**Subject Name:** **STRENGTH OF MATERIALS-II**

**Prepared by (Faculty (s) Name):Dr.C.S.C Devadass**

**Year and Sem, Department:II / II**

**Unit-I**

**TORSION OF CIRCULAR SHAFTS**

**Important points / Definitions: (Minimum 15 to 20 points covering complete topics in that unit)**

1. **Torsion of Shaft and Combined Stresses**: Torsion means twisting a structural Member when it is loaded by couplethat Produces rotation about longitudinal axis.If  be the intensity of shear stress, on any layer at a distance *r* from the centre of shaft
2. **Series connection:**Series connection of compound shaft as shown in figure. Due to series connection the torque on shaft 1 will be equal to shaft 2 and the total angular deformation will be equal to the sum of deformation of 1st shaft and 2nd shaft
3. Parallel connection: Parallel connection of compound shaft as shown in figure. Due to parallel connection of compound shaft the total torque will be equal to the sum of torque of shaft 1 and torque of shaft 2 and the deflection will be same in both the shafts.
4. **What is torsion of circular shaft:**

Shaft is straight and of uniform circular cross section over its length. Torsion is constant along the length of the shaft. Cross section of the shaft which are plane before torsion remain plane after torsion. Radial lines remain radial during torsion. Stresses induced during torsion are within the elastic limit

1. **What is torsion shaft:** Shear Stress in the Shaft When a shaft is subjected to a torque or twisting a shearing stress is produced in the shaft. ... the "Polar Moment of Inertia of an Area" is a measure of a shaft's ability to resist torsion. The "Polar Moment of Inertia" is defined with respect to an axis perpendicular to the area considered.
2. **shafts circular**:Generally for power transmission, circular shafts are used because there is uniform stress distribution along any radius of the shaft. Plane sections of shaft remain plane after the application of twisting moment, as a result there is no distortion in the sections of shafts and change in volume of the shaft is zero.
3. **J in torsion:**In the field of solid mechanics, torsion is the twisting of an object due to an applied torque. ... T is the applied torque or moment of torsion in Nm. (tau) is the maximum shear stress at the outer surface. JT is the torsion constant for the section
4. **Theory of pure torsion:**Pure torsion is a twisting loading, usually on a circular shaft produce by a torqueonly, with no axial, or lateral forces. It is also possible to have a pure torque loading on a beam. For it be in equilibrium, a pure torque must be reacted by a pure torque, otherwise axial of lateral forces are develope
5. D**ifference between torsion and torque:**Torque and torsion are both related to turning effects experienced by a body. The main difference between torque and torsion is that torque describes something that is capable of producing an angular acceleration, whereas torsion describes the twist formed in a body due to a torque
6. **Is torsion shear stress:**Shear Stress in ShaftsTwisting can be produced in the shaft when two equal and opposite couples acting in parallel planes. When a machine member is under the twisting force then it is said to be the shaft is subjected to torsion
7. T**heory of torsion:**In solid mechanics, torsion is the twisting of an object due to an applied torque, therefore is expressed in N. ... The theory of Torsion is based on the following Assumptions : The material in the shaft is uniform throughout. The twist along the shaft is uniform. The shaft is of uniform circular cross section throughout
8. **different types of shafts:**They are mainly classified into two types.
9. Transmission shafts are used to transmit power between the source and the machine absorbing por; e.g. counter shafts and line shafts.integral part of the machine itself
10. **shafts are there:** Transmission Shaft. & Machine Shaft.
11. **shaft in anatomy:**A long, generally cylindrical bar that rotates and transmits power, as the drive shaft of an engine. Zoology The main axis of a feather, especially its distal portion. Anatomy. a. The midsection of a long bone; the diathesis

**Short Questions**

|  |  |  |
| --- | --- | --- |
| 1 | Define Torque, Polar section modulus and Proof resilience. | **MAY-2018** |
| 2 | Define Spring constant. Differentiate and explain types of springs. | **DEC-2018** |
| 3 | Derive the equation for power transmitted by a shaft. | **MAY-2017** |
| 4 | Define spring and mention types of springs. | **DEC-2016** |
| 5 | State functions of springs. | **DEC-2014** |
| 6 | Write torsional equation and explain the terms. | **MAY-2015** |
| 7 | Derive the expression for torque transmitted by a hollow shaft | **MAY-2016** |
| 8 | Write the Polar Modulus (i) for a solid shaft and (ii) for ahollow shaft. | **DEC-2018** |
| 9 | Why hollow circular shafts are preferred when compared tosolid circular shafts? | **MAY-2015** |
| 10 | Write the equation for strain energy stored in a shaft due totorsion. | **DEC-2017** |

