Surfaces Of Revolution (S.O.R.)

الأسطح الدورانيه

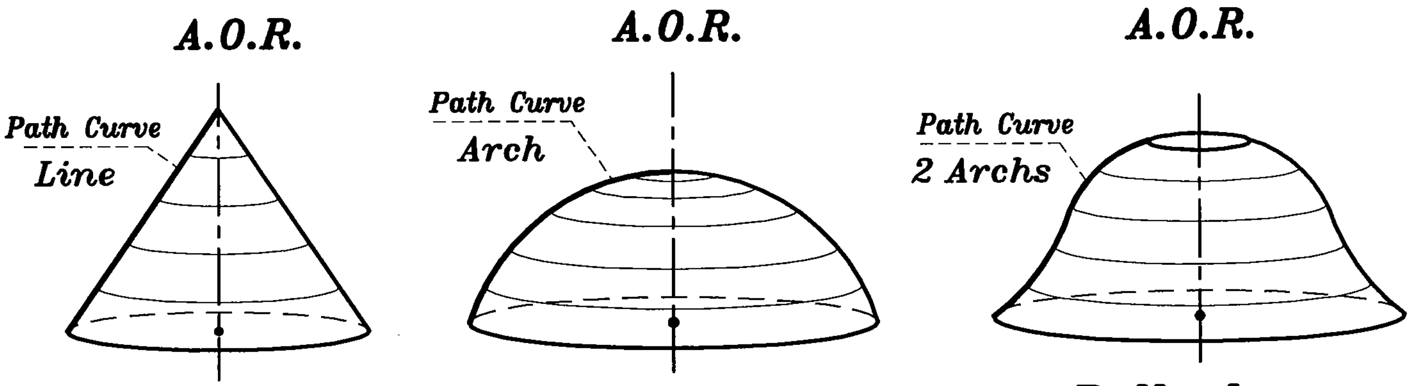
Part 1

هى عباره عن أسطح رفيعة **(غشاء)** تنشأ من دوران منحنى **(Path Curve)**
حول محور رأسى يسمى محور الدوران **(A.O.R.) Axis Of Revolution**

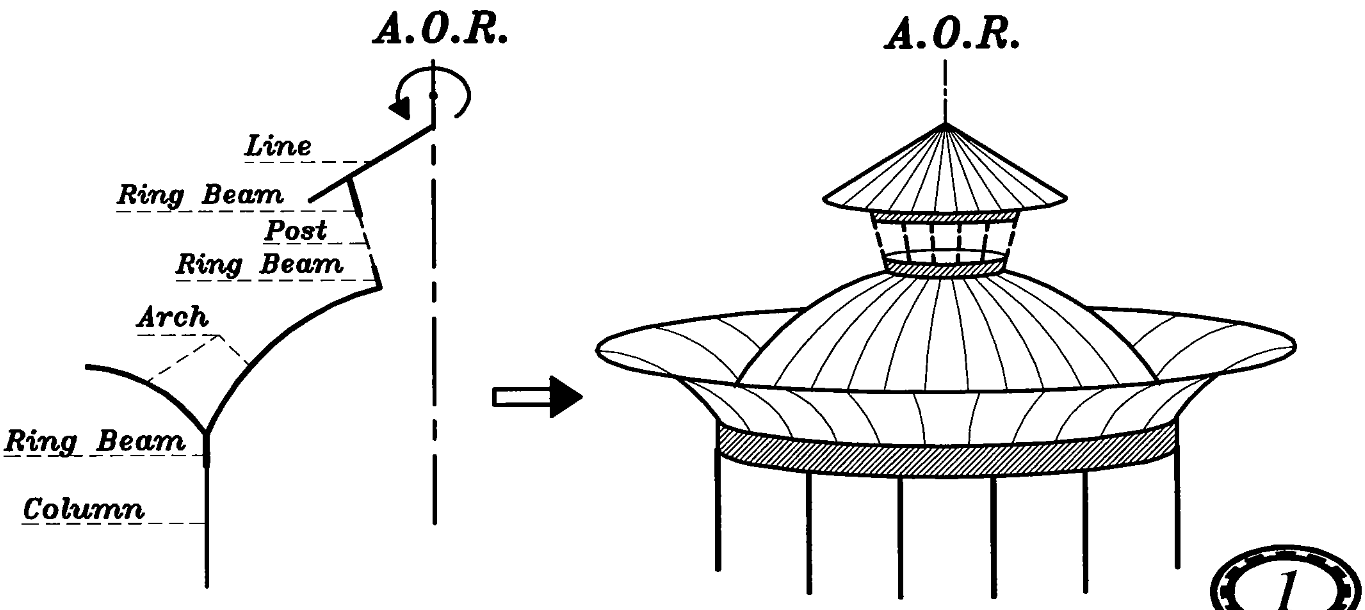
و ال **(Path Curve)** عباره عن المنحنى الذى يدور أفقيا دوره كامله
و ممكن أن يكون خط مستقيم أو قطعه من دائره *(Arch)* أو قطع ناقص *(Parabola)*
أو أى منحنى أخر .

Definition.

*Surfaces Of Revolution is a surfaces has a membrane behavior created by rotation of a curve called **Path Curve** around vertical axis called **Axis Of Revolution** (A.O.R.)*



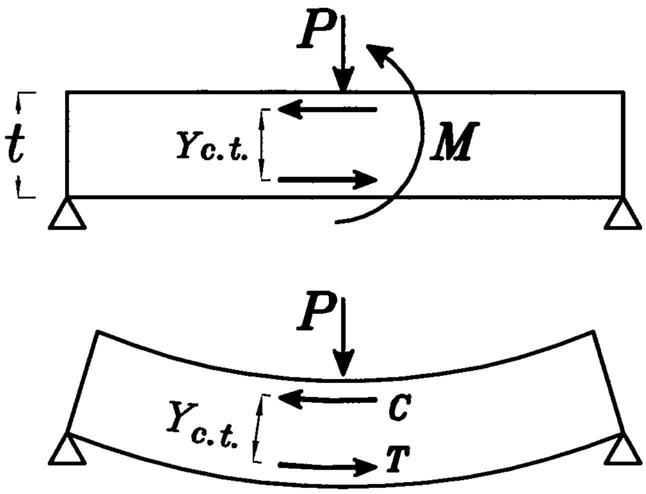
Cone　　Dome　　Bell shape



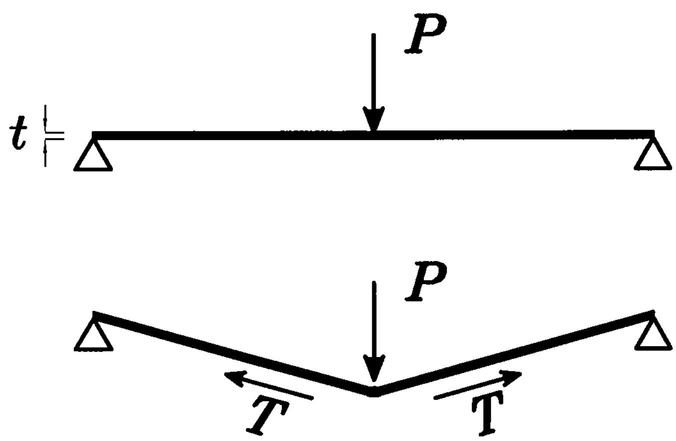
Membrane Theory. — نظريه الغشاء (القشره)

Beam or slab thikness (t) *has a big value.*

Shell (membrane) thikness (t) *has a very small value.*



Bending Moment
Compression & Tension



Axial Force
Compression only
or
Tension only

نظرا لصغر سُمك الأشكال القشريه (***Shells***) و صغر سُمك الأسطح الدورانيه فعند تعرضها للاحمال لن تكون هناك تخانه (t) كافيه ليحدث لها ***Bending*** أى أن يحدث لجزء ***Compression*** و الاخر ***Tension*** لكن الاحمال المؤثره تسبب ان يكون كل القطاع معرض اما لـ ***Compression*** فقط او لـ ***Tension*** فقط.

أى أن الـ ***Inertia*** للقطاع صغيره جدا فلا يكون هناك ***Bending Rigidity***.
فتقاوم هذه المنشآت الأحمال الواقعه عليها عن طريق (***Axial Forces***) فقط و لا توجد مقاومه للـ (***Bending Moments***)

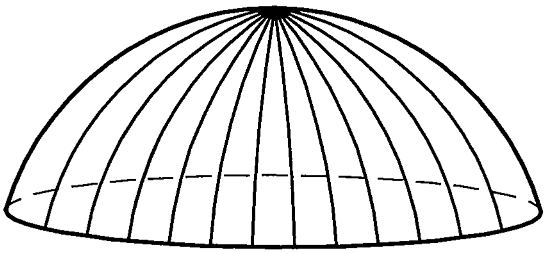
Because of the very small thickness of the shell, it works as a membrane, Which has No Bending Rigidity. Means NO Bending Moment acting on the shell. Only Axial Forces $\left[\textit{Meridian Force } (T_1) \ \& \ \textit{Ring Force } (T_2)\right]$ *acting on the Shell.*

Definitions & Signs.

هناك بعض التعريفات المهمه و الاشارات (الموجبه و السالبه) التى يجب ان نعرفها أولا .

* Meridian Direction & Ring Direction.

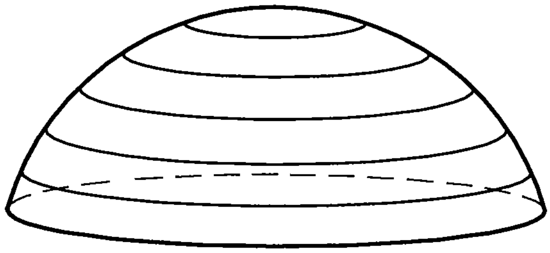
و هى عباره عن اتجاهات القوى المؤثره على ال **Surface**



Meridian Direction.

هو الاتجاه الطولى (الرأسى)

و يأخذ نفس شكل ال *Path Curve*



Ring Direction.

هو الاتجاه الدائرى العرضى (الافقى)

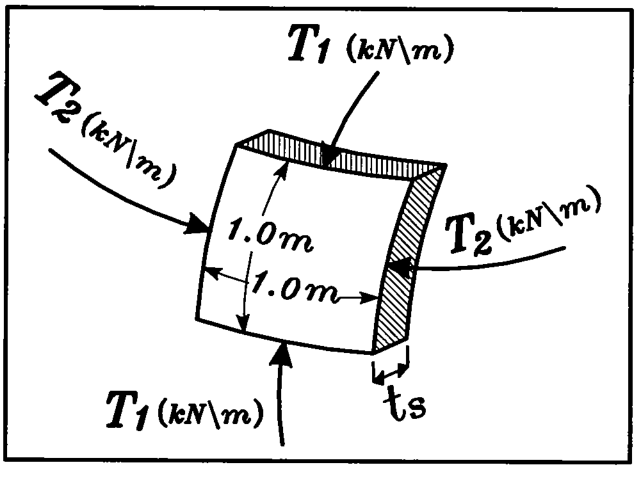
و دائما مركزه هو محور الدوران

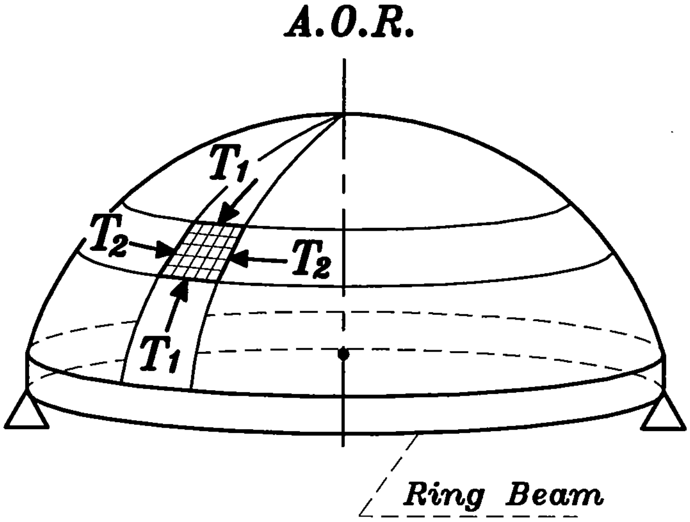
* Internal Forces (T_1) & (T_2).

هى قوى الضغط أو الشد المؤثره على **1.0 m** طولى من السطح فى الاتجاهين اتجاه **Meridian direction** و اتجاه **Ring direction**

T_1 is **Meridian Force.** (kN\m)

T_2 is **Ring Force.** (kN\m)





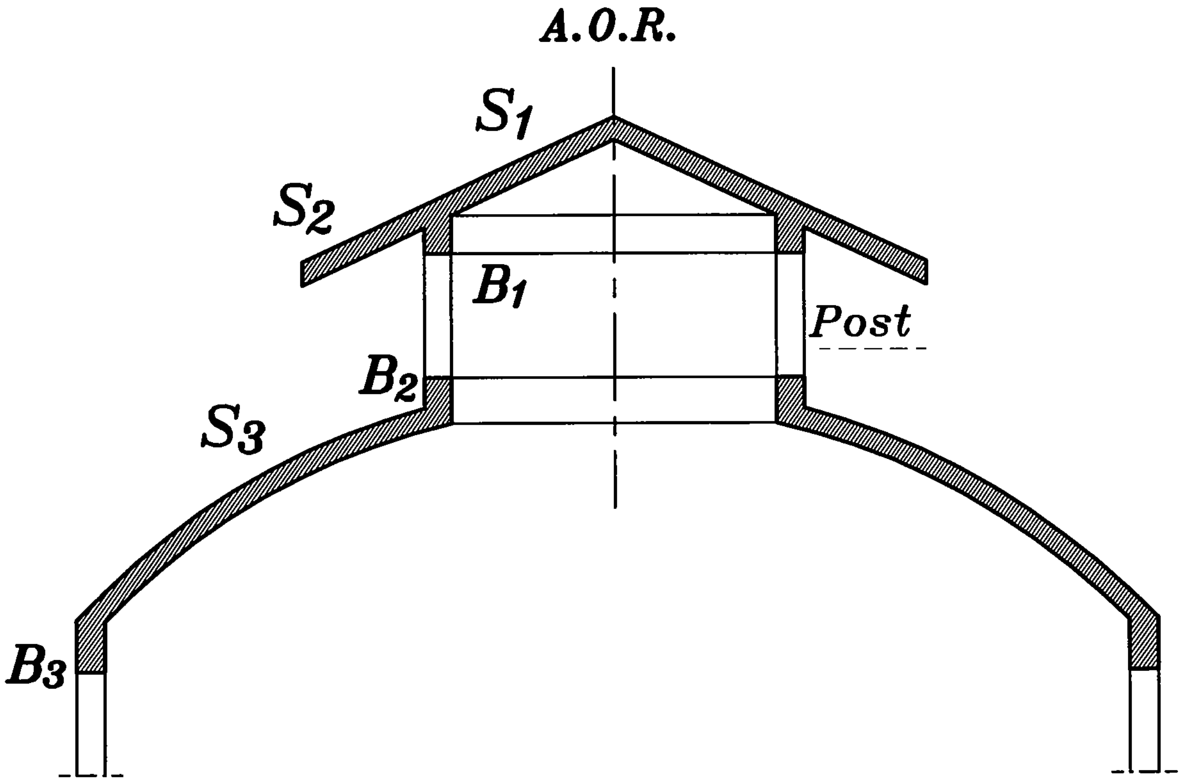
Signs of T_1 & T_2	$+Ve \longrightarrow$ Comparison
	$-Ve \longrightarrow$ Tension

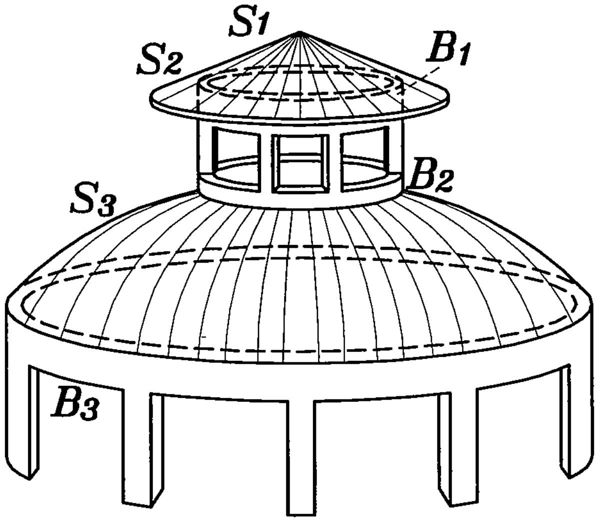
* *Shell Surface.*

و هى الاسطح الدورانيه التى يكونها ال *path curve*

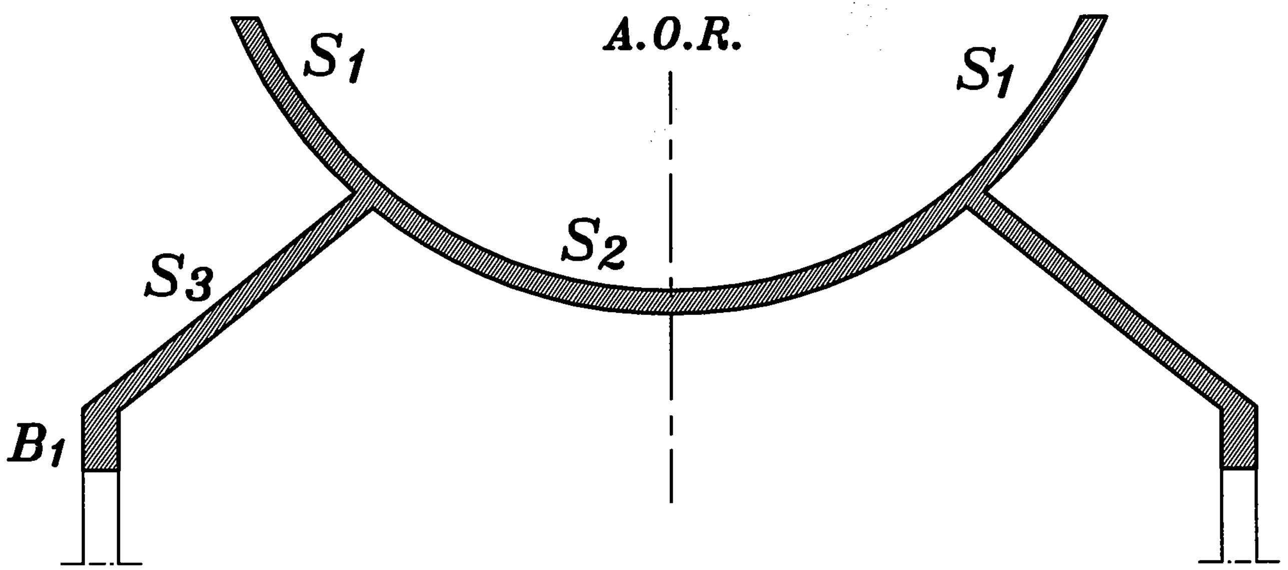
و تكون دائما محموله على *support* واحد فقط و هو اما كمره دائريه *Ring Beam* او محموله على سطح اخر .

