Bapuji Educational Association ®
Bapuji Institute of Engineering and Technology, Davangere – 577 004
Department of Civil Engineering

Course File Check List

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Revised-Acader (lendar of EVEN semesters o IC 'rogrammes for 2020-2021

Semesters EVENTS	IV semester B.E./B.Tech.	IV semester B.Arch./ B.Plan.	VI semester B.E./B.Tech.	VI semester B.Plan./B.Arch	VIII semester B.E./B.Tech.	VIII semester B.Plan.	VIII semester B.Arch
Commencement of EVEN Semester	19.04.2021	19.04.2021	19.04.2021	19.04.2021	19.04.2021	19.04.2021	19.04.2021
Last Working day of EVEN Semester	07.08.2021	07.08.2021	07.08.2021	07.08.2021	#20.07.2021	#20.07.2021	07.08.2021
Practical Examinations	09.08.2021 To 19.08.2021	09.08.2021 To 19.08.2021	09.08.2021 To 19.08.2021	---	---	---	---
Theory Examinations	23.08.2021 To 09.09.2021	23.08.2021 To 09.09.2021	23.08.2021 To 09.09.2021	10.08.2021 To 31.08.2021	22.07.2021 To 30.07.2021	22.07.2021 To 30.07.2021	10.08.2021 To 17.08.2021
Internship	---	---	---	---	---	---	---
Internship Viva-Voce/ Project Viva-Voce	---	---	---	---	02.08.2021 To 06.08.2021	---	---
Professional training / Organization study	---	---	---	---	---	---	---
Commencement of ODD Semester	13.09.2021	13.09.2021	13.09.2021	13.09.2021	---	---	23.08.2021

- The classroom sessions for even the semester should commence from the dates mentioned above.
- The Institute needs to function for **six days** a week with additional hours (**Saturday is a full working day**). #if required the college can plan to have extra classes even on Sundays also.
- If any of the above dates are declared to be a holiday then the corresponding event will come into effect on the next working day.
- Notification regarding the Calendar of Events relating to the conduct of **University Examinations** will be issued by the Registrar (Evaluation) from time to time.
- The faculty/staff shall be available to undertake any work assigned by the university.
- Academic Calendar may be modified based on guidelines/directions issued in the future by MHRD/UGC/AICTE/State Government.
- Revised Academic Calendar is also applicable for **Autonomous Colleges.** In case if any changes are to be affected by Autonomous Colleges in the academic terms and examination schedule, they could do so with the approval of the University.

21.04.2021.

REGISTRAR

Bapuji Institute of Engineering and Technology, Davanagere
CALENDER OF EVENTS-EVEN SEMESTER: APRIL 2021-SEP 2021 (Tentative)

PARTICULARS	IV sem BE/B.Tech	VI sem BE/B.Tech	VIII sem BE/B.Tech
Commencement of even sem	19-04-2021	19-04-2021	19-04-2021
Last Working Day	07-08-2021	07-08-2021	20-07-2021
1st IA Test Series	31-05-2021 To 05-06-2021	31-05-2021 To 05-06-2021	24-05-2021 To 29-05-2021
2nd IA Test Series	01-07-2021 To 07-07-2021	01-07-2021 To 07-07-2021	21-06-2021 To 26-06-2021
3rd IA Test Series	31-07-2021 To 06-08-2021	31-07-2021 To 06-08-2021	13-07-2021 To 19-07-2021
Practical Examination	09-08-2021 To 19-08-2021	09-08-2021 To 19-08-2021	—
Theory Examination	23-08-2021 To 09-09-2021	23-08-2021 To 09-09-2021	22-07-2021 To 30-07-2021
Internship Viva-Voce	—	—	02-08-2021 To 06-08-2021
Commencement of odd semester	13-09-2021	13-09-2021	—

Forum activities:

Dept. of Chemical Engg.	Dept. of E& C	Dept. of EEE	Dept. of Mech. Engg.
Interdepartmental Sports 25-05-2021 Anthyakshari 29-05-2021 CHEMEXCEL-2021 04-06-2021 Industrial Visit 05-06-2021 Guest Lecture 28-06-2021	NB Cup Cricket tournament inauguration 24-5-2021 E-Utsav 2021, Papyrus 2,3 June 2021	Online Impulse 26-5-2021 5 Day online Webinar on Operational Planning in Power System 10-14 May 2021	Mech-I-Prix State Level Paper Presentation Competition 25-05-2021

Principal

Vision of BIET

To be a center of excellence recognized nationally and internationally, in distinctive areas of engineering education and research, based on a culture of innovation and invention.

Mission of BIET

BIET contributes to the growth and development of its students by imparting a broad based engineering education and empowering them to be successful in their chosen field by inculcating in them positive approach, leadership qualities and ethical values

VISION OF THE DEPARTMENT

To train the students to become Civil Engineers with leadership qualities, having ability to take up professional assignments and research with a focus on innovative approaches to cater to the needs of the society.

MISSION OF THE DEPARTMENT

1. To provide quality education through updated curriculum and conducive teaching learning environment for the students to excel in higher studies, competitive examinations and professional career.
2. To impart soft skills, leadership qualities and professional ethics among the graduates to handle the projects independently with confidence.
3. To deal with the contemporary issues and to cater to the socio-economic needs.
4. To build industry-institute interaction and to establish good rapport with alumni.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Core Competence: Graduates will be able to plan, analyse, design and construct sustainable Civil Engineering Infrastructure.

PEO 2: Professional Skills: Graduates will be professional engineers with a sense of ethics, creativity, leadership, self-confidence and independent thinking to cater to the needs of the society.

PEO 3: Societal Needs: Graduates will be able to contribute effectively for the development of industry and professional bodies.

PEO 4: Cognitive Intelligence: Graduates will be able to take up competitive examinations, higher studies and involve in research and entrepreneurship activities.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Students after the completion of the Program will be able to

1. Apply the fundamental concepts, software and codal provisions in the analysis, design and construction of sustainable civil engineering infrastructure.
2. Inculcate professional and leadership qualities, sense of ethics and confidence related to civil engineering.

Faculty will be able to

3. Contribute to the overall development of civil engineering community through the professional bodies and offer services to the society.

TIME TABLE

Day ▼ / Time ▶	1	2	10.00 - 10.30	3	4	12.30 - 2.00	5	6	7
	8.00 - 9.00	9.00 - 10.00		10.30 - 11.30	11.30 - 12.30		2.00 - 3.00	3.00 - 4.00	4.00 - 5.00
MONDAY	20CSE043		SHORT BREAK			LUNCH BREAK	← 18CVL67	→	
TUESDAY		20CSE043			17CV833				
WEDNESDAY				17CV833					
THURSDAY		17CV833							
FRIDAY				20CSE043					
SATURDAY	20CSE043	← 18CVL 67		→					

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Jyothi S.H
Sign. of the Staff

Sign. of the HOD

Sign. of the Principal

B. E. CIVIL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII
PAVEMENT DESIGN

Course Code	17CV833	CIE Marks	40
Teaching Hours/Week(L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives: This course will enable students to

1. Gain knowledge about the process of collecting data required for design, factors affecting pavement design, and maintenance of pavement.
2. Excel in the path of analysis of stress, strain and deflection in pavement.
3. Understand design concepts of flexible pavement by various methods (CBR, IRC 37-2001, Mcleods, Kansas) and also the same of rigid pavement by IRC 58-2002
4. Understand the various causes leading to failure of pavement and remedies for the same.
5. Develop skills to perform functional and structural evaluation of pavement by suitable methods.

Module -1

Introduction: Desirable characteristics of pavement, Types and components, Difference between Highway pavement and Air field pavement, Design strategies of variables, Functions of sub grade, sub base, Base course, surface course, comparison between Rigid and flexible pavement

Fundamentals of Design of Pavements: Stresses and deflections, Principle, Assumptions and Limitations of Boussinesq's theory, Burmister theory and problems on above.

Module -2

Design Factors: Design wheel load, contact pressure, Design life, Traffic factors, climatic factors, Road geometry, Subgrade strength and drainage, ESWL concept Determination of ESWL by equivalent deflection criteria, Stress criteria, EWL concept, and problems on above.

Flexible pavement Design: Assumptions, Mcleod Method, Kansas method, CBR method, IRC Method (old), CSA method using IRC-37-2001, problems on above.

Module -3

Flexible Pavement Failures, Maintenance and Evaluation: Types of failures, Causes, Remedial/Maintenance measures in flexible pavements, Functional Evaluation by Visual inspection and unevenness measurements, Structural evaluation by Benkleman beam deflection method, Falling weight deflecto meter, GPR method. Design factors for runway pavements, Design methods for Airfield pavement and problems on above.

Module -4

Stresses in Rigid Pavement : Types of stress, Analysis of Stresses, Westergaard's Analysis, Modified Westergaard equations, Critical stresses, Wheel load stresses, Warping stress, Frictional stress, combined stresses (using chart / equations), problems on above.

Design of Rigid Pavement: Design of CC pavement by IRC: 58-2002 for dual and Tandem axle load, Reinforcement in slabs, Design of Dowel bars, Design of Tie bars, Design factors for Runway pavements, Design methods for airfield pavements, problems of the above.

Module -5

Rigid Pavement Failures, Maintenance and Evaluation: Types of failures, causes, remedial/maintenance measures in rigid pavements, Functional evaluation by Visual inspection and unevenness measurements, wheel load and its repetition, properties of sub grade, properties of concrete. External conditions, joints, Reinforcement, Requirements of joints, Types of joints, Expansion joint, contraction joint, warping joint, construction joint, longitudinal joint, Design of joints.

Course outcomes: After studying this course, students will be able to:

1. Systematically generate and compile required data's for design of pavement (Highway & Airfield).
2. Analyze stress, strain and deflection by boussinesq's, bur mister's and westergaard's theory.
3. Design rigid pavement and flexible pavement conforming to IRC58-2002 and IRC37-2001.
4. Evaluate the performance of the pavement and also develops maintenance statement based on site specific requirements.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.

- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks:

1. S K Khanna, C E G Justo, and A Veeraragavan, "Highway Engineering", Nem Chand & Brothers
2. L.R.Kadiyali and Dr.N.B.Lal, " Principles and Practices of Highway Engineering", Khanna publishers
3. Yang H. Huang , "Pavement Analysis and Design", University of Kentucky.

Reference Books:

1. Yoder & wit zorac, "Principles of pavement design", John Wiley & Sons.
2. SubhaRao, "Principles of Pavement Design".
3. R Srinivasa Kumar, "Pavement Design", University Press.
4. Relevant recent IRC codes

Title & Code	Pavement Design (17CV833)
CO	**Statement**
17CV833.1	**Explain** the types of pavements, their components and functions
17CV833.2	**Analyse** the stresses and deflection in pavements by different theories
17CV833.3	**Design** the flexible pavements by different methods
17CV833.4	**Explain** the causes and remedial measures for flexible pavement failures
17CV833.5	**Design** the rigid pavement for critical combination of stress
17CV833.6	**Explain** the causes and remedial measures for rigid pavement failures

Course Title		Pavement Design										
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
17CV833.1	2											2
17CV833.2	2	2		1								2
17CV833.3	2	2	3	1		2		2				2
17CV8334	2			1		2	2					2
17CV833.5	2	2	3	1		2		2				2
17CV833.6	2			1		2	2					2
Average	2	2	3	1		2	2	2				2

CO	PSO1	PSO2
17CV833.1	2	2
17CV833.2	2	2
17CV833.3	2	2
17CV8334	2	2
17CV833.5	2	2
17CV833.6	2	2
Average	2	2

TUTORIAL CLASSES

Date	Topics Discussed	Remarks

Test	Date	Class Strength	No. of Students Appeared	No. of Students Scored < 15	Signature of the HOD
T1					
T2					
T3					

LESSON PLAN

Subject : Pavement Design Subject Code : 17CV833 Class : 8th 'A'

Period	Date	Topics Planned	Date	Topics Covered	Remarks
1	27/4/21	Introduction, Desirable Characteristics of pavement	27/4/21	Introduction, Desirable characteristics of pavements	
2	28/4/21	Types & Components Difference b/n highway & Airfield Pavement.	28/4/21	Types & components, Difference b/n Highway & Airfield Pavements	
3	29/4/21	Design strategies of variables, Function of Subgrade, Sub base	29/4/21	Design strategies of variables, function of subgrade, subbase	
4	4/5/21	Base course, surface course Comparision b/n Rigid & Flexible pavement	4/5/21	Base course, surface course comparision b/n Rigid & Flexible Pavement	
5	5/5/21	Fundamentals of Design of Pavement stresses & Deflections.	5/5/21	Fundamentals of Design of Pavements stresses & Deflection	
6	6/5/21	Principle, Assumptions & limitations of Boussi-nesq's theory	6/5/21	Principle & Assumptions of Boussinesq's	
7	11/5/21	Burmister theory	11/5/21	limitations & problems of Boussinesq's	
8	12/5/21	Problems on theories	12/5/21	Burmister theory explanation.	
9	13/5/21	Module-2 Design wheel load, Contact pressure Design life	13/5/21	Problems on Burmister theory	
10	18/5/21	Traffic Factors, climatic factors Road geometry	18/5/21	Problems on theories	
11	19/5/21	Subgrade strength & drainage ESWL concept	19/5/21	Module-2. Design wheel load, contact pressure	
12	20/5/21	Determination of ESWL Deflection criteria, stress criteria.	20/5/21	Design life, Traffic Factors, climatic Factors.	
13	25/5/21	EWL concept, Problems on Above	25/5/21	Road geometry Determination of ESWL	
14	26/5/21	Flexible pavement design. Mcleod Method, Kansas method	26/5/21	Deflection criteria stress criteria	
15	27/5/21	CBR Method, IRC method (old) CSA method using IRC 37 2001	27/5/21	EWL concept	
16	1/6/21	Problems on above	1/6/21	Problems on ESWL	
		Module-3 Types of failures,			

LESSON PLAN

Subject : Pavement Design Subject Code : 17CV833 Class : 8th 'A'

Period	Date	Topics Planned	Date	Topics Covered	Remarks
18	10/6/12	Functional evaluation by visual inspection.	10/6/21	Flexible Pavement Design, Assumptions, on Mcleod Method	
19	15/6/21	unevenness measurements,	15/6/21	Kansas method, CBR Method	
20	16/6/21	Structural evaluation by Benkleman beam deflection Method	16/6/21	IRC Method (old) CSA Method IRC 37-2001	
21	17/6/21	Falling weight deflecto-meter, GPR Method.	17/6/21	Problem on Mcleoad Method	
22	22/6/21	Design factors for runway Pavements	22/6/21	Problems on Kansas & CBR Method	
23	23/6/21	Design Methods	23/6/21	Problems on IRC old Method	
24	24/6/21	Airfield Pavement & Problems on above	24/6/21	Design using IRC 37 2001	
25	29/6/21	Module-4: Types of Stress, Analysis of stresses, Westergaard's Analysis.	29/6/21	Module-3 Types of Failures, Causes, Remedial Measures, Functional evaluation by visual inspection	
26	29/6/21	Modified westergaard equations,	29/6/21	unevenness measurements, Structural evaluation by Benkleman beam deflection	
27	30/6/21	Critical Stresses, Wheel load stresses. Warping stresses.	30/6/21	Falling weight deflectionmeter, GPR method, Design factors for runway pavements	
28	30/6/21	Frictional Stress, Combined Stresses	30/6/21	Design Methods Airfield Pavements & Problem on above	
29	1/7/21	Problems on above Design of CC Pavement by IRC: 58-2002	1/7/21	Module-4; Types of stress, Analysis westergaard's Analysis Modified wester gaard eqn	
30	1/7/21	Dual & Tandem axle load. Reinforcement in slabs. Design of Dowel bars	1/7/21	Critical stress, Wheel load stress, warping stress. Functional & combined stresses	
31	2/7/21	Design of Tie bars, Design factors for Runway Pavements	2/7/21	Problems on above, Design of CC Pavement by IRC 58-2002	
32	6/7/21	Design methods for airfield pavements Problems on the above	6/7/21	Dual & Tandem axle load Reinforcement in slabs.	
33	7/7/21	Module-5: Types of Failures causes, Remedial / maintenance measures in RP	7/7/21	Design of Dowel bars, Design of Tie bars, Design Factors for Runway	
34		Functional evaluation by		Design methods for airfield	

LESSON PLAN

Subject : Pavement Design Subject Code : 17CV833 Class : 8th 'A'

Period	Date	Topics Planned	Date	Topics Covered	Remarks
35	8/7/21	Wheel load & its Repetitions	8/7/21	Module-5: Types of Failures, causes, evaluation, Remedial maintenance measure in RP	
36	13/7/21	Properties of Subgrade, Properties of concrete,	13/7/21	Functional evaluation by visual inspection & unevenness measurement wheel load & its repetitions	
37	13/7/21	external condition joints. Reinforcement, Requirements of joints	13/7/21	Properties of subgrade, Properties of concrete, external condition joints, Reinforcement	
38	13/7/21	Types of joints. expansion joint	13/7/21	Requirements of joints, Types of joints, expansion joint	
39	14/7/21	contraction joint, warping Joint, construction Joint	14/7/21	Contraction Joint, warping Joint construction joint	
40	14/7/21	longitudinal joint. Design of joints	14/7/21	longitudinal Joint, Design of joints,	

Class : 8th 'A' Subject Code : 17CV833 Subject : Pavement Design Total No. of Classes : 40

