RAJEEV GANDHI MEMORIAL COLLEGE
OF ENGINEERING & TECHNOLOGY

(AUTONOMOUS), NANDYAL – 518501, A.P.

(ESTD-1995)

DEPARTMENT OF CIVIL ENGINEERING

Subject: GEOTEHNICAL ENGINEERING – II (A0118156)

Faculty: C Krishnama Raju

Associate Professor

Department of Civil Engineering
RGMCET(Autonomous)

INDEX

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NANDYAL-518 501.

Department of Civil Engineering
RGMCET(Autonomous), NANDYAL

VISION

- To be an outstanding department devoted to provide value based education in Civil Engineering which will produce socially aware professionals to provide solutions of global standards.

MISSION

- To impart quality education that develops innovative professionals with research orientation and entrepreneurs.
- To prepare professionals with emphasizes on leadership, team work and ethical conduct.
- To undertake collaborative projects and consultancy works with academia and industry.

PRGRAM EDUCATIONAL OBJECTIVES

PEO-1: Assessing societal needs and plan suitable infrastructure

PEO-2: Excel in Civil Engineering and in other allied fields

PEO-3: Develop team spirit and inter personal dynamics for effective execution and management of projects

PEO-4: Adhering life-long learning skills and adopt to changing professional and societal needs

PROGRAM SPECIFIC OUTCOMES

PSO1 Capability to investigate, plan, analyze and design buildings for different purposes such as residential, commercial, public office, recreational etc. using STAAD Pro and relevant software

PSO2 Competency in preliminary engineering surveys, planning and design of infrastructure viz. roads, bridges and designing traffic control systems etc. using Mx-Roads and other relevant software programs

PSO3 Conduct field and laboratory tests for analysis and quality control of civil engineering projects

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RAJEEV GANDHI MEMORIAL COLLEGE OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

Academic Diary for II & III B.Tech., II-Semester (R15)

Academic Year: 2019-20

Day	Dec-19		Jan-20		Feb-20		Mar-20		Apr-20	
	Date	Class	Date	Class	Date	Class	Date	Class	Date	Class
Sun	1						1			
Mon	2	1					2	67		
Tue	3	2					3	68		
Wed	4	3	1	26			4	69	1	Mid-II
Thu	5	4	2	27			5	70	2	**Sri Rama Navami**
Fri	6	5	3	28			6	71	3	Mid-II
Sat	7	6	4	29	1	Mid-I	7	72	4	Mid-II
Sun	8		5		2		8		5	**R.JR's B'Day**
Mon	9	7	6	30	3	Mid-I	9	73	6	Mid-II
Tue	10	8	7	31	4	Mid-I	10	74	7	Mid-II
Wed	11	9	8	32	5	46	11	75	8	Mid-II
Thu	12	10	9	33	6	47	12	76	9	Preparation
Fri	13	11	10	34	7	48	13	77	10	**Good Friday**
Sat	14	12	11	35	8	49	14	78	11	II-II
Sun	15		12		9		15		12	
Mon	16	13	13	36	10	50	16	79	13	III-II
Tue	17	14	14	**Bhogi**	11	51	17	80	14	**BRA's B'Day**
Wed	18	15	15	**Sankranti**	12	52	18	81	15	II-II
Thu	19	16	16	**Kanuma**	13	53	19	82	16	III-II
Fri	20	17	17	37	14	54	20	83	17	II-II
Sat	21	18	18	38	15	55	21	84	18	III-II
Sun	22		19		16		22		19	
Mon	23	19	20	39	17	56	23	85	20	II-II
Tue	24	20	21	40	18	57	24	86	21	III-II
Wed	25	**Christmas**	22	41	19	58	25	**Ugadi**	22	II-II
Thu	26	21	23	42	20	59	26	87	23	III-II
Fri	27	22	24	43	21	**Sivaratri**	27	88	24	II-II
Sat	28	23	25	44	22	60	28	89	25	III-II
Sun	29		26	**Republic Day**	23		29		26	
Mon	30	24	27	45	24	61	30	90	27	II-II
Tue	31	25	28	Mid-I	25	62	31	Mid-II	28	Labs
Wed			29	Mid-I	26	63			29	Labs
Thu			30	Mid-I	27	64			30	Labs
Fri			31	Mid-I	28	65				
Sat					29	66				

1.	**First Spell of Instructions**	:	02/12/2019 – 27/01/2020
2.	**Slot for Assignment-I**	:	20/01/2020 – 27/01/2020
3.	**Mid-I Examinations**	:	28/01/2020 – 04/02/2020
4.	**Second Spell of Instructions**	:	05/02/2020 – 30/03/2020
5.	**Slot for Assignment-II**	:	23/03/2020 – 30/03/2020
6.	**Mid-II Examinations**	:	31/03/2020 – 08/04/2020
7.	**Preparation**	:	09/04/2020 – 10/04/2020
8.	**End Examinations**	:	11/04/2020 – 27/04/2020
9.	**End Practical Examinations**	:	28/04/2020 – 30/04/2020
10.	**Commencement of Class Work for I-Sem**	:	12/06/2020 Onwards

C.E. **PRINCIPAL**

Date: 23-11-2019

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SCHOOL OF *CIVIL ENGINEERING*

TIME TABLE FOR III B.TECH II -SEMESTER FOR 2019-20 **w.e.f: 09.12.2019** **V2.1**

LECTURE HALL: CB3010 **A Section**

PERIOD» (AM/PM) WEEK↓	9.30 To 10.20	10.20 To 11.10	11.10 To 11.30	11.30 To 12.20	12.20 To 1.10	1.10 To 2.10	2.10 To 3.00	3.00 To 3.50	3.50 To 4.50
MON	DSS	PESS	BREAK	P&S		LUNCH BREAK	EE-II	GE-II	
TUE	EE-II	WRE-II	BREAK	PESS	P&S	LUNCH BREAK	CAD LAB		
WED	PESS	WRE-II	BREAK	DSS		LUNCH BREAK	EE-II		WRE-II
THU	GE-II	TE LAB / EE LAB				LUNCH BREAK	TE LAB / EE LAB		
FRI	P&S	GE-II	BREAK	WRE-II		LUNCH BREAK	MOOCS		
SAT	EE-II	GE-II	BREAK	DSS		LUNCH BREAK	GATE		LIB

LECTURE HALL: CB3020

PERIOD» (AM/PM) WEEK↓	9.30 To 10.20	10.20 To 11.10	11.10 To 11.30	11.30 To 12.20	12.20 To 1.10	1.10 To 2.10	2.10 To 3.00	3.00 To 3.50	3.50 To 4.50
MON	EE-II	CAD LAB				LUNCH BREAK	P&S	DSS	PESS
TUE	GE-II	DSS	BREAK	P&S	EE-II	LUNCH BREAK	WRE-II		GE-II
WED	GE-II	WRE-II	BREAK	WRE-II	EE-II	LUNCH BREAK	P&S	EE-II	DSS
THU	WRE-II	MOOCS				LUNCH BREAK	DSS	P&S	EE-II
FRI	DSS	TE LAB / EE LAB				LUNCH BREAK	TE LAB / EE LAB		
SAT	PESS		BREAK	GE-II		LUNCH BREAK	GATE		LIB

Subect:	Name of Faculty (A-SEC)	Name of Faculty (B-SEC)
GE-II: Geotechnical Engineering-II	Mr.C.Krishnama Raju	Mr. P. Pramadhanadha Reddy
DSSE: Design of Steel Structural Elements	Ms. B. Rohini	Mr. S. Talha Zaid
WRE-II: Water Resources Engineering-II	Ms. J. Sravani	Mr. K. Gangadhar
EE-II:Environmental Engineering- II	Mr. M.P. Krishna Murthy	Mr. C. Ramanjaneyulu
Elective-I: MOOC	Mr. GN. Sreekanth	Mr. GN. Sreekanth
Elective-II: Probability & Statistics	Mr. D. Dastagiri Babu	Mr. Y. Raja Obul Reddy
PESS: Professional Ethics & Soft Skills (Skill Development Course)	Dr. G. Kiran Kumar Reddy	Mrs. M. Aparna
PRACTICAL:		
TEL: Transportation Engineering Lab	BNK / AM/ VNR	YTK / AM/ GS
EEL: Environmental Engineering Lab	MPK / KG/Dr. KM	PLR / MPK/BLE
CAD Lab	Dr. JJS / VNS/Dr.BLA	GNS / VNS/GK
Seminars:		
Class Teacher:	Ms. J. Sravani	Mr. M.P. Krishna Murthy
Co-Ordinator:	Mr. M.P. Krishna Murthy	Mr. M.P. Krishna Murthy

Note:	7th Period of every First Saturday of the Month is Counselling Period

9/12/19

HEAD - SCE

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Students Roll List

III B. Tech II Semester (AY: 2019-2020)

S.No	Branch	REGD. No	NAME
1	CVL	16091A0104	NAYAKALLU AKHIL RAJ
2	CVL	16091A0134	JANGAM JAYANNA
3	CVL	16091A0137	V KALYAN KUMAR
4	CVL	16091A0143	YALAMANDA MAHA DATTATREYA
5	CVL	16091A0150	SHAIK MANSOOR HUSSAIN
6	CVL	16091A0189	CHINNAMADUGULA SIVA
7	CVL	17091A0101	SHAIK AKBARVALI
8	CVL	17091A0102	PALLEKKAGARI ANIL KUMAR
9	CVL	17091A0103	MEKALA ANOOSHA
10	CVL	17091A0104	BAVANASI ASWINI
11	CVL	17091A0105	MULLA AZHARUDDIN
12	CVL	17091A0106	BILAVATH BALAJI NAIK
13	CVL	17091A0107	MULINTI BHAGYA SREE
14	CVL	17091A0110	JAKKAPOGU CHANDRAKALA
15	CVL	17091A0111	K DINESH
16	CVL	17091A0112	DORNALA DIVYA JYOTHI
17	CVL	17091A0113	PANDIKONA GOUTHAM GANGADHARA HARA
18	CVL	17091A0114	KARNATI GURUPRASAD REDDY
19	CVL	17091A0115	KORA HARATHI
20	CVL	17091A0116	SURE HARITHA
21	CVL	17091A0118	PARA HEMANTH CHOWDARY
22	CVL	17091A0119	RANGAM HEMANTH KUMAR
23	CVL	17091A0120	SHAIK HUSSAIN ABBAS
24	CVL	17091A0121	SHAIK HUSSAIN BASHA
25	CVL	17091A0122	SHAIK HUSSAIN VALI
26	CVL	17091A0123	SHAIK JAKEER HUSSAIN
27	CVL	17091A0124	MULLAPALLI JANARDHAN
28	CVL	17091A0125	M JYOTHSNA
29	CVL	17091A0126	SHAIK KARISHMA BEGUM
30	CVL	17091A0127	DHANIREDDY KAVYA
31	CVL	17091A0128	PALAMARI KESHAVULU
32	CVL	17091A0129	JANGLISAGARI SHAIK KHAJA MOHIDDIN
33	CVL	17091A0133	MARKAPURAM LAKSHMIMADHURYA
34	CVL	17091A0138	PERAPOGU MADHU
35	CVL	17091A0139	MURTHATI MAHESH
36	CVL	17091A0141	VADDE MEENAKSHI
37	CVL	17091A0142	K MOHAMMED SOHAIL
38	CVL	17091A0143	KURUVA MOHANAKRISHNA
39	CVL	17091A0144	MD MOIN AHAMMAD
40	CVL	17091A0145	MANGALI NAGA PAVAN

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41	CVL	17091A0146	NUGGU NAGA PHANEENDRA
42	CVL	17091A0147	SAGALA VENKATA NAGA SUMANTH KUMAR
43	CVL	17091A0148	GOLLA NAGARAJU
44	CVL	17091A0149	MEENUGA NAGESH
45	CVL	17091A0150	CHAVVA NARAYANA REDDY
46	CVL	17091A0151	B NAVEEN KUMAR
47	CVL	17091A0154	BHEEMASENI NIHARIKA
48	CVL	17091A0155	LEKKALA NITHISH KUMAR REDDY
49	CVL	17091A0156	ERAGANABOINA PAVAN KUMAR
50	CVL	17091A0157	T PAVAN KUMAR
51	CVL	17091A0160	RAMAJI PRAVEEN
52	CVL	17091A0162	NATTI RAJA SEKHAR
53	CVL	17091A0163	ASWANI RAJESH VARMA
54	CVL	17091A0164	KUCHI RAJESH
55	CVL	17091A0165	MACHA RAJESH
56	CVL	17091A0166	BANTROTH RAMAKRISHNA
57	CVL	17091A0167	MUPPASANI RAMESH
58	CVL	17091A0168	VALMIKI RAVI TEJA
59	CVL	17091A0169	DUDEKULA RIYAZ AHMED
60	CVL	17091A0170	KOTTAM ROHITH
61	CVL	17091A0171	KACHANA ROHITHESWARA REDDY
62	CVL	17091A0172	SHAIK SAFIYA BEGAM
63	CVL	17091A0173	SAI CHARAN KUMAR REDDY YEDDULA
64	CVL	17091A0174	PATURU SAI KUMAR REDDY
65	CVL	17091A0176	PHATAN SALMAN
66	CVL	17091A0178	VADITE SHILPA
67	CVL	17091A0180	BUJALA SHIVANI REDDY
68	CVL	17091A0182	KADIRI SIVA PRIYA
69	CVL	17091A0183	CHERUKU SRAVANI
70	CVL	17091A0184	KONDREDDY SREEDHAR REDDY
71	CVL	17091A0185	KUNCHALA SREEKANTH REDDY
72	CVL	17091A0186	RAMAVATHU SRIKANTH NAIK
73	CVL	17091A0187	BELLAM SUDHAKAR REDDY
74	CVL	17091A0188	YARAVA SUDHARSAN REDDY
75	CVL	17091A0189	MOTA SUNIL
76	CVL	17091A0190	VADDE SURENDRA
77	CVL	17091A0191	SIVARAM UPENDRA
78	CVL	17091A0193	METIKALA UPENDRANATH
79	CVL	17091A0194	BOMMASANI VAMSI KALYAN YADAV
80	CVL	17091A0195	SAMPANGI VASU
81	CVL	17091A0197	RAJAVOLU VEERA PRATHAP REDDY
82	CVL	17091A0198	T VENKAT SUJITH KUMAR
83	CVL	17091A0199	MADALA VENKATASUBBAIAH
84	CVL	17091A01A0	MURAHARI VIJAY KUMAR
85	CVL	17091A01A1	DINNE VIJAYKUMAR

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86	CVL	17091A01A2	PATIL VINAY KUMAR REDDY
87	CVL	17091A01A3	THOOMALA VINEETH
88	CVL	17091A01A5	BOOSA VISWANATHA REDDY
89	CVL	17091A01A6	BHUMIREDDYCHINNAMADANNAGARI YASASWINI
90	CVL	17091A01A7	PALLOLI YASWANTH
91	CVL	17091A01A8	SALUGARI VENKATA YATHISH CHANDRA
92	CVL	17091A01A9	MANAPATI YELLAIAH YADAV
93	CVL	18095A0101	SHAIK ABDUL RAFI
94	CVL	18095A0103	M ANUPAMA
95	CVL	18095A0104	DEVAGUDI BRAHMAIAH
96	CVL	18095A0105	S CHAITANYA SHIVA
97	CVL	18095A0106	AVULA CHANDRA SEKHAR REDDY
98	CVL	18095A0107	DURGAM CHANDRAKALA
99	CVL	18095A0108	GUMMALA CHARAN KUMAR
100	CVL	18095A0109	MALKARE CHATRAPATHI SIVAJI
101	CVL	18095A0110	OUKURU CHOUDAIAH
102	CVL	18095A0111	RAMAVATH DEVENDRA NAIK
103	CVL	18095A0113	PALLE DIVAKAR
104	CVL	18095A0115	JANGAM KARTHIK
105	CVL	18095A0116	KAKANURU KIRAN KUMAR REDDY
106	CVL	18095A0117	BUSIREDDY KUMAR REDDY
107	CVL	18095A0118	KAPPETA KUMAR REDDY
108	CVL	18095A0119	BOYA LAKSHMI NARAYANA
109	CVL	18095A0120	GARE MADHU SUDHAKAR
110	CVL	18095A0121	YENAKANDLA MAHENDRA REDDY
111	CVL	18095A0122	RAMATHEERTHAM VENKATA MANIKANTA SAI
112	CVL	18095A0123	MANISH KUMAR REDDY D
113	CVL	18095A0124	MULLA MANSOOR
114	CVL	18095A0125	SHAIK MOHAMMAD
115	CVL	18095A0126	DEVADURGAM NAVEEN KUMAR
116	CVL	18095A0127	MACHANI NAVEEN KUMAR
117	CVL	18095A0128	MARTHA NAVEEN KUMAR
118	CVL	18095A0129	NANNURU RAHUL
119	CVL	18095A0130	BONALA RANGASWAMY RAJAVARDHAN
120	CVL	18095A0131	BOYA RAJU
121	CVL	18095A0132	SONTI RAVI KIRAN REDDY
122	CVL	18095A0133	ENJETI RAVI KUMAR
123	CVL	18095A0134	GOVINDUGALLA RAVI TEJA
124	CVL	18095A0135	MANIYAR SHAKEER
125	CVL	18095A0136	KUDUMULA SIVA PRAKASH REDDY
126	CVL	18095A0137	JULAKUNTA VADIRAJ SREEVASTAV
127	CVL	18095A0138	ALIGOTI SRUTHI
128	CVL	18095A0139	GADDAM SUMANTH REDDY
129	CVL	18095A0141	UNDALA SURESH KUMAR
130	CVL	18095A0142	MARELLA SURYA TEJA

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131	CVL	18095A0143	GANNE THEJESWAR NAIDU
132	CVL	18095A0144	GUJJARLA UDAY KUMAR
133	CVL	18095A0145	KOMMOJI VANI
134	CVL	18095A0146	MALASALAVADI VASANTH KUMAR
135	CVL	18095A0147	SIGARAMBOTLA VASAVIPRANATHI
136	CVL	18095A0148	POSA VENKATA AKANKSHA
137	CVL	18095A0149	POREDDY VIJITHA
138	CVL	18095A0150	BHUMANAPALLE VISHNUKANTH REDDY

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CIVIL ENGINEERING

III B.Tech, II-Sem (CE)

T	C
3+1*	3

(A0118156) GEOTECHNICAL ENGINEERING – II

OBJECTIVES:

- ❖ Provide knowledge in soil exploration methods.
- ❖ Provide knowledge about various types of foundations and various bearing capacity equations.
- ❖ Provide knowledge about deep & well foundations.
- ❖ Learn various slope stability methods

OUTCOMES:

At the end of the course student is able to

- ❖ Determine the earth pressures on foundations and retaining structures
- ❖ Analyze shallow and deep foundations (including well foundations)
- ❖ Calculate the bearing capacity of soils and foundation settlements
- ❖ Able to design & execute the soil exploration scheme
- ❖ Able to perform the stability analysis of given slope

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	2	1	-	-	-	-	-	-	-	-	3	2	1
CO2	1	3	2	1	-	-	-	-	-	-	-	-	3	2	1
CO3	1	3	2	1	-	-	-	-	-	-	-	-	3	2	1
CO4	1	3	2	1	-	-	-	-	-	-	-	-	3	2	1
CO5	1	3	2	1	-	-	-	-	-	-	-	-	1	2	1
Avg.	1	3	2	1	-	-	-	-	-	-	-	-	3	2	1

UNIT – I

SOIL EXPLORATION: Need – Methods of soil exploration – Boring and Sampling methods – Field tests – Penetration Tests – Plate load test – Pressure meter – planning of Program and preparation of soil investigation report.

UNIT – IV

SHALLOW FOUNDATIONS: Types – choice of foundation – Location of depth – Safe Bearing Capacity – Terzaghi's, Meyerhoff's and Skempton's Methods

UNIT-V

ALLOWABLE BEARING PRESSURE: Safe bearing pressure based on N- value – allowable bearing pressure; safe bearing capacity and settlement from plate load test – allowable settlements of structures – Settlement Analysis.

UNIT – II

EARTH SLOPE STABILITY: Infinite and finite earth slopes – types of failures – factor of safety of infinite slopes – stability analysis by Swedish arc method, standard method of slices, Bishop's Simplified method – Taylor's Stability Number- Stability of slopes of earth dams under different conditions.

UNIT – III

EARTH PRESSURE THEORIES: Rankine's theory of earth pressure – earth pressures in layered soils – Coulomb's earth pressure theory – Rebhann's and Culmann's graphical method

RETAINING WALLS: Types of retaining walls – stability of gravity retaining walls.

UNIT –VI

PILE FOUNDATION: Types of piles – Load carrying capacity of piles based on static pile formulae – Dynamic pile formulae – Pile load tests – Load carrying capacity of pile groups in sands and clays – Settlement of pile groups.

WELL FOUNDATIONS: Types – Different shapes of wells – Components of wells – functions and Design Criteria – Sinking of wells – Tilts and shifts.

Note: Relevant IS: codes and tables are permitted for examination

TEXT BOOKS:

1. Soil Mechanics and Foundation Engineering by Arora, Standard Publishers and Distributors, Delhi
2. Foundation Engineering by Varghese,P.C., Prentice Hall of India., New Delhi.
3. Bowles, J.E., (1988) Foundation Analysis and Design – 4th Edition, McGraw-Hill Publishing company, Newyork.