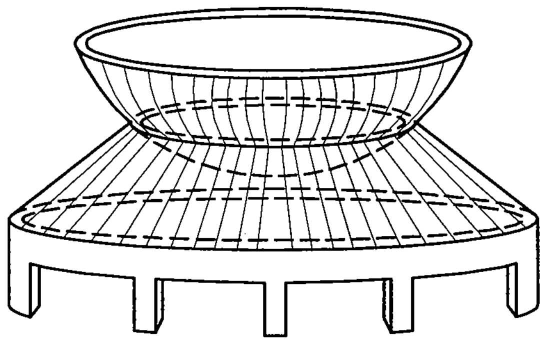
و يتم تحليل القوى فى كل سطح على حده ما دام بينهم ركيزه *support*





- السطح S_1 محمول على الكمره B_1
- السطح S_2 محمول على الكمره B_1
- الكمره B_1 محموله على ال *Posts*
- ال *Posts* محموله على الكمره B_2
- الكمره B_2 محموله على السطح S_3
- السطح S_3 محمول على الكمره B_3
- الكمره B_3 محموله على الاعمده

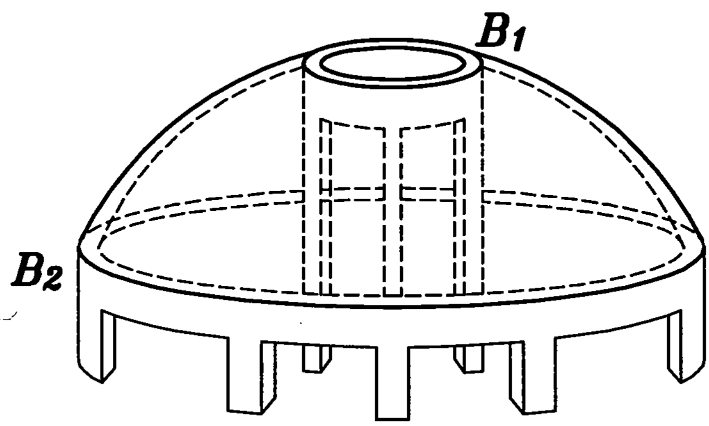


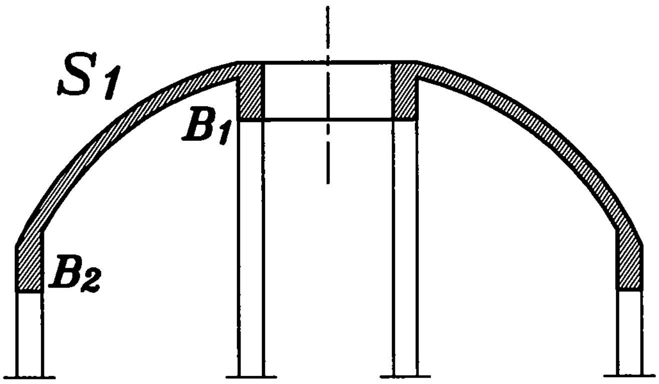


- السطح S_1 محمول على السطح S_3
- السطح S_2 محمول على السطح S_3
- السطح S_3 محمول على الكمره B_1
- الكمره B_1 محموله على الاعمده

ملحوظه هامه .

فى هذا الملف لن نتناول تحليل الاسطح المحموله على اكثر من *support* حيث يتم تحليلها بالكمبيوتر .



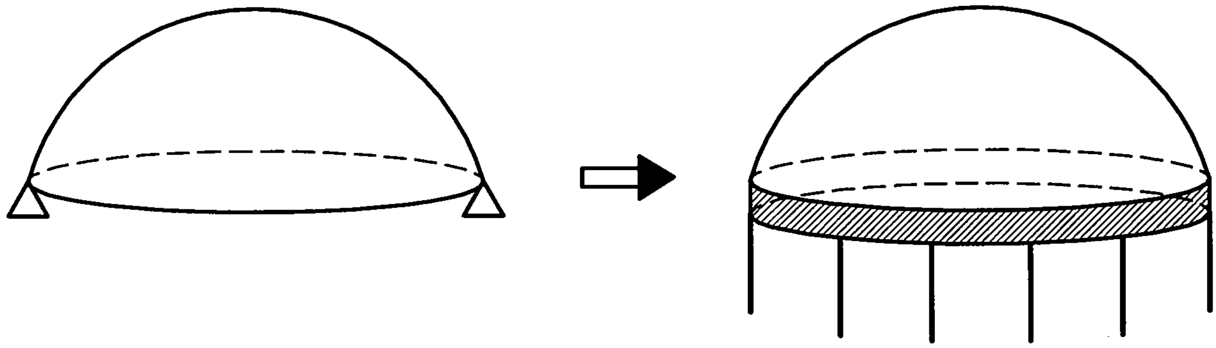


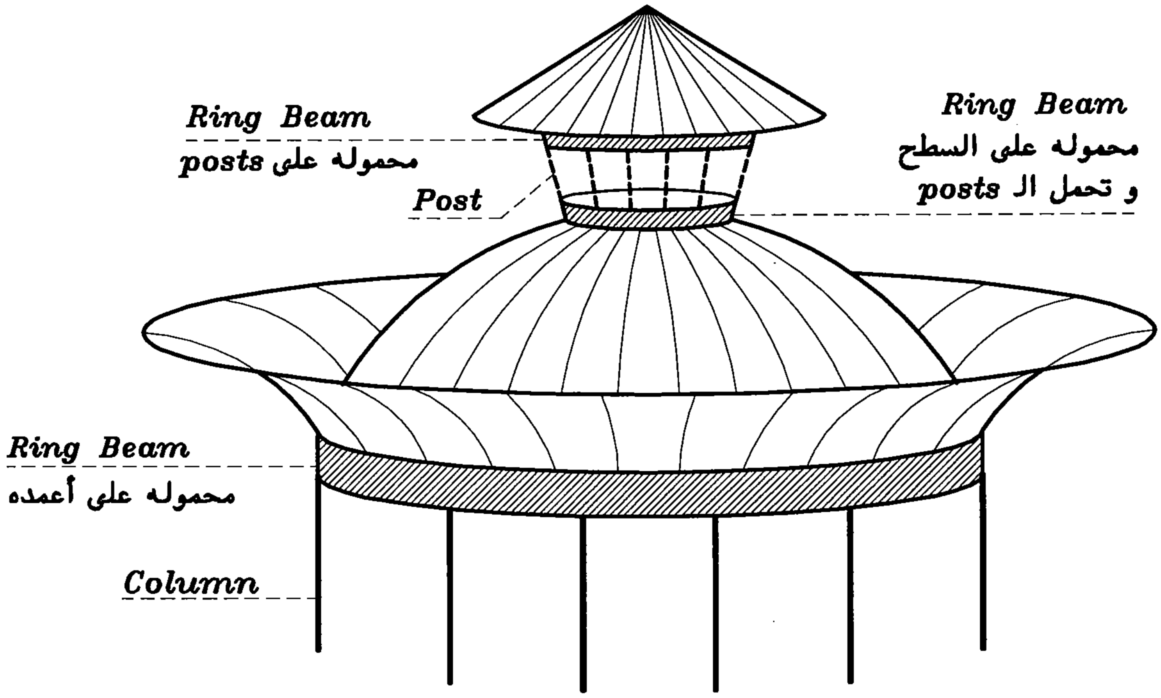
لن نستطيع تحليل السطح S_1 لانه محمول على *2 supports* لذا يجب تحليله بالكمبيوتر

* *Ring Beams.*

الكمرات الدائريه تعتبر *support* للاسطح الدورانيه .

و تكون محموله على أعمده أو *posts* او تكون محموله على السطح الدورانى و تحمل الـ *posts*





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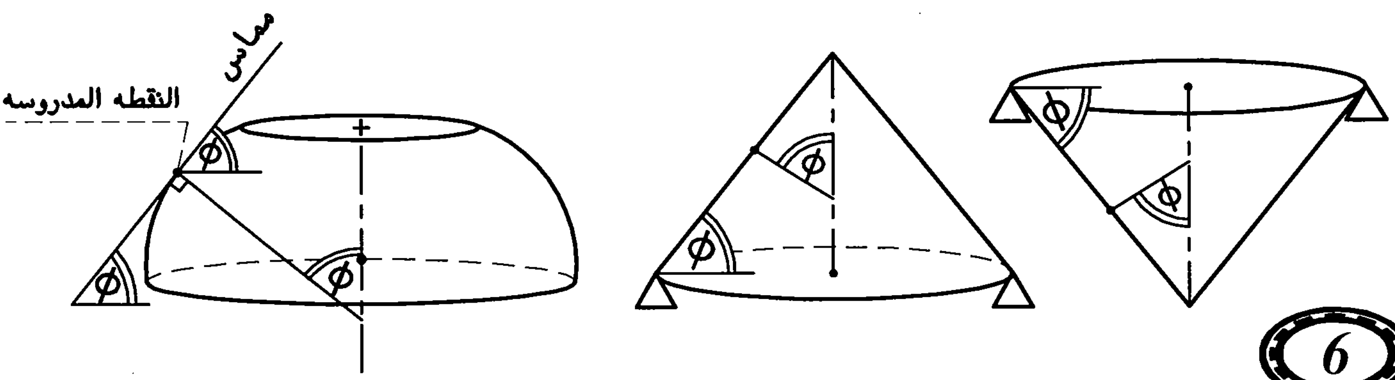
* ϕ

ϕ هى زاويه ميل المماس للسطح عند النقطه المدروسه مع المستوى الافقى .

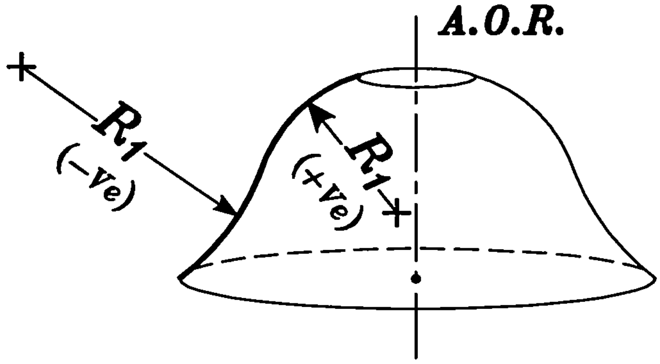
و فى حاله اذا كان المنحنى عباره عن خط مستقيم تكون الـ ϕ هى زاويه ميل هذا الخط مع الافقى .



* R_1

R_1 هو نصف قطر المنحنى (Path Curve)

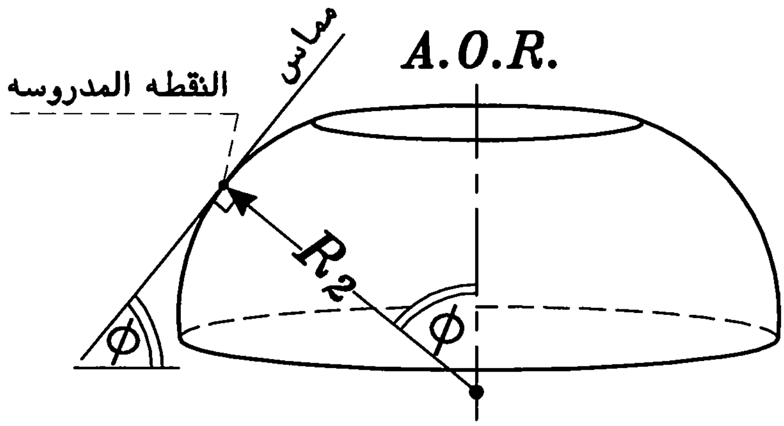
R_1 (+Ve) Sign
عندما تكون خارجه بعيدا عن ال (A.O.R.)
R_1 (−Ve) Sign
عندما تكون داخله فى اتجاه ال (A.O.R.)



* R_2

R_2 هو البعد العمودى على المماس من النقطه المدروسه حتى (A.O.R.)
و زاويه ميله مع الرأسى هى ϕ

$\boxed{R_2 \text{ دائما اشارتها } (+Ve)}$

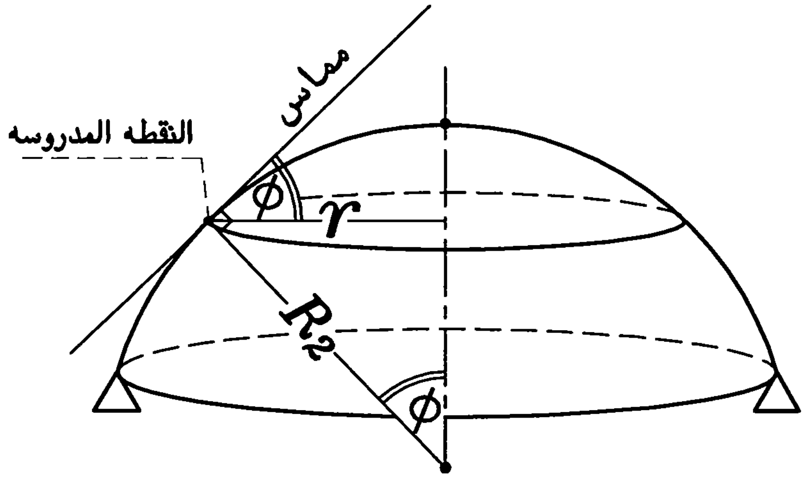


* r

r هو نصف قطر الدائره الافقيه عند النقطه المدروسه

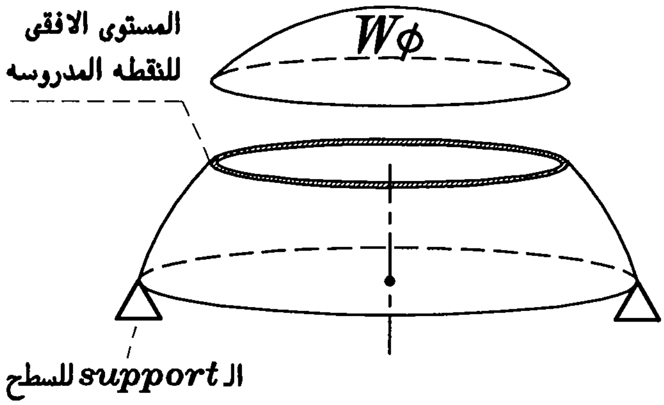
$$\boxed{r = R_2 * \sin \phi}$$

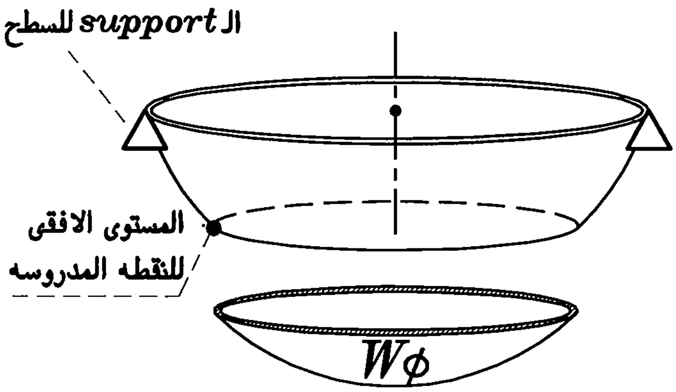
$\boxed{r \text{ دائما اشارتها } (+Ve)}$



* $\underline{\underline{W\phi}}$

$W\phi$ هى مجموع الاوزان الرأسيه المحسوبه عند المستوى الافقى عند النقطه المدروسه لسطح معين محسوبه من الجهه البعيده لل *support* الذى يحمل هذا السطح .





$$D.L. = g = t_s \, \gamma_c + F.C. = \checkmark \quad (kN \backslash m^2)$$

$$L.L. = P = \checkmark \quad (kN \backslash m^2) \;\; H.P. \quad (Horizontal \;\; Projection)$$

$$Water \;\; Weight = \gamma_w * Volume$$

$$\boxed{\gamma_w = 10.0 \quad (kN \backslash m^3)}$$

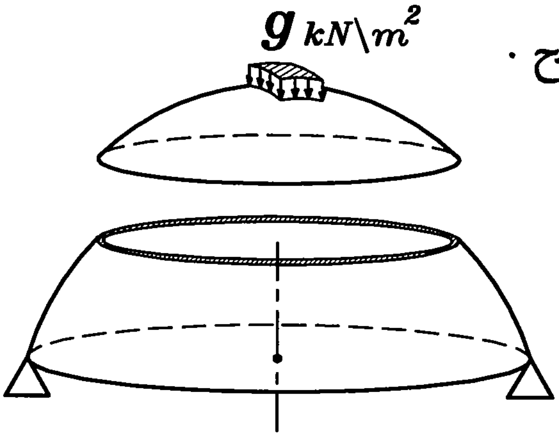
In Case of No Water $\longrightarrow \quad W_\phi = W\phi_{D.L.} + W\phi_{L.L.}$

In Case of Water $\longrightarrow \quad W_\phi = W\phi_{D.L.} + W\phi_{Water}$

$W\phi_{D.L.}$

$$D.L. = g = t_s\,\gamma_c + F.C. = \checkmark \ (kN\backslash m^2)$$

g هى الوزن الواقع على متر مربع من السطح .

