GYPSUM PRODUCTS

SURENDERA DENTAL COLLEGE & RESEARCH INSTITUTE
SRI GANGANGAR , RAJASTHAN

Introduction

- Gypsum is a mineral available in the various parts of the world and has the chemical formula of calcium sulfate dihydrate.

$CaSo_4 2H_4O$ (Dihydrate) $\xrightarrow[\text{Calcination}]{\text{110-130}^oC}$ $CaSo_4 1/2H_4O$ (hemihydrate) $\xrightarrow{\text{130-200}^oC}$ $CaSo_4$ (anhydrate; soluble) $\xrightarrow{\text{200-1300}^oC}$ $CaSo_4$ (anhydrate; insoluble)

Manufacturing

- There are mainly 2 varieties of gypsum products according to crystal or particle structure;
  - β-hemihydrate
  - α-hemihydrate
- **β-hemihydrate:** has crystalline structure but the particles are bigger, irregular, spongy or porous. There are two varities;
  - Type I: impression plaster
  - Type II: dental plaster or plaster of paris

- **a-hemihydrate:** The particles are crystalline smaller in size, more regular, prismatic or cuboidal, more dense and less porous. These are;
  - Type III: dental stone
  - Type IV: Improved stone, die stone or densite
  - Type V: High strength, high expansion stone

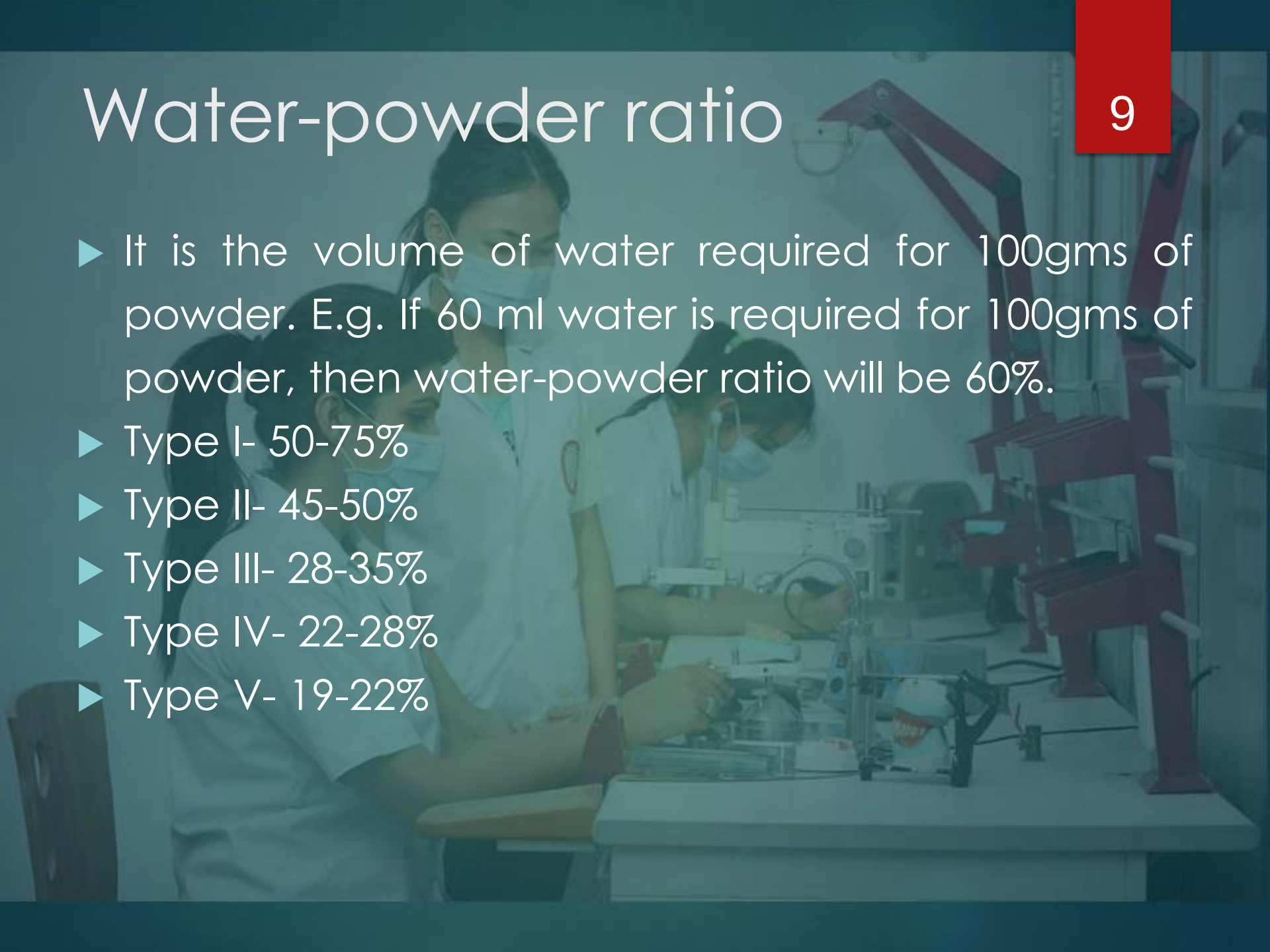
- **Type II** is obtained by heating fine powder of gypsum in a pan or a kettle which is open to atmosphere to a temp of 110-130°c for calcining for some time. This material is used to prepare large casts, models etc.
- **Type I** is obtained by modifying the type II material. This contains the calcined gypsum, chemical (accelerators, retarders) colouring agents & some times small amount of sugar or potato starch (to make it soluble plaster).