REFERENCES:

1. Das, B.M., - (1999) Principles of Foundation Engineering –6th edition (Indian edition) Thomson Engineering
2. Bowles, J.E., (1988) Foundation Analysis and Design – 4th Edition, McGraw-Hill Publishing company, Newyork.
3. Analysis and Design of Substructures – Swami Saran, Oxford and IBH Publishing company Pvt Ltd (1998).
4. Geotechnical Engineering by S. K.Gulhati& Manoj Datta – Tata Mc.Graw Hill Publishing company New Delhi. 2005.
5. Teng,W.C – Foundation Design , Prentice Hall, New Jersy
6. Geotechnical Engineering by C.Venkataramaiah,
7. Foundation Engineering by V.N.S.Murthy, CRC Press, New Delhi.
8. Soil Mechanics and Foundations by – by B.C.Punmia, Ashok Kumar Jain and Arun Kumar Jain, Laxmi, publications Pvt. Ltd., New Delhi

RGM COLLEGE OF ENGINEERING AND TECHNOLOGY(AUTONOMOUS)
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School Of Civil Engineering

LESSON PLAN

Name of the Faculty	: ***C. Krishnma Raju***		
Class & Semester	: ***III B.Tech II semester***	Academic Year	: **2019 - 2020**
Subject	: ***Geotechnical Engineering - II***	Total Hours	: 60
Semester start date	: ***02-12-2019***	Semester end date	: ***30 -03 -2020***

UNIT	TOPIC	HOURS	Total Periods /unit	Dates Planned	Dates Executed
I	**SOIL EXPLORATION:** Need – Methods of soil exploration Boring and Sampling methods Penetration Tests- SPT, CPT, DCPT Plate load test – Pressure meter Planning of Programme and preparation of soil investigation report	 1 2 2 **2** **1**	8	02-12-2019 to 16-12-2019	
II	**EARTH SLOPE STABILITY:** Introduction-Types of failures Factor of safety of infinite slopes Stability analysis by Swedish arc method Friction Circle method Bishop's Simplified method Taylor's Stability Number- Stability of slopes of earth dams under different conditions, Problems	 1 2 1 2 2 3	11	17-12-2019 to 03-01-2020	
III	**EARTH PRESSURE THEORIES:** Introduction Rankine's theory of earth pressure Earth pressures in layered soils Coulomb's earth pressure theory Rebhann's and Culmann's graphical method, Problems **RETAINING WALLS:** Types of retaining walls Stability of retaining walls.Problems	 1 2 1 1 1 2 1 2	11	04-01-2020 To 25-01-2020	

2/12/19

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UNIT	TOPIC	HOURS	Total Periods /unit	Dates Planned	Dates Executed
IV	**SHALLOW FOUNDATIONS:** Types -choice of foundation -Location of depth - Safe Bearing Capacity - Terzaghi`s, Meyerhoff's , Skempton`s Methods Problems	 2 3 2 3	10	26-01-2020 to 18-02-2020	
V	**ALLOWABLE BEARING PRESSURE :** Safe bearing pressure based on N- value SBC and settlement from plate load test Allowable settlements of structures -Settlement Analysis Problems	 1 2 2 3	08	19-02-2020 to 02-03-2020	
VI	**PILE FOUNDATION:** Types of piles Load carrying capacity of piles based on static pile formulae Dynamic pile formulae – Pile load tests Load carrying capacity of pile groups in sands and clays Settlement of pile groups, Problems **WELL FOUNDATIONS:** Types – Different shapes of wells Components of wells – functions and Design - Design Criteria Sinking of wells – Tilts and shifts.	1 2 2 2 1 1 2 1	12	03-03-2020 to 23-03-2020	
Total number of periods in semester			60		

02/12/19
Signature of the Faculty

Signature of H.O.D.

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School of Civil Engineering
Rajeev Gandhi Memorial College of
Engg. & Tech. (Autonomous)
NANDYAL-518 501.

Department Civil Engineering
RGMCET(Autonomous), Nandyal-518501

Course Delivery Method

Name of the Subject: Geotechnical Engineering – II

Subject Code: A0118156

Year & Sem: III B.Tech II Semester

Course Delivery Plan

Delivery Methods: Chalk & Talk, Power Point Presentation, Tutorials, Video Lecturers, Interactive Sessions, Group Discussions

Coverage of

Unit-I : Chalk & Talk, Power Point Presentation, Tutorials, Interactive Sessions

Unit-II : Chalk & Talk, Power Point Presentation, Tutorials

Unit-III : Chalk & Talk, Power Point Presentation, Tutorials

Unit-IV : Chalk & Talk, Power Point Presentation, Tutorials

Unit-V : Chalk & Talk, Power Point Presentation, Tutorials

Unit-VI : Chalk & Talk, Power Point Presentation, Tutorials, Video Lecturers

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(ESTD-1995)

Topic Covered Beyond Syllabus

Name of the Faculty: C Krishnama Raju
Class & Sem : III B. Tech & II Semester
Subject: Geotechnical Engineering –II
Credits: 4 AY: 2019- 2020

Designation: Associate Professor
Section: A
Code: A0118156
Regulations: R15

SNo	Topic Covered	Strengthening of CO, PO & PSO	
		CO	PO & PSO
1	Case Study: Site Investigation Work at Kallang Pudding Road, Singapore By Kwang Sing Engineering Pte Ltd, Singapore	➢ Able to design & execute the soil exploration scheme ➢ Calculate the bearing capacity of soils and foundation settlements	PO3, PO11, PSO1, PSO3

06/01/20
Signature of Faculty

6/1/20
HCED

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TOPIC BEYOND SYLLABUS

CASE STUDY ON SITE INVESTIGATION

KWANG SING ENGINEERING PTE LTD 有限公司 坤成工程
27 Foch Road #02-06
Hoa Nam Building, Singapore 209264
Tel: 6291 3218 Fax: 6467 7309
E-mail: kse2000@singnet.com.sg

Company Reg No. 198300405C GST Reg No. M2-0050746X

REPORT

ON

SOIL INVESTIGATION WORKS

AT

KALLANG PUDDING ROAD

TERM CONTRACT NO. URA 000/ CS/ 0706

PO NO. URA000EPO08000080/0

CLIENT	:	URBAN REDEVELOPMENT AUTHORITY
JOB NO.	:	KS07 / URA - 017
DATE	:	4th April 2008

KWANG SING ENGINEERING PTE LTD

CONTENTS

PROFESSIONAL ENGINEER CIVIL SAMUEL KUAN 3179 SINGAPORE

KS07/URA-017

Endorsed by P.E.

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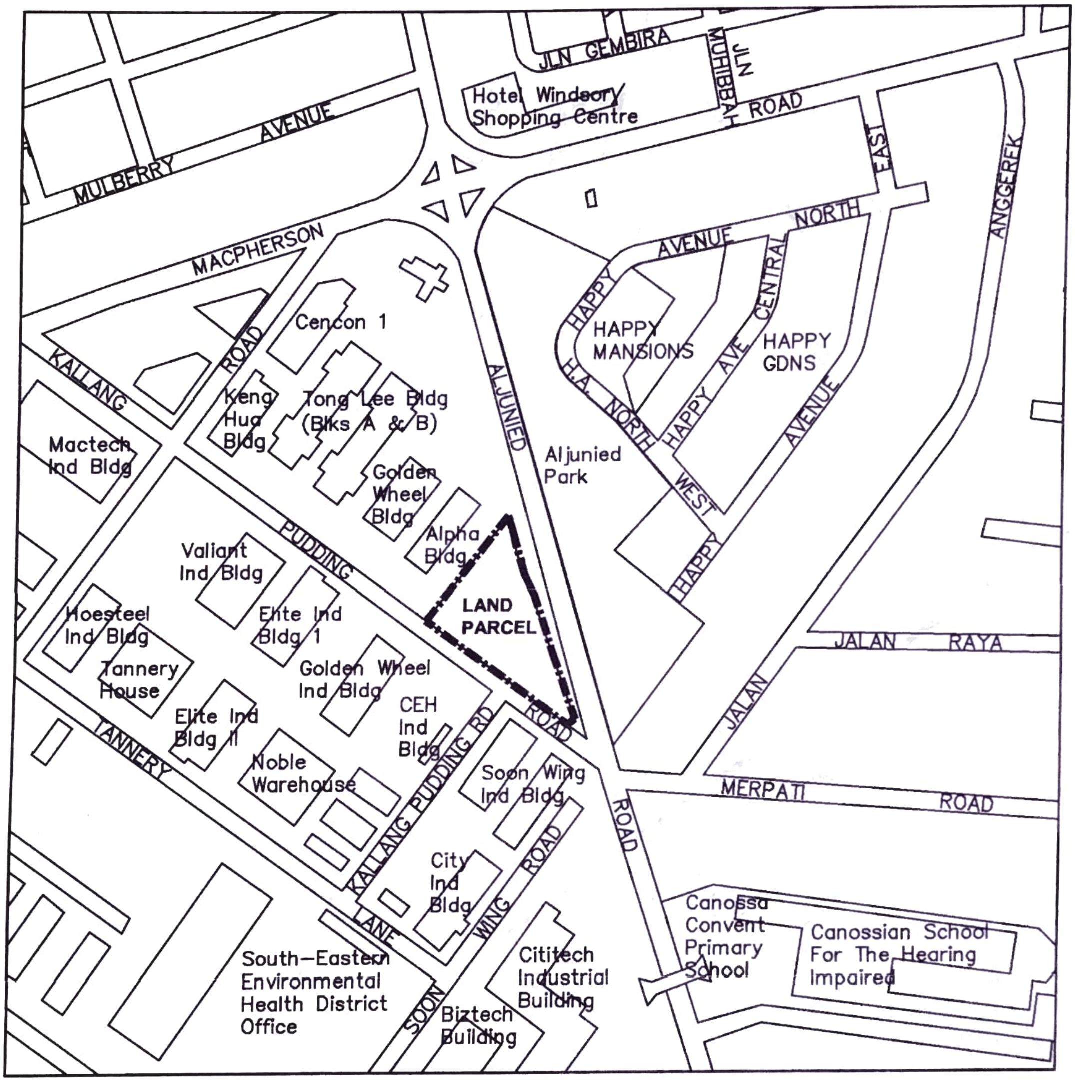
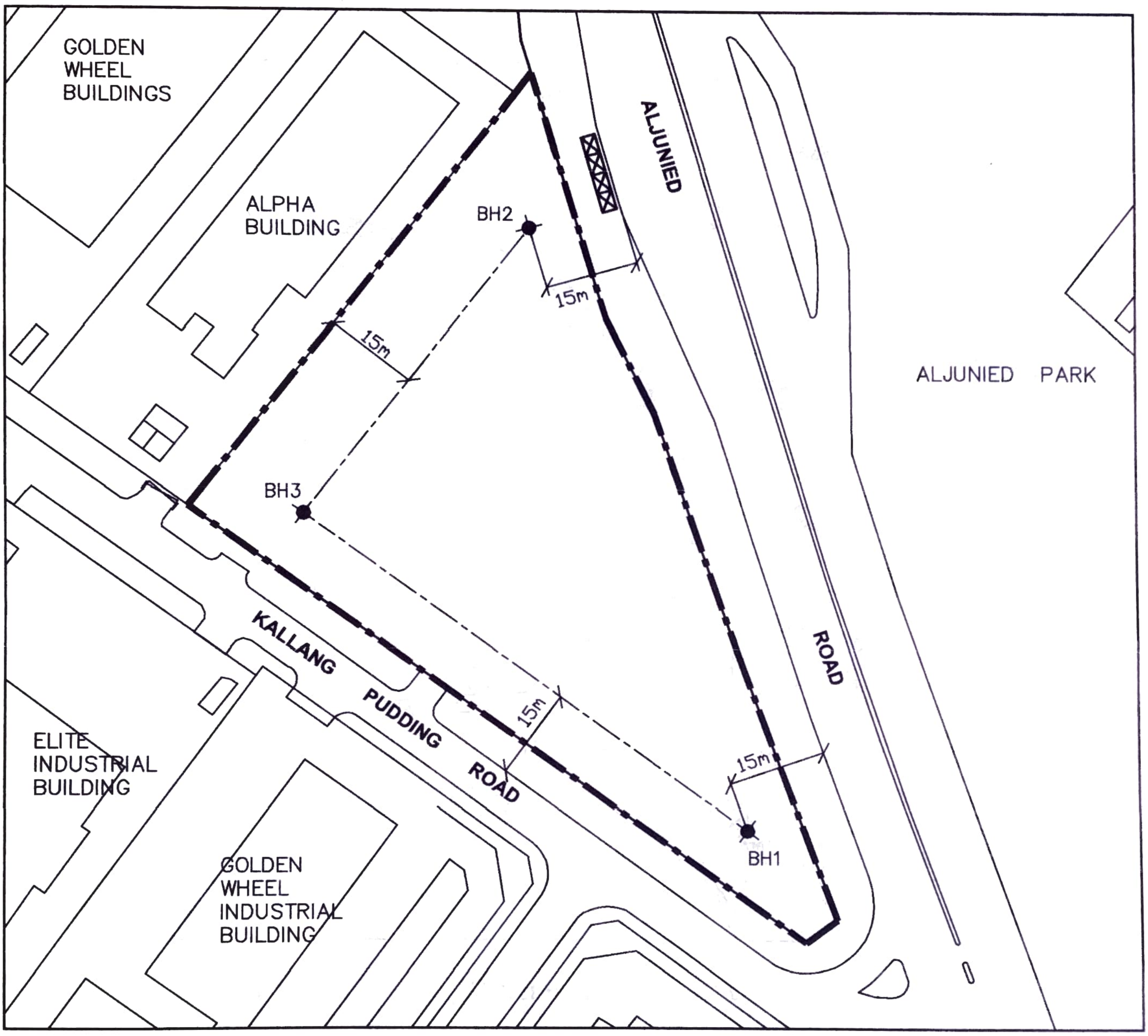


LOCATION PLAN
SCALE: 1:5000



BOREHOLE LOCATION PLAN (Indicative Only)
SCALE: 1:1000

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GEOTECHNICAL ENGINEERING-II

Assignment –I (10/01/2020)

17091A0101 - 17091A0110	a	For a Shelby tube, given outside diameter = 5.08 cm, inside diameter=4.7625 cm find the area ratio of the tube. Is it a good sampling tube?
	b	Determine the factor of safety with respect to cohesion for a submerged embankment 25 m high whose upstream face has an inclination of 45°. The soil has the following properties c= 40 kN/m^3, $\Phi=10^\circ$, γ= 18 kN/m^3. The relevant stability number is equal to 0.108.
	c	Calculate the factor of safety of a slope of infinite extent when slope angle is 20°. The properties of the soil are c= 25 kPa and Φ =20°.
	d	What is earth pressure at rest? Derive an expression for it in terms of Poisson's ratio.
17091A0111 - 17091A0119	a	What are the sources of sample disturbance?
	b	Explain the standard penetration test. Explain the corrections to be applied for standard penetration test N value. Write the limitations of standard penetration test.
	c	State the critical conditions for analysis of earth dam slopes.
	d	A masonry retaining wall of trapezoidal section has its top width equal to 0.75 m and height 5 m. Its face which is in contact with the retained earth is vertical. The earth retained is level at top. The soil weights 16 kN/m^3 and its Φ = 30°. The masonry weighs 24 kN/m^3. Determine the minimum width of the base to avoid tensile stresses and also determine the maximum and minimum compressive stresses for this base width. If the μ between base and soil is 0.60, check the stability of the retaining wall against sliding.
17091A0120 - 17091A0127	a	A slope is to be constructed at an inclination of β=30° with the horizontal. Determine the safe height of slope at a factor of safety of 1.5. The soil has the following properties: c= 15 kN/m^2, Φ=22.5°, and γ= 19 kN/m^3. [For β=30°, Φ=22.5°, Stability Number, S_n=0.02; For β=30°, Φ=15°, Stability Number, S_n=0.046
	b	Determine the factor of safety with respect to cohesion for a submerged embankment 25 m high whose upstream face has an inclination of 45°. The soil has the following properties c= 40 kN/m^3, $\Phi=10^\circ$, γ= 18 kN/m^3. The relevant stability number is equal to 0.108.
	c	Calculate the factor of safety of a slope of infinite extent when slope angle is 20°. The properties of the soil are c= 25 kPa and Φ =20°.
	d	What is earth pressure at rest? Derive an expression for it in terms of Poisson's ratio.
17091A0128 - 17091A0143	a	Describe SPT test. Explain the corrections to be applied for SPT data?
	b	Two test plates are loaded at a site are 60 x 60 cm and 75 x 75 cm. The smaller supports a load of 11450 kgf at 12.5 mm settlement and the larger supports 15,000 kgf at the same settlement. Determine the bearing capacity of a footing 3 m square for a maximum settlement of 12.5 mm.
	c	How a slope is analyzed using Swedish circle method? Derive an expression for the factor of safety.
	d	Stating assumptions, explain the Rankine's earth pressure theory with neat sketch.

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17091A0144 - 17091A0151

a) The number of blows observed in a SPT(Standard Penetration Test) for different penetration depths are given as follows.

Penetration of Sampler	0- 150 mm	150- 300 mm	300- 450 mm
Number of blows	6	8	10

What is the observed N value?

b) Determine the factor of safety with respect to cohesion for a submerged embankment 25 m high whose upstream face has an inclination of 45°. The soil has the following properties c= 40 kN/m³, Φ=10°,γ= 18 kN/m³. The relevant stability number is equal to 0.108.

c) Discuss the stability analysis of earth dam slopes.

d) What is earth pressure at rest? Derive an expression for it in terms of Poisson's ratio.

17091A0154 - 18095A0106

a) A building is proposed in an area having thick deposit of silty clay. The heaviest column in the building is likely to carry a load of 100 tons. Determine the minimum depth of exploration required for foundation design. The unit weight of silty clay is 1.7 g/cc. (Use De Beer's recommendation)

b) Find the factor of safety against sliding for the slope shown in figure using Bishop's simplified method? The weight of each slice is shown in

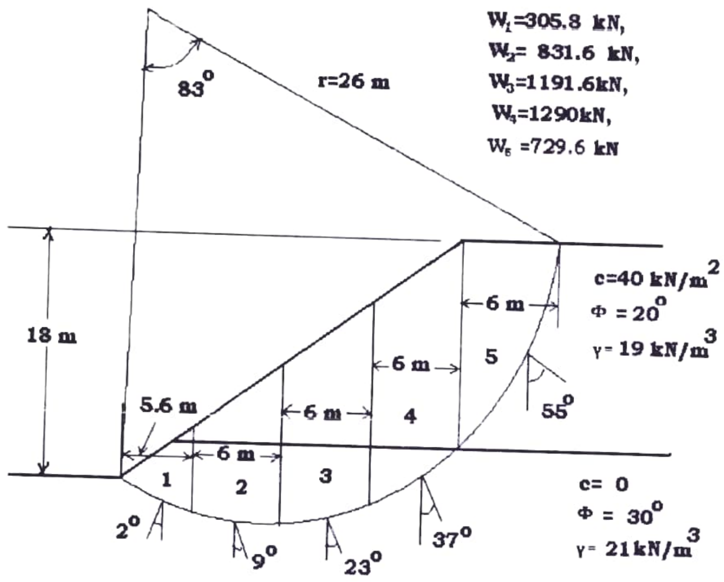

figure.

c) A road side retaining wall is subjected to active lateral earth pressure. The soil has the following properties Φ =45° & γ=18 kN/m³. If the road has a super elevation of 7% and the uniformly distributed surcharge due to moving vehicles is 50 kN/m². Take wall friction δ=15°. Calculate the total active earth pressure exerted on the wall.

d) Explain the standard penetration test. Explain the corrections to be applied for standard penetration test N value. Write the limitations of standard penetration test.

18095A0107 - 18095A0116	a	Describe the SPT. Explain the correction to be applied for SPT data.
	b	A retaining wall with a vertical back 6 m high supports cohesion less backfill (with unit weight 19.6 kN/m^2). The upper surface of the backfill rises at an angle of 10° with the horizontal from the crest of the wall. The angle of internal friction for the soil is 35° and angle of wall friction is 20°. Find the total active earth pressure per meter length of the wall using Rebhann's graphical method and mark the direction, point of application of the resultant earth pressure.
	c	Explain the friction circle method of finding the stability of slope.
	d	An embankment is to be made using a soil with c= 18 kN/m^2, Φ= 10°, and γ = 18.5 kN/m^3. The desired factory of safety with respect to cohesion as well as with respect to friction is 1.4. Find i) the safe height if the desired slope is 2
	e	Clearly explain the difference between the active earth pressure and passive earth pressure. What is meant by the "critical depth of vertical cut" for a soil?
18095A0117 - 18095A0124	a	Explain what is meant by disturbed and undisturbed samples. How the degree of disturbance is measured?
	b	A masonry retaining wall of trapezoidal section has its top width equal to 0.75 m and height 6 m. Its face which is in contact with the retained earth is vertical. The earth retained is level at top. The soil weights 16 kN/m^3 and its Φ = 30°. The masonry weighs 24 kN/m^3. Determine the minimum width of the base to avoid tensile stresses and also determine the maximum and minimum compressive stresses for this base width. If the μ between base and soil is 0.60, check the stability of the retaining wall against sliding.
	c	What is sheet pile wall? Explain the sheet pile wall analysis.
	d	What is bore log? Give a typical example.
	e	Match List -I and List –II. List –I / List –II A) Modulus of sub grade reaction — i) Cyclic pile load test B) Relative density and strength — ii)Pressure meter test C) Skin friction & point bearing resistance — iii)Plate Load test D) Elastic Constants — iv) SPT v) DCPT

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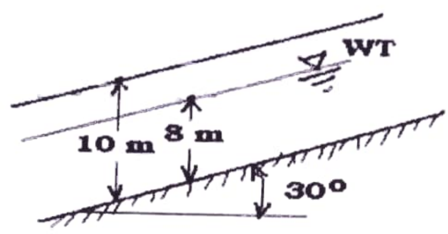
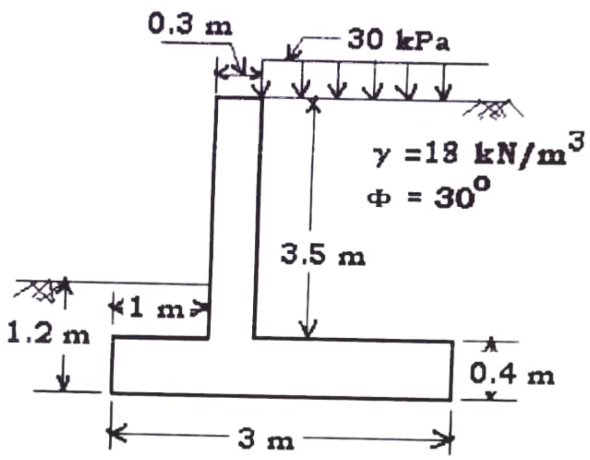
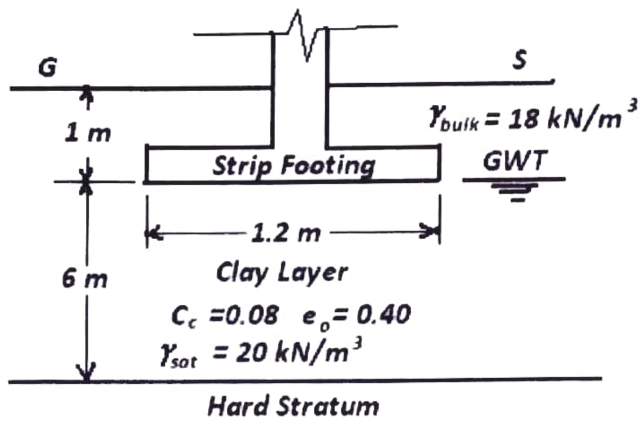
18095A0125 - 16091A0137

a	i) What is boring/bore log? Explain with a neat sketch? ii) Describe the salient features of a good sub-soil investigation report. iii) Two test plates are loaded at a site are 60 x 60 cm and 75 x 75 cm. The smaller supports a load of 11450 kgf at 12.5 mm settlement and the larger supports 15,000 kgf at the same settlement. Determine the bearing capacity of a footing 3 m square for a maximum settlement of 12.5 mm.
b	Find the factor of safety of an infinite slope shown in fig. The properties of the soil are c=o, Φ=35°; γ=16 kN/m³, γ_{sat}=20 kN/m³. 
c	Check the stability of the retaining wall shown in figure. 