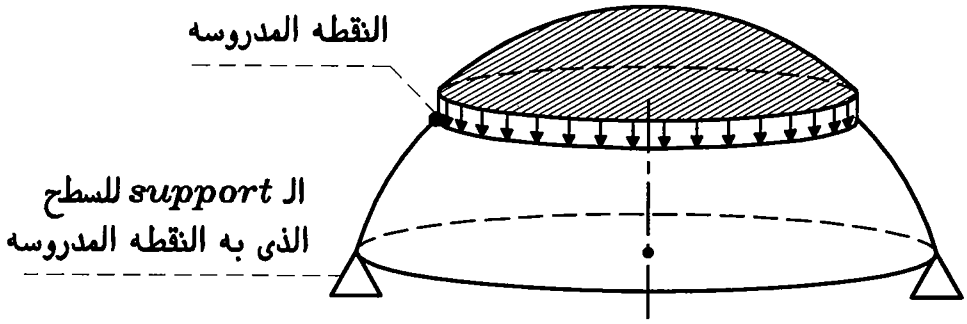


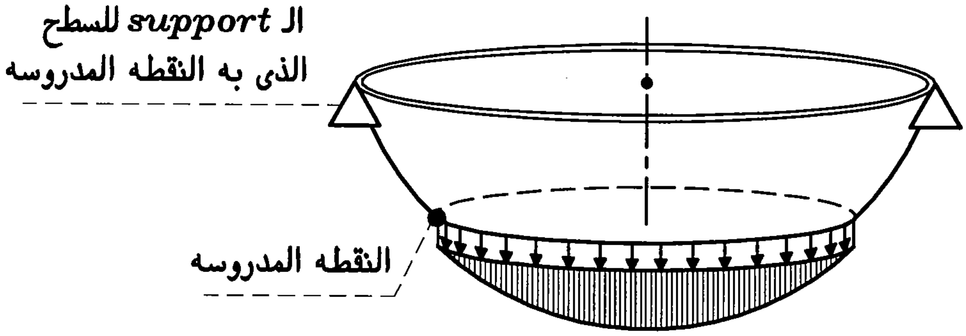
$W\phi_{D.L.}$ هو محصله الوزن من الجهه البعيده عن ال *support*

$$W\phi_{D.L.} = g * S.A. = \checkmark \ (kN)$$

$S.A. = Surface\ \ Area$

$$W\phi_{D.L.} = g * Surface\ \ Area$$

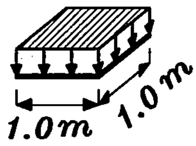




$$W\phi_{D.L.} = g * Surface\ \ Area$$

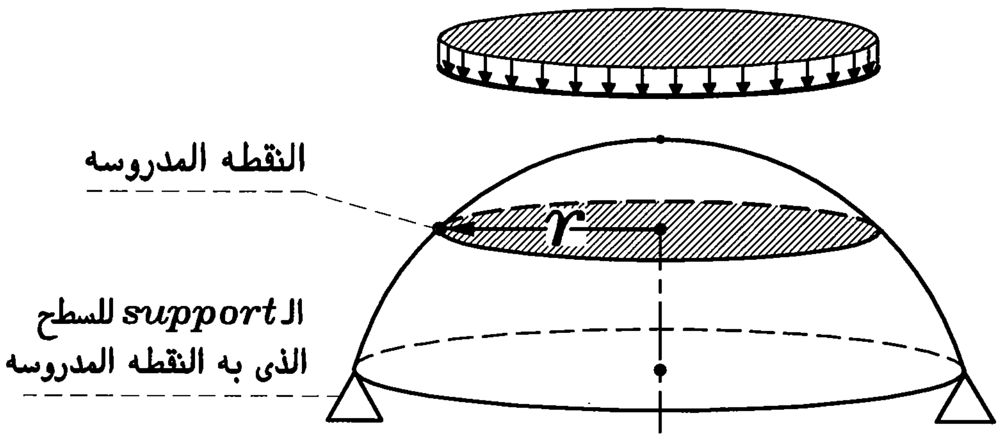
$W_{\phi\, L.L.}$

$L.L. = P = \checkmark\ (kN \backslash m^2)$ H.P. (Horizontal Projection)



$$W_{\phi\, L.L.} = P * \text{Projected Area} = P * \pi\, r^2 = \checkmark\ (kN)$$

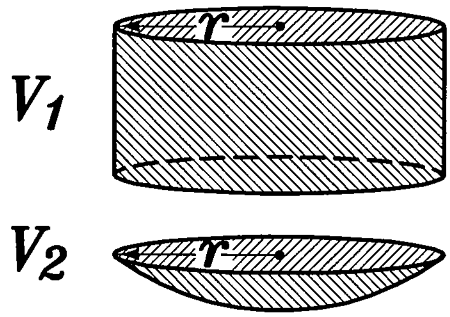
$$W_{\phi\, L.L.} = P * \text{Projected Area}$$

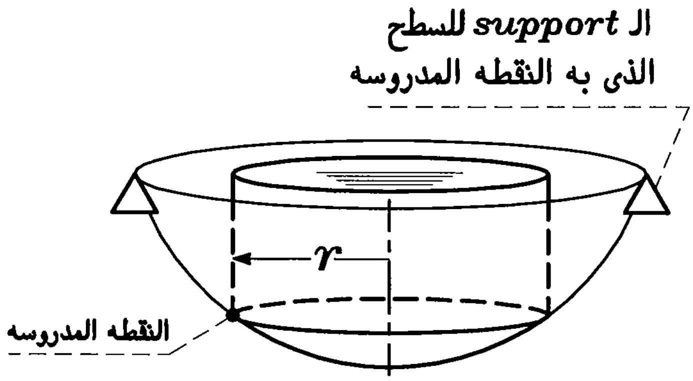


$W_{\phi\, Water}$

$$W_{\phi\, Water} = \gamma_w * \text{Volume} \qquad \boxed{\gamma_w = 10.0\ (kN \backslash m^3)}$$

Volume هو مجموع حجم الماء فوق المستوى الافقى للنقطه المدروسه للسطح من الجهه البعيده للـ support الذى يحمل هذا السطح .

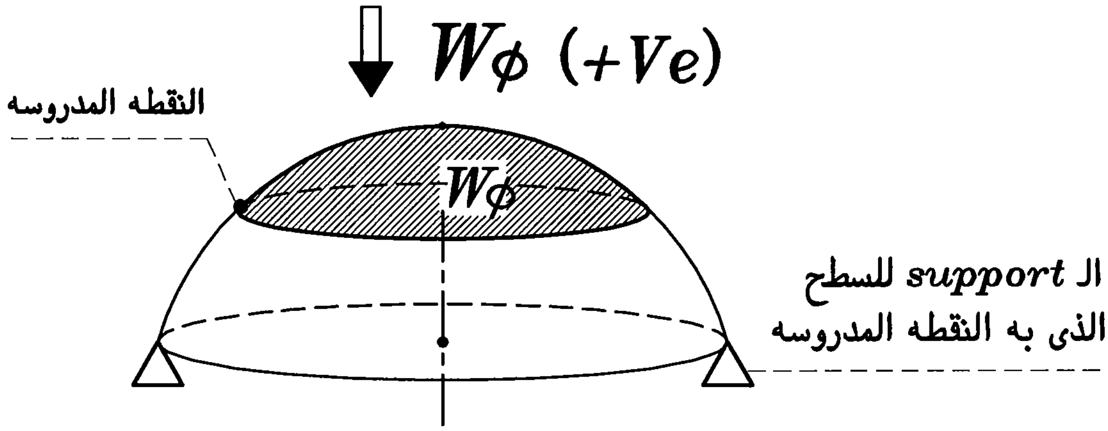




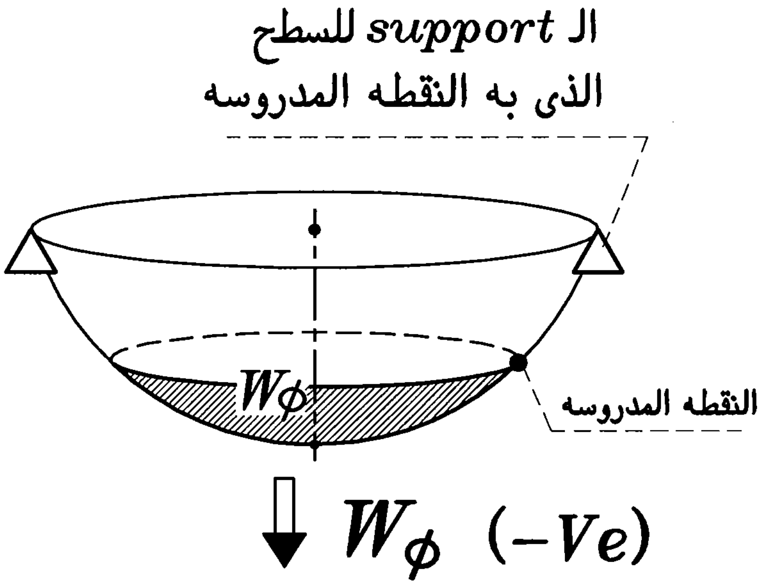
$$W_{\phi\, Water} = \gamma_w * (V_1 + V_2)$$

Signs of W_ϕ

$(+Ve)$ Sign عندما يكون اتجاه ال W_ϕ داخل الى ال Support

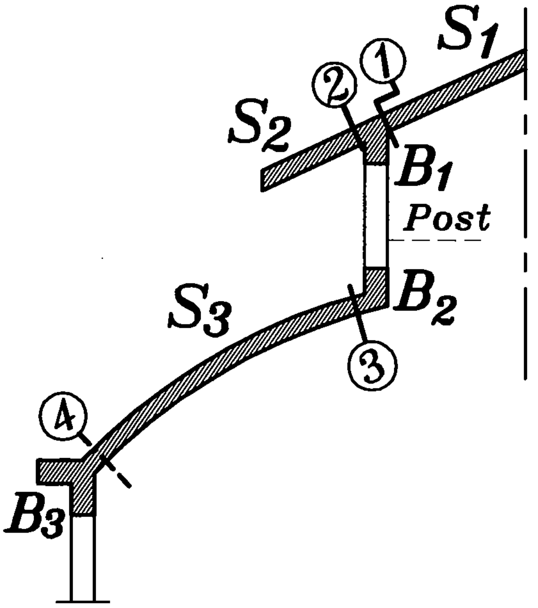


$(-Ve)$ Sign عندما يكون اتجاه ال W_ϕ خارج من ال Support



Special Cases of Calculating W_ϕ

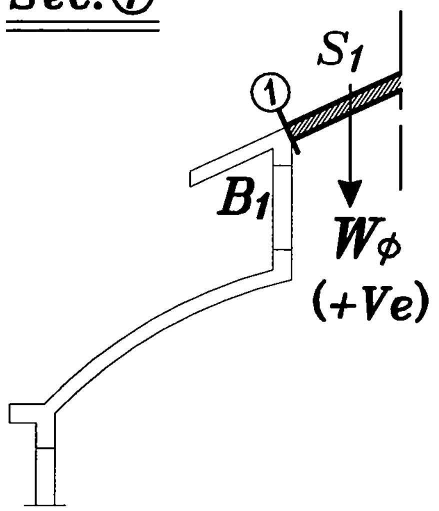
A.O.R.



الكمره B_1 هى ال support للسطحين S_1 & S_2

الكمره B_3 هى ال support للسطح S_3

Sec.①

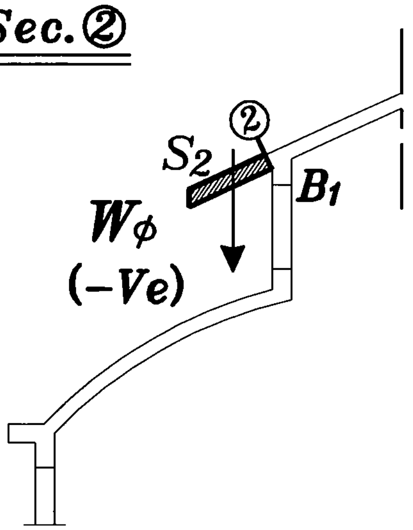


Sec.① موجود فى السطح S_1

الكمره B_1 هى ال support للسطح S_1

$$W_{\phi\,(Sec.\,1)} = \text{Total Loads on Slab } S_1$$

Sec.②



Sec.② موجود فى السطح S_2

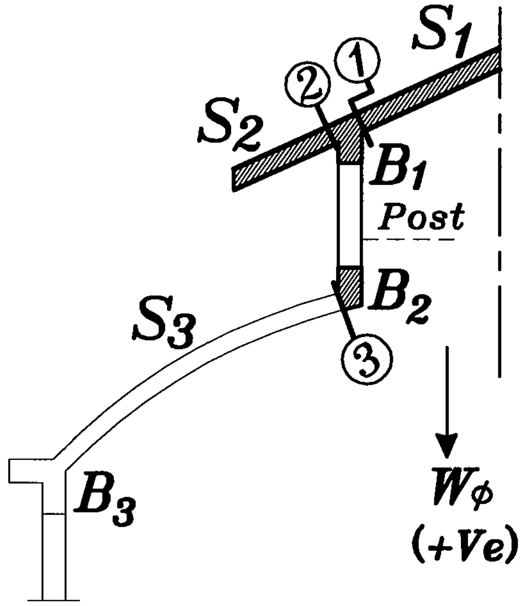
الكمره B_1 هى ال support للسطح S_2

$$W_{\phi\,(Sec.\,2)} = \text{Total Loads on Slab } S_2$$

Sec.③

Sec.③ موجود فى السطح S_3

الكمره B_3 هى ال *support* للسطح S_3

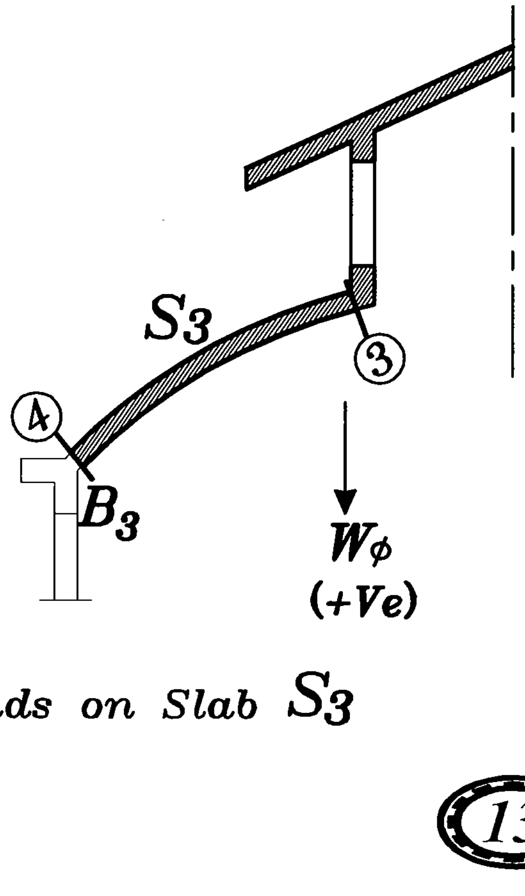


$$W_\phi{}_{(Sec.3)} = W_\phi{}_{(Sec.1)} + W_\phi{}_{(Sec.2)}$$
$$+ \text{Total weight of Beam } (B_1)$$
$$+ \text{Weight of all Posts}$$
$$+ \text{Total weight of Beam } (B_2)$$

Sec.④

Sec.④ موجود فى السطح S_3

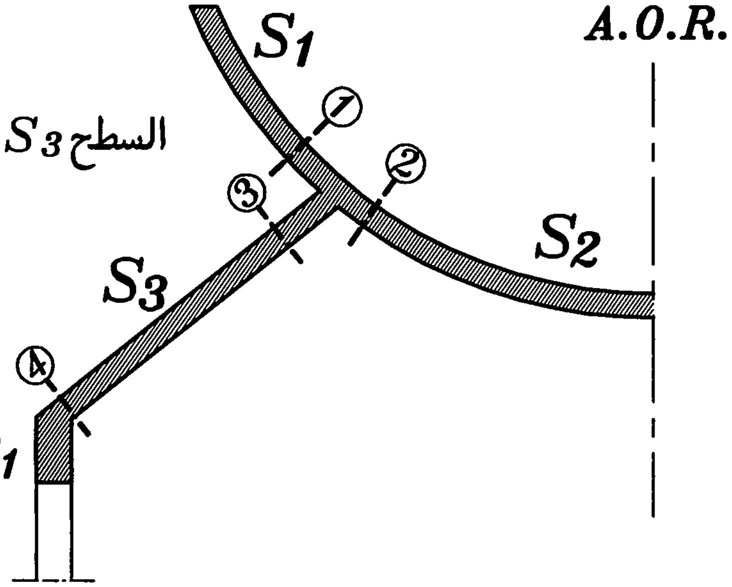
الكمره B_3 هى ال *support* للسطح S_3



$$W_\phi{}_{(Sec.4)} = W_\phi{}_{(Sec.3)} + \text{Total Loads on Slab } S_3$$

Special Case.

