$$

$$f_{ltb2} = 0.58\, F_y \qquad \text{for} \qquad L_u / r_t < 84\sqrt{C_b / F_y}$$

$$f_{ltb2} = \left(0.64 - \frac{(L_u / r_t)^2 F_y}{1.176 \times 10^5 C_b}\right) F_y \leq 0.58 F_y \qquad \text{for} \qquad 84\sqrt{C_b / F_y} \leq L_u / r_t \leq 188\sqrt{C_b / F_y}$$

$$f_{ltb2} = \left(\frac{12000 \cdot C_b}{(L_u / r_t)^2}\right) \leq 0.58 F_y \qquad \text{for} \qquad L_u / r_t > 188\sqrt{C_b / F_y}$$

For non-compact truss element:

$$t_{fl} \geq \frac{b\sqrt{F_y}}{64} \qquad t_{fl} \geq \frac{c\sqrt{F_y}}{21} \qquad t_w \geq \frac{d\sqrt{F_y}}{64}$$

Buckling length for compression members:

| | Buckling in plane | Buckling perpendicular to plane | |
|---|---|---|---|
| | | Upper bracing | Pony Bridge |
| Upper chord | 0.85 L | 0.85 L | $2.5\sqrt[4]{EI_y a\delta}$ |
| Web member | 0.70 L | 0.85 L | 1.20 L |

**The allowable stress in axial compression ( $F_c$ )**

$F_c = \lfloor 1.6 - 0.000085\lambda_{max}^{\,2} \rfloor$ $\qquad \lambda_{max} < 100$ $\qquad$ *For steel St 44.*

$F_c = \dfrac{7500}{\lambda_{max}^{\,2}}$ $\qquad \lambda_{max} > 100$

For bearing type bolted connections:

Shear strength $R_{sh}$ $= q_b . A_s . n$

$q_b$ = the allowable shear stress

$= 0.25 F_{ub}$ for bolts of grade 4.6, 5.6 and 8.8

$= 0.20 F_{ub}$ for bolts of grade 4.8, 5.8, 6.8 and 10.9

Bearing strength $R_b$ $= F_b . d . \min \Sigma t$

$F_b$ = the allowable bearing stress

$= \alpha F_u$

| | End distance in direction of force | | | |
|---|---|---|---|---|
| | ≥ 3.0 d | ≥ 2.5 d | ≥ 2.0 d | ≥ 1.5 d |
| α | 1.2 | 1.0 | 0.8 | 0.6 |

**Course Examination Committee**

Prof. Ehab Ellobody $\qquad$ Prof. Mahmoud El-Boghdadi $\qquad$ Dr. Khaled Ramzy

**End of Exam**

Grouting (Grout curtain), Cutoff trenches, Partial cutoff, Sheet piling cutoff, Upstream blanket, and Pressure downstream relief wells and Stone protection (Riprap) for slope protection in earth dams **(4 marks)**

E. For the following earth dam (Figure No.5), It is required the following: **(4 Marks)**
1. Draw only the free surface for horizontal filter in downstream with lengths= 10, 20, and 30m.
2. Draw only the phreatic line for inside sheet pile at the dam center with depths= 10, 15, and 20m.
3. Determine the seepage volume below the dam without blanket and without cutoff wall.
4. Design the upstream horizontal blanket to minimize the seepage under the dam to 50 % (width of core bottom B=20m).
5. Determine the seepage volume below the dam with cutoff wall only with depths=20, 32, and 36m.