Sl No.	USN	NAME / DATE	27/4/21	28/4/21	29/4/21	4/5/21	5/5/21	6/5/21	11/5/21	12/5/21	13/5/21	18/5/21	19/5/21	20/5/21	25/5/21	26/5/21	27/5/21	1/6/21	2/6/21	10/6/21	15/6/21	16/6/21	17/6/21	22/6/21	23/6/21	24/6/21	29/6/21	29/6/21	30/6/21	30/6/21	No. of Days Present	%	Test Marks			Average	Remarks
																																	I	II	III		
1	4BD14CV077	Prabhudeva NJ	1	2	3	4	5	6	7	A	A	8	9	10	11	12	13	14	15	16	A	17	18	19	20	21	22	23	24	A	35	88	13	13	13	5	18
2	4BD14CV129	Siddesh B.O	1	2	3	4	A	A	5	6	7	8	9	10	11	12	A	13	14	15	A	16	17	18	19	20	21	22	23	24	35	88	13	13	13	5	18
3.	4BD15CV113	Tejas R	1	2	A	3	4	5	6	A	A	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	A	A	35	88	13	13	13	5	18
4	4BD16CV062	Nikhitha S S	1	2	3	4	5	6	7	8	9	10	11	12	13	A	14	15	A	16	17	18	19	20	21	22	A	23	24	25	37	93	14	14	14	5	19
5	16CV115	Vahini V	1	2	3	4	5	6	7	8	9	A	A	10	11	12	A	13	14	15	16	17	18	A	A	19	20	21	22	23	34	85	14	14	14	5	19
6	16CV041	Karthik S.H	1	2	3	4	5	6	7	8	A	A	9	10	11	12	13	A	14	15	16	17	18	19	20	21	A	22	23	24	35	88	13	13	13	5	18
7	16CV122	Yashas H.V	1	2	3	4	A	5	6	7	8	9	10	A	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	36	90	13	13	13	5	18
8	16CV007	Ajay P.H	1	2	3	4	5	6	A	A	7	8	9	10	11	12	13	14	15	A	16	17	18	19	20	21	A	22	23	24	35	88	28	28	28	10	38
9	16CV019	Arpitha R	1	2	3	4	5	6	7	A	8	9	A	10	11	12	13	A	14	15	16	17	18	19	20	21	22	23	24	25	37	93	28	28	28	10	38
10	16CV059	Nanjanagowda	1	2	3	4	A	A	5	6	7	8	9	10	11	12	13	14	A	A	15	16	17	18	19	20	21	22	23	24	34	85	26	26	26	10	37
11	16CV065	Niveditha	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	A	A	20	21	22	23	24	25	A	35	88	28	28	28	10	38
12	16CV083	Renuka Prasad	1	2	3	4	5	6	7	8	9	10	11	12	13	A	14	A	15	16	17	18	19	20	21	A	A	22	23	24	35	88	27	27	27	10	37
13	16CV087	Sandeep B.R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	A	A	17	18	19	20	21	22	23	A	A	24	35	88	25	25	25	10	35
14	16CV089	Sanjay A,B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	A	A	15	16	17	18	19	20	21	22	23	24	A	25	37	93	26	26	26	10	36
15	16CV093	Shameer.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	A	16	17	18	A	19	20	21	22	23	24	25	35	88	26	26	26	10	36
16	4BD17CV001	Abhishek R.V	A	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	38	95	30	30	30	10	40
17	17CV003	Akash	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	A	A	26	35	88	26	26	26	10	36
18	17CV005	Akshitha M	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	A	A	18	19	20	21	22	A	23	24	25	36	90	30	30	30	10	40
19	17CV007	Anjan Kumar T.C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	A	20	21	22	A	A	23	24	25	34	85	27	27	27	10	37
20	17CV009	Anusha Nyamati	1	2	3	4	5	6	7	8	A	A	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	35	88	28	28	28	10	38
21	17CV011	Arunkumar Malagev	1	2	3	4	5	6	7	8	9	10	11	A	12	13	14	15	16	17	18	19	20	A	21	22	23	24	25	26	35	88	27	27	27	10	37
22	17CV013	B Shravan Reddy	1	2	3	4	5	6	7	8	9	10	11	12	A	A	13	14	15	16	A	17	18	19	20	21	22	23	24	25	35	88	26	26	26	10	36
23	17CV015	Bharath Kumar H	A	1	2	3	A	4	5	A	6	7	8	A	9	10	11	A	12	13	14	15	16	17	18	19	20	21	22	23	34	85	30	30	30	10	40
24	17CV017	Bhoomika S.P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	A	20	21	22	23	24	25	26	27	35	88	29	29	29	10	39
25	17CV019	Chandana R.G	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	A	A	35	88	28	28	28	10	38
26	17CV023	Darshan Patil G.P	1	2	3	4	5	6	7	8	9	A	10	A	11	12	13	14	15	16	17	18	19	20	21	22	23	A	24	25	35	88	27	27	27	10	37
27	17CV029	Girija Sharma	1	2	3	4	5	6	7	8	9	10	A	11	12	13	14	15	16	A	17	18	19	A	20	21	22	23	24	25	35	88	28	28	28	10	38
28	17CV031	Gouthamraj M R	1	2	3	A	4	5	6	7	8	9	10	11	12	13	A	A	14	15	16	17	18	19	20	21	22	23	24	A	35	88	28	28	28	10	38
29	17CV035	Jai Ram S Vaitla	1	2	A	3	4	A	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	A	A	23	24	35	88	27	27	27	10	37
30	17CV037	Jayashree K.R	1	2	3	4	5	6	A	A	7	8	9	10	11	12	13	14	15	A	A	16	17	18	19	20	21	22	23	24	35	88	28	28	28	10	38
31	17CV039	Kavya J L	1	2	3	4	5	6	7	8	A	9	10	11	12	13	14	15	16	A	17	18	19	20	21	22	23	A	A	25	35	88	29	29	29	10	39
		Initials of Teacher																																			
		Initials of H.O.D.																																			

Class : 8th 'A' Subject Code : 17CV833 Subject : Pavement Design Total No. of Classes : 40

Sl No.	USN	NAME	DATE																												No. of Days Present	%	Test Marks			Average	Remarks
			27/4/21	28/4/21	29/4/21	4/5/21	5/5/21	6/5/21	11/5/21	12/5/21	13/5/21	18/5/21	19/5/21	20/5/21	25/5/21	26/5/21	27/5/21	1/6/21	2/6/21	10/6/21	15/6/21	16/6/21	17/6/21	22/6/21	23/6/21	24/6/21	29/6/21	29/6/21	30/6/21	30/6/21			I	II	III		
32	4BD17CV041	Kiran R Arakeri	1	2	3	4	5	6	7	8	A	A	9	10	11	12	A	13	14	15	16	17	18	19	20	21	22	23	24	25	35	88	27	27	27	10	37
33	17CV043	Mahesh B.K	1	2	A	A	3	4	5	6	7	8	9	10	11	12	A	13	14	15	16	17	18	19	20	21	22	23	24	25	34	85	28	28	28	10	38
34	17CV045	Mallik Raiyan B.K	1	2	3	4	5	6	A	A	7	8	9	10	11	12	13	14	15	16	17	18	A	A	19	20	21	21	22	23	34	85	27	27	27	10	37
35	17CV047	Mallikarjuna B.D	1	2	3	4	5	6	7	8	A	9	10	11	12	13	14	A	15	16	17	18	19	20	21	22	A	23	24	25	34	85	28	28	28	10	38
36	CV049	Manjunath P. Naik	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	35	88	30	30	30	10	40
37	CV051	Mohamed Aaqib	1	2	3	4	5	6	7	A	A	8	9	10	11	12	13	14	15	16	17	18	A	19	20	21	22	23	24	25	36	90	27	27	27	10	37
38	CV053	Mohammed Thoufiq S	1	2	3	A	4	5	6	7	8	9	10	11	A	12	13	14	15	16	17	18	19	20	21	22	A	23	24	25	35	88	26	26	26	10	36
39	CV057	Nandeesh N N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	A	39	98	27	27	27	10	37
40	CV067	Piyush Ranjan	1	2	3	4	5	6	7	8	9	10	11	A	12	A	13	14	15	16	17	18	19	20	21	22	23	24	A	25	35	88	30	30	30	10	40
41	CV069	Prathvi R Dafedar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	A	21	22	23	24	25	26	A	35	88	28	28	28	10	38
42	CV070	Rachana KS	A	1	2	3	4	5	6	7	8	9	10	11	12	13	A	14	15	A	16	17	18	19	20	21	22	23	24	25	35	88	29	29	29	10	39
43	CV071	Rahul Alur	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	A	19	20	A	21	22	23	24	25	A	36	90	26	26	26	10	36
44	CV075	Rakshitha A	1	2	3	4	5	6	7	8	9	10	11	12	A	A	13	14	15	16	17	18	19	20	21	22	23	24	A	25	36	90	29	29	29	10	39
45	CV077	Rakshitha G R	1	2	3	4	5	6	7	8	9	10	11	A	12	13	14	15	16	17	18	19	20	21	A	21	A	22	23	24	35	88	28	28	28	10	38
46	CV079	Rishika R Kadekoppa	A	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	A	23	24	25	36	90	29	29	29	10	39
47	CV085	Salma D	A	1	2	3	4	A	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	A	22	23	24	25	37	93	27	27	27	10	37
48	CV089	Sanjay S.H	A	1	2	3	4	5	6	7	8	9	A	10	11	12	13	14	15	A	16	17	18	19	20	21	22	23	24	25	35	88	29	29	29	10	39
49	CV093	Shodhana D.N	A	1	2	3	4	5	A	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	35	88	30	30	30	10	40
50	CV097	Sowmya N	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	A	17	18	19	20	21	22	23	24	25	26	35	88	27	27	27	10	37
51	CV099	Suhas S	A	A	1	2	3	4	5	6	7	8	9	10	11	12	13	A	14	15	16	17	18	19	20	21	22	23	24	25	35	88	26	26	26	10	36
52	CV101	Suma R Olekar	A	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	36	90	30	30	30	10	40
53	CV103	Syed Umar Faruq	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	21	A	22	23	24	25	35	88	29	29	29	10	39
54	CV109	Varshitha E R	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	A	20	21	A	22	23	24	A	35	88	28	28	28	10	38
55	CV111	Veeresh T M	A	1	2	3	4	5	6	7	8	9	10	A	11	12	13	14	15	16	17	18	19	20	21	A	22	23	24	A	35	88	30	30	30	10	40
56	CV115	Vinayaka M Belavigi	A	1	2	3	4	5	6	7	8	9	10	A	A	11	12	13	14	15	16	17	18	19	20	21	22	23	24	A	36	90	28	28	28	10	38
57	CV117	Vismaya A.J	A	1	2	3	4	5	6	7	8	9	A	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	35	88	30	30	30	10	40
58	CV119	Sachin D S	1	2	3	4	A	A	5	6	7	8	9	10	11	A	12	13	14	15	16	17	18	19	20	21	22	23	24	25	35	88	28	28	28	10	38
59	CV121	Ankith Raj R V	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	A	22	23	24	25	A	A	35	88	29	29	29	10	39
60	18CV403	Chethan S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	A	A	18	19	20	21	22	A	23	24	25	36	90	28	28	28	10	38
61	18CV405	Ganesh K.V	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	A	19	20	21	A	22	23	24	25	26	37	93	26	26	26	10	36
62	18CV408	Harsha H.K.	1	2	3	4	5	6	A	A	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	A	25	36	90	27	27	27	10	37
		Initials of Teacher																																			
		Initials of H.O.D.																																			

Class : 8th 'A'   Subject Code : 17CV833   Subject : Pavement Design   Total No. of Classes :

Sl No.	USN	NAME / DATE	27/4/21	28/4/21	29/4/21	4/5/21	5/5/21	6/5/21	11/5/21	12/5/21	13/5/21	18/5/21	19/5/21	20/5/21	25/5/21	26/5/21	27/5/21	1/6/21	2/6/21	10/6/21	15/6/21	16/6/21	17/6/21	22/6/21	23/6/21	24/6/21	29/6/21	29/6/21	30/6/21	30/6/21	No. of Days Present	%	Test Marks I	Test Marks II	Test Marks III	Average	Remarks
63	CV409	Jothirani B N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	16	A	17	18	19	20	21	22	23	24	25	26	35	88	27	27	27	10	37
64	CV413	Lohith Kumar B	1	2	3	4	5	6	7	8	A	A	9	10	A	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	35	88	26	26	26	10	36
65	CV417	Nayanashree M	1	2	3	4	5	6	7	8	A	A	9	10	11	12	13	14	15	16	17	18	19	20	21	A	22	23	24	A	35	88	26	26	26	10	36
66	CV420	Prem V	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	16	17	18	19	20	21	22	23	A	24	25	A	35	88	29	29	29	10	39
67	CV421	Rakshitha K	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	16	17	18	19	20	21	22	A	23	24	25	A	36	90	26	26	26	10	36
68	CV423	Sachin K V	1	2	3	4	5	6	7	8	9	10	11	A	12	13	14	15	16	17	18	19	A	21	22	23	24	25	26	A	35	88	28	28	28	10	38
69	CV427	Shruthi R M	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	A	20	21	22	23	A	24	25	26	35	88	29	29	29	10	39
70	CV428	Sowmya K R	1	2	3	4	5	6	7	8	9	10	11	A	A	12	13	14	15	16	17	18	19	20	21	22	23	24	25	A	35	88	28	28	28	10	38
71	CV429	Varun Sagar R	1	2	3	4	5	6	7	8	9	10	11	A	12	13	14	15	16	A	17	18	19	20	21	22	23	A	24	25	35	88	27	27	27	10	37
72	CV430	Vinutha E	1	2	3	4	A	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	A	26	36	90	26	26	26	10	36
73	CV431	Yashwanth Rao Jadav S	1	2	3	4	5	6	A	A	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	A	24	25	35	88	27	27	27	10	37
74	CV432	Yatheesha G N	1	2	3	4	5	6	7	8	A	A	9	10	11	A	12	13	14	15	16	17	18	19	20	21	22	23	24	25	36	90	26	26	26	10	36
		Initials of Teacher																																			
		Initials of H.O.D																																			

①

PAVEMENT DESIGN

Characteristics of Pavement ;

A highway pavement is designed to support the wheel loads imposed on it from traffic moving over it. It should be strong enough to resist the stresses imposed on it and it should be thick enough to distribute the external loads on the earthern subgrade. So that the subgrade itself can safely bear it

To satisfy the above functions the pavement should have these characteristics ;

① It should be structurally sound enough to withstand the stresses imposed on it.

② It should be sufficiently thick to distribute the loads and stresses to a safe value on the subgrade soil.

③ It should provide a reasonably hard wearing surface so that the abrading action of wheels [pneumatic and iron tyred] does not damage the surface.

④ It should be dust proof so that traffic safety is not impaired

⑤ Its riding quality should be good It should be smooth enough to provide comfort to the road users at the high speed at which modern vehicles are driven.

⑥ The surface of the pavement should develop as low a friction with the tyres as possible this will enable the energy consumption of the vehicles to be low.

⑦ The surface of the pavement should have a texture and adequate roughness to prevent the skidding of vehicles

⑧ The surface should not produce excessive levels of sound from moving vehicles

⑨ The surface should be impervious so that water does not get into the lower layers of the pavement and the subgrade and cause deterioration.

⑩ The pavement should have long life and the cost of maintaining it annually should be low.

The Pavement structure consists of the Following layers;

a) Prepared soil subgrade
b) granular sub-base course, which also serves as a drainage layer within the pavement structure
c) Base course
d) Surface course

Types of Pavement structure;

Based on the structural behavior, road pavements are generally classified into 2 categories,

i) Flexible Pavement ii) Rigid pavement

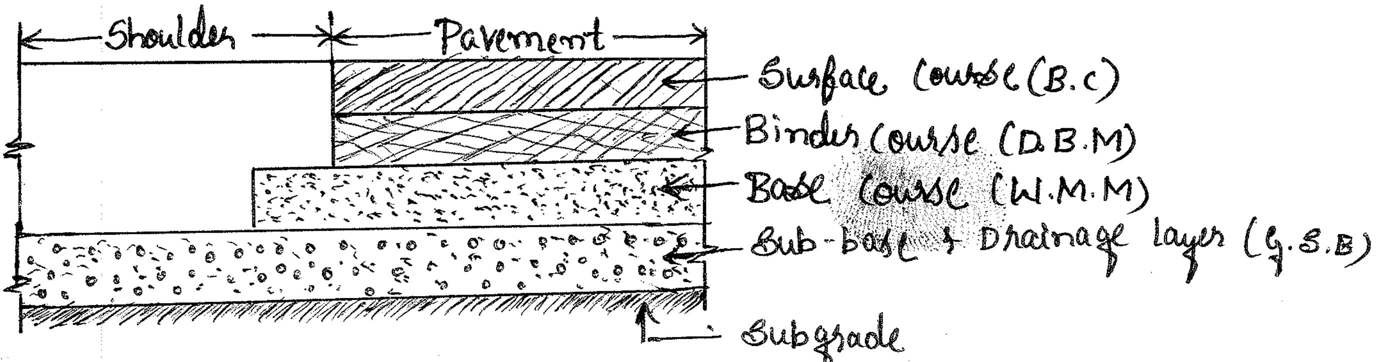
[Semi Rigid pavement & Interlocking cement concrete Block Pavement [ICBP] these are less common]

②

Flexible Pavement

On which there will be no or (little bit) Negligible Flexural strength and they are flexible in their structural action under the loads.

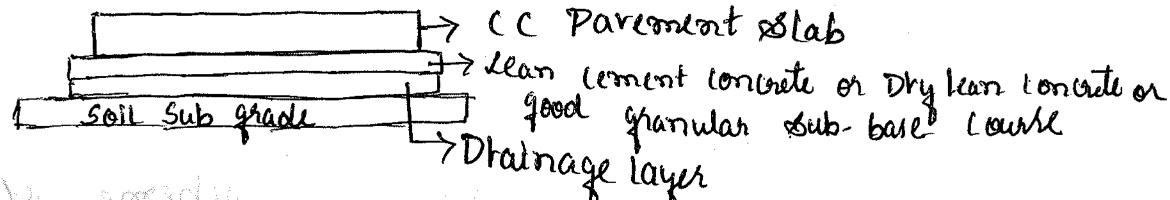
- * FP will show the recoverable deformations of the lower layers including the subgrade on to the upper layers and also to the pavement surface.
- * Flexible pavement the wheel load is distributed uniformly on the surface & the compressive stresses are also get distributed by taking advantage of the stress distribution 'Pavement layer system concept' was developed.
- * Top layer should be stronger to withstand the wheel load
- * Since lower layers of the pavement will take up only lesser magnitude of stresses there is no direct wearing action due to traffic loads and weathering action due to environmental factors therefore inferior materials with lower cost can be used in the lower layers
- * The lowest layer consists of selected soil which is compacted to the required thickness & density & is called the 'subgrade' which is laid over prepared / compacted soil or fill.
- * FP consists of a wearing surface at the top, the base course followed by the sub-base course-cum-drainage layer below. The lowest layer is the compacted soil subgrade which has also the lowest stability among the 4 typical flexible pavement components.
- * FP are designed for a life cycle of 15 years or more it needs re-surfacing or strengthening layers to be added / laid periodically on the surface



COMPONENTS OF A TYPICAL FLEXIBLE PAVEMENT

Rigid Pavements :

- RP are those which Posses noteworthy Flexural strength or Flexural rigidity.
- RP are generally made of portland cement concrete (cc) and are therefore called "CC Pavements"
- High quality Plain cement concrete meant for the Pavement called Pavement Quality concrete (PQC)
- They should sustain up to 45 kg/cm² of flexural stresses
- combined actions of wheel loads & temperature changes affects the flexural stress at a certain locations
- The stresses in rigid pavements are analysed using the elastic theory, assuming the pavement as an elastic plate resting over an elastic or a viscous foundation.
- Stresses developed and their distribution within the cement concrete pavement slab are quite different. compared to FP
- PQC served as a good wearing surface as well an effective base course
- Not directly laid over the soil subgrade
- A good base or sub base course laid under the cc pavement slab along with a good drainage layer underneath increases the life of the pavement considerably



COMPONENTS OF RIGID PAVEMENTS

- * CC pavements are usually designed for a life of 30 years
- * It only requires Maintenance of drainage system and the joints of the CC pavement

COMPARISION OF RIGID AND FLEXIBLE PAVEMENTS

1) Design Precision; RD are much more precise structural analysis than a FP [Flexural strength is Fixed in RP]

2) Life; RP 3 to 4 decades of trouble free performance till 40 Years

FP From 10 to 20 Years

3) Maintainance; RD requires little Maintenance only needed in joints

FP Maintainance of Pathholes by resurfacing and resealing and also due to oil spillage, Natural weathering air, water & temperature

usually for a 2 lane 30K to 1lakh Km/annum

RD have cost of RS 5000 - 10000 per Km/annum

Initial cost :

RP will be having more initial cost the FP

Construction Stage :

o RP do not fit into scheme of stage construction

Availability of Materials :

RP are More easily constructed than FP

Surface characteristics :

RP are free from rutting, potholes & corrugations riding quality of cement concrete surface is always assured.

Penetration of water :

RP slab is practically impervious except at joints if joints are faulty Mud pumping decreases that soil stability

utility location :

In RP it is difficult to open the slab & restore it to the original condition if any changes in the utility lines are to be made

Glare & Night Visibility :

RP are grey colour which can cause glare under sunlight, coloured cement can reduce the glare, black bituminous pavements are free from this defect on the other hand FP needs more street lighting

④ Traffic dislocation during construction

RP requires 28days before it can be thrown open to traffic

Bor FP can be thrown open to the traffic shortly after it is rolled

Environmental consideration during construction

FP are more hazardous to the environment

overall economy on a life cycle basis

RP are far more economical than a FP

COMPONENTS OF FLEXIBLE PAVEMENTS :

From the bottom :

a) Prepared soil subgrade
b) Granular sub-base cum drainage layer
c) Granular base course
d) Bituminous binder and /or surface course

Functions of soil subgrade :

★ It is a Natural soil from identified borrow pits fulfilling the specified requirements & Well compacted in layers to the desired density to required thickness

★ 500 mm thickness incase of State highways & National highways

★ 300 mm for rural roads.

★ It receives the loads from layers of pavement materials. The wheelloads of the pavement are ultimately received by the soil subgrade hence it is essential than stress induced on top of subgrade is within allowable limits to improve the strength of surface

Subbase coarse;

It is the layer provided next to the subgrade it is generally made up of soils like gravel which are stronger than subgrade soil. Subbase is necessary when subgrade is weak the subbase provides additional help to base coarse in distributing the loads

The thickness of subbase varies from 75-100mm for garden paths, 100-150mm for driveways & public foot paths, 150-225mm for heavy used roads.

