UNIVERSITY OF ENGINEERING & MANAGEMENT,JAIPUR

Lecture-wise Plan

Subject Name: Principles of Management **Subject Code-HU601**
Year: 3rd Year **Semester: Sixth**

Module Number	Topics	Number of Lectures
1	**Introduction:**	**7L**
	Basic concepts of Management: Definition, essence, Functions, Roles, Level.	2
	Functions of Management Planning : Concept, Nature, Types, Analysis, Management, objectives	2
	Structure : Concept, Structure, Principles, Centralization, Decentralization, Spn of Management, Organizational Effectiveness	3
		9L
2	Management and Society : Concept, external environment, CSR, Corporate Governance, Ethical Standards.	3
	People Management : Overview, Job design, Recruitment and Selection, Stress Management	3
	Managerial competencies : Communication, Motivation, Team Effectiveness, Conflict Management, Creativity, Enterprenuership.	3
		18L
3.	Leadership concept : Nature, Styles, Decision Making, Process, Tools and Techniques.	**3**
	Economic, Financial and quantitative Analysis : Production Markets, National Income Accounting, Financial Function, and goals, Fianancialststements, Ratio Analysis.	3
	Quantitative Methods : Statistical Interference, Forecasting, Regression Analysis, Ststistical Quality Control	3
4	Customer Management: Market planning and research, Market Mix, Advertising and Brand Management.	3
	Operations and Technology Management: Production and Operations Management, Logistics, & supply chain Management.	3
	TQM, Kaizen and Six Sigma, MIS.	3

Faculty In-Charge

HOD, Humantities Dept.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: Highway & Transportation Engineering **Subject Code-CE601**
Year: 3rd Year **Semester: Sixth**

Module Number	Topics	Number of Lectures
1	**Introduction to Highway Engineering:**	**2L**
	1. Scope of highway engineering; Jayakar Committee Report; saturation system.	1
	2. Saturation System, Highway financing and highway economics	1
2	**Highway Alignment:**	**2L**
	1. Factors controlling alignments	1
	2. Engineering surveys for highway alignment and location.	1
3	**Highway Geometric Design:**	**14L**
	1. Highway Cross-sectional elements	2
	2. Sight Distance (passing and non passing)	2
	3. PIEV theory, requirements and design principles of horizontal alignment including radius of curvature, super elevation, extra-widening	4
	4. Design of transition curves, curve resistance, set back distance	3
	5. Grade compensation and vertical alignment.	3
4	**Pavement design:**	**11L**
	1. Evaluation of soil subgrade, subbase, base and wearing courses	2
	2. Design factors for pavement thickness (including design wheel load and ESWL, strength of pavement materials and plate load tests, and effect of climatic variations) Group Index and CBR, IRC method of flexible pavement design;	4
	3. Westergaards analysis of wheel load stresses in rigid pavements, frictional stresses and warping stresses	2
	4. IRC recommendations for design of rigid pavements	1
	5. Design of expansion and contraction joints. Benkelmen Beam Test, Fialure of flexible and rigid pavements.	2
5	**Pavement construction Technique:**	**4L**
	1. Types of pavement; construction of earth roads, gravel roads,WBM, bitumen and cement concrete road	2
	2. Joints in cement concrete pavements.	2
	Traffic Engineering:	**8L**

6	1. Traffic characteristics	1
	2. Theory of traffic flow	2
	3. Intersection design	2
	4. Traffic sign and signal design	2
	5. Highway capacity	1
7	**Road Materials and Testing :**	**1L**
	1. Soil, Stone Aggregate, Bitumen, Marshal Stability Test	1
Total Number Of Hours = 42		

Faculty In-Charge HOD, CE Dept.

Assignment:

Module-1(Introduction to Highway Engineering):

1. Write short note on: Nagpur road plan, Indian Roads Congress, Jayakar Committee.
2. Explain why the saturation system is considered a rational method to decide the final road network and for phasing the road development programme. Illustrate the saturation system with an example. Discuss shrinkage and creep of concrete.
3. What are the various plans to be prepared after the planning surveys are carried out.

Module-2 (Highway Alignment):

1. What are the various requirements of an ideal highway alignment? Discuss briefly.
2. Briefly explain the engineering surveys needed for locating a new highway.

Module-3(Highway Geometric Design):

1. What are the objects of highway geometric design? List the various geometric elements to be considered in highway design.
2. Calculate the safe stopping sight distance for design speed of 50 kmph for a) two-way traffic on a two lane road b) two way traffic on a single plane road. Assume coefficient of friction as 0.37 and reaction time of driver as 2.5 seconds.
3. The radius of a horizontal circular curve is 100m. The design speed is 50 kmph and the design coefficient of lateral friction is 0.15.
   a) Calculate the super-elevation required if full lateral friction is assumed to develop
   b) Calculate the coefficient of friction needed if no superelevation is provided.
4. A national Highway passing through rolling terrain in heavy rainfall area ha a horizontal curve of radius 500 m. Design the length of transition curve assuming suitable data.
5. A vertical summit curve is formed at the intersection of two gradients, +0.3 and – 5.0 percent. Design the length of summit curve to provide a stopping sight distance for a design speed of 80 kmph. Assume other data.

Module-4(Pavement design):

1. The CBR value of subgrade soil is 5%, calculate total thickness of a pavement using
   i) design curve developed by California State Highway Department
   ii) design chart recommended by IRC
   iii) design formula developed by the US Crops Engineer
   Assume 4100 kg wheel load or medium light of 200 commercial vehicles per day for design.
2. Design the pavement section by triaxial test method using the following data

Wheel load= 4100 kg
Radius of contact area= 15cm
Traffic coefficient, X= 1.5
Rainfall coeffiecient, Y=0.9
Design deflection, 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

3. Calculate the stresses at interior , edge and corner regions of a cement concrete pavement using Westergaard's stress equations. Use the following data:
   Wheel load, P = 5100 kg
   Modulus of elasticity of cement concrete, E= 3 x 10^5 kg/cm^2
   Pavement thickness, h=18cm
   Poissions's ratio of concrete =0.15
   Modulus of subgrade reaction, k=6.0 kg/cm^3
   Radius of conctact area, a= 15 cm

Module-5 (Pavement construction Technique):

1. Write a short note on: seal coat, bitumen bound macadam, bituminous concrete.
2. Discuss with neat diagram: Expansion joints, contraction joints, warping joints, construction joints, longitudinal joints

Module-6(Traffic Engineering):

1. In a braking test, a vehicle travelling at aspeed of 30 kmph was stopped by applying brakes fully and the skid marks were 5.8 m in length. Determine the average skid resistance of the pavement surface.
2. Estimate the theoretical capacity of a traffic lane with one way traffic flow at a stream speed of 40 kmph. Assume the average space gap between vehicles to follow the relation S_g= 0.278 Vt where V is the stream speed in kmph, t is the average reaction time= 0.7 sec. Assume the average length of vehicles=5.0 m

Module-7(Road Materials and Testing):

1. Briefly explain Marshall method of design.
2. What are the different types of bituminous materials used in road construction? Under what circumstances each of these materials is preferred?

UNIVERSITY OF ENGINEERING & MANAGEMENT,JAIPUR

Lecture-wise Plan

Subject Name: Design of Steel Structures **Subject Code-CE 602**
Year: 3rd Year **Semester: Sixth**

Module Number	Topics	Number of Lectures
1.	**Materials and Specification** :-Rolled steel section,	**8 L**
	types of structural steel , specificationsStructure	**1L**
	connections: Riveted, welded and bolted including	**1L**
	High strength friction grip bolted joints– types of	**1L**
	riveted bolted joints, assumptions, failure of joints	**1L**
	,efficiency of joints, design of bolted ,riveted &	**1L**
	welded joints for axial load. ii) Eccentric	**1L**
	connection:- Riveted & bolted joints subjected to	**1L**
	torsion & shear, tension & shear, design of riveted,	**1L**
	bolted& welded connection.	
2.		**8 L**
	Tension members: Design of tension members, I.S	**4L**
	code provisions. Permissible stresses, Designrules,	**4L**
	Examples.	
3.	**Compression members**: Effective lengths about	**9L**
	major& minor principal axes, I.S code provisions.	**2L**
	Permissible stresses, Design rules, Design of one	**1L**
	component, two components and built up	**1L**
	compression members under axial load. Examples.	**2L**
	Built up columns under eccentric loading: Design of	**1L**
	lacing and batten plates, Different types of Column	**1L**
	Bases- Slab Base , Gusseted Base, Connection details.	**1L**
4.	**Beams:** Permissible stresses in bending, compression	**9L**
	and tension. Design of rolled steel sections,plated	**3L**
	beams. simple Beam end connections, beam -	**3L**
	Column connections. I.S code provisions.	**3L**
	curtailment of flanges – Riveted & weldedweb	**3L**
	stiffeners, web flange splices - Riveted, welded&	**2L**
	bolted. **Gantry Girder**: Design gantry girder	**3L**
	considering lateral buckling – I.S code provisions.	**2L**
Total Number Of Hours = 44		

Faculty In-Charge HOD, CE Dept.

Assignment:

Module 1:

1. Explain the advantages of steel as a structural material.

2. Explain the design philosophies of construction of steel structures in brief.

3. What is called clamping action and residual tension of rivets?

4. Explain the concept of gauge and pitch with the help of a diagram. Also explain the concept of Edge distance.

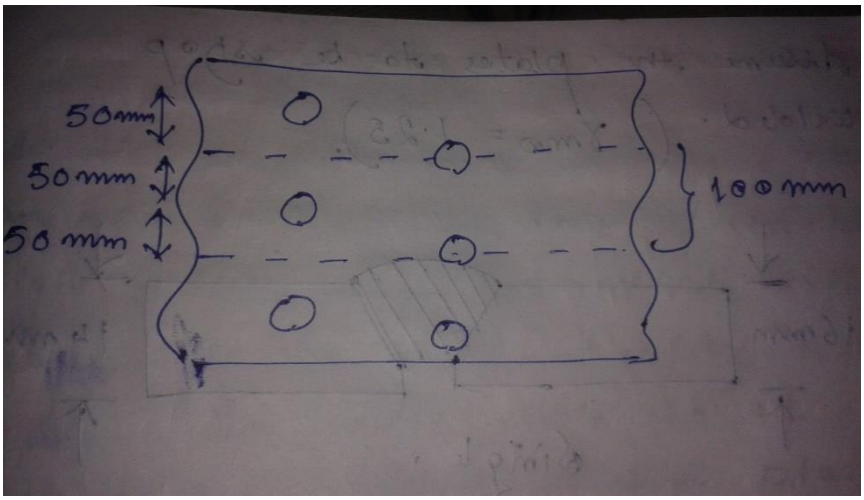
Module 2:

1. Calculate the strength of a 20 mm diameter bolt of grade 4.6 for the following cases –

(The main plates to be jointed are 12 mm thick)

a) Lap joint
b) Single cover Butt Joint, the cover plate being 10 mm thick
c) Double cover Butt joint, each of the cover plate being 8 mm thick

2. Determine the strength and efficiency of the lap joint as shown in the figure. The bolts are 20 mm diameter and of grade 4.6. The 2 plates to be jointed are 10 mm and 12 mm thick. (Steel is of grade Fe 410)



UNIVERSITY OF ENGINEERING & MANAGEMENT,JAIPUR

Lecture-wise Plan

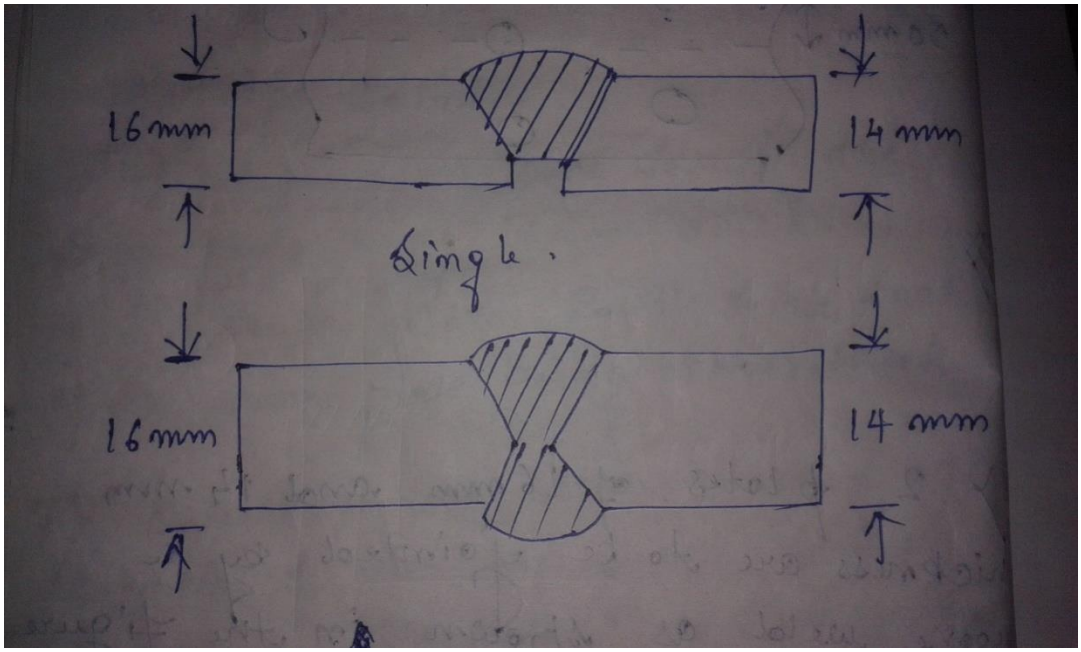
Module 3:

1. 2 plates of 16 mm and 14 mm thickness are to be jointed by a groove weld as shown in the figure. The joint is subjected to a factoral tensile force of 430 kN. Due to some reasons the effective length of the weld that could be provided was 175 mm only. Check the safety of the joint if –

a) Single V groove weld is provided

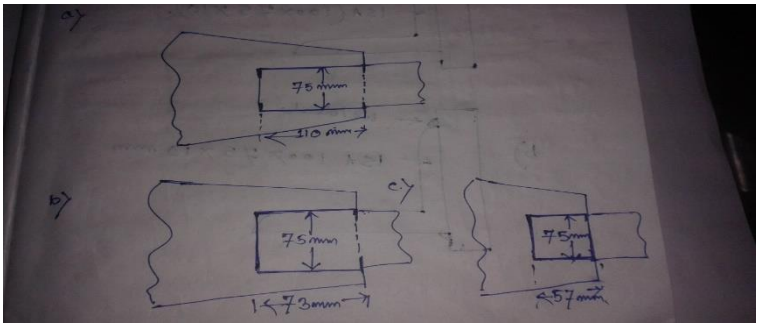
b) Double V groove weld is provided

Assume the plates to be shop welded.

