BDS Second Professional 2007
Science of Dental Materials (SEQs)
MODEL PAPER

Marks: 45 **Time: 2 hours 15 min**
Note: 3 marks for each SEQ
Total No. of SEQs 15

Q1. a. Define Creep and what are types of Creep?
b. Define Coefficient of thermal expansion and explain its dental application.

Table of Specification:
a. Physical Properties of Dental Materials.
b. Thermal Properties of Dental Materials.

Key:
a. Creep
Definition: Time-dependent plastic deformation is creep, for example,
When a metal is melted and held at a temperature close to its melting point and then subjected to a static load, the resultant strain, which is produced occurs over a period of time, and this strain is called creep.
Types:
i. Static
ii. Dynamic

Static creep: It is a time-dependent deformation produced in a completely set solid subjected to a constant stress.
Dynamic creep: It is when the applied stress is fluctuating such as a fatigue-type stress or masticatory forces.

b. Coefficient of Thermal Expansion
<u>DEFINITION</u>
The change in length per unit length of the material for 1ºC change in temperature is called: the linear coefficient of thermal expansion.
Units: m m/cm/ºC
(microns / cm / °C)
Dental Application
i. Selection of metals for bonding with ceramics. The metal should have the same or nearly same coefficient of thermal expansion. This is important for metal ceramic bonding.
ii. In casting investments the thermal expansion property of silica is used. The amount of expansion on heating is ‘critical for all the 4 crystalline forms of silica. Cristobalite has got the greatest expansion at the lowest temperature. This form is widely used in dental investments.
iii. In waxes, thermal expansion and cooling at room temperature causes distortion.

Reference: Restorative Dental Materials by Robert Craig.

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Q2. a. Define stress and strain. What are different types of stress?
b. What is stress – strain curve?

Table of Specification: Mechanical Properties.

Key:

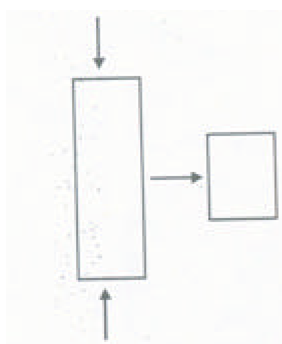
Strees
Strees is force per unit area.
Strees = load / area
Unit = pounds per sq. inch.
Strain
Strain is the change in length to the original length.

Strain = $\frac{[\text{Change in length}]}{Originallength}$

The compression or elongation of a loaded object is measured in terms of fractional change in length.

Types of stress

According to the Direction of Forces compression: it is a pushing or crushing stress



Compressive force applied reduction in length

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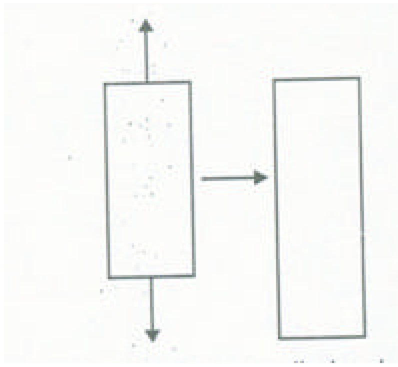
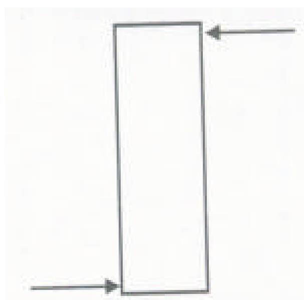
Tesion: it is a pulling stress.



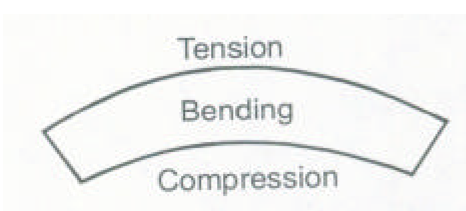
Tensile force applied – elongation or increase in length.

Shear (Slip): Stress occurs when parts of an object slide past one another.



Shear Stress – sliding occurs

Torsion: it is a twisting force.
Bending: Alternate compression and stretching occurs during bending.