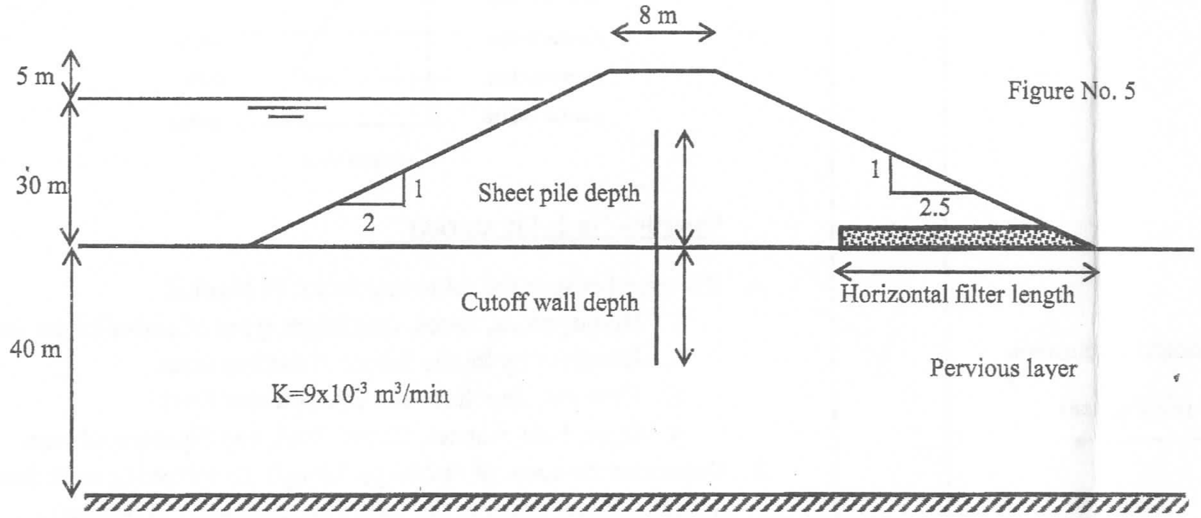



Figure No. 5

F. Design a suitable section for (Ogee spillway) overflow portion of a concrete gravity dam having the downstream face sloping at a slope 0.7 H: 1 V. The design discharge for the spillway is 8000 m³/sec. The height of the spillway crest is kept at RL 204 m. The average river bed level at the site is 100m. The spillway length consists of 6 spans having a clear width of 10m each. The thickness of each pier may be taken to be 2.5m. **(5 marks)**

Equations may be used:

$$K = tan^2\left(45^o - \frac{\alpha + \emptyset - 90^o}{2}\right)$$

$$F_{ice} = (15) h_{ice}$$

$$F_{E\ dam} = 1.5\ x\ W\ x\ K_E$$

$$(F_{EW})_H = \frac{2}{3}\ x\ a\ x\ H = 0.5\ x\ K_E\ x\ \gamma_w\ x\ H^2\ x\ cos^2\ (90^o - \alpha)$$

$$a = 0.75\ x\ K_E\ x\ \gamma_w\ x\ H\ x\ cos^2\ (90^o - \alpha)$$



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$$(F_{EW})_v = (F_{EW})_H\ x\ \cot\alpha$$

$$F_{wave} = 2\ x\ \gamma_w\ x\ {h_w}^2$$

$$h_w = 0.032\sqrt{V\ x\ F} \qquad B = \frac{H}{\sqrt{(G-C)}} \qquad B = \frac{H}{\mu(G-C)}$$

---

$$t = \frac{\gamma * h * r_e}{f_{max}} \qquad \sin\frac{\theta}{2} = \frac{L/2}{r_e} \qquad r_i = r_e - t \qquad V_{total} = h\left(\frac{A_1 + A_4}{2} + A_2 + A_3\right)$$

$$t = \frac{\gamma_w\, h\, r_c}{f_{all} - 0.5\gamma_w h} \qquad \sigma = \sigma_{all}\frac{r_m}{E}$$

---

$$q = \frac{K\,({h_1}^2 - {h_2}^2)}{2L} \qquad q = K\ x\ (a\sin\alpha)\ x\ (\tan\alpha)$$

$$a = \frac{L}{\cos\alpha} - \sqrt{\frac{L^2}{cos^2\alpha} - \frac{h^2}{sin^2\alpha}} \qquad Y^2 = \frac{2qX}{K} + {h_2}^2$$

$$q = K\ x\ a\ x\ \sin^2\alpha \qquad a = \sqrt{h^2 + d^2} - \sqrt{d^2 - h^2 cot^2\alpha}$$

$$q = K\ x\ I\ x\ \sin^2\beta \qquad I = \frac{mH}{sin\beta}$$

$$q = K\ x\ y_o \qquad y_o = \sqrt{h^2 + d^2} - d$$

$$y = \sqrt{2y_o x + {y_o}^2} \qquad h_2 = \frac{B}{cot\beta_2} + H_d - \sqrt{\left(\frac{B}{cot\beta_2} + H_d\right)^2 - {h_1}^2}$$

$$\frac{H - h_1}{cot\beta_1} Lin \frac{H_d}{H_d - h_1} = \frac{h_2}{cot\beta_2} \qquad q = \frac{Kh_2}{cot\beta_2}$$

---

$$Q = C.L_e.{H_e}^{3/2} \qquad L_e = L - 2[NK_P - K_a]H_e$$

$$Q = Av \qquad velocity\ approach = \frac{Q}{A} \qquad H_a = velocity\ head = \frac{{v_a}^2}{2g}$$

$$x^{1.85} = 2.{H_d}^{0.85}.y \qquad q = \frac{K.H}{N_d} N_f \qquad q = K\left(\frac{h}{B}\right) d \qquad L = \frac{Khd - \rho qB}{\rho q}$$

$$y = \frac{0.724\,(x + 0.27H_d)^{1.85}}{{H_d}^{0.85}} + 0.126\,H_d - 0.4315{H_d}^{0.375}(x + 0.27H_d)^{0.625}$$

كل الامنيات بالتوفيق ا.م.د / اسعد مطر ارمانيوس و اللجنة

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- *Systematic arrangements of calculations and clear neat drawings are essential.*
- *Any missing data can be assumed.*