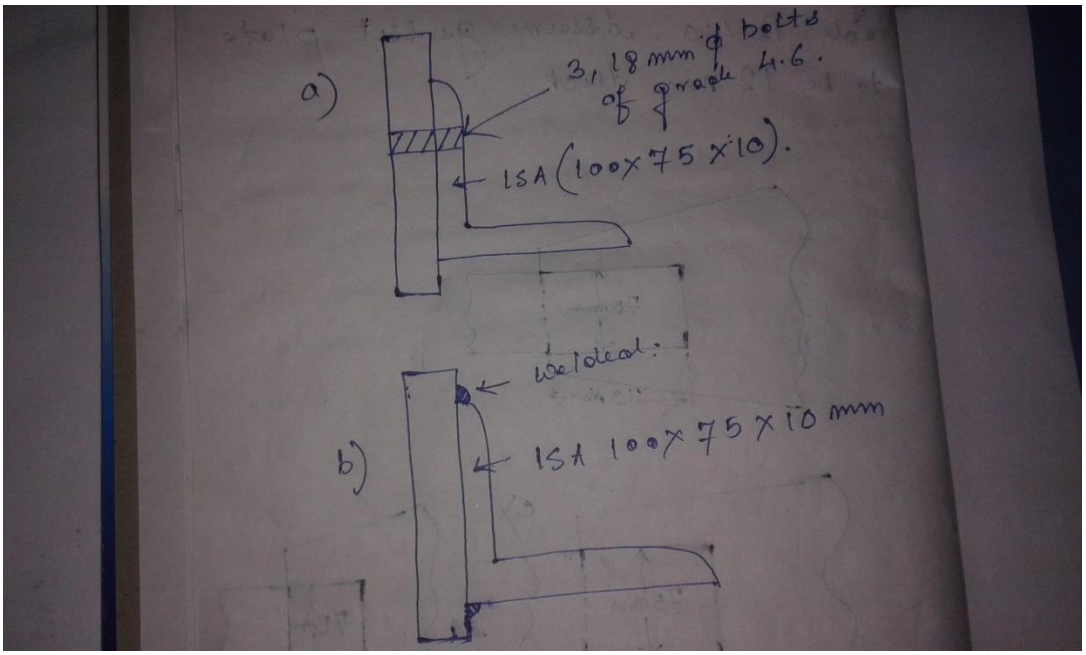


Module 4:

1. A tie member 75 mm * 8 mm is to transmit a factored load of 145 kN. Design fillet welds and necessary overlaps for the cases shown in the figure. The steel weld is of grade of Fe 410. Assume gusset plate to be 12 mm thick.



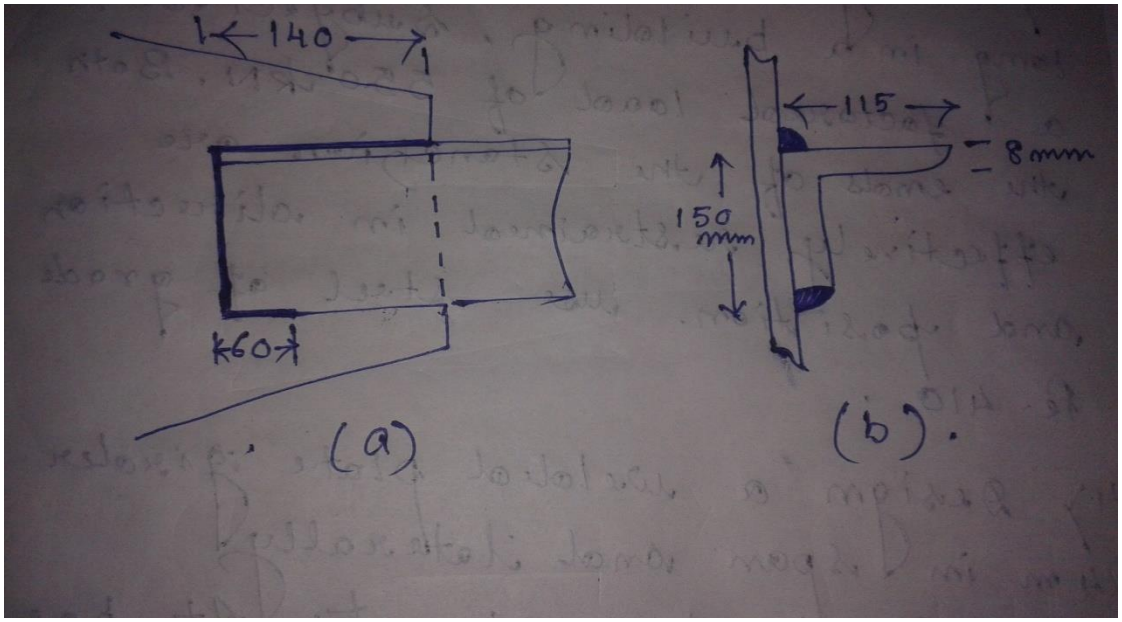
2. Determine the effective net area for the section shown in the figure. The angles are connected as shown in the figure. The steel is of grade Fe 410.



3. Compute the tensile strength of an angle section ISA 150*115*8 mm of Fe 410 grade of steel connected with gusset plate as shown in the figure, for the following cases:

a) Gross Section Yielding

b) Net Section Rupture



UNIVERSITY OF ENGINEERING & MANAGEMENT,JAIPUR

Lecture-wise Plan

Module 5:

1. Explain the concept of Effective Length of columns. Explain the steps for determining the effective length for Braced and Unbraced column.

2. Design a stanchion, 3.5 m long in a building, subjected to a factored load of 550 kN. Both the ends of the stanchion are effectively restrained in direction and position, use steel of grade Fe 410.

3. a)Explain the Slenderness Ratio for compression members, with Mathematical Expression.

b.) Explain the Euler's Formula for Column.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: Construction Planning & Management **Subject Code-CE603**
Year: 3rd Year **Semester: Sixth**

Module Number	Topics	Number of Lectures
1	**Planning:**	**2L**
	1. General consideration, Definition of aspect, prospect, roominess,	1
	2. Definition of grouping, circulation privacy, acclusion.	1
2	**Regulation and Bye laws:**	**4L**
	1. Bye Laws in respect of side space, Back and front space, Covered areas, height of building etc., Lavatory blocks, ventilation.	2
	2. Requirements for stairs, lifts in public assembly building, offices.	2
3	**Fire Protection:**	**2L**
	1. Fire fighting arrangements in public assembly buildings, planning, offices, and auditorium.	2
4	**Construction plants & Equipment:**	**8L**
	1. Plants & equipment for earth moving, road constructions, excavators, dozers, scrapers, spreaders, rollers, their uses.	4
	2. Plants & Equipment for concrete construction: Batching plants, Ready Mix Concrete, concrete mixers, Vibrators etc. quality control.	4
5	**Planning & Scheduling of constructions Projects:**	**8L**
	1. Definition of CPM & PERT, Planning by CPM & PERT, Preparation of network,	2
	2. Determination of slacks or floats. Critical activities .Critical path, project duration.	2
	3. Expected mean time, probability of completion of project,	2
	4. Estimation of critical path, problems.	2
6	**Management:**	**4L**
	1. Professional practice, Definition, Rights and responsibilities of owner, engineer.	2
	2. Contractors, types of contract.	2
7	**Departmental Procedures:**	**8L**
	1. Administration, Technical and financial sanction, operation of PWD,	2
	2. Tenders and its notification,	2
	3. EMD and SD, Acceptance of tenders,	2
	4. Arbitration.	2
Total Number Of Hours = 36		

Faculty In-Charge HOD, CE Dept.

Assignments:

Unit 1:

1. Define aspect, Prospect, Roominess.
2. Define grouping, circulation privacy, acclusion.

Unit 2:

1. What do you understand by Covered area of a building? How does FAR control the built-up area and height of a building?
2. What are the requirement of toilet and living room of a residential building? What is FAR? What are the provisions of the building law of FAR? A land having an area of 6 kathas is located beside a road of 2.4m wide. What is the maximum covered area available for building?
3. Define
   a) Carpet area
   b) Floor area ratio
   c) Means of access
   d) Ground coverage.

Unit 3:

1. What are the provisions for the fire safety for a residential building as per municipal law?
2. What are the provisions for the fire safety for a residential building as per National Building Code
3. Classify buildings based on fire-protection.
4. Describe dry riser and wet riser
5. Explain emergency lighting and escape lighting.

Unit 4:

1. Describe the equipment generally used in bituminous pavement construction.
2. Calculate the ideal output of a shovel with 1.5 m bucket capacity having a cycle time of 30 seconds. The soil has a swell factor of 20%. If the shovel is filling a dumper of 12 capacity and 2 minutes are lost for positioning of the dumper after each loaded dumper moves, what will be the effect on the output?
3. Define Resources in Construction industry.
4. Explain in details the importance of concrete mixtures in the construction work, mentioning the points which are to be carefully paid attention to when concrete mixtures are used.
5. Name the different types of excavators and describe briefly about each.
6. Short Notes on:
   a. Grader
   b. Conveyor
   c. Scrapper
   d. Co-efficient of traction.
   e. Dumper.
   f. Power Sholves
   g. Conveyors
   h. Backhoe.
   i. Sheep foot roller
   j. Batching Plant

Unit 5:

1. State Fulkerson's rule of numbering a network.
2. State three differences between PERT and CPM networks.
3. What do you understand by a project ? What is the objective of project management?
1. Define Earliest event time and latest event time, Time estimates for PERT activities, Total float and free float, Dummy activity, A-O-A and A-O-N Networks.
4. Define network. What are the advantages of network techniques? What are the components of network ? Explain the rules of network construction.
5. What are the different types of floats involved in CPM? Define looping and dummy activity with an example.
6. Draw a bar chart time (weeks) vs Activity break down as follows :
   Site selection and survey 0 - 4 weeks
   Design 0 - 5 weeks
   Drawing 4 - 7 weeks
   Specifications and tender document 6 - 8 weeks
   N.I.T. 8 - 12 weeks
   Selection of contractor 12 - 13 weeks
   Award of work order 13 - 14 weeks.

Unit 6:

2. What are the responsibilities of a Chief Engineer?

3. What is contract? What are the essentials of a contract?
4. Briefly describe about Lump Sum Contract and cost plus bid fee contract.
5. What are the duties and liabilities of the Engineer appointed by the Employer?
6. What are the advantages and disadvantages of percentage rate contract?
7. Distinguish between item rate contract and percentage rate contract.
8. What are the differences between Tern key contract and Item rate contract? What are the special features of cost-plus contract? What are the disadvantages of cost plus contract?
9. Define Continuing and Running Contracts
10. Explain the responsibilities of the following in a project :
    b) Contractor
    c) Architect
    d) Owner
11. Short Notes on:
    a. Rights and responsibilities of owner, contractor and engineer
    b. EMD and SD.

Unit 7:

1. What should a tender document include?
2. Draw the organization chart for PWD.
3. Describe about security deposit and retention money.
4. Write short notes on Earnest money and Security deposit. What is L.D.?
5. What is tender?
6. What is N.I.T ?
7. What do you mean by arbitration? What are the essential qualifications of a arbitrator ? What are the grounds to challenge arbitrator?
8. Write down the organizational set up in the PWD of any state Govt.
9. Explain
    a) Unbalanced tender
    b) Secured advance
    c) Liquidated damages.

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Bridge Engineering** Subject Code: **CE-604 A**

Year: **3rdYear** Semester: **6th**

Module No.	Topics	Planned Lectures(H)
1.	**Introduction :**	**4H**
	Definition & Basic forms, Component of bridge, Classification of bridge, short history of bridge	1 H
	I.R.C Loads . Analysis of IRC loads, Analysis of IRC loads, impact factors, and other loads	2H
	Importance of hydraulic factors of bridge design	1 H
2.	**Reinforced concrete solid slab bridge :**	**8H**
	1. Introduction , General design features, effective width method	3H
	2. Simply supported & Cantilever slab bridge, Analysis & Design	5H
3.	**Box Culvert :**	**2H**
	Introduction , Design method & Design Example	2H
4.	**Beam & Slab Bridges :**	**6H**
	1. Introduction, Design of interior panel of slab. Pigeauds method	2H
	2. Design of longitudinal girder	2H
	3. Calculation of longitudinal moment, Design examples	2H
5.	**Balanced Cantilever Bridge**	**5 H**
	1. General features , arrangement of supports Design features	2 H
	2. Articulation , Design examples	3H
6.	**Steel Bridges :**	**3H**
	1. General features, types of stress.	1H
	2. Design Examples	2H
7.	**Dimensional Analysis and Model studies:**	**4H**
	1. Dimensions and dimensional homogeneity, Importance and use of dimensional analysis.	1H
	2. Buckingham's Pi theorem with applications. Geometric, Kinematic and Dynamic similarity	2H
	3. Non Dimensional Numbers.	1H
8.	**Plate & Girder Bridge :**	**3 H**
	1. Elements ,design, Lateral bracing, Box-girder Bridges	3H
9	**Composite Bridges :**	**3H**
	1. General aspect, Method of construction, Analysis of composite section.	1H

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Bridge Engineering** Subject Code: **CE-604 A**

Year: **3rdYear** Semester: **6th**

	2. Shear connectors, Design of composite beam.	2H
	Cable stayed bridge :	**2H**
	1. General features , Philosophy of design	2H
TOTAL LECTURE IN HOURS		**40 H**

Faculty In-Charge HOD, CE

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Bridge Engineering** Subject Code: **CE604A**
Year: **3rd Year** Semester: **6th**

Assignment :

1. A reinforced concrete simply supported slab is required for the deck of a road bridge having the following data:- (i) clear span = 5.5 m. (ii) width of carriage way = 7.5 m. (iii) foot path on either side = 1m. wide. (iv) Materials = M20 grade concrete and Fe 415 steel. (v) Type of loading IRC class AA. Design the deck slab. Show the reinforcement details.
2. Briefly discuss the economic span for bridges.
3. Explain the various components of a bridge.
4. Calculate the distribution coefficients of the above bridge using Henry – Jaegar method.
5. Design the longitudinal girder of a T-beam and slab bridge for the following data. Effective span 18m, Carriage way width 7.5m, Kerb 600 mm on either side. Provide three longitudinal beams and five cross beams. Loading IRC class AA tracked vehicle. Adopt M25 Fe415 bars. Also provide the reinforcement details. Use Courbon's method for the calculation of reaction coefficients.
6. Design the intermediate beam of a pressurised concrete bridge of clear span 25m. Assume the roadway width as 7.5 m., loading IRC class 70R tracked vehicle.
7. What is the function of bearings in bridges?
8. Design an elastomeric bearing at the sliding end of a bridge for the following data. Maximum Normal load 1000 kN, Minimum-normal load 200 kN, Transverse lateral load 40 kN, Longitudinal load 60 kN, Total longitudinal translation 15 mm, Rotation at support 0.0025 radians. Shear modulus of elastomeric bearing = 1.2 N/mm2 . Allowable compressive stress for concrete = 7 N/mm2 . Allowable compressive stress for elastomeric = 10 N/mm2 .
9. Explain the functions of expansion joints and contraction joints.
10. Why is bridge inspection important?
11. Discuss in detail the inspection and maintenance of bridges.