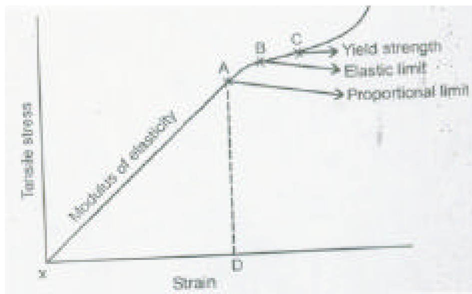


Bending-alternate compression and stretching occurs.

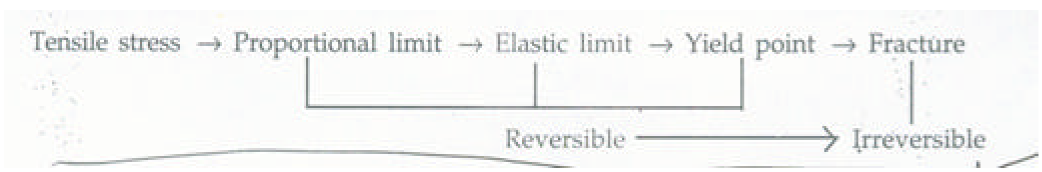
- Particular type of stress produces the corresponding type of strain.
- Usually no single pure stress occurs; a combination of stresses occurs.

b. Stress-Strain Curve

A convenient method of comparing the mechanical properties of materials is to apply various types of forces to the materials and determine the changes in stress and strain. A graph thus plotted with stress against strain gives the stress strain curve.



Stress-strain curve



Reference: Restorative dental material by Robert Craig.

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Q 3. Classify Gypsum products?

Table of specification: Gypsum Products

Key:

Classification and Types of Gypsum Products
Type I : Impression plaster
Type II : Model plaster
Type III : Dental stone or class I stone or Densite type
Type IV : High strength or class 11 stone or improved stone
Type V : High strength and high expansion stone

1. Type I: Impression plaster
   i. Modified model plaster.
   ii. Chemically it is 3—calcium sulfate hemi hydrate.
   iii. Used for making final wash impressions for complete denture patients.

2. Type II: Model plaster
   i. It is a laboratory material used to make casts.
   ii. Chemically it is 3—calcium sulfate hem '- hydrate.
   iii. It has less strength than other products.
   iv. More porous in nature due to irregular crystal shape.

3. Type III: Dental stone
   i. Used to make master casts for fabrication of final prosthesis.
   ii. Chemically it is a-calcium sulfate herni hydrate.
   iii. Has higher abrasion resistance and strength than model plaster.
   iii. Less porous due to regular crystal form and greater number of crystals.

4. Type IV: Die stone
   1. Used to make dies (single tooth positive reproduction).
   ii. These materials especially require greater abrasion resistance.
   iii. They have higher strength than stone or model plaster.

5. Type V: High strength and high expansion type
   i. In addition. to increased strength these materials have greater setting expansion.
   ii. This is to compensate for casting shrinkage of base metal alloys.

Reference: Notes on dental material by EC Comb

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Q4. a. What is the composition of alginate
b. Define the gellation process?

Table of specification: Impression Materials

Key:

Composition

Alginic acid is prepared from a marine plant and is a linear polymer of anhydro a —D mannuronic acid of high molecular weight.
The solutions of potassium and sodium salts of alginic acid react with calcium salt and produce an insoluble elastic gel.

1. Sodium or potassium alginate salts (18%):
To dissolve in water.

2. Calcium sulfate dthydrate (14%): To react' with dissolved alginate to form insoluble calcium alginate.

3. Sodium phosphate (2%): To react with" calcium sulfate and serve as a retarder.

4. Diatomaceous earth (or) silicate powder (56 To control consistency of the mix and flexibility of the impression.

5. Potassium sulfate (or) potassium zinc chloride [silicates (or) borates (1O%)]: To counteract the inhibiting effect of alginate on setting of gypsum.

6. Organic glycol (Small): To coat the powder particles to minimize dust during dispensing (dustless alginate).

7. Disinfectants: Quaternary ammonium compounds (or) chiorhexidine (1-2%):

b. Gelation Process

Gelation is a sol-gel reaction. This process is a chemical reaction. Calcium sulfate reacts with sodium alginate (or) potassium alginate so rapidly to form insoluble calcium alginate that it does not allow sufficient working time. Trisodium phosphate which is a retarder, first reacts with calcium sulfate until there is no supply of the retarder.

$$2Na_3PO_4 + 3CaSO_4 \longrightarrow Ca_3(PO_4)_2 + 3Na_2SO_4)$$

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The remaining calcium sulfate reacts with odium or potassium alginate and forms insoluble calcium alginate and thus providing adequate working time.

