Classification Based on force applied

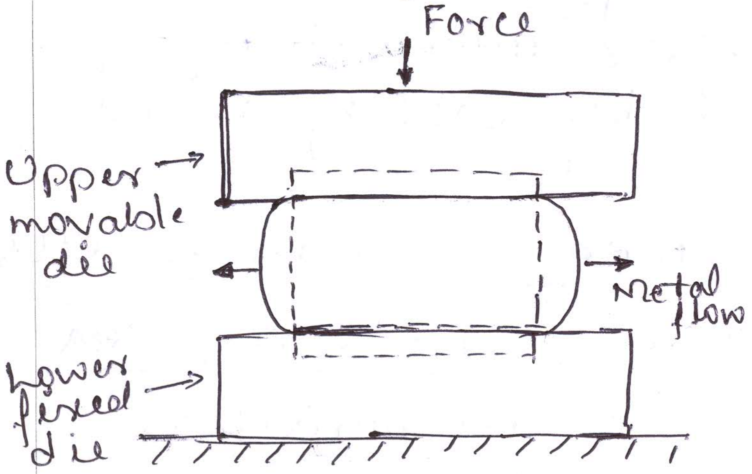
Forming process may be classified based on nature of force applied are as follows.

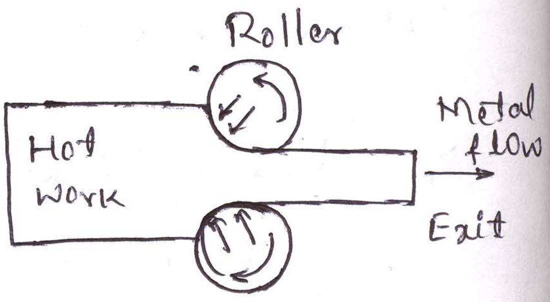
* Direct compression type process
* In-direct compression type process
* Tension type
* Bending type
* Shearing type

Direct compression type process

Compressive force is applied to the surface of the w/p causing the metal to flow at right angle to the direction of the applied force.

Ex:- Forging and Rolling





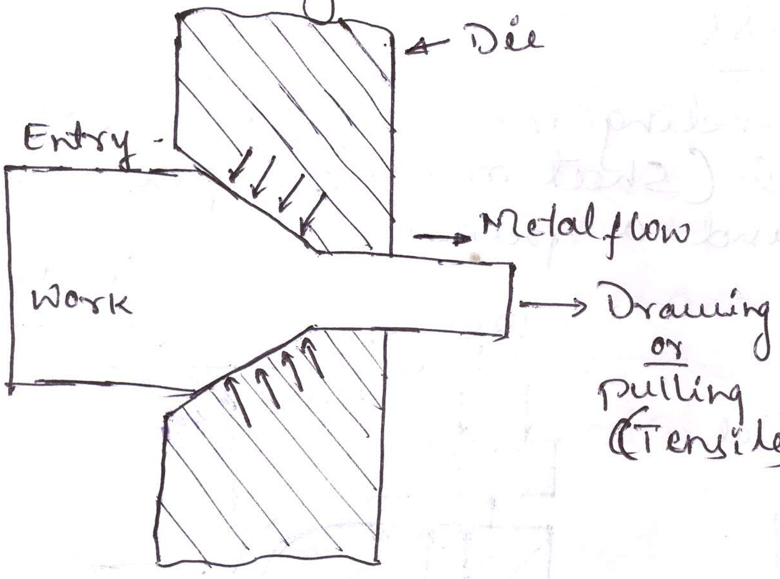
Forging

Rolling

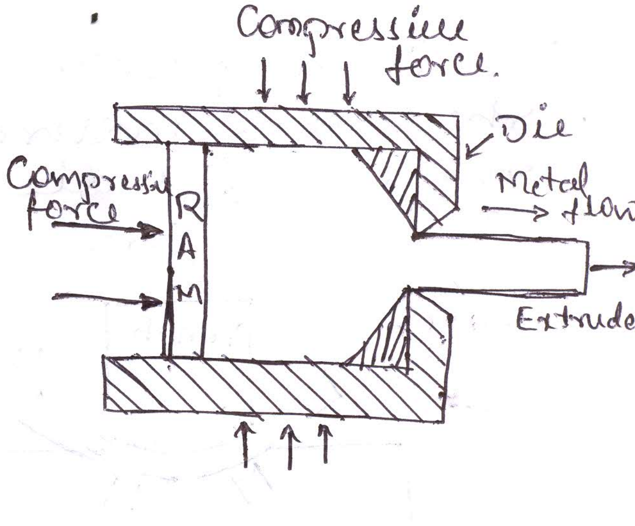
Indirect Compression process.