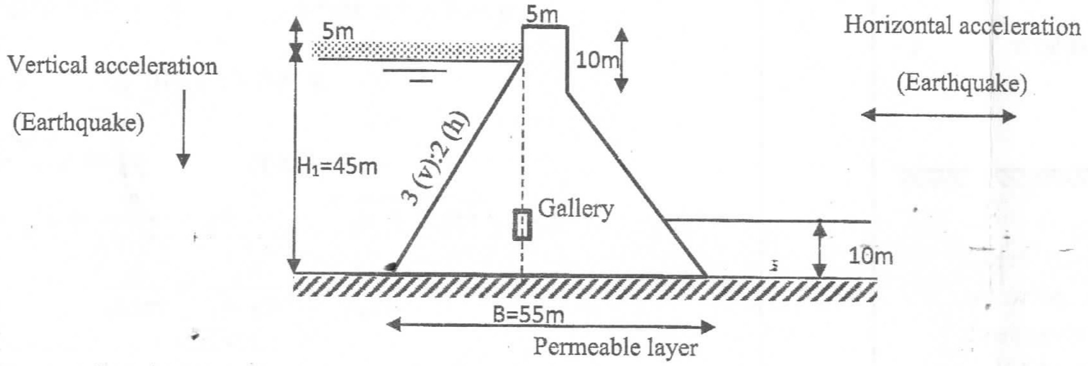
**Question No.1: (35 marks)**

A. Compare between the following items: **(3 Marks)**
   1. Types of dams according to its purposes
   2. The acting forces on the gravity dams
   3. Constant radius arch dams, constant angle arch dams and variable radius arch dams

B. Calculate the following acting forces on the gravity dam (P.C) showing Figure No.1: **(16 Marks)**

a. Weight of the dam
b. Hydrostatic water pressure
c. Uplift pressure
d. Ice force
e. Earthquake forces
f. Hydrodynamic water pressure
g. Wind force

(Fig-1)




Assume that $\phi = 45$, the wind velocity= 10 km/hr, F=35 km, Coefficient of friction=0.70, $K_E$=0.1for horizontal and hydrodynamic effect of earthquake, $K_v$=0.15 and the earthquake acting upward, $h_{ice}$=50 cm, $F_{ice}$=15 $h_{ice}$.

C. Design of the gravity dam showing Figure No.1: **(6 Marks)**
1. **Determine only** the factor of safety against sliding (1.5)
2. **Determine only** the factor of safety against overturning (2.0)
3. Check stress of concrete if $f_c$ allowable equals 30 t/m$^2$ and $f_t$ allowable equals 5 t/m$^2$

For the following load case: **Full reservoir+ Uplift force + Earthquake upward**

D. Prove relations for determining seepage through earth dams according to: Schaffernak and Iterson's solution. **(4 Marks)**



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E. A constant radius arch dam is designed for the river cross section shown in Figure 2. Figure 3 shows the vertical cross section at the center of the dam with external radius of 60m. The allowable compressive stress of concrete equals 300 t/m$^2$. It required the following: **(6 Marks)**
1. Check the safety of the dam section at levels A, B, C, D and E
2. Calculate the total volume of the dam: take 10m interval
3. Deflection displacement of the base of the dam

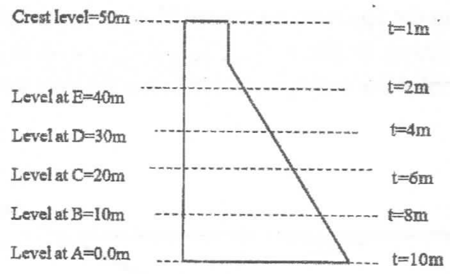



Figure No.3

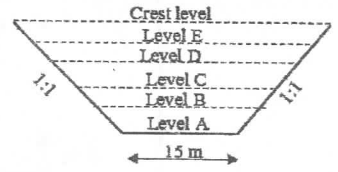


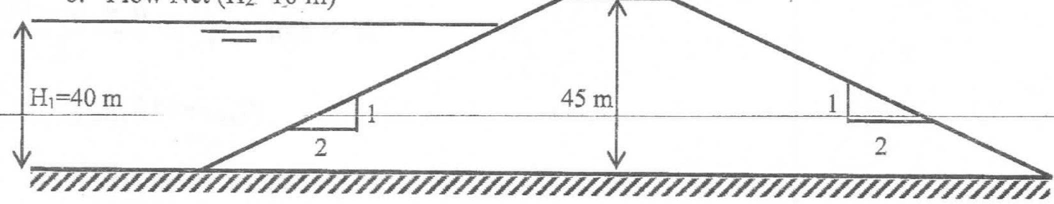

Figure No.2

**Question No.2: (35 marks)**

A. Compare between the following items: **(4 Marks)**
   1. Homogenous, zoned, diaphragm types of embankment dams
   2. Details of hydraulic failure of earthen dams
   3. Flow net, flow lines and equipotential lines
   4. Ogee, Side channel, Chute, Shaft, and Siphon spillways