K_2Alg + $nCaSO_4$ ---- nK_2SO_4 + CA_nAlg
(remaining) (insoluble calcium alginate)

Reference: Phillips Science of dental Materials.

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Q5. What is the composition, advantages & disadvantages of polyether Impression material?

Table of specification: Impression materials

Key:

POLYETHER IMPRESSION MATERIAL

Composition

Base Paste
i. Imine terminated polymer (polyether)— cross-links to form the set material.
ii. A colloidal silica as the filler gives bulk. fli. Glycol ether or phthalate acts as a plas ticizer. Gives bulk and controls viscosity.
Accelerator Paste
i. Alkyl aromatic sulfonate—initiates cross linkage.
ii. Colloidal silica as a filler—to form the paste.
iii. Plasticizers such as glycoether or .phthalate.

Advantages
1. Short working and setting time.
2. Proven accuracy.
3. Adequate tear strength.
4. Hydrophilic—better wetting.
5. Long shelf-life.
6. Less distortion on removal.
7. Good dimensional stability.

Disadvantages
1. Stiffness requires blocking of undercuts.
2. Slightly more expensive.
3. Multiple casts cannot be poured due to stiffness of the material.

Reference: Phillips Science of dental materials.

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Q6. What is the composition of inlay wax & its manipulation?

Table of specification: Dental Waxes

Key:

Composition

i. *Paraffin wax (40-60%)*
- Main ingredient.
- It determines the melting point.
- Main disadvantage is—it flakes when trimmed.
- It does not give a smooth surface, So to modify it other waxes are added.

ii. Ceresin (10%)
- It is added to partially replace paraffin.
- Reduces flakiness.
- Makes it easy to contour.

iii. Gum Dammar (1%) or Dammar resin
- It is a natural derivative from pine trees.
- Increases the finish and gives a smooth surface.
- Increases resistance to cracking and flaking making it harder.

iv. Carnauba wax (25%)
- It has a high melting point.
- It increases the hardness.
- It decreases the flow at mouth temperature.
- It gives glossiness to the surface.

v. Candellila wax
- It can be used instead of carnauba wax.
- It has a lower melting temperature than carnauba wax.
- It is not as hard as carnauba wax.

vi. Synthetic waxes
- In modern inlay waxes, carnauba wax is often replaced partly by certain synthetic waxes like Montan wax.
- They have high melting point.
- This allows greater paraffin cont€ of the wax which improves working Characteristics.

Manipulation of Inlay Wax

i. Direct Technique
- It is called so because the prepared cavity is recorded directly. The pattern is then invested.
- The inlay wax is manipulated over an open flame.
- The stick should be rotated over the flame for uniform heating.
- It is then placed into the cavity under finger pressure.
- It should be allowed to cool gradually to. mouth temperature.
- The pattern should be handled to the minimum to prevent temperature changes.

- It is, then invested.
- The main advantage of this technique is that it reduces time because there is no need to prepare a die.

ii. Indirect Technique

Pulled pattern technique.

- A die is prepared from. The impression.
- The die is coated with a die spacer to provide space for luting agent.
- A die lubricant is applied for easy removal of the pattern.
- The die is dipped into a was bath with melted inlay wax (dipping method).
  The pattern is made by adding additional layer of waxes (incremental wax addition technique)
- Finally the pattern is polished with a silk cloth.

Reference: Restorative dental material by Robert Craig

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Q 7. What are steps of processing of Denture base resin by compression moulding technique?

Table of specification: Non metallic denture base materials.

Key:

Processing of Denture Base Resins Compression Molding Technique

This is the most commonly used technique in the fabrication acrylic resin dentures.

Armentarium Required

i. Dental flask: It consists of a metallic flask and a clamp to hold the flask. The flask consists of three parts—the base, body and lid.
ii. Bench press: It is basically a clamping device which holds the flask. It has a clamp which should be tightened to apply pressure during packing.
iii. Acrylizer: A temperature controlled water bath.

consists of the following steps.