GEOTECHNICAL ENGINEERING-II

Assignment –II (06/03/2020)

17091A0101-102	Figure shows the geometry of a strip footing supporting the load bearing walls of a three storied building and the properties of the clay layer. If the pressure acting on the footing is 40kPa, find the consolidation settlement of the footing. If the elastic modulus and the Poisson's ratio of the clay layer are respectively 50 MPa & 0.4 and if the influence factor for the strip footing is 1.75, find the elastic settlement of the footing. 
17091A0103-104	For the design of a shallow foundation, given the following: Soil: ϕ=20°, c=72 kN/m^2 , Unit weight, γ=17 kN/m^3 Modulus of elasticity, E=1020 kN/m^2 , Poisson's ratio, μ=0.0.35 Foundation: L=1.5 m , B=1 m , D_f=1 m. Calculate the ultimate bearing capacity.
17091A0107-110	A concrete pile 20 m long having a cross section of 381 mm×381 mm is fully embedded in a saturated clay layer. For a clay, γ_{sat}=18.5 kN/m^3, ϕ_u=0, and c_u=70 kN/m^2. Assume that the water table lies below the tip of pile. Determine the allowable load that the pile can carry (FS=3). Use the α method to estimate the skin friction.

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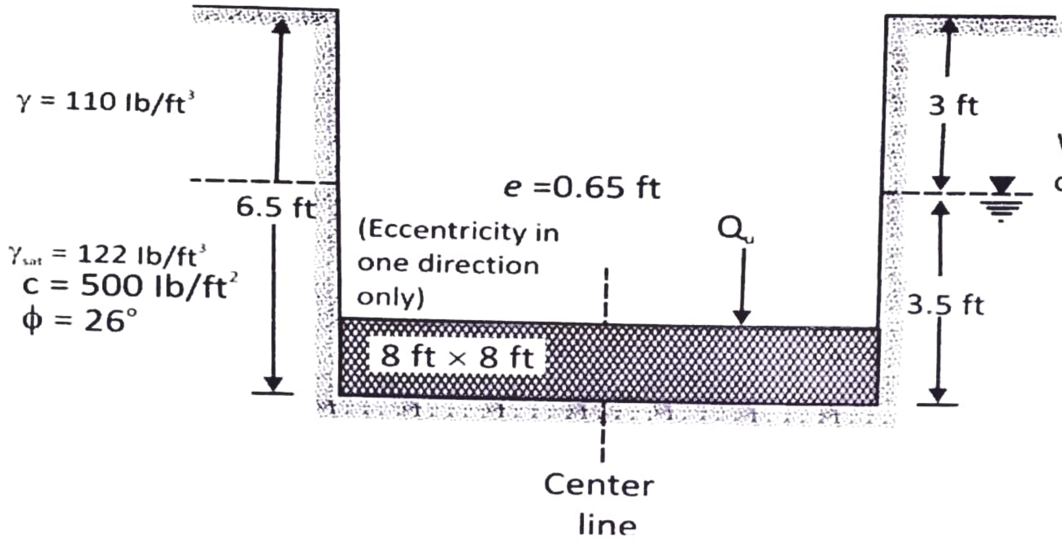
<tr><td>17091A0113-114</td><td>

An eccentrically loaded foundation is shown in figure. Determine the ultimate load, Q_u that the foundation can carry.



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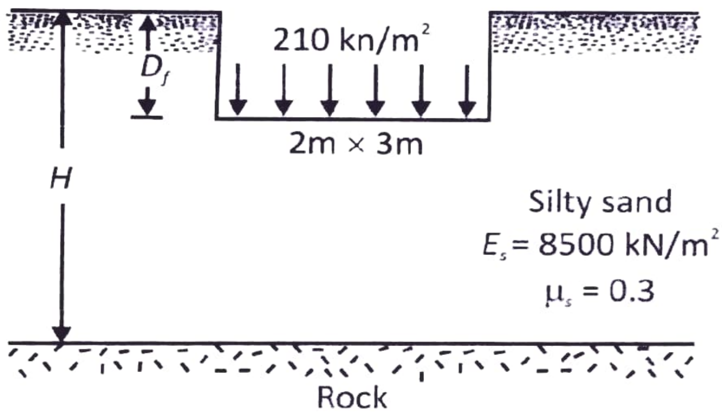
<tr><td>17091A0115-116</td><td>

A flexible load area shown in figure is 2m ×3m in plan and carries a uniformly distributed load of 210 kN/m². Estimate the elastic settlement below the center of the loaded area. Assume D_f=0 and H=∞.



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<tr><td>17091A0118-119</td><td>

Two plate load tests with square plates were conducted in the field. At 1-in. settlement, the results were

<table>
<tr><th>Width of plate (in.)</th><th>Load (lb)</th></tr>
<tr><td>12</td><td>8,070</td></tr>
<tr><td>24</td><td>25,800</td></tr>
</table>

What size of square footing is required to carry a net load of 150,000 lb at a settlement of 1 in.?

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<td>17091A0120-125</td>
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Following are the results of a standard penetration test in the field (sandy soil):
<table>
<tr><th>Depth (m)</th><th>Field value of N</th></tr>
<tr><td>1.5</td><td>9</td></tr>
<tr><td>3.0</td><td>12</td></tr>
<tr><td>4.5</td><td>11</td></tr>
<tr><td>6.0</td><td>7</td></tr>
<tr><td>7.5</td><td>13</td></tr>
<tr><td>9.0</td><td>11</td></tr>
<tr><td>10.5</td><td>13</td></tr>
</table>
Estimate the net allowable bearing capacity of a mat foundation 6.5 m x 5 m in plan. Here, D_f = 1.5 m, and allowable settlement 20 mm. assume that the unit weight of soil γ=16.5 kN/m^3.
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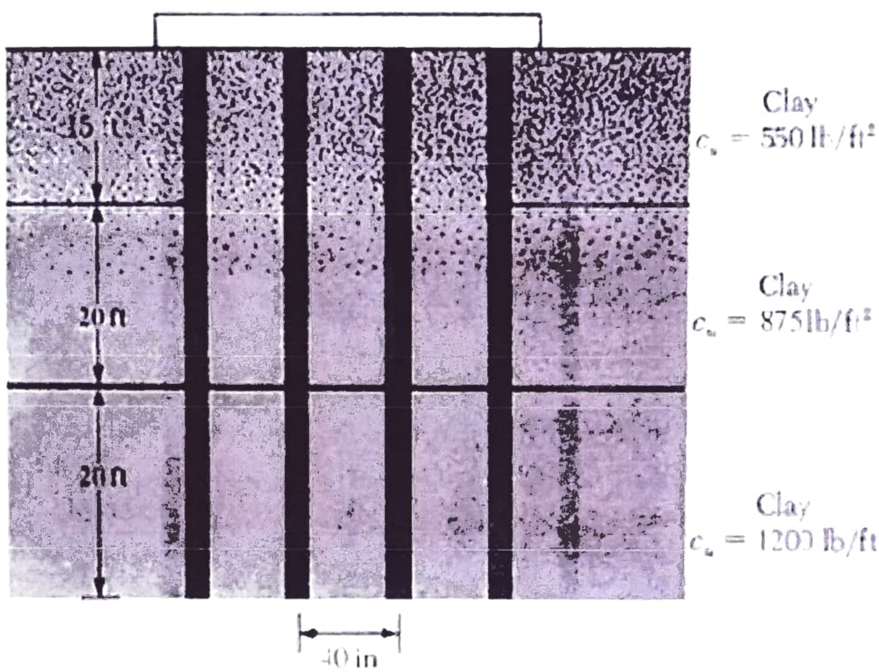
<td>17091A0126 - 127</td>
<td>
The section of a 3×4 group pile in layered saturated clay is shown in figure. The piles are square in cross section (14 *in.*×14 *in.*). the center-to-center spacing (d) of the piles is 40 in. Determine the allowable load-bearing capacity of the pile group. Use *FS*=4.



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17091A0133-139	Explain the methods of estimating the foundation settlements.
17091A0143-146	a) List the methods of estimation of settlements and explain one method briefly stating its utility. b) A 1.8 m side square column is founded at a depth of 1.8 m in sand, for which the corrected N value is 24. The water table is at a depth of 2.7 m. Determine the net allowable bearing pressure for a permissible settlement of 40 mm and with a factor of safety of 3 against shear failure
17091A0147-149	a) A square file group of 9 piles of 25 cm diameter is arranged with a pile spacing of 1 m. The length of piles is 9 m. Unit cohesion of clay is 75 kN/ m^2. Neglecting bearing at the tip of the piles, determine group capacity. Assume adhesion factor of 0.75. b) Classify the pile foundations on the basis of i) material ii) load transfer iii) method of installation.
17091A0150-151	A strip footing of 2 m width is founded at a depth of 4 m below the surround surface. Determine the net ultimate bearing capacity using a) Terzaghi Equation b) Skempton's Equation c) IS code. The soil is clay (Φ=0, c=10KN/m^2). The unit weight of clay is 20 kN/m^3.
17091A0155-18095A0103	Explain what is mean by Tilts and shifts in well foundation. Explain the various methods to rectify the Tilts and shifts. A 3m thick layer of a fill material (γ_{bulk} = 20 kN/m^3) is to be laid instantaneously on the top surface of a 10 m thick clay layer. If the coefficient of volume compressibility (m_v) and saturated unit weight (γ_{sat}) for clay are 2.2 × 10^{-4} m^2/kN and 18 kN/m^3 respectively, calculate the consolidation settlement of the clay layer (in mm) due to placing of fill material. (a) 75 (b) 123 (c) 132 (d) 278

18095A0107-108	What are mat/raft foundation. How do you estimate the bearing capacity and settlement of mat foundations
18095A0115-116	(a) Discuss the various forces acting on a well foundation. (b) Explain the process of sinking of an open well. c) A soft normally consolidated clay layer is 8 m thick with natural moisture content of 45%. The clay has saturated unit weight 18.0 kN/m^3, a particle specific gravity of 2.7, and a liquid limit of 65%. A foundation will subject the middle of the clay layer to a vertical stress increase of 15 kN/m^2. Determine the approximate value of the consolidation settlement of the foundation (in mm) if the ground water table is at the ground level. Take unit weight of water is 10 kN/m^3. (a) 448 (b) 355 (c) 322 (d) 298
18095A0117-118	a) What is the basis on which the dynamic formulae are derived? Mention two well known dynamic formulae and explain the symbols involved? (b) A 4x4 pile group in square pattern consists of 400mmx400mmx20m long concrete piles placed at 1.0m centers. The soil profile consists of 8m of soft clay (c=25 kPa, adhesion factor = 0.9) underlain by 20m of medium silty clay (c=50kPa, adhesion factor = 0.8). Estimate the safe bearing capacity of the pile group with a factor of safety of 3.0.
18095A0 119-121	(a) What are the limitations of plate load test? (b) A square footing is required to carry a net load of 1200 kN. Determine the size of the footing if the depth of foundation is 2m and tolerable settlement is 40mm. The soil is sandy with N=12, F.S=3, water table is very deep. Use Teng's equation.
18095A0122-123	a) Define gross pressure intensity at the base of the foundation and safe bearing capacity of soil. b) Differentiate between strip footing, combined footing, strap footing and mat foundation. c) Find the group efficiency of 4x3 pile group with 2 m spacing and diameter 0.5 m using Converse Laborre formula. d) A 30 cm diameter pile is driven 10 m into a homogeneous consolidated clay deposit. Find the safe load when the factor of safety is 2.5, unit cohesion is 40 kN/m^2 and adhesion factor is 0.70. e) List the methods commonly used for calculation of settlement of foundations.

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18095A0124-126	a) Explain the estimation of settlement from Meyerhof's method and De Beer method for cohesionless soils. b) A 1.8 m side square column is founded at a depth of 1.8 m in sand, for which the corrected N value is 24. The water table is at a depth of 2.7 m. Determine the net allowable bearing pressure for a permissible settlement of 40 mm and with a factor of safety of 3 against shear failure.
17091A0162-163	a) List the factors affecting the bearing capacity of foundations. b) Classify the pile foundations. c) A 30 cm diameter pile is driven 10 m into a homogeneous consolidated clay deposit. Find the safe load when the factor of safety is 2.5, unit cohesion is 40 kN/m^2 and adhesion factor is 0.70. d) Find the group efficiency of 4x3 pile group with 2 m spacing and diameter 0.5 m using Converse Laborre formula. e) With sketch explain negative skin friction.
17091A0164-165	a) Estimate the gross and net safe bearing capacity of 2.5 m x 3.5 m footing placed at a depth of 1.7 m on a strata of soil of unit weight 20 kN/m^2. The depth of water table is 1.2 m from the ground level. Assume soil properties c= 3 kN/m^2, and $\phi = 27^{\circ}$. Assume General shear failure. (N_c= 27, N_q= 13.2, N_γ= 9.3). b) A square column foundation has to carry a gross allowable load of 1805 kN (FS=3). Given: D_f=1.5 m,=15.9 kN/m^3, ϕ=34°, and c=0. Use Terzaghi's equation to determine the size of the foundation (B). Assume general shear failure. (N_c= 27, N_q= 13.2, N_γ= 9.3).
17091A0166-176	a) A strip footing 1.2 m wide is located at a depth of 1.5 m in a non-cohesive soil deposit for which the corrected N value of SPT is 20. Water table is located at depth of 2 m below the ground surface. Find allowable bearing pressure for the soil. b) Static cone penetration test was conducted in dry sand formation and the average cone resistance was found to be 50 kg/cm^2. Estimate the safe bearing pressure for the strip footing of width 1.5 m and depth 1.5 m for a permissible settlement of 25 mm. use factor of safety of 3 for shear failure. The soil has a unit weight of 17 kN/m^3.
17091A0180-182	a) Discuss the various remedial measures that can be adopted to rectify the tilts in a well foundation. (b) A concrete pile 20 m long having a cross section of 381 mm×381 mm is fully embedded in a saturated clay layer. For a clay, γ_{sat}=18.5 kN/m^3, ϕ=0, and c_u=70 kN/m^2. Assume that the water table lies below the tip of pile. Determine the allowable load that the pile can carry (FS=3). Use the α method to estimate the skin friction.

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17091A0183-188	a) Discuss the various methods of estimating pile capacity. b) a) A square file group of 9 piles of 25 cm diameter is arranged with a pile spacing of 1 m. The length of piles is 9 m. Unit cohesion of clay is 75 kN/ m^2. Neglecting bearing at the tip of the piles, determine group capacity. Assume adhesion factor of 0.75. c) The following data are given for the laboratory sample: $\sigma_o' = 160$ kPa; $e_o = 1.1$; $\sigma_o' + \Delta\sigma_o' = 300$ kPa; $e = 0.8$ If the thickness of the clay specimen is 45 mm, the value of coefficient of volume compressibility is __________ $\times 10^{-4}$ m^2 /kN. (a) 12.3 (b) 10.2 (c) 9.4 (d) 8.6
17091A0193-199	a) List the factors affecting the bearing capacity of foundations? b) A 30 cm diameter pile is driven 10 m into a homogeneous consolidated clay deposit. Find the safe load when the factor of safety is 2.5, unit cohesion is 40 kN/ m^2 and adhesion factor is 0.70. c) Differentiate between strip footing, combined footing, strap footing and mat foundation. d) List the methods commonly used for calculation of settlement of foundations. e) With sketch explain negative skin friction.
17091A01A3-1A5	a)A concrete pile 20 m long having a cross section of 381 $mm \times 381$ mm is fully embedded in a saturated clay layer. For a clay, γ_{sat}=18.5 kN/m^3, ϕ_u=0, and c_u=70 kN/m^2. Assume that the water table lies below the tip of pile. Determine the allowable load that the pile can carry (FS=3). Use the α method to estimate the skin friction. b) Explain what is mean by Tilts and shifts in well foundation. Explain the various methods to rectify the Tilts and shifts. c) Determine the ultimate load in kN which an eccentrically loaded square footing of 3 m size with an eccentricity of 0.3 m (in one-direction) can take when placed at a depth of 1.0 m in a soil with γ = 18 kN/ m^3 , c = 12 kN/ m^2, Φ =30°, N_c= 37.2, N_q=22.5 and N_γ=19.7. Ignore water table and use Terzaghi's theory.

17091A01A6-1A9	a) A 2.5 square footing is located in a dense sand at a depth of 1.5m, the shear strength parameters being c'=0, d'=38°. Determine the Ultimate bearing capacity for the following water table conditions. a) At ground surface b) At 1m below the ground surface c) At footing level d) At 0.5m below the footing, and at a depth greater than B below the footing. The moist unit weight of sand above water table is 18KN/m³ and the saturated unit weight is 20KN/m³. For d'=38°, N_q=48.9, N_r=58.9. b) A layer of normally consolidated, saturated silty clay of 10 m thickness is subjected to one dimensional consolidation under a pressure increment of 5 kPa. The properties of the soil are: initial void ratio (e_0) =1.325, compression index (C_c) = 0.45. The initial average effective stress within the layer is 50 kPa. Assuming Terzaghi's theory to be applicable, the primary consolidation settlement (rounded off to the nearest mm) is (a) 60 (b) 80 (c) 100 (d) 160
18095A0127-128	a) Discuss the various methods of estimating pile capacity. b) A square footing 2.5 m x 2.5 m carries a load of 2000 kN. Find the factor o safety against bearing failure, if the soil below the foundation has following values- c= 50 kN/m², ϕ = 15°, γ = 17.5 kN/m³ and foundation is taken to a depth of 1.5 m. Take N_c= 12.5, N_q= 4.5, N_γ= 2.5. c)
18095A0129-130	a) Explain the estimation of settlement from Meyerhof's method and De Be method for cohesionless soils. b) A 1.8 m side square column is founded at a depth of 1.8 m in sand, for whi the corrected N value is 24. The water table is at a depth of 2.7 m. Determi the net allowable bearing pressure for a permissible settlement of 40 mm with a factor of safety of 3 against shear failure. c) An isolated footing has a size 6 m × 6 m founded at a depth of 3 m below the ground level in medium dense sand. The footing is subjected to a vertical load at an eccentricity of $B/10$ along one of the axis. Using Meyerhof's expression, estimate the ultimate load Q_{ult}. $\phi = 33°$, γ =18.5 kN/m³, N_q = 26.3, N_γ = 26.55, $s_\gamma = s_q$ = 1.27, $d_\gamma = d_q$ = 1.115, c = 0. Neglect the water table effect. (a) 107.6 MN (b) 165.5 MN (c) 213.5 MN (d) 134.5 MN

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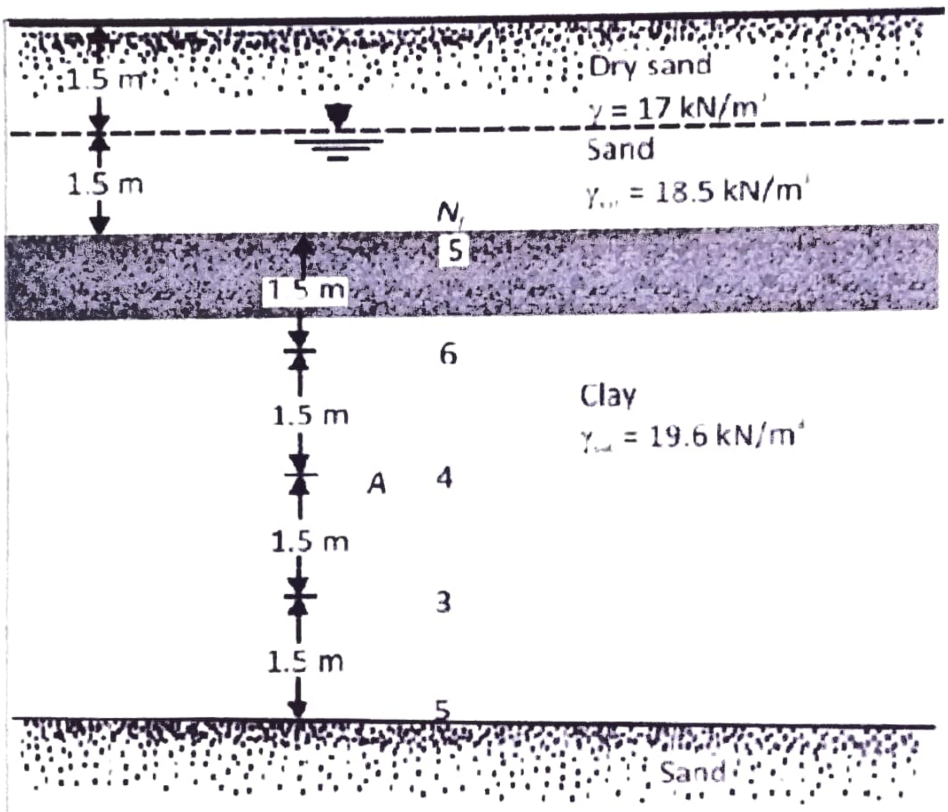
18095A0131-135	A soil profile is shown in figure along with the standard penetration numbers in the clay layers. Determine and plot the variation of c_u and OCR with depth. Hara et al. (1971) also suggested that $c_u(kN/m^2) = 29N^{0.72}$ $$OCR = 0.193\left(\frac{N}{\sigma'_v}\right)^{0.689}$$ Where σ'_v = effective vertical stress in MN/m^2 
18095A0137-138	a) Enumerate and reflect through sketches **the various** components of a foundation well. Discuss briefly the function and design of each of these components. b) Discuss the various remedial measures that can be adopted to rectify the tilts in a well foundation

18095A0141-142

1. A strip footing of width 1.0 m is resting on a soft clay strata at a depth of 1.0 m. The angle of internal friction is aero, and cohesion is 20 kN/mm². The water table is at a great depth. Find the ultimate bearing capacity of soil according to Terzaghi's equation.
2. A rectangular footing 1 m x 2 m is placed at a depth of 2 m in a saturated clay having an unconfined compressive strength of 100 kN/m². According to Skempton, find the net ultimate bearing capacity.
3. The ultimate bearing capacity of a soil is 300 kN/m² and unit weight of soil is 20 kN/m³. Find the net safe bearing capacity at 1 m below the ground surface taking a FOS = 2.5.
4. Name the two criteria for the determination of allowable bearing capacity of a foundation.