B. Determine the seepage discharge through the following earth dam (K=5x10$^{-4}$ m$^3$/min) shown in Figure No.4, consider the following methods: **(14 Marks)**
   1. Dupuit's solution
   2. Schaffernak and Iterson's solution
   3. Casagrande's solution (Analytical solution)
   4. Casagrande's solution (Graphical solution)
   5. Tylor's solution (Graphical solution) (m=0.35)
   6. Kozeny's solution (Filter Length=15m)
   7. Pavolvesky's solution
   8. Flow Net ($H_2$=10 m)

Figure No. 4




C. Using Kozeny's solution compute the free surface for the following case: (Filter Length=15m) **(4 marks)**

D. Define with details the following techniques to control seepage beneath earth dams:

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Department: Civil Engineering
Total Marks: 70 Marks

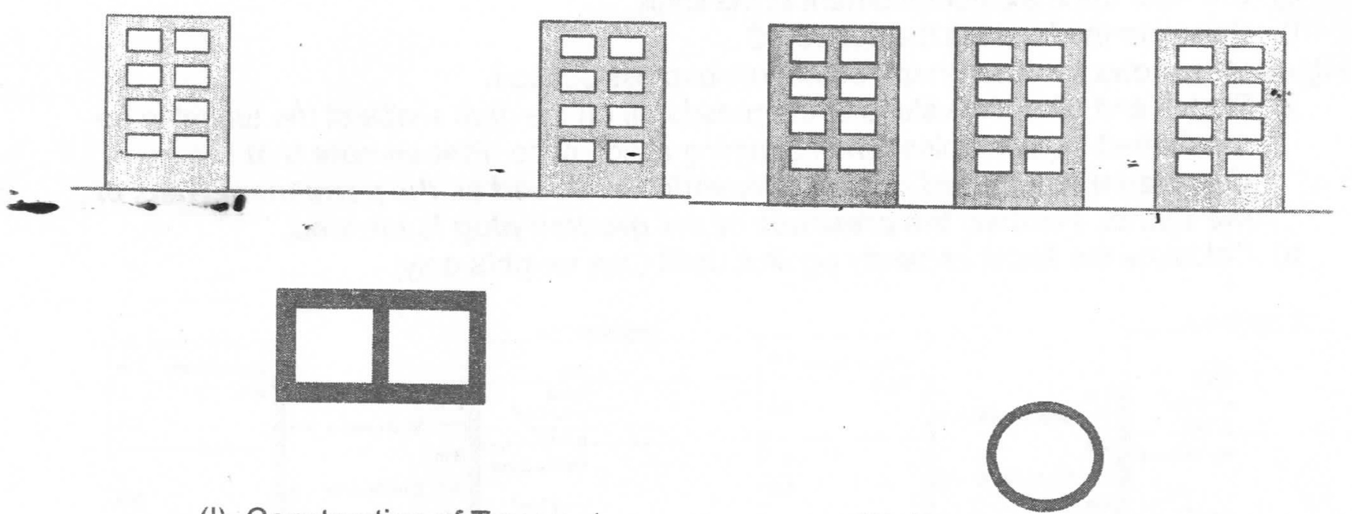
Faculty of Engineering

| | |
|---|---|
| Course Title: Tunnels and Underground Structures | 4th Year Structural Engineering Final Exam. |
| Date: 16 June 2023    Allowed time: 3 hrs | No. of Pages: (6) |

- Assume any missing data
- Answers should be supported by sketches

## Question 1 (10 Points)

(a) Mention and discuss using clear sketches what are the three major concerns of civil engineer in tunnelling projects in the following cases as shown in Fig. (1)



(I) Construction of Two vent tunnel using cut and cover Technique

(II) Construction of a Metro tunnel using tunnel boring machine

**Figure (1)**

(b) Using clear sketches show the construction sequence of the following construction techniques

(I) Tunnel boring using TBM

(II) Pipe Jacking

## Question 2 (10 Points)

A Metro line station shall be constructed using the cut and cover method of construction. The station has the following configurations:

- The station is 35 m wide and 90 m in length.
- The bottom level of the station is 25 m below the ground surface.
- The station is surrounded with many neighbouring buildings at the ground surface and shallow underground utilities.

If preliminary calculations resulted in the possibility of buckling of the wall to wall struts if used to support the sides of the excavation. **Discuss in details using demonstrative clear sketches all the alternative techniques to provide support to the sides of the excavation.**



## Question No. 3 (10 Points)

(a) Describe briefly using clear sketch the main construction sequence of soil nailing.
(b) Discuss the main difference between soil nailing and ground anchored walls.
(c) Using only clear sketch, show the modes of internal failure of soil nailed walls.
(d) A tunnel has to be constructed in an urban area with the cut and cover technique. Figure (2) shows a cross section of the 10.0 m deep excavation for tunnel construction. The excavation support system consists of diaphragm walls and tieback anchors. **It is required to** calculate the load in tieback B, the length LB and the length L2. The horizontal spacing between anchors is 4.0 m, and the diameter of grouted anchor is 0.80m.