12. Discuss in detail the major cause of bridge failures. Indicate how these failures could be avoided.
13. what kind of materials are used to prepare the pillars carring the main bridge
14. why in the bridge pier design is circular.
15. Describe the precautions which are considered during conducting the test of a bridge.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Prestressed Concrete** Subject Code: **CE-604B**
Year: **3rdYear** Semester: **6th**

Module No.	Topics	Planned Lectures(H)
1.	**Introduction of prestressed concrete:**	**7H**
	1. Materials, prestressing system, analysis of prestress and bending stress, resistance:	2 H
	2. losses Shear and torsional	1H
	3. design of shear reinforcement, design of reinforcement	2 H
	4. Deflections of prestressed concrete members:	2 H
2.	**Limit state design criteria:**	**7H**
	1. Inadequacy of elastic and ultimate load method,	3H
	2. criteria for limit states, strength and serviceability.	2H
	3. Design of sections for flexure: methods by Lin and Magnel	2H
3.	**Anchorage Zone stresses in post tensioned members:**	**5 H**
	1. stress distribution in end block.	2 H
	2. anchorage zone reinforcement	3 H
4.	**Composite construction of prestressed and in-situ concrete:**	**2H**
	1. types, analysis of stresses	2H
	Statically Indeterminate structures:	**7H**
	1. advantages of continuous member, effect of prestressing,	3 H
	2. methods of achieving continuity and method of analysis of secondary moments	4 H
5.	**Prestressed concrete poles and sleepers:**	**6 H**
	1. Design of sections for compression and bending	6H
6.	**Partial prestressing and non prestressed reinforcement:**	**6H**
	TOTAL LECTURE	**40 H**

Faculty In-Charge HOD, CE

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Prestressed Concrete** Subject Code: **CE-604 B**
Year: **3rd Year** Semester: **6th**

Assignment :

PRACTICE ALL THE TYPES OF PROBLEM FROM N. KRISHNA RAJU AND S. RAMAMURTHAN.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: Structural Dynamics & Earthquake Engineering **Subject Code-CE604C**
Year: 3rd Year **Semester: Sixth**

Module Number	Topics	Number of Lectures
1	**Theory of vibrations:**	**7L**
	1. Degrees of freedom, Undamped single degree freedom system	2
	2. Damped single degree freedom system, Natural frequency	2
	3. Modes of vibration, Introduction to multiple degree freedom system	3
2	**Response of single degree freedom system due to harmonic loading:**	**5L**
	1. Undamped harmonic excitation,	1
	2. Damped Harmonic excitation	4
3	**Response due to Transient loading:**	**6L**
	1. Duhamel's Integral, Response due to constant force, Rectangular load	3
	2. Introduction to numerical evaluation of Duhamel's integral of undamped system.	3
4	**Elements of seismology:**	**6L**
	1. Fundamentals: Elastic rebound theory, Plate tectonics, Definitions of magnitude, Intensity, Epicenter etc.,	3
	2. Seismographs, Seismic zoning, Response of Simple Structural Systems	3
5	**Principles of earthquake resistant design:**	**10L**
	1. Terminology, General principles and Design criteria, Methods of Analysis	2
	2. Equivalent lateral force method of Analysis for multistoried building as per Indian Standard Code of Practice	3
	3. Introduction to Response Spectrum Method,	2
	4. Fundamental concepts of Ductile detailing	3
Total Number Of Hours = 34		

Faculty In-Charge HOD, CE Dept.

Assignment:

Module-1 (Theory of vibrations):

1. A two-storey building has the following details : 15
Lumped mass of roof = 100000 kg
Lumped mass of first floor = 150000 kg
Storey stiffness of all stories is 2·25 ∞ 10 8 N/m.
Draw the free body diagram of the floor masses and write the equations of motion for vibration of the masses in the direction normal to the columns. Evaluate the natural frequencies and mode shapes

2. Derive the equation of motion for under-damped free vibration system?
3. Derive the equation of motion for undamped free vibration system?
4. A platform of weight 18 KN is being supported by four equal columns which are clamped to the foundation. Experimentally, it has been computed that a static force 5KN applied horizontally, to the platform produces a displacement of 2.5 mm. It is estimated that the damping in the structure is of the order of 5% of critical damping. Compute the following:
5. Explain the term 'Damping'. What are the different forms of damping agents ? Also,present the mathematical formulations of different types of damping.

Module-2 (Response of single degree freedom system due to harmonic loading:):

1. What do you understand by forced vibration? Derive the expression for steady state condition of SDOF system of mass m, stiffness k and damper c having a Fcoswt.
2. What is resonance? What is meant by dynamic amplification factor.

Module-3 (Response due to Transient loading):

1. Derive the response of pulse loading and step loading.
2. What is Duhamel's Integral?
3. Determine the response at time $t > \tau$ of a single degree spring (k), mass (m) system due to the forcing function characterised as impulse load of magnitude F having duration $d\tau$ at time $t = \tau$.

Module-4 (Elements of seismology:):

1. Write a short note on the following:
   i) Elastic Rebound theory
   ii) Intensity
   iii) Magnitude
   iv) Epicentre
   v) Focus
   vi) Plate tectonics
   vii) Seismic zoning
   viii) Seismograph

Module-5 (Principles of earthquake resistant design:):

1. Discuss the fundamental concept of ductile detailing. What are the provisions for ductile detailing as per IS 13920.
2. Discuss equivalent lateral load design method and response spectrum method as per IS 1893.

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Lecture-wise Plan

Subject Name: Solid Waste Management **Subject Code-CE605D**
Year: 3rd Year **Semester: Sixth**

Module Number	Topics	Number of Lectures
1	**Generation of Solid Waste:**	**13L**
	1. Goals and objectives of solid waste management	1
	2. Classification of solid waste	1
	3. Municipal solid waste	1
	4. Municipal solid waste handling rules, 2000	2
	5. Industrial solid waste	1
	6. Commercial solid waste	1
	7. Agricultural solid waste	1
	8. Hazardous solid waste	1
	9. Pathological waste	1
	10. Solid waste generation	1
	11. Characteristics of solid waste	1
	12. Analysis of solid waste	1
2	**Handling, Storage and Processing:**	**10L**
	1. Public health and aesthetics	1
	2. Onsite handling	1
	3. Community containers	1
	4. Container Locations	1
	5. Numericals on container locations	2
	6. On-site processing	4
3	**Recovery and disposal method:**	**8L**
	1. Collection systems	1
	2. Equipment and labour requirement	2
	3. Collection routes	1
	4. Land filling	1
	5. Incineration	1
	6. Composting	1
	7. Recycling	1
4	**Solid waste management and control:**	**6L**
	1. Biomedical waste	1
	2. Biomedical waste handling rules, 1998	2
	3. Hazardous waste	1
	4. Radioactive waste	1
	5. Disposal of radioactive waste	1
Total Number Of Hours = 36		

Faculty In-Charge HOD, CE Dept.

Assignments:

Unit 1:

1. What do you mean by Solid waste? Classify different types of solid waste and elaborate them.
2. Write the characteristics of Solid Waste?
3. Write the Objectives and Goals of Solid Waste Management.
4. Draw the flowchart of Solid Waste Generation.
5. Define Fusing Point of Ash.
6. Explain proximate analysis.
7. A residential area consisting of 1500 houses has an average four residents per house. For estimating the quantity of solid waste generated, the following observations are made at disposal site for a period of one week.

Type of Vehicle	No. of Trips	Volume(m^3)	Specific Weight(Kg/m^3)
I	10	15	300
II	8	2	150
III	25	0.50	100

Determine the unit rate of Solid Waste generation.

Unit 2:

1. Write a short note on Lawn Mulching
2. What are the objective and benefits of composting?
3. Write a short note on waste handling and separation at commercial and industrial facilities.
4. For separation and collection of items, three recycling containers have been provided to each resident of a community. Residents separate NEWSPAPER & CARDBOARD, PLASTICS & GLASS, and ALUMINIUM & TIN CANS, and place these segregated materials in separated materials in separate containers. The containers are emptied once per week for collection. The municipal Solid Waste has following composition:

TABLE

COMPONENT	% BY WEIGHT	SPECIFIC WEIGHT(Kg/m^3)
Food Wastes	8.0	288.34
Paper	35.8	89.7
Card board	6.4	49.66
Plastics	6.9	65.68
Textiles	1.8	65.68
Rubber	0.4	129.75
Leather	0.4	160.20
Yard Waste	17.3	100.92
Wood	1.8	237.10
Glass	9.1	195.43
Tin cans	5.8	89.70
Aluminum	0.6	160.20
Other metals	3.0	320.38
Slit and Ash	2.7	480.60

Note: Newspaper constitutes 20% of all paper by weight.
The MSW generation rate is 1.732 kg/capita/day. The total number of houses in the community is 1200 @ 3.5 residents per house. 60% of houses are expected to participate in this program. Assuming 80% material separation rate, determine

i) the proportion of the space required for each group of materials in the collection

vehicle,
the number of trips per week required if the size of the collection vehicle is $11.5m^3$.

5. Define Kick's Law.
6. A MSW having particles of average size 300mm, is to be reduced to a final size of 50mm in a plant having capacity of 80ton/hr. Determine the energy required by the plant if a specific energy of 20hp-hr/ton is required to reduce MSW of size 150mm to 50mm.
7. Define Waste containers. Briefly describe each type of containers.
8. Solid waste is collected from a locality using container collection system. The data pertaining to the collection are as follows:
   Time taken by the vehicle to reach the first container location from garage = 15mins
   Time taken by the vehicle to reach to garage from last container location = 20minns
   Average time required to drive the vehicle between consecutive containers = 6mins
   Round trip distance = 50km
   Time required to pick up loaded container and to unload empty container = 24mins
   At site time = 8min/trip
   Container co efficient, a= 0.016hr/trip,
   b= 0.011hr/km.
   Determine the number of trips of the collection vehicle per day; assuming 8hrs workday and off- route factor is equal to 0.15.
9. Write a short note on waste handling and separation of residential buildings.
10. Describe various on-site processing methods.
11. Write a short note on waste prohibited from processing.

Unit 3:

1. State the factors considered to determine the capacity of a transfer station.
2. Define Districting.
3. State the different layers of sanitary landfill.
4. Describe the elements considered in constructing engineered landfill.
5. What is routing? Discuss the different types of routing.
6. Discuss the factors considered in selecting solid waste collection equipment.

Unit 4:

1. Mention the responsibilities of Central Pollution Board and State Board to minimize Solid Waste Generation.
2. Define biomedical waste.
3. Define Hazardous waste
4. Define Radioactive waste
5. Mention the ways of disposal of radioactive waste

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Lecture-wise Plan

Subject Name: Operations Research **Subject Code-CS605A**
Year: 3rd Year **Semester: Sixth**

MODULE NO.	TOPICS	NUMBER OF LECTURES (35)
	Introduction	**1L**
1	**Linear Programming (LP):**	**7L**
	1. Formulation of LP Problems,Graphical solutions of two decision variable problems	2
	2. General form of LP model, Simplex method	3
	3. Big-M Method	2
	Transportation & Assignment Problems:	**6L**
	1. Nature of a transportation or distribution problem, North-West Corner initial solution	2
	2. Concept of dummy source or destination, Vogel's approximation method	2
	3. Nature of an Assignment problem:-Tabular representation Hungarian method	2
2	**Network Analysis:**	**6L**
	1. Shortest Path; Floyd Algorithm, Maximal Flow Problem (Ford-Fulkerson)	4
	2. PERT-CPM (Cost Analysis, Crashing, Resource Allocation excluded)	2
3	**Inventory Control**	**3L**
	Introduction to EOQ Models of Deterministic and Probabilistic, Safety Stock; Buffer Stock.	3
4	**Waiting line problems:**	**7L**
	1. Structure of a waiting line System distribution service times	1
	2. Queuediscipline,steadystageoperation;SinglechannelmodelwithPoissonarrivalsandexponentialservicetime	2
	3. MultiplechannelmodelwithPoissonarrivalandexponentialservicetimes;	2

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	4. SinglechannelmodelwithPoissonarrivalsandarbitraryservicetime(M/G/1); Economic analysis of waiting line	2
5	**Game Theory**	**5L**
	1. Introduction;2-PersonZero-sumGame;SaddlePoint;Mini-MaxandMaxi – Min Theorems (statementonly) and	3
	problems; Games without Saddle Point; Graphical Method; Principle of Dominance	2

Faculty In-Charge HOD, Maths Dept.

Assignments:

Unit-1(Linear Programming Problem):

1. The manager of the milk dairy decides that each cow should get at least 15 units, 20 units and 24 units of nutrients A, B and C daily respectively. Two varieties of feed are available. In feed of variety 1 and variant 2 the contents of nutrient A, B and C are respectively 1 and 3; 2 and 2; 3 and 2 units per kg. The costs of verities 1 and 2 are respectively Rs. 2 and Rs. 3 per kg. How much of feed of each variety should be purchased to feed a cow daily so that the expenditure is minimized. Formulate as an LPP.
2. Solve the LPP using graphical method

$$\text{Max } 2x_1 - 4x_2$$
$$\text{Subject to } \begin{aligned} 3x_1 + 5x_2 &\geq 15, \\ 4x_1 + 9x_2 &\leq 36, \\ x_1, x_2 &\geq 0 \end{aligned}$$

3. Solve the LPP using graphical method

$$\text{Min } 4x_1 + 6x_2$$
$$\text{Subject to } \begin{aligned} 6x_1 + 5x_2 &\geq 20, \\ 5x_1 + x_2 &\geq 10, \\ x_1 + 4x_2 &\geq 8, \\ x_1, x_2 &\geq 0 \end{aligned}$$

4. Solve the LPP using simplex method

$$\text{Min } -12x_1 - 15x_2$$
$$\text{Subject to } \begin{aligned} 4x_1 + 3x_2 &\leq 12, \\ 2x_1 + 5x_2 &\leq 10, \\ x_1, x_2 &\geq 0 \end{aligned}$$

5. Solve the LPP using Artificial variables technique

$$\text{Min } 3x_1 + 2x_2$$

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$$\text{Subject to} \quad \begin{aligned} & x_1 + x_2 \geq 2, \\ & x_1 + 3x_2 \leq 3, \\ & x_1 - x_2 = 1, \\ & x_1, x_2 \geq 0 \end{aligned}$$

Transportation Problems:-

1. Find the starting solution in the following transportation problems by
   (i) North-West Corner Method (ii) Least-Cost Method
   (i) Vogel's Approximation Method.