- **Type III:** This is alpha hemihydrate called autoclaved hemihydrate or hydrocal. It is manufactured by heating the gypsum powder in an autoclave or by mixing the gypsum powder with small amount of sodium succinate and then autoclaving.
- Used for preparing hard dentulous casts.

- **Type IV:** This is obtained by boiling the gypsum powder in 30% $CaCl_2$ or $MgCl_2$ solution, washing it with boiling water and then drying.
- This is more expensive and much harder than other varieties.
- Used for making dies.

- **Type V:** It is manufactured as type IV but it is not balanced by chemicals. It is added with color impurities, chemicals and surface tension reducing agents like lignon sulfonate to reduce the ratio of water-powder for increasing the strength.
- Used for very strong dies which are slightly bigger to compensate larger casting shrinkage.

Water-powder ratio



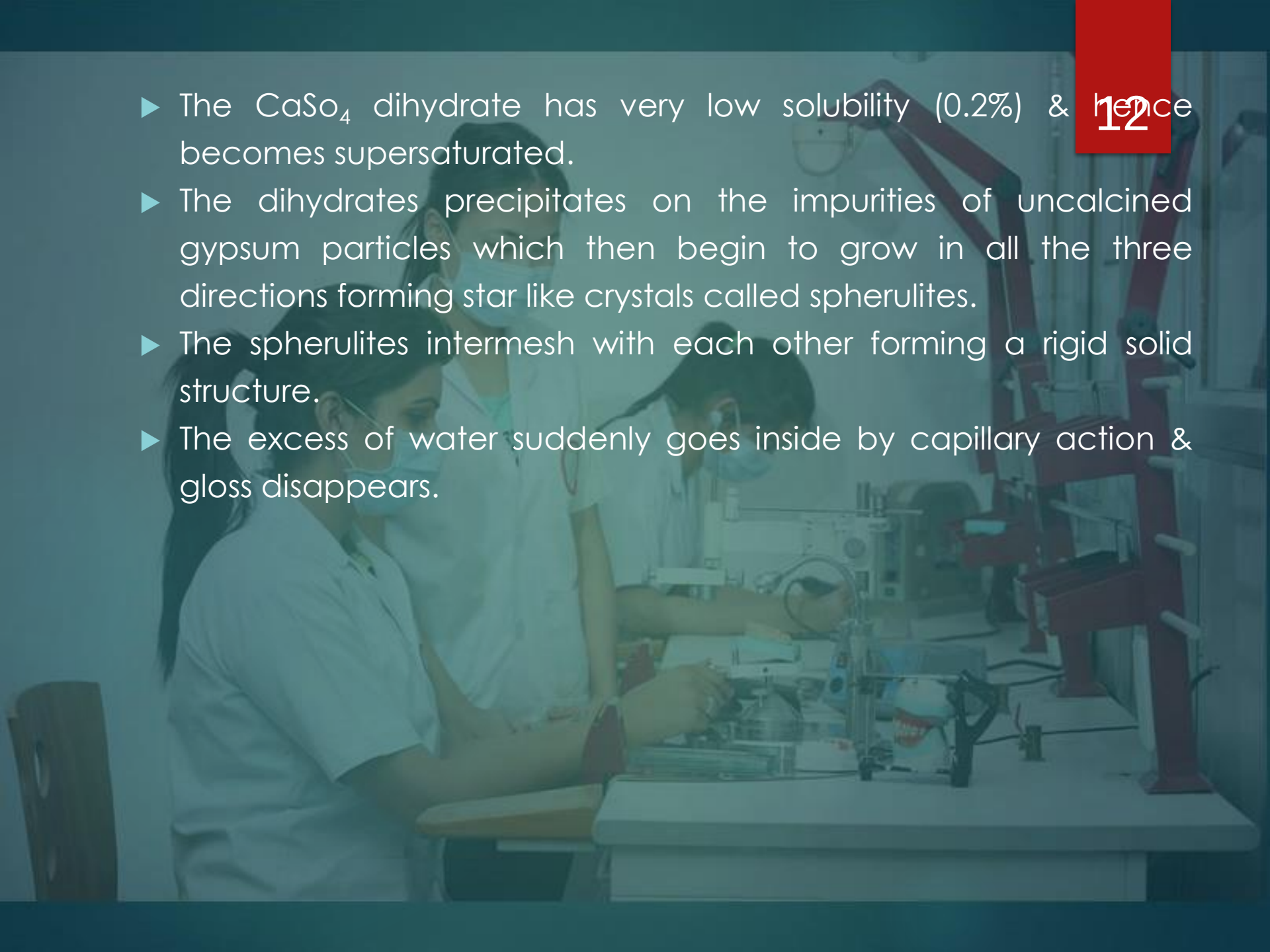
- It is the volume of water required for 100gms of powder. E.g. If 60 ml water is required for 100gms of powder, then water-powder ratio will be 60%.
- Type I- 50-75%
- Type II- 45-50%
- Type III- 28-35%
- Type IV- 22-28%
- Type V- 19-22%

