CEL 774 CONSTRUCTION PRACTISES

Concrete: Production

(Compaction)

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General Outline

- Concrete Production.
  - **Compaction**
    - Need
    - Vibrators
    - Mechanism & Fresh concrete under vibration
    - Execution
    - Special vibration

Compaction by vibration

- Placed concrete contains air voids (30%) .
- Seldom confirms intimately to the shape of the form.
- Compaction is required to drive entrapped air out **to densify concrete.**
- Increase homogeneity and uniformity are the other benefits.
- This compaction is achieved through vibration.
- Self compacting concrete does not need vibration.

Concrete vibration

- *Energy for compaction is supplied through oscillatory motion of vibration (nearly SHM).*
- *Vibration is usually generated by means of rotating eccentric having a frequency and amplitude of vibration.*
- *Although the frequency can be easily measured in air, it is difficult to measure within concrete although that is more relevant..*

Types of Vibrators

- ***Internal vibrators.***
  - *Flexible shaft type.*
  - *Electric motor in hand type.*
  - *Air vibrators.*

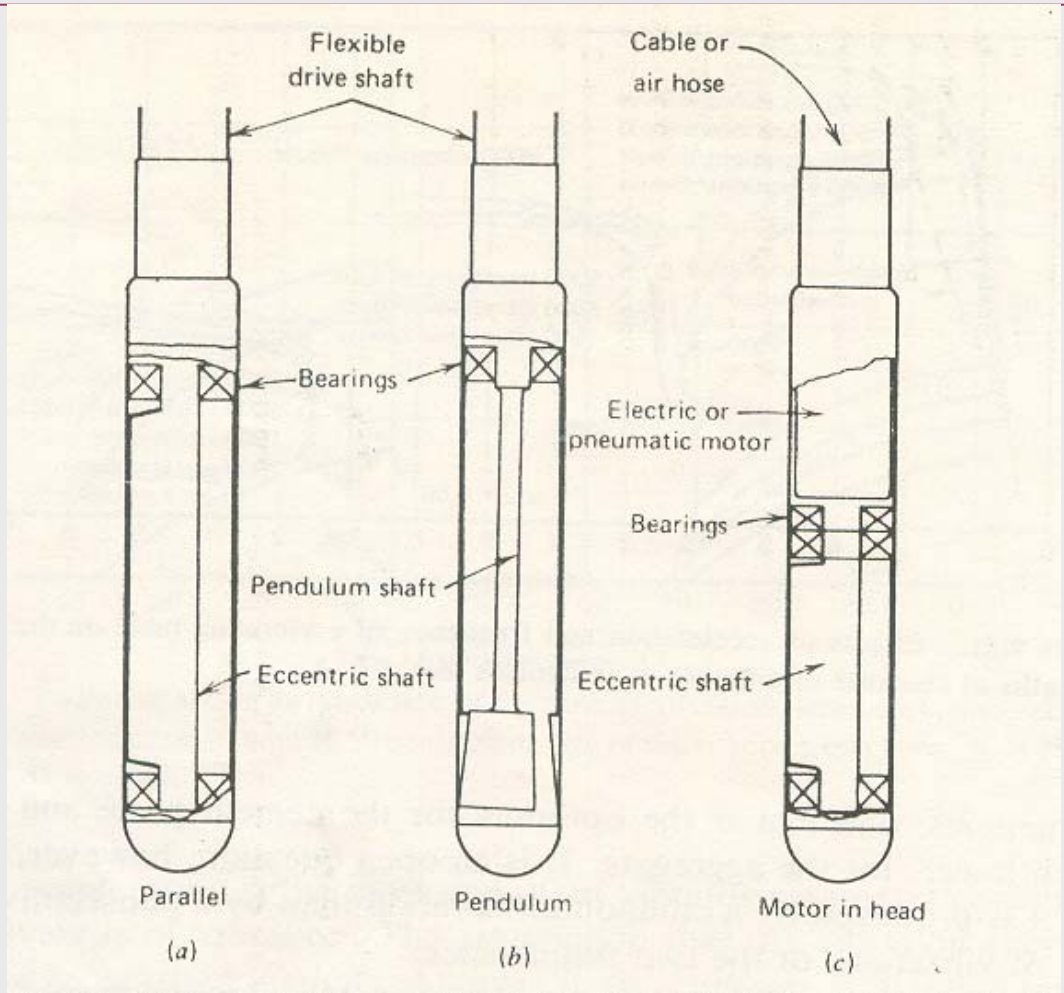
- ***Form vibrators.***
- ***Vibrating table.***
- ***Surface vibrators.***

