Maximum shear stress theory also called

Option 2 : Guest's theory Free 20 Questions 20 Marks 20 Mins Explanation: Maximum Shear Stress Theory: Applied satisfactorily to ductile materials. This theory states that the failure can be assumed to occur when the maximum shear stress in the complex stress system is equal to the value of maximum shear stress in simple tension. The relation between the theories of failure, their suitable materials, and graphical representation is given below. Theory Suitable Material Graphical Representation Maximum Normal Stress Theory Or Maximum Principal Stress Theory Or Rankine's Theory Brittle material Maximum Normal Strain Theory Or Maximum Principal Strain Theory Or St.Venant's Theory Ductile and brittle material but results are not accurate in both Maximum Shear Stress Theory Or   Guest & Tresca's Theory Ductile material Maximum Strain Energy Theory Or Haigh and Beltrami Theory Ductile material Maximum Shear Strain Energy Theory Or Distortion Energy Theory Or Von Mises Henky Theory Ductile material India's #1 Learning Platform Start Complete Exam Preparation Daily Live MasterClasses Practice Question Bank Mock Tests & Quizzes Get Started for Free Download App Trusted by 2,66,33,453+ Students Today we will understand here the theories of failure, in strength of material, with the help of this post. As we know very well that when a body or component or material will be subjected with an external load, there will be developed stresses and strains in the body or component. As per hook's law, stress will be directionally proportional to the strain within the elastic limit or we can say in simple words that if an external force is applied over the object, there will be some deformation or changes in the shape and size of the object. Body will secure its original shape and size after removal of external force. Within the elastic limit, there will be no permanent deformation in the body i.e. deformation will be disappeared after removal of load. If external load is applied beyond the elastic limit, there will be a permanent deformation in the body i.e. deformation will not be disappeared after removal of load. Component or material or body will be said to be failed, if there will be developed permanent deformation in the body due to external applied load. Theories of failure help us in order to calculate the safe size and dimensions of a machine component when it will be subjected with combined stresses developed due to various loads acting on it during its functionality. There are following theories as listed here for explaining the causes of failure of a component or body subjected with external loads. 3. The maximum shear stress theory 4. The maximum strain energy theory 5. The maximum shear strain energy theory We will now understand here the maximum shear stress theory with the help of this article. The maximum shear stress theory is also termed as Guest and Tresca's theory and this theory is only used for ductile materials. According to the theory of maximum shear stress, "The failure of a material or component will occur when the maximum value of shear stress developed in the body exceeds the limiting value of shear stress i.e. value of shear stress corresponding to the yield point of the material". Let us explain the maximum shear stress theory by considering here one component which is subjected with an external load and we have drawn here the stress-strain curve as displayed in following figure. Point A – It is proportionality limit; up to this point hooks law will be followed. Point B – Elastic limit, up to this point the deformation will be elastic. Point C – Lower yield stress. Point D – Ultimate stress, it is the maximum value of stress in stress – strain diagram. Point E- It is the fracture point, up to this point the material will have only elastic & plastic deformation ,but at this point fracture or rupture take place. If maximum value of shear stress developed in the body exceeds the value of shear stress corresponding to the point D, failure will take place. Therefore in order to avoid the condition of failure of the component, maximum value of shear stress developed in the body must be below than the value of shear stress corresponding to the point D. Maximum value of shear stress developed in the body > Yield strength in shear under tensile test i.e. value of shear stress corresponding to the yield point of the material Let us consider that σ1, σ2 and σ3 are the principle stresses at a point in material and σt is the principle stress in simple tension at elastic limit. Now as we know that maximum shear stress at a point in the material will be equal to the half of difference between maximum and minimum principle stress and therefore we will have following equation. Let us determine the value of shear stress corresponding to the yield point of the material. In case of simple tension, Stress will be available