In this process, primary applied forces are frequently tensile, due to the reaction of work piece with die, indirect compressive forces are developed.

Ex :- Wire drawing, extrusion and deep drawing.



Drawing.

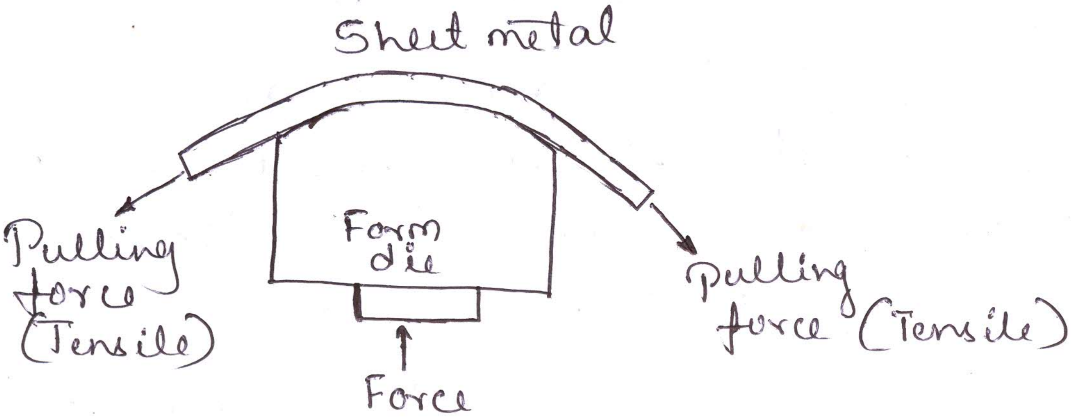


Extrusion

Tension type process

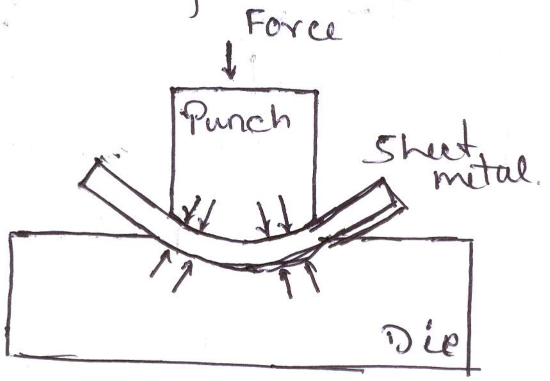
In this process tensile force is applied to both ends of the workspiece (sheetmetal) ~~and~~ is during forming process.

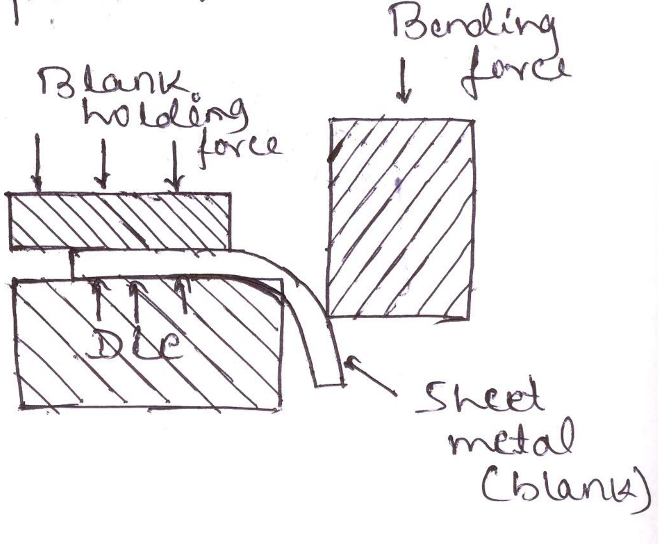
Ex :- Stretch forming.



Bending type process

In this process, bending movement is applied to the work-material (sheet metal), especially with the use of a die and a punch.