Functions;

① To provide additional support to base & surface coarses in distributing the load

② To prevent intrusion of fine grained road bed soil into base layers

③ To minimise the damaging effect of frost action

④ To facilitate drainage of free water that may be accumulated below the pavement.

Base coarse; [100-150mm]

It is the layer provided next to the base coarse it is generally madeup of crust or broken stones with some binder. The main function of the base coarse is to act as a structural portion of the pavement and distribute the wheel loads.

① To act as a structural portion of the pavement and distribute the load to subbase

② If constructed directly over the subgrade, intrusion of subgrade soil into pavement can be avoided and mud pumping is minimised in case of

③ To receive load from surface coarse & distribute the vertical stress gradually to subbase coarse

⑤ Varying surface [surface coarse]

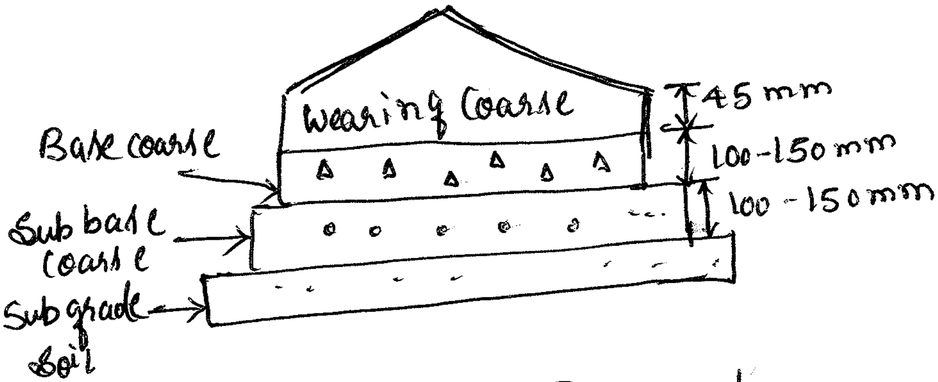
It is the topmost layer of the pavement

Functions;

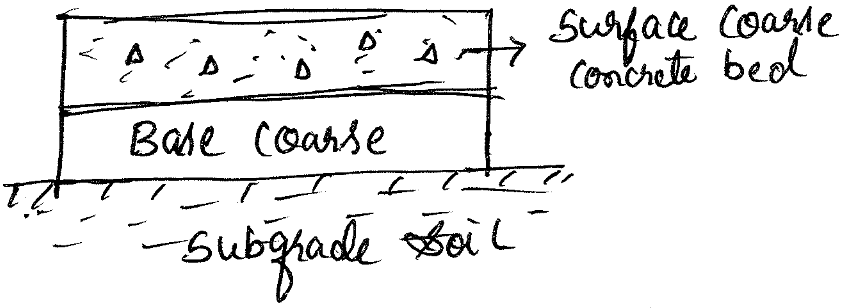
1. To perform as a structural portion of the pavement to withstand impact loading at the point of contact with wheel & surface
2. To restrict abrassive forces of traffic there by minimising vehicle damaging effect caused to structure of the pavement
3. To prevent surface water entering into the pavement

4) To provide skid resistance to surface

5) To provide smooth & uniform riding surface



Flexible Pavement



Rigid ~~Flexible~~ Pavement

PTO

Difference between Flexible and Rigid Pavement

Flexible Pavement	Rigid Pavement
1) Flexural strength is low or Negligable	★ Flexcural strength is very High
2) Life varies from 10-20 years Higher life demands additional Maintainance cost	★ Design life up to 40 years
③ Initial cost of investment is less but maintainance cost is more	★ Initial cost of investment is more but maintainance cost is less
④ Immediatly after 24 hours the construction of Flexible pavement can be opened to traffic	★ Requires 28 days of curing before opening to traffic
5) The thickness required for flexible pavement is influenced by the strength of subgrade	★ The Major factor considered during of rigid pavement is the flexural strength of concrete
6) consists of relatively thin WC built over a base & subbase resisting upon the compacted subgrade	★ A reigid pavement generally madeup of plain cement concrete that may or may not have subbase coarse b/w pavement & subgrade
7) Have the stability due to aggregate interlock particle friction & cohesion	★ Stability is provided slab due to its flexural strength
⑧ Design based on the layering system concept	★ It is designed based on slab action
9) The stress transfers from grain to grain & deformation on the top is reflected on the bottom layer	★ No such transfer & deformation if any is not reflected on the bottom layer

Difference b/n Highway & Airfield Pavement

	Highway	Air field Pavement
1) Volume of the traffic	Highway Pavement are typically constructed to support a high volume of auto mobile and truck traffic	The Majority of airport Pavement see only a few dozen aircraft passes per day
2) Repetition of loads	The No. of Repetition of load is about 1000 to 2000 trucks per day per lane	The No. of repetition considerably less ie 20000 to 40000
3) Distress type	Highway pavement are more prone to lead associated distresses types, such as rutting and fatigue cracking	Airport Pavement predominantly exhibit environmental associated distresses types such as weathering, ravelling & cracking
4) Gross load	It is less around 20tonnes for dual tandem wheels	Gross load on the airport Pavement is greater than on a highway pavement is about 80 to 250 tonnes
5) Application of loads	The Major Portion of load is applied just several feet from the edge of the rigid highway Pavement	Loads are primarily applied on the centre of the air field slabs
7) Tyre pressure	Highway pavement can with stand a tyre pressure up to 4 to 7kg/cm²	The tyre pressure of air craft pavement is much greater than highway vehicles upto 25 to 30 kg/cm²
8) Design criteria	The Design of Highway Pavement is based on moving load with the loading duration as an input for visco elastic behaviour	The Design of airport Pavement is based on moving load in the interior of runway but stationary load

		at the end of runway. As a result, thicker pavement is used at the runway end than in the interior
Major Failure	Pumping can be major Problem on highway	Pumping is of less important for rigid air field Pavement
Width of Pavement	width of highway pavement depends upon the No. lanes & the no. of lanes depends on the traffic intensity usual width of the 2 way pavement is 7m	width of air port Pavement depends upon the class of the airport type of the area in operation & standard clearance value. The width of air way Pavement ranges from 13-60m
Design of Wheel load	Design wheel load is about 5.1 tonnes	Design wheel load about 50 tonnes

Design statergies of variables:

In order to complete a pavement design, numerous variable must be determined

i) Pavement performance; serviceability of Pavement

According to the AASHTO design method the pavement performance & its condition is subjectively rated by a panel of experienced drivers according to their given scale of 0 to 5 presenting very poor & very good. that is termed as Present serviceability Rating (PSR)

Serviceability is a measure of functional level services at a given point on time of the life of a pavement in addition to serviceability the pavement service life or period of performance for a pavement must be established

Traffic; To the present analysis to the future forcasting

Subgrade soil characteristics; has impact on the structural requirement of a pavement

Material; Quality & quantity of a material to meet the specific requirement.

Environmental consideration:

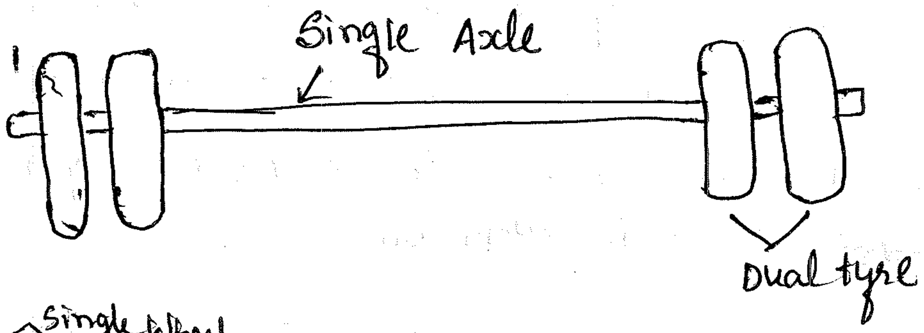
- Temperature
- Rainfall

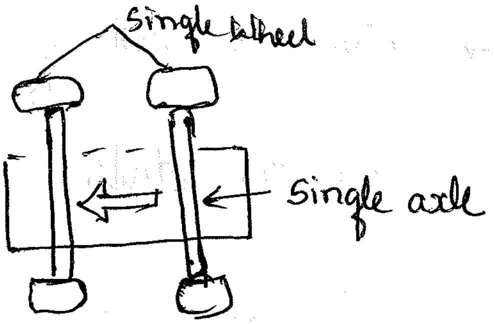
∴ AASHTO; Americal Association of State Highway & Transportation officials

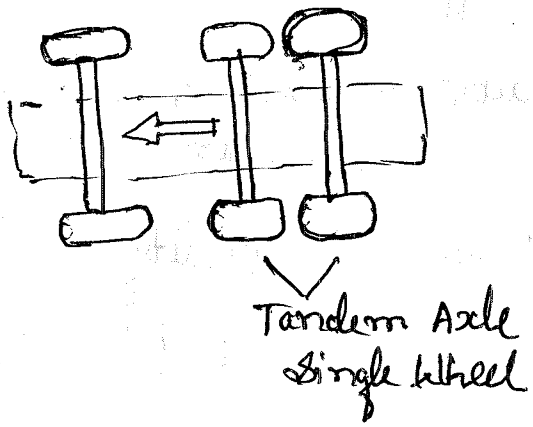
Factors Related to Axle & Wheel load;

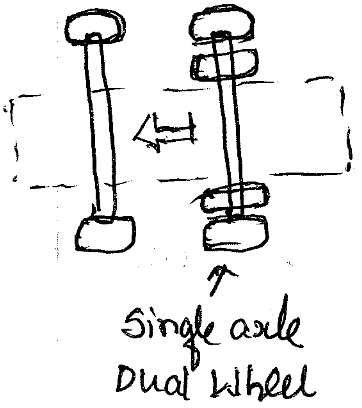
* The total weight of a vehicle is carried by its axles the load on the axles is transferred to the wheels & this load is ultimately trasferred on to the surface of the pavement in contact with the tyres

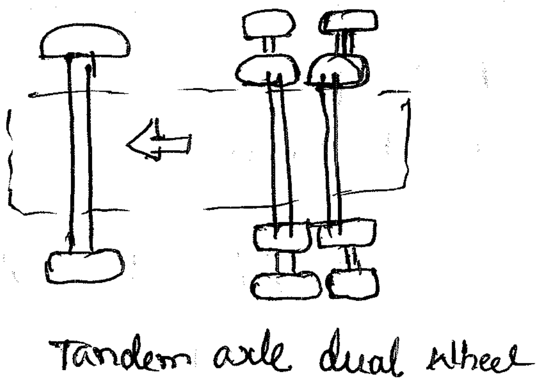
To keep wheel load induced stresses on pavements within allowable limits the total vehicle load is distributed onto wider areas of pavement by using more axles & wheels











~~Paver~~ Factors Affecting Pavement design; ⑧

Traffic & loading are the 2 Main Factors

Traffic;

★ contact pressure

★ Wheel load

★ Axle configuration

★ Moving loads

★ Repetition of loads

★ Environmental Factors:

Performance of the Pavement Material

a) Temperature ★ precipitation

↓

Flexible → ↑ temperature ↓ More the elastic modulus value [Binding of asphat also varies with temperature)

Rigid; severe pavement due to expansion, contraction. slab curling

[distillation of crude oil]

- Bitumen is a liquid that binds together asphatt
- Asphalt; mixture prepared by adding aggregates with bitumen

Bousi

Stresses in the Soils

Loads → Stress → Strain → Deformations

Stresses in the soil are due to ;

- Self weight of soil
- Structural loads, applied at or below the surface

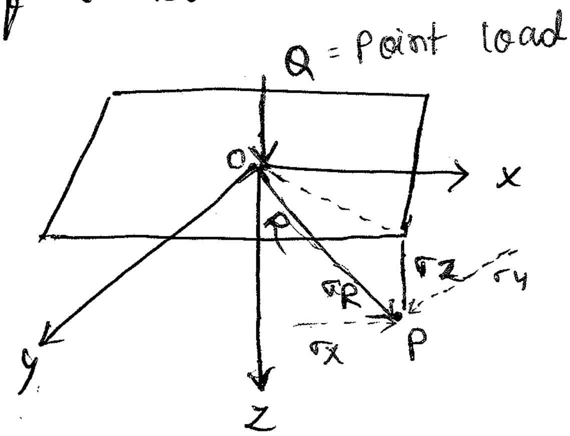
Depends on the factors ;
Drainage conditions, water content, void ratio, rate of loading the load level & the path followed by the stress

Bousinesq's theory
It gives the solution for the stresses caused by the application of the point load, at the surface of a elastic medium

Assumptions ;

1) The soil medium is an elastic continuum having a constant value of modulus of elasticity (E) i.e it obey's Hooke's law
2) The soil is homogeneous i.e it has identical elastic properties at all points in identical directions
3) The soil is isotropic. i.e it has identical elastic properties in all direction at a point
4) The soil mass is semi infinite. i.e it extends to infinity in the downward directions & lateral directions In other words it is limited on its top but a horizontal plane & extends to infinity in all other directions.

On a point load is acting on a vertical direction on the surface of a soil



R = Polar distance b/n the origin O & Point P
σR = Polar stress

Bossinesq already proved that the Polar stress σR at Point P is given by

$$\sigma_R = \frac{3}{2\pi}\left[\frac{Q\cos\beta}{R^2}\right] \text{ — ⓐ}$$

Assumptions ;

1. Soil mass is elastic continum having a constant value of MOE (E) i.e it obey HOOK'S law
2. Soil is homogeneous i.e it has identical elastic properties it all points in identical direction
3. The soil is isotropic, i.e it has identical properties in all direction at a point.
4. The soil mass is semi infinite i.e it extents to infinity in the down ward direction & lateral direction in other words, it is limited on its top but a horizontal Plane & extends to infinity in all other directions
5. The self weight of the soil is ignored
6. Initially unstressed
7. Top is free from shear stress & is subjected to only the point load
8. The stresses are distributed symmetrically with respect to Z axis

[β = angle which the line op makes with the vertical

or $R = \sqrt{r^2 + z^2}$

where $r^2 = x^2 + y^2$

$\sin\beta = \frac{r}{R}$ & $\cos\beta = \frac{z}{R}$

σ_z at point P is given by

$$\sigma_z = \sigma_R \cos^2\beta \rightarrow ②$$

$$\sigma_R = \frac{3}{2\pi}\left[\frac{Q\cos\beta}{R^2}\right]\cos^2\beta$$

$$= \frac{3Q}{2\pi}\left[\frac{\cos^3\beta}{R^2}\right]$$

$$\sigma_z = \frac{3Q}{2\pi}\left[\frac{\left(\frac{z}{R}\right)^3}{R^2}\right]$$

$$\sigma_z = \frac{3Q}{2\pi}\left[\frac{z^3}{R^5}\right]$$

$$= \frac{3Q}{2\pi}\left[\frac{z^2\,z^3}{z^2\,R^5}\right]$$

$$= \frac{3Q}{2\pi}\left[\frac{z^5}{z^2(R^5)}\right] \Rightarrow \frac{3Q}{2\pi z^2}\left[\frac{z^5}{(r^2+z^2)^{5/2}}\right]$$

$$= \frac{3Q}{2\pi}\,\frac{1}{z^2}\left[\frac{1}{\left[1+\left(\frac{r}{z}\right)^2\right]^{-5/2}}\right]$$ Not Needed

$$\frac{3Q}{2\pi}\left[\frac{z^3}{(r^2+z^2)^{5/2}}\right]$$

$$= \frac{3Q}{z^2\,2\pi}\left[\frac{1}{1+r}\right.$$

Examples :

1) calculate the vertical stress due to a point load of 4200kg at a depth of 4m from the surface and at a distance of 2m from the axis of load

P = Point Load = 4200kg

r = radial distance = 2m

Z = depth from surface = 4 m

$$\sigma_z = \frac{3P}{2\pi Z^2}\left[\frac{1}{1+\left(\frac{r}{z}\right)^2}\right]^{5/2}$$

$$\sigma_z = \frac{3 \times 4200}{2\pi \times 4^2}\left[\frac{1}{1+\left(\frac{2}{4}\right)^2}\right]^{5/2} = \underline{71.74} \text{ kg/m}^2$$

2) A semi infinite soil mass is subjected to stress under a circular plate having 15 cm radius the load intensity over the Plate is 4000 kg calculate the vertical stress in the soil under the axis of circular plate at 20cm depth

σ_z = vertical stress

P = uniformly distributed pressure = $\frac{\text{load intensity}}{\text{Area}} = \frac{4000}{\pi \times 15^2}$

= 5.66 kg/cm²

a = radius of plate = 15cm

Z = depth from the surface = 20 cm

$$\sigma_z = 5.\,p\left[1-\frac{1}{\left(1+\left(\frac{a}{z}\right)^2\right.}\right]^{3/2}$$

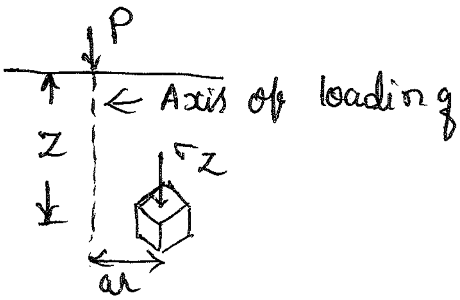
$$\sigma_z = 5.66\left(1-\frac{1}{1+\left(\frac{15}{20}\right)^2}\right]^{3/2} = \underline{\underline{2.76}} \text{ kg/cm}^2$$

Boussineq's theory ;

The following equations are based on Boussineq's theory & are widely used to calculate the stresses in the soil mass

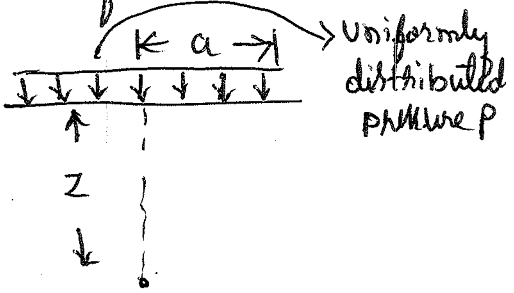
a) Point load

$$\sigma_Z = \frac{3P}{2\pi Z^2}\left[\frac{1}{\left[1+\left(\frac{r}{z}\right)^2\right]}\right]^{5/2}$$



P = Point load
Z = depth from surface
r = radial distance from axis of loading
σ_Z = Vertical stress

b) Uniformly distributed load over a circular Area



$$\sigma_Z = p\left[1 - \frac{1}{\left[1+\left(\frac{a}{z}\right)^2\right]}\right]^{3/2}$$

σ_Z = Vertical stress
a = radius of the loaded area
Z = depth from the surface
p = uniformly distributed pressure

Deflection ;

The Vertical displacement at the surface (zero) under the centre of the load is given by

i) $\Delta = \frac{1.5pa}{E}$ for flexible plate [Tyred loading

$$\Delta = \frac{2pa}{E}(1-\mu^2) \quad \mu = 0.5$$

ii) $\Delta = \frac{1.18pa}{E}$ for rigid plate loading

$$\Delta = \frac{\pi Pa(1-\mu^2)}{2E} \quad \mu = 0.5$$

Δ = vertical surface deflection
p = Applied pressure
a = radius of the circular loaded area
E = Modulus of elasticity

Generally displacement factor (Fw) is estimated by trial thickness for a ratio of E_1/E_2

where E_1 → Young's Modulus of elasticity of structure i.e Pavement

Note: the displacement under load is maximum, i.e 0.5cm for flexible pavement

* Design the thickness of flexible Pavement by Burmister two layer analysis for wheel load 40KN and tyre pressure 0.5 MN/m² and The Modulus of elasticity of pavement material is 150 MN/m² and that of the subgrade is 30 MN/m²

given, $P = 40\,KN$

$= 40 \times 10^3 N$

$p = 0.5 MN/m^2$

$= 0.5 N/mm^2$

$E_1 = 150 N/mm^2$

$E_2 = 30 N/mm^2$

$$a = \sqrt{\frac{P}{p\pi}}$$

$$= \sqrt{\frac{40 \times 10^3}{0.5 \times \pi}}$$

$a = 159.57mm$

$a = 16cm$

$$\frac{E_2}{E_1} = \frac{30}{150} = \frac{1}{5}$$

Let us assume trial thickness of Pavement as

$h = 2a$

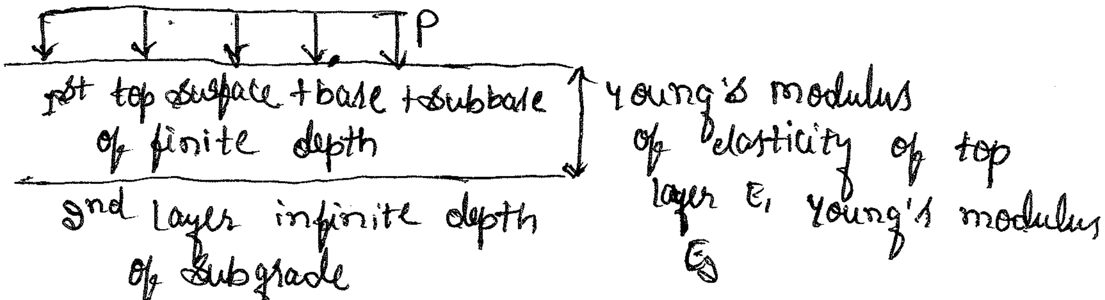
$= 2 \times 16 = \underline{32cm}$

For $\frac{E_2}{E_1} = \frac{1}{5}$ & $h = 32cm$ from chart

Burmister theory;

Typical flexible pavements are composed of layers so that the modulus of elasticity decrease with depth, the effect is to reduce stress and deflection in the subgrade from those obtained from homogenous case. The solution to such problem obtained by Burmister theory.