(A)

	D_1	D_2	D_3	D_4	Supply
S_1	19	30	50	10	7
S_2	70	30	40	60	9
S_3	40	8	70	20	18
Demand	5	8	7	14	

	D_1	D_2	D_3	D_4	Supply
S_1	3	7	6	4	5
S_2	2	4	3	2	2
S_3	4	3	8	5	3
Demand	3	3	2	2	

(B)

	D	E	F	G	Available
A	11	13	17	14	250
B	16	18	14	10	300
C	21	24	13	10	400
Demand	200	225	275	250	

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source		Destination				
		D_1	D_2	D_3	D_4	Supply
	S_1	20	25	28	31	200
	S_2	32	28	32	41	180
	S_3	18	35	24	32	110
	Demand	150	40	180	170	

Assignment Problems

1. A departmental head has four subordinates, and four tasks to be performed. The subordinates differ in efficiency, and the tasks differ in their intrinsic difficulty. His estimate, of the time each man would take to perform each task, is given in the table below:

Tasks	Men			
	E	F	G	H
A	18	26	17	11
B	13	28	14	26
C	38	19	18	15
D	19	26	24	10

How should the tasks be allocated, one to a man, so as to minimize the total man-hours by using Hungarian assignment method?

2. A pharmaceutical company is producing a single product and is selling it through five agencies located in different cities. All of a sudden, there is a demand for the product in another five cities not having agency of the company. The company is faced with the problem of deciding on how to assign the existing agencies to dispatch the product to needy cities in such a way that the travelling distance is minimized. The distance between the surplus and deficit cities (in Km) is given in the following table:

	Deficit cities					
Surplus cities		**a**	**b**	**c**	**d**	**e**
	A	**85**	**75**	**65**	**125**	**75**
	B	**90**	**78**	**66**	**132**	**78**
	C	**75**	**66**	**57**	**114**	**69**
	D	**80**	**72**	**60**	**120**	**72**
	E	**76**	**64**	**56**	**112**	**68**

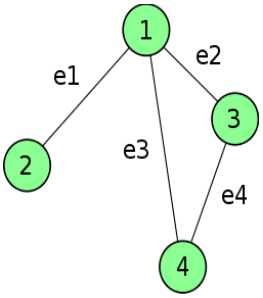
Determine the optimum assignment schedule.

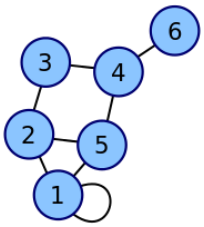
Unit 2: Network Analysis:

1. Draw a graph with 9 vertices having degree 1,5,2,7,10,8.
2. Determine the number of edges with 6 nodes, two of degree four and 4 of degree 2.
3. Find the maximum number of vertices in a connected graph having 17 edges.
4. Construct the graph corresponding to the following adjacency matrix:

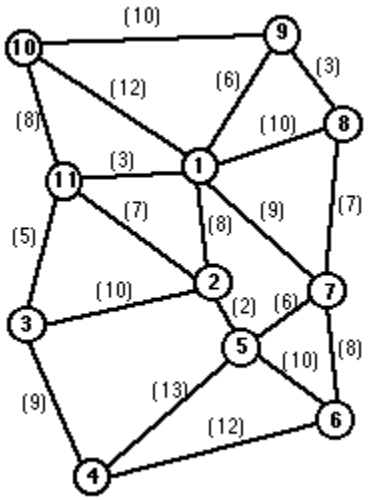
$$\begin{bmatrix} 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 \end{bmatrix}$$

5. Write down the adjacency matrix of the following graphs:





6. Find by kruskal's Algorithm and prim's algorithm a minimal spanning tree of the following graph:



7. Show that the number of vertices of a binary tree can't be even.
8. Show that every connected graph has a spanning tree.
9. Show that every edge of a connected graph is a branch of some spanning tree of G.
10. Prove that the number of cut vertices in a binary tree is always even.

11. Construct a graph having edge connectivity 4, vertex connectivity 3 and degree of each vertex $\geq$ 5.

Unit 4: Queuing theory:-

1. The arrival rate of cars at GRAND jewelers is 20 cars per hour. The service rate at jeweler shop is 8 cars per hour. The only parking area at GRAND jewelers is restricted to 6 cars only. The arrival rate and service rate follows Poisson distribution. Identify the type of queue and then determine the performance measures of this queue. Analyze the result if service rate goes to 20 cars per hour
2. A supermarket has a single cashier. During the peak hours, customers arrive at a rate of 20 customers per hour. The average number of customers that can be processed by the cashier is 24 hour. Calculate:
   (i) Probability that the cashier is idle (iii) Average number of customer in the system
   (ii) Average time a customer spends in the system (iv) Average time a customer spends in the queue
3. Patients arrive at a clinic according to Poisson distribution at the rate of 30 patients per hour. The waiting room does not accommodate more than 14 patients. Examination time per patient is exponential with mean rate 20 per hour.
   (ii) Find the effective arrival rate at the clinic.
   (iii) What is the probability that an arriving patient will not wait?
   (iv) What is the expected waiting time until a patient is discharged from the clinic?
4. In a railway marshalling yard, goods trains arrive at a rate of 30 trains per day. Assuming that the inter-arrival time follows an exponential distribution and the service time distribution is also exponential with an average of 36 minute. Calculate
   (i) Average number of customers in the system
   (ii) (ii) Probability that the queue size exceeds 10
   (iii) Average time a customer spends in the queue
5. If for a period of 2 hours in the day (8 to 10) trains arrive at the yard every 20 minutes but the service time continues to remain 36 minutes, then calculate for this period
   (i) The trains that the yard is empty
   (ii) (ii) What is the probability that an arriving patient will wait?
   (iii) The average number of trains in the system

   On the assumption that the line capacity of the yard is limited to 4 trains only.

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Lecture-wise Plan

Subject Name: Human Resource Management **Subject Code-CS605B**
Year: 3rd Year **Semester: Sixth**

Module Number	Topics	Number of Lectures
1	**Introduction :**	**3L**
	HR Role and Functions, Concept and Significance of HR, Changing role of HR managers - HR functions and Global Environment, role of a HR Manager.	3
2	**Human Resources Planning:**	**5L**
	HR Planning and Recruitment: Planning Process - planning at different levels - Job Analysis - Recruitment and selection processes - Restructuring strategies - Recruitment-Sources of Recruitment-Selection Process-Placement and Induction-Retention of Employees.	5
3	**Training and Development :**	**6L**
	need for skill upgradation - Assessment of training needs - Retraining and Redeployment methods and techniques of training employees and executives - performance appraisal systems.	6
4	**Performance Management System :**	**5L**
	Definition, Concepts and Ethics-Different methods of Performance Appraisal- Rating Errors- Competency management.	5
5	**Industrial Relations :**	**6L**
	Factors influencing industrial relations - State Interventions and Legal Framework - Role of Trade unions - Collective Bargaining - Workers' participation in management. **Case study.**	6
Total Number Of Hours = 25		

Assignment:

Module-1
1. Describe the role of HR.
Module-2
2. Write down all the restructuring strategies.
Module-3
3. What do you mean by performance appraisal system.
Module-4
4. Discuss competency management.
Module-5
5. Write down the factors influencing industrial management.

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Lecture-wise Plan

Subject Name: Materials Handling **Subject Code-CE605C**
Year: 3rd Year **Semester: Sixth**

Module Number	Topics	Number of Lectures
1.	**Introduction:** Definition, importance and scope of materials handling (MH); classification ofmaterials; codification of bulk materials ; utility of following principles of MH – (i) materials flow, (ii) simplification, (iii) gravity, (iv) space utilization, (v) unit size, (vi) safety, (vii) standardization, (viii) dead weight, (ix) idle time, (x) motion.	**8 L**
2.	**Unit load:** Definition; advantages & disadvantages of unitization; unitization by use of platform, container, rack, sheet, bag and self contained unit load; descriptive specification and use of pallets, skids, containers, boxes, crates and cartons; shrink and stretch wrapping. **Classification of MH Equipment :** Types of equipment –(i) industrial trucks & vehicles, (ii) conveyors, (iii) hoisting equipment, (iv) robotic handling system and(v) auxiliary equipment; Independent equipment wise sub classification of each of above type of equipment.	**8 L**
3.	**Industrial trucks & vehicles :** Constructional features and use of the following equipment – (i) wheeled hand truck, (ii) hand pallet truck, (iii) fork lift truck; Major specifications, capacity rating and attachments of fork lift truck.	**9L**
4.	**Conveyors:** Use and characteristics of belt conveyor, constructional features of flat and troughedbelt conveyor; Use and constructional features of Flg. types of chain conveyors – (i) apron, car and trolley type; Construction of link-plate chains; Dynamic phenomena in chain drive; Use and constructional features of roller conveyors; Gravity and powered roller conveyor; Pneumatic conveyor-use and advantages; Positive, negative and combination system of pneumatic conveyors; constructional feature, application and conveying capacity of screw conveyor.	**9L**
5.	**Hoisting Equipment :** Advantage of using steel wire rope over chain; constructional features ofwire ropes; Rope drum design; Pulley system-simple vs. multiple pulley; Load handling attachments : hooks, grabs, tongs, grab bucket; Arrangement of hook suspension with cross piece and pulleys (sheaves); Use and constructional features of (i) hand operated trolley hoist , (ii) winch; (iii) bucket elevator, (iv) Jib crane, (v) overhead traveling crane and (vi) wharf crane; Level luffing system of a wharf crane; Utility of truck mounted and crawler crane.	**10L**
Total Number Of Hours = 44		

Faculty In-Charge HOD, CE Dept.

Assignment:

Module 1:

1. Discuss on substitutional solid solution of isomorphous alloy system.

2. Brief on maximum percentage of carbon in ferrite and austenite based on the interstitial states.

3. Brief on Hardening and Tempering of Steel with respect to rate of cooling and tempering temperature respectively.

4. Compare Austempering and Martempering.

Module 2 & 3:

1.Brief on Jominy end quench test and interpretation of results.

2. Brief on the types of Carburizing and need for post carburizing heat treatments.

3. Compare Charpy and Izod Impact test. List the Applications of Impact Test.

4. Discuss the role of Slip and Twinning in plastic deformation of materials.

Module 4:

1. State the difference between properties like hardness, yield strength, ultimate tensile strength, fracture strength, creep strength, fatigue strength and impact toughness.

2. a.) Brief on the influence of Alloying elements in steel under classification of ferrite and austenite stabilizer.

b.) List the types and their typical applications of tool steel.

3. a.) What are the types of cast iron or copper alloy, their composition, properties and applications?

b.) Brief on the precipitation, hardening and ageing treatment of Al-Cu alloy.

Module 5:

1. a.) Differentiate between thermoplastic and thermosetting polymers.

b.) What are fibre reinforced plastics and state its applications ?

2. a.) Classify Engineering Ceramics and list properties and applications of any two of them.

b.) State the properties and applications of Polyurethane or Phenol Formaldehyde.

3. a.) Draw a typical S-N Curve and brief on the influence of any two design parameters and metallurgical properties.

b.) Brief on properties and applications of any two polymers from the list:
PMMA, PEEK, PPO, ABS and PS.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR
Lab Manual

Title of Course: Highway & Transportation Engineering Lab
Course Code: CE 691
L-T-P scheme: 0-0-3 **Course Credit: 2**

Objectives:
1. The students will be able to perform different tests on highway materials and develop a clear understanding of Impact Value, Los Angeles Abrasion Test, Elongation And Flakiness Index.
2. The students will be able to conduct basic tests to determine the properties of bitumen and bituminous materials like specific gravity, penetration value and softening point.
3. The students will be able to develop the concept of California Bearing Ratio test.

Learning Outcomes: The students will be able to understand the basic tests conducted on highway materials like Impact Value, Los Angeles Test, Abrasion Value, Water Absorption. The students will also develop an understanding of Elongation Index And Flakiness Index. They will also develop a clear understanding of Bitumen and Bituminous materials and the various tests conducted on them like penetration value, softening point and Flash And Fire Point Test. The students will also develop a clear understanding of California Bearing Ratio test.

Course Contents:
Practicals that must be done in this course are listed below:

1. Tests on highway materials – Aggregates- Impact value, Los-Angeles Abrasion value water absorption, Elongation & Flakiness Index.
2. Bitumen & bituminous materials: Specific gravity, penetration value, softening point, loss on heating. 3. Flash & Fire point test.
4. Stripping value test.
5. Design of B.C. & S.D.B.C. Mix
6. CBR Test.
7. Marshal Stability Test
8. Benkelman beam Test.

Text Book:
1. BIS codes on Aggregates & Bituminous materials.
2. Highway material testing(Laboratory Manual)by S.K. Khanna and CE.G. Justo.
3. Relevant IS & I.R.C. codes.

1. AGGREGATE CRUSHING VALUE TEST

AIM: To determine mechanical properties of road stone required are:
1. Satisfactory resistance to crushing under the roller during construction and
2. Adequate resistance to surface abrasion under traffic.

THEORY :.
The crushing strength of road aggregates is an essential requirement in India as they need to resist surface stress under rigid tire rims of heavily loaded animal drawn vehicles which is in considerable amounts.
Crushing strength of road stones may be determined either on aggregate or on cylindrical specimens cut of rocks. The two tests are quite different in not only the approach but also in the expression of the results.
Aggregates used in road construction, should be strong enough to resist crushing under traffic wheel loads. If the aggregates are weak, the stability of the pavement structures is likely to be adversely affected. The strength of coarse aggregates is assessed by aggregate crushing test.

The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load. To achieve a high quality of pavement, aggregate possessing low aggregate crushing value should be preferred.

DESCRIPTION OF THE APPARATUS:

The apparatus for the standard aggregate crushing test (figure 1) consists of the following:

1. Steel cylinder with open end internal diameter 25.2cm, square base plate plunger having a piston of diameter 15cm, with a hole provided across the stem of the plunger so that a rod could be inserted for lifting or placing the plunger in the cylinder.
2. Cylindrical measure having internal diameter of 11.5cm and a height 18cm.
3. Steel temping rod with one rounded end, having a diameter of 1.6cm and length 45 to 60cm.
4. Balance of capacity 3kg with accuracy up to 1kg.
5. Compression of testing machine capable of applying load of 40 tones, at a uniform rate of loading of 4 tones per minute.