- If water-powder ratio is higher:
  - Setting time increases
  - Setting expansion decreases
  - Strength decreases

Setting action

- The gypsum products set when converted into dihydrate.
- This can be explained by **crystalline theory**.
  - When the hemihydrate powder is added to water taken in a plastic bowl, it dissolves & form Ca & So_4 ions. Its solubility is 0.9 %.
  - Chemical reaction takes place to form dihydrate with the evolution of heat.

- The $CaSo_4$ dihydrate has very low solubility (0.2%) & hence becomes supersaturated.
- The dihydrates precipitates on the impurities of uncalcined gypsum particles which then begin to grow in all the three directions forming star like crystals called spherulites.
- The spherulites intermesh with each other forming a rigid solid structure.
- The excess of water suddenly goes inside by capillary action & gloss disappears.



Setting time

- It is the time interval from the beginning of addition of powder into water until the solid formed gets certain rigidity.

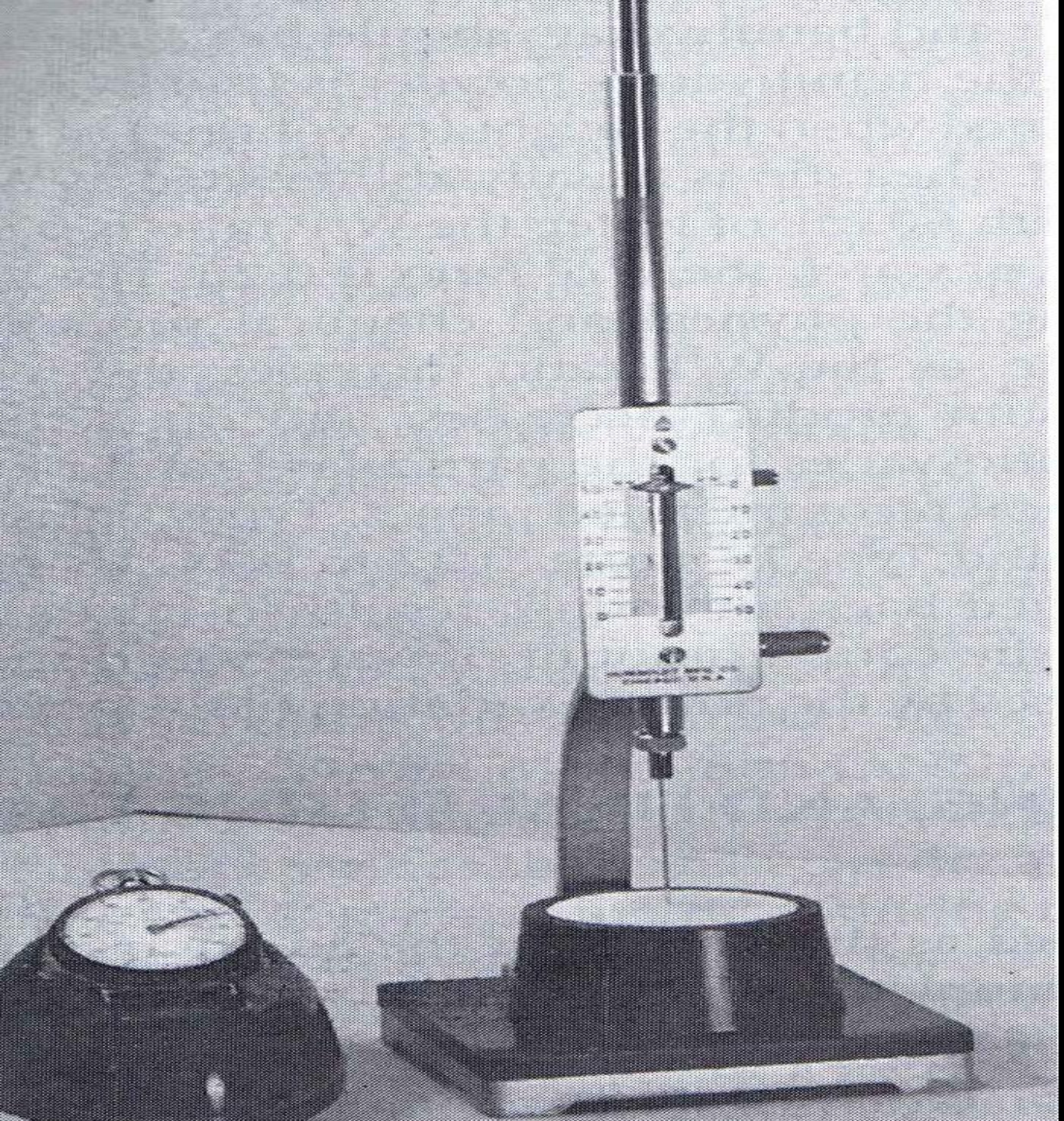
Measurement of setting time

- **Gloss disappearance method:** it is the time interval from the instant of addition of powder to water until the surface gloss just disappears. It may be 4-5 min.
- Working time is the time interval from the beginning of addition of powder to water until the mix starts thickening or shows increase of viscosity or the mix can be easily moulded. This is about 3-4 min.

Indentation method:

- **Initial setting time** is time interval from beginning of addition of powder to water until the tip of the smaller Gilimore needle having diameter 1/12 inch & weight ¼ pound just stops producing indentation. This is 6-8 min.
- **Final setting time** is the time interval from the beginning of addition of powder to water until the tip of the bigger Gillmore needle 1/24 inch, 1 pound just stops producing indentation. This is about 12-18 min.

- **Penetration method:** this contains a needle of 1mm diameter & about 8 cm length attached vertically to a loading system of weight 300 gm. A pointer & a scale are attached. The plaster mix is filled in a conical vessel of 5 cm height placed on a glass plate on a platform.