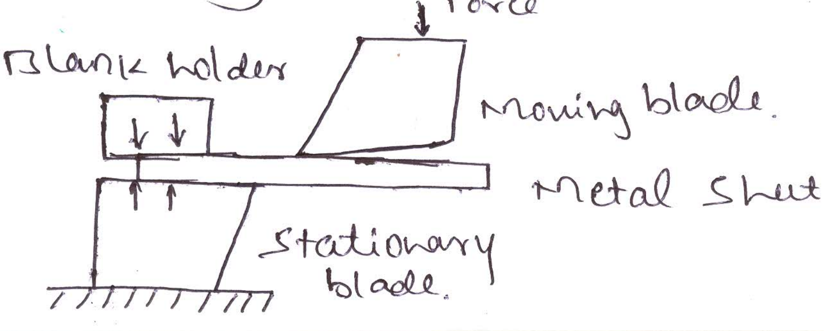




Shearing type Process

In this process, shear force is applied to rupture the material in the plane of shear.

Ex :- Shearing & Blanking process.



Yield Criteria

Plastic deformation takes place when applied stress exceeds a ~~ex~~ certain limit defined as yield stress.

During actual forming operations, the loading conditions are not uniaxial so. Hence there is need to consider the criterion for plastic yielding to take place.

Yield criteria is a hypothesis defines the limit of elasticity in a material and onset of plastic deformation under any possible combination of stresses.

The two general accepted criteria for predicting the onset of yielding in ductile materials are.

1) Tresca or Maximum Shear stress Criterion.

2) Von Mises or Distortion energy criterion

Tresca or Maximum Shear Stress

Plastic deformation depends on slip, which is essentially a shear force. Based on this concept Tresca suggested that

"Yielding or Plastic deformation starts when the maximum shear stress in the material (τ_{max}) ~~is~~ reaches ~~when~~ the value of the shear stress in the uniaxial tensile test (τ_0)"

i.e. $\tau_{max} = \tau_0$ — (1)

where

$$\tau_{max} = \frac{\sigma_1 - \sigma_3}{2} \quad \text{— (2)}$$

~~σ_1 = Largest maximum shear~~

σ_1 = Largest Principal stress (σ_{max})

σ_3 = smallest Principal stress (σ_{min})

In an uniaxial tensile test, $\sigma_1 \neq 0$, while all other components are zero. Hence yielding occurs when $\sigma_1 = \sigma_0$ yield strength.

Hence eqn (2) becomes.

$$\tau_{max} = \frac{\sigma_0}{2} \quad (\because \sigma_3 = 0.)$$

or $\tau_0 = \frac{\sigma_0}{2}$ from eqn (1).

According to Tresca's Hypothesis.

Yield strength ~~of~~ in Shear (τ_0) is equal to half the yield strength in tension ($\frac{\sigma_0}{2}$)

Von Mises or Distortion Energy Criterion or Shear Strain Energy Criterion.

Plastic deformation occurs when shear strain energy reaches a critical value.

$$(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2 \geq c \text{ (constant)} \quad (1)$$

Constant 'c' is evaluated based on relative yielding of uniaxial tensile test.

$$\sigma_1=\sigma_0, \text{ and } \sigma_2=\sigma_3=0.$$

where σ_0 = yield strength of the material at ~~tensile~~ uniaxial tensile load

Eqn (1) becomes.

$$\sigma_0^2+\sigma_0^2=c$$

$$2\sigma_0^2=c. \quad (2)$$

Substitute eqn (2) in eqn (1) we have.

$$(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2 \geq 2\sigma_0^2$$

or

$$\frac{1}{\sqrt{2}}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]^{1/2} \geq \sigma_0$$

$$\tau_{max} = \frac{\sigma_1 - (\sigma_2)}{2}$$

$$= \frac{200 - (-50)}{2} = \frac{250}{2}$$

$\tau_{max} = 125$ mpa

& $\tau_0 = \frac{\sigma_0}{2} = \frac{500}{2} = 250$ mpa.

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$\therefore$ $\tau_{max} \geq \tau_0$ is not true.

$125 \not\geq 250$

$\therefore$ According to tresca's yeild criteria material will not yeild.