PROCEDURE:

The aggregates passing through 12.5mm sieve and retained on 10mm IS sieve is selected for standard test. The aggregates should be in surface dry condition before testing. The aggregate may be dried by heating at a temperature of 1000C to 1100C for a period of 4 hours and is tested after being cooled to room temperature.

The cylindrical measure is filled by the test sample of aggregate in three layers of approximately equal depth, each layer being tamped 25 times by the rounded end of the tamping rod. After the third layer is tamped, the aggregates at the top of the cylindrical measure are leveled off by using the tamping rod as a straight edge. About 6.5kg of aggregate is required for preparing two tests samples. The test samples thus taken are then weighed. The same weight of the sample is taken in the repeat test.

The cylinder of the test apparatus is placed in position on the base plate; one third of the sample is placed in the cylinder and tamped 25 times by the tamping rod. Similarly, the other two parts of the test specimen are added, each layer being subjected to 25 tampings. The total depth of the material in the cylinder after tamping shall however 10cm. The surface of the aggregates is leveled and the plunger inserted so that it rests on this surface in level position. The cylinder with the test sample and plunger in position is placed on compression testing machine. Load is then applied through the plunger at a uniform rate of 4 tones per minute until the total load is 40 tones, and the load is released. Aggregates including the crushed portion are removed from the cylinder and sieved on a 2.36mm IS sieve. The material which passes this sieve is collected.

The above crushing test is repeated on second sample of the same weight in accordance with above test procedure. Thus two tests are made for the same specimen for taking an average value.

APPLICATIONS OF AGGREGATE CRUSHING TEST:

The aggregate crushing value is an indirect measure of crushing strength of the aggregates. Low aggregate crushing value indicates strong aggregates, as the crushed fraction is low. Thus the test cans be used to assess the suitability of aggregates with reference to the crushing strength for various types of pavement components. The aggregates used for the surface course of pavements should be strong enough to withstand the high stresses due to wheel loads, including the steel tires of loaded bullock-carts.

However as the stresses at the base and sub-base courses are low aggregates with lesser crushing strength may be used at the lower layers of the pavement. Indian Roads Congress and IS) have specified that the aggregate crushing value of the coarse aggregates used for cement concrete pavement at surface should not exceed 30 percent. For aggregates used for concrete other than for wearing surfaces, the aggregate crushing value shall not exceed 45 percent, according to the ISS. However aggregate crushing values have not been specified by the IRC for coarse aggregates to be used in bituminous pavement construction methods.

2. AGGREGATE IMPACT TEST

AIM:
To determine aggregate impact value of given aggregate.

THEORY:
Toughness is the property of a material to resist impact. Due to traffic loads, the road stones are subjected to the pounding action or impact and there is possibility of stones breaking into smaller pieces. The road stones should therefore be tough enough to resist fracture under impact. A test designed to evaluate the toughness of stones i.e., the resistance of the stones to fracture under repeated impacts may be called an impact test for road stones impact test may either be carried out on cylindrical stone specimens as in Page Impact test or on stone aggregates as in aggregate impact test. The Page Impact test is not carried out now-a-days and has also been omitted from the revised British Standards for testing mineral aggregates. The aggregate impact test has been standardized by the British standards institution and the Indian Standards Institution.

The aggregate impact value indicates a relative measure of the resistance of an aggregate to a sudden shock or an impact, which in some aggregates differs from its resistance to a slow compressive load. The method of test covers the procedure for determining the aggregate impact value of coarse aggregates.

APPARATUS:
The apparatus consists of an impact testing machine, a cylindrical measure, tamping rod, IS sieves, balance and oven.
(a) Impact testing machine: The machine consists of a metal base with a plane lower surface supported well on a firm floor, without rocking. A detachable cylindrical steel cup of internal diameter 10cm and depth of 5cm is rigidly fastened centrally to the base plate. A metal hammer of weight between 13.5 and 14.0kg having the lower end cylindrical in shape, 10cm in diameter and 5 cm long, with 2 mm chamber at the lower edge is capable of sliding freely between vertical guide and fall concentric over the cup. There is an arrangement for raising the hammer and allowing it to fall freely between vertical guides froma height of 38 cm on the test sample in the cup, the height of fall being adjustable up to 0.5cm. A key is provided for supporting the hammer while fastening or removing the cup.

(b) Measure: A cylindrical metal measure having internal diameter 7.5 cm and depth 5cm for measuring at one end.

(c) Tamping rod: A straight metal tamping rod of circular cross section, 1cm in diameter and 23cm long, rounded at one end.

(d) Sieve: IS sieve of sizes 12.5mm,10 mm and 2.36 mm for sieving the aggregates.

(e) Balance: A balance of capacity not less than 500 g to weigh accurate up to 0.1 gm.

(f) Oven: A thermostatically controlled drying oven capable of maintaining constant temperature between 100°C and 110°C.

PROCEDURE:
The test sample consists of aggregates passing 12.5mm sieve and retained on 10 mm sieve and dried in an oven for four hours at a temperature 100°C to ll0oC and cooled. Test aggregates are filled up to about one-third full in the cylindrical measure and tamped 25 times. The surplus aggregates are struck off using the tamping rod as straight edge. The net weight of the aggregates in the measure is determined to the nearest gram and this weight of the aggregates is used for carrying out duplicate test on the same material.

The impact machine is placed with its bottom plate fiat on the floor so that the hammer guide columns are vertical. The cup is fixed firmly in position on the base of the machine and the whole of the test sample from the cylindrical measure is transferred to the cup and compacted by tamping with 25 strokes. The hammer is raised until its lower face is 38cm above the upper surface of the aggregates in the cup, and allowed to fall freely on the aggregates.

The test sample is subjected to a total of 15 such blows, each being delivered at an interval of not less than one second. The crushed aggregate is then removed from the cup and the whole of it sieved on the 2.30 mm sieve until no further significant amount passes. The fraction passing the sieve is weighed accurate to 0.1g.

The fraction retained on the sieve is also weighed and if the total weight of the fractions passing and retained on the sieve is added it should not be less than the original weight of the specimen by more than one gram, if the total weight is less than the original by over one gram, the result should be-discarded and a fresh test made. The above test is repeated on fresh aggregate sample.

3. DEVAL ATTRITIONTEST

AIM: To determine the Deval attrition value.

APPARATUS: The apparatus as per IS: 2386 (Part IV) – 1963 consists of:

(i) Deval machine: The Deval abrasion testing machine shall consist of one or more hollow cast iron cylinders closed at one end and furnished with a tightly fitting iron cover at the other. The inside diameter of the cylinders shall be 20 cm and depth 34 cm. The cylinders shall be mounted on a shaft at an angle of 30 degrees with the axis of rotation of the shaft.

(ii) Sieve: 1.70, 4.75,10,12.5,20,25,40 mm IS Sieves.

(iii)Balance of capacity 5kg or 10kg.

(iv) Drying oven.

(v) Miscellaneous like tray.

PROCEDURE:

The test sample consists of clean aggregates dried in oven at 105° – 110°C. The sample should conform to any of the gradings shown in table.

- Select the grading to be used in the test such that it conforms to the grading to be used in construction, to the maximum extent possible.
- Place the aggregates on the cylinders and fix the cover.
- Rotate the machine at a speed of 30 – 33 revolutions per minute. The number of revolutions is 10000. The machine should be balanced and driven such that there is uniform peripheral speed.
- The machine is stopped after the desired number of revolutions and material is discharged to a tray.
- The entire stone dust is sieved on 1.70 mm IS sieve.
- The material coarser than 1.7mm size is weighed correct to one gram.

4. AGGREGATE ABRASION VALUE TEST

INTRODUCTION:
Due to the movement of traffic, the road stones used in the surfacing course are subjected to wearing action at the top. Resistance to wear or hardness is hence an essential property for road aggregates, especially when used in wearing course. Thus road stones should be hard enough to resist the abrasion due to traffic. When fast moving traffic fitted with pneumatic types move on the road, the soil particles present between the wheel and road surface causes abrasion on the road stone. Steel tires of animal drawn vehicles, which rub against the stones, can cause considerable abrasion of the stones on the road surface. Hence in order to test the suitability of road stones to resist the abrasion action due to traffic, tests are carried out in the laboratory.

Abrasion test on aggregates are generally carried out by any one of the following methods:
a) Los Angeles abrasion test
b) Deval's abrasion test
c) Dorry's abrasion test

Of these tests, the Los Angeles abrasion test is more commonly adopted as the test values of aggregates have been correlated with performance of studies. The ISI has suggested that wherever possible, Los Angeles abrasion test should be preferred.
In addition to the above abrasion tests, another test, which is carried out to test the extent to which the aggregates in the wearing surface get polished under traffic, is "Polishing stone value" test. Samples of aggregates are subjected to an accelerated polishing test in a machine and a friction test is carried out on the polished specimen. The results of this test are useful only for comparative purpose and specifications are not yet available.

Los Angeles Abrasion Test

AIM:
To determine Los Angeles abrasion value of the aggregate.

THEORY:
The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between aggregates and steel balls used as abrasive charge. The pounding action of these balls also exits while conducting the test. Some investigators believe this test

to be more dependable as rubbing and pounding action simulate the field conditions where both abrasion and impact occur. Los Angeles abrasion test has been standardized by the ASTM, AASHO and also by the ISI. Standard specification of Los Angeles abrasion values is also available for various types of pavement constructions.

APPARATUS:
The apparatus consists of Los Angeles machine and sieves.

Los Angeles machine consists of a hollow steel cylinder, closed at both ends having an inside diameter 70cm and an inside length of 50cm, mounted on stub shafts about which it rotates on a horizontal axis. An opening is provided in the cylinder for the introduction of the test sample. A removable cover of the opening is provided in such a way that when closed and fixed by bolts and nut, it is dust-tight and the interior surface is perfectly cylindrical. A removable steel shelf projecting radially 8.8 cm into the cylinder and extending to the full length of it is mounted on the interior surface of the cylinder rigidly parallel to the axis.

The shelf is fixed at a distance of 125 cm from the opening, measured along the circumference in the direction of rotation, Abrasive charge, consisting of cast iron spheres approximately 4.8 cm in diameter and 390 to 445 g in weight are used.

The weight of the sphere used as the abrasive charge and the number of spheres to be used are specified depending on the gradation of the aggregates tested. The aggregate grading have been standardized as A. B. C, D. E, F, and G for this test and the IS specifications for the grading and abrasive charge to be used are given in Table. IS sieve with l.70 mm opening is used for separating the fines after the abrasion test.

PROCEDURE:
Clean aggregates dried in an oven at 105-110°C to constant weight. Conforming to anyone of the grading A, to G, as per Table 3.l. is used for the test. The grading or gradations used in the test should be nearest to the grading to be used in the construction. Aggregates weighing 5 kg for grading A. B, C or D and 10 kg for grading E, F or G may be taken as test specimen and placed in the cylinder.

The abrasive charge is also chosen in accordance with Table 3.1 depending on the grading of the aggregate and is placed in the cylinder of the machine. The cover is then fixed dust-tight. The machine is rotated at a speed of 30 to 33 revolutions per minute. The machine is rotated for 500 revolutions for gradations A. B, C and D, for gradations E, F and G, it shall be rotated for 1,000 revolutions. The machine should be balanced and driven in such a way as to maintain uniform peripheral speed.

After the desired number of revolutions, the machine is stopped and the material is discharged from the machine taking care to take out entire stone dust. Using a sieve of size larger than 1.70 mm IS sieve, the material is first separated into two parts and the finer position is taken out and sieved further on a 1.7 mm IS sieve. The portion of material coarser than 1.7mm size is washed and dried in an oven at 105 to ll0°C to constant weight and weighed correct to one gram.

CALCULATIONS:
The difference between the original and final weights of the sample is expressed as a percentage of the original weight of the sample is reported as the percentage wear.

RESULT:
The result of the Los Angeles abrasion test is expressed as a percentage wear and the average value of two tests may be adopted as the Los Angeles abrasion value.

DISCUSSION:
It may seldom happen that the aggregates desired for a certain construction project has the same grading as anyone of the specified gradations. In all the cases, standard grading or gradations nearest to the gradation of the selected aggregates may be chosen.

Different specification limits may be required for gradations E, F and G, when compared with A, B, C and D. Further investigations are necessary before any such specifications could be made.

Los Angeles abrasion test is very commonly used to evaluate the quality of aggregates for use in pavement construction, especially to decide the hardness of stones. The allowable limits of Los Angeles abrasion values have been specified by different agencies based on extensive performance studies in the field. The ISI has also suggested that this test should be preferred wherever possible.

However, this test may be considered as one in which resistance to both abrasion and impact of aggregate may be obtained simultaneously, due to the presence of abrasive charge. Also the test condition is considered more representative of field conditions. The result obtained on stone aggregates is highly reproducible.

Applications of Los Angeles Abrasion Test:
Los Angeles Abrasion test is very widely accepted as a suitable test to assess the hardness of aggregates used in pavement construction. Many agencies have specified the desirable limits of the test, for different methods of pavement construction. The maximum allowable Los Angeles abrasion values of aggregates as specified by Indian Roads Congress for different methods of construction are given in Table.

5. SHAPE TEST

INTRODUCTION:
The particle shape of aggregate is determined by the percentage of flaky and elongated particles contained in it. In case of gravel it is determined by its angularity number. For base course and construction of bituminous and cement concrete types, the presence of flaky and elongated particles are considered undesirable as they may cause inherent weakness with possibilities of breaking down under heavy loads.

Rounded aggregates are preferred in cement concrete road construction as the workability of concrete improves. Angular shape of particles is desirable for granular base course due to increased stability derived from the better interlocking. When the shape of aggregates deviates more from the spherical shape as in the case of angular, flaky and elongated aggregates, the voids content in an aggregate of any specified size increases and hence the grain size distribution of a grade aggregate has to be suitably altered in order to obtain minimum voids in the dry mix or the highest dry density.

The angularity number denotes the void content of the same size. Thus angularity number has considerable importance in the gradation requirements of various types of mixes such as bituminous concrete and soil-aggregate mixes.

Thus evaluation of shape of the particles, particularity with reference to flakiness, elongation and angularity is necessary.

A. FLAKINESS INDEX TEST

AIM:
To determine flakiness index of a given aggregates sample.

DEFINITION:
The flakiness index of aggregate is the percentage dry weight of particles whose least dimension (thickness) is less than three-fifths (0.6) of their mean dimension. The test is not applicable to sizes smaller than 6.3 mm.

APPARATUS:
The apparatus consists of a standard thickness gauge shown in fig 5.1, IS sieves of the sizes 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10 and 6.3 mm and a balance to weight the samples.