- The needle is allowed to penetrate by its own weight & tested every min interval.
- The setting time is the interval between the start of mixing to when Vicat needle if 1mm diameter 300 gm weight just can not penetrate 5 cm depth or just can not reach the bottom.



VICAT PENETROMETER USED TO DETERMINE THE SETTING TIME OF GYPSUM PRODUCTS

Factors effecting setting time

- The setting time is shortened if,
  - No. of nuclei of crystallization is more.
  - Solubility of hemihydrate is higher.
  - Rate of crystallization is higher.

- Factors under the control of manufacturer:
  - To decrease & adjust the setting time manufacturer can add uncalcined gypsum (impurities).
  - Solubility of hemihydrate is adjusted by addition of accelerator & retarder.
  - The rate of crystallization is adjusted by decreasing the particle size & addition of chemicals.

- Factors under the control of dentist:
  - **Water powder ratio:** setting time is directly proportional to water powder ratio. The spherulites grow for every nuclei of crystallization (uncalcined gypsum). If more water powder ratio, no. of nuclei of crystallization per unit volume will decrease so the rate of crystallization decreases. Thus setting time is longer if more water is added.

- **Spatulation time (mixing time):** if the mixing time is more, setting time is shorter. If the mixing is done faster & longer the growing spherulites are broken & each fragment acts as the nucleus hence setting time decreases. Hand mixing 30-60 sec. & mechanical mixing 20-30 sec.
- **Impurities:** the uncalcined gypsum is sometimes added to decrease setting time as it act as nuclei of crystallization.

- **Temp of mixing water:** not effected seriously from 0 to 50°c except a very small increase. From 50-80°c it increases rapidly & above 80°c it does not set at all. This is because the solubility of hemihydrate decreases with temp very fast.

- **Particle size:** smaller size less setting time.
- **Old stock** or material exposed to moisture containing air will set slowly. The more soluble hemihydrate particles are coated by less soluble dihydrate particles when they come in contact with moisture, hence it dissolves slowly & setting time increases. Hence large amount of plaster should be preserved in dry conditions.