السطح S_3 هى ال *support* للسطحين S_1 & S_2

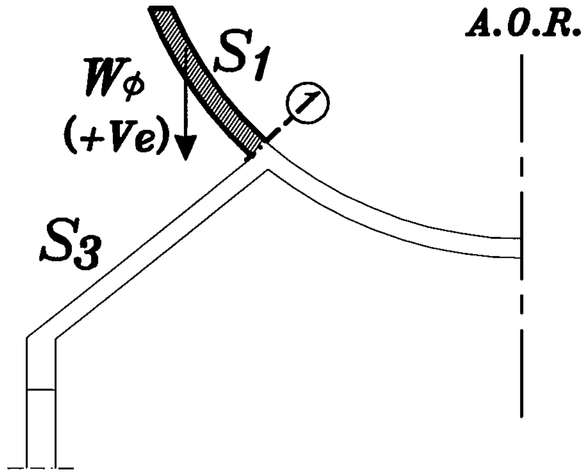


Sec. ①

Sec. ① موجود فى السطح S_1

السطح S_3 هو ال *support* للسطح S_1

$$W_\phi \,_{(Sec.\,1)} = \text{Total Loads on Slab } S_1$$

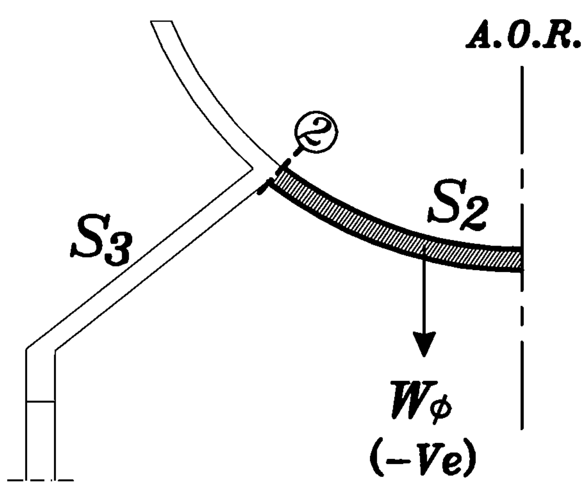


Sec. ②

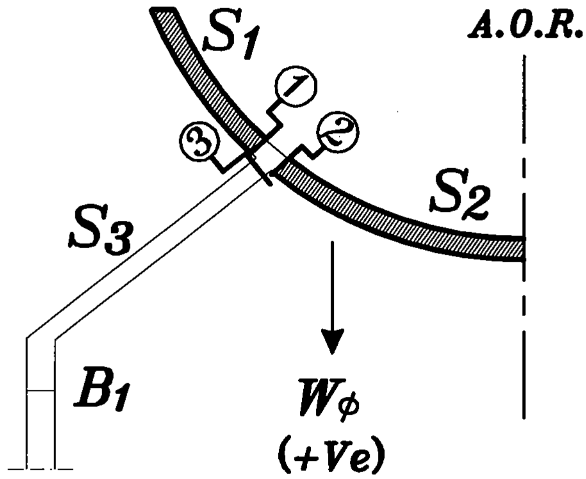
Sec. ② موجود فى السطح S_2

السطح S_3 هو ال *support* للسطح S_2

$$W_\phi \,_{(Sec.\,2)} = \text{Total Loads on Slab } S_2$$



Sec.③

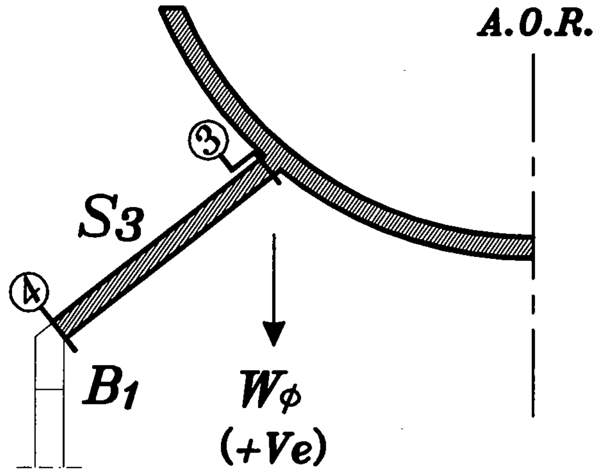


Sec.③ موجود فى السطح S_3

الكمره B_1 هى ال support للسطح S_3

$$W_{\phi\,(Sec.3)} = W_{\phi\,(Sec.1)} + W_{\phi\,(Sec.2)}$$

Sec.④



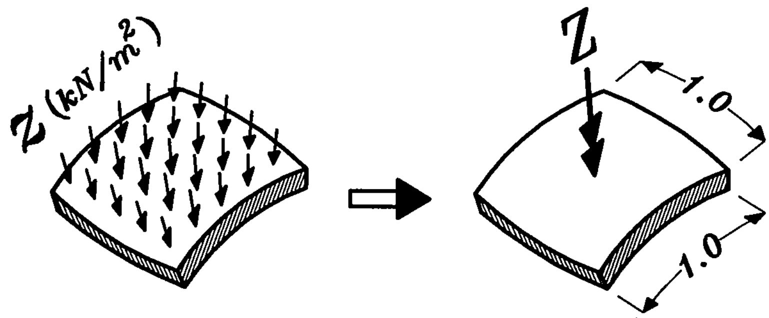
Sec.④ موجود فى السطح S_3

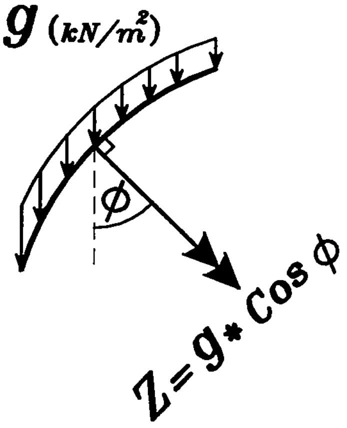
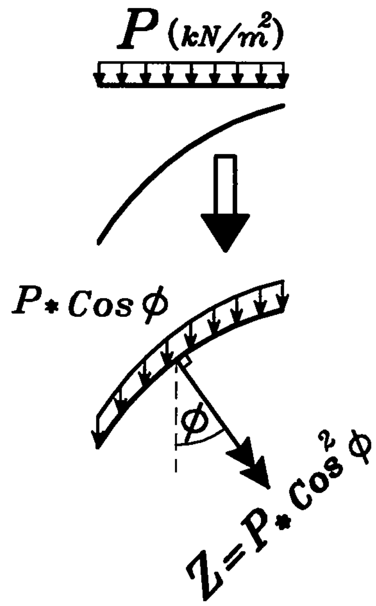
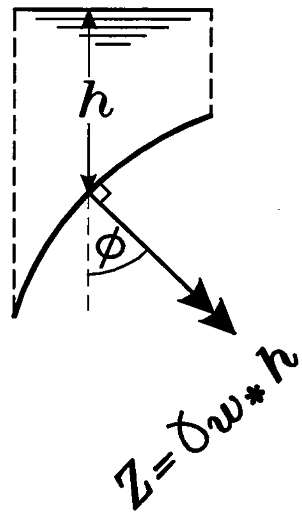
الكمره B_1 هى ال support للسطح S_3

$$W_{\phi\,(Sec.4)} = W_{\phi\,(Sec.3)} + Total\ Loads\ on\ Slab\ S_3$$

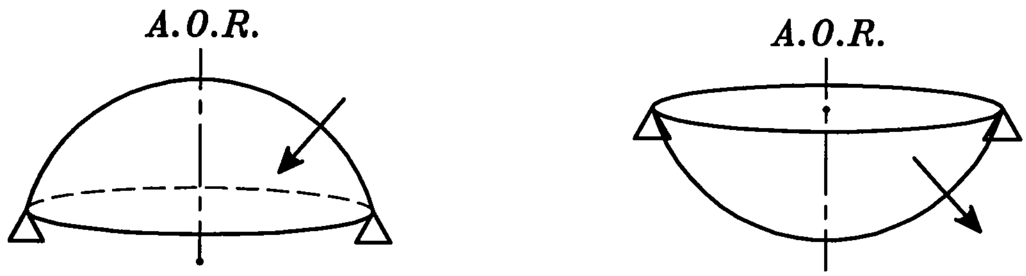
* Z

(Z) هى محصله القوى الخارجيه العموديه على وحده المساحات من السطح .
و وحداتها (kN/m^2)



<table>
<tr><th>Dead Load</th><th>Live Load</th><th>Water Load</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>$Z = g * Cos\ \phi$</td><td>$Z = P * Cos^2 \phi$</td><td>$Z = \gamma_w * h$</td></tr>
</table>

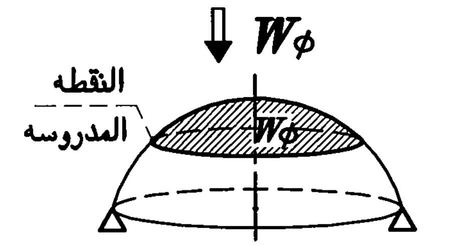
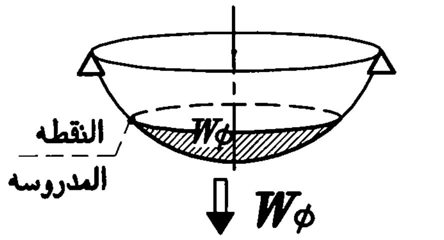
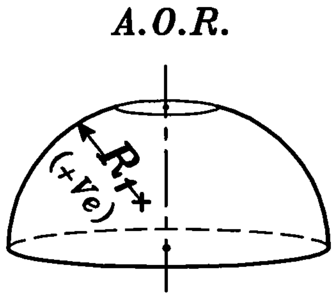
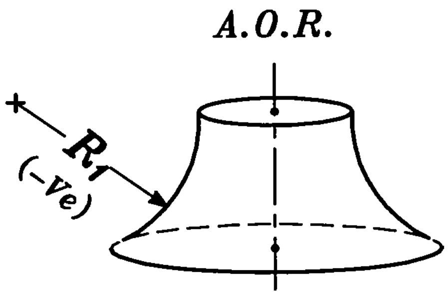
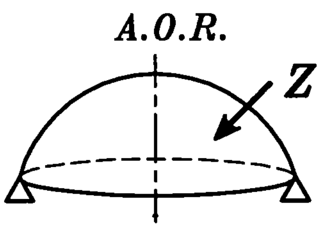
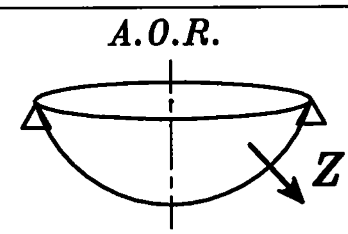
Sign of Z



Z (+Ve) Sign
عندما تكون Z داخله
فى اتجاه الـ (A.O.R.)

Z (−Ve) Sign
عندما تكون Z خارجه
بعيدا عن الـ (A.O.R.)

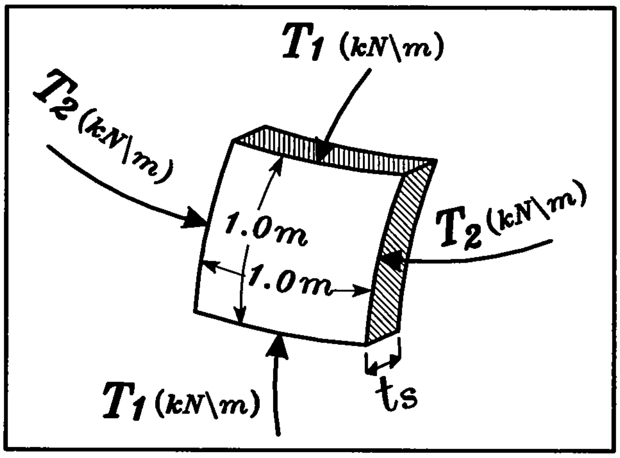
Parameter Signs.

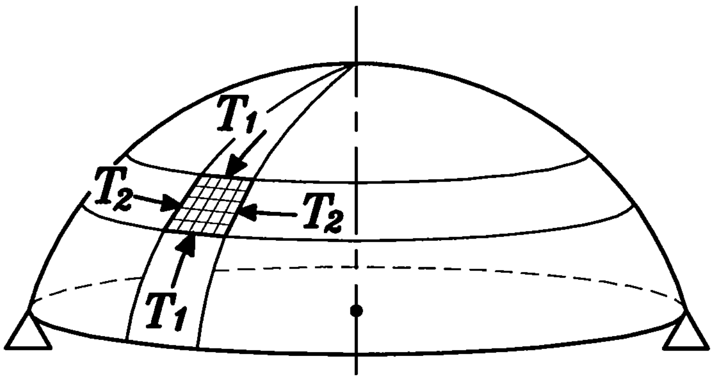
Parameter	(+Ve) Sign	(−Ve) Sign
T_1	Compression Force	Tension Force
T_2	Compression Force	Tension Force
W_ϕ	 Support داخله الى ال W_ϕ	 Support خارجه من ال W_ϕ
r	دائماً (+Ve)	
ϕ	دائماً (+Ve)	
R_1	 عندما تكون خارجه بعيدا عن ال(A.O.R.)	 عندما تكون داخله فى اتجاه ال (A.O.R.)
R_2	دائماً (+Ve)	
Z	 عندما تكون Z داخله فى اتجاه ال (A.O.R.)	 عندما تكون Z خارجه بعيدا عن ال (A.O.R.)

Calculation of Internal Forces (T_1) & (T_2).

T_1 is **Meridian Force.** $(kN\backslash m)$

T_2 is **Ring Force.** $(kN\backslash m)$





$$\boxed{T_1 = \frac{W\phi}{2\pi r \, Sin\phi}}$$

حفظ

اثبات القانون فى صفحه 113

$$\boxed{\frac{T_1}{R_1} + \frac{T_2}{R_2} = Z}$$

حفظ

اثبات القانون فى صفحه 114

ملحوظه هامه .

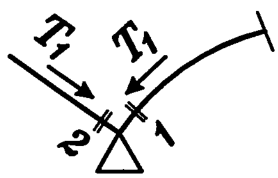
$$T_1 = \frac{\pm W\phi}{2\pi r \, Sin\phi}$$

* تحديد اشاره (T_1) يعتمد على اشاره (W_ϕ) فقط

* تحديد اشاره (T_2) يعتمد على اشاره (T_1) و اشاره (R_1) و اشاره (Z)

$$\frac{\pm T_1}{\pm R_1} + \frac{T_2}{R_2} = \pm Z$$

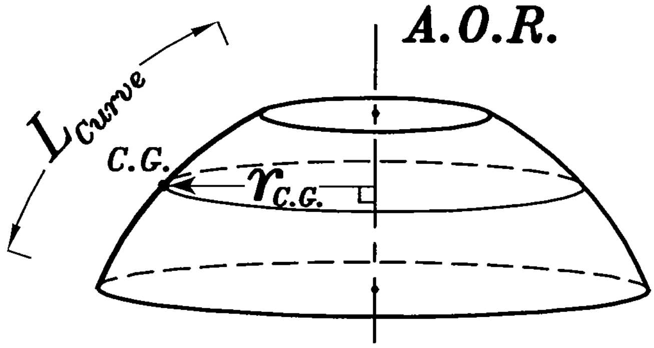
فى حاله وجود ركيزه تفصل بين سطحين يتم التعامل مع كل سطح على حده و لا يوجد بينهما أى أثر .

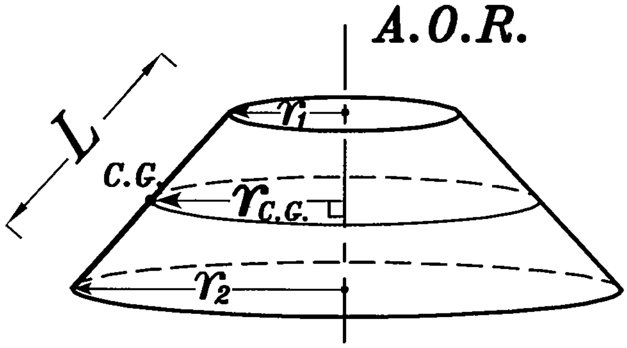


T_1, T_2 ل Sec.① لا علاقه لها ب T_1, T_2 ل Sec.②

Theory of Surface Areas of S.O.R.

مساحه السطح الناتجه من دوران خط أو منحنى حول محور
تساوى طول الخط أو المنحنى مضروبا فى محيط الدائره الناتجه عن
دوران نقطه مركز ثقل (C.G.) هذا الخط أو المنحنى حول نفس المحور.



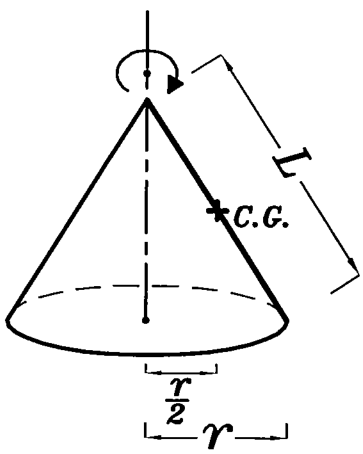


$$\boxed{r_{C.G.} = \frac{r_1 + r_2}{2}}$$

$$\boxed{S.A. = L_{Curve} * 2\pi * r_{C.G.}}$$

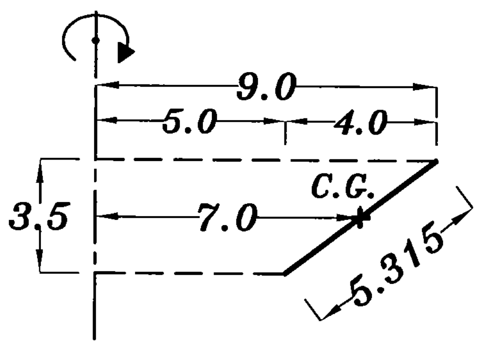
$$\boxed{S.A. = L * 2\pi * r_{C.G.}}$$

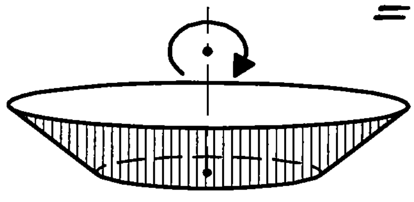
Example.



$$S.A. = L * 2\pi * r_{C.G.}$$

$$= L * 2\pi * \frac{r}{2} = \pi * r * L$$





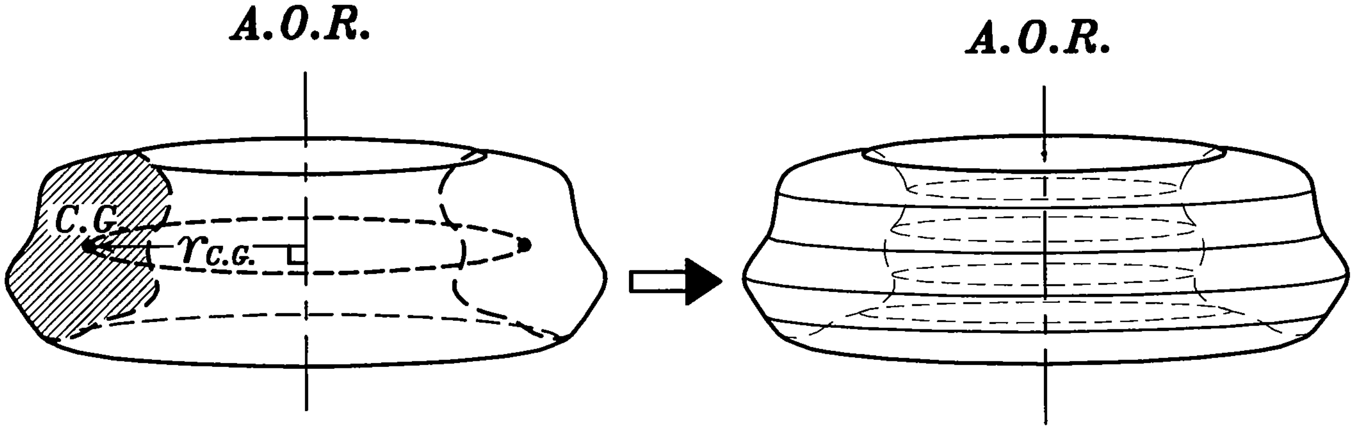
$$S.A. = L * 2\pi * r_{C.G.}$$

$$= 5.315 * 2\pi * 7.0$$

$$= 233.76\ m^2$$

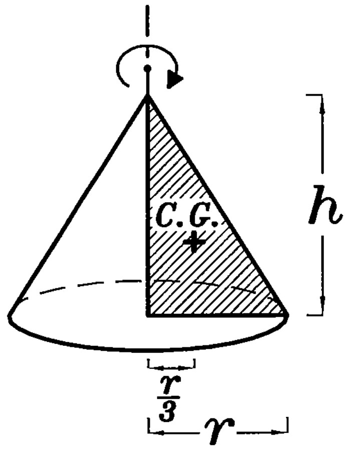
Theory of Volumes of S.O.R.