Types of Vibrators

– *Immersion/ Submersible/ Poker/ spud type*

– *Flexible shaft Vibrator &*

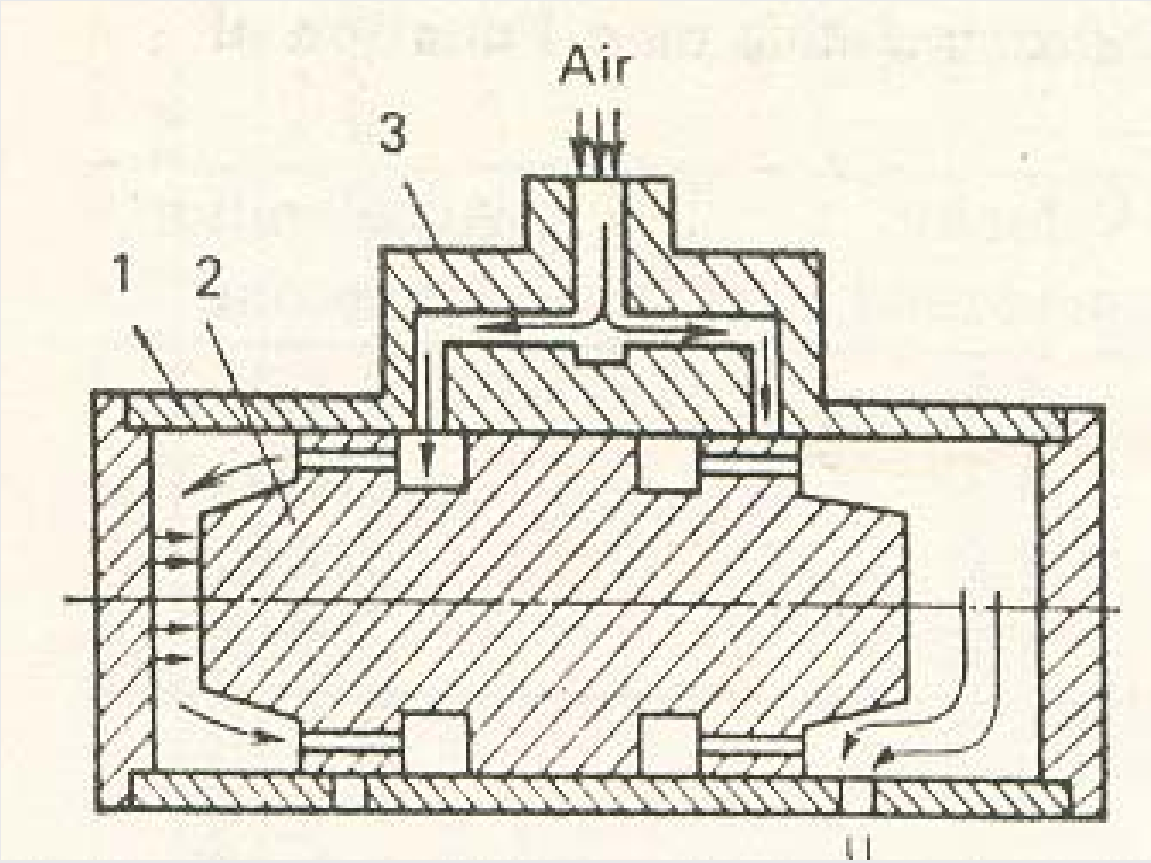
➢ *Motor in head*



Types of Vibrators

1. ***Casing***
2. ***Plunger***
3. ***Distribution box***

Compressed air
Moves the plunger
To one or other side
25mm to 150mm
diameter



Air Vibrator

Types of Vibrators

- *Flexible shaft type most common (fig a &b) ranges from a diameter of 20 to 180 mm.*
- *Vibration is usually generated by means of rotating eccentric having a frequency and amplitude of vibration.*
- *Although the frequency can be easily measured in air, it is difficult to measure within concrete although that is more relevant. (given in table).*

Immersion Vibrators

$$a_2 = a_1\left(\sqrt{R_1/R_2}\right)e^{[-0.5\Omega(R_2-R_1)]}$$

– *a_2 is the amplitude of vibration at a distance R_2 From center line of vibrator.* Ω is coeff. Of damping

– *a_1 is the amplitude of vibration at the surface of the vibrator having a radius equal to R_1*

– *P is plastic concrete, M is Mass concrete,* T is thin member, C stands for congested, S stands for slump, St stands for structure & O stands for open forms

Immersion Vibrators

Head dia (mm)	Reco f (k cyl/min)	Average Amp (mm)	Radi actn. (cm)	Comp. rate cm./h	Applic-n
20-40	10-15	0.4-0.8	8-15	0.8-4	P, t, C
30-60	9-13.5	0.5-1.0	13-25	2.3-8	P, wall, col, beam
50-90	8-12	0.6-1.3	18-36	4.6-15	S<75 mm
80-150	7-10.5	0.8-1.5	30-51	11-31	M, St, O S<50 mm
130-180	5.5-8.0	1.0-2.0	40-61	19-38	M in dams

Form Vibrators

- Form vibrator are external vibrators, transmits impulses both in plane and perpendicular to the form.
- Form is vibrated and the vibration is transmitted from the form to concrete.
- Acceleration is 1g-3g for adequate amplitude.
- Both rotary and reciprocating types are used and can either be electrically (3000-6000rpm) pneumatically (6000-12000 cycle/min) driven

Form Vibrators

- Reciprocating type accelerates in a given direction and imparts impact causing vibration.
- Reciprocating vibrators are usually pneumatically driven.
- Frequencies are in the range of 1000-5000 cycles/minute.
- The impulses are mostly perpendicular to the form

Vibrators

- Vibrating table are usually used for pre-cast elements, frequency <6000 vibrations/min and amplitude > 0.12mm.
- Surface vibrators exerts their effects at top surface and include:
- Vibrating screed, pan type vibrator, Vibrating roller screed, vibrating plate and vibratory roller for pavement concrete.

Vibrators

- *Form vibrators are used where it is impractical to use internal vibrators.*
- *Vibrating screed are used in thin slabs.*
- *High frequency and low amplitude vibrations generally results in more efficient compaction .*

Fresh concrete under Vibration

- Prior to compaction concrete is a mass of separate particles coated with mortar held in a pile by arching action of coarser particle.
- The arching is result of friction between aggregate particles, surface tension & cohesive forces of the cement paste.
- The voids caused by arching are filled with air up to about 30%.