PROCEDURE:
The sample is sieved with the sieves mentioned in the table 5.1 A minimum of 200 pieces of each fraction to be tested are taken and weighed =W1g. in order to separate flaky materials, each friction is then gauged for thickness on a thickness gauge shown in fig 5.1 or in bulk on sieves having elongated slots. The width of the slot used should be of the dimensions specified in column (3) of table 5.1 for the appropriate size of the material. The amount of flaky material passing the gauge is weighed to accuracy of at least 0.1 percent of the test sample.

B. ELONGATION INDEX

AIM: To determine elongation index of given aggregate sample.

DEFINITION: The elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four fifth (1.8 times) of their mean dimension. The elongation test is not applicable to sizes smaller than 6.3 mm.

APPARATUS: The apparatus length gauge consists of the Standard length gauge. IS sieve of size 50, 40, 25, 20, 16, 12.5, 10 and 6.3 mm .A balance to weigh the samples.

PROCEDURE: The sample is sieved through the specified set of IS sieves. A minimum of 200 pieces of each fraction is taken and weighed. In order to separate elongated material, each fraction is then gauged individually for length gauge. The gauge individually for length gauge. The gauge length used should be those specified in column 4 of the table for the appropriate material. The pieces of aggregates from each fraction tested which could not pass through the specified gauge length with its long side are elongated particles and are collected separately to find the total weight of aggregate retained by the length gauge are weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

6. SPECIFIC GRAVITY AND WATER ABSORPTION TESTS OF AGGREGATES

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Aggregates having low specific gravity are generally weaker than those with high specific gravity. This property helps in a general identification of aggregates.
Water absorption also gives an idea on the internal structure of aggregate. Aggregates having more absorption are more porous in nature and are generally considered unsuitable, unless found to be acceptable based on strength, impact and hardness tests.

AIM:
To determine the specific gravity and water absorption of the given aggregate.

Apparatus:
The apparatus required for these tests are:
1. A balance of at least 3 kg capacity, with a accuracy to 0.5 g.
2. An oven to maintain a temperature range of 100 to 1100 C.
3. A wire basket of not more than 6.3 mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance.
4. A container for filling water and suspending the wire basket in it.
5. An airtight container of capacity similar to that of basket, a shallow tray and two dry absorbent clothes.
6. Pycnometer of 100ml for aggregates finer than 6.3 mm and Specific gravity bottle

Procedure for aggregate coarser than 6.3 mm:
1. About 2 kg of aggregate sample is taken, washed to remove fines and then placed in the wire basket. The wire basket is then immersed in water, which is at a temperature of 220 C to 320 C.
2. Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per second.
3. The basket, with aggregate are kept completely immersed in water for a period of 24 ± 0.5 hour.
4. The basket and aggregate are weighed while suspended in water, which is at a temperature of 220 C to 320 C.
5. The basket and aggregates are removed from water and dried with dry absorbent cloth.
6. The empty basket is suspended back in water tank and weighed.
7. The surface dried aggregates are also weighed.
8. The aggregate is placed in a shallow tray and heated to about 110 0C in the oven for 24 hours. Later, it is cooled in an airtight container and weighed.

Procedure for specific gravity determination of aggregate finer than 6.3 mm :
1. A clean, dry pycnometer is taken and its empty weight is determined.
2. About 1000g of clean sample is taken into the pycnometer, and it is weighed.
3. Water at 27 0C is filled up in the pycnometer with aggregate sample, to just immerse sample.
4. Immediately after immersion the entrapped air is removed from the sample by shaking pycnometer, placing a finger on the hole at the top of the sealed pycnometer.
5. Now the pycnometer is completely filled up with water till the hole at the top, and after confirming that there is no more entrapped air in it, it is weighed.
6. The contents of the pycnometer are discharged, and it is cleaned.
7. Water is filled up to the top of the pycnometer, without any entrapped air. It is then weighed.

For mineral filler, specific gravity bottle is used and the material is filled upto one-third of the capacity of bottle. The rest of the process of determining specific gravity is similar to the one described for aggregate finer than 6.3 mm.

Applications:
Specific gravity of aggregates is considered as an indication of strength. Material having higher specific gravity is generally considered as having higher strength. Water absorption of aggregate is a measure of porosity. This value is considered as a measure of resistance to frost action, and as a measure of sustaining weathering action.

7. PENETRATION TEST

AIM: To determine grade of given bitumen

THEORY: The consistency of bituminous materials vary depending upon several factors such as constituents, temperatures etc. At temperature ranges between 25 and 50 degrees centigrade most of the paving bitumen grades remain in semisolid or in plastic states and their viscosity of most of the tars and cut baks are sufficiently low at this temperature range.To permit these bituminous materials to be in a liquid state, enabling some of the grades are mixed with aggregates even without heating.

Determination of absolute viscosity of bituminous materials is not so simple. Therefore the consistency of bitumen is determined by penetration test which is a very simple test, the viscosity of tars and cutback bitumen is determined indirectly using an orifice viscometer in terms of time required for a specified quantity of bituminous materials, wherein the materials is too soft for penetration test, but the viscosity is so high that the material cannot flow through the orifice of the viscometer, the consistency of such materials is measured by ‘float test’.

Various types and grades of bituminous materials are available depending on their origin and refining process. The penetration test determines the consistency of this materials for the purpose of grading them, my measuring the depth (in units of one tenth of a millimeter or one hundredth of a centimeter) to which a standard needle will penetrate vertically under specified conditions of standard load, duration and temperature. Thus the basic principle of penetration test is the measurement of the penetration (in units of 1/10th of mm) of standard needle in a bitumen sample maintained at 250C during 5 seconds. The total weight of the needle assembly being 100g, the softer the bitumen the greater will be the penetration.

The penetration test is widely used world over for classifying the bitumen in to different grades. The ISI as standardized the penetration test equipment and the test procedure in figure7.1. Even though it is recognized that the empirical test like penetration, softening point etc. cannot only fully qualify the paving binder for its temperature susceptibility characteristics the simplicity and quickness of operation of this test cannot be ignored for common use.

APPARATUS:
It consists of items like container, needle, water bath, penetrometer, stop watch etc. The following are the standard specifications as per ISI from the above apparatus.

Container:-A flat bottomed cylindrical metallic container 55 mm in diameter 35 mm or 57 mm in height.

Needle: A straight highly polished cylindrical hard steel needle with conical end having the shape and dimensions as given in figure 7.2. The needle is provide with a shank approximately 3.0 mm in diameter in to which it is immovably fixed.

Water bath: A water bath is maintained at 25 + 10C containing not less than 10 liters of water. The simple is immersed to depth not less than 100mm from the top and supported on a perforated shelf not less than 50mm from the bottom of the bath.

Penetrometer: It is an apparatus which allows the needle assembly of gross weight 100g to penetrate without appreciable friction for the desire duration of time. The dial is accurately calibrated to give penetration value in units one tenth of mm.

Electrically operated automatic penetrometers are also available. Typically sketch of penetrometer as shown in fig.

Transfer tray: A small tray which can keep the container fully immersed in water during the test.

PROCEDURE:
The bitumen is softened to a pouring consistency between 750C and 1000C above the approximate temperature at which bitumen softens. The sample material is thoroughly stirred to make it homogenous and free from air bubbles and water. The sample material is then poured in to the container to a depth at least 15 mm more than the expected penetration. The sample containers are cooled in atmosphere of temperature not lower than 130C for one hour. Then they are placed in temperature controlled water bath at a temperature of 250C for a period of one hour.

The sample container is placed in the transfer way with water from the water bath and placed under the needle of the penetrometer. The weight of needle, shaft and additional weight are checked. The total weight of this assembly should be 100g. Using the adjusting screw, the needle assembly is lowered and the tip of the needle is made to just touch the top surface of the sample; the needle assembly is clamped in this position. The contact of the tip of the needle is checked using the mirror placed on the rear of the needle. The initial reading of the penetrometer dial is either adjusted to zero or initial reading is taken before releasing the needle. The needle is released exactly for a period of 5.0 seconds by pressing the knob and the final reading is taken on the dial. At least three measurements are made on this simple by testing at distance of less than 100 mm apart. The sample container is also transferred in the water bath before next testing done so as to maintain a constant temperature of 250C. The test is repeated with sample in the other container.

RESULTS:
The difference between the initial and final penetration reading is taken as the penetration value. The mean value of three consistent penetration measurements is reported as the penetration value. It is further specified by ISI that results of each measurement should not vary from the mean value reported above by more than the following:

DISCUSSION:

It may be noted that the penetration value is influenced by any inaccuracy as regards:
- Pouring temperature.
- Size of needle.
- Weight placed on the needle.
- Test temperature.
- Duration of releasing the penetration needle.

It is obvious to obtain high values of penetration if the test temperature and/or weight (place over the needle) are/is increased. Higher pouring temperature than that specified may result in hardening of bitumen and may give lower penetration values. A higher test temperature gives considerably higher penetration values. The duration of releasing the penetration needle can be exactly 5.0 sec`s. It is also necessary to keep the needle clean before testing in order to get consistent results. The penetration needle should not be placed closer than 10 mm from the side of the dish.

APPLICATION OF PENETRATION TEST:
Penetration test is the most commonly adopted test on bitumen to grade the material in terms of it hardness.

Depending up on the climatic condition and type of construction, bitumen of different penetration grades are used.80/100 bitumen denotes that the penetration value ranges between 80 and 100. The penetration value of various types of bitumen used in pavement construction in this country range between 20 and 225.

For bitumen macadam and penetration macadam Indian roads congress suggest bitumen grades 30/40, 60/70 and 80/100. In warmer regions lower penetration grades are preferred and in colder regions bitumen with higher penetration values are used.

The penetration test is not intended to estimate the consistency of softer materials like cutback or tar, which are usually graded by viscosity test in an orifice viscometer.
The Indian standards institution has classified paving bitumen available in this country into the following six categories depending on the penetration values grades designated 'A'(such as A35) are from Assam petroleum and those designated 'S'(such as S35) are from other sources.

8. DUCTILITY TEST

AIM:
To determine ductility of the given bitumen.

THEORY:
In the flexible pavement construction where bitumen binders are used, it is of significant importance that the binders form ductile thin films around the aggregates .This serves as a satisfactory binder in improving the physical interlocking of the aggregates .The binder material which does not possess sufficient ductility would crack and thus provide pervious pavement surface .

This in turn results in damaging effect to the pavement structure. It has been stated by some agencies that the penetration and the type of bitumen depends on crude source of the bitumen, sometimes it has been observed that the above statement is incorrect .It may hence be mentioned that the bitumen may satisfy the penetration value, but may fail to satisfy the ductility requirements.

Bitumen paving engineer would however want that both test requirements are satisfied in the field jobs. penetration and ductility can not in any case replace each other .The ductility is expressed as the distance in centimeters to which a standard briquette of bitumen can be stretched before the thread breaks .The test is conducted at 27 0 + 0.50C and a rate of pull of 50 + 2.5mm per minute .The test has been standardized by the ISI .The ductility test concept is show in fig 10.1.

APPARATUS:
The ductility test apparatus consists of items like sample(briquette)moulds water bath square-end trowel or putty knife sharpened on end and ductility machine .Standard specifications as per ISI being:

(a)Briquette mould: Mould is made of brass metal with shape and dimensions as indicated in fig10.2. Both ends called clips possess circular holes to grip the fixed and movable ends of the testing machine. Side pieces when placed together from the briquette of the following dimensions:
Length ----75mm
Distance between clips ----30mm
Width at mouth of clips ----20mm
Cross section at minimum width ----10mm x10mm
(b)Ductility machine: It is an equipment which functions as constant temperature water bath and a pulling device at a pre-calibrated rate .The central rod of the machine is threaded and through a gear system provides movement to one end where the clip is fixed during initial placement .The clips are thus pulled apart horizontally at a uniform speed of 50 + 2.5mm per minute .The machine may have provision to fix two or more mould so as to test these specimens simultaneously.

PROCEDURE:
The bitumen sample is melted to a temperature of 750C to 1000C above the approximate softening point until it is fluid .It is strained through IS sieve 30, poured in the mould assembly and placed on a brass plate ,after a solution of glycerin and dextrin is applied at all surfaces of the mould exposed to bitumen .Thirty to forty minutes after the sample is poured into the moulds the plate assembly along with the sample is placed in water bath maintained at 270C for 30 minutes .The sample and mould assembly are removed from water bath excess bitumen is cut if by to level the surface using hot knife .After trimming the specimen, the mould assembly containing sample is replaced in water both maintained at270C for 85 to 95 minutes.

The sides of the mould are now removed and the clips are carefully booked on the machine without causing any initial strain .Two or more specimens may be prepared in the moulds and clipped to the machine so as to conduct these tests simultaneously.

The pointer is set to read zero .The machine is started and the two clips are thus pulled apart horizontally .While the test is in operation, it is checked whether the sample is immersed in water at depth of at least 10 min. The distance at which the bitumen thread of each specimen breaks, is recorded (in cm) to report as ductility value.

DISCUSSION:
The ductility value gets seriously affected if any of the following factors are varied:

(1)Pouring temperature
(2)Dimensions of briquette
(3)Improper level of briquette placement
(4)Rate of pulling
Increase in minimum cross section of 10sq.mm and increase in test temperature would record increased ductility value.

APPLICATIONS OF DUCTILITY TEST:
A certain minimum ductility is necessary for a bitumen binder .This is because of the temperature changes in the bitumen nixes and the repeated deformations that occur in flexible pavements due to the traffic loads .If the bitumen has low ductility value, the bituminous pavement may crack, especially in cold weather .The ductility values of bitumen vary from 5 to over 100.

Several agencies have specified the minimum ductility values for various types of bituminous pavement .Often a minimum value of 50cm is specified for bituminous construction.

9. FLASH AND FIRE TEST

AIM:
To determine the flash and fire point of the bitumen.

THEORY:
Bitumen materials leave out volatiles at high temperatures depending upon their grades. These volatile vapours catch fire causing flash.This condition is very hazardous and it is therefore essential to qualify the temperature for each bitumen grade so that the paving engineers may restrict the mixing or application temperature well within the limit .

The flash point is the lowest temperature at which the ignition of the volatile vapors occurs when small flame is brought in contact with the vapors of a bituminous product.When the bituminous materials are further heated to a higher temperature,burning of material takes plac.Tthis is called fire point. Flash point is always less than fire point of bitumen.

Flash point "The flash point is the lowest temperature at which the vapors of substance momentarily takes fire in the term of a under specified point test.
Fire point "The point is the lowest temperature at which the material gets ignited and burns under specified condition of test".