- **Chemical accelerators and retarders:** many chemicals affect the setting time either by increasing the solubility or inhibiting or preventing growth of spherulites.
- **Accelerators:** NaCl less than 2% & Na_2so_4 3.4% act as accelerator but above this concentration they retard the reaction. K_2So_4 is very effective accelerator above 2%.

- **Retarders**: many chemicals like borax form an envelope on the growing sperulites & prevent the setting. Citrates, acetates, hydrocolloids, dried blood, saliva etc are retarders.

Setting expansion

- Setting expansion is due to the outward thrust exerted by growing spherulites. It can be 0.1 – 0.5% linear.
- When the hemihydrate is added to water first a slight contraction is expected during wetting & mixing & then expansion takes place called normal setting expansion.
- NSE can be defined as the percentage of linear expansion taking place when the plaster mix sets in the normal condition.

Factors affecting NSE

- Setting expansion is greater if **W/P ratio** is smaller as there are greater no. of spherulites per unit volume exerting outward force.
- Setting expansion increases if the **mixing time** is more as more spherulites are formed due to the fracture of growing spherulites during mixing.

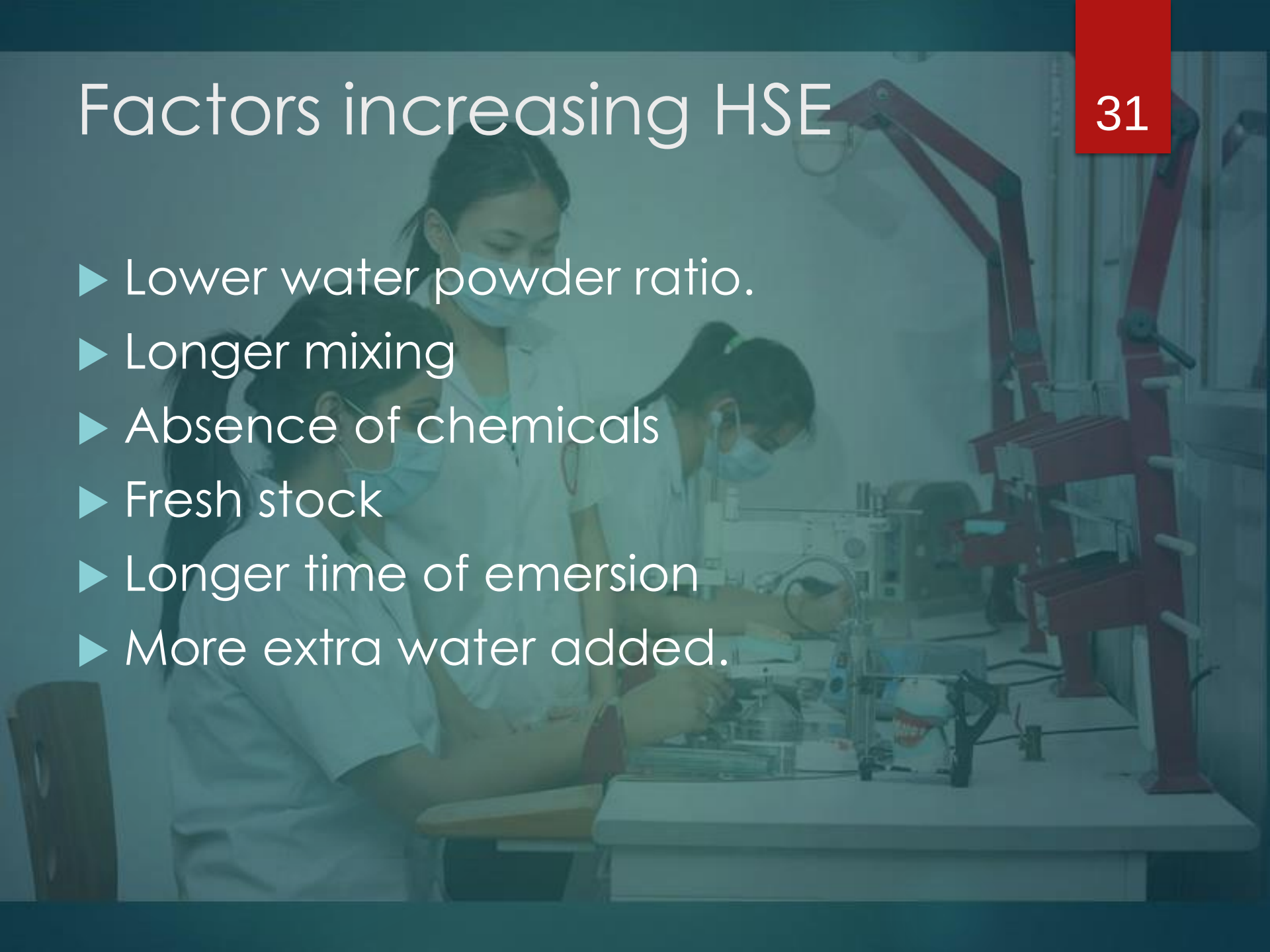
- **Chemicals:** small amount of NaCl, $CaCl_2$ increase the setting expansion. Retarders envelope the growing spherulites thus reducing the outward thrust so reducing the setting expansion.
- To get minimum setting expansion without altering the setting time the accelerators & retarders can be used together.