Burmister proposed an analysis for top layer finite thickness and bottom layer of semiinfinite mass The top layer represents surface, base & subbase coarse. whereas the bottom layer represents the subgrade soil



For flexible plate

$$\text{Deflection} = \Delta = \frac{F_w \times 1.5 \times pa}{E_2}$$

For rigid plate

$$\Delta = \frac{F_w \times 1.18 \times pa}{E_2}$$

Δ = Deflection at the surface

p = Type pressure

a = Radius of contact area of plate

E_2 = modulus of elasticity of lower layer (subgrade soil)

F_w = Displacement factor can be obtained by Burmister graph or chart

* calculate the deflection at the surface of the Pavement due to wheel load 40KN & tyre pressure of 0.5 MN/m² for both flexible as well as rigid plate the value of Young's modulus of Pavement subgrade maybe assumed to be uniformly equal to 20MN/m² calculate the vertical stress & radial stress at depth equal to a, 2a, 3a.

$P = 40KN = 40 \times 10^3 N$ $\quad E = 20 N/mm^2$

$p = 0.5 MN/m^2 = 0.5 N/mm^2$

For flexible Plate

$$\Delta = \frac{1.5pa}{E}$$

$$a = \sqrt{\frac{P}{p\pi}} = \sqrt{\frac{10 \times 10^3}{0.5 \times \pi}}$$

$$a = 159.57 mm$$

$$\Delta = \frac{1.5 \times 0.5 \times 159.57}{20} = 5.98 mm$$

For rigid ~~Pavem~~ plate

$$\Delta = \frac{1.18pa}{E}$$

$$= \frac{1.18 \times 0.5 \times 159.57}{20} = 4.7 mm$$

To estimate vertical & radial stress at different depth when poison's ratio of soil $\mu = 0.5$

Vertical stress;

$$\sigma_z = p\left[1 - \frac{z^3}{(a^2+z^2)^{3/2}}\right]$$

$$= 0.5\left[1 - \frac{(160)^3}{(160^2+160^2)^{3/2}}\right]$$

$$= 0.323$$

Radial stress

$$\sigma_x = \sigma_y = \frac{p}{2}\left[(1+2\mu) - \frac{2(1+\mu)z}{(a^2+z)^{1/2}} + \frac{z^3}{(a^2+z^2)^{3/2}}\right]$$

$$= \frac{0.5}{2}\left[(1+2 \times 0.5 - \frac{2(1+0.5) \times 160}{(160^2+160^2)^{3/2}} + \frac{160^3}{(160^2+160^2)^{3/2}}\right]$$

$= 0.05$

Depth under consideration	Vertical stress	Radial stress
a = 160mm	0.323	0.05
2a = 320mm	0.142	1.186
3a = 480mm	0.073	0.27

$$\sigma_z = p\left[1 - \frac{z^3}{(a^2+z^2)^{3/2}}\right]$$

$$\sigma_x = \sigma_y = \frac{p}{2}\left[(1+2\mu) - \frac{2(1+\mu)z}{(a^2+z^2)^{1/2}} + \frac{z^3}{(a^2+z^2)^{3/2}}\right]$$

①

Module - 2

Design Factors ; Design Wheel load, Contact pressure, Design life, Traffic factors, climatic factors, Road geometry, Subgrade strength and drainage. ESWL concept determination of ESWL by equivalent deflection criteria, stress criteria, EWL concept & problems on above.

Flexible Pavement Design : Assumptions, Mcleod Method, Kansas method, CBR method, IRC method (old) CSA method using IRC - 37 - 2001 Problems on above

Factors to be considered in Design of Flexible Pavements ;

Design of Flexible pavement consists of 2 parts

i) Mix design of Materials to be used in each Pavement component layer

ii) Thickness design of the Pavement & the components layers.

The Material used in the Pavement layers have to withstand the expected stresses and deterioration caused by the traffic loads and various other climatic and environmental factors. The pavement layers are constructed with appropriately designed mixes using aggregates & binders Bituminous mixes are designed & laid on surface course of Flexible pavements as this layer has to withstand the stresses, wear & tear & deterioration caused by the moving traffic and effects of climatic and other factors.

Various Factors to be considered are ;

a) Wheel loads of heavy vehicles or the traffic loads
b) Subgrade soil
c) climatic factors
d) Pavement component Materials in different layers
e) Drainage and environmental factors.

Design Life ;

The initial and terminal serviceability of the Pavement are required inputs. serviceability is a measure of the functional level of service at a given point ~~on~~ time of the life of a pavement. In addition to serviceability the Pavement service life. or period of performance, for a Pavement must be established.

The Design life or performance ~~ref~~ Period refers to the Period of time for which the road is initially designed.

The AASHO guidelines in this regard are given is table below.

Highway conditions	Analysis period (in years)
High- volume, urban	30-50
High- volume, rural	20-50
Low volume paved	15-25
Low volume aggregate surface	10-20

⑤

Climatic Factors;

Among climatic factors rainfall & Frost action affects a lot on pavements.

At high temperatures the bituminous pavement layers of flexible pavements, binders as well as the mixes become softer whereas at very low temperatures they become stiffer. results in the chang in fatigue characteristics under repeated application of the wheel loads.

Where freezing temperature are prevalent during winter, the possibility of frost action in the subgrade and the damaging effects should be considered at the design stage itself. Roads passing through locations with adverse climatic conditions will need higher thickness of flexible pavement structures.

Major effects on the road pavements;

i) variation in moisture condition
ii) Frost action
iii) variation in temperature.

Factors to be considered for design of durable & weather resistant pavements

* Intensity & duration of rainfall, fog or snowfall
* Temperatures of air & pavement
* Surface & sub-surface drainage conditions
* Type of landscape & soil type
* Water bodies nearby
* Ground water level
* Intensity of wind
* Cloud coverage
* Relative humidity
* Solar Radiation

Moisture;

The presence of moisture other than OMC from any source in the Pavement structure is an undesirable condition which causes volumetric changes in compacted layers at different location & thereby results in failure in different Modes. In Particular, parameters related to strength of subgrade & granular layers are highly sensitive to little change in OMC

The surface water due to rainfall and snowfall should be suitably drained off to side or underground. drains & further on to a safe disposable location.

High intensity rainfall of short duration will not cause as much of damage as compared low intensity rainfall over a long duration & absorb more moisture.

Data related to precipitation, viz, rainfall. intensity, duration wind humidity air temp. are collected from Meteorological dept.

Change in Moisture content in pavement is possible under;

a) seepage/ infiltration of surface water into the pavement structure takes place from the

- unpaved shoulders
- cracked pavement surfaces
- unsealed pavement joints.

If the pavement surface is not completely impermeable to the presence of cracks, hotspots, potholes, depressions & open joints of cement concrete slabs, the rate of infiltration will increase

b) capillary rise of ground water due to a higher water table and movement of moisture through side drains & nearby water bodies

The severity of distress to the Pavement is more if ground water level is raised by surrounding water bodies such as ponds, lakes, rivers, & canals. Certain type of soils especially clay-rich soils having Particles of size less than 75 microns are more prone to become water logged. To avoid this undesirable condition granular materials are used to form a water filtering layer which is placed over the sub grade.

Mud Pumping is a widely known distress condition in cement concrete Pavements. It is a phenomenon in which water seeps through cracks or enters into joints of concrete slabs. & decreases the stiffness of the layers below the slab. Due to weak support, on wheel loading the slab deflects downward & causes the expulsion of seeped water with small particles of fine grained sands onto the surface of the slab through the cracks. Under such repetative application of wheel loads bigger size voids or cavities will be formed beneath of the slab. Ultimately the slab breaks into small pieces & settles down forming depressions

FROST ACTIONS;

Refers to the adverse effect of due to frost heave, frost melting or thaw and the alternate cycles of freezing & thawing. The frost action in general refers all the effects associated with freezing temperature on Pavement performance

- The held water in subgrade soil forms ice crystals at some spots if the freezing temperatures continue for a certain period
- These ice crystals grow further in size if there is a continous supply of water due to capillary action & the depressed temp continues.
- This results in raising of portion of the pavement structure known as Frost heave.
- If the frost heave cases uniform raising of pavement structure the subgrade support is not adversly affected at this stage.
- Subsequent increase in temperature would result in melting or thawing of the frozen ice crystals & soften the road bed.
- The load carrying capacity of the subgrade is considerably decreased at this stage due to the voids created by the melted ice crystals & the excessive water trapped in the thawed soil below the pavement.
- Under heavy traffic the pavement would deflect excessively causing progressive failure due to decreased load carrying capacity of the subgrade
- The freezing & thawing which occur alternately due to the variation in weather causes undulations & considerable damages to the pavement
- Hence the overall effects due to frost heave, frost melting & alternate freeze- thaw cycles is called the frost action

④

The various factors on which frost action depends may be broadly classified as ;

* Frost Susceptible Soil

The soil type grain size distribution, permeability & capillarity of soil influence frost action

* Depressed temperature below freezing point

The temp. below freezing point & duration of the freezing temperature determines the depth up to which frost action exceeds unless there is a continuous supply of water the small ice crystals formed cannot grow in size

* Supply of water ;

may be from the ground water due to the capillary action or soil section. The rate of heat transfer depends on soil density & texture moisture content & the proportion of frozen moisture in the soil mass under consideration

* cover ;

The type ~~&~~ cover of the cover affects the heat transfer from the atmosphere to the soil beneath the cover for example temperature under a black top pavement will be higher than that under a light colored pavement or base course.

Remedial Measure to reduce Frost Action ;

* one of the most effective & practical methods to decrease the damaging affects due to water & frost action is to install proper surface & subsurface drainage system

* Construction of base, sub-base & top layer of subgrade. upto the desired depth, by granular & non frost susceptible material with good drainage characteristics would withstand the adverse climatic conditions

- Yet another effective method is by providing a suitable capillary cut-off
- It is also possible to reduce the adverse effects of frost action on pavements by soil stabilization the stabilized soil mix may be designed to withstand the adverse climatic conditions of alternate wet-dry & freeze thaw cycles.
- Suitable stabilized soil mixes may be designed & provided for base course, sub base courses & even at the top layer of subgrade. Salts like calcium chloride. or sodium chloride when mixed with subgrade soil lowers the freezing temperature of the soil-water & hence temporarily decreases the intensity of frost action

Variation in Temperature ;

- wide variation in temperature due to climatic changes may cause damaging effects is some pavements
- Temperature stresses of high magnitude are induced in cement concrete pavements due to daily variations in temperature & consequent warping of the pavement takes place
- Bituminous pavement becomes soft in hot weather & brittle in very cold weather

Flexible Pavement Design

Assumptions;

★ In flexible Pavements under the application of load, none of the layers are overloaded i.e at any given instance, no section of the pavement structure is subjected to excessive deformation to form differential settlement.

★ The Maximum intensity of stress occurs in the top layer the magnitude of stress occured at the lower layers are comparati-vely less hence superior pavement materials are used in the top layer of flexible pavement.

★ It is not possible to have rational method of design where in the design process & serviceability behaviour of Pavement is expressed In flexible Pavement design they are Predicted theoritically by mathematical laws It is one of the limitation of flexible pavement design

★ In the design of flexible Pavements the methods employed for design are based on semi empirical & classical approach here for empirical & semi-empirical approach the knowledge & experience gained on the behaviour of the pavement in past are effectively utilised.

★ Some of the methods are directly based on soil classification & california Resistance value, which may be estimated by sieve analysis, CBR. test, plate bearing test depending upon the condition of the soil. Here the thickness required is directly estimated using the results obtained from the experiments under ideal condition.

Design Methods of FP

- Empirical Methods
- Semi - theoretical Methods
- Theoretical Methods

Empirical Methods : In this soil strength may or may not carried out depends on physical parameters of soil subgrade

Semi theoretical ; Design is based on stress - strain function & modified based on experience.

Theoretical Methods : Design approaches have also been developed based on theoretical analysis & methematical computations.

MCLEOD METHOD;

The canadian department of transport conducted extensive plate bearing tests to investigate the stability of airfields and Pavement under the direction of norman . W mcleod the test were made on surface , base course & subgrade etc. at large number of locations. on basis of his test results, he developed a definite design method which is known as Mcleoad method after his name.

Plate load test ;

conducted to determine the modulus of sub-grade reaction (K value) of in situ sub-grade soil for analysis of Pavements. In this test , sub grade soil is subjected to different compressive stresses through some standard circular rigid plates. The corresponding vertical surface deflection of the plate are measured . Magnitude of surface deflection due to applied ~~of~~ compressive stresses depends mainly on the supporting capacity of the soil below & its stiffness or the load bearing capacity of the soil

Contact pressure :

The influence of tyre pressure is predominant in the upper layer At a greater depth the effect of high pressure diminishes and the total load exhibits a considerable influence on the vertical stress magnitude Tyre pressures of high magnitude demand high quality materials in the upper layer of the pavement with contact pressure the total load governs the stress on the top of the subgrade within the allowable limits

Generally the wheel load is assumed to be distributed over a circular area . But the measurements of imprints of tyres with different load, & inflation pressures, it is seen that the contact areas in many cases. are elliptical shape two terms in the with reference to tyre pressure are

i) Tyre or inflation pressure
ii) Contact Pressure

The Contact pressure (P_c) is found to be more than the type pressure (P_t) when the tyre pressure is less than 7kg/cm2 , it is vice-versa, when the tyre pressure is more than 7kg/cm2 The variation b/n contact pressure (P_c) & tyre pressure (P_t)

The ratio of contact Pressure (P_c) to tyre pressure (P_t) is known as the "Rigidity Factor" (R_F) i.e $R_p = \frac{P_c}{P_t}$

$R_F > 1$ for $P_t > 7kg/cm2$

$R_F < 1$ for $P_t < 7kg/cm2$

$R_p = 1$ for $P_t = 7kg/cm2$

Wheel load and contact Pressure;

The Magnitude of the Wheel load (P) & the loaded area (A) or the contact pressure (p) are to be taken into account for the analysis of stresses and the stress distribution within the pavement. Contact pressure can be measured by the relationship;

$$\text{Contact pressure, } p = \frac{\text{Load on Wheel}}{\text{Contact area or of imprint}} = \frac{P}{A}$$

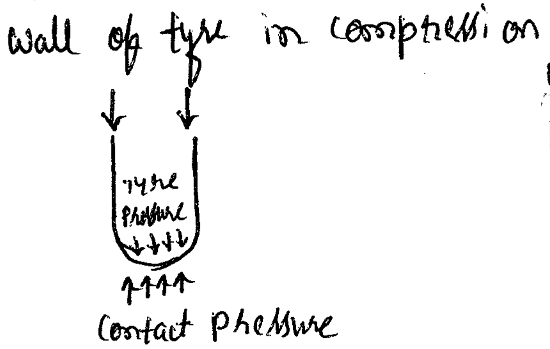
if the loaded area or the contact area, A of the wheel load is assumed to be circular in shape of radius 'a' then the relationship b/n the load P, Loaded area A and contact Pressure p may be expressed as;

$$P = Ap = \pi a^2 p$$

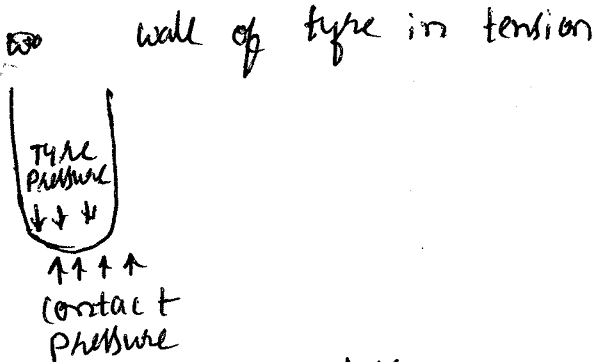
Design Wheel load; The total weight of a vehicle is carried by its axles. The load on the axle is transferred to the wheel & the load is ultimately transferred on to the surface of the pavement. in contact with the tyres.

Standard axle load; generally the load carried by any truck is same as that carried by an axle. each axle load will impact a certain amount of damage or distress on the Pavement.

Contact area ; In the pavement design, it is necessary to know the contact area b/w tyre & pavement The size of contact area depends on the contact pressure. As indicated in the following contact pressure is greater than the tyre pressure for low pressure tyres because the wall of tyres is in compression similarly the contact pressure is similar than the tyre pressure for high pressure tyres because the wall of tyres is in tension



a) Low pressure tyre



b) High pressure tyre

ESWL ;

The values of sub grade reaction are dependent on the type of sub-grade soil, density, frost action, saturation & intensity of stress applied. To analyse Pavements, we need to find a representative value of Modulus of subgrade reaction, From different studies & based on past experience it has been found that the most representative value of sub-grade reaction can be obtained at a pressure of 0.7kg/cm²

Apparatus ;

1. Loading Plates : A mild steel plate of 75cm with diameter of 20 to 40mm thickness is used as the main loading plate. Three other mild steel plates of the same thickness having diameters of 60.96cm, 45.72cm & 30.48cm are used as stiffeners. the main plate is in contact with the sub-grade soil & the remaining plates are placed over. Stacking of plates is useful to avoid bending of the main plate during loading.
2. Loading system : A dead load & a hydraulic or reaction loading system of about 15 tonnes capacity is used along with dial gauge fitted with a proving ring or electronic load measuring system to read up to half per cent of load applied
3. Deflection sensors ; Three dial gauges or LVDTs (linear variable differential transformers) with suitable electronic devices are used to measure deflections with a least count of 0.002mm the plate deflections are measured with reference to a datum or independent support which is not in the deflected area of the soil the reference datum may be selected at least four 4 & ½ metres away from the loading plate the deflection sensors are fixed along the periphery of the main loading plate of 120° apart
4) other tools : mild steel spacer blocks, spirit level & others

Wheel Load Repetitions;

Effect of Repeated Application of Wheel loads;

Higher the Number of load repetitions during the design life of the pavement, higher the thickness of flexible pavement or structure will be required. The deformation of pavement or Subgrade due to a single application of wheel load may be small but due to repeated application of heavy wheel loads there would be increased magnitude of both Plastic & elastic deformations

The rate of increase in the elastic or recoverable deformation with the load repetitions will be at a very slow rate for strong flexible pavements but will be at a rather faster rate in case of weak Pavements This will also depend on the thickness of the pavement structure

Effect of No. of Repetition of different magnitude of loads

Extensive traffic Studies & analysis have been carried out for taking into account the effect of repetition of different magnitudes of wheel loads in Pavement design. The axle loads of different magnitudes are converted in terms of repetation of a Standard axle load or Standard wheel load as explained in the Subsequent paragraphs. traffic Composition in India is of mixed type & it is essential to convert the various wheel loads to one single Standard wheel load for the structural design of flexible pavements.

equivalent wheel load factors (EWLF)

If a particular Pavement structure fails with N_1 number of repetitions of load P_1 kg & similarly of if N_2 Number of repetitions of load P_2 kg can also cause failure of the same pavement structure, then P_1N_1 & P_2N_2 are considered equivalent. Extensive Road test studies were carried out by the "Americal Association of State Highways officials" (AASHO)

Module -3

Introduction ;

- Road Maintenance is the one of the most important component of the road system.
- It involves the assessment of road condition, diagnosis of the problems & adopting the most appropriate maintance step.
- Even if the highway are well designed, they may require maintenance due to its less design life.
- Various types of failures occurs in the pavement which ranges from minor to major distresses.