Fresh concrete under Vibration

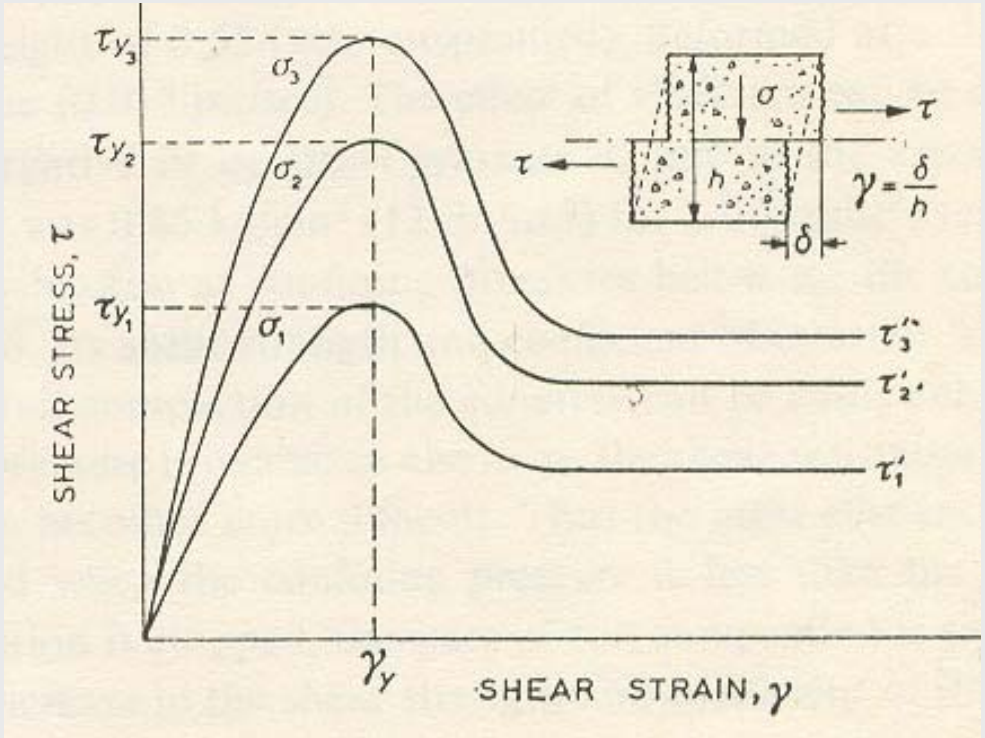
- *Vibratory impulse liquefy the mortar portion of concrete and thus reduce the internal friction resulting in consolidation by force of gravity . In vibrated concrete friction is reestablished cohesion is restored and strength increases.*
- *The velocity of compression waves generated is 45m/sec in the beginning of vibration and increases to240 m/sec at the end.*

Fresh concrete under Vibration

- For 200 Hz these velocities correspond to 0.2 m and 1.2 m wavelength.
- The waves moves water more than the solids and generates hydraulic pressure within interstitial water filled space .
- The pressure is maximum in most constricted space and causes reduced internal friction giving the paste temporary fluidity.

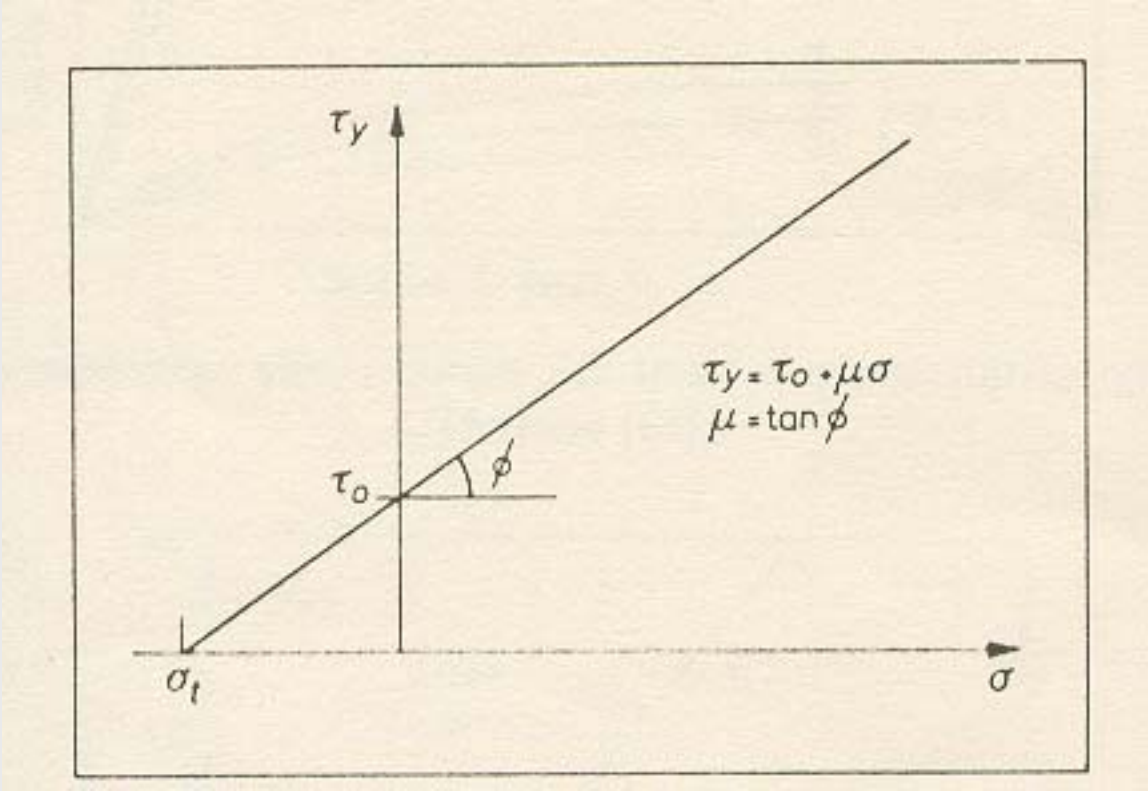
Fresh concrete under Vibration

– ***Process of liquefaction is easily understood through box shear test results.***