**Long Questions**

|  |  |  |
| --- | --- | --- |
| 1 | a) Explain the theory of pure torsion with assumptions.b) Define solid length, spring rate, pitch | **May-2015** |
| 2 | Derive expression equations for strength and stiffness of a circular shaft when an external torque T is acting on it. | **May -2015** |
| 3 | Derive expression for strain energy for a solid circular shaft. | **Dec-2015** |
| 4 | Calculate the maximum stress in a propeller shaft with a 400mm external and 200mm internal diameter, when subjected to a twisting moment of 4650Nm. If the modulus of rigidity, C=82GN/ how much is the twist in a length 20 times the diameter? | **Dec-2015** |
| 5 | The stiffness of a closely coiled helical spring is 1.5 N/mm of compression under a maximum load of 100N. The maximum shearing stress produced in the wire of the spring is 130 N/mm2. The solid length of the spring (when the coils are touching) is given as 5cm. Find (i) Diameter of the wire (ii) Mean diameter of the coils and (iii) No. of coils required. Take C=4.5X104N/mm2 | **May-2016** |
| 6 | Determine the diameter of a solid steel shaft which will transmit 112.5kW at 200rpm. Also determine the length of the shaft if the twist must not exceed 1.50 over the entire length. The maximumshear stress is limited to 55 N/mm2. Take G = 8x104N/mm2 | **May-2016** |
| 7 | The internal diameter of a hollow shaft is 2/3rdof its external diameter.Compare its resistance to torsion with that of solid shaft of the same weight and material. | **Dec-2016** |
| 8 | A hollow shaft of diameter ratio 3/5 is required to transmit 800kW at 110rpm. The maximum torque being 20% greater than the mean. The shear stress is not to exceed 63MPa and the twist in a length of 3m is not to exceed 1.40. Calculate the minimum external diameter satisfying these conditions. | **Dec-2016** |
| 9 | A propeller shaft 280mm in diameter transmits 2.5mW at 250rpm. The propeller weighs 50kN and overhangs its support by 400mm. If the propeller thrust is of 123kN weights. Calculate the maximum principal stress induced in the cross-section and indicates its position.C=80MPa | **May-2017** |
| 10 | In an open coil helical spring having 10 coils, the stresses due to bending and twisting are 98MPa and 105MPa respectively, and the spring is axially loaded. Assuming the mean diameter of the coils to be 8 times the diameter of wire, find the maximum permissible load and the diameter of wire for a maximum extension of 2cm. E=210GPa and G=82GPa. | **May-2017** |

**Fill in the Blanks / Choose the Best:**

**1-A shaft is said to be in pure torsion if**

1. Turning moment is applied at one end and other end is free
2. Turning force is applied at one end and other end is free
3. **Two opposite turning moments are applied to the shaft**
4. Combination of torsional load and bending load is applied to the shaft

**2-In power transmission equation, P=2ΠNT/60×1000**

1. P is in kw and T is maximum torque
2. P is in NM/sec and T is maximum torque
3. P is in NM/sec and T is mean torque
4. **P is in kw and T is mean torque**

**3-Which property is not required for shaft materials?**

1. High shear and tensile strength
2. Good machinability
3. High fatigue strength
4. **Good castability**

**4-Which material is suitable for shaft material?**

1. High speed steel
2. Stainless steel or high carbon steel
3. Grey cast iron
4. **Steel having approx. 0.4% carbon and 0.8% manganese**

**5-If diameter of a shaft is doubled the power transmitted capacity will be**

1. Either twice or half
2. Four times
3. **Eight times**
4. Same

**6-Two shafts in torsion will have equal strength if**

1. Only diameter of the shafts is same
2. Only angle of twist of the shaft is same
3. Only material of the shaft is same
4. **Only torque transmitting capacity of the shaft is same**