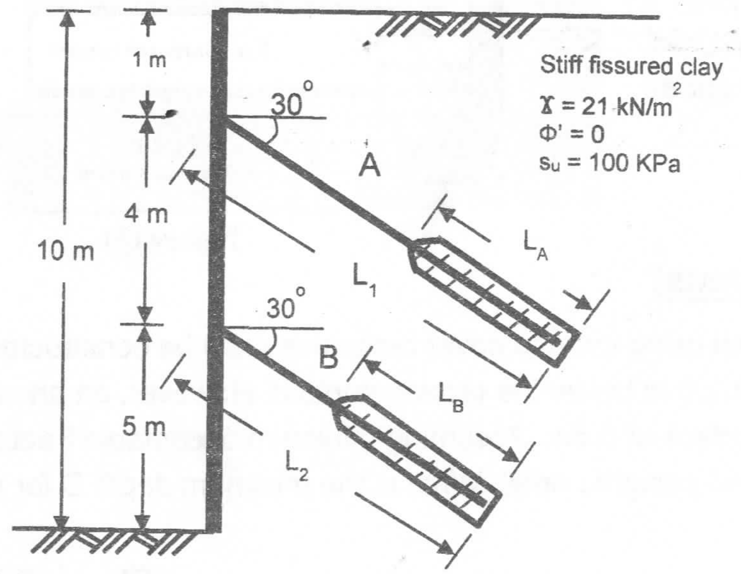



**Fig. (2)**

## Question No. 4 (20 Points)

(a) A circular shaft with inner diameter of 20.0 m and reinforced concrete wall of a thickness 1.25 m is required to be sunk to a depth of 30.0 m .The soil profile in a site consist of an extended silty sand layer ($\gamma$= 1.80 t/m$^3$ , c = 2.0 t/m$^2$ and $\Phi$= 32°). Assuming that the ground water table is located 2.00 m below the ground level, it is required to make a sinking analysis chart at each 3.00 m of the shaft height.

(b) Using the chart produced by the sinking analysis in **problem (a)**, it is required to determine:

i) The maximum additional force required during sinking,
ii) At what depths such force shall be required.
iii) The maximum braking force required during sinking.
iv) The depths at which the breaking system should work.

(c) For the same shaft, estimate the thickness of a simply supported concrete seal (concrete slab) to prevent the water inters the shaft [consider fcu = 250 kg/cm$^2$].

**Hint:** $T = 1.09\sqrt{\frac{q_o R^2}{f'_c}}$, $\quad f'_c = 0.15$ fcu

## Question 5 (10 Points)

a) Using clear sketches discuss and illustrate the deformation patterns and influence on adjacent structures id deep excavations

b) (I) Discuss the importance of instrumentation and monitoring in deep excavation projects and (II) provide a sample of instrumentation plan for deep excavation project

## Question 6 (5 Points)

The Figure at the side shows the construction of a 10 m long segment tunnel that is 3 m in diameter using Jacking in clay layer to under pass a canal. Six jacks are used. **Estimate the required force per jack.**

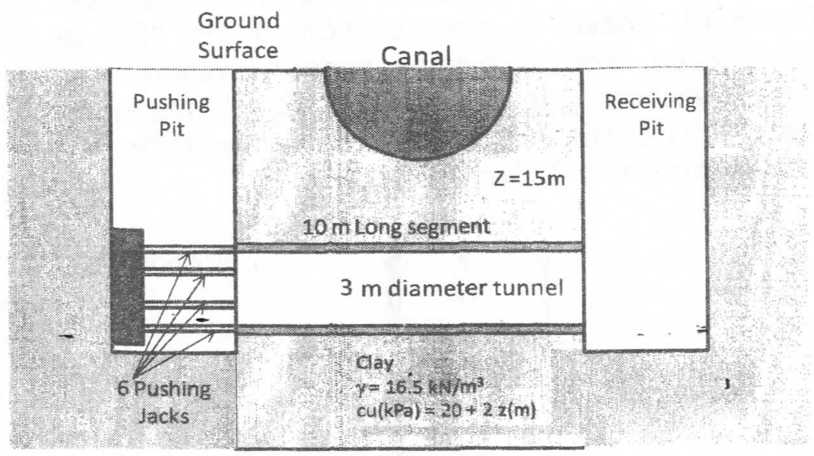



**Figure (3)**

## Question 7 (7 Points)

A segment of a tunnel using cut and cover technique shall be constructed (Figure 4). The ground water level is 2.0 m below the ground surface. However, an artesian water level above the ground surface of 0.5m. Assuming minimum acceptable Factor of safety against up hurst failure of 1.05 (weights only), What is the minimum depth D for no relief wells?