18095A0143-147

5. Two footings one circular and the other square, are founded on the surface of a purely cohesionless soil. The diameter of the circular footing is same as that of the side of the square footing. Find the ratio of their Ultimate bearing loads as per IS 6403-1981.
6. What uniform surcharge intensity should be applied to have zero active pressure intensity at the tip of a wall in a cohesive soil.
7. The width and depth of a footing are 2 and 1.5 m respectively. The water table at the site is at a depth of 3 m below the ground level. Find the water table correction factor for the calculation of bearing capacity of the soil in third term in bearing capacity equation.
8. Two circular footings of diameters D_1 and D_2 are resting on the surface of the same purely cohesive soil. Find the ratio of their gross ultimate bearing capacities.

18095A0148-149

2. a) Estimate the gross and net safe bearing capacity of 2.5 m x 3.5 m footing placed at a depth of 1.7 m on a strata of soil of unit weight 20 kN/m². The depth of water table is 1.2 m from the ground level. Assume soil properties c= 3 kN/m², and ϕ = 27°. Assume General shear failure. (N_c= 27, N_q= 13.2, N_γ= 9.3).

b) A square column foundation has to carry a gross allowable load of 1805 kN (*FS*=3). Given: D_f=1.5 m,=15.9 kN/m³, ϕ=34°, and c=0. Use Terzaghi's equation to determine the size of the foundation (*B*). Assume local shear failure.

Φ	N_c	N_q	N_γ	N_q / N_c		Φ	N_c	N_q	N_γ		
19	13.93	5.80	4.68	0.42	0.34	45	133.88	134.88	271.76	1.01	1.00
20	14.83	6.40	5.39	0.43	0.36	46	152.10	158.51	330.35	1.04	1.04
21	15.82	7.07	6.20	0.45	0.38	47	173.64	187.21	403.67	1.08	1.07
22	16.88	7.82	7.13	0.46	0.40	48	199.26	222.31	496.01	1.12	1.11
23	18.05	8.66	8.20	0.48	0.42	49	229.93	265.51	613.16	1.15	1.15
24	19.32	9.60	9.44	0.50	0.45	50	266.89	319.07	762.89	1.20	1.19
25	20.72	10.66	10.88	0.51	0.47						

[a] After Vesic (1973)

18095A0150	a) A 20 m thick clay layer is sandwitched between a silty sand layer and a gravelly sand layer. The layer experiences 20 mm settlement in 2 years. Given $T_v = \begin{cases} \frac{\pi}{4}\left(\frac{U}{100}\right)^2 & for\ U \leq 60\% \\ 1.781 - 0.933 log_{10}(100 - U) & for\ U > 60\% \end{cases}$ If the coefficient of consolidation of the layer is 0.003 cm^2/s, find the time in years for 30 mm settlement. b) A 3 m thick layer of a fill material (γ_{bulk}=20 kN/m^3) is to be laid instantaneouly on the top surface of a 10 m thick clay layer. If the coefficient of volume compressibility (m_v) and saturated unit weight (γ_{sat}) for clay are 2.2 x 10^{-4} m^2/kN and 18 kN/m^3 respectively, calculated the consolidation settlement of the clay layer(in mm) due to placing of fill material.

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J. Chandrakala
17091A0110
Civil-3A

GEOTECHNICAL ENGINEERING -II

ASSIGNMENT-II

17091A0107-110	A concrete pile 20 m long having a cross section of 381 $mm \times 381$ mm is fully embedded in a saturated clay layer. For a clay, γ_{sat}=18.5 kN/m^3, ϕ_u=0, and c_u=70 kN/m^2. Assume that the water table lies below the tip of pile. Determine the allowable load that the pile can carry (FS=3). Use the α method to estimate the skin friction.

Sol:-

Given data,

$l = 20m$

Size = 381mm x 381mm

= 0.381 x 0.381

γ_{sat} = 18.5 kN/m3

c_u = 70kN/m²

ϕ_u = 0

FS = 3

✓ 16/3/2° (u/c)

$q_{allowable} = N_c C_u A_p$

N_c = Bearing capacity

Depends $(B/B \le 5.0)$ value factor

$q_a = 9 \times 70 \times (0.381 \times 0.381)$

Skin friction = $\alpha \bar{c} A_B$

$= 1 \times 70 \times 4 \times 0.381 \times 20 = 2133.6$ kN

Here, $\alpha = 1$ α why 1?   use appropriate α

$q_u = N_c \times C_u \times A_p + \alpha \bar{c} A_s$

$= 9 \times 70 \times (0.381 \times 0.381) + 2133.6$

$= 2225.05$ kN

$$q_a = \frac{2225.05}{3} = 741.6 \text{ kN.}$$

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III B. Tech. II-Semester(R15) MID – I Examinations

Geotechnical Engineering – II

CE

Max. Marks: 25 **Date: 28.01.2020** Set: A **Time: 2 Hours**

Note: 1.Answer FIRST question compulsorily. (5 x 2 = 10Marks)

2. Answer Any *THREE* from 2 to 5 questions. (3 x 5 = 15 Marks)

Q.1	a)	For a Shelby tube, given outside diameter = 5.08 cm, inside diameter=4.7625 cm find the area ratio of the tube. Is it a good sampling tube?	2M	CO4
	b)	Determine the factor of safety with respect to cohesion for a submerged embankment 25 m high whose upstream face has an inclination of 45°. The soil has the following properties c= 40 kN/m², Φ=10°, γ= 18 kN/m³. The relevant stability number is equal to 0.108.	2M	CO5
	c)	Calculate the factor of safety of a slope of infinite extent when slope angle is 20°. The properties of the soil are c= 25 kPa and Φ =20°.	2M	CO5
	d)	What is earth pressure at rest? Derive an expression for it in terms of Poisson's ratio.	2M	CO1
	e)	What are the sources of sample disturbance?	2M	CO4
Q.2	a)	Explain the standard penetration test. Explain the corrections to be applied for standard penetration test N value. Write the limitations of standard penetration test.	2M	CO4
	b)	Explain the plate load test with neat sketch. How do you estimate the settlement and bearing capacity from plate load test?	3M	CO4
Q.3	a)	Explain the Culmann's method for the determination active earth pressure with neat sketch.	2M	CO1
	b)	A masonry retaining wall of trapezoidal section has its top width equal to 0.75 m and height 5 m. Its face which is in contact with the retained earth is vertical. The earth retained is level at top. The soil weights 16 kN/m³ and its Φ = 30°. The masonry weighs 24 kN/m³. Determine the minimum width of the base to avoid tensile stresses and also determine the maximum and minimum compressive stresses for this base width. If the μ between base and soil is 0.60, check the stability of the retaining wall against sliding.	3M	CO1
Q.4	a)	How a slope is analyzed using Swedish circle method? Derive an expression for the factor of safety.	2M	CO5
	b)	Find the factor of safety against sliding for the slope shown in figure using Bishop's simplified method? The weight of each slice is shown in figure.	3M	CO5

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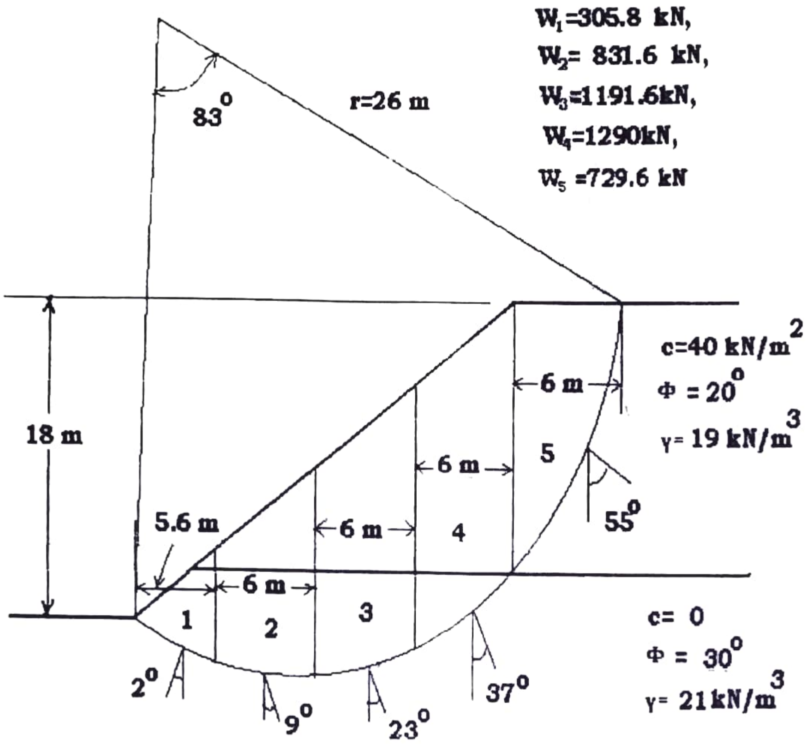

Q.5 a) A 4 m wall retains a dry sand backfill with unit weight of 18.3 kN/m³, angle of internal friction of 36° and a porosity of 31%. The backfill is fully drained through weep holes. 5M CO1

a) What is the magnitude of the backfill force on a 1 m wide slice of wall, if it is not allowed to deflect?
b) What is the magnitude of the backfill force on the same 1 m wide slice, if the wall does deflect enough to develop a Rankine's active earth pressure condition?
c) What is the new force on the wall, and its location from its heel, if the wall's weep holes are clogged and the water table now rises to within 1 m of the ground surface behind the wall?

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III B.Tech II Semester (R18) Mid-I Examinations

GEOTECHNICAL ENGINEERING-II

CE

Scheme & Valuation

C. KRISHNAMA RAJU

1 a) Shelby Tube $D_0 = 5.08$ cm $D_i = 4.7625$ cm

Area Ratio, $A_r = \frac{D_0^2 - D_i^2}{D_i^2} \times 100 = \frac{3.125}{22.681} \times 100 = 13.78\%$.

According Hvorslev, A_r for good sample $A_r \le 10\%$. Hence according him, it is not a good sample. But Practicing engineers consider upto 15% as good sample. — 2M

b) $H = 25$ m, $\beta = 45°$, $c = 40$ kN/m^2, $\phi = 10°$, $\gamma = 18$ kN/m^3

$S_n = 0.108$ Using Taylor's stability number, for submersed slope

$$F_c = \frac{c}{S_n \gamma' H} = \frac{40}{0.108 \times 8.19 \times 25} = 1.809$$ — 2M

$\gamma' = 18 - 9.81 = 8.19$

c) Infinite slope, $\beta = 20°$, Soil Properties $c = 25$ kPa, $\phi = 20°$

$$F = \frac{c'}{\gamma z}\frac{\sec^2\beta}{\tan\beta} + \frac{\gamma'}{\gamma_{sat}}\frac{\tan\phi}{\tan\beta} \quad \text{or} \quad = \frac{c'l + (W\cos\theta - ul)\tan\phi}{W\sin\beta}$$

Assuming partially saturated soil.n pore water pressure zero

$$F = \frac{c'}{\gamma z}\frac{\sec^2\beta}{\tan\beta} + \frac{\tan\phi'}{\tan\beta} = \frac{25}{\gamma z} \times \frac{\sec^2 20}{\tan 20°} + \frac{\tan 20°}{\tan 20}$$

$$= \frac{77.8}{\gamma z} + 1$$

Assuming $\gamma = 18$ kN/m^3 & $z = 10$ m — 2M

$$F = \frac{77.8}{18 \times 10} + 1 = 1.432$$

d) The horizontal pressure in a natural or artificially placed soil deposit which is not subjected to lateral yield is called lateral earth pressure at rest. We can write $\sigma_h' = K_0 \sigma_v'$, K_0 = coefficient of earth pressure at rest.

A theoretical expression of K_0 for an isotropic, homogeneous material can be obtained from the condition of zero lateral strain...

$$\epsilon_h = \frac{1}{E}\left[\sigma_h' - \nu(\sigma_v' + \sigma_h')\right]$$

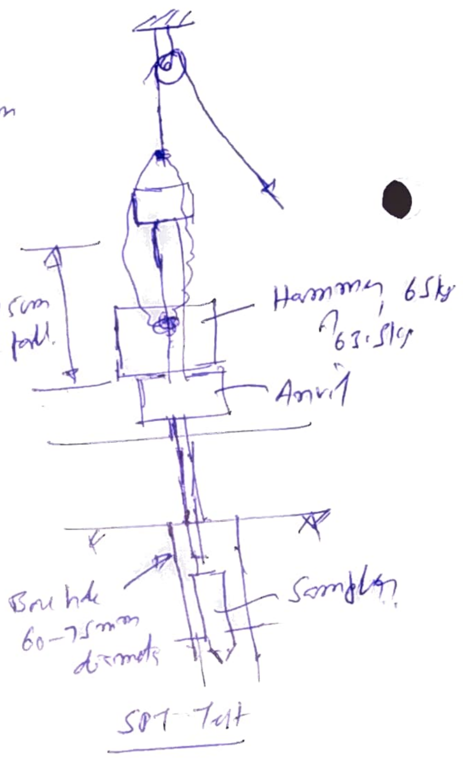
$$\therefore \sigma_h' = \frac{\nu}{1-\nu}\sigma_v' = K_0 \sigma_v' \quad , \quad \nu = \text{Poisson's ratio}$$ — 2M

e) The disturbance to the soil samples is generally caused by the following

i) Method of advancing the bore hole
ii) Mechanism used to advance the sampler
iii) dimension and type of the sampler
iv) Procedure followed in sampling / boring.
v) Stress relief in soil.

2 a) SPT test is performed in a cased or uncased bore hole, 60-75 mm diameter. A split spoon sampler (50 mm OD and 35 mm ID and about 650 mm length) attached to a string of drill rods (A-type rods 41.27 mm OD 28.57 mm ID) is lowered to the bottom of the bore hole and allowed to rest under self weight. The drill rods are connected to the drive assembly which consists of hoisting equipment, a drive mass of 65 kg and a guide to ensure a 750 mm free fall of hammer on anvil.

The sampler is driven into the soil through a 450 mm, recording no. of blows for each 150 mm penetration. The number of blows for last 300 mm penetration is recorded as the N value.



Correction to SPT test:

i) overburden correction:

$N' = C_n N$, C_n = over burden pressure correction

$C_n = 0.77 \log \frac{2000}{\sigma_0}$, σ_0 in kPa.

ii) submergence correction

$N'' = 15 + \frac{1}{2}(N' - 15)$

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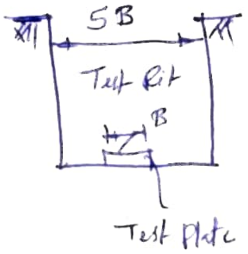
3 2b) Plate Load test



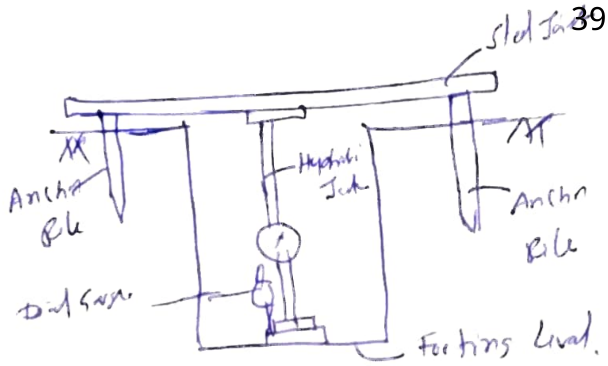


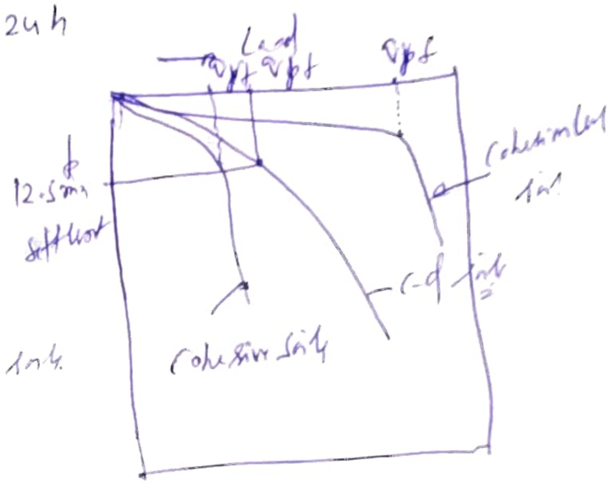
Plate load test with reaction loading.

A seating load 70 g/cm² & settlement recorded.

Test load applied: In increments of $\frac{1}{5}$ of estimated allowable bearing (q_a) capacity. But not more than 10t upto max of $1\frac{1}{2}$ q_a.

Settlement recorded by two dial gauges for each load increment at intervals of 1, 4, 10, 20, 40, 60 min and thereafter at hourly intervals.

clayey soils: min load increment time 24h



For extrapolating the load test result to prototype footing

$$q_{uf} = q_{pf} \quad \text{— For clays}$$

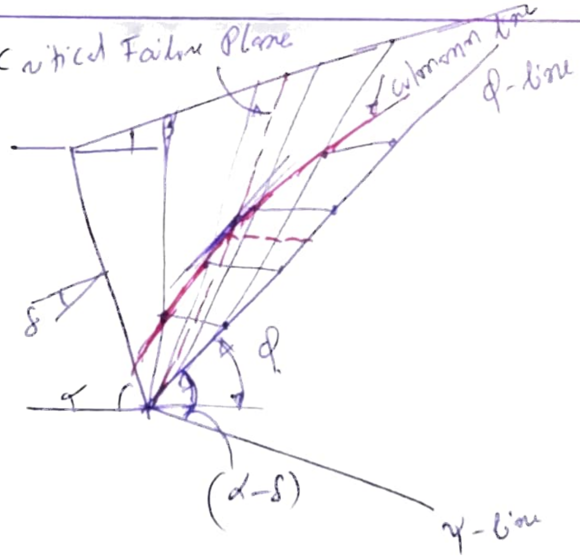
$$q_{uf} = q_{pf}\left(\frac{B_f}{B_p}\right) \quad \text{For cohesionless soils}$$

Estimation of settlement:

For clays $S_f = S_p\left(\frac{B_f}{B_p}\right)$

For cohesionless soils, $S_f = S_p\left[\frac{B_f(B_p+0.3)}{B_p(B_f+0.3)}\right]^2$ — 3M

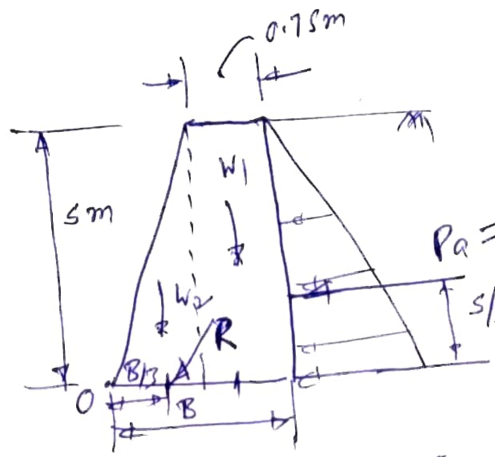
3 a)



3 b) $\phi = 30°$, $\gamma = 16\ kN/m^3$

$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1}{3}$

$\gamma_m = 24\ kN/m^3$



$P_a = \frac{1}{2}\times\frac{1}{3}\times 16\times 5^2 = 66.67\ kN/m$

$W_1 = 0.75\times 5\times 1\times 24$
$= 90\ kN/m$

$R_v = W_1 + W_2 = 60B + 45$

$W_2 = \frac{1}{2}\times 5\times(B-0.75)\times 24 = 60x = 60B - 45$

For no tension, R should pass through B/3 from O. (for minimum B)
$e = B/6$

Applying Principle of moments

$\Sigma M_O^R = \Sigma M_O^F \Rightarrow$ or $\sigma = \frac{V}{B}\left(1 \pm \frac{6e}{B}\right)$

$(60B+45)\ B/3 = (60B-45)\times\frac{2}{3}(B-0.75) + 90(B-0.375)$
$- 66.67\times 1.6667$

$20B^2 + 15B = (40B-30)(B-0.75) + 90B - 33.75 - 111.12$
$= 40B^2 - 60B + 22.5 + 90B - 144.87$

$20B^2 + 15B - 122.37 = 0 \quad \therefore B = \frac{-15 \pm 100.073}{40} = 2.13m$

$R_v = 60\times 2.13 + 45 = 172.8\ kN/m$

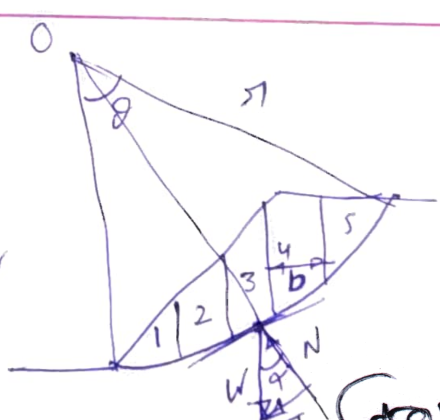
Factor of Safety against sliding, $F_s = \frac{\mu R_v}{R_h} = \frac{0.6\times 172.8}{66.67} = 1.55 > 1.5$

$\therefore$ Safe against sliding

$\sigma_{min} = 0$, $\sigma_{max} = \frac{172.8}{2.13}(1+1) = 162.25\ kN/m^2$

— 3M

4 a) Swedish Circle Method:



The slope is divided into number of slices. Taking moments about the center of rotation for all the restoring forces and sliding forces.

