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Exam Preparatory Manual for Undergraduates

Dental Material Science

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4 CHAPTER

Mechanical Properties of Dental Materials

Q. 1. What are mechanical properties?
Ans. Mechanical properties are defined by the laws of mechanics, that is the physical science that deals with the energy and forces and their effects on bodies and the resultant motion, deformation or stresses that those bodies experiences.

Q. 2. What is force?
Ans. Force is an agency or influence that, when exerted on a body tends to set the body into motion or to alter its present state of motion. Force when applied to any material causes deformation of that material. The unit of force is c/a Newton or Pound. Force is that which alter the state of rest or motion possessed by a body. It has three characteristics:
1. Point of application,
2. Magnitude and
3. Direction of application.

Q. 3. What is stress?
Ans. Stress is the internal resistance or force to an applied external load. It is equal and opposite of the load. It is the force per unit area within a structure subjected to an external force or pressure or load.

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

Q. 4. What is strain?
Ans. It is the deformation due to stress. It is the change in length per unit original (initial) length when stress is applied. Strain may be either elastic or plastic or a combination of both. Elastic strain is reversible while plastic strain is permanent.

$$\text{Strain} = \frac{\text{Change in length}}{\text{Per unit original length}}$$

Q. 5. What is plastic and elastic strain?
Ans. If the deformation disappears after stress is removed it is called elastic stress. And if deformation remains permanent even after removal of stress then it is plastic stress.

Plastic strain is the irreversible deformation that remains when the externally applied force is reduced or eliminated.

Elastic strain is the amount of deformation that is recovered instantaneously when an externally applied force or pressure is reduced or eliminated.

Q. 6. What are the types of stress and strain?
Ans. Different types of stress and strains are:
- Tensile stress and strain
- Compressive stress and strain
- Shear stress and strain.

Tensile stress is the ratio of tensile force to the original cross sectional area perpendicular to

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the direction of applied force. A tensile stress is caused by a load that tends to stretch or elongate a body. Strain under tensile is an elongation in the direction of loading.

Compressive stress is the ratio of compressive force to cross-sectional area perpendicular to the axis of applied force. If a body is placed under a load that tends to compress or shorten it, the internal resistance to such a load is called as compressive stress. Strain under compressive stress is shorting of the body.

Shear stress is the ratio of force to the original cross sectional area parallel to the direction of the force applied to a test specimen. Shear stress tends to resist the sliding or twisting of one portion of a body over another.

All types of stresses are accompanied by strains.

Q. 7. What is strength?

Ans. Strength is the ability of the material to resist breaking up.

It is the maximum stress required to fracture, or cause permanent damage or deformation of a structure. It is the maximum stress that a structure can withstand without sustaining a specific amount of plastic strain or stress at the point of fracture.

Ultimate strength is the point at which the material breaks. Materials should have strength to withstand stresses due to the forces of mastication.

Types of strength depend on the types of stress applied.

Tensile strength is the strength which resists fracture when material is pulled apart.

Compressive strength is the strength which resists under pressing or load from above.

Flexure or transverse strength is the strength which resists bending which involves complex stresses and strains.

Fatigue strength is the strength which resists repeated stresses falling on it over and over again.

Tear strength is the capability of a material to withstand fracture under tearing force

Impact strength is the strength which resists fracture under impact or motion.

Impact strength may be defined as the energy required for fracturing a material under an impact force.

Impact force is a dynamic force in its reaction during collision with a structure.

It is the energy of the impact of teeth on the food bolus which determines the effectiveness of the mastication.

Q. 8. What is Poisson's ratio?

Ans. The ratio of strain in the direction perpendicular to the stress. All materials change shape in three dimensions even if the stress is in one direction. The strain in the direction of force is called as longitudinal strain and that perpendicular to it is called as lateral strain. The ratio between lateral strain and longitudinal strain is called as Poison's ratio.

$$\text{Poison's ratio} = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

Q. 9. What is flexural (bending) stress and strength?

Ans. Flexural stress is the force per unit area of a material subjected to flexural loading and flexural strength or modulus of rupture is the force per unit area at the point of fracture subjected to flexural loading. These stresses are produced by bending forces in the dental appliances.

Q. 10. What is Young's modulus of elasticity?

Ans. Young's modulus of elasticity (YMOE) is the ratio of elastic stress to strain. Or it is a measure of relative stiffness or rigidity of a material within the elastic range.

$$\text{YMOE} = \frac{\text{Stress (longitudinal)}}{\text{Strain (elongation)}} = \frac{\text{F/A}}{\text{Lc/Lo}}$$

F = Force, **A** = Area, **Lc** = Change in length, **Lo** = Original length.

Q. 11. What is brittleness?

Ans. Brittleness is the relative inability of a material to deform plastically before it fractures. It is the tendency to fracture without appreciable deformation. It is opposite of ductility.

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Q. 12. What is proportional limit?
Ans. Proportional limit is the maximum stress on which stress is proportional to strain and above which plastic deformation occurs. It is the limit of stress above which stresses are no longer proportional to strain. It is the greatest stress that a material will sustain without deviation from the proportionality of stress to strain.