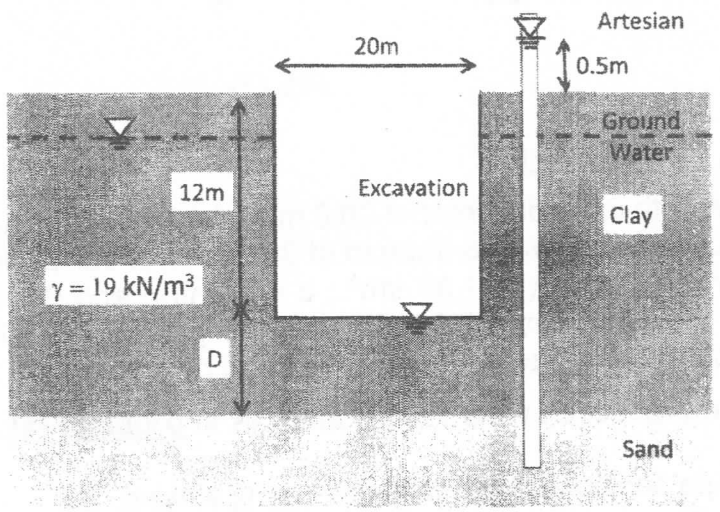



**Figure (4)**

## Question 8 (13 Points)

Asegment of a tunnel using cut and cover technique shall be constructed. The ground water level is 2.0 m below the ground surface. The top two meters are excavated first. Two diaphragm walls (100cm in thickness) are embedded in the ground as shown in the following Figures (5) and (6). During excavation, there is a need to support the side walls at levels A and B. The depth of the wall in the ground shall be determined by the engineer. There are two options



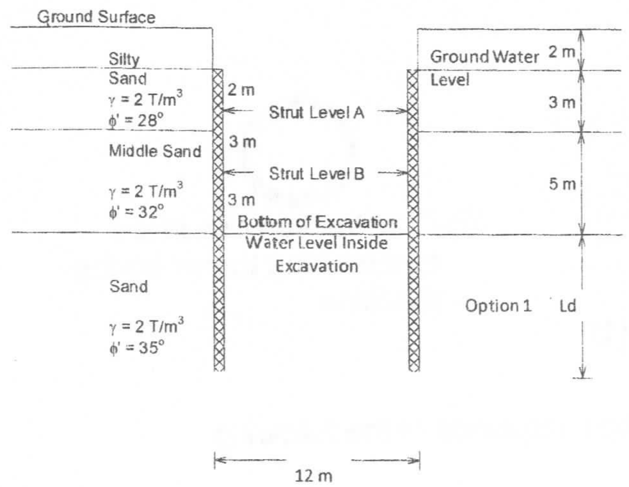
**Option 1:** To extend the wall to a depth Ld below bottom of excavation and use appropriate system of deep wells for dewatering. As shown in Figure (6)
( ختيار الأول: مد الحائط الخرساني بعمق لابد من حسابه أسفل قاع الحفر مع إستخدام نظام من الأبار العميقة لنزح المياه الجوفية)

**Option 2:** To extend the wall to a depth Ds below bottom of excavation with a grouted plug with thickness t. As shown in Figure (7)
( الإختيار الثاني: مد الحائط الخرساني بعمق لابد من حسابه أسفل قاع الحفر مع تركيب سدادة من الحقن بسمك t )

a) Using the Terzaghi's method, calculate the minimum thicknesses Ld to avoid hydraulic failure at the bottom of excavation in case of Option 1 in Figure 6.
b) Calculate the thicknesses t and Ds in case of Option 2 in Figure 7
c) Comment on the results of the two options.
d) Calculate and sketch the pressure distribution along one side of the diaphragm wall.
e) Estimate the maximum moment in the walls
f) Calculate the loads at the support B.

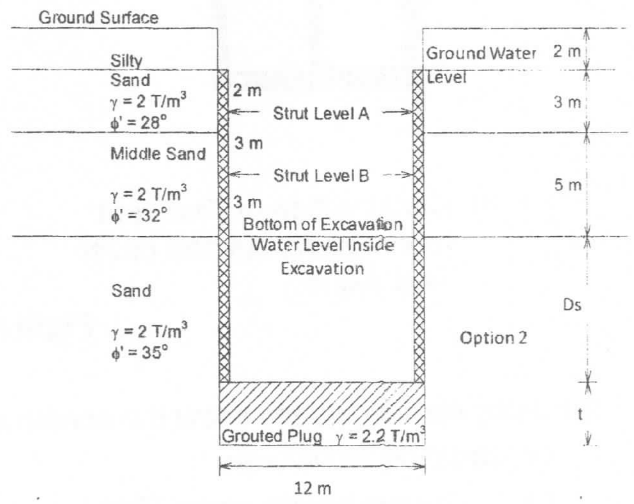
Figure (10) shows the final shape of the tunnel cross section.

g) Sketch and label the values of the pressures on the final shape of the tunnel to be considered for determination of straining action case. ***Please note that the diaphragm walls used during excavation are used as the permanent walls of the tunnel. Further, the presence of the grouted plug is ignored.***
h) Calculate the factor of safety against uplift (use weights only).