Factor of Safety, $F = \frac{\text{Restoring moment}}{\text{Sliding Moment}}$

$= \frac{c\,b\sec\alpha + \Sigma W\cos\alpha\tan\phi}{\Sigma W\sin\alpha} = \frac{c\,r\theta + \Sigma N\tan\phi}{\Sigma T}$

b) The factor of safety for the slope by Bishop's simplified method is given by the expression

$$F = \frac{1}{\Sigma W \sin\theta} \Sigma \left[\frac{\{c'b + W(1-r_u)\tan\phi'\}\sec\theta}{1 + (\tan\theta \tan\phi')/F} \right] \quad \leftarrow \text{Expn}$$

From the given figure $b_i = 6m$, for first slice $b_1 = 5.6\ m$, ϕ_1 to $\phi_4 = 30°$, $\phi_5 = 20°$

$c = 40\ kN/m^2$, $c'b_5 = 240\ kN$, $u = 0$, $r_u = 0$

Slice No	θ	W kN	W sinθ kN	Expn value F = 1.0	F = 1.25	F = 1.32	F = 1.326	c'b + W tanφ'	× secθ
1	-2	305.8	-10.67	180.28	179.55	179.34	179.38	176.55	176.65
2	9	831.6	130.09	445.37	452.96	454.61	454.74	480.12	486.10
3	23	1191.6	465.60	600.27	624.87	630.35	630.80	687.97	747.38
4	37	1290	776.34	649.84	691.78	701.40	702.17	744.78	932.56
5	55	729.6	597.65	579.94	622.53	632.38	633.19	505.55	881.40
	Σ		1959.01	2455.7	2571.69	2598.08	2600.28		

$$F = \frac{2455.7}{1959.01} = 1.25$$

$$F = \frac{2571.69}{1959.01} = 1.32$$

$$F = \frac{2598.08}{1959.01} = 1.326$$

$$F = \frac{2600.28}{1959.01} = 1.327$$

$\therefore F = 1.327 \simeq 1.33$

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III B. Tech. II-Semester mid II *Examinations*

GEOTECHNICAL ENGINEERING-II (A0118156)

(Civil Engineering)

Max. Marks: 25 **Date: 16-11-2020** **Time: 2 Hours**

Note: 1. Answer **first** question compulsory. (2 x 5 = 10Marks)

2. Answer any *three* from 2 to 5 questions (5 x 3 = 15Marks)

Q.1	a)	Define ultimate bearing capacity?	**2M**	**CO3**
	b)	What are the conditions where pile foundation is more suitable than a shallow foundation?	**2M**	**CO2**
	c)	What do you understand by grip length?	**2M**	**CO2**
	d)	Sketch the pressure distribution beneath a rigid footing on cohesive soils and cohesion less soils?	**2M**	**CO3**
	e)	Define safe bearing capacity?	**2M**	**CO3**
Q.2		Explain the effect of water table on the bearing capacity of soil.	**5M**	**CO3**
Q.3		A strip footing 2m wide is to be laid at a depth of 4m in a purely cohesive soil ($C = 150kN/m^2$; $\gamma = 19kN/m^3$). Determine the ultimate bearing capacity from: (i) Terzaghi's theory (ii) Skempton's theory.	**5M**	**CO3**
Q.4	a)	What are the different types of settlements which can occur in a foundation? How are these estimated?	**2M**	**CO3**
	b)	Using Terzaghi's Theory determine the ultimate bearing capacity of a strip footing 1.5m width resting on a saturated clay ($C_u = 30kN/m^2$, $\phi = 0$, $\gamma_{sat} = 20kN/m^3$) at a depth of 2m from the ground level. If the W.T rises by 1m. Calculate the % Reduction in the ultimate bearing capacity. Depth of water not given	**3M**	**CO3**
Q.5	a)	Write brief critical note on engineering news formula.	**2M**	**CO2**
	b)	A pile group consists of 9 friction piles of 30cm diameter and 10m length driven in clay ($C_u = 100kN/m^2$, $\gamma = 20kN/m^3$), the c/c spacing between the piles is 0.75m, Determine the safe load for the group ($FS = 3, \alpha = 0.6$)	**3M**	**CO2**

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RGMCET (Autonomous), Nandyal

III B.Tech II Semester Mid-II Examination

16/11/2020 Geotechnical Engineering - II (CE)

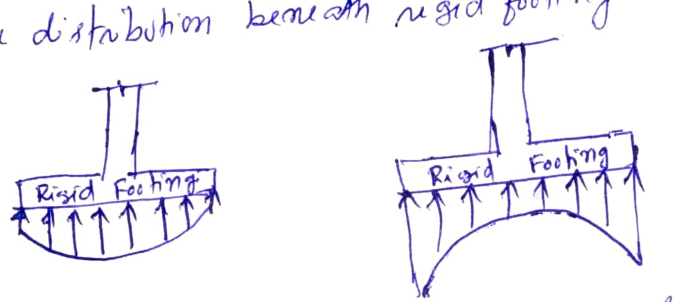
Scheme of Valuation

1 a) Ultimate Bearing Capacity: Maximum pressure the soil can withstand without shear failure.

b) Pile foundations are more suitable i) where the structures are large & heavy. ii) soil underlying is weak. iii) where settlement issues are common due to soil liquefaction or water table.

c) Grip Length: The depth of well foundation, below the lowest scour level is known as the grip length. Well foundation should be provided with adequate grip length such the required passive resistance of the soil on the rear side of the well is generated to resist lateral loads.

d) Pressure distribution beneath rigid footing



Cohesionless Soil   Cohesive Soil

e) Safe bearing capacity: Ultimate bearing capacity divided by factor of safety or The maximum gross pressure, the soil can carry safely without shear failure.

2. Terzaghi's Bearing Capacity equation for strip footing

$$q_f = cN_c + \gamma D_f N_q + \frac{1}{2}\gamma B N_\gamma$$

Effect is on c & φ, γ. But effect on c & φ is small hence ignored. But effective unit weight γ' is roughly half γ_{sat}, hence ≈ 50% reduction in the value of the corresponding term in Bearing capacity formula.

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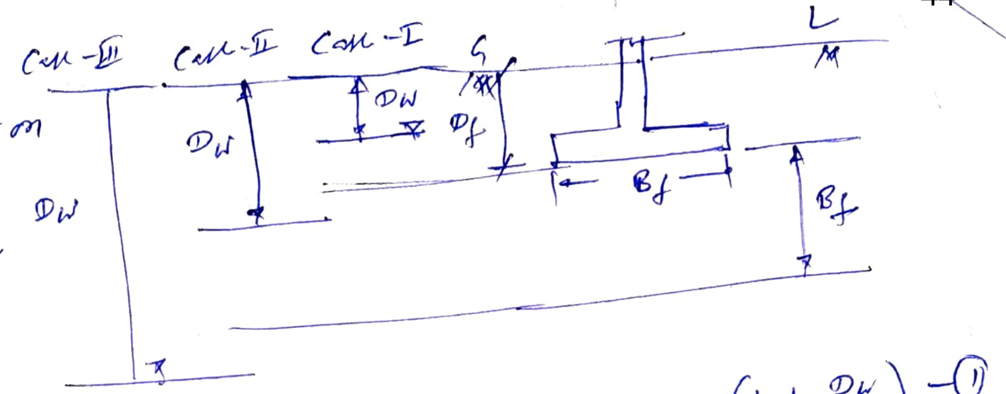
Based on the depth of water table, the effect on bearing capacity is divided into three cases



Case-I $D_w < D_f$

$$R_q = 0.5\left(1 + \frac{D_w}{D_f}\right) \quad -(1)$$

$$R_\gamma = 0.5\left(1 + \frac{D_w - D_f}{B_f}\right) \quad -(2)$$

$$q_f = cN_c + \gamma D_f N_q R_q + \gamma B N_\gamma R_\gamma$$

R_q = Reduction factor calculated using (1)

$D_w < D_f, \; R_\gamma = 0.5$

$D_w > D_f, \; R_q = 1.0$

Case-II $D_w > D_f$ & $D_w < (D_f + B_f)$

R_γ = Reduction factor calculated using (2).

Case-III $R_q = R_\gamma = 1$, No effect on Bearing capacity.

---

3 Strip footing, $B_f = 2m$, $D_f = 4m$, Purely cohesive soil.

$c = 150\ kN/m^2$, $\gamma = 19\ kN/m^3$

Terzaghi's Theory: $q_f = cN_c + \gamma D_f N_q + \frac{1}{2}\gamma B_f N_\gamma$ for $\phi = 0$, $N_c = 5.7$, $N_q = 1.0$, $N_\gamma = 0$

$$q_f = 150 \times 5.7 + 19 \times 4 \times 1.0 = 855 + 76 = 931\ kN/m^2$$

Skempton's Theory:

$$N_c = 5\left(1 + 0.2\, D_f/B_f\right) \text{ for strip footing, maximum } 7.5$$

$$= 6\left(1 + 0.2\, D_f/B_f\right) \text{ for Square \& circular, maximum } 9.0$$

$$q_f = cN_c$$

$$N_c = 5\left(1 + 0.2 \times 4/2\right) = 7$$

$$q_f = 150 \times 7 = 1050\ kN/m^2$$

---

4 a) The total settlement is divided into three types. i) Initial settlement or Elastic settlement ii) consolidation settlement or Primary consolidation iii) Secondary settlement or Secondary compression.

$$S_i = qB\frac{(1-\nu^2)}{E_s} I$$

$$S_c = \frac{C_c}{1+e_0} H \log_{10}\left(\frac{\bar{\sigma}_0 + \bar{\sigma}}{\bar{\sigma}_0}\right)$$

i) uniform settlement ii) differential settlement.

4b) Strip footing $B_f = 1.5\,m$, $D_f = 2\,m$, $C_u = 30\,kN/m^2$, $\phi = 0$, $\gamma_{sat} = 20\,kN/m^3$

$q_f = cN_c + \gamma D_f N_q R_q + \frac{1}{2}\gamma B N_\gamma R_\gamma$

$\phi = 0$, $N_c = 5.7$, $N_q = 1.0$, $N_\gamma = 0.0$

Assuming depth of water table is 5m, $D_w > D_f \Rightarrow$, $R_q = 1$.
$(D_w - D_f) > B_f$, $R_\gamma = 1$.

$q_f = 30 \times 5.7 + 20 \times 2 \times 1.0 = 211\ kN/m^2$

If water table rises by 1m, $D_w = 4.0$, then $D_w > D_f$, $R_q = 1$
$(D_w - D_f) > B_f$, $R_\gamma = 1$

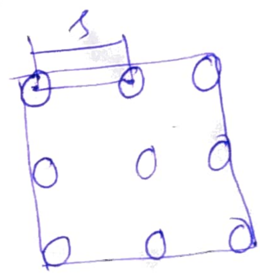
$\therefore$ % Reduction in ultimate bearing capacity $= 0$

5a) Engineering News formula: $q_{a} = \frac{W_h H}{(s + C)}$ $C = 2.5\,cm$ for drop hammer, $c = 0.25$ cm for steam hammer

$q_a = \frac{W_h H}{6(s+C)}$, F.S = 6.0

5b) $d = 30\,cm$, $L = 10\,m$, $C_u = 100\,kN/m^2$, $\gamma = 20\,kN/m^3$

$s = 0.75\,m$, F.S = 3, $\alpha = 0.6$



Ignoring bearing resistance, $\tau_f = \alpha C_u$

$Q_u = A_s \tau_f = \pi \times 0.30 \times 10 \times 0.6 \times 100$
$= 565\ kN$

Group load $Q_{ug} = 9 \times 565 = 5085\ kN$ – Based on individual pile failure

Block Failure:

$Q_{ug} = A_g \tau_f = 4 \times 1.8 \times 10 \times 100$
$= 7200\ kN$

$\therefore$ System Fails by Individual Pile failure, $Q_a = \frac{Q_{ug}}{F} = \frac{5085}{3} = 1695\ kN$

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RGM COLLEGE OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

16th November 2020

III B.Tech II Semester (R15) End Examinations (Regular)

GEOTECHNICAL ENGINEERING –II

CE

Time: 3 Hrs **Total Marks: 70**

Note 1:Answer Question No.1 (Compulsory) and 4 from the remaining

2:All Questions Carry Equal Marks

1a Write equation for ultimate bearing capacity of circular footing in general shear failure and local shear failure.

b Write the uses of stability charts.

c What is the effect of differential settlements on the structures?

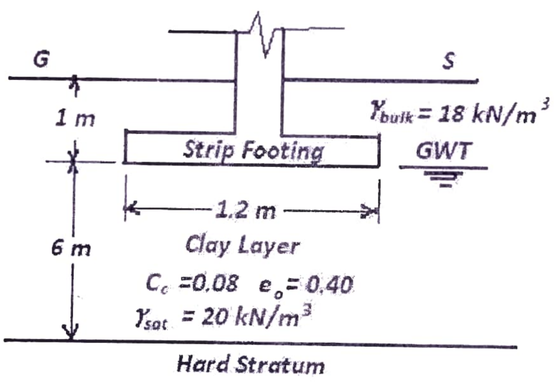
d What is sub-surface profile?

e What is the function of well curb?

f A 3 m high retaining wall, is supporting a saturated sand (saturated due to capillary action) of bulk density 18 kN/m³ and Φ=30°. Find the change in magnitude of active earth pressure at the base due to rise in ground water table from the base of the footing to the ground surface.

g General failure occurs in cohesion-less soils, if density index is more than_____.

2 Figure shows the geometry of a strip footing supporting the load bearing walls of a three storied building and the properties of the clay layer. If the pressure acting on the footing is 40kPa, find the consolidation settlement of the footing. If the elastic modulus and the Poisson's ratio of the clay layer are respectively 50 MPa& 0.4 and if the influence factor for the strip footing is 1.75, find the elastic settlement of the footing.



3 a) Discuss the various methods of improving the stability of slopes.

b) Determine the factor of safety with respect to cohesion for a submerged embankment 25 m high whose upstream face has an inclination of 45°. The soil has the following properties c= 40 kN/m³, Φ=10°,γ= 18 kN/m³. The relevant stability number is equal to 0.108.

4 a) Explain criteria for the selection of piles.
b) A 30cm concrete pile was driven in to homogenous consolidated clay deposit (c_u=40 kN/m^2), adhesion factor=0.7. If the embedded length is 10m, estimate the safe load, factor of safety of 2.5.

5 a) A retaining wall 8 m high with its back face inclined at 80° with the horizontal retains a silty clay backfill having c= 0.1 kg/cm^2, Φ=15° and γ=1.76 g/cc. The backfill slopes 15° to the horizontal and the wall friction is 10° while the adhesion between the backfill and the wall 0.15 kg/cm^2. Determine the lateral thrust and its point of application. What will be the lateral thrust and its point of application if the tension crack is assumed to be filled with water?
b) A retaining wall with a vertical back 6 m high supports cohesion less backfill of unit weight 19.6 kN/m^2. The upper surface of the backfill rises at an angle of 10° with the horizontal from the crest of the wall. The angle of internal friction for the soil is 35° and angle of wall friction is 20°. Find the total active earth pressure per meter length of the wall using Rebhann's graphical method and mark the direction, point of application of the resultant earth pressure.

6 a) What is boring/bore log? Explain with a neat sketch? (8)
b) Describe the salient features of a good sub-soil investigation report. (6)

7 a) What are the general requirements of shallow foundation?
b) Write in detail about the factors influencing bearing capacity.

- xxx -

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Geotechnical Engineering - II. 1/14

CE

A0118156R1120

1. (a) The equation of ultimate Bearing capacity for circular footing in case of General shear failure as

$$q_u = 1.2CN_c + \gamma D N_q + 0.3\gamma B N_\gamma$$

→ 1M

local shear failure:-

$$C_m = \frac{2}{3}c.$$

$$\phi_m = Tan^{-1}\left(\frac{2}{3}\tan\phi\right).$$

→ 1M.

(b) uses:-

(i) The stability number can be used to determine the factor of safety of a given slope. For the known values of i and ϕ_m, The value of stability number (S_n) is determined.

→ 1M.

(ii) The stability charts can also be used to determine the steepest slope for a given factor of safety.

→ 1M

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(c) This unequal and non uniform settlement is called as differential settlement and occurs when the soil beneath the structure expands, contracts & shifts away. These effects are a Result of increased axial force, shear force and Bending moments in the structure.

→ 2M.

(d) A subsurface Profile is a vertical section Through the Ground along the line of exploration. it indicates the boundaries of different strata, along with their classification.

→ 2M.

(e) The Tapered Portion of the well above the cutting edge is known as well curb. it is designed for Supporting the weight of the well.

→ 2M.

(f) Sol:-

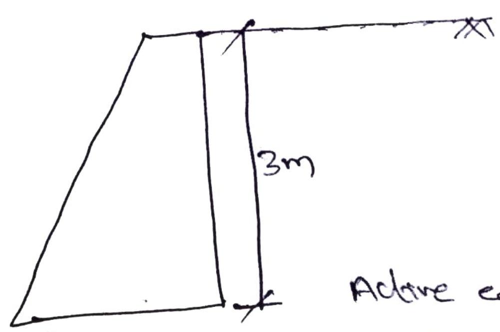
Given data:-

Height = 3m.

$\gamma_{sat} = 18 kN/m^3$

$\phi = 30°$.

$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \boxed{1/3}$ → 1M.



@ top $\sigma_v = 0$.

@ Bottom

$\sigma_v = 18 \times 3$
$= 54 kN/m^2$

Active earth pressure @ Bottom

$P_a = \frac{1}{3} \times 54 = 18 kN/m^2$

Active earth Pressure due to Rise of water table from Base to Ground surface.

$\sigma_v = (18-9.81)\times 3$

$= 24.57\ kN/m^2$.

$P_a = K_a \cdot \sigma_v + \gamma_w \cdot h$

$= \left(\frac{1}{3}\times 24.57\right) + 9.81\times 3$

$= 8.19 + 29.43$

$= 37.62\ kN/m^2$.

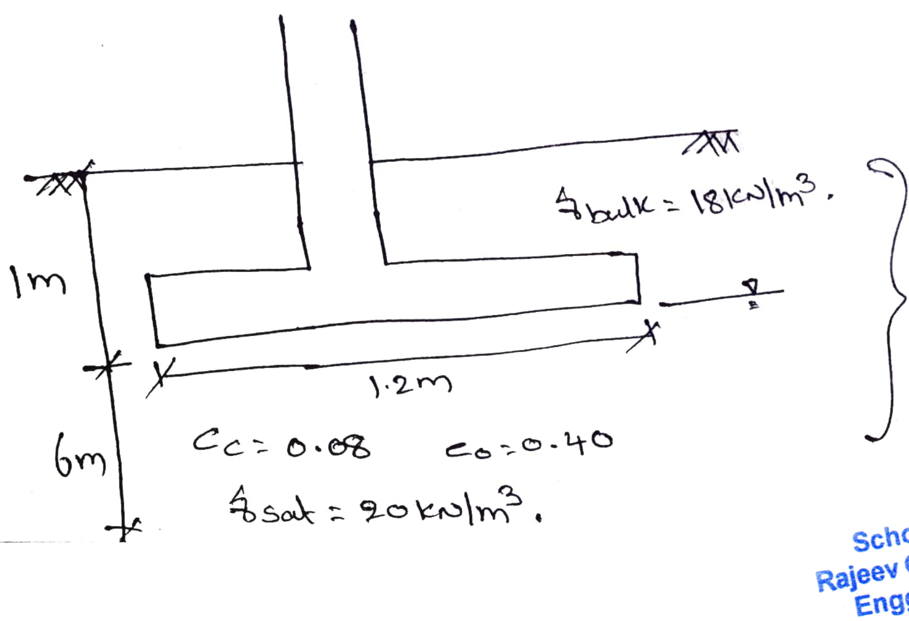
∴ change in magnitude $= 37.62 - 18$

$= \boxed{19.62\ kN/m^2}$ → 1M.

(9) Sol:- If the Relative Density is Greater than 70%. General Shear failure occurs.

→ 2M.

(2)



2M.

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Consolidation settlement :-

$\because \sigma_0' = (18\times1) + (10\times3)$
$= 18 + 30$
$= 48 kN/m^2$.

$$S_f = H_0 . \frac{C_c}{1+e_0} \log_{10}\left(\frac{\sigma_0' + \Delta\sigma'}{\sigma_0'}\right).$$

$$= 6\times\frac{0.08}{1+0.40}\log_{10}\left(\frac{48+40}{48}\right).$$

$$= 0.090m. \simeq 90.25 mm.$$

5m.

Elastic settlement :-

$$S_i = \frac{q_n}{E_s} . B . (1-\mu^2) . I$$

$$= \frac{40}{50\times10^3} \times 1.2 \times (1-(0.4)^2) \times 1.75$$

$$= \boxed{0.00141 m} \simeq \boxed{1.41 mm}$$

5m.

3 a) The slopes which are susceptible to failure by sliding can be improved and made usable and safe. various methods are used to stabilize the slopes. The methods Generally involve one & more of the Following measures, which either Reduce the mass which may cause sliding & improve the shear strength of soil in failure zone.

1) slope flattening Reduces the weight of the mass tending to slide. it can be used wherever possible.

2) Providing the beam below the toe of the slope increases the Resistance to movement.

⟶ 3m.

3) Drainage helps in Reducing the seepage forces and hence increases the stability. The zone of subsurface water is lowered and infiltration of surface water is Prevented.

4) Densification by use of explosives, vibro flotation, & tera probe helps in increasing the shear strength of cohesionless soils and thus increasing stability.

5) consolidation by surcharging, electro-osmosis or other methods helps in increasing the stability of slopes in cohesive soils.

⟶ 2m.

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b) Grouting and injection of cement & other compounds into specific zones help in increasing the stability of slopes.

In the interest of economy, Relatively inexpensive methods, such as slope flattening and drainage control, are Generally Preferred.

→ 1M.

3 b) Given data:-

Sol:-

Height of embankment = 25m.

inclination = 45°.

Cohesion $c = 40 kN/m^2$

$\phi = 10°$; $\gamma_{sat} = 18 kN/m^3$.

$S_n = 0.108$.

} 1M.

$$S_n = \frac{c}{F_c \cdot \gamma' \cdot H}$$

→ 2M.

→ if slope is submerged.

$$0.108 = \frac{40}{F_c \times (18 - 9.81) \times 25}$$

$$F_c = 1.808$$

} 4M.

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4 a) Piles may be classified in a number of ways based on different criteria:-

a) Function & Action.
b) Composition and material.
c) Installation.

} 1M.

* classification based on function & Action:-

(i) End-bearing piles.
(ii) Friction piles.
(iii) Tension & uplift piles.
(iv) Compaction piles.
(v) Anchor piles.
(vi) Fender piles.
(vii) Sheet piles.
(viii) Batter piles.
(ix) laterally-loaded piles.

} 2M.

classification Based on material and composition:-

(i) Timber piles.
(ii) Steel piles.
(iii) Concrete piles.
(iv) Composite piles.

} 2M.

classification Based on method of installation:-

(i) Driven piles.
(ii) Cast-insitu-piles.
(iii) Driven and cast-insitu piles.

} 2M.

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4b) Given data:

Sol:-

Diameter = 30cm.

$C_u = 40 kN/m^2$

$\alpha = 0.7$;

Embedded length = 10m; FOS = 2.5. } 1M.

$Q_u = A_b \cdot f_b + A_s \cdot f_s$. → 1M.

A_b = End base area.

A_s = Surface area.

$f_b = C \cdot N_c$; $f_s = \alpha \cdot C$. → 2M.

$$Q_u = \frac{\pi}{4} \times (0.3)^2 \times 40 \times 9 + (\pi \times 0.3 \times 10) \times 0.7 \times 40$$

$$= 289.34 \text{ kN}.$$

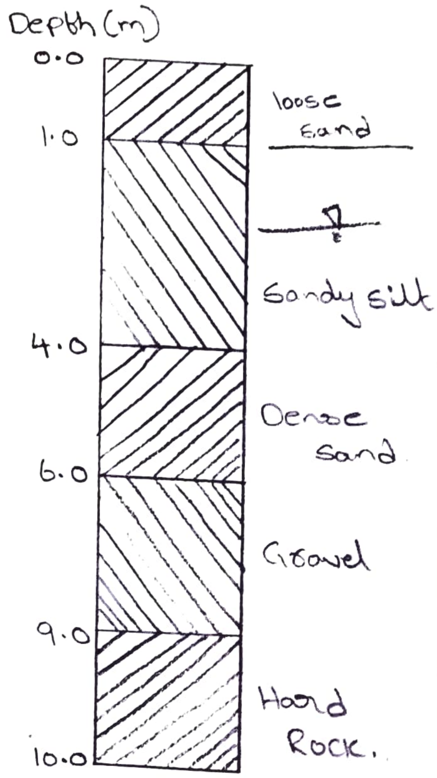
$$Q_a = \frac{Q_u}{FOS} = \frac{289.34}{2.5} = 115.73 \text{ kN}.$$ } 8M.