الحجم الناتج من دوران مساحه حول محور تساوى قيمه هذه المساحه مضروبا فى محيط الدائره الناتجه عن دوران نقطه مركز ثقل $(C.G.)$ هذه المساحه حول نفس المحور .



$$\boxed{Volume = Area * 2\pi * r_{C.G.}}$$

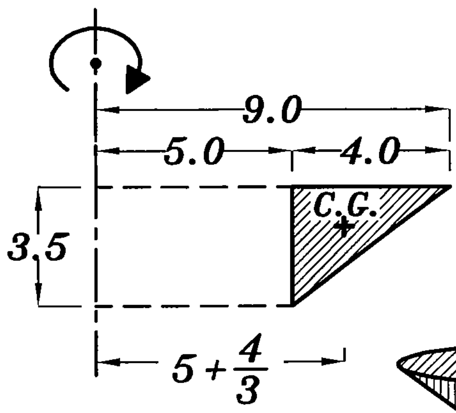
Example.



$$Volume = Area * 2\pi * r_{C.G.}$$

$$= \left(\frac{1}{2} * r * h\right) * 2\pi * \frac{r}{3}$$

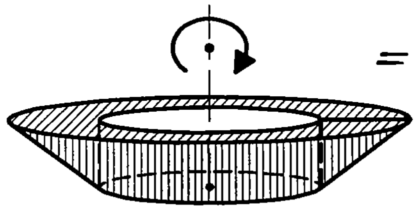
$$= \frac{\pi * r^2 * h}{3}$$



$$Volume = Area * 2\pi * r_{C.G.}$$

$$= \left(\frac{1}{2} * 3.5 * 4\right) * 2\pi * \left(5+\frac{4}{3}\right)$$

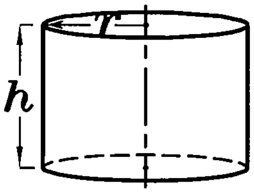
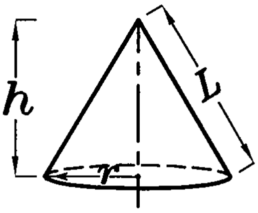
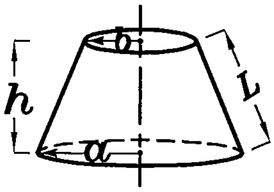
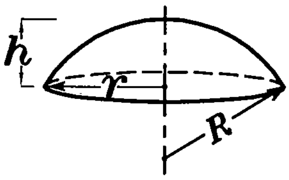
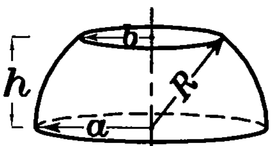
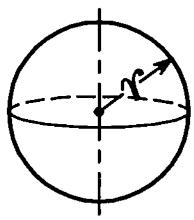
$$= 278.55\ m^3$$



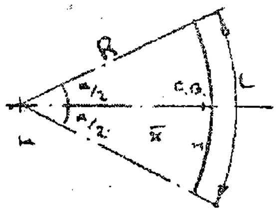
Volume and Surface Areas For some shapes.

Old tables Page 121

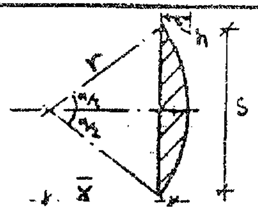
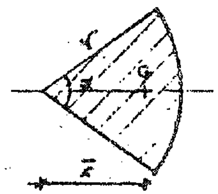
للأسف **حفظ**

Name	Shape	Surface Area	Volume
Cylinder		$S.A. = 2\pi r * h$	$V = \pi r^2 * h$
Cone		$S.A. = \pi * L * r$	$V = \frac{1}{3} * \pi * r^2 * h$
Part Of Cone		$S.A. = \pi * L\,(a+b)$	$V = \frac{\pi h}{3}(a^2+b^2+ab$
Dome		$S.A. = 2\pi * R * h$	$V = \pi * h^2 (R - \frac{h}{3})$
Part Of Dome		$S.A. = 2\pi * R * h$	$V = \frac{\pi h}{6}(3a^2+3b^2+h^2)$
Sphere		$S.A. = 4 * \pi * r^2$	$V = \frac{4}{3} * \pi * r^3$

Arc of a Circle

	$\bar{X} = R \sin(a/2) / (a/2)$ $L = r \cdot a$

Segment and Sector of a Circle

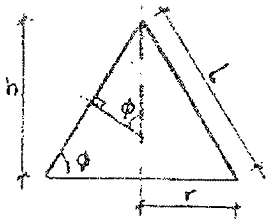
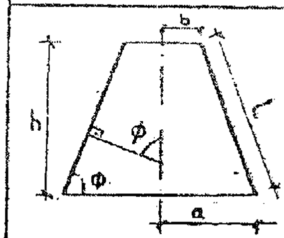
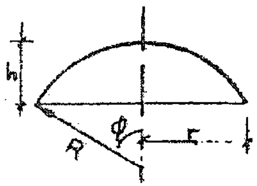
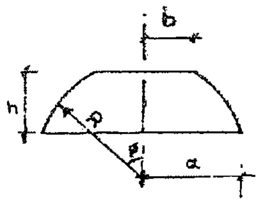
Shape	Area	C.G. ($\bar{X}$)
	$r^2 \, a/2$ $- s(r-h)/2$	$s^3/(12 A)$
	$r^2 \, a / 2$	$\dfrac{2 r \sin(a/2)}{(3a/2)}$

For Surfaces of Revolution :

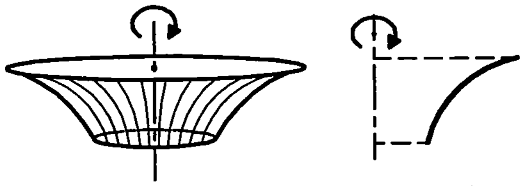
* Meridian Force = T_1
$T_1 = W\phi / 2 \; \pi r \sin(\phi)$

* Ring Force = T_2
$T_1/R_1 + T_2/R_2 = Z$

Solid Bodies

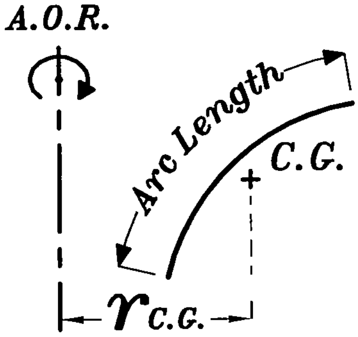
Shape	Volume	Surface Area
	CONE $\pi r^2 h / 3$	$\pi r l$
	PART OF CONE $\dfrac{\pi h (a^2+b^2+ab)}{3}$	$\pi l (a+b)$
	DOME $\pi h^2 (R-h/3) =$ $\pi h (3r^2+h^2)/6$	$2 \pi R h =$ $\pi (r^2+h^2)$
	PART OF DOME $\dfrac{\pi h (3a^2+3b^2+h^2)}{6}$	$2 \pi R h$

Special Cases.

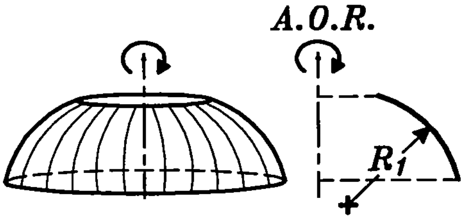


اذا كان المنحنى للخارج (كما بالشكل)

فانه يجب لحساب الـ *Surface Area* استخدام القانون :

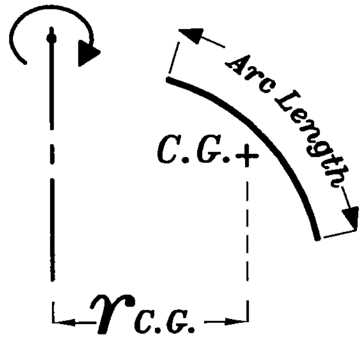


$$\boxed{S.A. = Arc\ Length * 2\pi * r_{C.G.}}$$



اذا كان المنحنى للداخل لكن مركزه ليس على الـ *A.O.R.*

فانه يجب لحساب الـ *Surface Area* استخدام القانون:



$$\boxed{S.A. = Arc\ Length * 2\pi * r_{C.G.}}$$

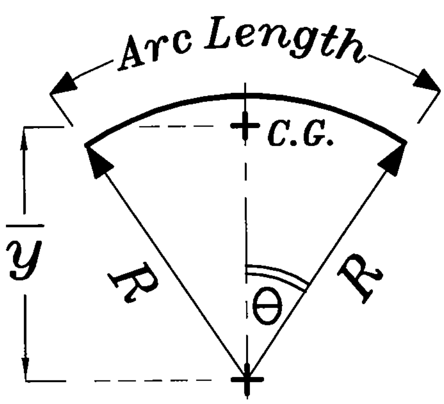
لاى قوس فى دائره .

Radian

$$\boxed{Arc\ Length = 2 * R * \theta}$$

$$\boxed{\overline{y} = \frac{R * Sin\,\theta}{\theta}}$$

Radian



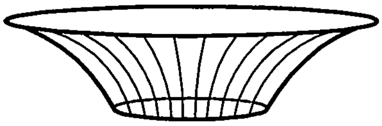
where: θ *is the Centeral Angle.*

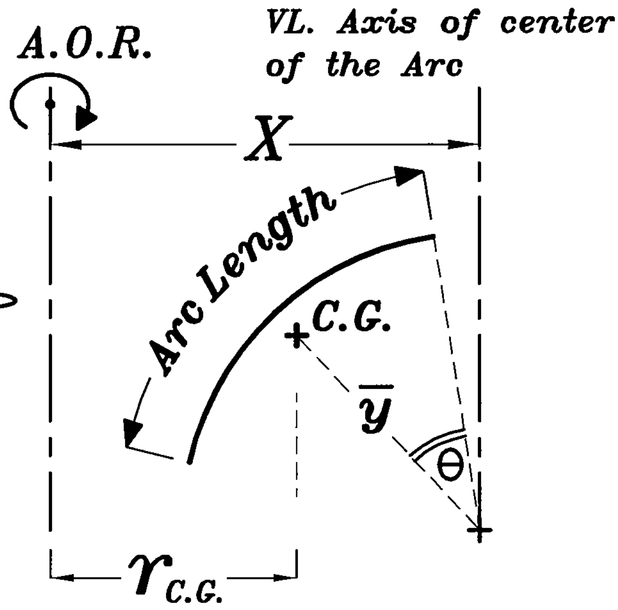
R *is the Radius of the Arc.*

$$\boxed{S.A. = Arc\ Length * 2\pi * r_{C.G.}}$$

$$\boxed{Arc\ Length = 2 * R * \Theta}$$

$$\boxed{\bar{y} = \frac{R * \sin\Theta}{\Theta}}$$





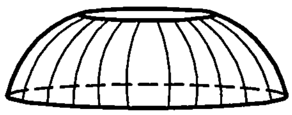
X is the HL. distance between the Axis of Revolution and the VL. Axis of center of the Arc.

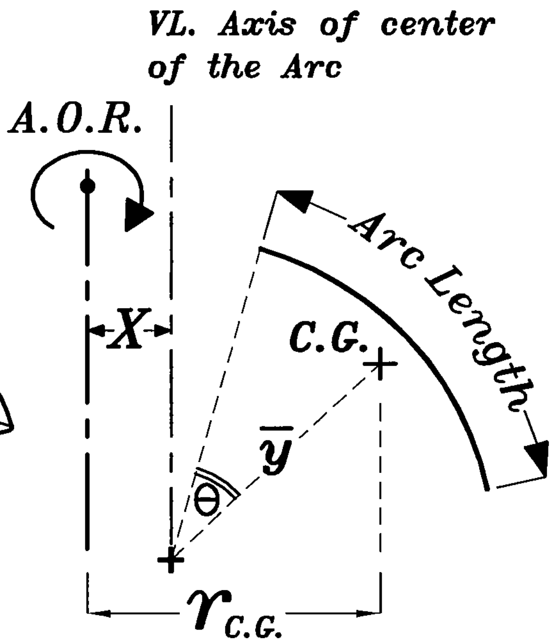
المنحنى للداخل لكن مركزه ليس على ال A.O.R.

$$\boxed{S.A. = Arc\ Length * 2\pi * r_{C.G.}}$$

$$\boxed{Arc\ Length = 2 * R * \Theta}$$

$$\boxed{\bar{y} = \frac{R * \sin\Theta}{\Theta}}$$





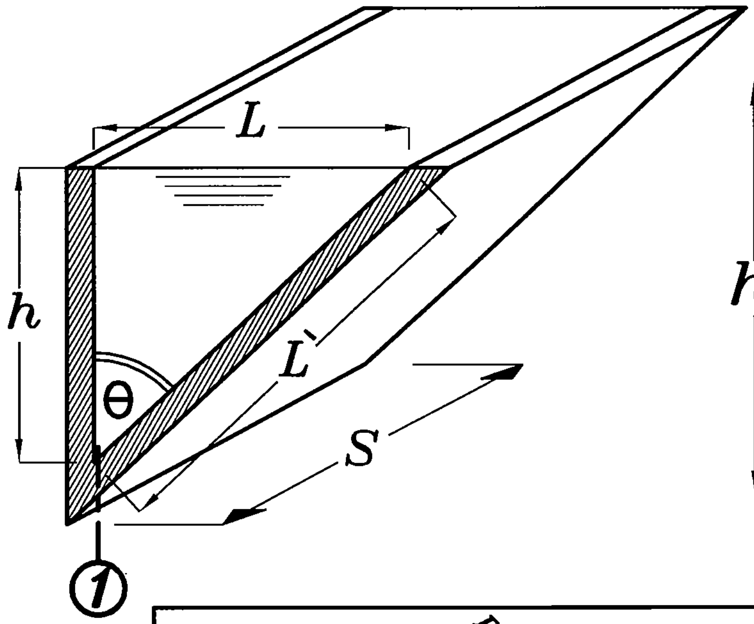
X is the HL. distance between the Axis of Revolution and the VL. Axis of center of the Arc.

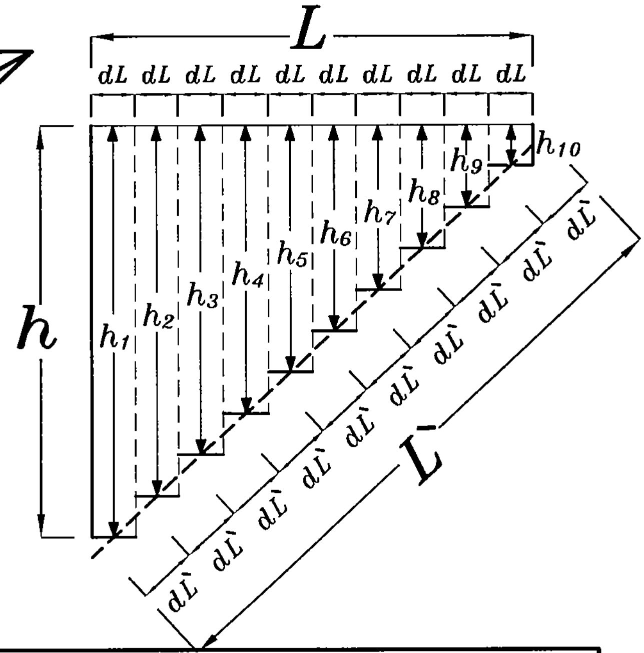
سيتم شرح هذا الجزء بالتفصيل و الامثله لاحقاً

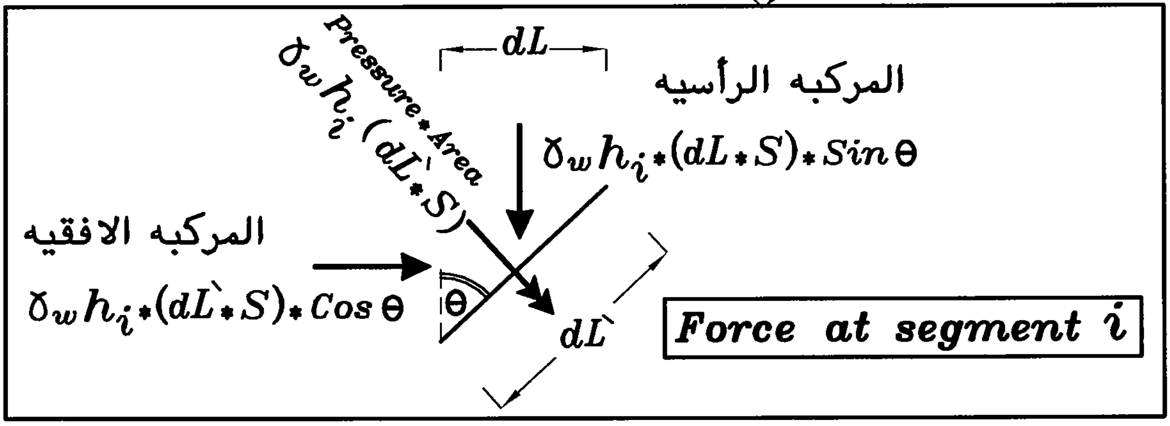
Water pressure effect.

اذا كان السطح مائل للخارج أى ان الماء تضغط على السطح العلوى .

Calculate W_ϕ For section ① due to water pressure only.







Force at segment i

محصله قوى الضغط العموديه على السطح فى طول $dL`$ =

$Pressure * Area = \gamma_w\, h_i * (dL` * S)$ اتجاهها لاسفل ↘

المركبه الرأسيه لقوى الضغط فى طول dL للجزء i = اتجاهها لاسفل↓

$$= \gamma_w\, h_i * (dL` * S) * Sin\,\Theta = \gamma_w\, h_i * (dL` * S) * \frac{dL}{dL`} = \gamma_w\, h_i * (dL * S)$$

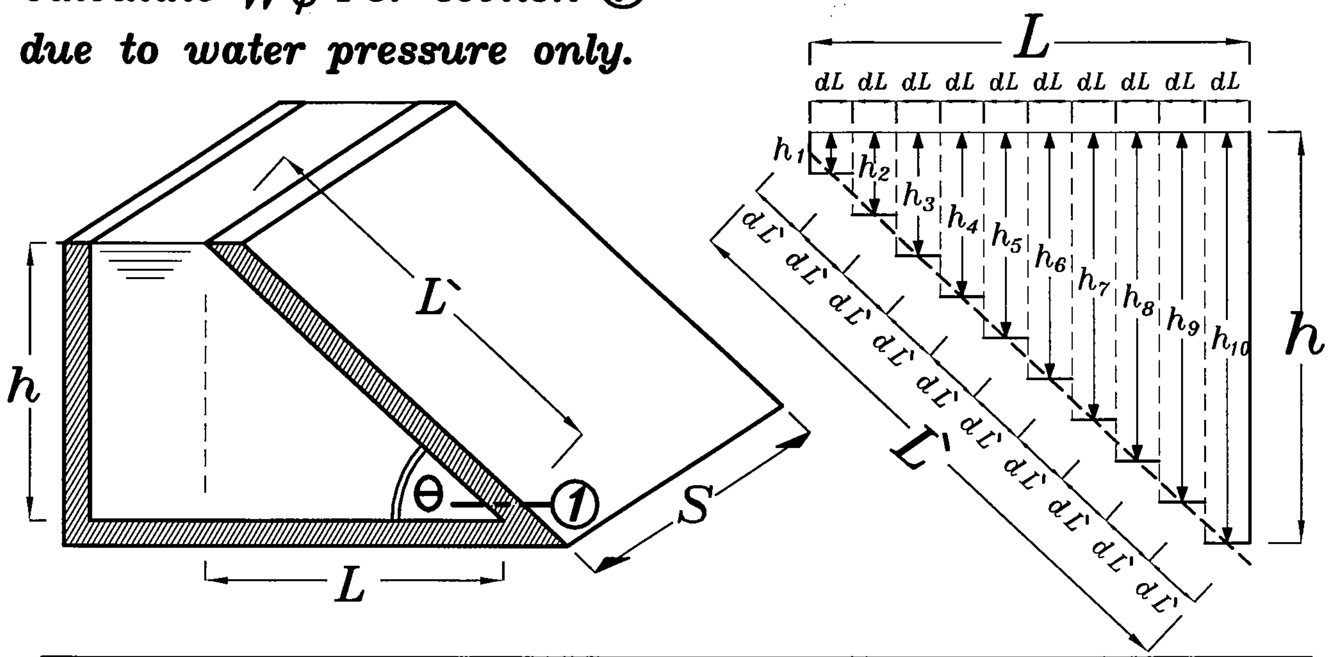
محصله المركبه الرأسيه لقوى الضغط فى طول L = W_ϕ اتجاهها لاسفل↓

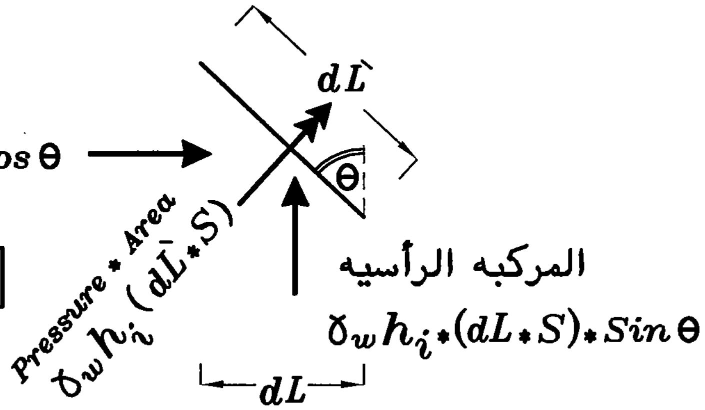
$$W_\phi = \gamma_w * (\Sigma\, h_i * dL) * S = \gamma_w * \Sigma Area * S = \gamma_w * Water\ Volume$$

$$\boxed{W_\phi = \gamma_w * Volume\ of\ water\ above\ the\ surface. \downarrow}$$

اذا كان السطح مائل للداخل أى ان الماء تضغط على السطح السفلى .