- Denture wax up—preparation of waxed denture pattern.
- Flasking the wax pattern—preparation Of the split mold.
- Dewaxing—elimination of wax.
- Preparation of mold—application of separating medium.
- Dispensing.
- Packing the resin—filling the mold space with resin.
- Trial closure.
- Curing-heating the resin to initiate poly merization.
- Bench cooling—the flask is allowed to cool to room temperature.
- Deflasking—the denture is removed from
- The investing medium.
- Finishing and polishing.

Preparation of the waxed de pattern:

i. After completion of the wax try-in in the patient a wax up should be done.
ii. This helps to give proper contour and mooth surface to the waxed pattern.
iii. If wax-up is done properly it minimizes the finishing time of the denture as it is easier to correct irregularities in wax than in resin.
iv. Bulky wax-up should be avoided. The additional bulk of acrylic resin may con tribute to the porosity and processing errors.
v. After the wax pattern has been contoured, it is smoothened by flaming and then it is polished with wet cotton.
vi. Then the completed pattern is sealed to the master cast by adding wax along the margins of the pattern.

Reference:Clinical handling of dental materials by B.N. Smith

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Q8. Classify the Composites by particle size, based on composition & base on application?

Table of Specification: Composites.

Key

CLASSIFICATION

Based on the Filler Particle

I. Lutz and Philips

a. Conventional -8-12 *m*.
b. Small particle -1-5 *m*.
c. Micro filled -0.04-0.4 *m*.
d. Hybrid -1.0 *m*.

II. According to the size of the filler

a. Mega fill 0.5 mm to 2 mm silane coated inserts of sizes 0.5 mm to 2 mm.
b. Macro fill 10 *m*—iOU*m*.
c. Midfill 1 *m*—lU *m*.
d. Minifill 01 *m*—i *m*.
e. Microfill O.Ol *m*—O.l *m*.
f. Nanofill 0.005 p to 0.01 p permits an overall filler level of 90 to 95 percent by weight.

Miscellaneous composites

- With sintered agglomerates.
- Traditional composites.
- Fiber-reinforced composites.

Based on the Composition

I. According to resin matrix

a. Polymethyl methacrylate.
b. Bis-GMA.
c. Urethane diethacrylate.

II. Based on curing mechanism

a. Chemically activated.
b. Photo chemical polymerization
    - UV light activated.
    - Visible light activated. III.According to ADA sp. no.27
c. Unfilled resins.
d. Composite resins (filled resins).

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Based on Application

I. Based on technique used
   a. Direct. composites—composites are placed on the tooth and cured.
   b. Indirect .composites: An impression of the tooth is made and a cast is prepared. The composite restoration is cured on the cast and cemented to the tooth.

II. Based on area of use.
   a. Anterior composite
   b. Posterior

Reference: Clinical handling of Dental Materials by B.N. Smith.

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Q9. How will you classify Glass ionomer cements?

Table of specification: Glass ionomers

Key:
Classification

1. By Wilson and Mclean (1988)
   Type I: Luting.
   Type II: Restorative.
   - Restorative aesthetic (Includes both
   - autocure and dual cure).
   - Restorative reinforced.

   Type III: Lining or base cements.

2. Mclean et al classification (1994)
   - Glass ionomer cement.
   - Resin modi mfied glass ionomer cement.
   - Polyacid modified composite resins.

3. Classification by Bayne and Taylor

I. Traditional glass ionomer cement for purpose of:
- lining.
- luting.
- restoration.

II. Metal modified glass ionomer cement the purpose of:
- lining.
- core build -up.
- restoration.

III. Light cured glass ionomer cement for the purpose of:
- lining,
- luting.
- restoration.

IV. Hybrid resin modified glass ionomer cement for the purpose of:
- lining
- lutmg.
- restoration.

4. Classified according to application
   Type I: Luting agent.
   Type II: Restorative material.
   - Anterior aesthetic material
   - Core build up material—combined with silver particles (metal modified. GIC) or ceramic particles (cermet)

   Type III—Fast setting lining cements.
   Type IV—Fissure sealing cements.
   Type V—Orthodontic cements.
   Type VI—Core build material (meta modified).