- 4% K_2So_4 & 0.4% borax in water is called anti expansion solution. With this we get minimum setting expansion. They are added in powder itself & called balanced stone or balanced plasters.
- Old stock has lower setting expansion.
- Finer particles produce slightly greater expansion.

Hygroscopic setting expansion (HSE)

- During the initial setting, the cast is kept immersed in excess water. This extra water will be present in between the spherulites & help them to exert extra outward thrust during setting to produce more expansion. Thus HSE is more than NSE.

Factors increasing HSE



- Lower water powder ratio.
- Longer mixing
- Absence of chemicals
- Fresh stock
- Longer time of emersion
- More extra water added.

Strength

- The strength of a material can be defined as the maximum stress it can withstand before fracture.
- **Factors affecting stress:**
  - **Time:** as the time elapses the intermeshing becomes more stronger & the strength increases. The strength at the end of 1 hour is known as wet or green strength.

- **Water powder ratio:** the strength is very larger for smaller W/P ratio. However if a less than a minimum value of water used, the strength can decrease due to improper wetting & reaction.
- **Time & speed of mixing & spatulation:** if the spatulation is done more, the strength will decrease due to interruption of growth of spherulites.

- **Particle or crystal structure:** smaller the particle size & regularity in the crystal structure, higher is the strength.
- All impurities, chemical accelerators, retarders etc slightly decrease the strength.
- Modifiers can improve the strength e.g. gum arabic, polymerised resins.
- Old stock has got poor strength.

Dry strength

- This is the maximum strength reached when the cast or model is completely dried.
- It may take 24-48 hours for complete drying if exposed to atmosphere.
- The dry strength increases from type I to type V.

Tensile strength

- All gypsum products have very low tensile strength which may be 1/5 to 1/10 of the corresponding compressive strengths.
- Approximately value is 1-10mpa.

Material	Setting time	Setting expansion	Wet strength	Dry strength	Hardness
Type I	4±1min	0-0.15%	2-6mpa	----------	Very low
Type II	12±4	0-0.3%	8-20	60	60
Type III	12±4	0-0.2%	21-35	80	82
Type IV	12±4	0-0.1%	35-45	90	92
Type V	12±4	0-0.3%	48-60	100	100