**7-Which of the following is not designed under torsion equation?**

1. Spindle
2. **Axle**
3. Low cost shaft
4. Shaft with variable diameter

**8-Which of the following is incorrect?**

1. **In torsion equation, we use mean torque**
2. In torsion equation, we use maximum torque
3. Many shafts are designed under combined bending and torsion load
4. Shafts are also designed for torsional rigidity

**9-Which of the following is incorrect?**

1. In a solid shaft maximum shear stress occurs at radius = radius of shaft
2. **In a solid shaft maximum shear stress occurs at center**
3. In a hollow shaft maximum shear stress occurs at outer radius
4. In a hollow shaft minimum shear stress occurs at inner radius

**10-The following option is correct**

1. There is neither advantage nor disadvantage in transmitting power at high speed
2. **There is advantage in transmitting power at high speeds**
3. There is disadvantage in transmitting power at high speeds
4. There is advantage in transmitting power at high speed provided shafts are made of high speed steel

**11-Torsional rigidity is defined**

1. T/θ
2. Cθ
3. CIp
4. **= θ**

**12-Which of the following is not an assumption in derivation of torsion equation?**

1. Circular shaft remains circular after twisting
2. Plane section of the shaft remain plane after twisting
3. Material of shaft is isotropic
4. **Angle of twist is proportional to radius**

**13-Strength of a shaft**

1. Is equal to maximum shear stress in the shaft at the time of elastic failure
2. Is equal to maximum shear stress in the shaft at the time of rupture
3. Is equal to torsional rigidity
4. **Is ability to resist maximum twisting moment**

**14-For same weight, same material, same length**

1. Solid shaft is always stronger than a hollow shaft
2. **Solid shaft is always weaker than a hollow shaft and strength ratio will depend upon Do/Di of hollow shaft**
3. Strength of both the shafts in equal
4. Strength of a solid shaft is always weaker and the strength ratio will depend upon Do/Di of hollow shaft

**15-For same length, same material, same length**

1. Weight of solid shaft is less than weight of hollow shaft
2. Weight of solid shaft is more than weight of hollow shaft
3. Weight of hollow and solid shafts will be same
4. **Sometime more sometime less**

**Unit-II**

**COLUMNS AND STRUTS**

**Important points / Definitions:**

1. **Difference between column and strut?**

Basic difference between Strut and column:

Both the Strut and Column are compression structural members. Struts fail due to buckling, but columns fail in compression. Slenderness ratio of struts is high, whereas it is low for columns.

1. **mean by column and strut?**

Columns and struts: Structural members subjected to compression and which are relatively long compared to their lateral dimensions are called columns or Struts. Generally, the term column is used to denote vertical members and the term strut denotes inclined members

1. **What is strut in civil engineering?**

A strut is a structural component commonly found in engineering, aeronautics, architecture and anatomy. Struts generally work by resisting longitudinal compression, but they may also serve in tension.

1. **What is a strut in a structure?**

In general a “strut” is a rigid triangulated member of a structural framework of some kind, which carries loads in either tension or compression to help keep the structure as a whole in proper alignment. For instance, a load bearing building structure such as a bridge or a roof truss may contain strut.

1. **What is strut in structure?**

Answered Nov 2, 2017. Both column and a strut are compression members. Strut- It is mostly used in roof trusses and steel bridges. The main purpose of strut is to maintain the rigidity of the structure and to take compressive forces (axial). It is not designed to take any gravity loads

1. **What is discontinuous strut?**

The discontinuous members may consist of single angle strut or double angle strut. When an angle strut is connected to a gusset plate or to any structural member by one leg, the load transmitted through the strut, is eccentric on the section of the strut

1. **What is the difference between a strut and a tie?**

All structures have forces acting on them. You should have an understanding of tensile, compressive and shear forces (see previous sheet). The part of the structure that has a tensile force acting on it is called a TIE and the part that has a compressive force acting on it is called a STRUT.

1. **What is meant by short strut?**

What are the lengths of a short and long strut of the standard A truss? A strut is glued to a horizontal surface AB.