APPARATUS:
1) Pensky martens closed tester consists of cup device cover shutter exposure device etc.
2) Pensky marten open tester as above with the modification, that the cover of the cup replaced by a clip which encircles the upper rim of the cup and carries the thermometer and test flame.

PROCEDURE:
1) All parts of the cup are cleaned and dried thoroughly the test is started.The material is filled in the cup up to a filling mark. The lid is placed to close the cup in a closed system.
2) All accessories including thermometer of specified range are suitably fixed. The bitumen sample is then heated. The test flame is lit and adjusted in such a way that the size of a beed is of 4mm diameter. The heating is done at rate of 5 degrees to 6 degrees per minute the string is done at a rate of approximately 60 revolutions per minute. The test flame is applied

at intervals depending upon the expected flash and fire points. First application is made at least 17°Cbelow the actual flash point and then at every 1°C to 3°C.

RESULTS:
The flash point is taken as the temperature used on the on thermometer at the of the flame application that causes a bright flash in the interior of the cap in closed system. For open cap it is the instance when flash appears best any point on the surface of the material. Flash heat continued until the volatile ignites and the material continuous to burn for 5 seconds. The temperature of the sample material when this occurs is recorded as the fire point.

DISCUSSION:
It is specified that in closed cup system, the test result should not differ from the mean by more than 30 C. For materials flashing above 1040C and not than 10 C from the mean flashing below 1040 C. sometimes bluish hallow that surrounds the test flame confused with true flash. For open cup system, it is specified that ISI that the mean value should not differ from the individual values by more than 30 C. for flash point, and by 60 C. for fire point.

APPLICATIONS OF FLASH AND FIRE POINT TEST:
Different bituminous materials have quite different values of flash and fire points. When the bitumen or cutback is to be heated before mixing or application. Utmost care is taken to see that heating is limited to a temperature well below the flash point this is essential from safety point of view.

The minimum value of flash point by Pensky marten's closed type apparatus specified by ISI 175 for all the grades of bitumen.

10. MARSHALL STABILITY TEST

AIM:
To find out optimum bitumen content of given mix.

Theory:
Bruce Marshall, formerly bituminous engineer with Mississippi state highway department, USA formulated Marshall'smethod for designing bituminous mixes. Marshall's test procedure was later modified and improved upon by U.S.corps of engineers through their extensive research and correlation studies .ASTM and other agencies have standardized the test procedure. Generally, this stability test is applicable to hot-mix design using bitumen and aggregates with maximum size of 25mm.

In this method, the resistance to plastic deformations of cylindrical specimen of bituminous mixture is measured when the same is loaded at the periphery at 5 cm per minute. This test procedure is used in designing and evaluating bituminous paving mixes. The test procedure is extensively used in routine test program for the paving jobs. There are two major features of the Marshall method of designing mixes namely, (i) Density-voids analysis, (ii) stability-flow tests. The Marshall stability of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature at 600C. The flow value is a deformation the Marshall test specimen undergoes during the loading up to the maximum load in 0.25 mm units. In this test an attempt is made to obtain optimum binder content for the type of aggregate mix and traffic intensity. The proposed designed steps for the design of bituminous mix are given below.

 Select grading to be used.
 Select aggregates to be employed in the mix.
 Determine the proportion of each aggregate required to produce design grading.
 Determine the specific gravity of the aggregate combination and of the asphalt cement.
 Make up trail specimens with varying asphalt contents.
 Determine the specific gravity of each component specimen.
 Make stability tests on the specimens.
 Calculate the percentage of voids, VMA and the percent voids filled with bitumen each specimen.
 Select the optimum bitumen content with design requirements. The design may be required if necessary after altering the gradation so as to fulfill the design requirements.

APPARATUS:

1. Mould assembly: Cylindrical moulds of 10cm diameter and 7.5cm height are required. It further consist of a base plate and collar extension. They are designed to be interchangeable with either end of cylindrical mould.

2. Sample Extractor: For extruding the compacted specimen from the mould, an extractor suitably fitted with a jack or compression machine.

3. Compaction pedestal and hammer: It consist of a wooden block capped with M.S. plate to hold the mould assembly in position during compaction. The compaction hammer consist of a flat circular tamping face 8.8 cm diameter and equipped with a 4.5 kg. Weight constructed to provide a free fall of 47.5cm. Mould holder is provided consisting of spring tension device designed to hold compaction mould in place on the compaction pedestal.

4. Breaking head: It consist of upper and lower cylindrical segments or test heads having an inside radius of curvature of 5cm. The lower segment is mounted on a base having two vertical guide rods which facilitate insertion in the holes of upper test head.

5. Loading machine: See fig. 14.1. The loading machine is provided with a gear system to lift the base in upward direction. On the upper end of the machine, a pre-calibrated proving ring of 5 tonne capacity is fixed. In between the base and the proving ring, the specimen contained in test head is placed. The loading machine produces a movement at the rate of 5cm per minute. Machine is capable of reversing its movement downward also. This facilitates adequate space for placing test head system after one specimen has been tested.

6. Flow Meter: One dial gauge fixed to the guide rods of a testing machine can serve the purpose. Least count of 0.025 mm is adequate. The flow value refers to the total vertical upward movement from the initial position at zero load to a value at maximum load. The dial gauge or the flow meter should be able to measure accurately the total vertical movement upward.

Besides the above equipment, the following are also required.,
 Ovens on hot plate,
 Mixing apparatus,
 Water bath, thermometers of range up to 2000C with sensitivity of 2.50C.

PROCEDURE:

In the Marshall method each compacted test in specimen is subjected to the following tests and analysis in the order listed below:

- Bulk density determination,
- Stability and flow test,
- Density and voids analysis,

At least three samples are prepared for each binder content.

PREPARATION OF TEST SPECIMENS:

The coarse aggregates, fine aggregates and the filter material should be proportioned and mixed in such a way that final mix after blending has the gradation within the specified range.The specified gradation of mineral aggregates and the bitumen binder as per IRC: 29-1968 are given in table.

The aggregates and filter are mixed together in the desired proportion as per the design requirements are fulfilling the specified gradation. The required quantity of mix is taken so as to produce a compacted bituminous mix specimen of thickness 63.5mm approximately.

Approximately 1200g of aggregates and filter are taken and heated to a temperature of 175 to 1900C. The compaction mould assembly and rammer are cleaned and kept pre heated to a temperature of 100 to 1450C. The bitumen is heated to temperature of 121 to 1380C and the required quantity of first trail percentage of bitumen (say 3.5% by weight of mineral aggregates) is added to the heated aggregate and thoroughly mixed using a mechanical mixer or by hand mixing with trowel. The mixing temperature for 80/100 grade bitumen may be around 1540C and that for 60/70 grade about 1600C.

The mix is placed in a mould and compacted by rammer, with 75 blows on either side. The compacting temperatures may be about 1380C for 80/100 grade bitumen and 1490C for 60/70 grade. The compacted specimen should have a thickness of 63.5 mm. The weight of the aggregate taken may be suitably altered to obtain a thickness of 63.5 + 3.0 mm.

At least two specimens, but preferably three or four specimens should be prepared at each trail bitumen content which may be varied at 0.5 percent increments up to about 6.0 or 6.5 percent. The compacted specimens are allowed to cool to room temperature, the sample height and weight is determined, theoretical density is calculated. The specimen is then weighed in air and then in water for determining volume and later bulk density. The specimens are then transferred into a water bath, kept at 600 C for 30 to 40 minutes. They are then removed, dried and placed in Marshall test head. Their Stability and flow values are noted. They are corrected for variation from average height.

Marshall Stability and flow values:

The specimens to be tested are kept immersed under water in a thermostatically controlled water bath maintained at 600C for 30 to 40 minutes. The specimens are taken one by one, placed in the marshall test head and the Marshall stability value (maximum head carried in kg. before failure load in o.25mm units) are noted. The corrected Marshall stability value of each specimen is determined by applying the approximate correction factor, if the average height of the specimen is not exactly 63.5mm the correction factors are given in table.

DETERMINATION OF OPTIMUM BITUMEN CONTENT

Five graphs are plotted with values of bitumen content against the value of:

- Density Gb. g/cm3,
- Marshall stability S, kg,

 Voids in total mix Vv %,
 Flow value ,F (0.25mm units)
 Voids filled with bitumen , VFB %,

Let the bitumen content corresponding to maximum density be B1, corresponding to maximum stability be B2 and that corresponding to the specified voids content Vv (4.0% in the case of dense AC mix) to B3. Then the optimum bitumen content for deign mix is given by

B0= (B1+B2+B3)/3.

The value of flow and VFB are found from the graphs, corresponding to the bitumen content B0. All the design values of Marshall Stability, flow, voids and VFB are checked at the optimum bitumen content B0, with the specified design requirements of the mix.

DESIGN REQUIREMENTS OF THE MIX:

As per IRC: 29-1968, when the specimens are compacted with 50 blows on either face of the designed AC mix should fulfill the following requirements.

 Marshall stability value Kg(minimum) =340
 Marshall flow value , 0.25mm units = 8 to 16
 Voids in total mix, Vv% =3 to 5

Voids in mineral aggregates filled With bitumen,VFB %=75 to 85

The highest possible Marshall Stability values in the mix should be aimed at consistent with the other three requirements mentioned above. In case the mix designed does not fulfill any one or more of the designed requirements, the gradation of the aggregates or filter content or bitumen content or combination of these are altered and the design tests are repeated till all the requirements are simultaneously fulfilled.

DISCUSSION:

The Marshall stability test method is very simple and rapid method for designing bituminous mixes scientifically. The stability values obtained in the test produce indirectly represent the strength of a paving mix at a zero vertical stress less which is critical.

Mixes with very high Marshall stability values and very flow values are not desirable as the pavements of such mixes may be brittle and are likely to crack under heavy traffic.

11. SOFTENING POINT TEST

AIM: To determine softening point of a given bitumen sample.

THEORY: Bitumen does not suddenly change from solid to liquid state ,but as the temperature increases it gradually becomes softer until it flows readily .A semi solid state bitumen grades need sufficient fluidity before they are used for application with the aggregate mix .For this purpose bitumen is sometimes cut back with a solvent like kerosene .The common procedure however is to liquefy the bitumen by heating .The softening point is the temperature at which the substance attains particular degree of softening under specified condition of test . For bitumen it usually determined by Ring and Ball test. Brass ring test containing the test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen and liquid medium is then heated at a specified distance below the ring is recorded as the softening point of a particular bitumen. The apparatus and test procedure are standardized by ISI. It obvious but harder grade bitumen posses higher softening point than softer grade bitumen. The concept of determining the softening point by Ring and Ball apparatus is shown fig8.1

APPARATUS:

 It consists of Ring and Ball apparatus
 Steel Balls they are two in number.Each as a diameter of 9.5 mm and weight 2.5 to 5 g.
 Brass Rings there are two rings of the following dimensions.
Depth 6.4 mm
Inside diameter at top 17.5 mm
Inside diameter at bottom 15.9 mm
Outside diameter 20.6 mm
 Brass rings are also placed with ball guides as shown in fig 8.1
 Support the metallic support is used for placing pair of rings .
 The upper surface of the rings is adjusted to be 50mm below the surface of the water or liquid contained in the bath. A distance the bottom of the rings on top surface of the bottom plate of support is provided it has a housing for a suitable thermometer.
 Bath and Stirrer: A heat resistance glass container of 85mm dia and 120mm materials having softening point above 80 degree C and glycerin for materials having softening point above 80 degree C. Mechanical stirrer is used for ensuring uniform distribution all times through out the bath.

PROCEDURE:
Sample material is heated to a temperature between 75 and 1000C above the approximate softening point until it is fluid and is poured in heated rings placed on metal plate .To avoid sticking of the bitumen to metal plate coating is done to this with a solution of glycerin and dextrin .After cooling the rings in air for 30 minutes .

The excess bitumen is trimmed and rings are placed in the support as discussed in item above. At this time the temperature of distilled water is kept at 50C. This temperature is maintained for 15 minutes after which the balls are placed in position.

The temperature of water is raised at uniform rate of 50C per minute with a controlled heating unit the bitumen softens and touches the bottom plate by sinking of balls. At least two observations are made. For material whose softening point is above 800C, glycerin is used as a heating medium and the starting temperature is 350 C, instead of 50 C.

RESULTS: The temperature at the instant when each of the ball and sample touches the bottom plate of support is recorded as softening value . The mean of duplicate determinations is noted. It is essential that the mean value of softening point (temperature) does not differ from individual observations by more than the following limits.

Softening point Repeatability Reproducibility
Below 30°C 2°C 4°C
30 to 80°C 1°C 2°C
Above 80°C 2°C 4°C

DISCUSSION:
As in the other physical tests on bitumen it is essential that the specifications discussed above are strictly observed. Particularly, any variation in the following point would effect the result considerably
1) Quality and type of liquid
2) Weight of balls
3) Distance between bottom of ring and bottom base plate
4) Rate of heating

Impurity in water or glycerine has been observed to effect the result considerably. It is logical to observe lower softening point if there weight of ball is excessive on the other hand increased distance between bottom of ring and bottom of plate increases the softening point.

APPLICATIONS OF SOFTENING POINT TEST:

Softening point is essentially the temperature at which the bituminous binders have an equal viscosity. The softening point of tar is therefore related to the equi-viscous temperature. The softening point found by the ring and ball apparatus is approximately 200C lower than the e.v.t.

Softening point, thus gives an idea of the temperature at which the bituminous material attains a certain viscosity. Bitumen with higher softening point may be preferred in the warmer place.

12. VISCOSITY TEST

AIM : To determine the viscosity value of the given bitumen sample.

INTRODUCTION:

Viscosity is defined as the inverse of fluidity. Viscosity thus defines the fluid property of bituminous material. The degree of fluidity at the temperature greatly influences the ability of bituminous materials to spread, penetrate into the voids and also coat the aggregates hence effects the strength characteristics of the resulting paving mixes. High or low fluidity at mixing and compaction have been observed to result in lower stability values.

There is an optimum value of fluidity or viscosity for mixing and compacting for each aggregate gradation of the mix and bitumen grade. At high fluidity or low viscosity, the bitumen binder simply "lubricants" the aggregate particles instead of providing uniform film thickness for binding action. Similarly, low fluidity or high viscosity does not enable the bitumen to coat the entire surface of aggregates in the mix easily and also resists the competitive effort and the resulting mix is heterogeneous in character exhibiting low stability values. The ISI specifies a test procedure for liquid binders like cutback bitumen, emulsion and liquid tar.

One of the methods by which viscosity is measured is by determining the time taken by 50 CC of the material to flow from a cup through specified orifice at given temperature. This is illustrated in Fig 21.11 In the range of consistency of bituminous materials when neither orifice viscometer test nor penetration test could be conducted; float test may be carried out.