in one direction only and therefore at elastic limit, principle stresses will be σt, 0 and 0. Value of shear stress corresponding to the yield point of the material = (1/2) x σt Let us write here the condition of failure (1/2) x (σ1- σ3) > (1/2) x σt Maximum value of shear stress developed in the body ≤ Permissible value of shear stress (τPer) Permissible shear stress is basically defined as the ratio of yield strength in shear under tensile test i.e. value of shear stress corresponding to the yield point of the material to the factor of safety. Permissible shear stress = Yield strength in shear under tensile test / F.O.S Permissible shear stress = Value of shear stress corresponding to the yield point of the material / F.O.S Permissible shear stress = (σt /2)/ F.O.S Permissible shear stress = σt / (2 x F.O.S) For tri-axial state of stress For tri-axial state of stress, we will have following equation Do you have suggestions? Please write in comment box. We will now discuss the maximum strain energy theory, in the category of strength of material, in our next post. Strength of material, By R. K. Bansal report this ad State the theories of elastic failure. Explain maximum normal stress theory and maximum shear stress theory with equations. Or Explain Maximum shear stress theory. {Maximum shear stress theory is also called as?} Theories of Failures Maximum shear stress theory is explained below The principal theories of failure for a member are as follows: (i) Maximum principal or normal stress theory (ii) Maximum shear stress theory (iii) Maximum principal or normal strain theory (iv) Maximum strain energy theory (v) Maximum distortion energy theory Maximum normal stress theory (Maximum principal stress theory or Rankines theory According to this theory, the elastic failure occurs when the greatest principal stress reaches the elastic limit value in a simple tension test irrespective of the value of other two principal stresses. Taking factor of safety (F. S.) into consideration, the maximum principal or normal stress (σt) is given by, σt = σyt / F. S. (for ductile materials) σt = σu / F. S. (for brittle materials) where, σyt = Yield point stress in tension as determined from simple tension test σu = Ultimate stress This theory ignores the possibility of failure due to shear stress, therefore it is not used for ductile, However, for brittle materials which are relatively strong in shear but weak in tension and compression, this theory is generally used. This theory is also known as maximum principal stress theory or Rankine's theory. Maximum Shear Stress Theory (Guest's theory or Tresca's theory) Maximum Shear Stress Theory According to this theory, the failure or yielding occurs at a point in a member when the maximum shear stress reaches a value equal to the shear stress at yield point in a simple tension test. Mathematically, τmax = τyt / F. S. where, τmax = Maximum shear stress τyt = Shear stress at yield point as determined from simple tension test F. S = Factor of safety. Since the shear stress at yield point in a simple tension test is equal to one half the yield stress in tension, therefore τmax = σyt / (2 x F. S.).This theory is mostly used for designing members of ductile materials. This theory is also known as Guest's theory or Tresca's theory. ===================Answer to question ends here======================= For further understanding and details follow following material. Failure is generally perceived to be fracture or complete separation of a member. However, failure may also occur due to excessive deformation (elastic or inelastic) or a variety of other reasons. Failure Modes 3 Excessive elastic deformation Yielding Fracture stretch, twist, or bending buckling vibration plastic deformation at room temperature creep at elevated temperatures yield stress is the important design factor sudden fracture of brittle materials fatigue (progressive fracture) stress rupture at elevated temperatures ultimate stress is the important design factor During the latter part of the 19th century and continuing up to the present, a number of basic failure theories were proposed and tested on a few materials.1 Most of the theories were based on the assumption that failure occurs when some physical variable such as stress, strain, or energy reaches a limiting value. Deformation: Elastic deformation is temporary (reversible) and involves bond stretching. Plastic deformation is permanent (irreversible), and involves bond breaking. Fracture is catastrophic. 