1. **What is the difference between short and long column?**

A column is considered to be short if the ratio of effective length to its least lateral dimension is less than or equal to 12. A column is considered to be long if the ratio of effective length of column to its least lateral dimension is greater than 12. ... The failure of the short column is by crushing

1. **What is slenderness ratio of column?**

Slenderness ratio is the ratio of the length of a column and the least radius of gyration of its cross section. Often denoted by lambda. It is used extensively for finding out the design load as well as in classifying various columns in short/intermediate/long

1. **What is strut in truss?**

Ties and struts. ... Compression members in trusses are called struts and these are members which are being shortened. The industry convention shows arrows which are pushing outwards. Compare this to the compression in a beam in which the forces push inwards as shown in the bottom diagram

1. **What is buckling of column?**

Introduction to column buckling. • Buckling: “Buckling can be defined as the sudden large deformation of structure due to a slight increase of an existing load under which the structure had exhibited little, if any, deformation before the load was increased.”

1. **What is the purpose of a strut?**

They provide support to the suspension springs. Their main job is to act as shock absorbers to support the weight of the vehicle and ensure a smooth ride. Shocks and struts are terms often used interchangeably, but there are differences. Many vehicles come with struts on the front, and shocks on the back end.

1. **How does a strut work?**

Internally, a strut is similar to a shock absorber. A piston is attached to the end of the piston rod and works against hydraulic fluid to control spring and suspension movement. ... Struts also perform a second job. Unlike shock absorbers, struts provide structural support for the vehicle's suspension.

1. **What is strut channel used for?**

Strut channel is used to mount, brace, support, and connect lightweight structural loads in building construction. These include pipes, electrical and data wire, mechanical systems such as ventilation, air conditioning, and other mechanical systems.

1. **What is strut and tie model?**

Strut and Tie Modelling (STM) is a simple method which effectively expresses complex stress patterns as triangulated models. ... The intention of The Concrete Centre publication, Strut-and-Tie Models is therefore to give guidance and impart understanding of the method.

1. **What is compression strut?**

connect compression strut systems made from unalloyed structural steel or stainless steel are approved by the building authority and can absorb tensile forces, yet they are specially designed to absorb and distribute compressive forces.

**Short Questions**

|  |  |  |
| --- | --- | --- |
| 1 | Define column and effective length of a column. Distinguish between a column and a strut | May-2016 |
| 2 | Distinguish between short column and long column | May-2016 |
| 3 | Define slenderness ratio, crippling load | Dec -2016 |
| 4 | Explain the Limitations of Euler‘s Formula? | Dec-2016 |
| 5 | What are the assumptions made in Euler‘s theory to arrive at buckling load on column | May-2017 |
| 6 | Calculate the slenderness ratio of a strut made from a hollow tube of 20mm outside diameter, 16mm inside diameter and 1.2m long. | May2017 |
| 7 | State the secant formula and explain each of the terms in it | Dec-2018 |
| 8 | Why is it necessary to use the minimum radius of gyration of a section to calculate the crippling load? | May-2018 |
| 9 | What is the slenderness ratios of the column of square section of 30 mm side and length 2 m | Dec-2018 |
| 10 | Explain the parameters influencing buckling load of a long column | May-2015 |