General causes of Pavement Failure ;

1) Poor soil ; It is the most common problem in the pavement design. The most common soil problem in the southest is a high water table. If not accounted for at the time of construction, a high water table will erode the soil & eventually lead to pavement failure.

2) Inferior material quality ; If the material laid on the ground is not good enough, will be leads to severe defects & failures.

3) Improper geometry : Due to improper geometry of road, of lot of factors may arise which keeps the pavement deformation.

4) overloading of vehicles : A vehicle is said to be heavy loaded when it is being loaded more than its carrying capacity. Acc. to IRC, the maximum wheel load for standard axle is 80KN. Due to heavy movement of vehicles or overloaded vehicles or increase traffic volume, severe distresses takes place.

5) Environmental Factors:

It includes heavy rainfall, soil erosion, high water table, snow fall, frost action etc.

6) Inadequate drainage:

Due to improper drainage resulting in stagnation of water in the subgrade which could be the main reason pavement failure in future

Flexible Pavement failures;

i. Surface deformation
- Corrugations
- Rutting
- Shoving
- Settlement & upheaval

ii. Cracking
- Fatigue cracking
- Transverse cracking
- Longitudinal cracking
- Edge cracking

iii) Disintegration
- Potholes
- Patches

iv) Surface defects
- Ravelling
- Bleeding

Flexible pavement Failures;

- Alligator cracks; known as map cracking or crocodile cracking or Fatigue failure. Since it appears similar as alligator skin so it is called alligator cracks.
- The Failure can be due to weakness in the surface, base or subgrade, a surface or base that is too thin; poor drainage or the combination of all three
- The main reason of this type of failure is the repetitive application of heavy movement of traffic

◎ Block Cracks ;

- Block cracks look like large interconnected rectangles (roughly)
- generally it is caused by shrinkage of the asphalt pavement due to an inability of asphalt binder to expand or contract with temperature cycles.
- This can be because the mix was mixed & placed too dry.
- The size of each rectangle may vary from one foot by one foot to ten foot by ten foot
- It spreads over a larger area of ground.

Longitudinal cracks ;

- Longitudinal cracks are individual & run parallel to the centreline This distress can be considered as either a structural or an environmental distress
- This can be a result of both pavement fatigue, reflective cracking, and/or poor joint construction

Transverse cracks ;

- Transverse cracks are single cracks perpendicular to the pavement's centreline or lay down direction
- Transverse cracks can be caused by reflective cracks from an underlying layer, daily temperature cycles & poor construction due to improper operation of the paver

Patch

- A Patch is an area or Portion of Pavement greater than 0.1 sq. m that has been removed or replaced with new material to repair the existing pavement

- A patch is considered a defect no matter how well it is performing (a patched area of adjacent area usually doth not perform ~~as well as an~~ underlying layer, daily temperature cycles & poor construction ~~due to improper~~ ~~operation~~ of ~~the~~ Paver does not perform as well as an original pavement ~~Solution~~. section).

- These defects can be improved by taking the measurement in ft^2 or m^2 & filling it with a fresh layer of the bitumen.

Potholes ;

- These are small, bowl-shaped depressions in the pavement surface that penetrate all the way through the asphalt layer down to the base course.
- In the western United States, these are known as chuckholes.
- The pothole can expand to several feet in width the later it leads to the formation of patches they don't develop too much in depth.
- The vehicle tires are damaged due to large potholes
- The cold temperatures, the water trapped in the pothole will carry out the freezing & thawing action that leads to additional stresses

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- ★ The Vehicle tires are damaged due to large Potholes
- ★ In cold temperatures, the water trapped in the Potholes will carry out the freezing & thawing action that leads to additional Stresses & crack Propogation.
- ★ Potholes are also repaired by Patchwork.

Edge cracking & shoulder drop off.

- ✱ Edge cracks travel along the inside edge of a pavement surface within one or two feet.
- ✱ The common cause for this type of crack is poor drainage conditions & lack of support at the pavement edge.
- ✱ As a result underlying base materials settle & become weakened
- ✱ Heavy vegetation along the pavement edge & heavy traffic can also be the instigator of shoulder drop off.
- ✱ It can be improved by rooting out existing vegetation & by fixing the drainage problem
- ✱ It can be removed by filling the cracks or seal the

Slippage cracks ;

- ✱ Slippage cracks are crescent-shaped or horse shoe shaped cracks or tears in the surface layer.
- ✱ It is the asphalt where the new material has slipped over the underlying course
- ✱ It is caused by a lack of bonding between layers
- ✱ Acceleration, deceleration & sudden brakes on the road are leads to slippage cracks.
- ✱ Mostly these cracks show on intersections due to stopping

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* Mostly these cracks show on intersections due to stopping

Weathering & raveling:

* It is the adhesion between the asphalt cement & aggregate
* Deformation starts with breaking up of fine aggregates in small pieces & leaves small patches over the Pavement.
* Later the larger aggregates breaks & leave rough & surface
* There are many reasons why raveling can occur, but one common cause is placing asphalt too late in the season
* Traffic loading is also one of the reason of raveling

Rutting:

- ✩ The depression formed in the surface is called rutting
- ✩ This is formed in the wheel path surface along the way of road.
- ✩ This depression will make the other sides of the wheel to undergo uplift.
- ✩ It is caused by insufficient pavement thickness; lack of compaction of the asphalt, stone base, or soil, weak asphalt mixes or moisture infiltration
- ✩ If rutting is minor or if it has stabilized the depressions can be filler & overlaid. if the deformation are severe, the rutted area should be removed and replaced with suitable material
- ✩ Transverse undulations appear at regular intervals due to the unstable surface course caused by stop & go traffic
- ✩ The only difference b/n rutting & corrugation is the direction of ~~distress~~ unduations. in rutting, distresses takes place along the direction of the road & in corrugation, distresses appears in the transverse direction
- ✩ Where the traffic starts & stops these distress are observed.

Pavement evaluation
- Functional evaluation
- Structural evaluation

Functional evaluation

- ★ Pavement condition survey - visual
- ★ Pavement roughness
- ★ Skid resistance

Structural evaluation

- ★ Based on deflection measurement under standard axle load
- ★ Benkleman beam

Functional evaluation;

- ★ Pavement condition survey
- ★ A no. of distresses may occur simultaneously, because many of the distresses are interrelated & the occurence of one may as well initiate the other
- ★ Individual assessment & quantification of the distresses may not therefore be very useful.
- ★ Rather, there is a need to assess the functional condition of the pavement as a whole.

Pavement condition survey:

- ★ The survey on general pavement condition was primarily a visual exercise undertaken by means of slow drive over survey & supplemented with measurements wherever necessary.
- ★ visual assessment was carried out from a vehicle, with speed not exceeding 15km/hr & stopping at various locations at suitable intervals & wherever necessary depending on variations in pavement conditions
- ★ Ascepts of pavement conditions assessed include surface defects, rut depth, cracking potholes, patched areas, shoulder condition etc.

* An overall assessment of performance serviceability of the road was also done to qualitatively rate the existing pavement & shoulder condition

* ~~Po~~ The survey was recorded under the following sub-heads:

* Shoulders:
    * composition / condition / material loss
    * Riding quality (Good / Fair / poor / very poor)
* Pavement condition (Surface distress type & extent):
    * Cracking (%), Ravelling (%), Potholes (%), Patching (%), Rut depth (mm)
    * Edge break (m); Pavement edge Drop (mm)
* Embankment condition (Good / Fair / Poor)
* Road side Drain (Non existing / partially Functional / Functional)
* Drainage condition

⑤ Bleeding:

- Excess bituminous binder occurring on the Pavement surface causes bleeding
- Bleeding causes a shiny, glass-like, reflective surface that may be tacky to the touch.
- Usually found in the wheel paths.

Frost heaving or swelling

- upheaval is a localized upward movement or the formation of upward bulge in a pavement due to swelling of the subgrade.
- This can be due to expansive soils that swell due to moisture or frost heave (ice under the pavement)
- It can be recovered by full depth patch

Maintenance of failures.

- Bituminous surface treatment : also known as a seal coat or chip seal, is a thin protective wearing surface that is applied to a pavement or base course
- It is provided to protect the underlying pavements, improved skid resistance etc.
- A BST offers preventive maintenance from the effect of sun & water both of which may deteriorate the pavement structure. Seal coat

Continue :

Asphalt overlay :

- Asphalt overlay is a paving method of applying a new layer of alphalt ~~to~~ a deteriorating surface

- An asphalt overlay project will use the existing layers as a base for the new asphalt pavement
- Some asphalt surfaces with severe damage like rutling, Potholes. large cracks & expansions will need to be milled before an overlay is applied. (milling is the removal of the top layer of asphalt that has been taken on cracks ravelling or other kind of deformation.

Slurry Seal~~s~~, Crack Seals

- Slurry seals is a homogenous mixture of emulsified asphalt water, well graded fine aggregate & mineral filler that has a creamy fluid-like appearance when applied
- Slurry seals are used to fill existing pavement surface defects as either a ~~p~~preparatory treatment for other maintenance treatments or as a wearing course
- Crack seal products are used to fill individual pavement cracks.
- It is used to prevent entry of water or other non-compressible substances such as sand, dirt, rocks or weeds
- Cracks sealant is typically used on early stage longitudinal cracks, transverse cracks, reflection cracks & block cracks.
- Crack filler material is typically some form of rubberized asphalt or sand slurry.

Module -4

① Design of Rigid Pavements

Factors affecting Design

Loading

1) Wheel load & its repetitions
2) Area of contact of wheel
3) Location of load with respect to slab

Stresses in Rigid pavements

Factors Affecting Design

★ Properties of Subgrade

1. Subgrade strength & properties
2. Sub-base provision or omission

★ Properties of Concrete

1. Strength
2. Modulus of elasticity
3. Poisson's ratio
4. Shrinkage properties
5. Fatigue behaviour

★ External conditions

1. Temperature changes
2. Friction between slab & subgrade

★ Joints

1. Arrangement of joints

★ Reinforcement

1. Quantity of reinforcement
2. Continuous reinforcement

3 Positions of loading are generally considered for estimating the stresses in a slab in a conventional method of design

* Interior loading produces tensile stresses at the bottom of the slab
* edge loading produces tensile stresses at the bottom of the slab parallel to the edge & another smaller tensile stress at the top of the slab at right angles to the edge
* corner loading produces tensiles stresses at the top of the slab parallel to the bisector of the corner angle.

Analysis of stresses

The stresses acting on a rigid pavement are;

1. Wheel load stresses &
   * westergard's Analysis of stresses
   * modified westergard's analysis
2. Temperature stresses
   * warping stresses
   * Frictional stresses

⑤ Westergard's modulus of Subgrade reaction

The Modulus of Subgrade reaction, K is proportional to the displacement.

The displacement level Δ is taken as 0.125cm in calculating K.

If P is the pressure sustained in kg/cm² by the rigid plate of diameter 75cm at a deflection $\Delta = 0.125$cm the modulus of subgrade reaction K is given by:

$$K = \frac{P}{\Delta} = \frac{P}{0.125} \text{ in kg/cm}^3$$

Relative Stiffness of Slab to Subgrade.

- A certain degree of resistance to slab deflection is offered by the Subgrade this is dependent upon the stiffness or pressure deformation properties of the subgrade material

Westergard defined this term as the Radius of relative Stiffness

$$l = \left[\frac{Eh^3}{12K(1-\mu^2)}\right]^{1/4}$$

l = radius of relative stiffness
E = MOE, μ = Poisson's ratio
h = slab thiness
K = Subgrade modulus

Equivalent radius of Resisting section

- Considering the case of interior loading, the maximum bending moment occurs at the loaded area & acts radially in all directions
- With the load concentrated on a small area of the pavement the question arises as to what sectional area of the pavement is effective in resisting the Bending moment

$$b = \sqrt{1.6a^2 + h^2} - 0.675h$$

When a is greater than 1.724h the value of a=b

Westergaard's stress equation for wheel loads;

The critical stresses Si, Se, & Sc at the typical locations i.e interior, edge & corner are given below,

Interior Loading:

$$S_i = \frac{0.316P}{h^2}\left[4\log_{10}(l/b) + 1.069\right]$$

Edge loading:

$$S_e = \frac{0.572P}{h^2}\left[4\log_{10}(l/b) + 0.359\right]$$

Westergaard's stress equation for wheel loads:

The critical stresses Si, Se & Sc at the typical locations. i.e interior, edge & corner are given below

corner loading:

$$S_c = \frac{3P}{h^2}\left[1 - \left(\frac{a\sqrt{2}}{l}\right)^{0.6}\right]$$

Modified Westergaard's analysis;

* Westergaard's wheel load stress equations for interior, edge & corner have been modified by various investigators based on their research work on cement concrete pavement slabs.
* The stresses at the edge & corner regions are generally found to be more critical for the design of rigid pavement for highways
* The IRC congress recommends the following 2 formula for the analysis of load stresses at the edge & corner regions & for the design of rigid pavements.

④

Modified Westergaard's Analysis:

i) Westergaard's edge load stress formula, modified by Teller & Sutherland for finding the load stress Se in the critical edge region

$$S_e = 0.529 \frac{P}{h^2} (1+0.54\mu) \left[4\log_{10}(4/b) + \log_{10} b - 0.4048 \right]$$

ii) Westergaard's corner load stress analysis modified by Kelley

$$S_c = \frac{3P}{h^2} \left[1 - \left(\frac{a\sqrt{2}}{l} \right)^{1.2} \right]$$

Modified Westergaard's equations using charts

- ★ The equation for finding load stresses at the edge & corner regions are presented in the form of stress charts by the IRC & these are shown
- ★ These charts are applicable for a particular set of design parameters only viz
- ★ P = 5100kg, a = 15cm, E = 3X10kg/cm, μ = 0.15 but different curves are given for different values of K between 6.0 & 30kg/cm
- ★ The design curves are for slab thickness values, h = 14 to 25cm
- ★ The design curves are very handy & save considerable these stress charts are very handy & save considerable time when the stresses are to be evaluated for various trial thickness of the slab while designing a pavement

Temperature stresses:

Westergaard's concept for temperature stresses

Temperature tends to produce two types of stresses in a concrete pavement. These are

i) Warping stresses
ii) Frictional stresses

Warping stresses:

Whenever the top & bottom surfaces of a concrete pavements simultaneously possess different temperature the slab tends to warp downward or upward inducing warping stresses

$$S_{t(i)} = \frac{Eet}{2}\left[\frac{C_x + \mu C_y}{1-\mu^2}\right]$$

S_t = Warping stress at interior Kg/cm²
E = MOE of concrete Kg/cm²
e = thermal coefficient of concrete per °C
t = temp. difference b/n the top & bottom of the slab in °C
C_x = Coefficient based on L_x/l in desired direction
C_y = Coefficient based on L_y/l in right angle to the above direct
μ = Poisson's ratio

L_x & L_y are the dimensions of the slab considering along X & Y directions along the length & width of slab

Warping stress at the edge region is given by:

$$S_{e(i)} = \frac{C_x Eet}{2}$$

$$S_{e(i)} = \frac{C_y Eet}{2}$$, whichever is higher

Warping stress at the corner region is given by

$$S_c(t) = \frac{Eet}{3(1-\mu)}\sqrt{\frac{a}{l}}$$

The warping stress at the corner region is given by

$$S_c(t) = \frac{Eet}{3(1-\mu)}\sqrt{\frac{a}{l}}$$

a is the radius of contact
l = radius of relative stiffness

Temperature stresses;

The values of the warping stress coefficients C_x & C_y for cement concrete pavement are taken from the chart developed by Bhadbury

Frictional stresses

$$S_f = \frac{Wlf}{2\times10^4}$$

S_f = unit stress developed in cement concrete pavement, kg/cm²
W = unit weight of concrete, kg/cm³ (about 2400 kg/cm³)
f = coefficient of subgrade restraint (Maximum value is about 1.5)
L = slab length, metre

Critical combination or Worst combination of stresses

i) During summer;
Critical combination of stresses = (load stress + warping stress - Frictional stress), at edge region

ii) During Winter:
The critical stress combination = (load stress + warping stress + Frictional stress), at edge region

iii) At corner region:
The critical stress combination = (load stress + warping stress), at corner regions

Construction of joints in cement concrete Pavements

Joints are provided in cement concrete roads for expansion, contraction & warping of the slabs due to the variation in the temperature of slabs.

Following are the requirement of a good joint;

a) Joint must move freely
b) Joint must not allow infiltration of rain water & ingress of stone grits
c) Joint must not protrude out the general level of the slab

Longitudinal Joints and Transverse joints

1. Transverse Joints:
   - ★ Expansion joint
   - ★ Contraction Joint
   - ★ Warping Joint
   - ★ Construction Joint
2. Longitudinal joints:

Expansion joints:

★ These joints are provided to allow for expansion of the slabs due rising in slab temperature above the construction temperature of the cement concrete

★ Expansion joint also permit the contraction of slabs.

★ Expansion joints in India are provided at interval of 50 to 60 metre for smooth interface laid in winter & 90 to 100 metre for smooth interface laid in summer

Module -5

① Rigid Pavement Failures maintainance & evaluation.

Failure of Rigid pavement is recognised mainly by the formation of structural cracking the failure are mainly due to 2 factors.

- * Deficiency of pavement materials.
- * Structural inadequacy of the Pavement System.

Types of Failures in Regid Pavements.

1) Joint Spalling 2) Faulting 3) polished aggregate 4) shrinkage cracking ~~5~~ pumping 6) Punchout 7) linear cracking 8) Durability cracking 9) corner break

1) Joint Spalling:

Excessive compressive stress causes deterioration in the joints called as spalling which is caused by the reactive aggregates Poor quality concrete also result in joint spalling small edge to large spalls in the back of the slap & down to the joints can be observed.

Causes for joint spalling:

- * Joints subjected to excessive stress due to high traffic or by infiltration of any incompressible materials
- * The joint that are constructed with weak concrete
- * Joint that is accumulated with water that results in rapid freezing & thawing.

2) Faulting: The difference ~~btn~~ in elevation b/w the joints is called as faulting

Causes for Faulting:

- * Settlement of the pavement that is caused due to soft foundation
- * The pumping or the erosion of material under the pavement resulting in voids under the pavement slab causing settlement

Cause

* The temperature changes & moisture changes that cause curling of the slab edges.

③ Polished Aggregates :-

The repeated traffic application leads to this distress there are the Failures in Rigid Pavements caused when the aggregates above the cement paste in the case of PCC is very small or the aggregates are not rough or when they are angular in shape, that it cannot provide sufficient 'skid resistance' for the vehicles

④ Shrinkage cracking:

These are hairline cracks that are less than 3m in length they donot cross the entire slab the setting & curing process of the concrete slab results in such cracks these are caused due to higher evaporation of water due to higher temperature cracks Improper curing can also create shrinkage cracks in rigid pavements

⑤ Pumping effects.

The expulsion of water from the under a layer of the pavement is called as pumping the distress is caused due to the active vehicle loads coming over the pavement in repetitive manner this will result in fine material present in the subbase to move along with water & get expelled out with the water

Pumping can be avoided by prevention of water accumulation at the pavement sub-base interface

⑥ Punch-out in Regid Pavements :

A localized area of concrete slab that is broken into pieces will be named as Punchout distress this distress can take any shape or form. these are mainly defined by joints & cracks. the joints & cracks will mainly keep 1.5m width

The main reason behind Punchouts is heavy repeated loads. the slab thickness inadequacy. the foundation support loss or the construction deficiency like honey combing

⑦ linear cracking :

These types of failures in rigid Pavements divides the slab into two or three pieces the reason behind such failure is traffic loads at repeated levels the curling due to thermal gradient & moisture loading repeatedly.