202003/LectureNotes/ Classification System for Mechanical Failure Modes 4 Stress Theories Maximum Principal Stress Theory (Rankine, Lamé) Applied satisfactorily to many brittle materials, the theory is based on a limiting normal stress. Failure occurs when the normal stress reaches a specified upper limit.1 Failure is predicted when either of the principal stresses, σ1 or σ2, equals or exceeds the yield strength, σyp, of the material.3 σ1 < σyp σ2 < σyp Examples Click on image for full size. Maximum Shear Stress Theory (Tresca, Guest, Coulomb) Applied satisfactorily to ductile materials, the theory is based on the concept of limiting shearing stress at which failure occurs.1 Failure by yielding in a more complicated loading situation is assumed to occur when the maximum shearing stress in the material reaches a value equal to the maximum shearing stress in a tension test at yield. This yield criterion gives good agreement with experimental results for ductile materials; because of its simplicity, it is the most often used yield theory.2 The main objection to this theory is that it ignores the possible effect of the intermediate principal stress, σ2. However, only one other theory, the maximum distortional strain energy theory, predicts yielding better than does the Tresca theory, and the differences between the two theories are rarely more than 15%. Failure is predicted when any of the three shear stresses corresponding to the principal stresses, σ1,2, equals or exceeds the shear stress corresponding to the yield strength, σyp, of the material in uniaxial tension or compression.3 Maximum Octahedral Shearing Stress Theory Failure by yielding in a more complicated loading situation is assumed to occur when the octahedral shearing stress in the material reaches a value equal to the maximum octahedral shearing stress in a tension test at yield. Plane stress case Uniaxial stress case Note: This theory gives the same results as the maximum distortion energy theory. Strain Theories Maximum Principal Strain Theory (Saint-Venant) The theory is based on the assumption that inelastic behavior or failure is governed by a specified maximum normal strain.1 Failure will occur at a particular part in a body subjected to an arbitrary state of strain when the normal strain reaches a limiting level. Failure is predicted when either of the principal strains, resulting from the principal stresses, σ1,2, equals or exceeds the maximum strain corresponding to the yield strength, σyp, of the material in uniaxial tension or compression.3 σ1 - ν(σ2 + σ3) < σyp Total Strain Energy Theory (Beltrami-Haigh) Applicable to many types of materials, the theory predicts failure or inelastic action at a point when the strain energy per unit volume exceeds a specified limit.1 Failure is predicted when the total strain energy associated with the principal stresses, σ1,2, equals or exceeds the total strain energy corresponding to that for the yield strength, σyp, of the material in uniaxial tension or compression.3 σ12 + σ22 + σ32 -2ν(σ1σ2 + σ2σ3 + σ1σ3) < σyp2 Maximum Distortion Energy Theory (Huber-Henky-von Mises) The theory is based on a limiting energy of distortion, i.e. energy associated with shear strains.1 Strain energy can be separated into energy associated with volume change and energy associated with distortion of the body. The maximum distortion energy failure theory assumes failure by yielding in a more complicated loading situation to occur when the distortion energy in the material reaches the same value as in a tension test at yield. This theory provides the best agreement between experiment and theory and, along the Tresca theory, is very widely used today.2 Note: This theory gives the same results as the octahedral shear stress theory. Failure is predicted when the distortional energy associated with the principal stresses, σ1,2, equals or exceeds the distortional energy corresponding to that for the yield strength, σyp, of the material in uniaxial tension or compression.3 0.5 ((σ1 - σ2)2 + (σ2 - σ3)2 + (σ3 - σ1)2) < σyp2 Summary Of the failure criteria, the Tresca is the most conservative for all materials, the von Mises the most representative for ductile materials, and the Rankine the best fit for brittle materials.3 Laminated-Composite Failure Envelopes More on failure theories Below is a summary of two of most popular theories of failure applied to a simple uniaxial stress state and to a pure shear stress state. Failure Criteria Theory Loading Relationship Uniaxial Pure Shear Maximum principal stress σmax = σYP σmax = τYP τYP = σYP Maximum principal strain εmax = σYP / E εmax = 5τYP / 4E τYP = 0.8 σYP Maximum octahedral shear stress τYP = 0.577 σYP Maximum distortional energy density   τYP = 0.577 σYP Maximum shear stress τmax = σYP / 2 τmax = τYP τYP = 0.5 σYP References Mechanics of Wood and Wood Composites, by J. Bodig & B.A. Jayne, Krieger Publishing, 1993, pp. 314-5. The Science and Technology of Civil Engineering Materials, by J.F. Young, S. Mindess, R.J. Gray, & A. Bentur, Prentice Hall, 1998, pp. 115-7. "Failure Prediction and Avoidance," Experimental Stress Analysis Notebook, Issue 22, Dec. 1993, Measurements Group, pp. 6-11. Failure of Materials in Mechanical Design - Analysis Prediction Prevention, by J. A. Collins, John Wiley and Sons, 1981, pp. 6-8.