Reference: Phillips science of Dental materials

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Q10. What is the composition of Glass ionomer cements?

Table of specification: Glass ionomers

Key:

Composition
Powder

i. Powder is an acid soluble calcium fluoroalumino silicate glass.

Table
Components of glass ionomer cement

Components	Wt %
SiO_2 (Quartz)	29.0
Al_2O_3 (Alumina)	16.0
CaF_2 (Fluorite)	34.2
$Na_3\ AIF_6$ (Cryolite)	5.0
AIF_3	5.3
$AIPO_4$	9.9

ii. Phosphates and fluorides are used to decrease the glass fusion temperature. They also. improve handling properties and increase cement strength.

iii. Lanthanum and strontium oxide, barium sulfate and zinc oxide provide radio pacity.

iv. Fluorides—anticariogenic property.

Liquid

i. Originally it was an aqueous solution of polyacrylic acid in a concentration of about 50 percent. This was viscous and tended to gel over time.

ii. In most of the current cements, acid is in the form of a cop olymer with itaconic, maleic or tricarboxylic acid.

iii. These acids tend to increase the reac tivity, decrease the viscosity and reduce the tendency for gelation.

iv. Tartaric acid—5 to 15 percent is• also added. It improves handling characteris tics and increases the working time. However it shortens the setting time.

Reference: Phillips Science of dental materials.

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Q11. Briefly narrate the properties of ceramics?

Table of specification: Ceramics

Key:

Properties of ceramics

Biocompatibility

It is well tolerated by soft tissues. A will glazed porcelain restoration is highly biocompatible with the oral tissues.

Esthetics

It is available in varying shades and can simulate natural teeth very closely, especially the translucency of enamel. It can, be characterized to closely resemble tooth color.

Abrasion Resistance

It has a high abrasion resistance. This can. be

a disadvantage in that the opposing natural teeth undergoes wear. It is an important clinical consideration in placement of these restorations.

Chemical Properties

1. It is extremely resistant to chemicals arid solvents.
2. I- acid alone dissolves ceramic materials:

Thermal Properties

1. Thermal conductivity is low (20 x1^{0-6})/^{o}C)
2. Linear shrinkage:
   - 14 percent for low fusing porcelain.
   - 11.5 percent for high fusing porcelain.
3. Volumetric shrinkage
   - 2 to 37 percent for low fusing porcelain.
   - 28 to 34percent for high fusing porcelain.

   Precise control of condensation is required to compensate for the shrinkage.

Physical Properties

1. Ceramics are considered as super cooled liqtiIds or non-crystalline solids.
2. Its properties are dependent not only on the composition but also on the thermal hIstory.
3. Ceramics are brittle materials as they lack t strength.
4. When stress is applied they do not deform plastically, instead develop surface flaws or, cracks. It has low fracture toughness and: so techniques have been used to strengthen ceramics.

Mechanical Properties

1. Compressive strength —172 MN/m^2
2. Shear strength —11O MN/m^2
3. Transverse strength—62-90 MN/m^2
4. Djametrical tensile strength—34 MN/ m^2
5. It has high compressive strength.
6. It has low tensile strength.

Reference: Phillips science of dental materials

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Q12. What are the requirements of particular type of alloy for crown & bridge and partial dentures?

Table of specification: Metals and alloys

Key:

Requirements of Particular Types of Alloys

Crown and bridge alloys: It should have suitable mechanical properties:

High yield strength as these restorations are subjected to greater masticatory stress.

- If the alloy is insufficiently ductile, it may fracture during the burnishing process.
- Hardness of the alloy is an indication of the difficulty of grinding and finishing of the alloy.

Metal ceramic alloys: The main function of metal ceramic alloys is to reinforce porcelain, thus increasing its resistance to fracture.

- The alloy must form surface oxides to bond to porcelain.
- Its coefficient of thermal expansion should be compatible with that of porcelain.
- Its melting temperature should be Ii igher than the porcelain firing temperature. It should be able to resist creep (or) sag at these temperatures.
- It should not stain or discolor porcelain.