⑧ Durability cracking :

The freezing & thawing action will create regular expansion & contraction which will result in the gradual breakdown of the concrete. this type of distress is Patterns of cracks on the concrete surface as layers that are parallel & closer to the joints

Joints & cracks are the areas where the concrete seem to be more saturated here. a dark deposit is found & called the 'D' cracks this failure of rigid Pavement will finally result in the complete disintegration of the whole slab

⑨ corner breaks:

These are the failures in rigid Pavements that is caused due to Pumping in excessive rate when the Pumping completely remove the underlying support that no more support exists below to taken the Vehicle load the corner cracks are created the repair method is either full slab replacement or the repair for the full depth must be carried out

Causes for the failure in Rigid Pavement

Following are the chief causes which would give rise to the different failures of cement concrete pavement

* Soft aggregate
* Poor workmanship in joint construction
* Poor joint Filler & sealer materials
* Poor surface finish
* Improper & insuffient curing

Remedial / maintainance measures in Rigid Pavement.

① crack filling
② crack sealing
③ stitching
④ Partial depth repair
⑤ Full depth repair
⑥ Dowel bar retrofit
⑦ Diamond grinding

③

evaluation of Rigid pavement :

Pavement evalulation involves a through study of various factors such as subgrade support, pavement composition & its thickness, traffic loading & environmental conditions.

evaluation by visual inspection :

visual inspection is a method of inspecting the pavement surface for detecting & assessing the amount & severity of various types of damage visual survey conducted from a moving vehicle to the more detailed survey that involves trained engineers & technicians walking the entire length of the selected areas & measuring & mapping out all distresses identified on the pavement surface, shoulder & drainage system Recently automated visual survey techniques have become more common & are being adopted for distress surveys & pavement condition evaluation

evaluation of unevenness measurements

The pavement unevenness may be measured using unevenness indicator profilograph, profilometer or roughometer an equipment capable of integrating the unevenness of pavement surface to a cumulative scale & that gives the unevenness index of the surface in cm/km length of road may be called unevenness integrator the pavement unevenness criteria to indicate the pavement riding qualities expressed in terms of unevenness index recommended

29	The word Ecosystem was coined by			
	a) A G Tansley	b) Ernest Haeckel	c) Odum	d) None
30	Abiotic Components includes			
	a) Soil	b) Temperature	c) Both a & b	d) None
31	Which of the following is a Terrestrial Ecosystem			
	a) Forest	b) Grass land	c) Desert	d) All the above
32	Which of the following is not a part of Atmosphere			
	a) Lithosphere	b) Troposphere	c) Mesosphere	d) All the above
33	Startospheric ozone is responsible for all of the following, except			
	a) Screening UV light	b) Preventing Ozone formation	c) Allowing the Evolution of life on land	d) None
34	India has the largest share of which of the following			
	a) Manganese	b) Mica	c) Copper	d) Diamond
35	Study of population is called			
	a) Demography	b) Species Ecology	c) Both a & b	d) None of these
36	Community ecology is also called as			
	a) Species Ecology	b) Syne Ecology	c) Both a & b	d) none of these
37	Ozone day is observed on			
	a) September 16	b) January 15	c) April 22	d) June 5
38	Ozone layer thickness is measured			
	a) ppm	b) ppb	c) Decibels	d) Dobson unit
39	The number of hotspots in India			
	a) 02	b) 03	c) 01	d) 04
40	Population Explosion will causes.			
	a) Socio Economic problems	b) Food Scarcity	c) Energy crisis	d) All of these

④ Joints ;

Requirements of joints :

- The joint must permit movement of the slabs without restraint
- The joints should not unduly weaken the slab structurally & the load should be transferred from one slab to another effectively
- The joints must be sealed to exclude water grit & other external matter
- The riding quality of the pavement should not be improved
- The construction of the joints must interface as little at possible with laying of the concrete

Need for Joints :

Concrete pavements are subjected to volumetric changes produced by temperature variations. Shrinkage during setting & changes in moisture content if a long slab is built ~~but~~ it is bound to crack at close intervals because of such factors A pavement reasonably free from cracks can only be built if it is divided into small slabs by interposing joints these joints will then ensure that the stresses developed due to expansion contraction & warping of the slabs are within reasonable limits the longer the length b/w joints the greater is the warping stress & greater is the need for reinforcing steel

Types of joints :

① expansion joints
② contraction joints
③ warping joints
④ construction joints
⑤ Longitudinal joints

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Semester	5th Sem	Section	B Sec
Subject Name	Environmental Studies	Subject Code	18CIV59

Date of the Internal Test 2:

	(a)	(b)	(c)	(d)		(a)	(b)	(c)	(d)
1	○	○	●	○	2	○	●	○	○
3	○	○	●	○	4	●	○	○	○
5	●	○	○	○	6	●	○	○	○
7	●	○	○	○	8	●	○	○	○
9	○	○	●	○	10	○	●	○	○
11	○	○	●	○	12	○	●	○	○
13	○	○	●	○	14	●	○	○	○
15	●	○	○	○	16	●	○	○	○
17	●	○	○	○	18	●	○	○	○
19	○	○	●	○	20	○	●	○	○
21	○	○	○	●	22	○	●	○	○
23	○	○	●	○	24	●	○	○	○
25	○	●	○	○	26	●	○	○	○
27	●	○	○	○	28	●	○	○	○
29	○	○	●	○	30	○	●	○	○
31	○	○	●	○	32	●	○	○	○
33	●	○	○	○	34	●	○	○	○
35	○	○	○	●	36	○	○	●	○
37	●	○	○	○	38	●	○	○	○
39	●	○	○	○	40	○	○	○	●

CBCS SCHEME

17CV833

USN

Eighth Semester B.E. Degree Examination, July/August 2021
Pavement Design

Time: 3 hrs.

Max. Marks: 100

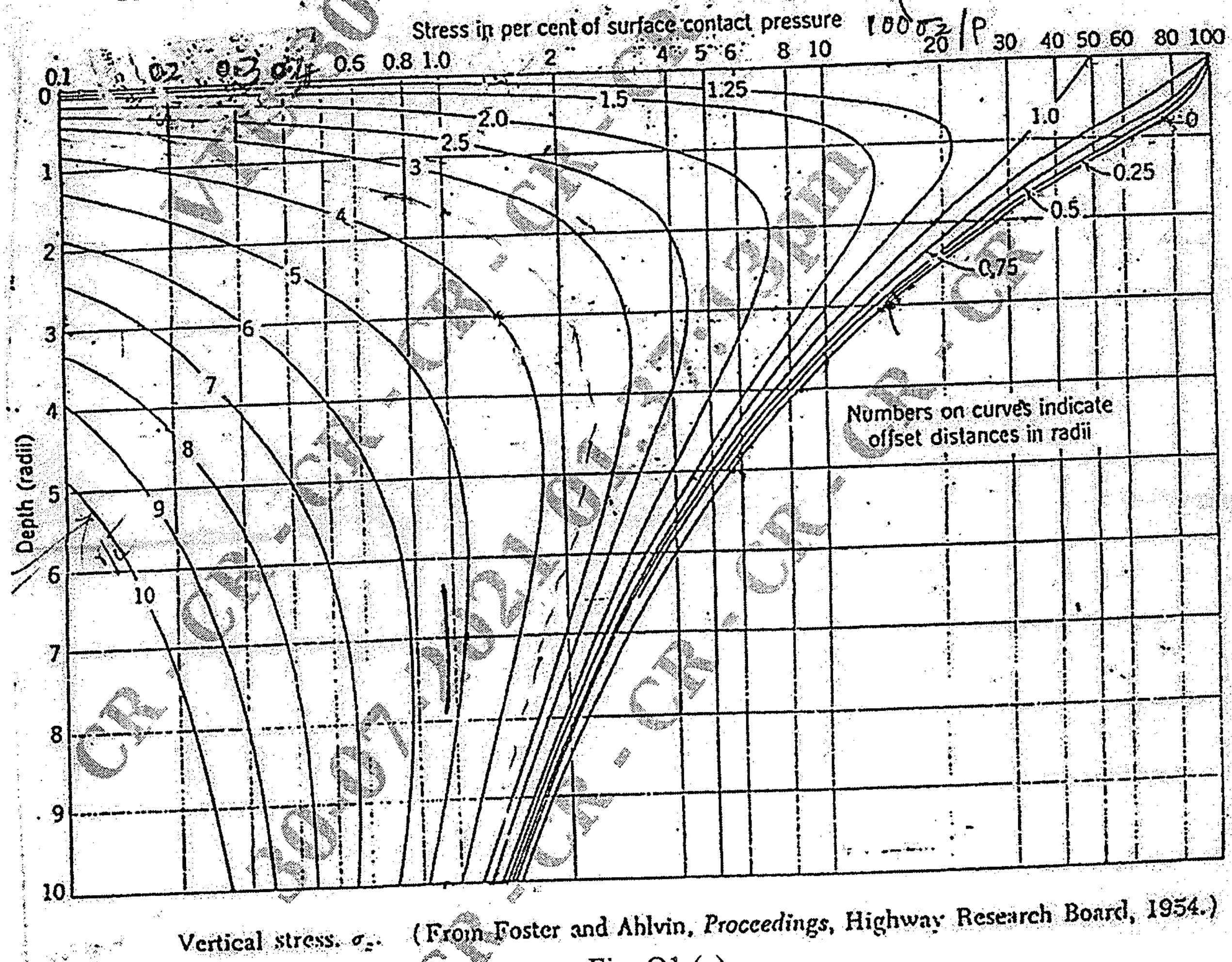
Note: *Answer any FIVE full questions.*

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. Explain the desirable characteristics of the pavement. (06 Marks)

b. For a wheel load of 40 kN and a tyre pressure of 0.5 MN/mm^2. If the value of E of the pavement and subgrade is assumed to be uniformly equal to 20 MN/mm^2. Compute deflection at the surface of the pavement. (07 Marks)

c. Determine the vertical stress under to the centre of the load at a depth of 45 cm from the surface for a circular load of radius 15 cm with uniform contact pressure of 7.0 kg/cm^2 is applied on the surface of a homogeneous elastic mass. (07 Marks)



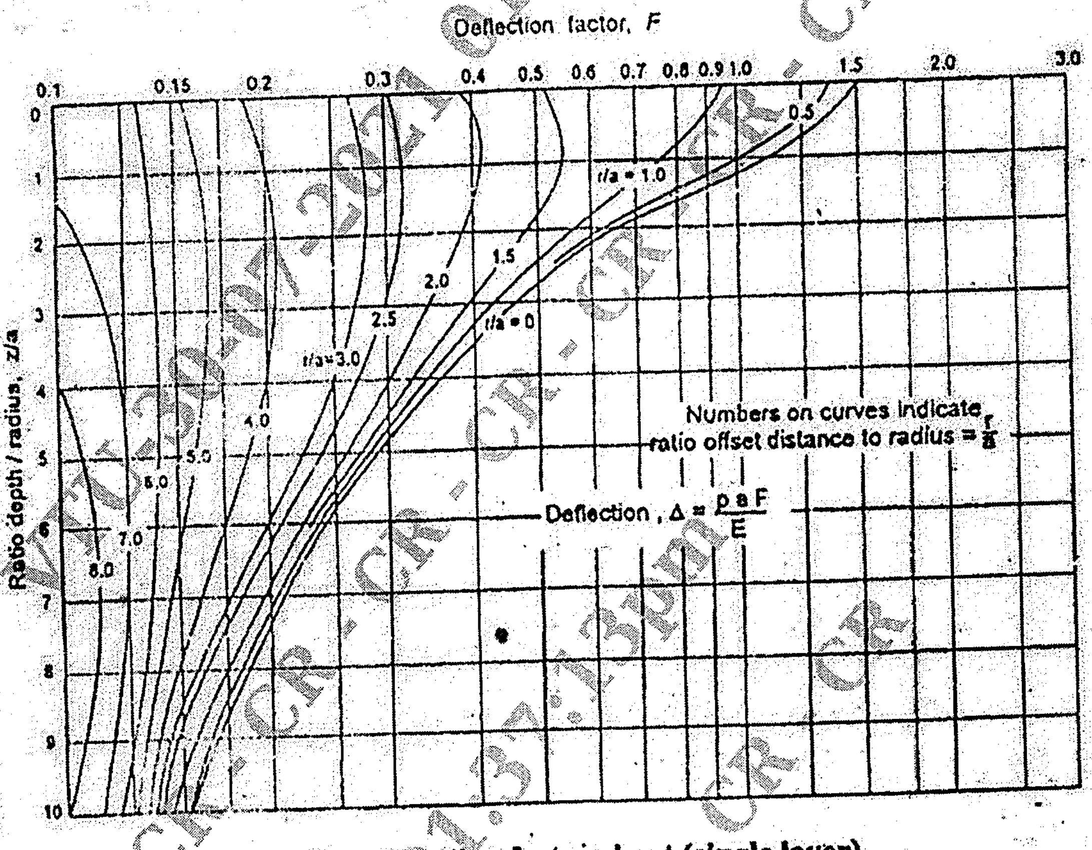
(From Foster and Ahlvin, *Proceedings*, Highway Research Board, 1954.)

Fig. Q1 (c)

2 a. Compare flexible pavement and rigid pavement. **(05 Marks)**

b. Draw a neat sketch of cross section of the flexible pavement and explain function of each layer. **(07 Marks)**

c. Determine the pavement thickness required to limit max deflection of 0.90 cm under a wheel load of 5000 kg at a contact pressure 6 kg/cm^2 and the ε-value of sub grade soil is 50 kg/cm. **(08 Marks)**



Deflection factor chart (single layer)

Fig. Q2 (c)

3 a. Calculate the ESWL of a dual wheel assembly carrying 2400 kg each for pavement for pavement thickness of 20 cm, 25 cm and 30 cm. The centre to centre tyre spacing is 300 mm and the distance between the walls is 120 mm. **(10 Marks)**

b. Design the pavement section by triaxial tent (Kansas method) using the following data

Wheel load = 4100 kg ;
Radius of contact area = 15 cm
Traffic coefficient x = 1.5 ;
Rainfall coefficient y = 0.9
Design deflection $\Delta = 0.25$ cm;
E-value of subgrade soil $E_s = 100$ kg/cm^2 ;
E-value of base course material, $E_b = 400$ kg/cm^2 ;
E-value of 7.5 cm thick Bituminous concrete surface course = 1000 kg/cm^2. **(10 Marks)**

4 a. Design the pavement for a two way road on a soil of CBR 4% for an initial traffic of 1200 CV/day. The period of construction is 5 years and the design life is 15 years after opening to traffic. The vehicle damage factor is 2.5. The rate of growth traffic is 8% per annum. Show with a sketch to composition of designed pavement, use chart. **(10 Marks)**

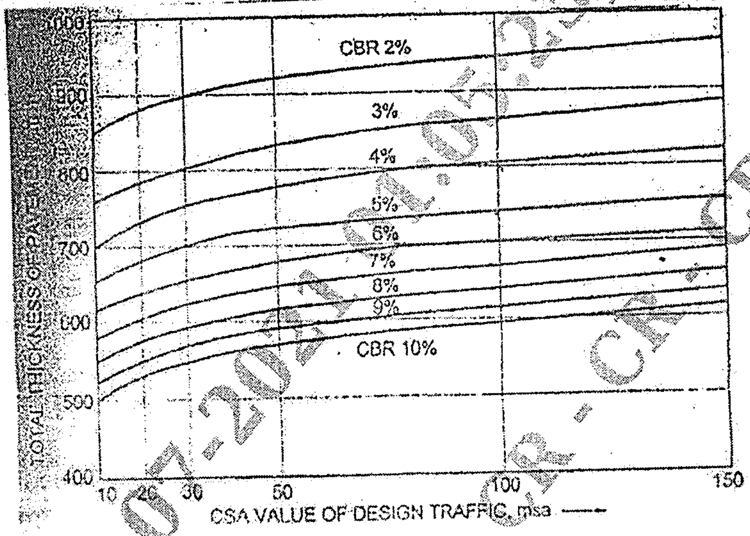


Fig. 7.15 CBR design chart for determination of total pavement thickness for traffic with CSA of 10 to 150 msa

Table 7.4, Pavement design with recommended component layers for cumulative traffic range 10 to 150 msa

CBR, %	CSA, msa	Total pavement thickness, mm	Granular sub-base, mm	Granular base, mm	Dense bituminous Macadam binder course, mm	Bituminous concrete surface course, mm
3	10	760	380	250	90	40
	20	790			120	40
	30	810			140	40
	50	830			160	40
	100	860			180	50
	150	890			210	50
4	10	700	330	250	80	40
	20	730			110	40
	30	750			130	40
	50	780			160	40
	100	800			170	50
	150	820			190	50
6	10	615	260	250	65	40
	20	640			90	40
	30	655			105	40
	50	675			125	40
	100	700			140	50
	150	720			160	50
8	10	550	200	250	60	40
	20	575			85	40
	30	590			100	40
	50	610			120	40
	100	640			140	50
	150	660			160	50
10	10	540	200	250	50	40
	20	565			75	40
	30	580			90	40
	50	600			110	40
	100	630			130	50
	150	650			150	50

Fig. Q4 (a)

b. Calculate the design repetitions for 20 years period for various wheel load equivalent to 2268 kg of wheel load using the following data on a four lane road. The mixed traffic in both direction is 2100 Veh/day.

Load kg	2268	2722	3175	4082	4536	4990	5443
% of total traffic	25	12	9	4	3	2	1

Assume (ELF) for different wheel load.