Fresh concrete under Vibration

– *Shear strength*



– *Normal Stress*

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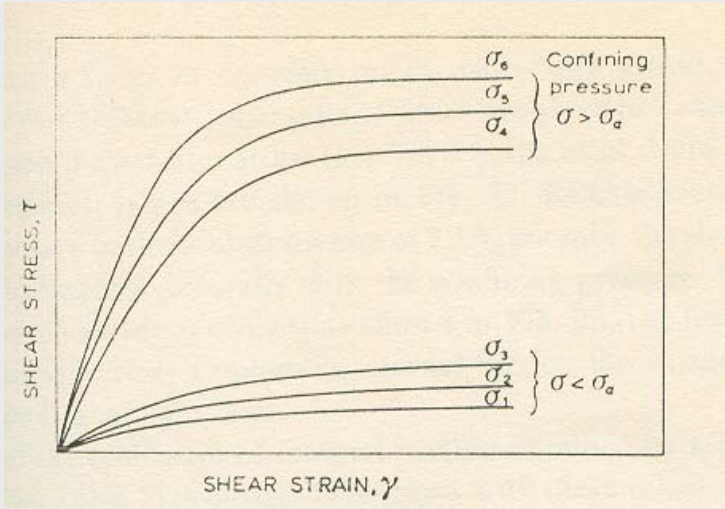
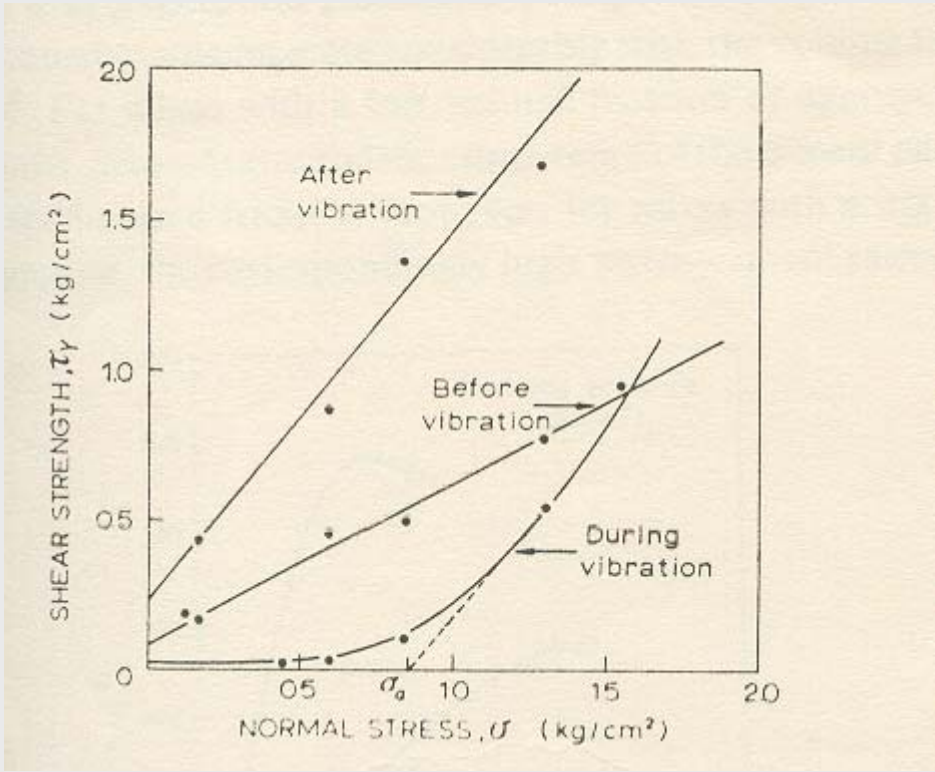
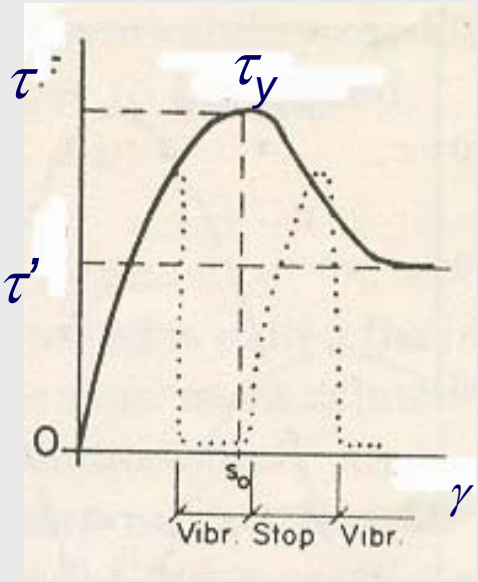
Fresh concrete under Vibration

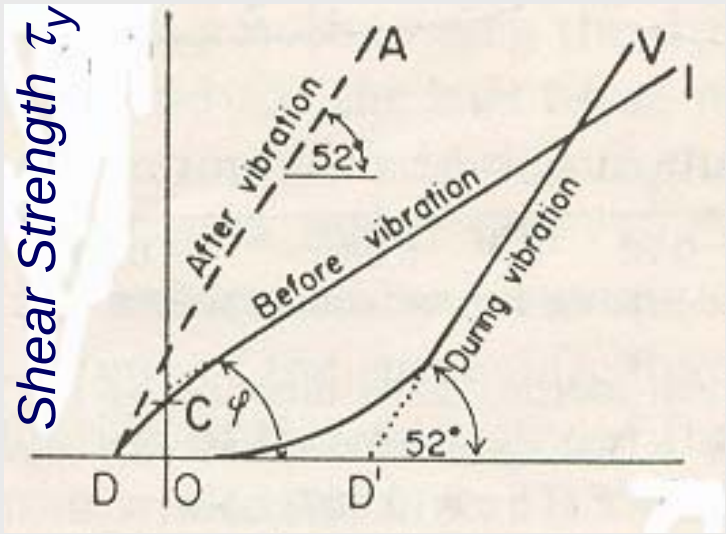
– *Shear Stress-strain relationship during vibration*