Equipment like sliding plate micro-viscometer and Brookfield viscometer are however in use for defining the viscous characteristics of the bitumen of all grades irrespective of testing temperature. The viscosity of bitumen of all grades irrespective of temperature. The viscosity of bitumen can also be measured by capillary tube viscometer.

APPARATUS:

Ten millimeter orifice viscometer is specified for testing road tar and is called tar viscometer 4.0 mm orifice is used to test cutback grades 0 and 1 and 10 mm orifice to test all other grades. The apparatus consists of main parts like cup, valve, water bath, sleevs, stirrer, receiver and thermometers, etc.

PROCEDURE:

The tar cup is properly levelled and water in the bath is heated to the temperature specified for the test and maintained throughout the test. Stirring is also continued. The sample material heated at the temperature 200C above the specified test temperature, and the material is allowed to cool. During this the material is continuously, stirred.

When material reaches slightly above test temperature, the same is poured in tar cup, until the levelling peg on the valve rod is just immersed. In the graduate receiver (cylinder), 20ml of mineral oil or one percent by weight solution of soft soap is poured. The receiver is placed under the orifice. When the sample material reaches the specified temperature within + 0.10C and is maintained for 5 min, the valve is opened. The stop watch is started when cylinder records 25ml. The time is recorded for flow up to a mark of 75ml.

The viscosity test on road tar is carried out using 10mm orifice and the standard test temperature for road tar grades RT1, RT2, RT3 and RT4 are 35, 40, 45, and 550C respectively. In case the viscosity test is being carried out to classify a given sample of road tar or to find its grade, then the test should be first conducted at the lowest temperature of testing road tar is 350C, if the time taken for 50ml of the tar sample to flow through the 10mm orifice is more than 55s or if the Sample does not flow freely test may be repeated at the highest temperature till the viscosity value falls in the specified range.

RESULT:
The time in seconds for 50ml of the test sample to flow through the orifice is defined as the viscosity at a given test temperature. Therefore the temperature at which the test was conducted and the diameter of the orifice used should also be mentioned. The viscosity values of repeat tests should not vary by more than 4.0 percent from the mean value.

DISUSSION:
The results of the viscosity test will get affected greatly if the test temperature of the sample is not correctly maintained throughout the test. Erratic results are obtained due to clogging of the orifice and due to the presence of lumps in the sample of bituminous material.

APPLICATION OF VISCOSITY TEST:
Orifice viscosity test gives an indirect measure of viscosity of tars and cutbacks in seconds, higher the duration, more viscous is the material.
The determination of viscosity by orifice viscometer in seconds is an indirect measure of viscosity. The absolute unit of viscosity dyne-second per cm2 or poise.

13. STRIPPING VALUE OF AGGREGATES

AIM: To determine the stripping value of aggregates by static immersion method.

THEORY: Bitumen and tar adhere well to all normal types of aggregates provided they are dry and are not exceptionally dusty. Largely the viscosity of the binder controls the process of binding. When the viscosity of the binder is high, coating of aggregates by the binder is slower.

In the absence of water there is practically no adhesion problem in bituminous road construction. Two problems are observed due to presence of water. First, if aggregate is wet and cool it is normally not possible to coat with a bituminous binder.

This problem can be dealt with by removing the water film on aggregate by drying, and by increasing the mixing temperature. Second problem is stripping of coated binder from the aggregate due to presence of water. This problem of stripping is experienced only with bituminous mixtures, which are permissible to water.

APPARATUS: Thermostatically controlled water bath , beaker.

PROCEDURE:

1. This method covers the procedure for determining the stripping value of aggregates by static immersion method, when bitumen and tar binder are used. 200gm of dry and clean aggregates passing 20mm IS sieve and retained on 12.5mm sieve are heated up to 1500C
2. When these are to be mixed with bitumen, the aggregates are heated up to 1000C.
3. The aggregates and binder are mixed thoroughly till they are completely coated and the mixer is transferred to 500ml beaker and allowed to cool at room temperature for about 2 hours.
4. Distilled water is then added to immerse the coated aggregates. The beaker is covered and kept in water bath maintained at 400C, taking care that level of water bath is at least half the height of the beaker.
5. After 24 hours the beaker is taken out, cooled at room temperature and the extent of stripping is estimated visually while the specimen is still under water.
6. The stripping value is the ratio of the uncovered area observed visually to the total area of aggregates in each test, expressed as a percentage.

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR
Lab Manual

Title of Course: Detailing of RC & Steel Structures Lab
Course Code: CE 692
L-T-P scheme: 0-0-3 **Course Credit: 2**

Objectives:
1. The students will be able to develop the concept of the design principle of RCC Sections.
2. They will be exposed to the different types of loads and the corresponding stresses to be considered in the design as per the IS Code provision.
3. The students will be able to design different components such as slabs, beam columns, roofing and staircase from floor plan of multistoried frame building.
4. The students will be able to understand the typical detailing of a two way floor slab.

Learning Outcomes: The students will be able to develop the basic concepts of design of RCC and Steel structures as per IS Code. They will be able to develop the concepts of design and detailing of simply supported RCC beam and continuous T Beam. They will also have an understanding of design and detailing of columns and isolated and combined footings. The students will also be able to understand the concept of Limit State Method of Design Loads and the stresses to be considered in the design as per the IS Code provision. The students will be able to design the different components of a roof truss. The students will also develop an understanding of column base plate and column foundation.

Course Contents:
Exercises that must be done in this course are listed below:

RCC structures
1. General considerations: Design principle of R.C.C. sections. Limit state method of design Loads and stresses to be considered in the design as per I.S. code provision.
2. Design & detailing of a i) simply supported R.C.C Beam ii) Continuous T- Beam.
3. Design & Detailing of columns, isolated and combined footing
4. Design & detailing of a i) simply supported one way slabii) One way Continuous slab.
5. Design of different units: Slab, beam column, roofing and staircase from floor plan of a multi-storied frame building, typical detailing of a two way floor slab.

Steel structures
Problems on general consideration and basic concepts.
Discussion on different loads (i.e. wind load, Dead load, live load and others) as per IS875.
Design & drawing of the following components of a roof truss:
1. Members of the roof truss.
2. Joints of the roof truss members
3. Purlins
4. Gable bracings
5. Column with bracings
6. Column base plate
7. Column foundation

Text Book:
1.I.S- 456-2000, SP 34, SP 16,I.S. 875, I.S. Code 800 – 2007, Standard text books on RCC & Steel Design

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR
Lab Manual

Title of Course: CAD Lab
Course Code: CE 693
L-T-P scheme: 0-0-3 **Course Credit: 2**

Objectives:
1. The students will be able to develop the concepts of Computer Aided Design Of Structures.
2. They will be exposed to latest CAD CAM software environment and will be able to develop efficiently the detailed design and drawings including the floor plans of different kinds of structures.
3. The students will be able to prepare the detailed drawings of different structural elements including the ductility detailing of RCC slab, beam, column and footing design.

Learning Outcomes: The students will be able to develop the understanding of CAD software and develop a clear understanding of the analysis and design of a multistoried buildings using softwares. The students will be able to prepare the detailed drawings of different structural elements including the ductility detailing of RCC slab, beam, column and footing design.

Course Contents:
Exercises that must be done in this course are listed below:

1. Introduction and important features ofa software dealing with analysis and design of structures.
2. Analysis and design of a multistoried building using software, Preparation of detailed drawings of different structural elements including ductility detailing RCC Slab, beam, column and footing design.

Text Book:
1. CAD CAM Standard Manual.

INTRODUCTION to CAD

1. INTRODUCTION

Computer Aided Drafting is a process of preparing a drawing of an object on the screen of a computer. There are various types of drawings in different fields of engineering and sciences. In the fields of mechanical or aeronautical engineering, the drawings of machine components and the layouts of them are prepared. In the field of civil engineering, plans and layouts of the buildings are prepared. In the field of electrical engineering, the layouts of power distribution system are prepared. In all fields of engineering use of computer is made for drawing and drafting. The use of CAD process provides enhanced graphics capabilities which allows any designer to Conceptualize his ideas Modify the design very easily Perform animation Make design calculations Use colors, fonts and other aesthetic features.

The use of CAD process provides enhanced graphics capabilities which allows any designer to Conceptualize his ideas Modify the design very easily Perform animation Make design calculations Use colors, fonts and other aesthetic features.

REASONS FOR IMPLEMENTING A CAD SYSTEM

Increases the productivity of the designer:

CAD improves the productivity of the designer to visualize the product and its component, parts and reduces the time required in synthesizing, analyzing and documenting the design

Improves the quality of the design: CAD system improves the quality of the design. A CAD system permits a more detailed engineering analysis and a larger number of design alternatives can be investigated. The design errors are also reduced because of the greater accuracy provided by the system

Improves communication: It improves the communication in design. The use of a CAD system provides better engineering drawings, more standardization in the drawing, and better documentation of the design, few drawing errors and legibility.

Create data base for manufacturing:

In the process of creating the documentation for these products, much of the required data base to manufacture the products is also created.

Improves the efficiency of the design:

It improves the efficiency of the design process and the wastage at the design stage can be reduced.

APPLICATION OF CAD:

There are various processes which can be performed by use of computer in the drafting process.

1. Automated drafting: This involves the creation of hard copy engineering drawings directly from CAD data base. Drafting also includes features like automatic dimensioning, generation of cross – hatched areas, scaling of the drawing and the capability to develop sectional views and enlarged views in detail. It has ability to perform transformations of images and prepare 3D drawings like isometric views, perspective views etc.

2. , Geometric modeling: concerned with the computer compatible mathematical description of the geometry of an object. The mathematical description allows the image of an object to be displayed and manipulated on a graphics terminal through signals from the CPU of the CAD system. The software that provides geometric modeling capabilities must be designed for efficient use both by computer and the human designer.

BENEFITS OF CAD:

The implementation of the CAD system provides variety of benefits to the industries in design and production as given below:

1. Improved productivity in drafting

2. Shorter preparation time for drawing

3. Reduced man power requirement

4. Customer modifications in drawing are easier

5. More efficient operation in drafting

6. Low wastage in drafting

7. Minimized transcription errors in drawing

8. Improved accuracy of drawing

9. Assistance in preparation of documentation

10. Better designs can be evolved

11. Revisions are possible

12. Colors can be used to customize the product

13. Production of orthographic projections with dimensions and tolerances

14. Hatching of all sections with different filling patterns

15. Preparation of assembly or sub assembly drawings

16. Preparation of part list

17. Machining and tolerance symbols at the required surfaces

18. Hydraulic and pneumatic circuit diagrams with symbols

19. Printing can be done to any scale

LIMITATIONS OF CAD

1. 32 – bit word computer is necessary because of large amount of computer memory and time

2. The size of the software package is large

3. Skill and judgment are required to prepare the drawing

4. Huge investment

AUTO CAD

Auto CAD package is suitable for accurate and perfect drawings of engineering designs. The drawing of machine parts, isometric views and assembly drawings are possible in AutoCAD. The package is suitable for 2D and 3D drawings.

2. AutoCAD – BASICS

2.1 STARTING WITH ACAD CAD uses four basic elements for preparation of any drawing:

1. Line

2. Curves

3. Text

4. Filling point.

Computer Aided Drafting is done by the operator by placing the mouse pointer by placing the mouse pointer at the desired location and then executing the command to draw the graphic elements using different methods. Advanced computer aided drafting packages utilize four areas on the screen.

1. CURVES

Following are the various types of curves used in the drawings:

i. Circle

ii. Ellipse

iii. Arc

Regular or any other type.

Aim: to draw the following figure using ACAD

PROCEDURE

STEP 1:

Draw axis lines in the respective format with their intersection point at (0,0) Go to PROPERTIES tool bar Load line type as ISO LONG DASH SHORT DASH in the line type area. Select line type ISO LONG DASH SHORT DASH in the line type area.

STEP 2

a Draw circles of given dimensions using circle command with their centre as the intersection of the axis lines. 3 circles of diameters 94, 74 and 54 are to be drawn The circle with 74 diameter is of ISO LONG DASH SHORT DASH format

STEP 3: Draw two construction lines at an angle of 30o to the vertical axis line

STEP 4: With A as center an radius 100 draw an arc between the above lines

STEP 5: Offset the arc on the either side by the distances as mentioned in the figure.

STEP 6: Complete the figure by using fillet command.

STEP 7: Give dimensions to the completed figure. Command: _qsave

PRECAUTIONS:

Put ORTHO ON where ever necessary. Use the required modify tool bar commands like TRIM, ERASE, COPY, MIRROR ETC.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lab Manual

Civil Engineering Department

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Course Description

Title of Course: Seminar **Course Code: CE681**
L-T –P Scheme: 0-0-3 **Course Credits: 2**

Course Description & Objectives:

1. Understand the diverse social and economic, racial and gender contexts within which Henrietta Lacks lived and died. Understand the themes of this seminar. Appreciate the legacy and implications of these medical, ethical and social understandings on today's society.

2. **Identify**, understand and discuss current, real-world issues.

3. **Distinguish** and **integrate** differing forms of knowledge and academic disciplinary approaches (e.g., humanities and sciences) with that of the student's own academic discipline (e.g., in agriculture, architecture, art, business, economics, education, engineering, natural resources, etc.). And apply a **multidisciplinary strategy** to address current, real-world **issues**.

4. Improve oral and written **communication** skills.

5. Explore an appreciation of the **self** in relation to its larger diverse social and academic contexts.

6. Apply principles of **ethics** and **respect** in interaction with others.

Course Outcomes:

After the completion of this course, the student should be able to:

1. **Learn and integrate.** ***Through independent learning and collaborative study, attain, use, and develop knowledge*** *in the arts, humanities, sciences, and social sciences, with disciplinary specialization and the ability to integrate information across disciplines.*

2. *Use multiple thinking strategies to* ***examine real-world issues****,* ***explore creative avenues of expression****,* ***solve problems, and make consequential decisions***

3. **Learn and integrate.** Communicate**.** *Acquire, articulate, create and convey intended meaning using* ***verbal*** *and* ***non-verbal method of communication*** *that demonstrates respect and understanding in a complex society.*

4. *Use multiple thinking strategies to examine* ***real-world issues****,* ***explore creative avenues of expression****,* ***solve problems, and make consequential decisions.***

5. **Clarify purpose and perspective.** *Explore* ***one's life purpose and meaning*** *through transformational experiences that foster an understanding of* ***self****,* ***relationships****, and* ***diverse global perspectives****.*

6. **ractice citizenship.** *Apply principles of **ethical** leadership, **collaborative engagement**, **socially responsible behavior**, **respect for diversity** in an interdependent world, and a service-oriented commitment to advance and sustain local and **global communities**.*