$\therefore$ FOS $= \frac{\text{max stress}}{\text{allowable stress}} = \frac{500}{125}$

FOS $= 4$ $= \frac{\text{shear stress}}{\text{allow m}} = \frac{250}{125} = 2$

(ii) According to von misses criteria :-

the material will yeild when it is satisfy the following condition

$$\frac{1}{\sqrt{2}}\left[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2\right]^{1/2} \geq \sigma_0$$

$$\frac{1}{\sqrt{2}}\left[(200 - 100)^2 + (100 + 50)^2 + (-50 - 200)^2\right]^{1/2} \geq \sigma_0$$

$$\frac{1}{\sqrt{2}}\left[(100)^2 + (150)^2 + (-250)^2\right]^{1/2} \geq \sigma_0$$

217.945 ≯ σ₀ = 500.

thus by Von mises yeild criteria, the materia Yeilding not takes place thus.

4

Factor of safety = $\frac{500}{217.945} = 2.29$ $\frac{\sigma_{allow}}{\sigma_{max}} = 0.436$

(4) data :-

$\sigma_0 = 950$ mpa.

Stress state = $\begin{bmatrix} 0 & 0 & 300 \\ 0 & -400 & 0 \\ 300 & 0 & -800 \end{bmatrix}$ mpa.

$\Rightarrow \begin{bmatrix} \sigma_x - \sigma & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_y - \sigma & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_z - \sigma \end{bmatrix}$

According to stress state, there is no principle plane acting on the y axis $\therefore \sigma_y = \sigma_2 = -400$ Mpa.

$\therefore \begin{bmatrix} -\sigma & 300 \\ 300 & -800-\sigma \end{bmatrix} = 0.$

$\therefore -\sigma(-800-\sigma) - (300 \times 300) = 0.$

$800\sigma + \sigma^2 - 90000 = 0$

$\therefore \sigma_1 = 100$ Mpa. $\sigma_3 = -900$ mpa

No.	Description	Marks.
4)	The stress system	
	$\begin{bmatrix} \sigma_x-\sigma & \tau_{xy} & \tau_{xz} \\ \tau_{xy} & \sigma_y-\sigma & \tau_{zy} \\ \tau_{xz} & \tau_{yz} & \sigma_z-\sigma \end{bmatrix} = 0$	1
	Thus	
	$\sigma_x = 0, \quad \tau_{xy} = \tau_{yx} = 0.$	
	$\sigma_y = -400\,MPa \quad \tau_{xz} = \tau_{zx} = 300\,MPa.$	
	$\sigma_z = -800\,MPa \quad \tau_{yz} = \tau_{zy} = 0$.	
	Re-writing the eqn	
	$\begin{bmatrix} 0-\sigma & 300 \\ 300 & -800-\sigma \end{bmatrix} = 0.$	1
	$\left[-\sigma(-800-\sigma) - 300^2\right] = 0.$	1
	$\sigma^2 + 800\sigma - 300^2 = 0.$	
	we get $\sigma_1 = 100\,MPa. \quad \sigma_3 = -900\,MPa.$	1
	Von-Mises criteria	
	$\frac{1}{\sqrt{2}}\left[(\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_3-\sigma_1)^2\right]^{1/2} \geq \sigma_0$	1
	$\frac{1}{\sqrt{2}}\left[(100+400)^2 + (-400+900)^2 + (-900-100)^2\right]^{1/2} \geq 950.$	
	$866 \geq 950.$ which is not true	1
	* Yielding will not occur	1

Q. NO.

Tresca. Criteria

$$\tau_{max} = \frac{\sigma_1 - \sigma_3}{2} = \frac{100-(-900)}{2}$$ 1

$$\tau_{max} = 500 \text{ MPa}$$

$$\tau_0 = \frac{\sigma_0}{2} = \frac{950}{2} = 475 \text{ MPa}$$ 1

$\tau_{max} \geq \tau_0$ which is true. 1

yielding will occur.

(5) The effects of following parameters in metal working process:

(i) Temperature :

During the metal forming process, the material in metal forming reacts differently to a different kinds of temperature. therefore, temperature is considered to be as very important parameter to affects the metal working process. & it ~~incr~~ Enhances good physical properties

During hot temperature metal working process, materia get high temperature gets easily deformed, the force required to draw to plastic deformation is less compared to the cold working process. but in hot temperature. the materia while drawing. high friction & not get surface finish. but heating up to its recrystallization temp. the fine grain particles formed during hot working process.