Fresh concrete under Vibration





Normal stress σ

– *D' represent σ_a called agitation pressure*

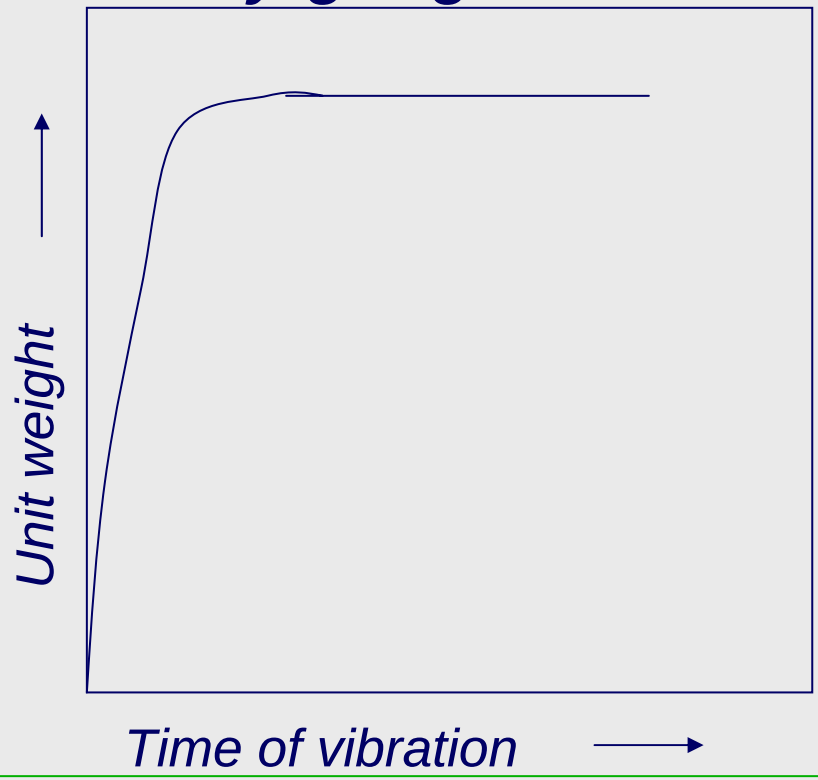
Fresh concrete under Vibration

- *Consolidation of concrete takes place in two stages.*
- *In the first stage vertical settlement of coarse aggregate takes place in a manner similar to packing of granular material and shape of the aggregate plays a major role, air voids up to 5% remains after this stage.*
- *In the second stage concrete behaves like dense liquid and air voids are removed from the surface forcing mortar to appear at the surface .*

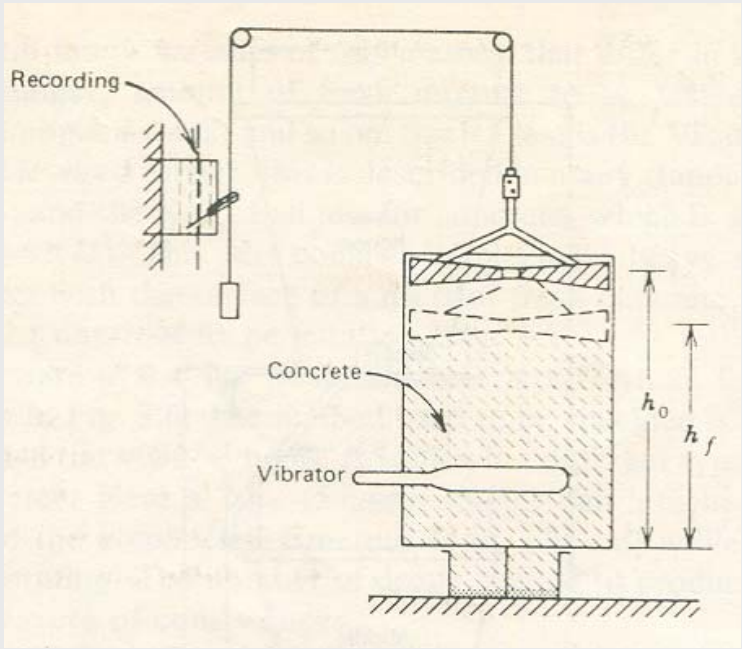
Measurement of compaction

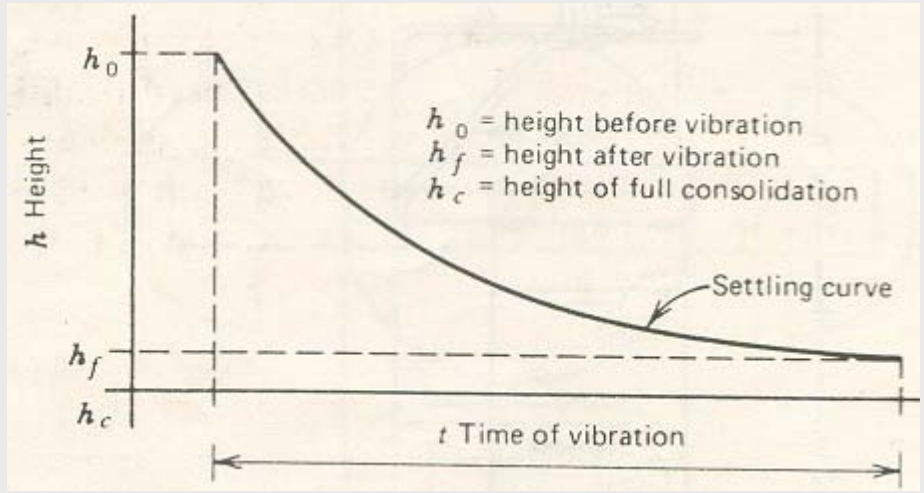
– *Unit weight can be a measure of compaction*