Q. 13. What is elastic limit?
Ans. It is the greatest force which makes an object to go out the shape, yet shape is regained when force is removed. It is the greatest stress to which a material may be subjected and still be capable of returning to its original dimensions when forces are released (GPT).

Q. 14. What is torsion and bending?
Ans. Torsion is the twisting force while bending is a combination of several types of stresses.

Q. 15. What is Hook's law?
Ans. It is a fundamental law which states that the stress is directly proportional to the strain in elastic deformation. It states that the direct proportionality between two quantities is always a straight line graphs.

Q. 16. What is yield strength or proof stress?
Ans. Yield strength is the stress at which a test specimen exhibits specific amount of plastic strain. It is the point at which the material begins to yield and change occur. This point is slightly higher than proportional limit.

Q. 17. What is flexibility?
Ans. It is the ability to bend within its elastic limit. Maximum flexibility is defined as the flexural strain that occurs when material is stressed to its proportional limit, e.g. Impression materials should be flexible for easy removal from the undercut areas. Or in orthodontic appliance a spring which is bent due to stress should be flexible. The maximal flexibility is defined as the strain which occurs when the material is stressed to its proportional limit.

Q.18. What is resiliency?
Ans. Resiliency is relative amount of elastic energy per unit volume released on unloading of a test specimen. It is defined as the amount of energy absorbed by a structure when it is stressed not to exceed its proportional limit. Resilience is measured in terms of modulus of resilience.

$$R = \frac{P2}{2E}$$

R = Modulus of resilience, **P** = Proportional limit, **E** = Modulus of elasticity.

Resilience is associated with springiness. Resilience of a material is usually measured in terms of its modulus of resilience which is the amount of energy stored in a body when one unit volume of a material is stressed to its proportional limit. It is the energy needed to deform the material to its proportional limit, e.g. resilient liners.

Q. 19. What is toughness and fracture toughness?
Ans. Toughness is the property of being difficult to break. It can be defined as the energy required to fracture a material.

It is the ability of a material to withstand stresses and strains without breaking.

Presence of cracks, defects or porosities in the material makes it to fracture easily. Toughness is the ability of the material to absorb elastic energy and to deform plastically before fracturing. It is measured as the total area under a plot of tensile stress verses tensile strain.

Metal has high fracture toughness and glass has low fracture toughness.

Q. 20. What is transformation toughening?
Ans. It is a method of adding zirconium oxide to ceramic material for increasing fracture resistance by preventing crack formation.

Q. 21. What is stress relaxation?
Ans. It is slow reduction in force over a period of time.

Q. 22. What is strain hardening?
Ans. Increase in strength and hardness and corresponding decrease in ductility of metal that is caused by plastic deformation is known as strain or work hardening.

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Q. 23. What is ductility?

Ans. Relative ability of a material to withstand permanent deformation (to deform plastically) under a tensile load before it fractures is called as ductility. It is the property of metal which allows it to be drawn into wires under tensile stress, e.g. gold, silver, platinum. Ductility is dependent upon plasticity and tensile strength.

Q. 24. What is malleability?

Ans. It is the property of a metal to be hammered or rolled into sheets without breaking it under compressive load. It represents the ability of a material to sustain a large permanent deformation under a compressive load. It is dependent on plasticity only, e.g. gold, silver, copper, stainless steel orthodontic wires and stainless steel denture base.

Q. 25. What is pressure?

Ans. Force per unit area acting on the external surface of a material is called as pressure.

Q. 26. What is hardness?

Ans. Hardness is the resistance of a material to being indented, cut and scratched or it is the resistance to indentation or scratching.

Q. 27. What are the standard hardness tests?

Ans. Standard hardness test are the indentation test. Different hardness test are:

Macro hardness tests are—

- Brinell test done by steel ball for metals. Here the diameter is measured.
- Rockwell test by steel ball or cone shaped diamond point. Here the depth of indentation is measured. Applied for materials that exhibit elastic recovery.

Micro hardness tests are—

- Vickers test by square based pyramid shaped diamond.
- Knoop test by rhombic shaped diamond tool.

Q. 28. What is Moh's scale?

Ans. It is the scale to determine hardness of minerals developed by Frederick Moh in 1822.

In the scale there are 10 minerals arranged in the order of increasing hardness. 01 is the smallest, e.g. Talc and 10 is the hardest, e.g. diamond.

- Knoop hardness for enamel 300 KHN
- Dentine 65 KHN
- Amalgam 90 KHN
- Composite 55 KHN
- Pure gold 32 KHN
- Acrylic resin 16 KHN

Q. 29. What is flow?

Ans. Flow is the deformation under static load before the material has completely hardened. It is the ability of a material to undergo plastic deformation by the external force or by its own weight. Factors affecting flow are temperature, load applied and time for which force is applied.

Q. 30. What is stress concentration?

Ans. When a stress is focused around a crack or defect in a material it breaks easily. Stress concentration is an area or point of significantly higher stress associated with a structural discontinuity such as crack or pores or a marked change in dimension of a structure.

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Dental Material Science

Salient Features

- Deals with all the materials used in dentistry for clinical as well as laboratory procedures
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- Covers Dental Material Science Syllabus in Question-Answer format
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