Wheel load	22.68	27.22	31.72	40.82	45.36	49.90	54.43
ELF	1	2	4	16	32	64	128

(10 Marks)

5 a. List the general causes of flexible pavement failures and analysis the failure with respect to sub base and base course. **(07 Marks)**

b. Explain with details the various maintenance of operations. **(06 Marks)**

c. Explain maintenance of Bituminous surfaces. **(07 Marks)**

6 a. Justify the evaluation of flexible pavement by present serviceability index method. **(06 Marks)**

b. The BBD data were analysed and modified characteristics deflection value after applying corrections for pavement temperature and subgrade moisture was found to be 2.20 mm, the design traffic in terms of CSA is found to be 20 mSa. Using overlay chart determine the thickness of overlay. **(07 Marks)**

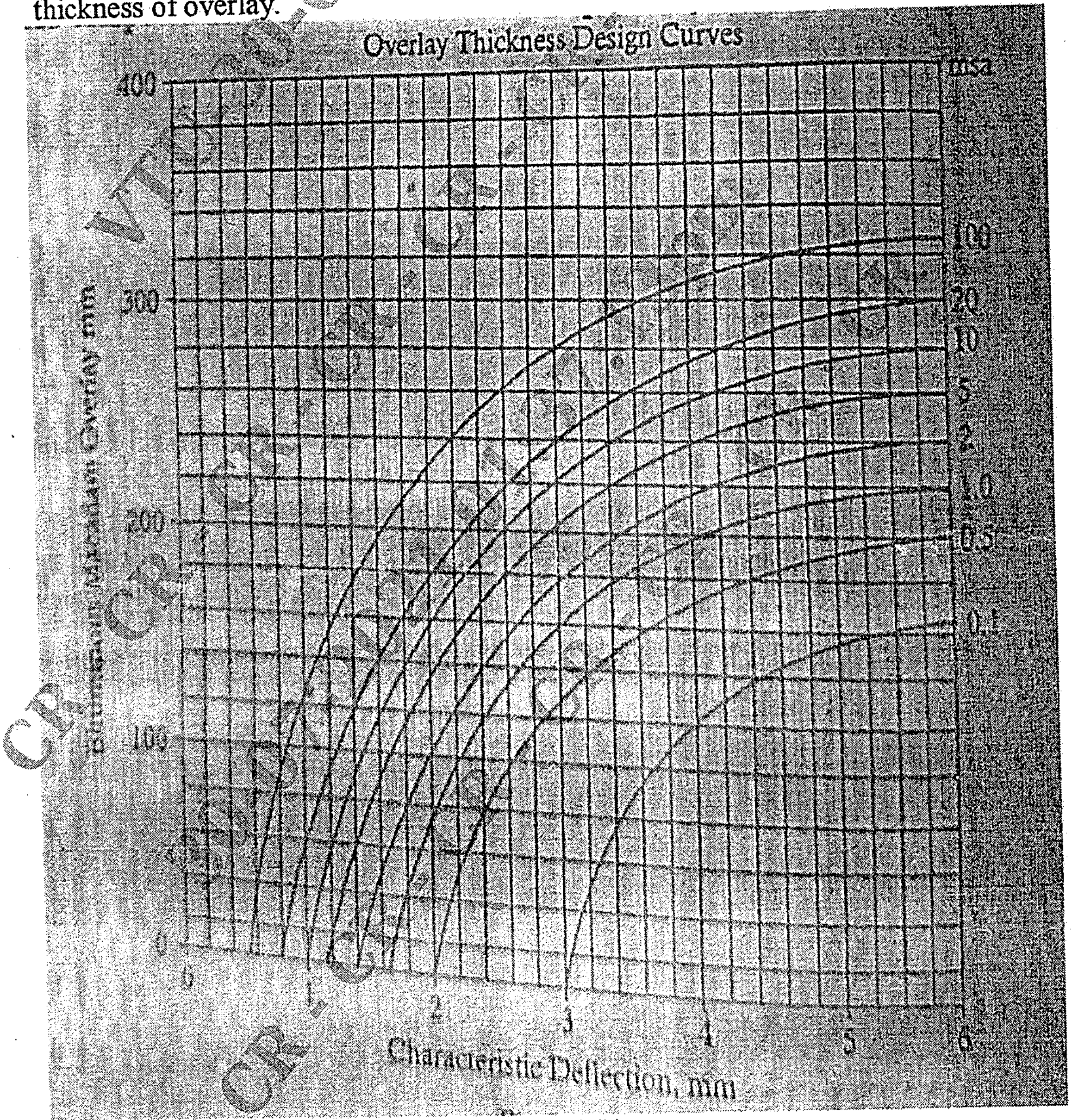
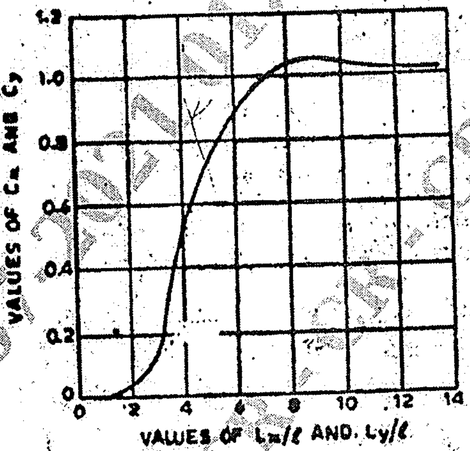


Fig. Q6 (b)

c. List and explain general types of distress in bituminous pavement. **(07 Marks)**

7 a. Determine the warping stress of interior, edge and corner regions in a 28 cm thick cement concrete pavement with transverse joints at 5.5 mt interval and longitudinal joints at 3.5 mt intervals. Modulus of subgrade reaction is 5.0 kg/cm^2. Temperature deterential is 0.80°C per cm slab thickness. If the tyre pressure is 5.0 kg/cm^2 for a wheel load of 51000 kg. Elastic modulus of pavement interval/CC/ E = 3×10^5 kg/cm^2, Poisson's ratio = 0.15. Assume suitable required. **(10 Marks)**



Warping Stress Coefficient

Fig. Q7 (a)

b. Write the step by step procedure for the design of concrete pavements as recommended by IRC-58-2002. **(10 Marks)**

8 a. Design the dowel bars for the following data design of wheel load. 98 Perceutile angle load is 8000 kg. Slab thickness is 33 cm. Joint width 2 cm, radius of relative stiffness is 103.53 cm, compressive strength of concrete at 28 days is 400 kg/cm^2. Elastic modulus of concrete 0.3×10^5 kg/cm^2 and Poisson's ratio is 0.15. **(10 Marks)**

b. Explain the significance of relative stiffness and radius of resisting section. **(10 Marks)**

9 a. Evaluate the various design factors to be considered in Air port pavement. **(10 Marks)**

b. With the help of neat sketches, explain "mud pumping" in concrete pavements. **(10 Marks)**

10 a. Explain with neat sketches the various types of joints in C.C pavements and its functions. **(10 Marks)**

b. Explain the various types of failures in cement concrete pavements and their causes. **(10 Marks)**

* * * * *

15CV833

Eighth Semester B.E. Degree Examination, Dec.2019/Jan.2020

Pavement Design

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. What are the desirable characteristics of pavement? **(08 Marks)**

b. List out the difference between highway pavement and airfield pavement. **(08 Marks)**

OR

2 a. List out the assumptions of Burmister's theory. **(08 Marks)**

b. A dual wheel load assembly with 70kN load on each wheel and contact pressure of 0.7kN/mm^2 is applied on a homogeneous mass with modulus of elasticity 12N/mm^2. If the centre to centre distance between the two wheel is 600mm, determine the deflection value at a depth of 0.5m at four points, at the centre of dual wheels and at radial distance of 300, 600 and 900mm from this centre along the line joining centers of the two wheel loads. Use deflection factor chart Fig.Q.2(b). **(08 Marks)**

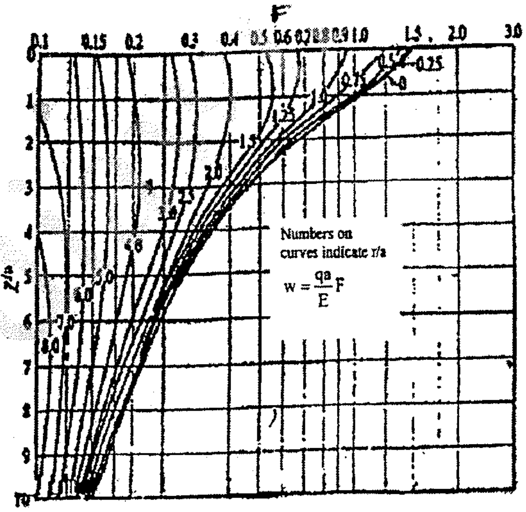


Fig.Q.2(b)

Module-2

3 a. What are the design factors considered in the design of pavement? Explain any three in detail. **(08 Marks)**

b. Calculate the design repetition for 20 years period for various wheel loads equivalent to 22.68kN. Wheel load using the following data on a four lane road. **(08 Marks)**

Load kN	22.68	27.22	31.75	40.82	45.36	49.90	54.43
Volume per day	30	25	20	15	10	5	1

OR

4 a. Explain the significance of ESWL in pavement design. **(08 Marks)**

b. It is proposed to widen an existing 4 lane NH section to 3 lane dual carriage way road. Design the pavement for new carriage way with following data:

Initial traffic in both directions = 4932 CVPD
Construction period = 20 months
Design life = 15 years
Design CBR of soil = 7%
Traffic growth rate = 8%
VDF = 4.5.
Land distribution factor = 75% (0.75)

Pavement Design Catalogue
Plate 2- Recommended Designs for Traffic Range 10-150 msa

CBR 7%				
Cumulative traffic (msa)	Total pavement thickness (mm)	Pavement Composition		
		Bituminous Surfacing		Granular base and sub-base (mm)
		BC (mm)	DBM (mm)	
10	580	40	60	
20	610	40	90	
30	630	40	110	Base = 250
50	650	40	130	
100	575	50	145	Sub-base = 230
150	695	50	165	

(08 Marks)

Module-3

5 a. Explain different types of flexible pavement failure. **(08 Marks)**

b. Explain the various design factors for runway pavement. **(08 Marks)**

OR

6 a. What are the causes of formation of waves and corrugations in flexible pavement? Suggest remedial measures. **(08 Marks)**

b. Explain step by step procedure of conducting Benkleman beam-deflection studies for-evaluation of flexible pavement surface condition. **(08 Marks)**

Module-4

7 a. Write Westergaard's load stress equations at critical regions and discuss critical combination of stresses. **(08 Marks)**

b. Explain IRC recommendation's is the design of dowel bar, tiebar and RCC in pavements. **(08 Marks)**

OR

8 a. Calculate wheel load stresses at interior, edge and corners using Westergaard's equations for wheel load = 51kN, tyre pressure = 0.75N/mm^2, E = 30kN/mm^2, K = 0.08N/mm^2 slab thickness 250mm. **(08 Marks)**

b. A cement concrete pavement has a thickness of 20cm on a 2 lane road of 7.5m with a longitudinal joint along the centre. Design the dimensions and spacing of tie bars for the following data. Working stress in tension S_s = 1400 kg/cm^2 density of concrete W = 2500kg/m^3, friction coefficient 1.5. Allowable bond stress in concrete, Sb = 24.6kg/cm^2. **(08 Marks)**

Module-5

9 a. What are the various types of joints in C.C. pavements? Explain their functions with neat sketches. **(08 Marks)**

b. Explain briefly the pavement evaluation. **(08 Marks)**

OR

10 a. Explain various types of rigid pavement failures, with neat sketch. **(08 Marks)**

b. Explain the following:

i) Fatigue behavior of concrete

ii) Maintenance of Joints. **(08 Marks)**

Bapuji Educational Association ®
Bapuji Institute of Engineering and Technology, Davangere–577 004
Department of Civil Engineering

USN										

Course/Subject Title	Pavement Design	**Course/Subject Code**	17CV833
Semester	8th	**Scheme**	2017
Date	05.06.2021	**CIE No.**	1
Time	9.00 to 10.00 AM	**Max. Marks**	30

Course Outcome Statements : After the successful completion of the course, the students will be able to	
CO1	**Explain** the types of pavements, their components and functions
CO2	**Analyse** the stresses and deflection in pavements by different theories
CO3	**Design** the flexible pavements by different methods
CO4	**Explain** the causes and remedial measures for flexible pavement failures
CO5	**Design** the rigid pavement for critical combination of stress
CO6	**Explain** the causes and remedial measures for rigid pavement failures

Q. No.	**Question**	**Marks**	**RBT Level**	**CO**
1	**List** the difference between Highway and Airfield pavement.	10	L1	1
	OR			
	With the help of sketches **List** the different layers of rigid and flexible pavement and also write the functions of each layer.	10	L1	1
2	**Determine** the deflection values under a wheel load of 60KN and contact pressure 0.7 N/mm^2 in a homogenous mass of soil at a depth of Z=2.5a upto a radial distance of r = 5a. Take modulus of elasticity of subgrade as 8 N/mm^2. Sketch the deflection curve.	10	L3	1
	OR			
	A plate load test was carried out on subgrade using 300mm diameter plate and corresponding to a deflection of 5mm, the load sustained on the plate per unit area was 0.08 N/mm^2. The test was repeated on base course of thickness 300mm and unit load sustained was 0.45 N/mm^2 at the same deflection. **Find** I. Elastic modulus of subgrade and the ratio E_P/E_S. II. What should be the thickness of base course as to sustain wheel load of 50KN and contact pressure 0.6 N/mm^2 so that maximum deflection does not exceed 5mm. Use required charts.	10	L3	1

<table>
<tr><td>3</td><td>Find ESWL by graphical method for a dual wheel load assembly with 200kg on each wheel and tyre pressure of 6.5 kg/km^2 if the centre spacing between the wheels is 25cm. Consider the pavement thickness of 25cm and 45cm (use plain graph paper).</td><td>10</td><td>L3</td><td>2</td></tr>
<tr><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Explain Equivalent wheel factor. Calculate design repetitions for 20 years period for various wheel load equivalent to 22.68KN wheel load using the following survey data on a four lane road.
<table>
<tr><th>Wheel load, KN</th><th>ADT, both directions</th><th>% of traffic volume</th></tr>
<tr><td>22.68</td><td>Total volume of traffic consisting of traffic growth = 5000</td><td>13.17</td></tr>
<tr><td>27.22</td><td></td><td>15.30</td></tr>
<tr><td>31.25</td><td></td><td>11.36</td></tr>
<tr><td>36.29</td><td></td><td>14.11</td></tr>
<tr><td>40.82</td><td></td><td>6.21</td></tr>
<tr><td>45.36</td><td></td><td>5.84</td></tr>
</table></td><td>10</td><td>L3</td><td>2</td></tr>
</table>

RBT (Revised Bloom's Taxonomy) Levels : Cognitive Domain		
L1 : Remembering	L2 : Understanding	L3 : Applying
L4 : Analysing	L5 : Evaluating	L6 : Creating

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Bapuji Institute of Engineering and Technology, Davangere–577 004
Department of Civil Engineering

USN										

Course/Subject Title	Pavement Design	**Course/Subject Code**	17CV833
Semester	8th	**Scheme**	2017
Date	30.06.2021	**CIE No.**	2
Time	9.00 to 10.00 AM	**Max. Marks**	30

Course Outcome Statements : After the successful completion of the course, the students will be able to	
CO1	**Explain** the types of pavements, their components and functions
CO2	**Analyse** the stresses and deflection in pavements by different theories
CO3	**Design** the flexible pavements by different methods
CO4	**Explain** the causes and remedial measures for flexible pavement failures
CO5	**Design** the rigid pavement for critical combination of stress
CO6	**Explain** the causes and remedial measures for rigid pavement failures

<table>
<tr><th>Q. No.</th><th>Question</th><th>Marks</th><th>RBT Level</th><th>CO</th></tr>
<tr><td>1</td><td>Design the Flexible Pavement by tri-axial method using the following data E-value of Sub-grade soil-100kg/cm^2 , E value of Base Course-400kg/cm^2,E value of 8cm thick bituminous surface -1000 kg/cm^2, Design wheel load-6000kg , radius of contact area-15cm, traffic co effiecient-1.5,rainfall co effiecient-0.6, design deflection-0.25cm.</td><td>10</td><td>L3</td><td>3</td></tr>
<tr><td>2</td><td>Design a highway pavement of wheel load 4100kg with a tyre pressure of 5kg/cm^2 by Mc Leod method, plate bearing test carried out on subgrade soil using 30cm dia plate yielded a pressure of 2.5 kg/cm^2 after 10 repetitions load at 0.5cm deflection.</td><td>10</td><td>L3</td><td>3</td></tr>
<tr><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>The penetration test on the subgrade soil of a road project gave the following results.
<table>
<tr><td>Load in kg</td><td>5</td><td>15</td><td>25</td><td>30</td><td>40</td><td>50</td><td>60</td><td>69</td><td>80</td><td>90</td><td>100</td><td>107</td></tr>
<tr><td>Penetration mm</td><td>0.8</td><td>1.0</td><td>1.3</td><td>1.5</td><td>1.85</td><td>2.4</td><td>3.0</td><td>4.0</td><td>5.5</td><td>7.1</td><td>10.0</td><td>12.5</td></tr>
</table>
Further the CBR value of different layers were derived as follows compacted soil subgrade-7%, poorly graded gravel layer-20%,well graded gravel layer-90%,minimum thickness of bitumen concrete surfacing as 5cms Design the pavement for 4000commercial vehicles by IRC curves</td><td>10</td><td>L3</td><td>3</td></tr>
<tr><td>3</td><td>The initial traffic after completion of construction of a four lane divided highway is estimated to be 3500CV per day Design the flexible pavement for a life of 15 years using the data
Design CBR value=8%,growth rate CV=6.5%p a, Average VDF value of CV=4.0</td><td>10</td><td>L3</td><td>3</td></tr>
</table>

RBT (Revised Bloom's Taxonomy) Levels : Cognitive Domain		
L1 : Remembering	L2 : Understanding	L3 : Applying
L4 : Analysing	L5 : Evaluating	L6 : Creating

Jyothi S.H 29/6/21
Course Coordinator
Jyothi S H

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Bapuji Educational Association ®
Bapuji Institute of Engineering and Technology, Davangere–577 004
Department of Civil Engineering

USN										

Course/Subject Title	Pavement Design	**Course/Subject Code**	17CV833
Semester	8th sem , A sec	**Scheme**	2019
Date	17.07.21	**CIE No.**	3
Time	9.00 to 10.00 AM	**Max. Marks**	30

Course Outcome Statements : After the successful completion of the course, the students will be able to	
CO1	**Explain** the types of pavements, their components and functions
CO2	**Analyse** the stresses and deflection in pavements by different theories
CO3	**Design** the flexible pavements by different methods
CO4	**Explain** the causes and remedial measures for flexible pavement failures
CO5	**Design** the rigid pavement for critical combination of stress
CO6	**Explain** the causes and remedial measures for rigid pavement failures

Note :Answer the following question

Q. No.	**Question**	**Marks**	**RBT Level**	**CO**
1	Briefly **explain** the typical types of flexible pavement failures.	10	L1	4
2	As per IRC 58-2002 **explain** the procedure of design of rigid pavements	10	L2	5
3	**Determine** the warping stress at corner, interior and edge regions of a cement concrete pavement of thickness 200mm,contraction joint spacing of 5m & longitudinal joint spacing of 4.0m on a runway. The E value of concrete is 0.3×10^5N/mm^2 and K value of subgrade =0.15N/mm^2. Assume the temperature differential as 17 °c. Take α=10×10-6 /°c ,μ=0.15 Assume radius of contact area of loads as 150mm	10	L3	5

RBT (Revised Bloom's Taxonomy) Levels : Cognitive Domain		
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L4 : Analysing	L5 : Evaluating	L6 : Creating

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Department of Civil Engineering

USN										

Date	**01**	**07**	**2021**

Course/Subject Title	Pavement Design	**Course/Subject Code**	17CV833
Semester	8th	**Scheme**	2017
Assignment No.	1	**Max. Marks**	10

Course Outcome Statements : After the successful completion of the course, the students will be able to	
CO1	**Explain** the types of pavements, their components and functions
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CO6	**Explain** the causes and remedial measures for rigid pavement failures

Q. No.	**Question**	**Marks**	**RBT Level**	**CO**
1	Draw the neat sketch of flexible and rigid pavement and show the components and parts , briefly **Explain** them.	2	L1	1
2	**Explain** the factors affecting the design of flexible pavements.	2	L1	2
3	**List** the assumptions and limitations of Boussinesq's theory.	2	L2	2
4	**Explain** Frost action ,what are the measures adopted to reduce its effects.	2	L2	2
5	**Explain** Burmister's theory.	2	L2	2

RBT (Revised Bloom's Taxonomy) Levels : Cognitive Domain		
L1 : Remembering	L2 : Understanding	L3 : Applying
L4 : Analysing	L5 : Evaluating	L6 : Creating

Jyothi S.H 29/6/21
Course Coordinator
Jyothi S H

29/06/2021
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Bapuji Educational Association ®
Bapuji Institute of Engineering and Technology, Davangere–577 004
Department of Civil Engineering

USN										

Course/Subject Title	Pavement Design	**Course/Subject Code**	17CV833
Semester	8th	**Scheme**	2017
Date	13.07.2021	**Assignment No.**	2
Course Co-Ordinator	Jyothi S H	**Max. Marks**	10

Course Outcome Statements : After the successful completion of the course, the students will be able to	
CO1	**Explain** the types of pavements, their components and functions
CO2	**Analyse** the stresses and deflection in pavements by different theories
CO3	**Design** the flexible pavements by different methods
CO4	**Explain** the causes and remedial measures for flexible pavement failures
CO5	**Design** the rigid pavement for critical combination of stress
CO6	**Explain** the causes and remedial measures for rigid pavement failures

Q. No.	**Question**	**Marks**	**RBT Level**	**CO**
1	**Design** Pavement slab thickness by IRC 58-2002 method using the following data, modulus of subgrade reaction=8kg/cm3 , present traffic intensity=1000CVD,design wheel load=5100kg, radius of contact area=15cm,trial design thickness=25cm, temperature differential=17.6oc use the charts if needed	5	L3	5
2	**List** the general causes for flexible pavement failure. **List** and **explain** the failures in sub-base and base courses.	5	L2	4

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Department of Civil Engineering

USN										

Course/Subject Title	Pavement Design	**Course/Subject Code**	17CV833
Semester	8th	**Scheme**	2017
Date	13.07.2021	**Assignment No.**	3
Course Co-Ordinator	Jyothi S H	**Max. Marks**	10