6a) A boring log gives the description & classification of

Ans:- various strata encountered at different depths. Any additional information that is obtained in the field, Such as soil consistency, unconfined compression strength

Cone Penetration Test, is also indicated on the boring log. it should also show the water table. if the laboratory Tests have been conducted, The information about index properties, compressibility, shear strength, permeability, etc.. should also be provided.

→ 4M.



N	qu	W	LL	PI
15				
		20%	50%	20%
10	50kN/m²	30%	60%	20%
40				
50				

→ 3M.

Boring log.

6. b) Ans:- A Good sub soil investigation Report should normally Comprise the Following:-

i. Introduction, which includes the scope of the investigation.

ii. Description of the proposed structure, The location and the Geological conditions at the site.

→ 2M.

iii Details of the field exploration programme, indicating number of borings, Their location and depths.

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iv) Details of the methods of exploration. → 2M.

v) General description of the sub-soil conditions as obtained from insitu Tests, such as standard Penetration Test, cone Test.

vi) Details of the laboratory Test conducted on the soil samples obtained and the Results obtained.

vii) Depth of the Ground water table and the changes in water levels. → 2M

viii) Recommendation about the allowable bearing Pressure, The type of foundation / structure. → 1M.

7a) General Requirements of shallow foundations:-

Ans:-

→ IS : 1904 : 1986 ; minimum depth of foundation = 0.5m.

→ foundation shall be Placed below the zone of

- Excessive volume change due to moisture variation.
- Top soil & organic material.

→ 2M.

→ foundations adjacent to flowing water, shall be Protected against Scouring.

→ A Raised water table may cause damage to the foundation by:- → 2M.

- Floating the structure.
- Reducing the effective stress beneath the foundation.
- Proper Drainage system around the foundation m...

Required so that water does not Accumulate.

→ minimum horizontal distance b/w the foundations shall not be lessthan the width of larger footing. otherwise, The principal of 2H:1V distribution be used to minimize influence to old structure.

→ 3M.

7 b) The bearing capacity of soil is influenced by many factors for instance soil strength, foundation width and depth, soil weight and surcharge, and Spacing between foundations. These factors are Related to the loads exerted on the soil and considerably affect the bearing capacity.

→ 2M.

Soil strength:-

Bearing capacity of cohesionless soils and mixed soil increases unpropotionally with the increase of in the effective friction angle.

→ 1M.

foundation width:-

Foundation width affects bearing capacity of cohesionless soils. The bearing capacity of a footing placed at the surface of cohesionless soil, where the soil shear strength is considerably

→ 1M

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dependent on internal friction, is proportional to the width of foundation.

Foundation depth:-

The Greater the bearing capacity the deeper the foundation. This is specifically obvious in a uniform cohesionless soil. In contrary, if foundation is carried down to a weak soil layer, The bearing capacity is declined.

→ 1M

Soil weight and surcharge:-

The contribution of subsurface and surcharge soil, which are influenced by water table, to the bearing capacity cannot be ignored. The water table should not be above the base of the foundation to avoid construction, seepage, uplift problems.

→ 1M

Spacing between foundations:-

it is Recommended to consider minimum spacing between footings, which 1.5 times foundation width, during the design of foundation in order to avoid Reduction in bearing capacity.

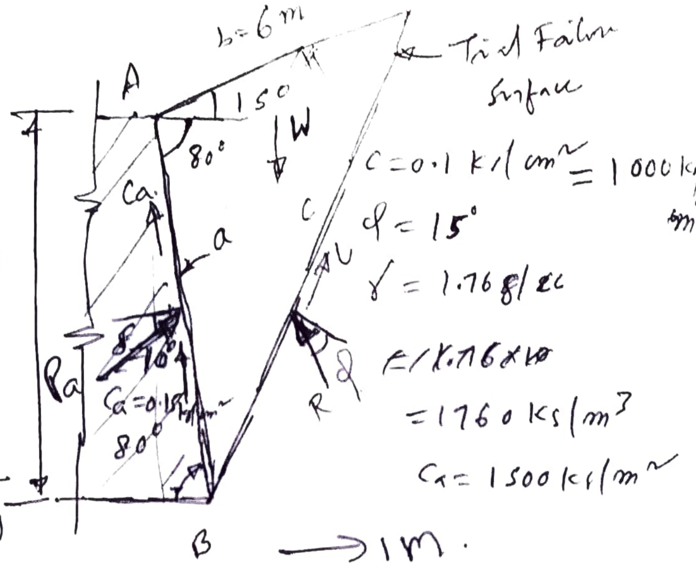
→ 1M.

5 a) $\sin 80^\circ = \frac{8}{a}$

$a = \frac{8}{\sin 80^\circ} = 8.123\ m$

$c = \sqrt{6^2 + 8.123^2 - 2 \times 6 \times 8.123 \cos 95^\circ}$

$= 10.511\ m$



→ 1M.

Area of ABC1, $A = \sqrt{s(s-a)(s-b)(s-c)}$

$s = \frac{a+b+c}{2} = \frac{8.123 + 6 + 10.511}{2} = 12.317\ m$

$A = \sqrt{12.317 \times 4.194 \times 6.317 \times 1.806} = \sqrt{589.335} = 24.28\ m^2$

$W = \gamma \times A \times 1 = 1760 \times 24.28 \times 1 = 42,732.8\ kg$

$C = c \times C = 10.511 \times 1000 = 10,511\ kg$

$C_a = a \times C_a = 8.123 \times 1500 = 12,184.5\ kg$

→ 3M.

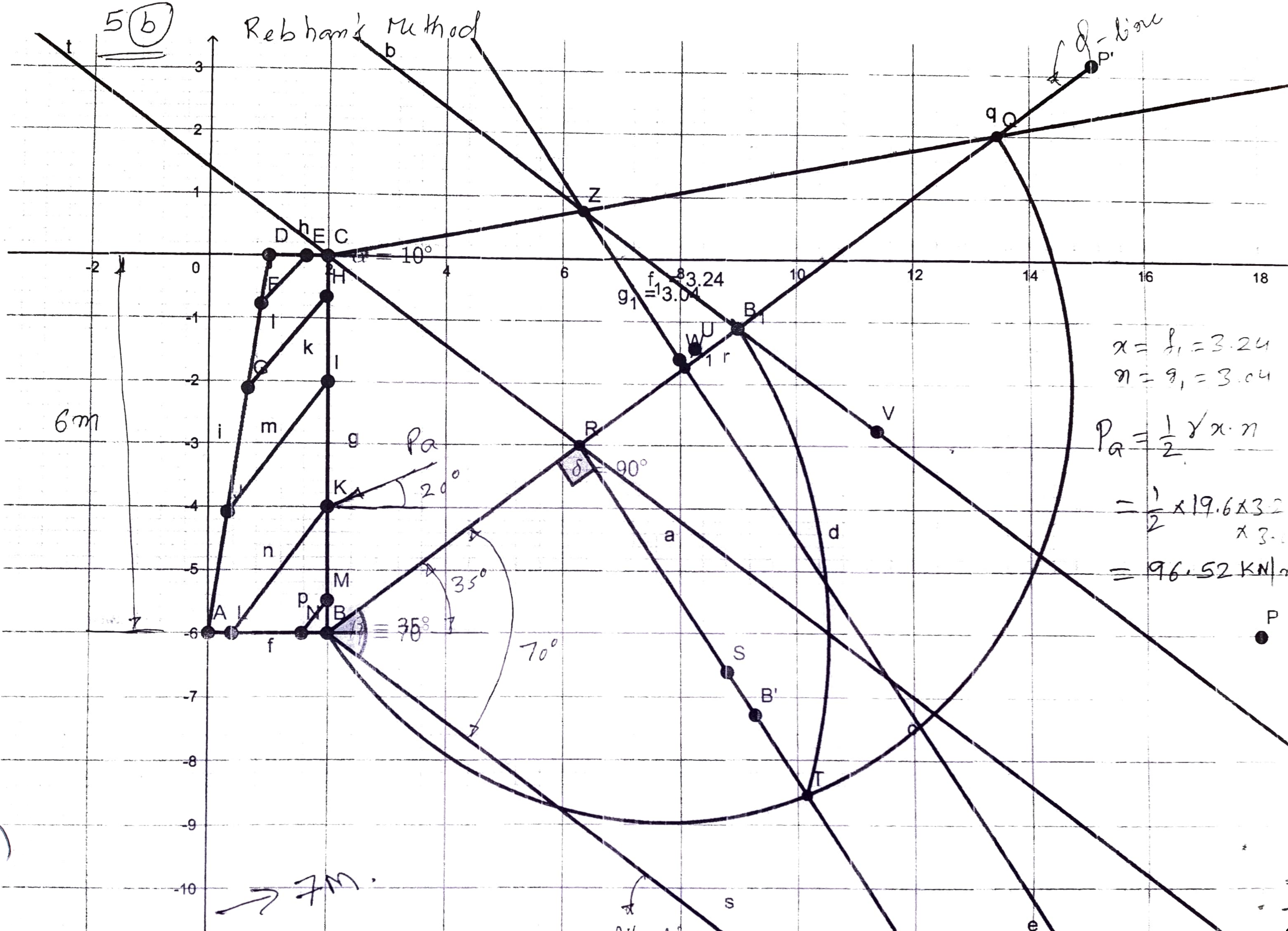
The Forces, R, P_a, W, C, & C_a should be in equilibrium of solving for R & P_a we get P_a lateral Earth Pressure.

consider number of points, C_2, C_3 .. on backfill line, using above procedure solve for P_{a_2}, P_{a_3} ....

From the set P_a (P_{a_1}, P_{a_2} ...) select the maximum P_a, That gives the lateral earth pressure acting on the wall.

→ 3M.

5(b) Rebhann's Method



$x = f_1 = 3.24$

$n = g_1 = 3.04$

$P_a = \frac{1}{2} \gamma x \cdot n$

$= \frac{1}{2} \times 19.6 \times 3. \times 3.$

$= 96.52$ KN/m

Scheme Prepared by.

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Caluculation of CO Attainment of Subject									
Total	134			CO-1	CO-2	CO-3	CO-4	CO-5	
Above 50%	3			74	83	70	80	80	
30% to 50%	2			50	40	53	44	44	
Below 30%	1			10	11	11	10	10	
CO Score Value				2.48	2.54	2.44	2.52	2.52	
CO Attainment				55	62	52	60	60	
CO Threshold				55	55	55	55	55	
CO Attained or Not (Yes/N				Y	Y	N	Y	Y	

Caluculation of PO Attainment of Subject															
	COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2.48	1	3	2	1									3	2	1
CO2	2.54	1	3	2	1									3	2	1
CO3	2.44	1	3	2	1									3	2	1
CO4	2.52	1	3	2	1									3	2	1
CO5	2.52	1	3	2	1									1	2	1
Total PO		5	15	10	5	0	0	0	0	0	0	0	0	13	10	5
PO Attain	A	2.50	2.50	2.50	2.50									2.50	2.50	2.50

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Mid -I

Q No	CO-1	CO-2	CO-3	CO-4	CO-5		
1 a)				2			
1 b)					2		
1 c)					2		
1 d)	2						
1 e)				2			
2 a)				2			
2 b)				3			
3 a)	2						
3 b)	3						
4 a)					2		
4 b)					3		
5 a)	5						
5 b)							
	40.00	0.00	0.00	30.00	30.00	0.00	100.0

Mid-II

Q No	CO-1	CO-2	CO-3	CO-4	CO-5		
1 a)			2				
1 b)		2					
1 c)		2					
1 d)			2				
1 e)			2				
2 a)			5				
2 b)							
3 a)			5				
3 b)							
4 a)			2				
4 b)			3				
5 a)		2					
5 b)		3					
	0.00	30.00	70.00	0.00	0.00	0.00	100.C

End Exam

Q No	CO-1	CO-2	CO-3	CO-4	CO-5		
1 a)			2				
1 b)					2		
1 c)			2				
1 d)				2			
1 e)		2					
1 f)	2						
1 g)			2				
2 a)			14				
2 b)							
3 a)					7		
3 b)					7		
4 a)		7					
4 b)		7					
5 a)	7						
5 b)	7						
6 a)				8			
6 b)				6			
7 a)		7					
7 b)			7				
	16.33	23.47	27.55	16.33	16.33	0.00	100.0C

Exam weightages to Each CO

Asses	CO-1	CO-2	CO-3	CO-4	CO-5		
COiFE	16.3	23.5	27.6	16.3	16.3	0.0	100.C
COiIM	20.0	15.0	35.0	15.0	15.0	0.0	100.C
COiA	20.0	20.0	20.0	20.0	20.0	0.0	100
COiW/	17.43	21.18	29.04	16.18	16.18	0	100.C

Note: FE Final Exam Marks
IM Internal Marks
A Assignment
WA Weighted Average

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III B. Tech II Semester
Geotechnical Engineering -II

CO Attinment Calculatior ((COiFE*FE)+(COiIM*IM)+(COiA*A))/COiWA
Caluculation of CO Attainment of Subject

A: Assignment Marks, IM: Internal Marks, FE: Final Exam Marks

Reg No	IM	A	FE	CO-1	CO-2	CO-3	CO-4	CO-5
16091A0104	8.25	3.5	33.3	45	46	44	46	46
16091A0134	8.25	3.5	37.3	48	50	48	50	50
16091A0137	1.5	3.5	0.0	6	4	4	6	6
16091A0143	8.75	4	27.3	40	40	39	41	41
16091A0150	9	4	52.0	64	68	63	66	66
16091A0189	9.5	3.5	34.0	47	48	46	47	47
17091A0101	10	2	48.0	59	62	59	60	60
17091A0102	15	2	37.0	54	54	55	54	54
17091A0103	11	4	46.0	60	63	60	62	62
17091A0104	10.5	4	37.5	52	53	51	53	53
17091A0105	4	4	27.0	34	37	33	36	36
17091A0106	9	4	54.0	66	70	65	68	68
17091A0107	6.75	4	51.3	60	65	60	63	63
17091A0110	15.5	4	58.5	77	80	77	78	78
17091A0111	7	4	1.0	14	10	12	12	12
17091A0112	8.75	4	48.3	60	63	59	62	62
17091A0113	8.25	4	41.8	53	56	52	55	55
17091A0114	7.75	4	39.3	50	53	49	52	52
17091A0115	13.25	4	50.8	67	69	67	68	68
17091A0116	9.5	4	55.5	67	72	67	70	70
17091A0118	11.75	4	38.3	54	54	53	54	54
17091A0119	11.75	4	48.3	63	66	63	65	65
17091A0120	4.5	2	0.5	8	6	7	7	7
17091A0121	2.25	2	35.8	38	43	38	41	41
17091A0122	4	3.5	37.5	44	48	43	46	46
17091A0123	7	3.5	43.5	53	56	52	55	55
17091A0124	5.25	3.5	42.3	50	54	49	52	52
17091A0125	8	2	49.0	57	62	58	59	59
17091A0126	9.25	4	43.8	56	59	55	58	58
17091A0127	11.25	4	49.8	64	67	64	66	66
17091A0128	6.5	4	0.5	13	9	11	11	11
17091A0129	5.75	3.5	40.8	49	53	48	51	51
17091A0133	12	4	53.0	68	71	68	70	70
17091A0138	5	3.5	38.5	46	50	45	48	48
17091A0139	4.75	4	38.3	46	50	45	48	48
17091A0141	6.75	4	49.3	58	63	58	61	61

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17091A0142	3.75	3.5	0.8	9	7	8	9	9
17091A0143	7.75	4	48.3	59	63	58	61	61
17091A0144	3	3	0.0	7	5	6	6	6
17091A0145	8.25	4.5	40.3	52	55	51	54	54
17091A0146	15.5	4	59.5	78	81	78	79	79
17091A0147	13.75	4	41.3	59	59	58	59	59
17091A0148	5.5	4	45.5	54	58	53	56	56
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17091A0170	6.75	3.5	31.8	42	43	41	43	43
17091A0171	7.5	4.5	44.0	55	58	54	57	57
17091A0172	5	4	35.0	43	46	42	45	45
17091A0173	8	3.5	44.5	55	58	54	57	57
17091A0174	7.25	3.5	34.3	44	46	44	46	46
17091A0176	7.5	2	37.5	46	49	46	47	47
17091A0178	9.75	3.5	58.8	70	75	70	73	73
17091A0180	17.75	4.5	50.8	73	73	73	73	73
17091A0182	10.5	4.5	53.0	67	70	66	69	69
17091A0183	11.25	4.5	34.3	50	50	49	51	51
17091A0184	7.75	3.5	30.8	42	43	41	43	43
17091A0185	9.75	4	49.3	62	65	61	64	64
17091A0186	3.5	3.5	7.0	15	14	13	15	15
17091A0187	8	4	39.0	50	53	49	52	52
17091A0188	9.5	4	34.5	48	49	47	49	49
17091A0189	6.25	3	48.8	56	61	56	59	59
17091A0190	7	3.5	37.5	47	50	46	49	49
17091A0191	7.75	4	43.3	54	57	53	56	56
17091A0193	8	4.5	41.5	53	56	52	55	55

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17091A0194	10.25	3.5	36.3	50	51	49	50	50
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17091A01A1	10.75	4.5	45.8	60	63	59	62	62
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17091A01A6	10.75	4.5	50.8	65	68	64	67	67
17091A01A7	8.25	3	37.8	48	51	48	49	49
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17091A01A9	19	4.5	27.5	53	48	52	51	51
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18095A0104	8	4	31.0	43	44	42	44	44
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18095A0107	5.75	4	36.3	45	48	44	47	47
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18095A0113	10.25	3.5	12.3	27	24	26	26	26
18095A0115	8.75	4	35.3	48	49	47	49	49
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18095A0117	8.25	4	32.8	45	46	44	46	46
18095A0118	13.5	4	46.5	64	65	63	64	64
18095A0119	8.5	4	41.5	53	56	52	55	55
18095A0120	4.75	3.5	34.8	42	45	41	44	44
18095A0121	7.75	4	43.3	54	57	53	56	56
18095A0122	8	4	44.0	55	58	54	57	57
18095A0123	10.5	2	35.5	48	49	48	48	48
18095A0124	6.75	4	20.3	31	31	30	32	32
18095A0125	8.75	3.5	37.8	49	51	49	51	51
18095A0126	8.25	4	27.8	40	40	39	41	41
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18095A0129	13	2.5	42.5	58	59	58	58	58
18095A0130	5.25	2	23.8	31	32	30	31	31
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18095A0138	10.5	4.5	54.0	68	72	67	70	70
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18095A0149	14.5	4.5	41.0	60	60	59	60	60
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POs/PSOs Performance Quality Levels

Division of Performance Quality Levels based on Attainment levels of POs and SOs

Sl No.	**Levels**	**Performance quality**
1	PO/PSO ≤ 1.5	Unsatisfactory/ Does Not Meet Expectations
2	1.5 ≤ (PO/PSO) ≤ 2.25	Satisfactory/ Marginal Expectations
3	2.25 ≤ (PO/PSO) ≤ 2.7	Good/ Meets Expectation
4	2.7 ≤ (PO/ PSO) ≤3	Excellent/ Exceeds Expectations

Performance Quality of POs and PSOs of Geotechnical Engineering -II

SNo	POs and PSOs	Attainment	Performance Quality
1	PO1, PO2, PO3, PO4, PSO1, PSO2, PSO3	>2.25	Good/Meets Expectation

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UNIT 1: SOIL EXPLORATION

Soil Exploration… WHAT ?? WHY ??

- For construction of any structure, a **knowledge about the ground** conditions is important. The soil structure, **capacity and behaviour** under various loading conditions will help design the substructures and retaining structures, and to suggest remedial actions to **improve** ground conditions when required.
- Exploration in soil- involves a site visit, quick visual inspection and detailed tests to determine the behaviour
- ***"The field and laboratory investigations required to obtain necessary data regarding the soil, for proper design and successful construction of any structure at the site are collectively called soil exploration."***

Objectives of Soil Investigation

1. To assess the general suitability of site
2. To determine the bearing capacity of the soil
3. To Select the type and depth of foundation for a given structure Estimate max. probable settlement (total and differential)
4. Investigate the nature and depth of each stratum and assess required properties
5. To select the suitable construction technology based on availability and economy
6. To know the ground water conditions
7. Predict possible difficulties and problems in site and suggest remedial actions
8. Ensure safety of existing structures
9. Investigate the occurrence of any natural or manmade changes in conditions and the result from those changes

This information obtained by - Drilling holes, taking samples, finding Index and Engineering properties Conducting some field tests

HOW TO DO IT??

- For any project, soil investigation Costs of 0.05%-0.2%- Even 1% in some cases- So proper planning must!!
- It depends on
  - Type and importance of structure and its weight, size and shape.
  - Nature of subsoil(strata variability)
  - Budget/economy
- Involves
  - Location and depth of boreholes
  - Tests to be done, and test methods
  - Sampling methods
- 3 important phases: Planning→ execution→ report writing

Detailed information→ Less uncertainty later→ less factor of safety(or *factor of Ignorance!!*)→less cost of construction

Stages in Subsoil Exploration

Reconnaissance	Preliminary Investigation	Detailed investigation
Involves a site visit and visual inspections at the site Rough Idea about work that how to start	▪ To assess the need for detailed investigation ▪ Determination of depth, thickness, extent and composition of each layer ▪ Depth of bedrock and Ground water table also studied ▪ Lab and field tests to assess basic properties ▪ Chemical and bacteriological tests if needed ▪ Methods: • Boreholes, test pits, Cone penetrometer, Sounding rods, Geophysical methods	▪ Mainly for big projects- Dams, bridges, multistoried buildings ▪ Also for newly built up soil ▪ Involves extensive boring programme → sampling → lab and field testing ▪ For small projects on site with uniform strata or clear history, info. from reconnaissance and prelim. investigation sufficient ▪ Uniform strata → boreholes at regular spacing

BOREHOLE (BH)

Depth, lateral extent and number of boreholes data are important for any soil investigation before construction

- **Depth of Exploration:** Depends on *type of structure, intensity of load, soil profile, and the physical properties of soil*

  (Based on few trial pits and test borings, or an experienced person's judgement)

Significant Depth:

"Depth upto which the superimposed loads can produce considerable settlement and shear stresses"

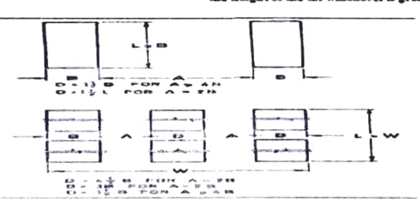
- Generally, significant depth is that at which vertical stress is 20% (or 1/5th)of the load intensity (considering 2:1 load distribution, stress at D=1.5B is nearly 1/5th)
- ***Depth of exploration must be greater than or equal to significant depth***

Depth of exploration for some structures
(Code: IS 1892-1979)

IS : 1892 - 1979

TABLE 1 DEPTH OF EXPLORATION
(Clause 2.3.2.1)

Sl. No.	Type of Foundation	Depth of Exploration (D)
i)	Isolated spread footing or raft	One and a half times the width (B) (see Fig. 1)
ii)	Adjacent footings with clear spacing less than twice the width	One and a half times the length (L) of the footing (see Fig. 1)
iii)	Adjacent rows of footings	See Fig. 1
iv)	Pile and well foundations	To a depth of one and a half times the width of structure from the bearing level (toe of pile or bottom of well)
v)	1. Road cuts	Equal to the bottom width of the cut
	2. Fill	Two metres below ground level or equal to the height of the fill whichever is greater



- For hospitals and office buildings, the following rule could be use to determine boring depth
- Deep excavations, the depth of boring should be at, least 1.5 times the depth of excavation.
- ***The minimum depth of core boring into the bedrock is about 3m.*** If the bedrock is irregular or weathered, the core borings may have to be extended to greater depths.
- If there are weak zones at depth (zone of volume change, seasonal variations, swelling and shrinkage), boring should be continued below this weak zones.