Calculate W_ϕ For section ① due to water pressure only.





محصله قوى الضغط العموديه على السطح فى طول $dL` =$

$$Pressure * Area = \gamma_w h_i * (dL` * S)$$ اتجاهه لاعلى ↗

المركبه الرأسيه لقوى الضغط فى طول dL للجزء $i =$ اتجاهه لاعلى ↑

$$= \gamma_w h_i * (dL` * S) * Sin\,\Theta = \gamma_w h_i * (dL` * S) * \frac{dL}{dL`} = \gamma_w h_i * (dL * S)$$

محصله المركبه الرأسيه لقوى الضغط فى طول L $= W_\phi$ اتجاهه لاعلى ↑

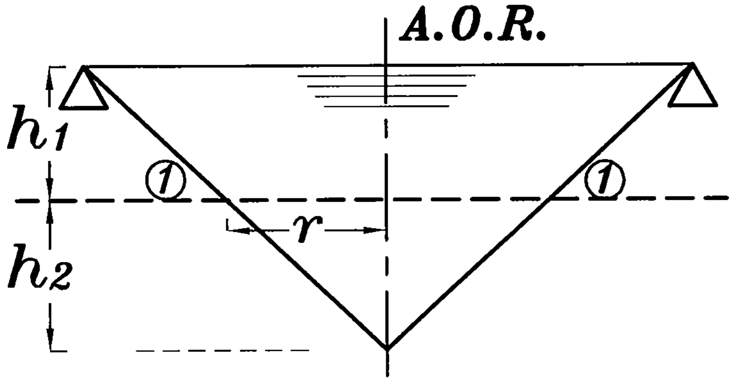
$$W_\phi = \gamma_w * (\Sigma h_i * dL) * S = \gamma_w * \Sigma Area * S = \gamma_w * \text{Water Volume}$$

$$\boxed{W_\phi = \gamma_w * \text{Vertiual Volume of water above the surface.} \uparrow}$$

يساوى الحجم الوهمى للماء فوق السطح مباشره حتى منسوب سطح الماء .

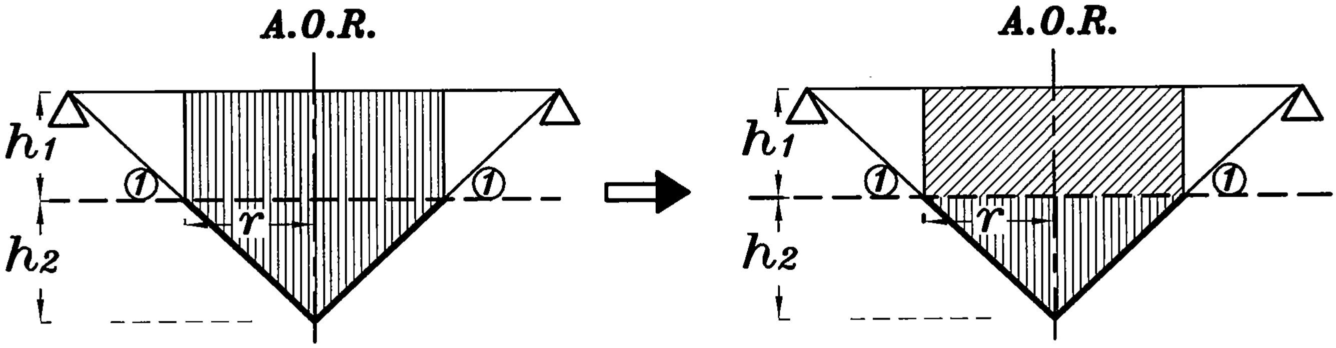
Example.

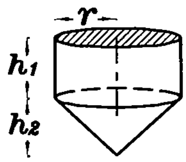
Calculate (W_ϕ & Z) For section ① due to water pressure only.

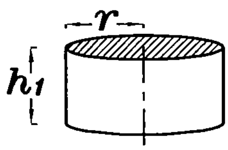
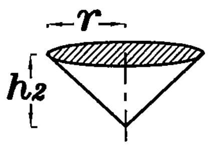


W_ϕ

عند Sec. ① سيكون ضغط الماء بعيدا عن ال *support* كله لاسفل .



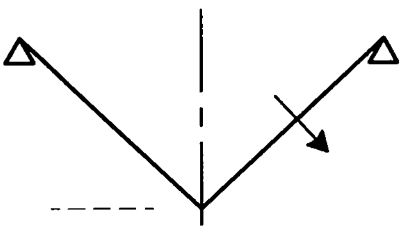
$W_\phi = \gamma_w *$ [Volume of  ↓]

$\therefore W_\phi = \gamma_w *$ [Volume of  ↓ +  ↓]

$\boxed{\gamma_w = 10\ kN/m^3}$

اشاره W_ϕ (−Ve) لان اتجاهها خارج من ال Support

Z

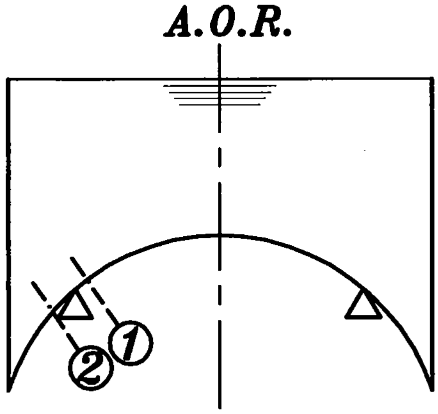


عند Sec. ① $\boxed{Z = \gamma_w * h_1}$

اشاره Z (−Ve) لان اتجاهها خارج من المحور

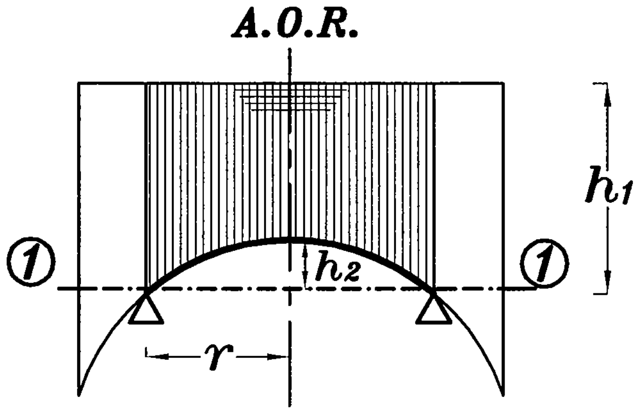
Example.

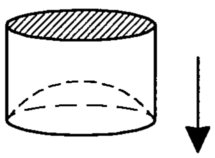
Calculate (W_ϕ & Z) For sections ①, ② due to water pressure only.

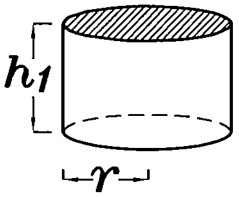
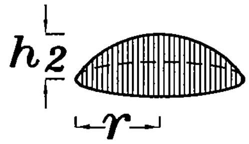


Sec. ①

عند Sec. ① أعلى الـ support
سيكون ضغط الماء بعيدا عن الـ support كله لاسفل .



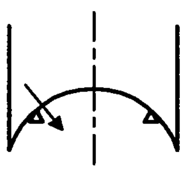
$W_\phi = \gamma_w *$ [Volume of ]

$W_\phi = \gamma_w *$ [Volume of  $-$ ]

$\boxed{\gamma_w = 10\ kN/m^3}$

اشاره W_ϕ (+Ve) لان اتجاهها داخل الى الـ Support

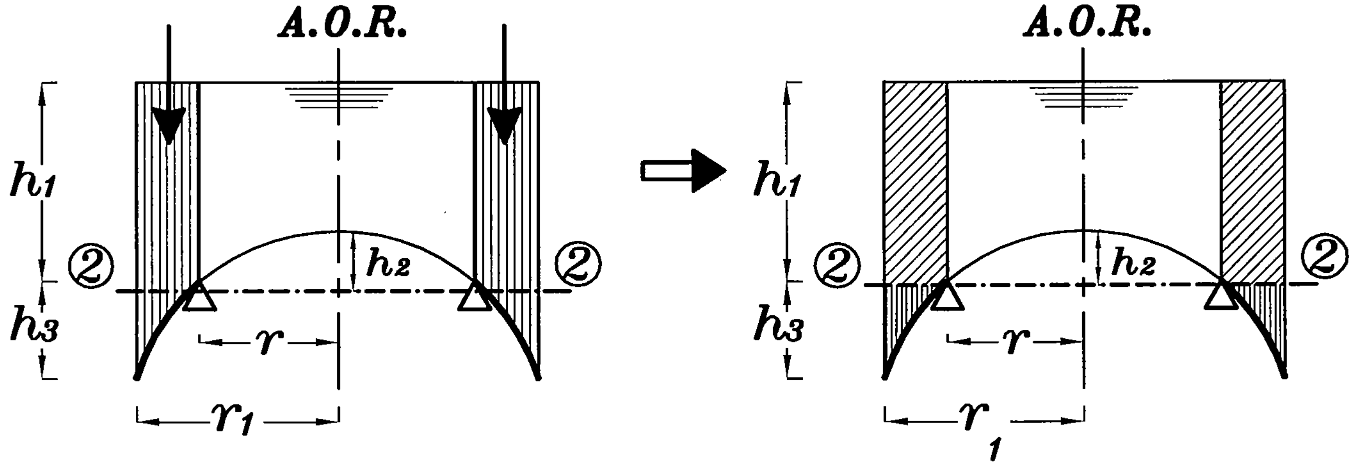
اشاره Z (+Ve) لان اتجاهها داخل الى المحور

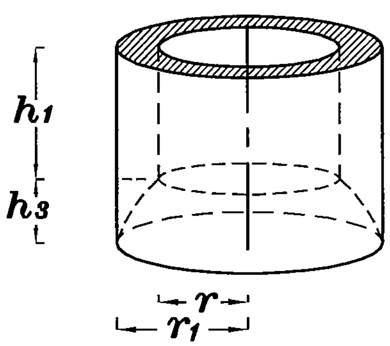


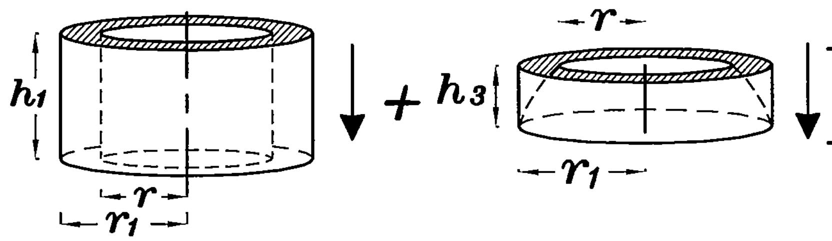
عند Sec. ① $\boxed{Z = \gamma_w * h_1}$

Sec. ②

عند *Sec.* ② أسفل ال *support*
سيكون ضغط الماء بعيدا عن ال *support* كله لاسفل .



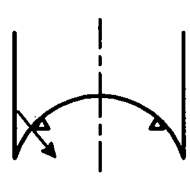
$W_\phi = \gamma_w *$ [Volume of ]

$W_\phi = \gamma_w *$ [Volume of ]

$\boxed{\gamma_w = 10\, kN/m^3}$

اشاره W_ϕ $(-Ve)$ لان اتجاهها خارج من ال *Support*

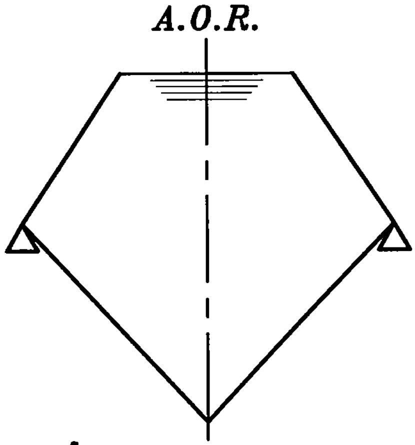
اشاره Z $(+Ve)$ لان اتجاهها داخل الى المحور



$\boxed{Z = \gamma_w * h_1}$ عند *Sec.* ②

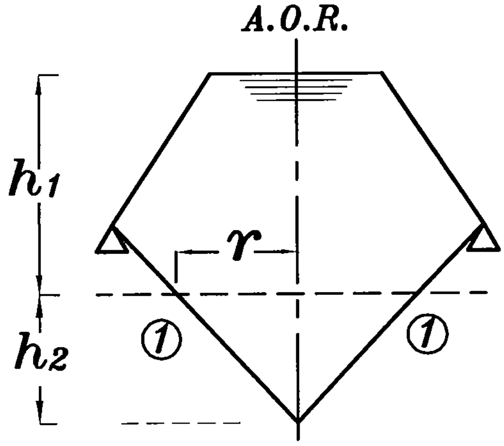
Example.

Calculate (W_ϕ & Z) For sections above & under the supports due to water pressure only.

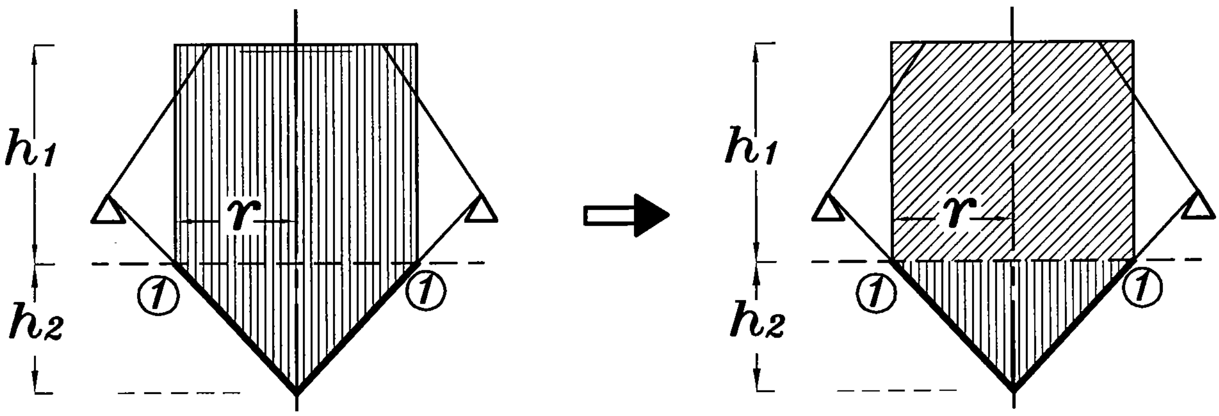


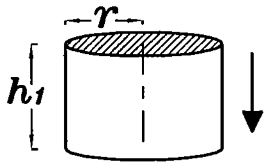
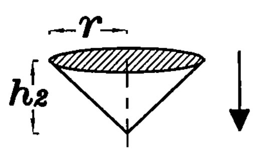
1- For section under the support.

W_ϕ



عند Sec. ① سيكون ضغط الماء
بعيدا عن ال support كله لاسفل .

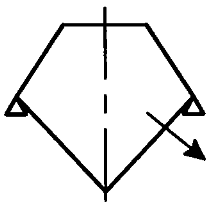


$\therefore W_\phi = \gamma_w * \Big[$ Volume of  $+$  $\Big]$

$\boxed{\gamma_w = 10\ kN/m^3}$

اشاره W_ϕ (-Ve) لان اتجاهها خارج من ال Support

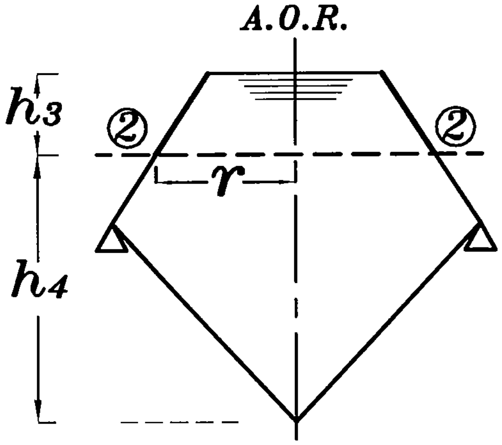
اشاره Z (-Ve)
لان اتجاهها خارج من المحور



عند Sec. ① $\boxed{Z = \gamma_w * h_1}$

2- For section above the support.

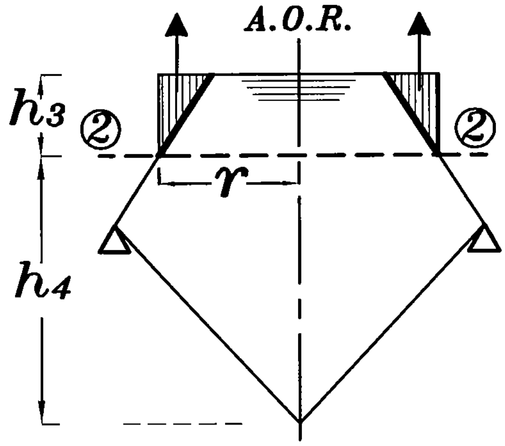
W_ϕ

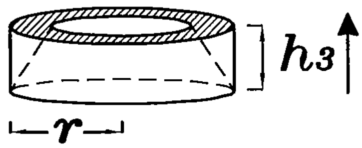


عند ② $Sec.$ سيكون ضغط الماء

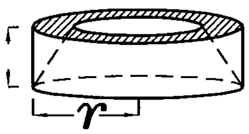
بعيدا عن ال $support$ كله لاعلى .