Course Outcome Statements : After the successful completion of the course, the students will be able to	
CO1	**Explain** the types of pavements, their components and functions
CO2	**Analyse** the stresses and deflection in pavements by different theories
CO3	**Design** the flexible pavements by different methods
CO4	**Explain** the causes and remedial measures for flexible pavement failures
CO5	**Design** the rigid pavement for critical combination of stress
CO6	**Explain** the causes and remedial measures for rigid pavement failures

Q. No.	**Question**	**Marks**	**RBT Level**	**CO**
1	Briefly **Explain** the mud-pumping phenomenon in concrete roads	2.5	L2	6
2	**List** are the factors considered in design of rigid pavement? **Explain** any three factors in that.	2.5	L2	6
3	With a neat sketches. **Describe** the various types of joints and their requirements in rigid pavement.	5	L2	6

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Scheme of Valuation

Course/Subject Title	Pavement Design	**Course/Subject Code**	17CV833
Semester	8th Sem 'A' Sec	**CIE No.**	1
Date	21/5/21	**Max. Marks**	30

1) Differences b/n Highway & Airfield pavement — 1X10 = 10M

10 Differences

or

Sketch of both Rigid & Flexible Pavement — 5M

functions of them — 5M

10M

2) Given Data — 1M

i) $\frac{z}{a} = 2.5, \frac{h}{a} = 0$

$F = 0.52$ [chart]

$\Delta = \frac{PaF}{E_S} = 7.5$ mm

ii) $\frac{z}{a} = 2.5, \frac{h}{a} = 0.5$

$F = 0.51$

$\Delta = \frac{PaF}{E_S} = 7.37$ mm

iii) $\frac{z}{a} = 2.5, \frac{h}{a} = 1.0$

$F = 0.47$

$\Delta = 6.79$ mm

iv) $\frac{z}{a} = 2.5, \frac{h}{a} = 2.0$

$F = 0.35$

$\Delta = 5.05$ mm

v) $\frac{z}{a} = 2.5$ $\frac{h}{a} = 3.0$ — 8M

$F = 0.265$

$\Delta = 3.03$ mm

vi) $\frac{z}{a} = 2.5, \frac{h}{a} = 4.0$

$F = 0.21$

$\Delta = 3.03$ mm

vi) $\frac{z}{a} = 2.5, \frac{h}{a} = 5.0$

$F = 0.175$

$\Delta = 2.53$ mm

Draping Deflection Curve — 1M

10M

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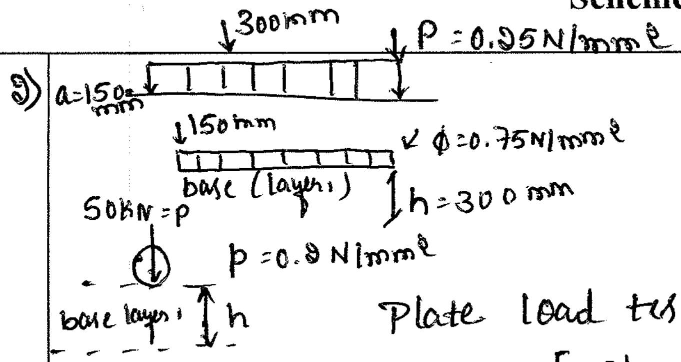
Scheme of Valuation

3)



1M

Plate load test on subgrade

$F_2 = 1$, $P = 0.25 N/mm^2$ $a = 150 mm$

$$A = 1.18 \left[\frac{Pa}{E_2}\right] F_2$$

$A = 2.5 mm$

4M

$E_2 = 17.7 N/mm^2$

Plate load test on base of known thickness

$$A = 1.18 \left[\frac{Pa}{E_2}\right] E_2$$

$A = 2.5 mm$ $P = 0.75 N/mm^2$ $a = 150 mm$

$E_2 = 17.7 N/mm^2$

$E_2 = 0.33$

From chart $\frac{h}{a} = \frac{300}{150} = 2$ & $E_2 = 0.33$

$E_1/E_2 = 10$

Wheel load on base of unknown thickness

$\Delta = 5mm$ $p = 0.8 N/mm^2$

4M

$$A = 1.5 \left[\frac{pa}{E_2}\right] F_2$$

$$a = \sqrt{\frac{P}{\pi p}} = \sqrt{\frac{50 \times 1000}{\pi \times 0.8}}$$

$F_2 = 0.52$

$a = 141. mm$

$E_2' = 17.7 N/mm^2$

From chart for $\frac{E_1}{E_2} = 10$ $F_2 = 0.52$

1M

$\frac{h}{a} = 1.2$

10M

$\therefore h = 169.32 mm$

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3) Given $p = 63.74\ N/mm^2$ $P = 200Kg$ 2M

$s = 25\ mm$

$p = \frac{load}{Area\ of\ imprint}$ 3M

$a = 32cm$

$2P = 41KN$ $2S = 50KN$, $\frac{d}{2} = 12.5cm$

$\log(2P, 2S) = (41, 50) = (1.612, 1.698)$ 5M

$\log(P, d/s) = (21, 12.5) = (1.322, 1.0969)$

10M

25CM depth = 250 KN
45KM depth = 398 KN } From graph

3)

Wheel load	ADT	Total traffic volume	Days in a Year	No. of Years	EWLF	Design Repetitions
2268	5000	0.1317	365	20	1	4807050
2722	5000	0.153	365	20	2	11169000
3175	5000	0.1176	365	20	4	16585600
3629	5000	0.1411	365	20	8	41201200
4082	5000	0.0621	365	20	16	36266400
4536	5000	0.0581	365	20	32	68211200

8M

Total = 178240450

Per lane = 4450112.5 2M

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Scheme of Valuation

Course/Subject Title	Pavement Design	**Course/Subject Code**	18CV833
Semester	8th 'A'	**CIE No.**	2
Date	30/6/21	**Max. Marks**	30

1)	given calculation of pavement thickness Formula & substitution $T = \sqrt{\left(\frac{3P\times4}{2\pi\Delta E_s}\right)^2 - a^2} \times \left(\frac{E_s}{E_B}\right)^{1/2}$ $= \sqrt{\left[\frac{3\times6000\times1.5\times0.6}{2\pi\times0.25\times100}\right]^2 - (15)^2 \times \left(\frac{400}{400}\right)^{1/2}}$ $= 64.29cm \simeq 64.3cm$	5
	thickness of base course $\frac{t_b}{t_p} = \left(\frac{E_p}{E_B}\right)^{1/3}$ $t_b = 10.85cm$	2
	Required base course thickness $= 64.3 - 12.65 = 53.45$ →	2
	Diagram	1
		10M
2)	Finding radius of contact area, $a = 16.2cm$	2
	P/A ratio $= 0.129$	1
	Value of K through graph, 0.96kg/cm²	2
	Finding unit support $= 2.40$ kg/cm²	1
	Design subgrade support S, = 1979kg	2

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Pavement thickness , $T = K \log_{10}\left(\frac{P}{5}\right)$ — 2

$T = 28.5 \simeq 29cm$ — 10M

or

given data

Graph Plotting

Load at 2.5mm penetration = 62kg

Load at 5mm Penetration = 82kg — 5M

CBR at 2.5mm = 4.5%, CBR at 5mm = 4%

Curve F is used to find the CBR

i) Total thickness above subgrade = 51cm — 5M

compacted soil subgrade = 51-40 = 11cm

Poorly graded gravel layer = 40-21 = 19cm — 10M

Well graded gravel layer = 21-9 = 12cm

Bituminous Surfacing = 9cm

③ given data

taking LDF by Code IRC 37 2001 , 0.75 — 5M

$$CSA = \frac{365\left[NFD\left((1+r)^{n}-1\right]\right.}{r}$$

$= 100.39MSA$

Using CBR design chart - for CBR of 8% & CSA value 100MSA thickness of flexible Pavement = 640mm — 5M

10M

GSB = 200mm
GB = 250mm
DBM = 140 mm
BC = 50mm
} 640mm

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Scheme of Valuation

Course/Subject Title	Pavemen Design	**Course/Subject Code**	17CV833
Semester	8th Sem 'A' Sec	**CIE No.**	3
Date	17/7/21	**Max. Marks**	30

1)	Mentioning the types of Failures * Alligator cracking * Consolidation of pavement layer * Shear Failure * longitudinal cracking * Frost heaving * lack of binding to the lower course * Reflection cracking * Formation of waves & corrugation	5M
	Brief explanation about them	5M 10M
2)	Design procedure According to IRC 58 2002 * collection / determination of Design Parameters * Decision on spacing of transverse joints & longitudinal joints * Design of slab thickness * Design of Dowel bars * Design of Tie bars	
3)	given $h = 20cm$ $\mu = 0.15$ $E = 3 \times 10^5 kg/cm^2$ $t = 17^\circ C$ $\alpha = 10 \times 10^{-6} /^\circ C$ $a = 15cm$ Radius of Relative Stiffness $l = \left[\frac{Eh^3}{12K(1-\mu^2)}\right]^{1/4} = \left[\frac{3 \times 10^5 \times 20^3}{12 \times 1.5 (1-0.15^2)}\right]^{1/4}$ $l =$ ~~60 1080cm~~ 607.72mm	

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$\frac{Lx}{l} = \frac{5000}{607.72} = 8.23$ $\frac{Ly}{l} = \frac{4000}{607.72} = 6.58$

$C_x = 1.052$ from graph
$C_y = 6.58$ from graph

Warping stress at interior

$$\sigma_i = \frac{Ect}{2}\left[\frac{C_x + \mu C_y}{1-\mu^2}\right] =$$

$= 3.03\ N/mm^2$

Warping stress at edge region

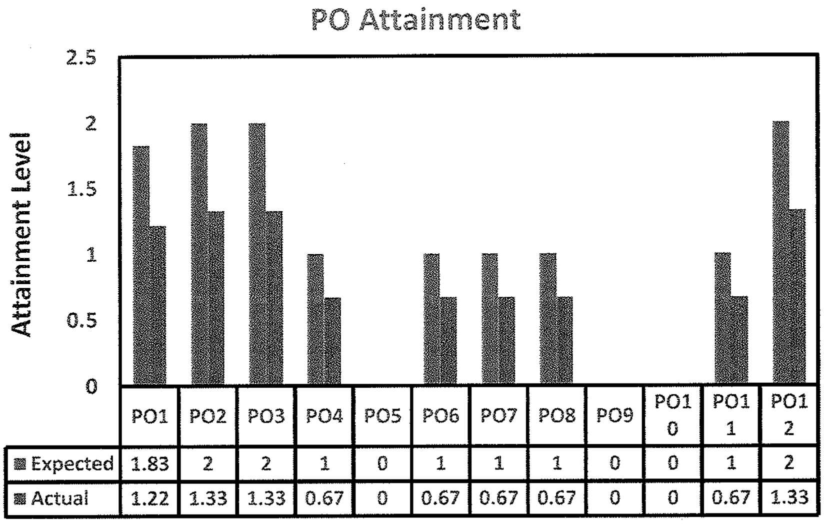
$$\sigma_e = (C_x \text{ or } C_y)\frac{E\alpha t}{2}$$

$\sigma_e = 2.60\ N/mm^2$

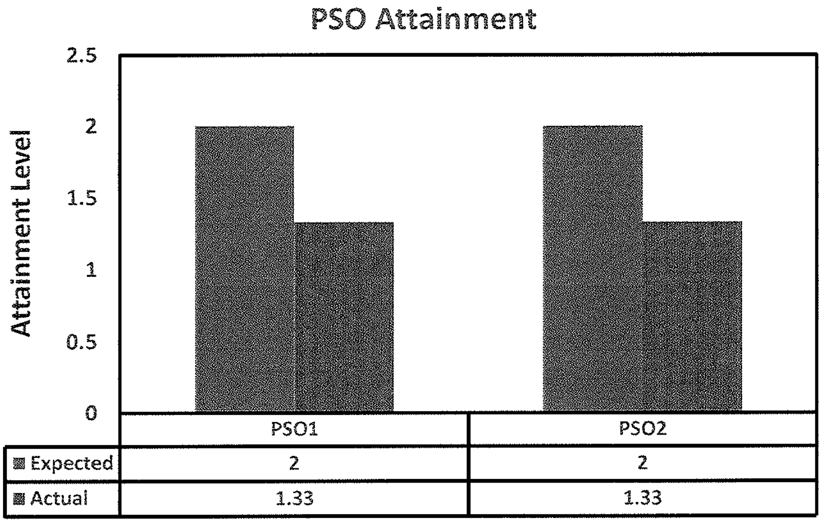
Warping stress at corner region

$$\sigma_c = \frac{E\alpha t}{3(1-\mu)}\sqrt{\frac{a}{l}}$$

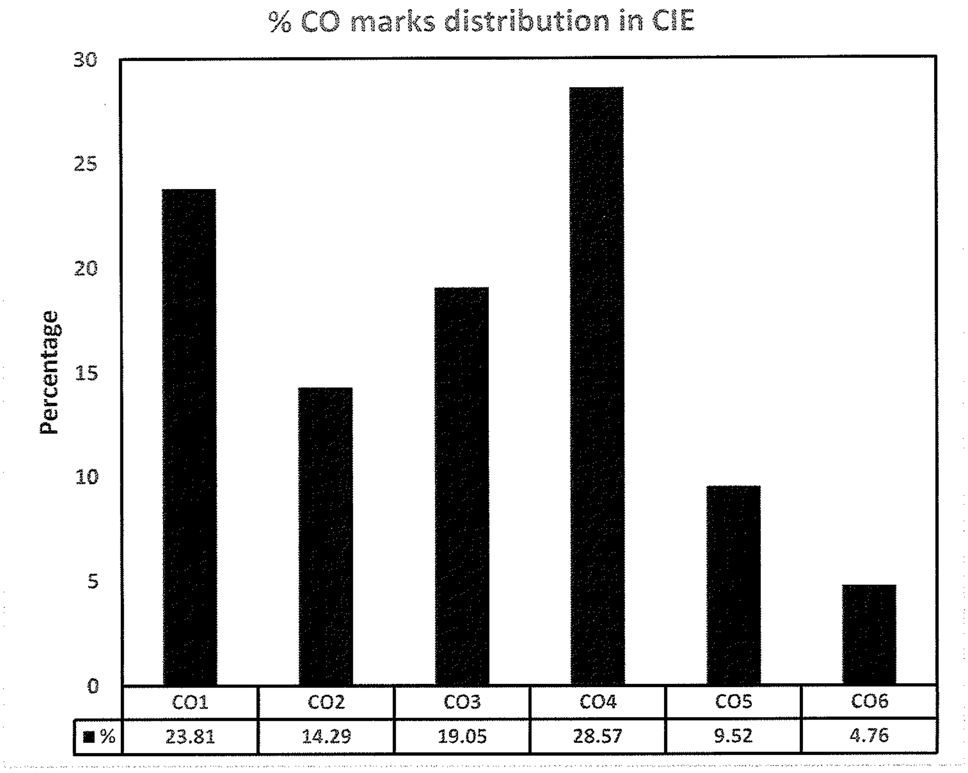
$\sigma_c = 0.99\ N/mm^2$



	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
▨ Expected	1.83	2	2	1	0	1	1	1	0	0	1	2
▨ Actual	1.22	1.33	1.33	0.67	0	0.67	0.67	0.67	0	0	0.67	1.33

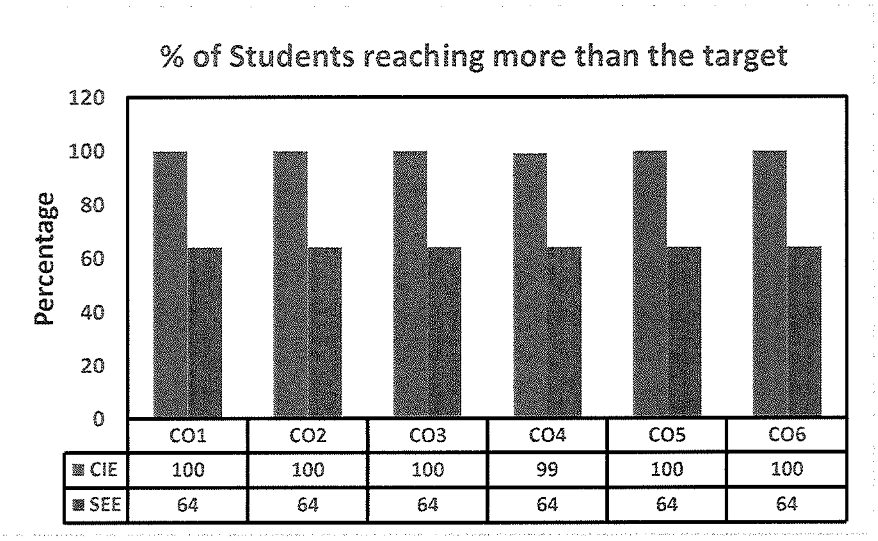


	PSO1	PSO2
▨ Expected	2	2
▨ Actual	1.33	1.33



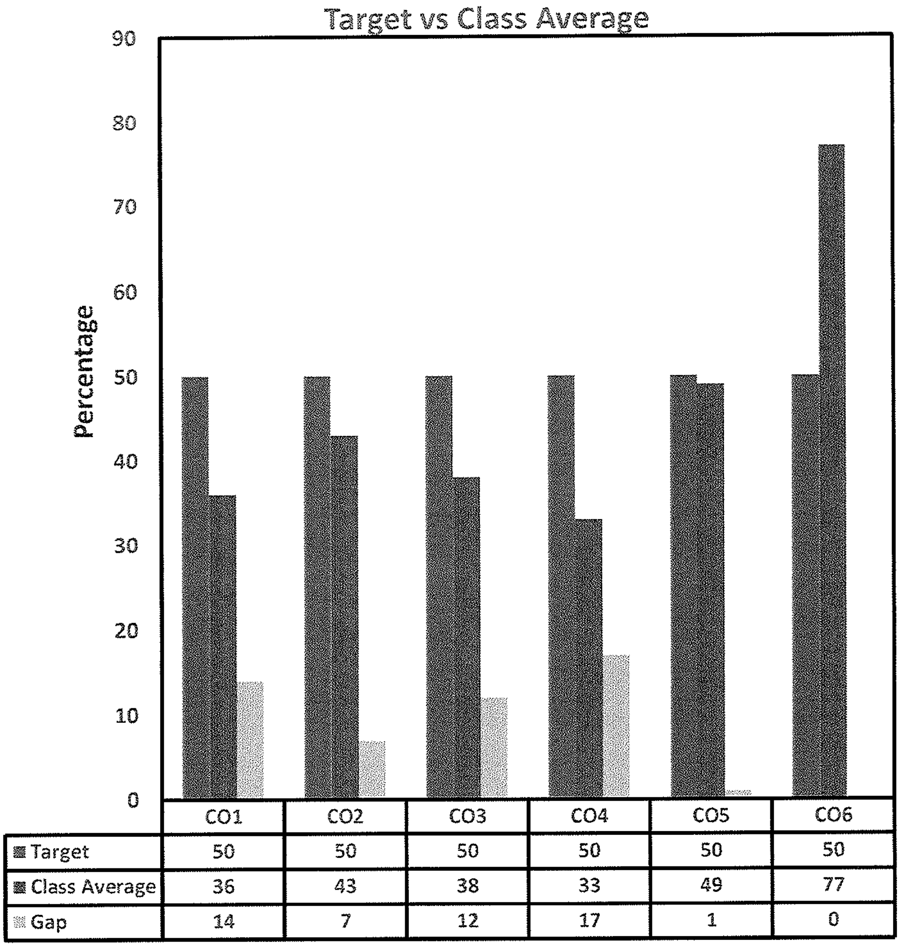
% CO marks distribution in CIE

	CO1	CO2	CO3	CO4	CO5	CO6
■ %	23.81	14.29	19.05	28.57	9.52	4.76



% of Students reaching more than the target

	CO1	CO2	CO3	CO4	CO5	CO6
■ CIE	100	100	100	99	100	100
■ SEE	64	64	64	64	64	64



Target vs Class Average

	CO1	CO2	CO3	CO4	CO5	CO6
▨ Target	50	50	50	50	50	50
▨ Class Average	36	43	38	33	49	77
▨ Gap	14	7	12	17	1	0