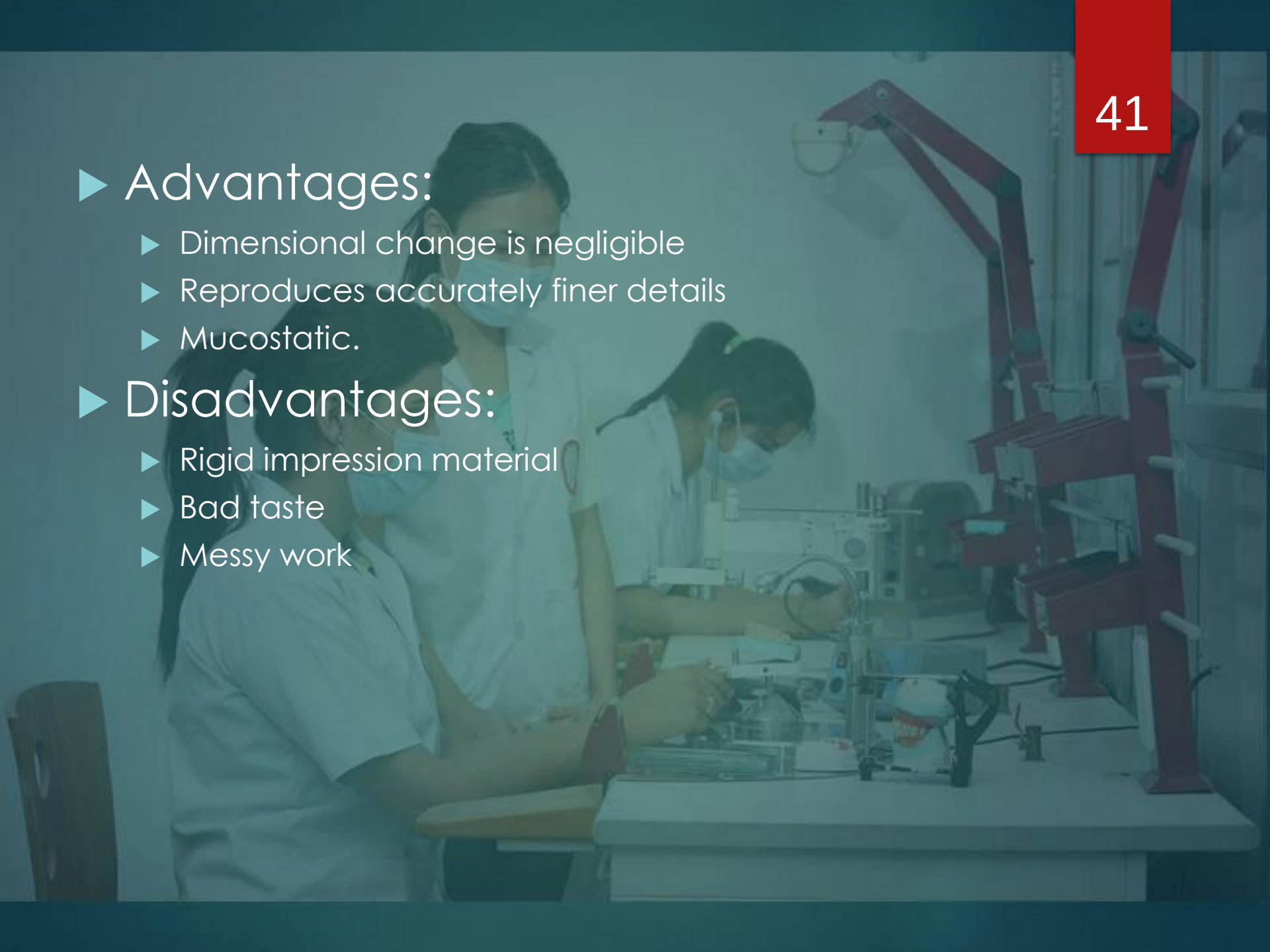
Surface hardness

- It is the ability of the surface of a material to resist scratching, indentation, penetration, or abrasion.
- Usually Rockwell method is employed to measure hardness.
- Type III & type IV have approximately 82 & 92 RHN respectively.

Impression plaster

- **Composition:** β hemihydrate, accelerators, retarders, potato starch or sugar (soluble plaster), color agents.
- **Properties:** low setting time, low strength, low setting expansion.
- **Manipulation:** use a clean plaster bowl & spatula. Take measured quantity of water & powder, mix thoroughly for 30-40 sec.

- Place the mix in the tray & immediately place it in the mouth until it sets.
- Carefully remove the impression.
- Apply a thin coating of separating medium. Pour the stone cast, allow it to set for 30-60 min.
- Carefully separate the cast from the impression.
- The potato starch in the impression absorbs water swells & breaks into pieces & cast separates out.



- Advantages:
  - Dimensional change is negligible
  - Reproduces accurately finer details
  - Mucostatic.
- Disadvantages:
  - Rigid impression material
  - Bad taste
  - Messy work

Dental stone

- **Properties:**
  - 1 hour strength should be more than 25 mpa & need not be greater than 34-35 mpa.
  - Maximum dry strength around 80 mpa.
  - Surface hardness around 82 RHN.
  - Setting time 12±4 min.

- **Uses:**
  - Used for preparing edentulous casts during fabrication of complete dentures.
  - To prepare dentulous casts for preparation of partial dentures.
  - Used as a binder in gypsum bonded investment materials.

Die stone

- **Properties:**
  - very fine cuboidal or prismatic crystals.
  - Low water powder ratio (22-28%)
  - Low setting expansion (0.1%)
  - Setting time (12±4 min)
  - 1 hour compressive strength more than 34.5 mpa
  - Dry strength about 90 mpa
  - Surface hardness 92 RHN
  - Coloured.