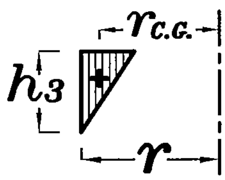
الحجم الوهمى للماء فوق السطح مباشره حتى منسوب سطح الماء .



$W_\phi = \gamma_w * \text{Volume of}$ 

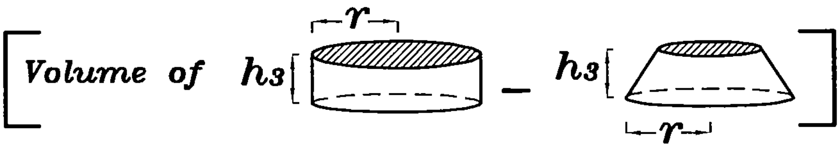
اشاره W_ϕ $(-Ve)$ لان اتجاهها خارج من ال $Support$

لحساب حجم  h_3 توجد طريقتين :

اما بطريقه 

$$\boxed{Volume = Area * 2\pi * r_{c.G.}}$$

او بطرح حجم اسطوانه- مخروط ناقص

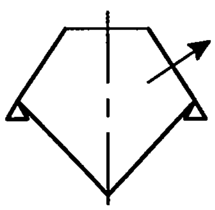


Z

عند ② $Sec.$ $\boxed{Z = \gamma_w * h_1}$

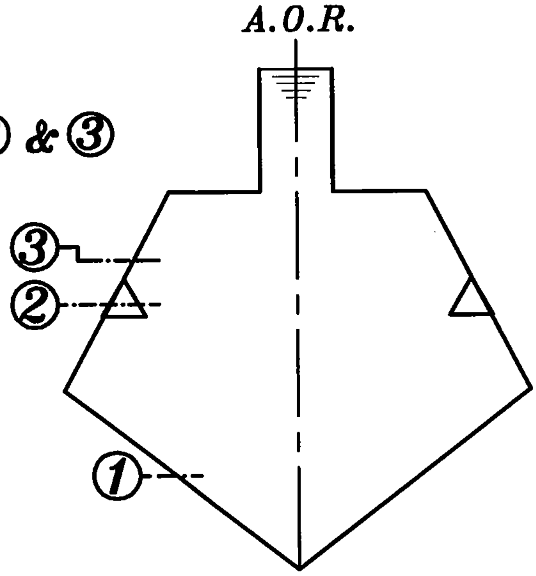
اشاره Z $(-Ve)$

لان اتجاهها خارج من المحور



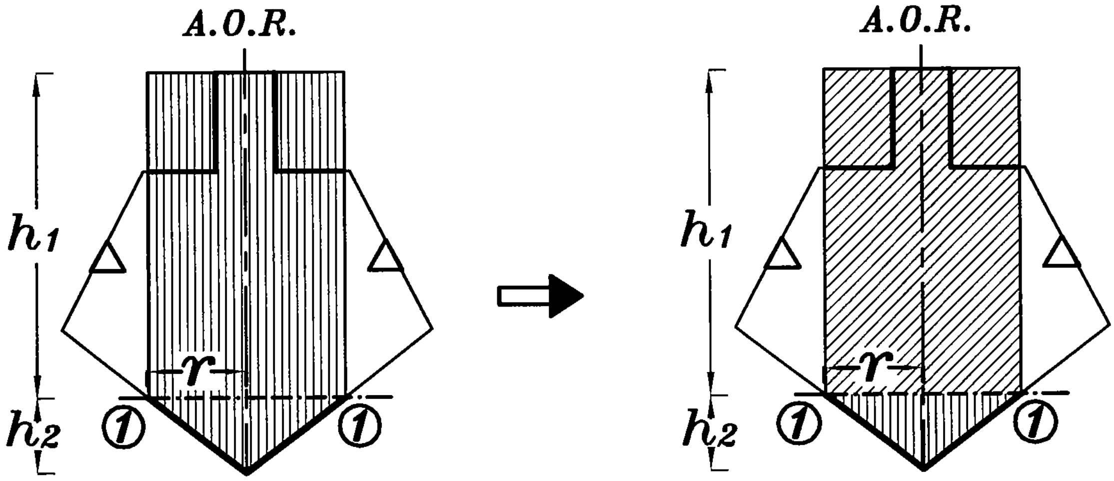
Example.

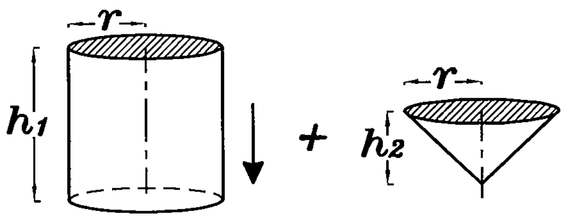
Calculate (W_ϕ & Z) For sections ①, ② & ③ due to water pressure only.



Sec. ①

عند ① *Sec.* سيكون ضغط الماء بعيدا عن ال ~~*support*~~ كله لاسفل .

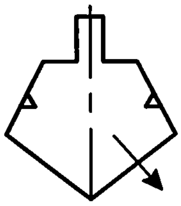


$\therefore W_\phi = \gamma_w * \Big[$ Volume of  $\Big]$

$\boxed{\gamma_w = 10\ kN/m^3}$

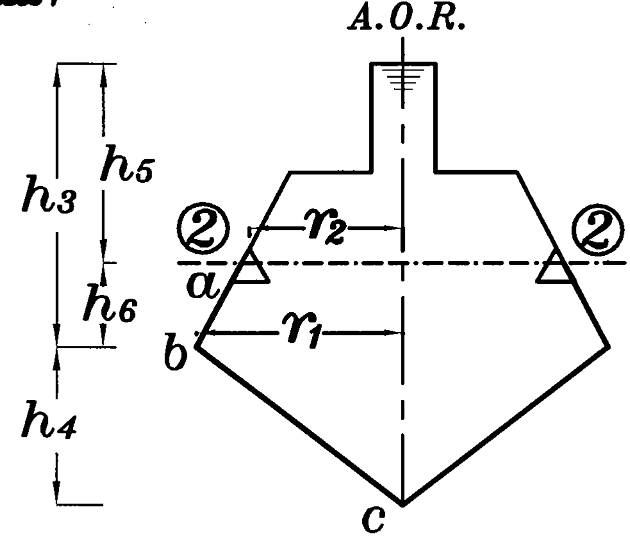
اشاره W_ϕ (−Ve) لان اتجاهها خارج من ال *Support*

عند ① *Sec.* $\boxed{Z = \gamma_w * h_1}$



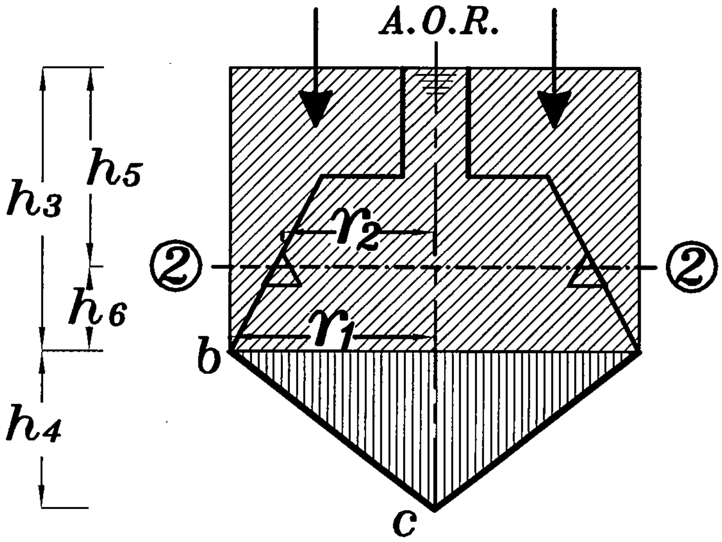
اشاره Z (−Ve) لان اتجاهها خارج من المحور

Sec. ② أسفل ال *support*



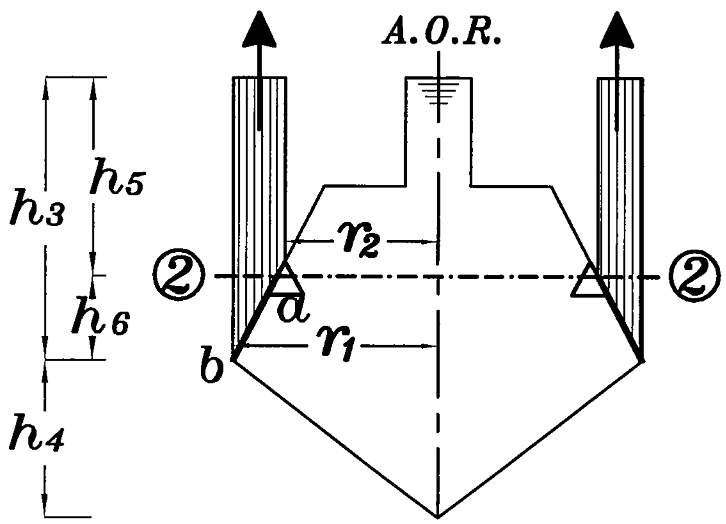
عند ② .Sec سيكون ضغط الماء بعيدا عن ال *support* لاسفل عند السطح $b\ c$

و سيكون لاعلى عند السطح $b\ a$



سيكون ضغط الماء لاسفل

عند السطح $b\ c$

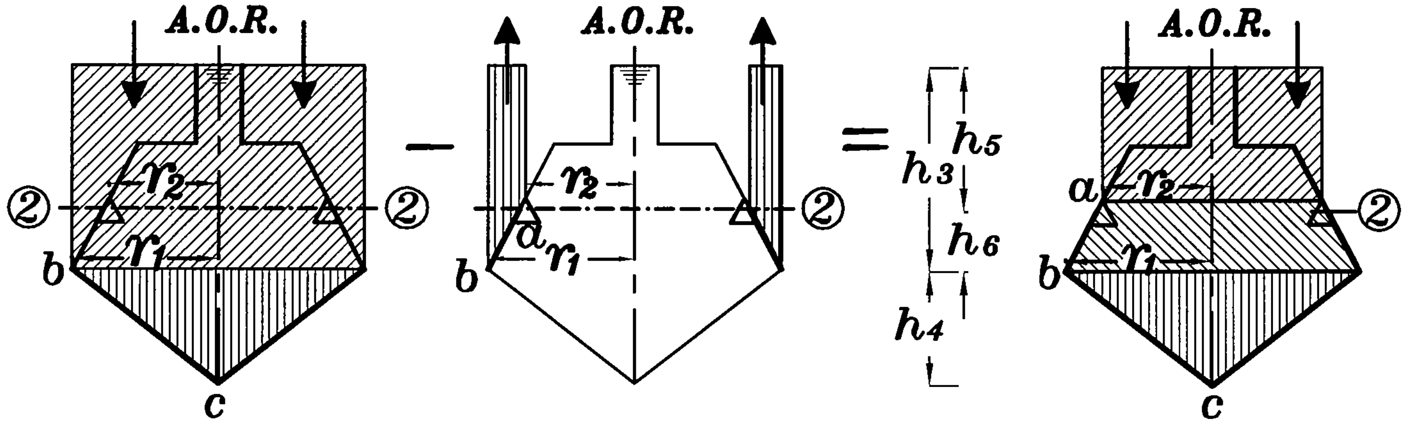


سيكون ضغط الماء لاعلى

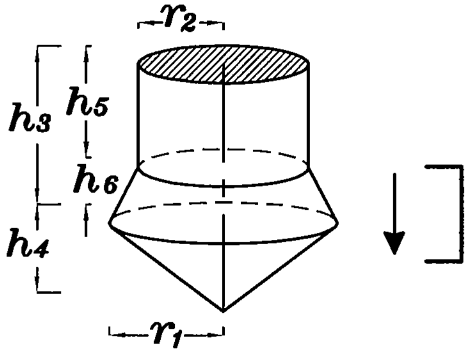
عند السطح $b\ a$

محصله ضغط المياه عند Sec. ② بعيدا عن ال *support* ستكون لاسفل

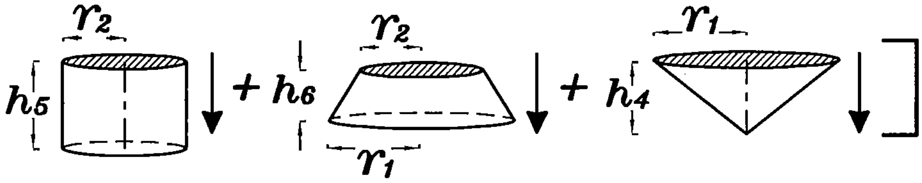
ستكون ضغط المياه على السطح **b c** لاسفل مطروحا منه ضغط المياه على السطح **a b** لاعلى



$$W_\phi = \gamma_w * \Big[\text{Volume of}$$



$$W_\phi = \gamma_w * \Big[\text{Volume of}$$

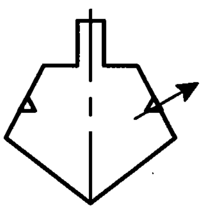


$\boxed{\gamma_w = 10\ kN/m^3}$

اشاره W_ϕ $(-Ve)$ لان اتجاهها خارج من ال **Support**

اشاره Z $(-Ve)$

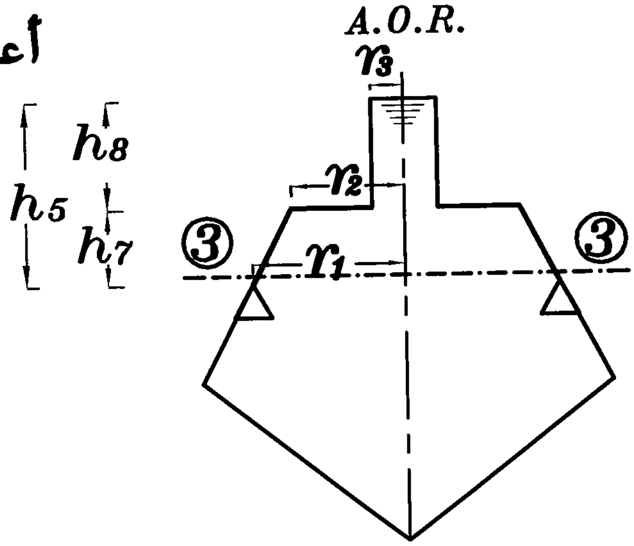
لان اتجاهها خارج من المحور

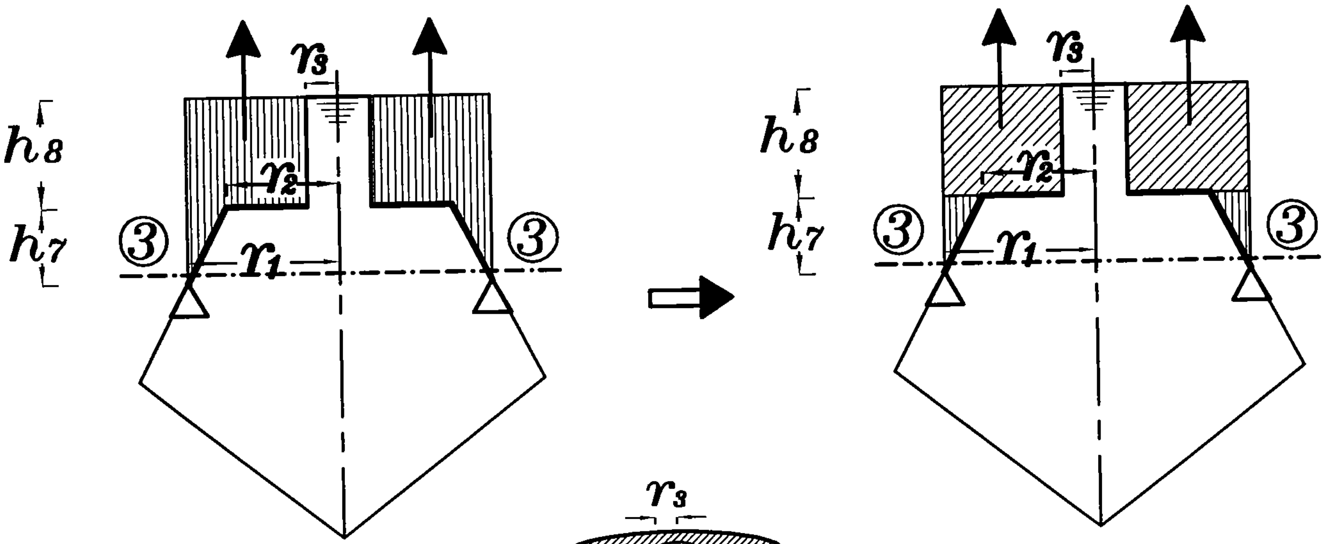


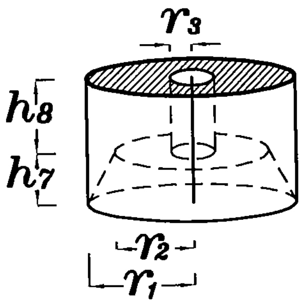
عند ② Sec. $\boxed{Z = \gamma_w * h_5}$

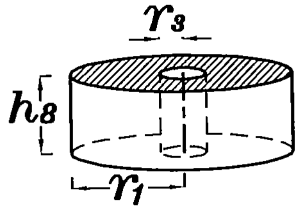
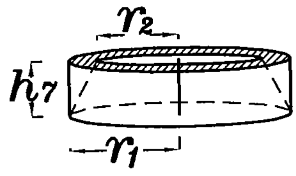
Sec. ③ أعلى ال *support*

عند ③ .*Sec* سيكون ضغط الماء بعيدا عن ال *support* كله لاعلى .





$W_\phi = \gamma_w *$ [Volume of  ↑]

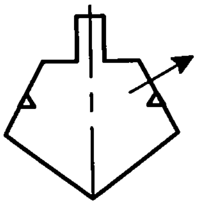
$W_\phi = \gamma_w *$ [Volume of  ↑ +  ↑]

$\boxed{\gamma_w = 10\,kN/m^3}$

اشاره W_ϕ (Ve−) لان اتجاهها خارج من ال *Support*

اشاره Z (Ve−)

لان اتجاهها خارج من المحور

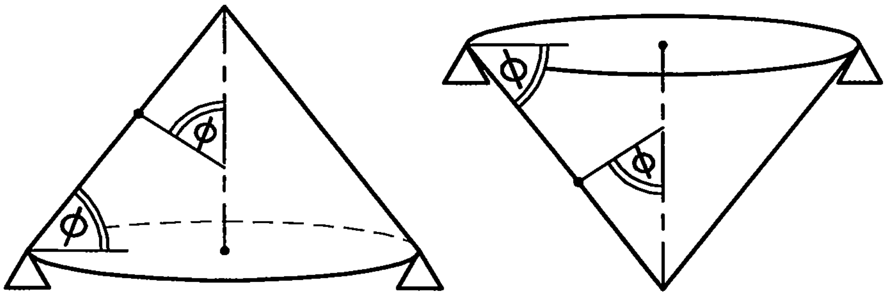


عند ③ .*Sec* $\boxed{Z = \gamma_w * h_5}$

Properties of Important Surfaces.