**Long Questions**

|  |  |  |
| --- | --- | --- |
| 1 | Derive the equivalent length of a column whose both ends are hinged using Euler’s theory. | **May -2018** |
| 2 | The channel section shown in figure is used as a column, 3 m long, with both ends hinged. Compare the load carrying capacities obtained using Euler’s and Rankine’s formulae. E = 200 GPa and σy= 300 MPa. | **Dec-2016** |
| 3 | A hollow steel strut, 2.4 m long, is pin-jointed at the ends. It has an outer diameter of 40 mmand a thickness of 5 mm. If the yield stress is 320 N/mm2 and E = 200 GPa, comparethe crippling load given by Euler’s and Rankine’s formulae. Also determine the minimum l/rratio for which Euler’s formula applies. | **May-2018** |
| 4 | Determine the safe axial load a timber column of cross-sectional area150mm X 150mm and of 4m length can carry using a factor of safety, 8.Take E = 10kN/mm2and for (a)hinged ends (b) fixed ends (c)one end freeand other end fixed (d)one end hinged and other end fixed | **Dec-2015** |
| 5 | Derive the maximum bending moment, maximum shear force for a circular beam loaded uniformly and supported on symmetrically placed columns | **Dec-2017** |
| 6 | What is the ratio of strength of a solid steel column of 150mm diameter tothat of a hollow circular steel column of the same crosssectional area anda wall thickness of 15mm? The two columns have the same length andhave pinned ends. | **May-2017** |
| 7 | From the Euler’s crushing load for a hollow cylindrical cast iron column, 150mm external diameter and 20mm thick, if it is 6m long and hinged atboth ends. Compare this load with that obtained by the Rankinesformulausing constants 550N/mm2 and 1/1600. For what length of the columnwould these twoformulae give the same crushing loads? E for thematerial = 80kN/mm2 | **Dec-2015** |
| 8 | A steel column consists of two channels ISMC 300 X 35.8 kg/m placedback to back at a clear distance of 15cm and two plates of 350mm X20mm are connected to the flanges. Find the crippling load for thecolumn if the distance between the hinged ends is 8m. Take E =210kN/mm2Properties of channel sections:Area of cross-section of each channel = 45.64cmIxx = 6362.6 cmIyy = 310.8 cmCry = 2.36 cmThickness of web = 7.6mmThickness of flange = 13.6mm | **May-2015** |
| 9 | Compare the critical stresses using Euler’s and Rankine’s formulae for struts with slendernessratios 50, 100, 150, and 200. Assume that both ends are hinged. E = 200 GPa, Rankine’s constant = 1/7500, and σy = 300 MPa. | **Dec-2018** |
| 10 | Derive the equivalent length of a column for which both ends are fixed using Euler’s theory | **May-2016** |

**Fill in the Blanks / Choose the Best:**

### 1. The load at which a vertical compression member just buckles is known as

(a) Critical load

(b) Crippling load

(c) Buckling load

**(d) Any one of  these**

2. A column that fails due to direct stress is called

**(a) Short column**

(b) Long column

(c) Medium column

(d) Slender column

### 3. A column whose slenderness ratio is greater than 120 is known as

(a) Short column

**(b) Long column**

(c) Medium column

(d) Composite column

### 4. The direct stress included in a long column is………….. as compared to bending stress.

(a) More

(b) Less

(c) Same

**(d) Negligible**

### .5. For long columns, the value of buckling load is……………..crushing load.

**(a) Less than**

(b) More than

(c) Equal to

(d) None of these

### .6. The slenderness ratio is the ratio of

**(a) Length of column to least radius of gyration**

(b) Moment of inertia to area of cross-section

(c) Area of cross-section to moment of inertia

(d) Least radius of gyration to length of the column

### 7. Compression members always tend to buckle in the direction of

(a) Vertical axis

(b) Horizontal axis

(c) Minimum cross-section

**(d) Least radius of gyration**

### 8. A column has moment of inertia about X-X and Y-Y axis as follows

### IXX=4234.4 mm4

### IYY=236.3 mm4

### This column will buckle about

(a) X-X axis

**(b) Y-Y axis**

(c) It depends upon the applied load

(d) None of these

### 9. The Rankine formula holds good for

(a) Short column

(b) Long column

(c) Medium column

**(d) Both short and long column**

10. A column of length 4m with both ends fixed may be considered as equivalent to a column of length ………….with both ends hinged.

(a) 2 m

(b) 1 m

(c) 3 m

**(d) 6 m**

### 11. According to Euler, the buckling load for a column is given by http://engineering.myindialist.com/wp-content/uploads/2015/04/041015_0548_FifteenMCQs1.png. In this equation, the value of x for a column with one end fixed and other end free is

(a) 1

(b) 2

**(c) 4**

(d) 1/2

### 12. According to Euler, the buckling load for a column is given by http://engineering.myindialist.com/wp-content/uploads/2015/04/041015_0548_FifteenMCQs2.png. In this equation, the value of x is minimum when

**(a) Both ends fixed**

(b) One end fixed, other free

(c)Both ends hinged

(d) One end fixed other hinged

### 13. Rankine’s formula is generally used when slenderness ratio lies in between

(a) 0-60

(b) 0-80

(c) 0-100

**(d) Any value**

### 14. Euler’s formula is not valid for mild steel column when slenderness ratio is

(a) More than 100

(b) Less than 100

**(c) Less than 80**

(d)More than 80

### 15. An electric pole is 6.5 m high from the ground level. Its effective length for design purposes will be

(a) 6.5 m

(b) 3.25 m

**(c) 13.0 m**

(d) 12.0 m