Removable partial denture alloys

- The material for the connectors of a partial denture should have the following mechanical properties.
- A high modulus of elasticity, so that it is rigid in thin sections.
- A high proportional limit, so that permanent deformation is unlikely to occur.

For clasp construction, the material should have:

- A high proportional limit.
- But a lower modulus of elasticity, so that the clasp is flexible enough to be with drawn over undercuts, without either the tooth or clasps being overstressed.

Guidelines for Selection of Alloys

1. The composition of alloys used in the laboratory should be known.
2. The alloy to which the patient has known allergy should be specified in the laboratory prescription.'•
3. Selection of the alloy should be based on long-term usage and documented clinical results.
4. Alloys with minimal tarnish and corrosion should be chosen.
5. Single phase alloys should be chosen in comparison to multiphase alloys.

Reference: Restorative dental materials by Robert Craig

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Q13. Give classification of dental Amalgam and its basic composition?

Table of specification: Amalgam

Key

Classification

Dental amalgam can be classified according to:

1. Dental amalgam alloy particle geometry:
   Spherical and lathe cut.
2. Depending• on copper content:
   - Low copper/High copper
   - High copper amalgam can be admixed and single composition.

Composition of low copper amalgam:

Silver	69.4%
Tin	26.2%
Copper	2.5%
Zinc	0.8%

Composition of high copper amalgam:

Silver	60%
Tin	27%
Copper	12.30%
Zinc	0%

High copper amalgams are preferred to low copper amalgams as they have better corrosion resistance.

3. Depending on zinc content: Zn containing/non-Zn containing.
4. Depending on size: Macrocut and microcut.

Basic Composition

1. Silver: Increases strength, expansion and reactivity. Decreases creep. Corrosion are AgC1 and AgS.
2. Tin: Increases reactivity and reduces resistance to corrosion. Decreases strength and hardness. Corrosion products are SnO, SnC1, and SnS.
3. Copper: Increases strength, expansion and hardness. Decreases creep. Corrosion products are CuO and CuS.
4. Zinc: Increases plasticity, strength and the Hg: alloy ratio. Decreases creep. Causes secondary expansion. Corrosion products are ZnC1 and ZnO.
5. Mercury: Wets, the alloy particles. Decreases strength if. in excess amount. Implicated in toxic and allergic reactions.

Reference: Restorative dental material by Craig

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Q14. What is amalgamation reaction for different type of alloys?

Table of specification: Amalgam.

Key

Amalgamation Reaction

The following phases form during the setting of amalgam:

γ phase gamma	AgSn	Silver-Tin
γ_1 phase gamma 1	AgHg	Silver-Mercury
γ_2 phase gamma-2	SnHg	Tin Mercury
η phase eta	Cu-Sn	Copper-Tin

β phase—Crystallographically similar to silver-tin phase.

- Beta-AgSn.
- Beta 1-AgHg.

Basic Reaction

Alloy particles (γ and β phase) + mercury ---- γ_1 Phase will form + Unreacted powder particles (γ)

γ_2 --- Is eliminated in higher copper amalgam. η phase --- IS formed in higher copper amalgam.

Reference: Clinical handling of dental materials by B.N.Smith

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Q15. Give the properties of Gypsum products? Gypsum products, Model & Die Material.

Topic of Specifications: Gypsum Products

Key

Type	*Name*	*W/P ratio*	*Compressive strength (psi)*
I	Impression plaster	0.5-0.75	580
II	Model plaster	0.45-0.5	1300
III	Dental stone	0.28-0.30	3000
IV	Dental stone High strength	0.22-0.24	5000
	Dental stone High strength, High expansion	0.18-0.22	7000

II. *Properties of types I to IV gypsum products*

Property	*Type I*	*Type II*	*Type III*	*Type IV*	*Type V*
Initial setting time min	-	5-10	5-20	5-20	5-20
Setting time (min)	4	20	20	20	20
Setting expansion	0-0.15	0-0.30	0-0.20	0-0.15	0.16-0.3
Compressive strength (1 hr) (MPa)	6	12	25	40	40
Compressive strength 24 hr (MPa)	-	24	70	75	75
Flexural strength (MPa)	1	1	15	20	20
Detail reproduction	75	75	50	50	50

Reference: Clinical handling of dental materials by B.N. Smith