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But in cold working process the stress required is more and we can get good surface finish & but in cold working process due to strain hardening the cracks may be formed. the Residual stress is also a important parameter in metal working process

(ii) Strain rate:-

The metal working process is usually measu... by strain rates. the strain rate is equal to the speed of the ~~sho~~ working to the height of the metal being formed

$$\text{Strain rate } \varepsilon' = \frac{v}{h}$$

when v - speed
h - heigh of meta... gets deformed.

the high strain rate, represents the faster deformation of metal & high flow rate. the force required to continous deformation and yeilding takes place. In low strain rates, the material having more friction & it is directly proportional to the speed of the drawing process.

(iii) Friction:-

Friction losses is considered to be a important parameters in metal forming process, the Friction caused by the dies present in drawing process cause considerble effect on the drawing stress & back stress.

CMR

the Friction in the metal to metal contact causes the material to get produce high friction heats & the material may damage in the frictional area and causes improper surface finish.

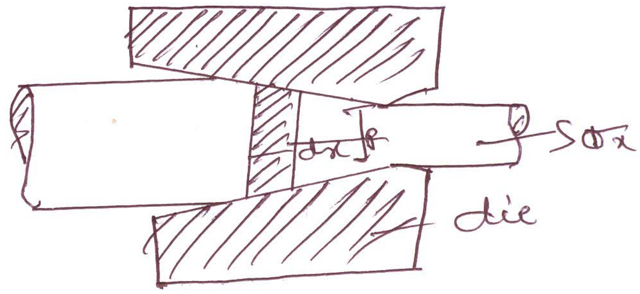
The friction is depends on the.

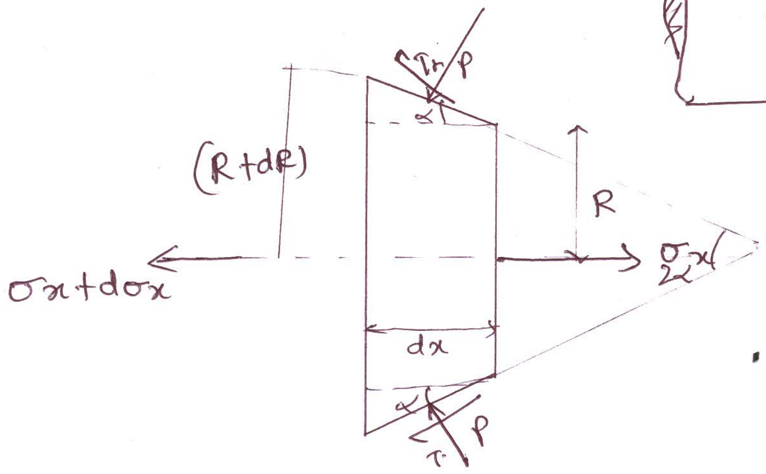
The columb's friction law

$\tau = \mu p.$ — μ - Friction factor.

→ it depends also on the material, drawing speed, use of lubricants etc.

7) The Expression for drawing load by a slab Analysis :-





consider a small portion of a slab in a deformation zone, then $\Sigma F = 0$.

then. Stress = force / Area

Force = Stress x area

$$= (\sigma_x + d\sigma_x)(\pi(R+dR)^2) - \sigma_x \pi R^2$$

$$\Rightarrow (\sigma_x + d\sigma_x)[\pi(R+dR)^2] - \sigma_x \pi R^2 + P \cancel{\cos}\alpha\left(\frac{2\pi R\,dx}{\cos\alpha}\right) + P\sin\alpha\left[\frac{2\pi R\,dx}{\cos\alpha}\right] = 0. \quad -(1)$$

$$\Rightarrow \cancel{\sigma_x \pi R^2} + \sigma_x \cancel{\pi dR^2}^{\,0} + 2\sigma_x \pi R\,dR + d\sigma_x \pi R^2 + d\sigma_x \cancel{\pi dR^2}^{\,0} + 2\cancel{d\sigma_x \pi R\,dR}^{\,0}$$
$$- \cancel{\sigma_x \pi R^2} + \tau 2\pi R\,dx + 2\pi R P\,dx \tan\alpha = 0 \quad -(2)$$

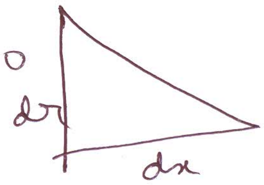
Since dR & σ_x are very small thus square of this is too small hence these are neglected

$$2\sigma_x \pi R\, dR + d\sigma_x\, \pi R^2 + \tau\, 2\pi R\, dx + p\, 2\pi R\, dx \tan\alpha = 0$$