Various density gauges can be used



Measurement of compaction





Settlement

$h=h_f+(h_0-h_f)\, e^{-b(\omega a \omega/g)ty}$

ω Is angular frequency

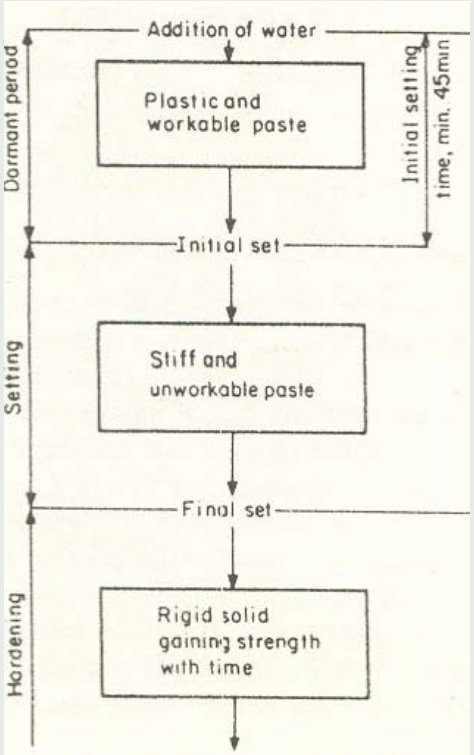
b experimental factor

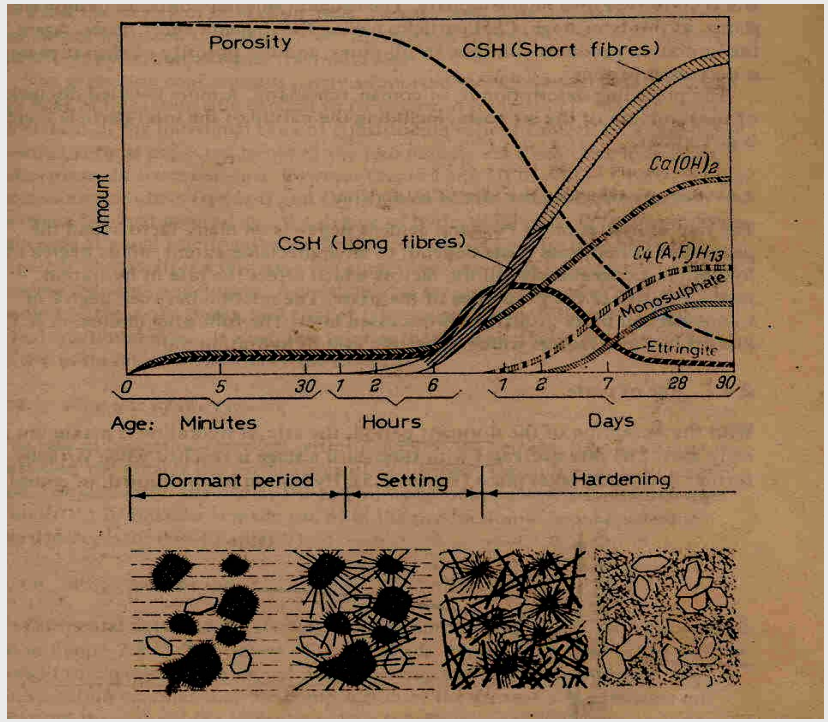
a amplitude

g acceleration due to gravity

y depends on mix consistency

Execution of vibration





– *Vibration shall be completed when is in dormant period; penetration resistance 35 kg/sq.cm*

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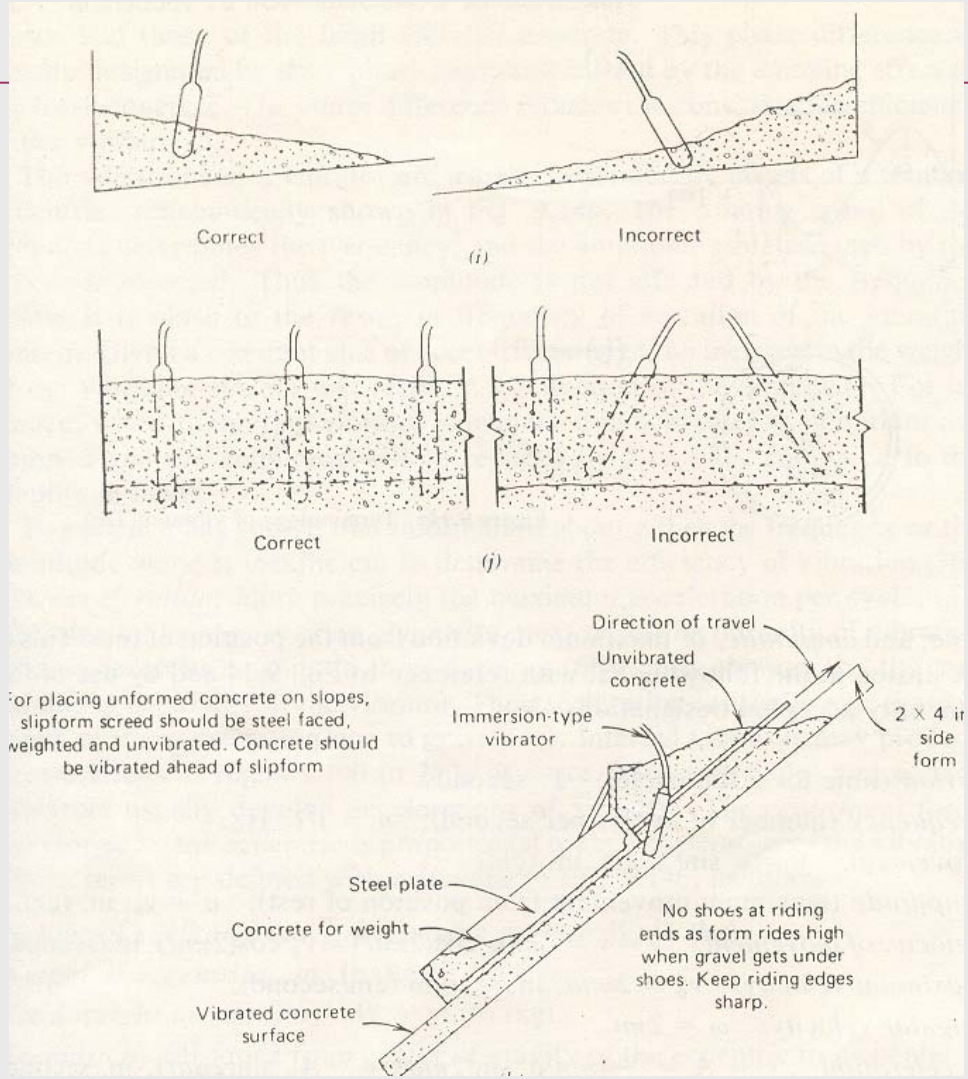
Dos & Don'ts in concrete vibration