  Always ensure: Exploration depth such that load can be carried by that stratum without undesirable settlement and shear failure

Lateral extent of exploration

- Number and spacing of boreholes must be such as to reveal any major changes in the thickness, depth and properties of strata over the base area of the structure and its immediate surroundings.
- More uniform strata- less no: of BH and more spacing can be adopted
- Erratic variation- more no: of boreholes at reduced spacing
- Wherever possible, BH must be sunk close to the proposed foundation, especially in soils of erratic variation
- When layout not planned before- Best pattern is evenly spaced grid of BH
- Cone penetration tests can be performed T every 50m intervals
- Gravelly and boulderous strata- CPT not feasible, hence geophysical methods adopted

Lateral extent of exploration (IS: 1892)

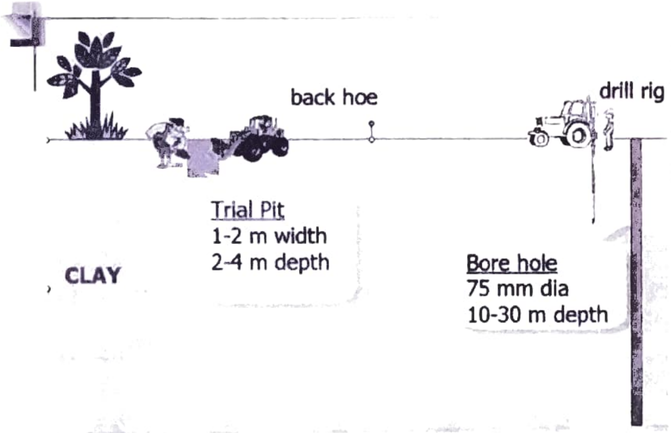
UNIT	NO OR SPACING OF BORE HOLES
Small &less important **buildings**	**1** at centre may suffice.
Compact **buildings** (covering an area of 0.4 hectares)	At least **5** (1 at centre & 4 at corner).
Large multistoreyed **buildings**	At all important locations, spacing should be **10 to 30m.**
Highways	Along centre line, spacing should be **150 to 300m**.
Concrete dams	Spacing generally varies between **40 to 80m.**

Different Methods of Exploration in soils

Direct/Open excavation (<6m)
- Drifts
- Shafts
- Pits
- Trenches

Semi direct/Boring
- Auger boring
- Wash boring
- Percussion boring
- Rotary boring
- Core Drilling

Indirect methods
- Geophysical methods
- Sounding rods



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Open excavation (for depth <6m)

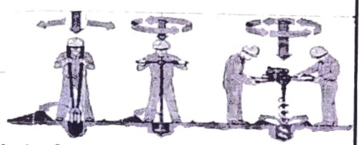
- **Trial pits**-1.2m X1.2m (IS 4453-1967)
  - Depth > 3m →lateral support
  - Proper ventilation and dewatering if necessary
- **Trenches**-long shallow continuous pit, exposing a line
- **Drifts(adits)**-horizontal tunnels along hillside, especially for rocks
  - Min 1.5m(b) X 2m (h)
  - Lateral support if unstable
  - Generally expensive
  - Helps to establish minimum excavation limits to reach sound rocks, & to locate failure and shear zones
- **Shafts:** Large vertical holes (min 2.4m width or diameter)
  - For D>4m
  - Proper support and ventilation required

Boring methods

- Boring refers to advancing a hole in the ground, used especially when D > 6m
- It is a semi direct method of exploration
- **Necessity:**
  - To obtain representative soil and rock samples for laboratory tests.
  - To identify the groundwater conditions.
  - Performance of in-situ tests to assess appropriate soil characteristics.
- Extensometers and pressure meters can be installed
- Results → Borelog and subsurface profiles can be obtained

  Drilling borehole → taking samples → testing → Borelog
- Types: (1)Auger boring (2)Wash boring (3) Percussion drilling (4) Rotary drilling (5) Core drilling

Auger Boring

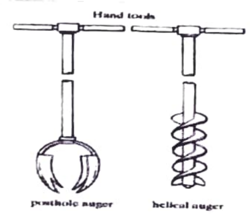


- Simplest and most common method of boring for small projects in soft cohesive soils. – *Fast, economical, light, inexpensive and flexible*
- Auger a drill for advancing holes
  - Has a shank with cross wise handle to apply torque
  - The length of the auger blade varies from 0.3-0.5m.
  - Diameter of central rod almost 18mm
  - Auger held vertically and driven by applying torque, either manually or mechanically
  - **Driving force: Torque on handle+ downward pressing force**
  - The auger is rotated until it is full of soil, then it is withdrawn to remove the soil and the soil type present at various depths is noted.
  - Hand augers and mechanically operated auger
  - Post hole augers: for taking samples when hole is already dug/driven

- **Hand-operated** →can be made upto about 6m depth
- Usually used for shallow depth applications→ rail road, highways etc
- Highly disturbed samples (but better than other boring methods)→ used for classification purpose and basic tests only

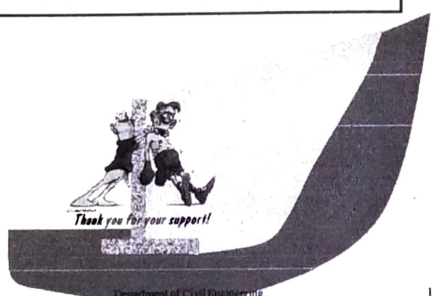
- **Power operated** →The power required to rotate the auger depends on the type and size of auger and the type of soil.
- can be made upto about 12m depth

Downwards pressure → applied hydraulically, mechanically or by dead weight



N. Sivakugan

UNIT-II Lateral Earth Pressures



Duration:

SIVA

Contents

- Geotechnical applications
- K_0, active & passive states
- Rankine's Earth Pressure Theory
- Coulomb's Earth Pressure Theory
- Design of retaining walls
- A Mini Quiz

SIVA

Lateral Support

In geotechnical engineering, it is often necessary to prevent lateral soil movements.

➢**A retaining wall** is a structure that is used to support a vertical or near vertical slopes of soil. The resulting horizontal stress from the soil on the wall is called ***lateral earth pressure***.

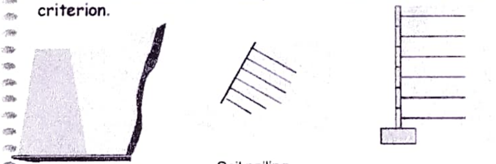
Cantilever retaining wall   Braced excavation   Anchored sheet pile

SIVA

Lateral Support

We have to estimate the lateral soil pressures acting on these structures, to be able to design them.

➢In the evaluation of the magnitude of this lateral earth pressure, it is assumed that the soil behind the wall (called **backfill soil**) is on the verge of failure and obeys some failure criterion, for example, the Mohr-Coulomb failure criterion.



Gravity Retaining wall   Soil nailing   Reinforced earth wall

SIVA

Soil Nailing

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Sheet Pile

Sheet piles marked for driving

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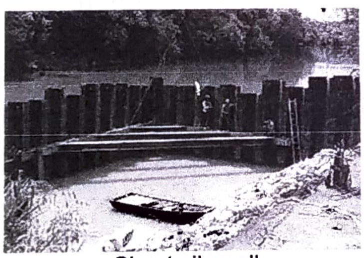
Sheet Pile



Sheet pile wall

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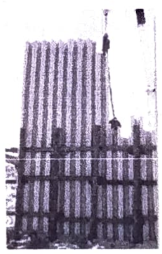
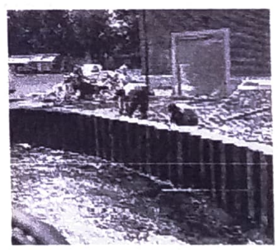
Sheet Pile



During installation



Sheet pile wall

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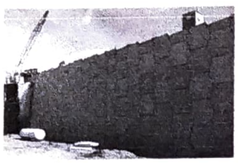
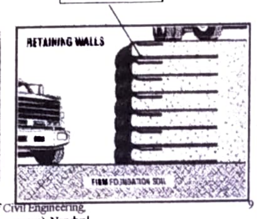
Lateral Support

Reinforced earth walls are increasingly becoming popular.





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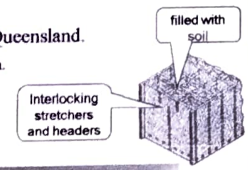
SIVA

Lateral Support

Crib walls have been used in Queensland.

Good drainage & allow plant growth.

Looks good.



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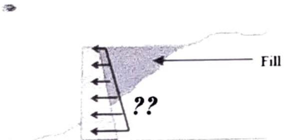
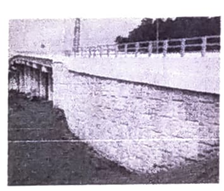
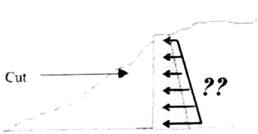
SIVA

Lateral Earth Pressure



Retaining Wall to Support a Fill.
(R.P. Weber)





Retaining Wall to Support a Cut.
(R.P. Weber)

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11

SIVA

Factors Affecting Lateral Earth Pressure

- The type & amount of wall movement
- Type of backfill used
- The effective unit weight of the backfill soil,
- Ground water position
- The drainage condition in the backfill
- Ground Surcharge
- Surcharge application

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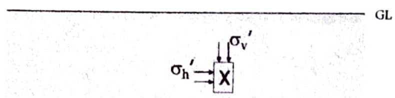
12

SIVA

Earth Pressure at Rest

In a homogeneous natural soil deposit,



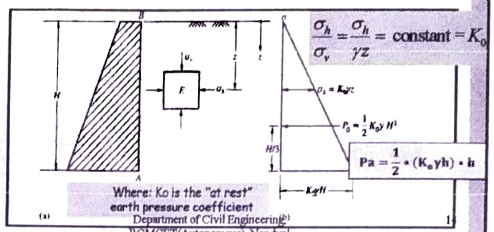
the ratio σ_h'/σ_v' is a constant known as coefficient of earth pressure at rest (K_0).

Importantly, at K_0 state, there are no lateral strains.

SIVA

Earth Pressure at Rest

➤ ***If the wall is rigid and does not move with the pressure exerted on the wall, the soil behind the wall will be in a state of elastic equilibrium. Consider a prismatic element E in the backfill at depth z shown in Fig.***



SIVA

Estimating K_0

For normally consolidated clays and granular soils,

$$K_0 = 1 - \sin\phi'$$

For over consolidated clays,

$$K_{0,overconsolidated} = K_{0,normally\ consolidated}\, OCR^{0.5}$$

Brooker and Ireland (1965) for normally consolidated clay: $K_0 = 0.95 - \sin\phi'$

From elastic analysis, $K_0 = \frac{\upsilon}{1-\upsilon}$ (υ: Poisson's ratio)

✓**Based on experiments, the typical value of K_0 is about 0.40 - 0.50 for sand, 0.35 - 0.70 for normally consolidated clay, and 0.50 - 3.00 for over-consolidated soil**

SIVA

Estimating K_0

✓ Empirical correlation between the coefficient of lateral earth pressure K_0 and the plasticity of normally consolidated clay is proposed by Alpan (1967) $K_0 = 0.19 + 0.233\log(PI)$

✓ Where PI is the plasticity index of the soil. other empirical correlations were proposed by Mayne and Kulhawy (1982)

$K_0 = 0.4 + 0.007(PI)$ for $0 < PI < 40$

$K_0 = 0.64 + 0.001(PI)$ for $40 < PI < 80$

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Module 5:

Lecture -1 on Stability of Slopes

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Contents

- ➢Stability analysis of a slope and finding critical slip surface;
- ➢Sudden Draw down condition, effective stress and total stress analysis;
- ➢Seismic displacements in marginally stable slopes;
- ➢Reliability based design of slopes,
- ➢Methods for enhancing stability of unstable slopes.

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Contents of this lecture

- Types of slopes
- Failure types
- Causes of slope failures
- Analysis of slopes by using LE methods
- Comparison
- Concluding remarks

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Application of shear strength theory

- Earth pressure theories
- Stability analysis of slopes
  - Infinite slopes: Slope that extends over a long distance and the conditions remain identical along some surface or distances for quite some distance.
  - Finite slopes: Slope that connect land at one elevation to land that is not far away but is at different elevation.
    ❖Can also exist in nature and man-made.

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Type of slopes

Slopes

Natural
- ♦Hill side and valleys
- ♦Coastal and river cliffs

Man-made
- ♦ Cuttings and embankments for highways and rail roads
- ♦ Earth and ash pond dams
- ♦ Temporary excavations
- ♦ Waste heaps (landfill slopes)
- ♦ Landscaping for site development

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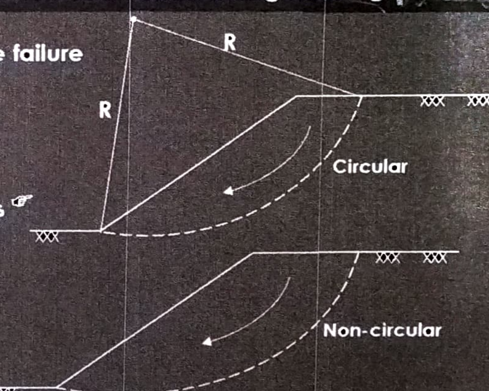
Types of slope failure

Rotational slips



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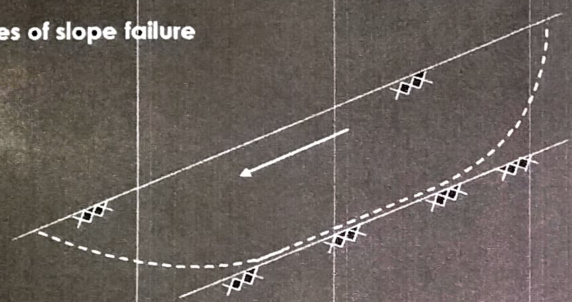
Types of slope failure



Translational slip

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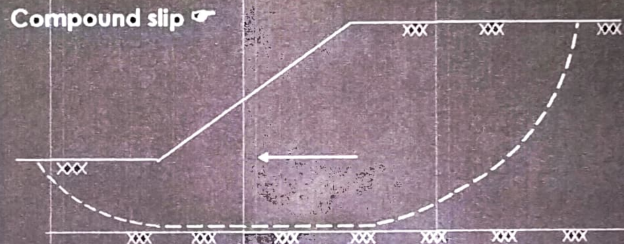
Types of slope failure

Compound slip



Rigid stratum

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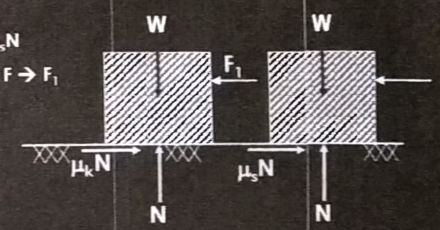
Block movement

Resisting force F_R : $\mu_s N$

Disturbing force F_D : $F \rightarrow F_1$

$$FS = \frac{F_R}{F_D}$$



As long as $\mu_s N > F$ --- block is said to be stationary

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Causes of slope failure

- Gravity
- Seepage
- Earthquake
- Erosion
- Geological features
- Construction activities

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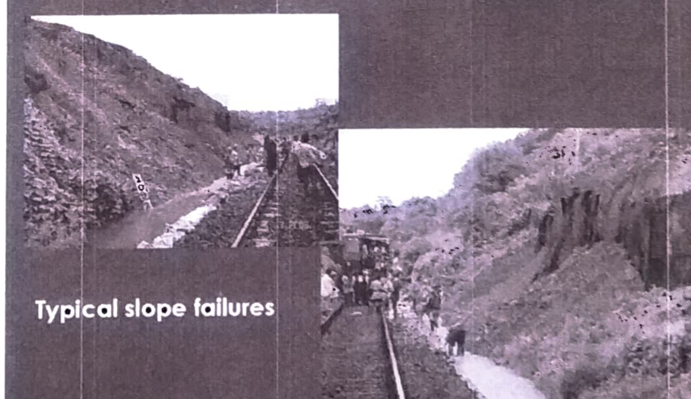

Typical slope failures

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Typical slope failures

Courtesy: Geological natural hazards

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Landslide damage adjacent to a residential structure

Courtesy: North Carolina Geological Survey

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Typical slope failures

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Highway slope failure at Krishnabhir, Tribhuwan highway Nepal (Aryal, 2003)

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Typical sacrificial slope failure in highway embankment

(After Loher et al. 2002)

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Uttarakand (2013)

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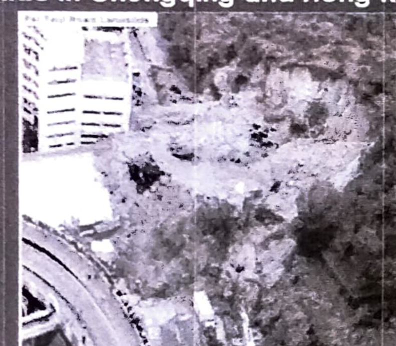
Landslide in Chongqing and Hong Kong



After Kwong et al. 2004

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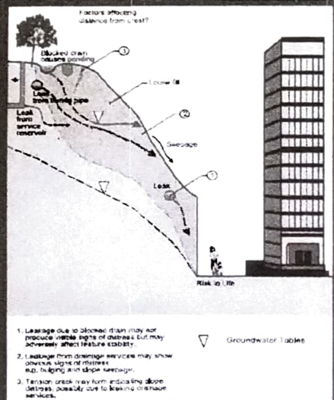
Effect of raising GWT →



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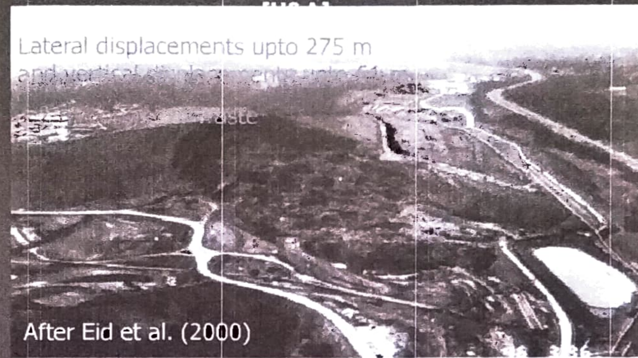
Aerial view of Waste slide on March 16, 1996



After Eid et al. (2000)

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Aerial view of landfill on Feb. 6, 1996→

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Slope Failure

Slope failures depend on

- Soil type
- Soil stratification
- Ground water
- Seepage
- Slope geometry

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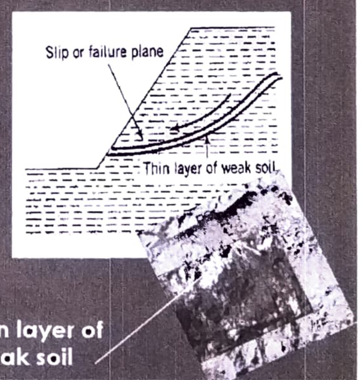
Types of Slope Failure

Translational Slide

- Failure of a slope along a weak zone of a soil
- Sliding mass travels long distances before coming to rest.
- Common in coarse-grained soils.



Thin layer of weak soil

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Types of Slope Failure

Rotational slide

- Common in homogenous fine-grained soil
- It has its point of rotation on an imaginary axis parallel to the slope
- There are three types of rotational failure:
  - Base slide
  - Toe slide
  - Slope slide

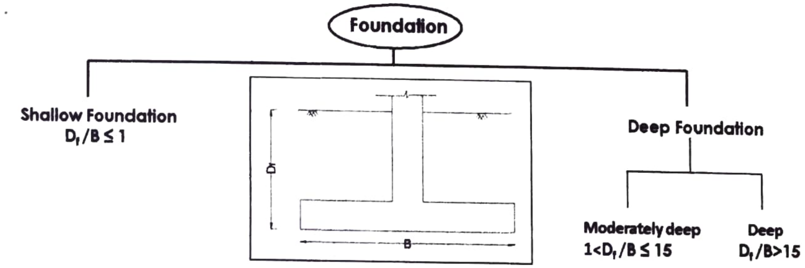
FOUNDATION ENGINEERING

Kousik Deb
Associate Professor
Department of Civil Engineering
IIT Kharagpur

UNIT-4: Shallow Foundation : Bearing Capacity

Foundation

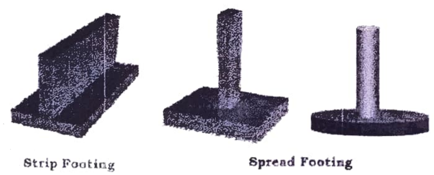
A foundation is that part of structure which transfers the load of the structure to the sub soil.



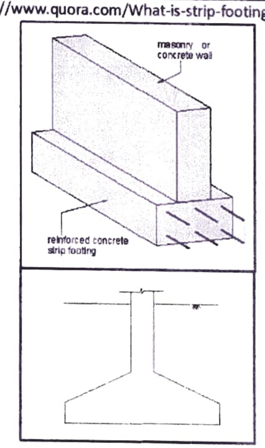
Shallow Foundation

1. **Strip Footing or Continuous Footing (L>>B)**

- Provided for load bearing wall
- Provided for a row of columns which are closely spaced that their footings overlap each other.