- **Uses:**
  - To prepare hard dies
  - Used in casting procedures

High strength high expansion die stone

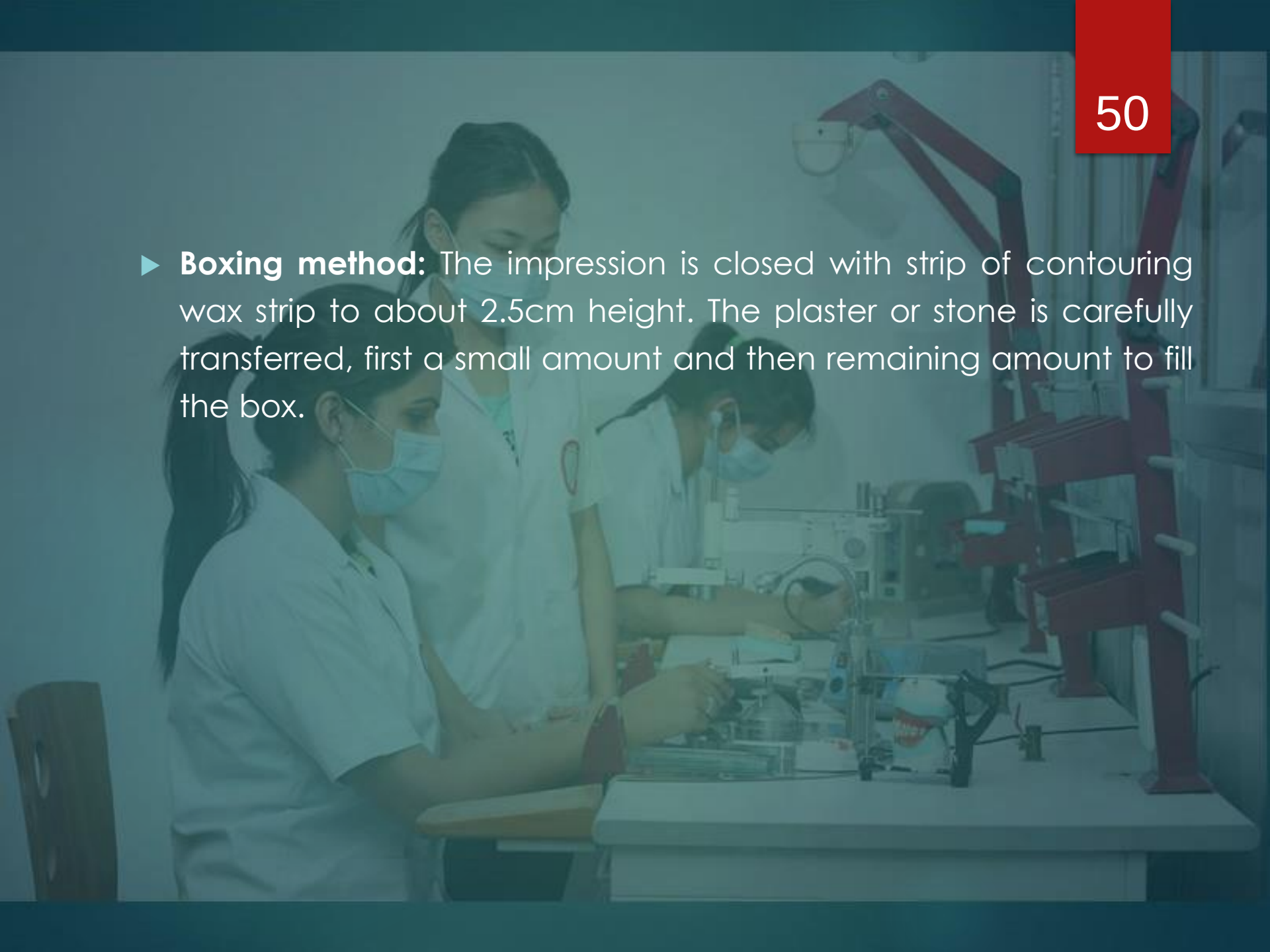
- **Properties:**
  - very fine cuboidal, prismatic crystals
  - Very low water powder ratio (19-22%)
  - Setting time (12±4 min)
  - Setting expansion large 0.1-0.3%
  - 1 hour compressive strength more than 48 mpa
  - Dry strength 100mpa
  - Surface hardness 100 RHN

- **Uses:**
  - To prepare very hard & slightly enlarged dies
  - In casting procedures for compensation of casting shrinkage.

Manipulation of gypsum products

- Take clean flexible plaster bowl and rigid stainless steel spatula.
- Take measured amount of water in bowl and add weighed quantity of powder by sifting to minimize trapping of air bubbles.
- It is spatulated for 30-40 seconds to get a homogenous creamy mix.

- The cast or model is prepared mainly by 2 methods:
  - Small mix is transferred to the impression and vibrated well to remove the trapped air and then filled with remaining mix. To prepare base, mix plaster again. Place the mix on glass slab. The poured impression is placed on the mix which is then shaped with plaster knife.



- **Boxing method:** The impression is closed with strip of contouring wax strip to about 2.5cm height. The plaster or stone is carefully transferred, first a small amount and then remaining amount to fill the box.