– Concrete shall not be moved using internal Vibrator, results In segregation



Execution of Vibration

- Penetrate vertically to sufficiently embed in concrete, held stationary and removed slowly (7.5 cm/sec) .
- At regular spacing to ensure compaction of all portions if required with adequate overlap.
- A minimum of 10 secs is necessary for complete compaction . Vibration time needed is given by:

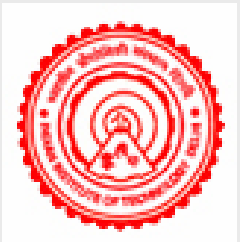
$$t = -\frac{g}{b\omega^2 ay} \ln \frac{(h - h_f)}{(h_0 - h_f)}$$

EQUATIONS FOR TIME NEEDED FOR VIBRATION

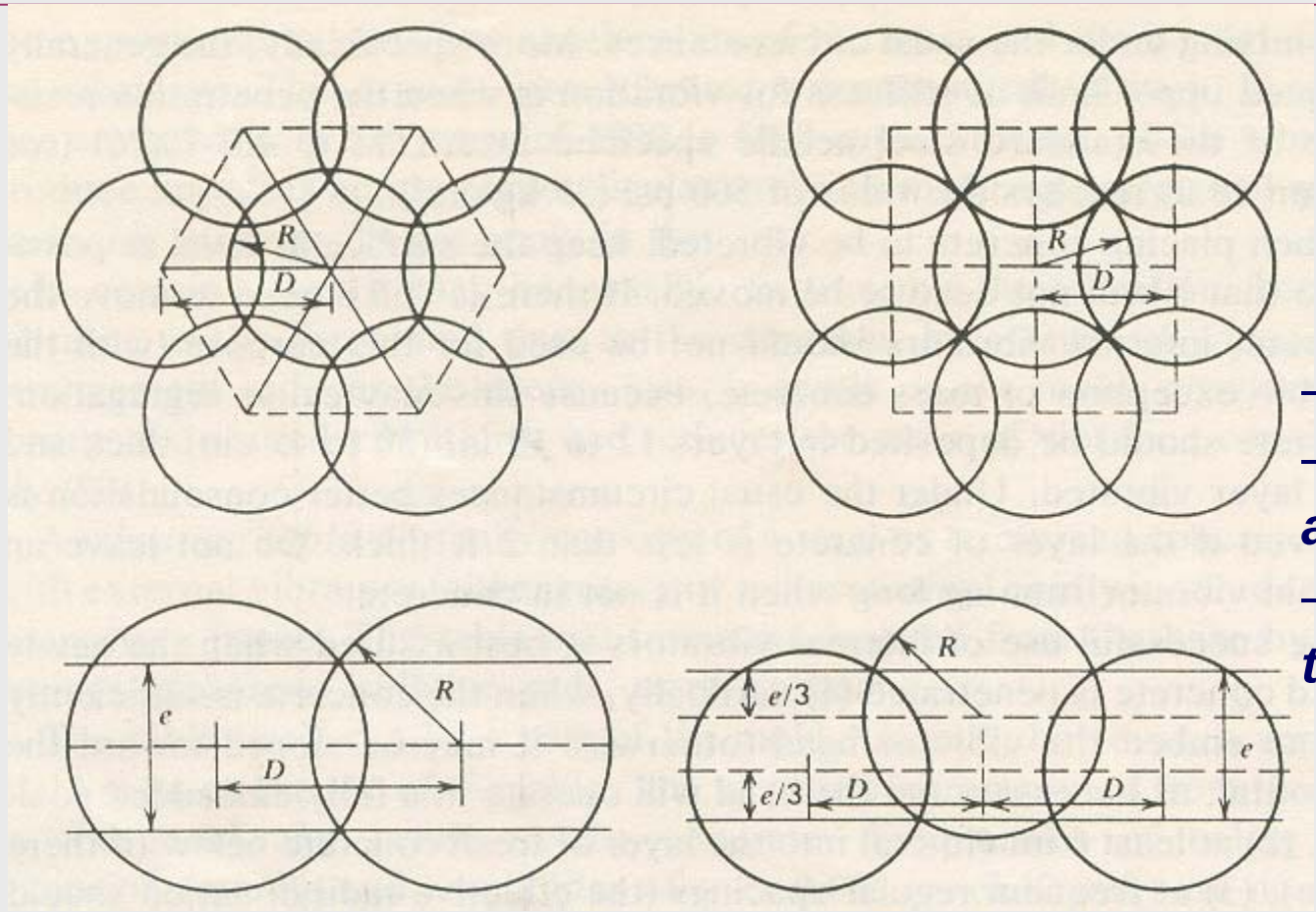
$$t = \frac{25}{\phi}\left(\frac{100}{S+5} + A\right)F\sqrt{V}$$ – ***For V < 25 liters***

$$t = \frac{25}{\phi}\left(\frac{100}{S+5} + A\right)F(0.1V + 2.5)$$ – ***For V > 25 liters***