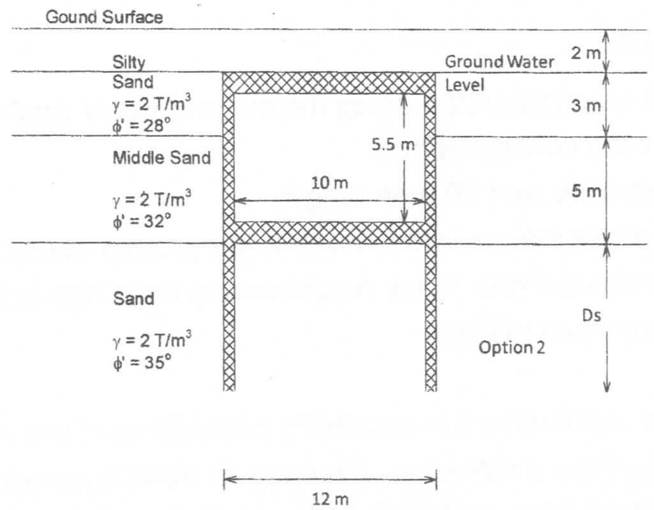

During Excavation

**Figure (5)**




During Excavation

**Figure (6)**

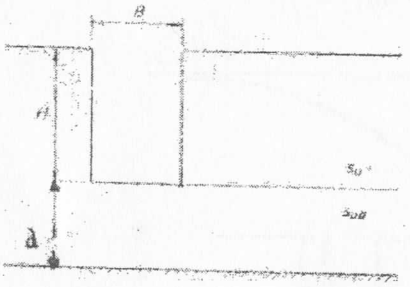



Final Shape of Tunnel

**Figure (7)**



**End of Questions**



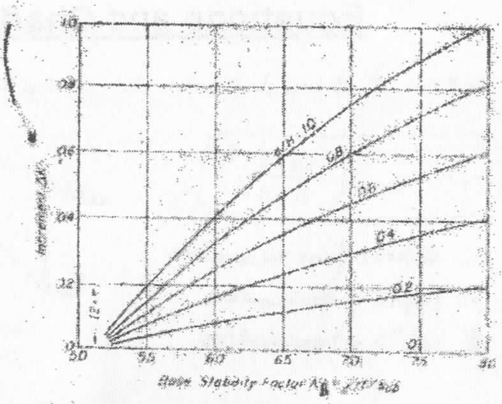
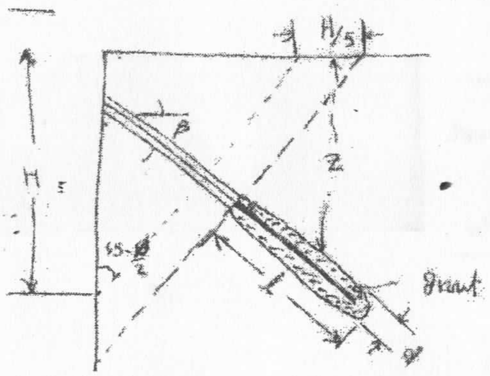



Figure 37.8 Increment ΔK in coefficient of lateral earth pressure against supports of open cut in clay under undrained conditions when base stability factor exceeds 5.14 (after Henkel 1971).

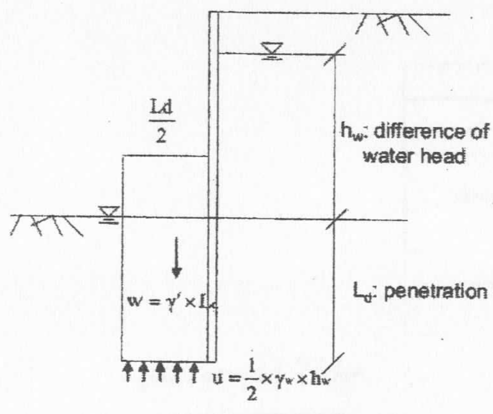



In Sand,
ultimate resistance, $P_u$

$$P_u = \pi d l \sigma'_v K \tan\delta$$

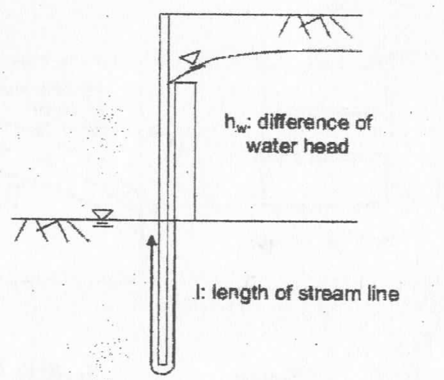
In clays

$$P_u = \pi d l C_a$$




a)Terzaghi's formula

$$F_s = \frac{W}{u} = \frac{2\times\gamma'\times L_d}{\gamma_w\times h_w}$$




b) critical hydraulic gradient expression

$$F_s = \frac{i_c}{i} = \frac{G_s-1}{1+e}\times\frac{l}{h_w} = \frac{\gamma'\times l}{\gamma_w\times h_w}$$