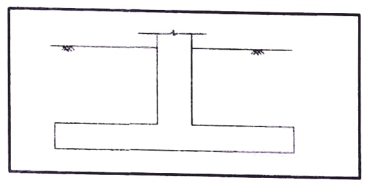


https://www.quora.com/What-is-strip-footing

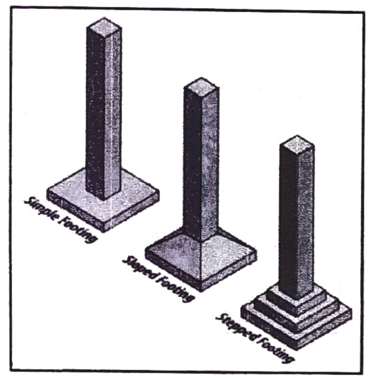


2. **Spread Footing or Isolated Footing**

- Provided to support an individual column
- Circular, Square and rectangular



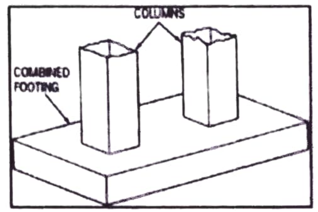
https://civilread.com/different-types-footings/

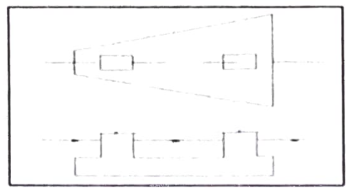


3. Combined Footing

- Provided to support more than one column

Combined Footing   Mat Foundation

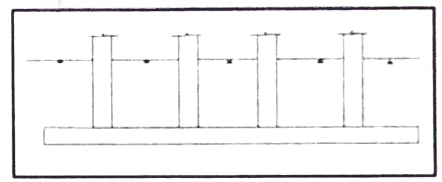


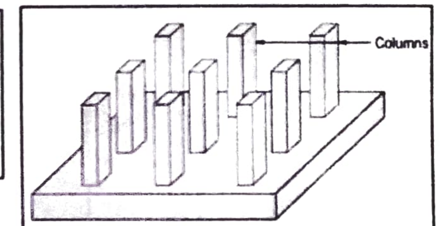


https://www.pinterest.com/pin/373446994077811715/

4. Mat or Raft Foundation

- Large slab supporting number of columns and walls under the entire structures





Mat /Raft Foundation

https://www.quora.com/How-many-types-of-footings-are-there-in-civil-engineering

Choice of particular type of foundation depends on the

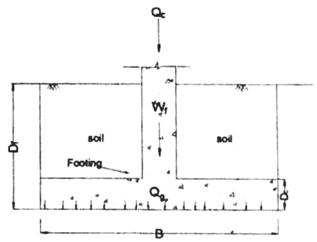
- Magnitude of loads
- Nature of the subsoil strata
- Nature of the superstructure
- Specific requirements

Two basic criteria for **design of foundation**

- Shear failure or Bearing capacity criteria
- Settlement criteria

Shear failure or Bearing Capacity Criteria :

The foundation should be design such that the soil below does not fail in shear



$$Q_g = Q_c + W_f + W_s$$

Q_c = wt. of superstructure

W_f = wt. of footing

W_f = wt. of soil/fill

The gross pressure or the gross load intensity (q_g)

$$q_g = Q_g / A$$

Gross Loading Intensity (q_g) : Total pressure at the level of foundation including the weight of superstructure, foundation, and the soil above the foundation.

$$q_g = \frac{Q_{Superstructure} + Q_{Foundation} + Q_{Soil}}{A_{Foundation}}$$

Net Loading Intensity (q_n) : Pressure at the level of foundation causing actual settlement due to stress increase. This includes the weight of the superstructure and foundation only.

$$q_n = q_g - \gamma D_f$$

Ultimate bearing capacity (q_u) : The maximum gross intensity of loading that soil can support before it fails in shear.

$$q_{nu} = q_u - \gamma D_f$$

Net ultimate bearing capacity (q_{nu}) : The maximum net intensity of loading at the base of the foundation that the soil can support before fail in shear.

Net safe bearing capacity (q_{ns}) : The maximum net intensity of loading that soil can safely support without the risk of shear failure.

$$q_{ns} = q_{nu} / F$$

Gross safe bearing capacity (q_s) : The maximum gross intensity of loading that soil can carry safely without failing in shear.

$$q_s = \frac{q_{nu}}{F} + \gamma D_f$$

$$q_s = \frac{q_u - \gamma D_f}{F} + \gamma D_f$$

Settlement Criterion

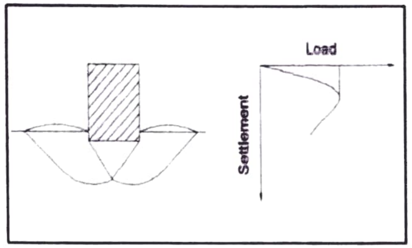
Safe bearing pressure : The maximum net intensity loading that can be allowed on the soil without the settlement exceeding the permissible value.

Allowable bearing pressure ($q_{a\text{-}net}$) : The maximum net intensity of loading that can be imposed on the soil with no possibility of shear failure or the possibility of excessive settlement. It is the smaller of the net safe bearing capacity (shear failure criterion) and safe bearing pressure (settlement criterion)

Modes of soil failure

General shear failure (Dense sand / stiff clay)

- A well defined failure surface
- A bulging of ground surface adjacent to the foundation
- The ultimate load can be easily located.



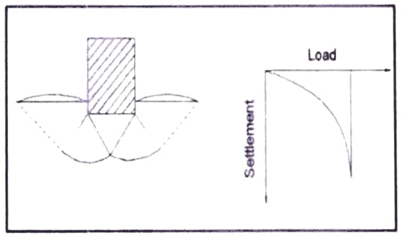
c_u (kPa)	consistency
0 – 12.5	very soft
12.5-25	soft
25-50	medium
50-100	stiff
100-200	very stiff
>200	hard

D_r (%)	consistency
0-15	very loose
15-35	loose
35-65	medium
65-85	dense
85-100	very dense

N Sivakugan

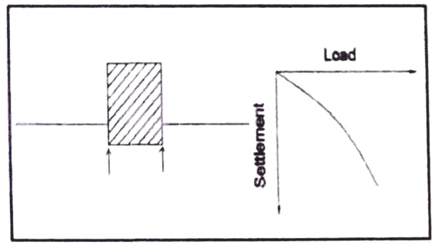
Local shear failure (medium or relatively loose sand /medium and relatively soft consistency clay)

- Well defined wedge and slip surfaces only beneath the foundation
- Slight bulging of the ground surface adjacent to the foundation
- Load settlement curve does not indicate ultimate load clearly
- Significant compression of the soil directly beneath the footing



Punching shear failure (very loose sand / very soft clay)

- Poorly defined shear planes
- Soil zones beyond the loaded area being little affected
- Significant penetration of a wedge shaped soil zone beneath the foundation
- Ultimate load can not be clearly recognized



UNIT-V

Settlement of Shallow Foundations

ALLOWABLE BEARING CAPACITY

- The allowable bearing capacity is the smaller of the following two conditions:

$$q_a = smallest \quad of \begin{cases} q_{ab} = \dfrac{q_{nu}}{F_s} + q' \ (Shear \quad Failure) \\ q_{as} \ (Settlement \quad Criteria) \end{cases}$$

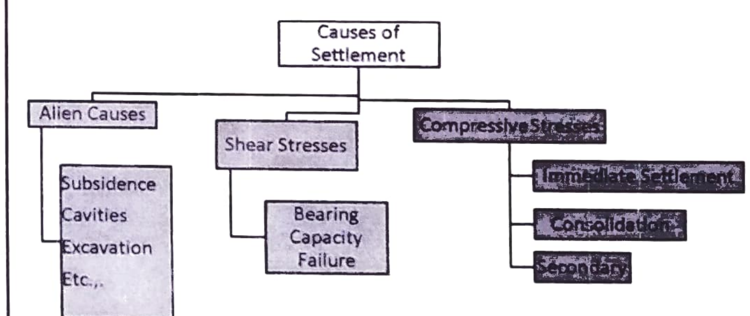
CAUSES OF SETTLEMENT

Settlement of a structure resting on soil may be caused by two distinct kinds of action within the foundation soils:-

I. Settlement Due to Shear Stress (Distortion Settlement)
In the case the applied load caused shearing stresses to develop within the soil mass which are greater than the shear strength of the material, then the soil fails by sliding downward and laterally, and the structure settle and may tip of vertical alignment. This is what we referred to as BEARING CAPACITY.

I. Settlement Due to Compressive Stress (Volumetric Settlement) As a result of the applied load a compressive stress is transmitted to the soil leading to compressive strain. Due to the compressive strain the structure settles. This is important only if the settlement is excessive otherwise it is not dangerous.

CAUSES OF SETTLEMENT



Settlement Calculation

1. Immediate Settlement(S_i):

$$S_i = \frac{qB}{E_s}\left(1-\mu_s^2\right)I_f$$

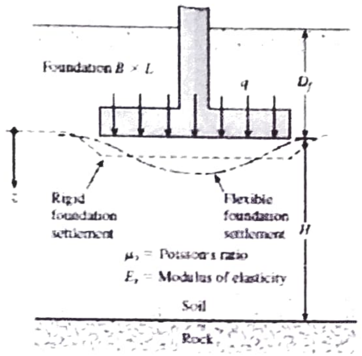
q = Net Foundation Pressure,

B = Width of the Foundation

μ_s = Poisson's Ratio (Soil),

E_s = Young's Modulus (For Soil)

I_f = Influence Factor



Source: Ranjan & Rao 2003

Shape	I_f for Flexible Foundation			I_f for Rigid Foundation
	Center	Corner	Average	
Circle	1.0	0.64	0.85	0.86
Square	1.12	0.56	0.95	0.82
Rectangle				
L/B =1.5	1.36	0.68	1.20	1.06
L/B =2.0	1.52	0.76	1.30	1.20
L/B =5	2.10	1.05	1.83	1.70
L/B =10	2.52	1.26	2.25	2.10
L/B =100	3.38	1.69	2.96	3.40

Consolidation Settlement

$S_c = \frac{C_c}{1+e_0} H \log_{10}\left(\frac{\bar{p}_0+\Delta p}{\bar{p}_0}\right)$ or $S_c = m_v H \Delta p$

$\bar{p}_0$: initial effective overburden pressure before applying foundation load

Δp = Vertical stress at the centre due to applied load

e_0 : initial void ratio

H : thickness of soil layer

C_c = Compression Index.

m_v : Compressibility.

Corrections

a) Rigidity Correction

$S_{rigid} = 0.8 \times S_{center}$ (flexible)

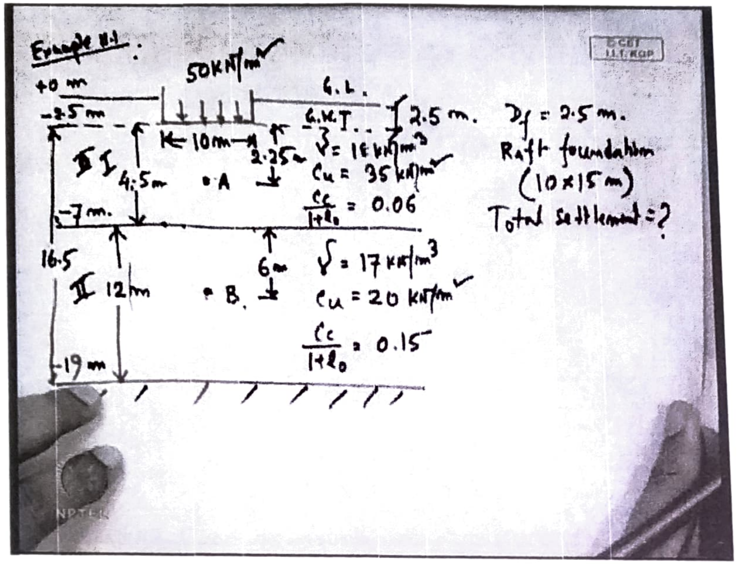
↑ Correction Factor

b) Depth Correction

$$\text{Depth correction factor} = \frac{S_{embedded}}{S_{surface}}$$

c) Correction for the effect of 3D Consolidation

S_c (3D) = C_r S_c (1D), Where Cr = Correction factor



a) **Immediate Settlement**

$$S_i = \frac{q_m B}{E}(1-\mu^2) I_p$$

Given $E = 700\,C_u$

$q_m = 50\ kN/m^2$, $B = 10\ m$, $\mu = 0.5$

$\frac{L}{B} = \frac{15}{10} = 1.5$, $I_f = 1.36$

$E = 700\ C_u$, $C_{u1} = 35\ kN/m^2$, $C_{u2} = 20\ kN/m^2$

$E_1 = 700 \times 35 = 24500\ kN/m^2$

$E_2 = 700 \times 20 = 14000\ kN/m^2$

$$E_{avg.} = \frac{24500 \times 4.5 + 14000 \times 12}{16.5} = 16864\ kN/m^2$$

$$S_i = \frac{50 \times 10}{16864}(1-0.5^2) \times 1.36 = 30.24\ mm$$

S_i (Without Corrections) = 30.24 m.

Rigidity Correction factor = 0.8

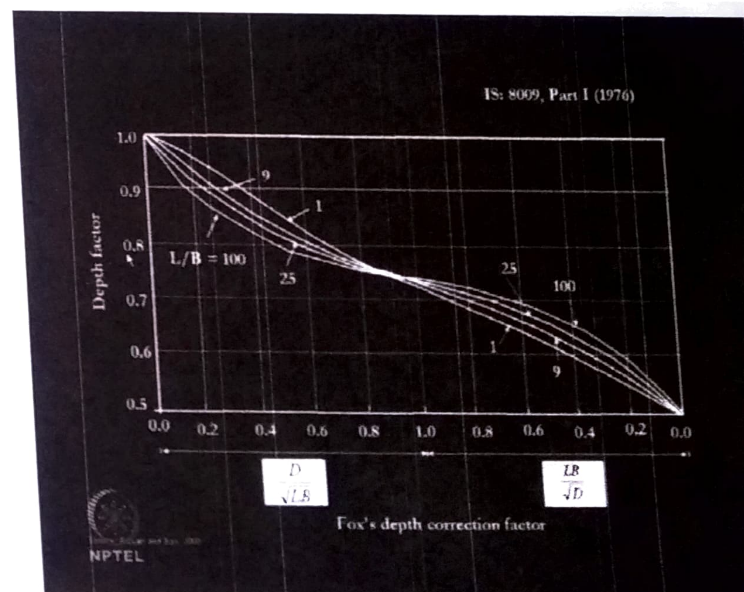
Depth Correction factor = ??

$L/B = \frac{15}{10} = 1.5$; $\frac{D}{\sqrt{LB}} = \frac{2.5}{\sqrt{10 \times 15}} = 0.2$ ($\because D_f = 2.5\ m$)

Depth factor = 0.97

S_i (Corrected) $= 30.24 \times 0.97 \times 0.8$

$= 23.47\ mm$



Fox's depth correction factor

b) Consolidation Settlement.

$$S_c = \sum \frac{C_c}{1+e_0} H \log_{10}\left(\frac{\Delta p + \bar{p}_0}{\bar{p}_0}\right)$$

at point A. $\bar{p}_0 = 18 \times 2.5 + 8 \times 2.25 = 63 \text{ kN/m}^2$ (18−10)

$$\Delta p = \frac{50 \times 10 \times 15}{(10+2.25)(15+2.25)} = 35.5 \text{ kN/m}^2$$

at point B. $\bar{p}_0 = 18 \times 2.5 + 4.5 \times 8 + 7 \times 6 = 123 \text{ kN/m}^2$

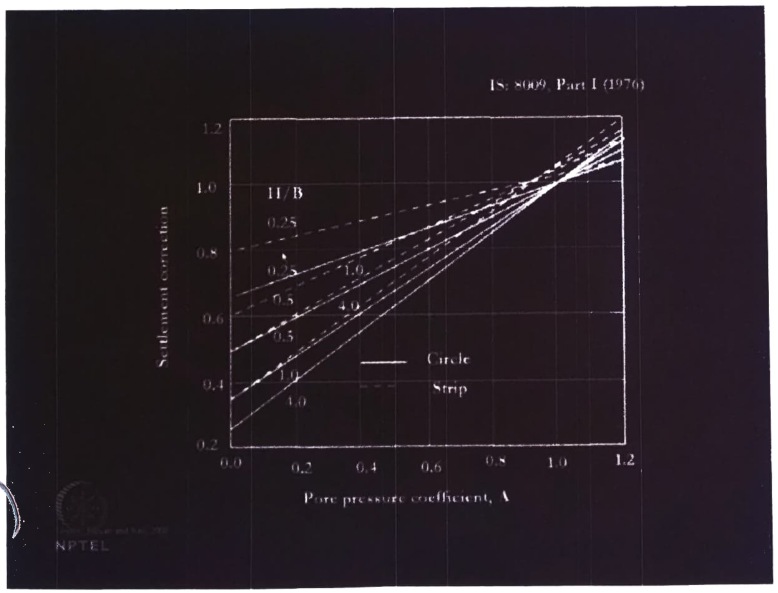
$$\Delta p = \frac{50 \times 10 \times 15}{(10+10.5)(15+10.5)} = 14.35 \text{ kN/m}^2$$

$$S_c = 0.06 \times 4.5 \times \log_{10}\left(\frac{63+35.5}{63}\right) + 0.15 \times 12 \times \log_{10}\left(\frac{123+14.35}{123}\right)$$

$$= (52.4 + 86.25) \text{ mm}$$

$$= 138.7 \text{ mm.}$$

a) Rigidity Correction factor = 0.8
b) Depth " " = 0.97
c) 3-D Consolidation " " =



$$S_c = 0.06 \times 4.5 \times \log_{10}\left(\frac{63+35.5}{63}\right) + 0.15 \times 12 \times \log_{10}\left(\frac{123+14.35}{123}\right)$$

$$= (52.4 + 86.25) \text{ mm}$$

$$= 138.7 \text{ mm.}$$

a) Rigidity Correction factor = 0.8
b) Depth " " = 0.97
c) 3-D Consolidation " " = 0.81

Given A = 0.86 ; A = 0.6, $\frac{H}{B} = \frac{16.5}{10} = 1.65$, Strip

S_c (corrected) $= 138.7 \times 0.97 \times 0.8 \times 0.81 = 87.2$ mm.

$S_t = S_i + S_c = 23.47 + 87.2 = 110.7 \simeq 111$ mm

Uses of piles

1. To carry vertical load

If all the (majority amount) loads are transferred to the pile tips

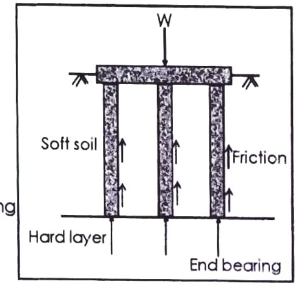
↓

End bearing pile

If all the (majority amount) loads are transferred to the soil along the length of pile

↓

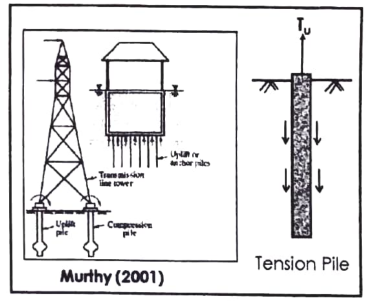
Friction pile



Compaction pile: *Short piles used for compacting loose sand.*

2. To resist uplift load

Tension pile or Uplift: Below some structures such as transmission tower, offshore platform which are subjected to tension.

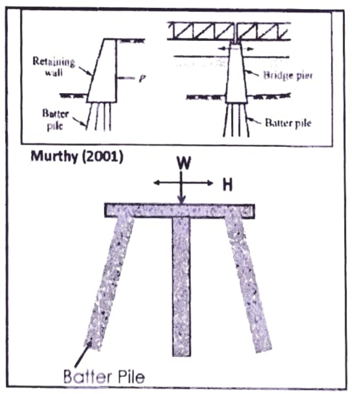


3. To carry inclined and horizontal load (foundation for retaining wall, bridge, abutments and wharves)

Laterally loaded piles: Horizontal load acts perpendicular to the pile axis.

Batter piles: Driven at an angle

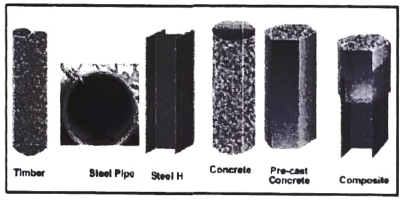
Carry large horizontal load



Types of pile

- **Material used**
  - Steel pile
  - Timber pile
  - Concrete pile
  - Composite pile
- **Cross-section**
  - Circular
  - Square
  - Hexagonal
  - I-section
  - H- section
  - Pipe
- **Shape**
  - Cylindrical
  - Tapered
  - Under-reamed
- **Mode of load transfer**
  - End bearing
  - Friction
  - Combined
- **Method of installation**
  - Driven
  - Bored
  - Jetted
- **Method of forming**
  - Pre-cast
  - Pre-stressed
  - Cast *in situ*
- **Based on displacement of soil**
  - Displacement piles
  - Non displacement piles

Based on material used :



https://www.slideshare.net/shivamsgandhi/pile-foundation

https://in.pinterest.com/pin/680043612452541560/

Concrete Pile

Steel Pile

http://www.86steelpipe.com/cs/gr-50-steel-pipe-piles.html

Timber Pile

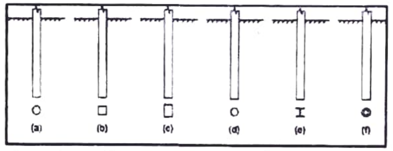
http://www.reidmiddleton.com/reidourblog/timber-pile-removal-and-the-benefits-to-our-environment/

Timber pile: suitable for light loads varies from 100 to 250 kN per pile. Suitable for soft cohesive soil.

Concrete Pile: all load condition. Most frequently used piles. Strong, durable.

Steel pile: Used to carry heavy load

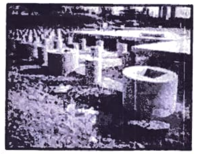
Based on crosssection:



http://www.soilmanagementindia.com/pile-foundations/classification-of-pile-foundations-9-criterions-soil-engineering/14179

a) circular, **b)** square, **c)** rectangular, **d)** hexagonal, **e)** H- section, **f)** pipe

https://www.dreamstime.com/stock-photo-pile-hexagon-concrete-foundation-piles-image55167024



http://www.zakladani.cz/en/piles

http://www.ffgb.be/Business-Units/Piles/Stalen-profiel-paal.aspx?lang=en-US

Rock or very dense sand – H pile and open ended pipe pile (least driving effort)

Under the vertical load, the type of pile cross section does not play a important role. However, under horizontal load, **square and H section pile perform well as compared to circular pile**

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