- **t =total needed vibration time (s) for V liters concrete**
- **ϕ = diameter of the needle vibrator in mm.**
- **S= Slump of the concrete in cm**
- **A = Coefficient representing shape of aggregate. For rounded aggregate A=1 for crushed aggregate A=5**
- **F=Coefficient representing denseness of steel; F=1.5 for very dense and F= 1 for no reinforcement**



Vibrator Spacing



- *D is spacing*
- *R radius of action*
- *E is section thickness*

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Vibration

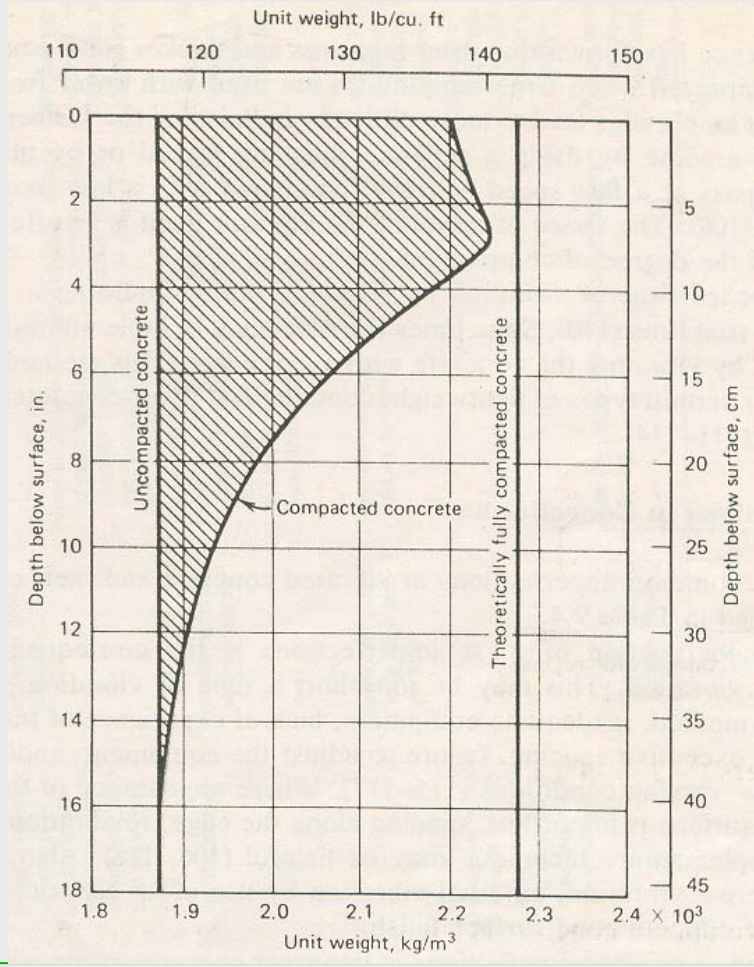
$$q = \frac{7200uR^2s}{t + t_1}$$

- q = volume of compacted concrete cu.m/hr
- u= utilization factor.
- R= radius of action
- s= thickness of the layer in m
- t= time of vibration in one place
- t_1= time of moving the vibrator from one place to another

Execution of Vibration

- For form vibrators fastening with the form is important, vibration time is 2 minutes to 30 minutes depending upon concrete and vibrator .
- Vibrating screed need s two passes.
- Degree of vibration achieved by surface vibrator is shown in fig.

Execution of Vibration



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Imperfection in Vibrators

Name	Descript-ion	Design	Form & Cond	Concrete & Place	Compact-ion
Honecom-b	Stony, Air voids	Narrow section	Grout loss temp	Free fall low slump	Poor vibration
Blow/ bug holes	Small holes		Excess form oil	Lean, low slump	Inadequat e
Subsidenc e cracking	Short cracks		Plastic settlement	High water c	In-adequate
Form offset	Irregular surface		Weak form		Non uniform D
Cold Joints	discontinu ity		Poor planning	Delayed placing	Inadequat e lower L

Special Vibration

- *Re-vibration can be done as long as the running internal vibrator sink in the concrete by its own weight. This corresponds to a penetration resistance of 3.5 MPa. Can increase strength, bond, impermeability, reduced shrinkage and creep.*

- *Vacuum Vibration is accomplished by applying vacuum to surface of fresh concrete. Cement paste is densified by removal of air from the surface and water from certain depth.*

Special Vibrations

- *Vacuum Vibration allows placing of concrete with higher water content by extracting extra water. Thus an enhancement in strength is observed. Commonly used for slabs, walls etc. Vacuum between 30-50 cm of Mercury is applied by means of special for liners or mat. Shall be applied as early as possible. Penetration of vacuum is up to 30 cm. Is less efficient in air entrained concrete.*

- *Fresh mix subjected to high frequency vibration >100Hz u\is called vibro-activation increases the strength by intensifying hydration, generally does not have any thing to do with compaction*

THANK YOU FOR HEARING