Equ (3) $\div\ \pi R^2 dR$

$$\frac{2\sigma_x \cancel{\pi} R\, dR}{\cancel{\pi} R^2 dR} + \frac{d\sigma_x \cancel{\pi} \cancel{R^2}}{\cancel{\pi} R^2 dR} + \frac{\tau\, 2\cancel{\pi} R\, dx}{\cancel{\pi} R^2 dR} + \frac{p\, 2\pi R\, dx \tan\alpha}{\pi R^2 dR} = 0$$

$$\frac{2\sigma_x}{R} + \frac{d\sigma_x}{dR} + \frac{2\tau}{R}\frac{dx}{dR} + \frac{2p}{R}\frac{1}{\cancel{\tan\alpha}}\cancel{\tan\alpha} = 0$$



$$\therefore \frac{d\sigma_x}{dR} + \frac{2\tau}{R}\cot\alpha + \frac{2}{R}(\sigma_x + p) = 0 \quad (4) \qquad \tan\alpha = \frac{dr}{dx}$$

by Tresca's criteria

$$\sigma_0 = \sigma_1 - \sigma_3$$

here $\sigma_1 = \sigma_x$

$\sigma_2 = -p$

$\therefore\ \sigma_x + p = \sigma_0.$

then by coulombs law of friction

$$\tau = \mu p = \mu(\sigma_0 - \sigma_x)$$

Substituting in Equ (4) we get

$$\frac{d\sigma_x}{dR} + \frac{2}{R}\sigma_0 + \frac{2}{R}\mu(\sigma_0 - \sigma_x)\cot\alpha = 0 \quad (5)$$

consider $\mu \cot\alpha = \beta$

CMR

$$\therefore \frac{d\sigma_x}{dR} + \frac{2}{R}\sigma_0 + \frac{2}{R}(B(\sigma_0 - \sigma_x) = 0.$$

$$\therefore \frac{d\sigma_x}{dR} = \frac{2}{R}(B\sigma_x - (1+B)\sigma_0) \quad \text{— ⑥}.$$

$$\therefore \frac{dR}{R} = \frac{d\sigma_x}{2(B\sigma_x - (1+B)\sigma_0)}$$

$$\ln R + \ln C = \frac{1}{2}\left(\frac{\ln(B\sigma_x - (1+B)\sigma_0)}{B}\right)$$

$$\ln R + \ln C = \frac{1}{2B}\ln(B\sigma_x - (1+B)\sigma_0)$$

$$RC^{2B} = [B\sigma_x - (1+B)\sigma_0] \quad \text{— ⑦}.$$

Applying first boundary condition to the Eqn 7 we get

$$R = R_0 \ \& \ \sigma_x = \sigma_1$$

$$R_0 C^{2B} = [B\sigma_1 - (1+B)\sigma_0]$$

$$C = \frac{(B\sigma_1 - (1+B)\sigma_0)^{1/2B}}{R_0}$$

Substitute C in Eqn ⑦ we get.

$$\left[\frac{R}{R_0}(B\sigma_1 - (1+B)\sigma_0)^{1/2B}\right]^{2B} = [B\sigma_x - (1+B)\sigma_0$$

$$= \left(\frac{R}{R_0}\right)^{2B}(B\sigma_1 - (1+B)\sigma_0) = (B\sigma_x - (1+B)\sigma_0$$

$$\therefore \sigma_x = \frac{\left(\frac{R}{R_0}\right)^{2B}\left[B\sigma_1 - (1+B)\sigma_0\right] + (1+B)\sigma_0}{B}.$$

$$\sigma_x = \left(\frac{R}{R_0}\right)^{2B}\sigma_1 + \frac{(1+B)}{B}\sigma_0\left(1-\left(\frac{R}{R_0}\right)^{2B}\right) \quad \text{— (8)}$$

by applying second boundary condition we get :-

$R = R_f$. & $\sigma_x = \sigma_2$.

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$\therefore$ ~~σ_2~~ = & σ_1 is very small we neglect it

$$\boxed{\sigma_2 = \left(\frac{1+B}{B}\right)\sigma_0\left(1-\left(\frac{R_f}{R_0}\right)^{2B}\right)} \quad \text{— (9)}$$

Expression for drawing load by slab analysis

method :