*Best Wishes.........*

*Prof. Dr. Marawan Shahien*

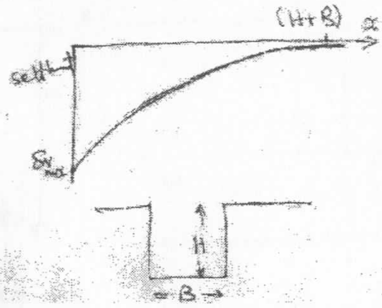
*and The Course Examination Committee*

# Equations and Charts

Calculate settlement at any distance $x$ $(0 \le x \le (H+B))$

$$\delta_v = \delta_{vmax}\left(\frac{H+B-x}{H+B}\right)^2$$

$x$ distance from excavation
$H$ Depth of excavation
$B$ width of excavation



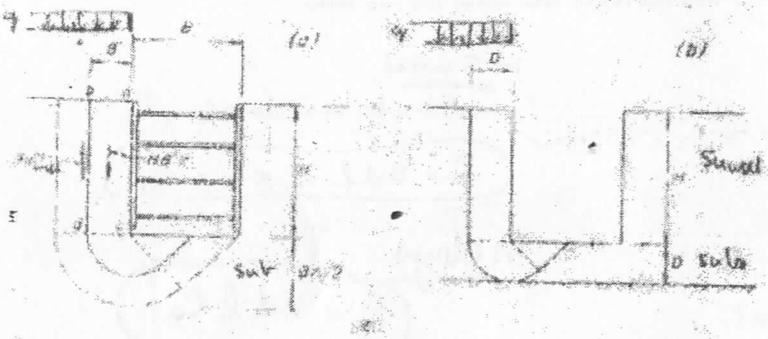



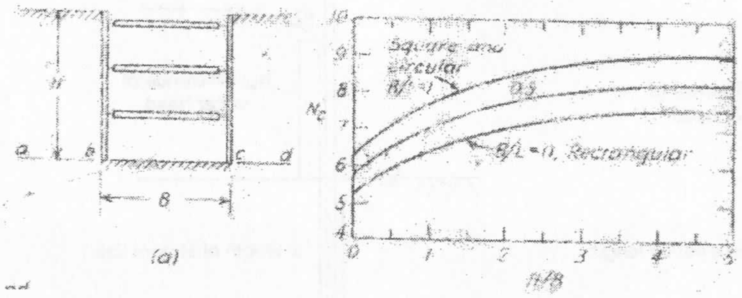

**Figure . ...** Section through open cut in deposit of soft clay. (*a*) Failure surfaces for deep deposit; (*b*) failure surface if hard bottom exists at depth *D* below base of cut.

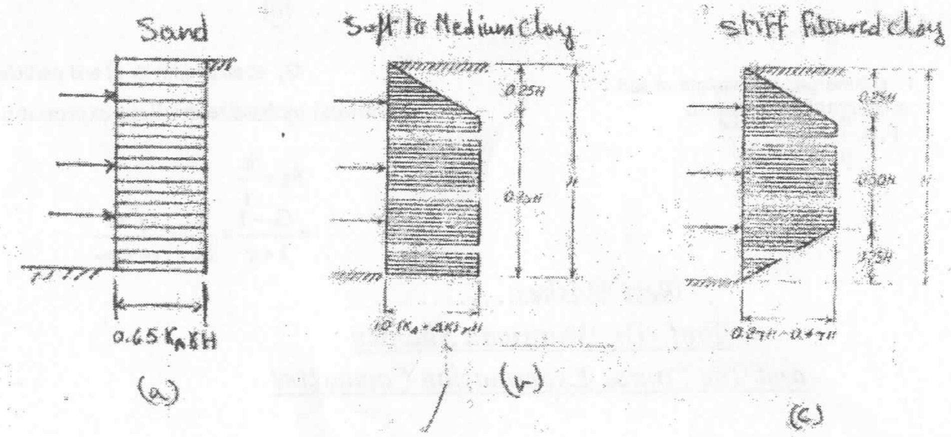
The factor of safety against heaving of the base is

$$F = \frac{N_c s_{ub}}{\gamma H + q - \frac{s_{u(wall)}}{B'}H} \qquad B' \le \frac{B}{\sqrt{2}}$$

If a hard base is located at depth D below the bottom of the cut, B' = D

$$F = \frac{N_c s_{ub}}{\gamma H + q - (s_{u(wall)} H / D)}$$




$$K_A = 1 - \frac{4s_u}{\gamma H}$$ for soft to medium clays

$$K_A = \frac{1-\sin\phi'}{1+\sin\phi'}$$ for sands