Cone.

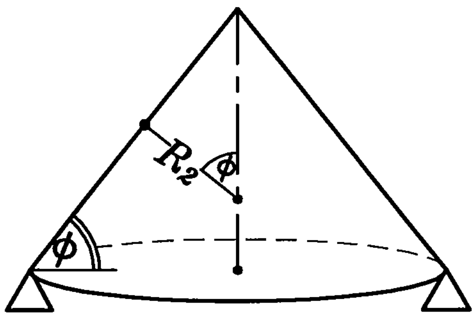
ϕ هى زاويه ميل السطح مباشره مع الافقى .



$$\boxed{R_1 = \infty}$$

$$\because \frac{T_1}{R_1} + \frac{T_2}{R_2} = Z$$

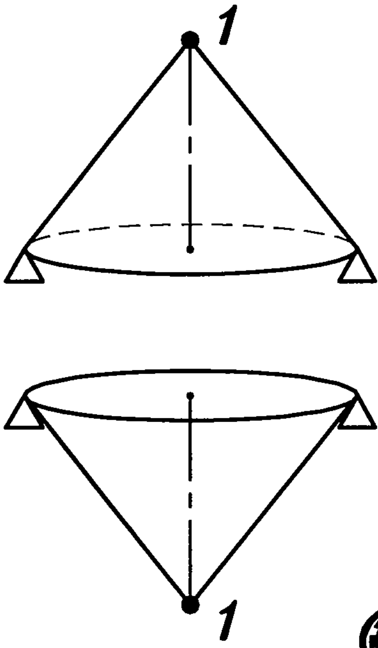
$$\therefore Zero + \frac{T_2}{R_2} = Z$$



$$\boxed{T_2 = R_2 Z}$$ حفظ

<u>At Cone Vertex</u> Point ①

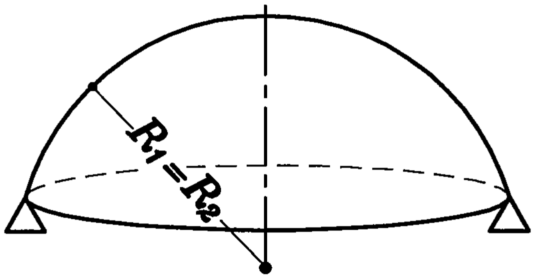
$$\boxed{T_1 = T_2 = Zero}$$ حفظ



اثباته فى صفحه 110

Dome.

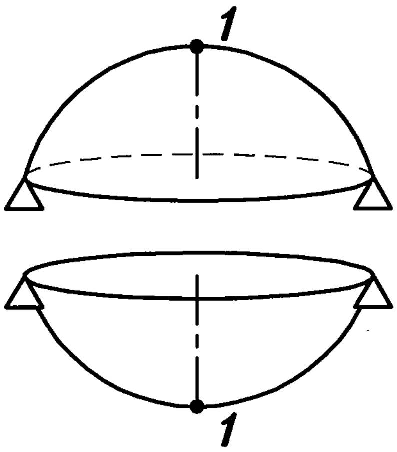
$$\boxed{R_1 = R_2 = R}$$



$$\because \ \frac{T_1}{R_1}+\frac{T_2}{R_2}=Z \qquad \therefore \ \frac{T_1+T_2}{R}=Z$$

$$\boxed{T_1 + T_2 = RZ}$$ حفظ

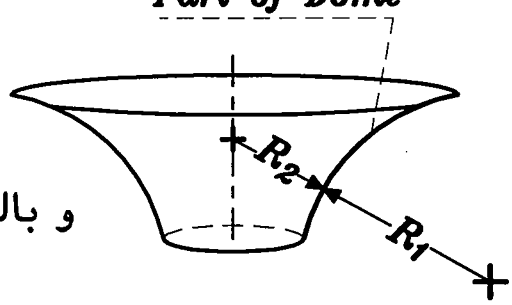
At Dome Vertex Point ①



$$\boxed{T_1 = T_2 = \frac{RZ}{2}}$$ حفظ

اثباته فى صفحه 111

Special Case.

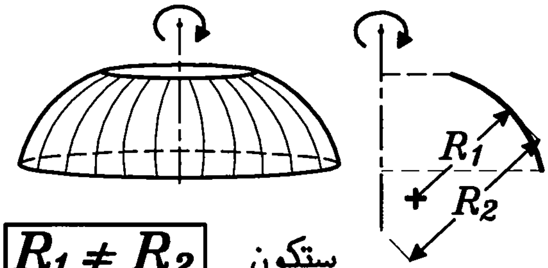


$\boxed{R_1 \neq R_2}$ اذا كان المنحنى للخارج ستكون

و بالتالى معادله $\boxed{T_1 + T_2 = RZ}$ لن تكون صحيحه

و سنضطر لاستخدام المعادله الاصليه $\boxed{\frac{T_1}{R_1}+\frac{T_2}{R_2}=Z}$

Special Case.



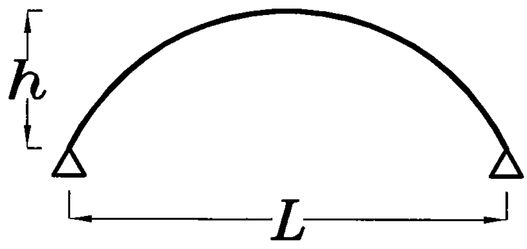
اذا كان المنحنى للداخل لكن مركزه ليس على الـ A.O.R.

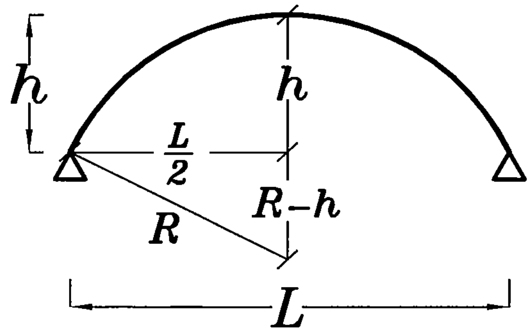
ستكون $\boxed{R_1 \neq R_2}$ و بالتالى معادله $\boxed{T_1 + T_2 = RZ}$ لن تكون صحيحه .

و سنضطر لاستخدام المعادله الاصليه $\boxed{\frac{T_1}{R_1}+\frac{T_2}{R_2}=Z}$

Calculations of Dome Radius.

من الممكن ان يكون معطى لل *Dome* عرض قاعدتها و ارتفاعها .
و بالطبع سنحتاج ان نحدد نصف قطرها لتكمله حسابات المسأله .





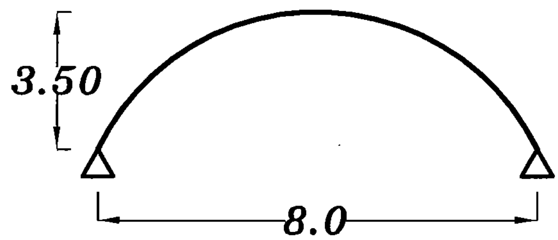
$$R^2 = \left(\frac{L}{2}\right)^2 + (R-h)^2$$

$$\cancel{R^2} = \frac{L^2}{4} + \cancel{R^2} - 2Rh + h^2$$

$$R = \frac{L^2/4 + h^2}{2h}$$

Example.

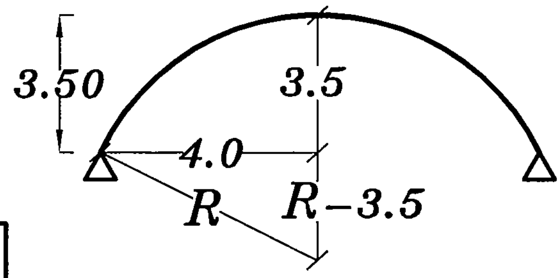
Fined the radius
For the given Dome.



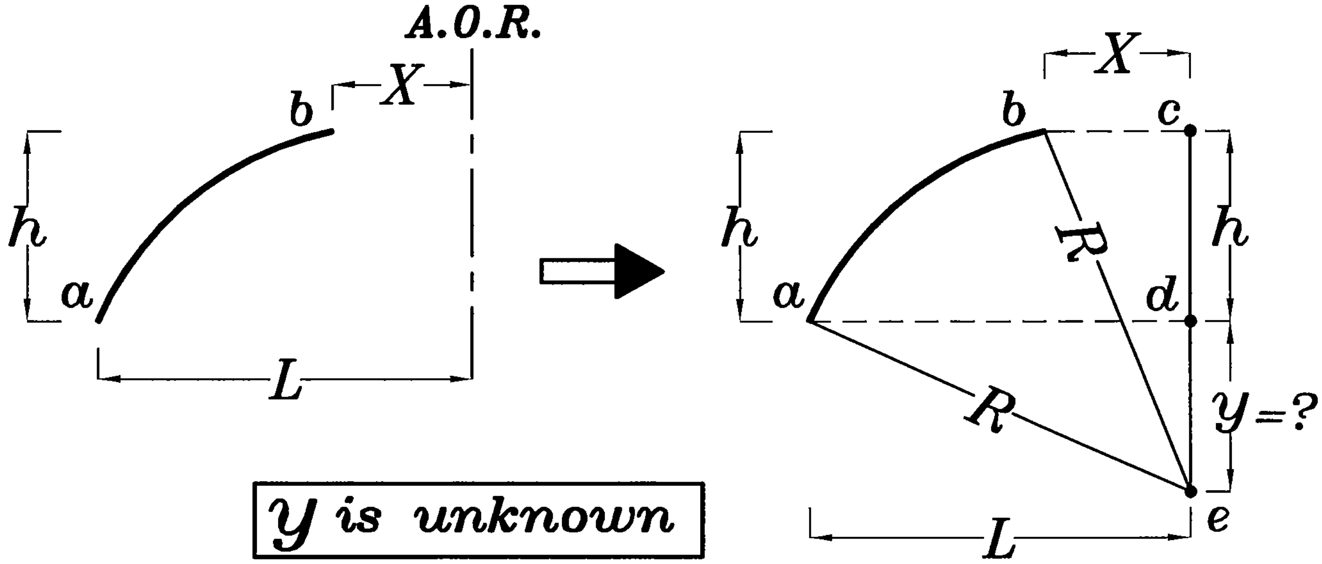
$$R^2 = 4.0^2 + (R-3.5)^2$$

$$\cancel{R^2} = 16 + \cancel{R^2} - 7.0R + 12.25$$

$$7.0R = 28.25 \longrightarrow \boxed{R = 4.03\,m}$$



اذا كان معطى جزء من الـ *Dome* و لا توجد *Vertex*
و معطى فقط ارتفاع هذا الجزء و عرضه و بعده الافقى عن المحور .
و بالطبع سنحتاج ان نحدد نصف قطرها لتكمله حسابات المسأله .



y is unknown

<u>For Triangle ade</u>

$$R^2 = L^2 + y^2 \quad \overset{R,y}{------} (1)$$

<u>For Triangle ecb</u>

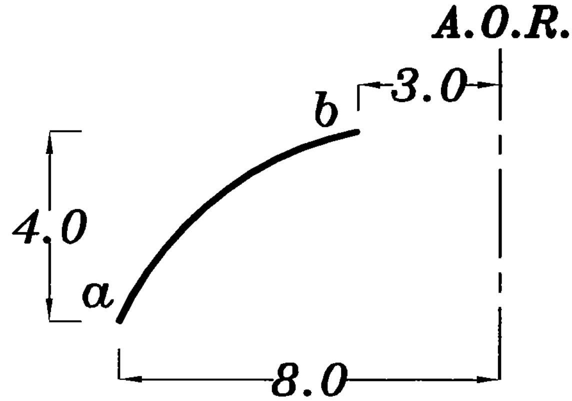
$$R^2 = X^2 + (y+h)^2 = X^2 + y^2 + 2yh + h^2$$

$$R^2 = X^2 + y^2 + 2yh + h^2 \quad \overset{R,y}{------} (2)$$

Solve the Two equations and Get y, R

Example.

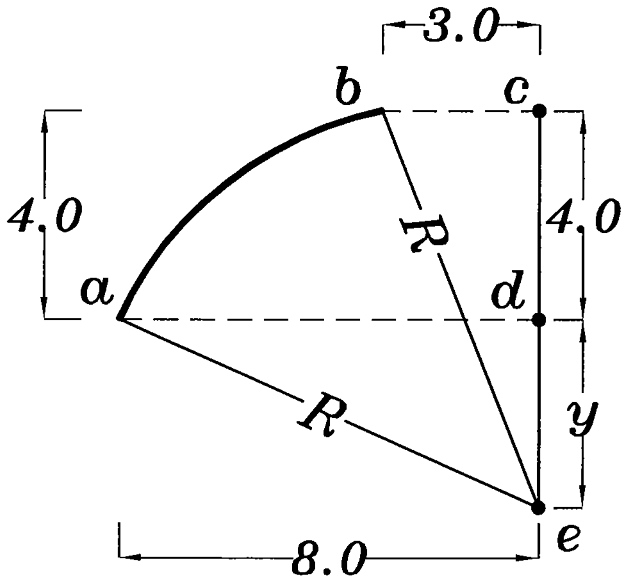
Fined the radius For the Dome Contains the Arch ab



For Triangle ade

$$R^2 = 8.0^2 + y^2$$

$$\therefore R^2 = 64 + y^2 \quad \underline{\;R, y\;} \text{------} (1)$$



For Triangle ecb

$$R^2 = 3.0^2 + (y + 4.0)^2$$

$$R^2 = 9.0 + y^2 + 8.0\,y + 16.0$$

$$R^2 = 25.0 + y^2 + 8.0\,y \quad \underline{\;R, y\;} \text{------} (2)$$

بتعويض R^2 من المعادله الاولى فى المعادله الثانيه

$$\therefore\ 64 + \cancel{y^2} = 25.0 + \cancel{y^2} + 8.0\,y \longrightarrow y = 4.875\ m$$

$$\therefore R^2 = 64 + 4.875^2 = 87.76\ m^2 \longrightarrow \boxed{R = 9.37\,m}$$

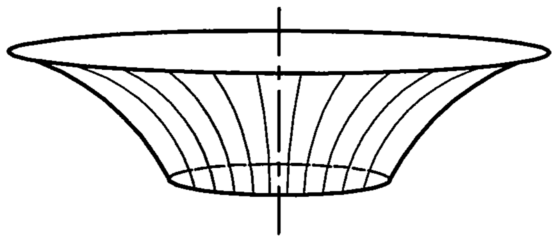
Special Case.

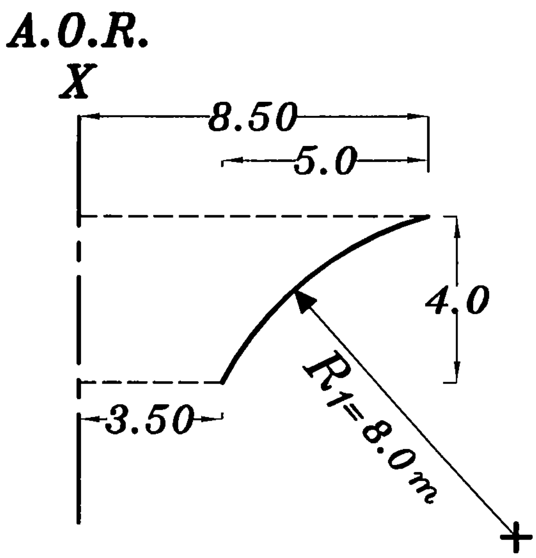
ممكن تأجيل قراءه هذه الحاله حتى الانتهاء من الدرس و بدء حل الامثله

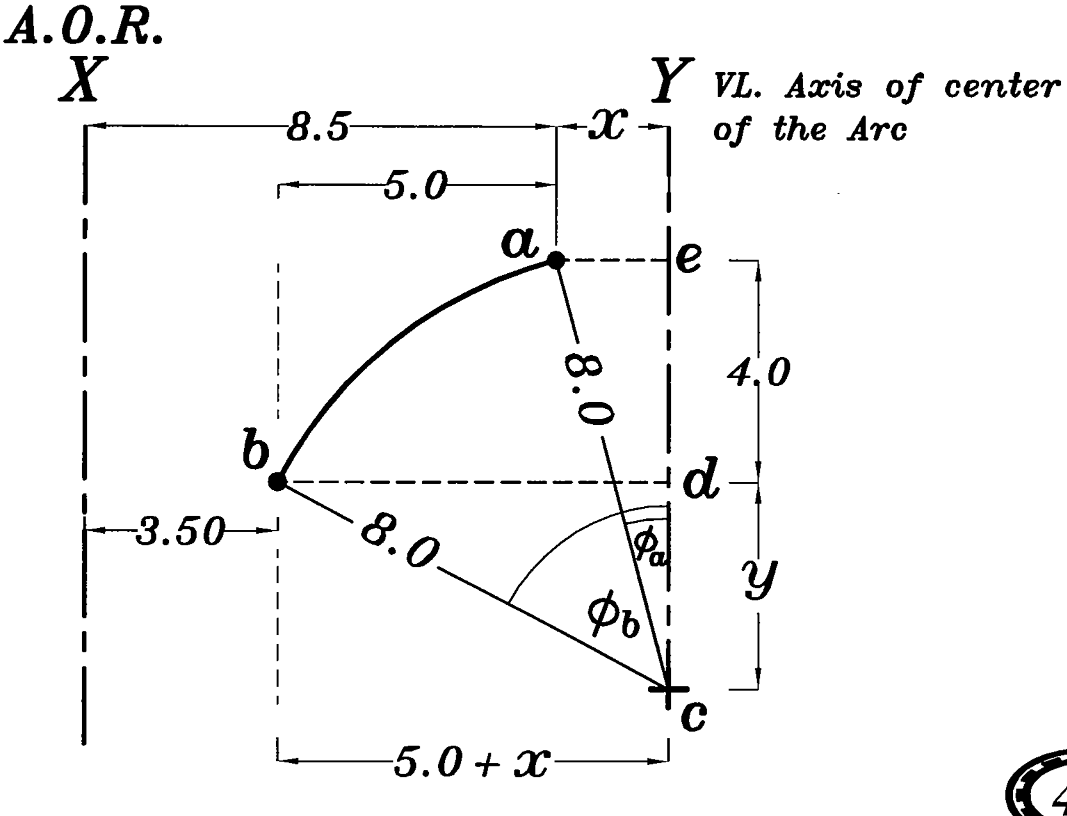
اذا كان المنحنى للخارج (كما بالشكل فى الاسفل) ستكون $\boxed{R_1 \neq R_2}$
و يجب ان يكون نصف قطر المنحنى (R_1) معطى لكى نستطيع تكمله حسابات المسأله.
سنحتاج لتحديد مكان المحور (Y) الذى يوجد عنده مركز الدائره المكونه لهذا المنحنى .
ثم نحدد المسافه الافقيه بين المحور (Y) و محور الدوران (X) .

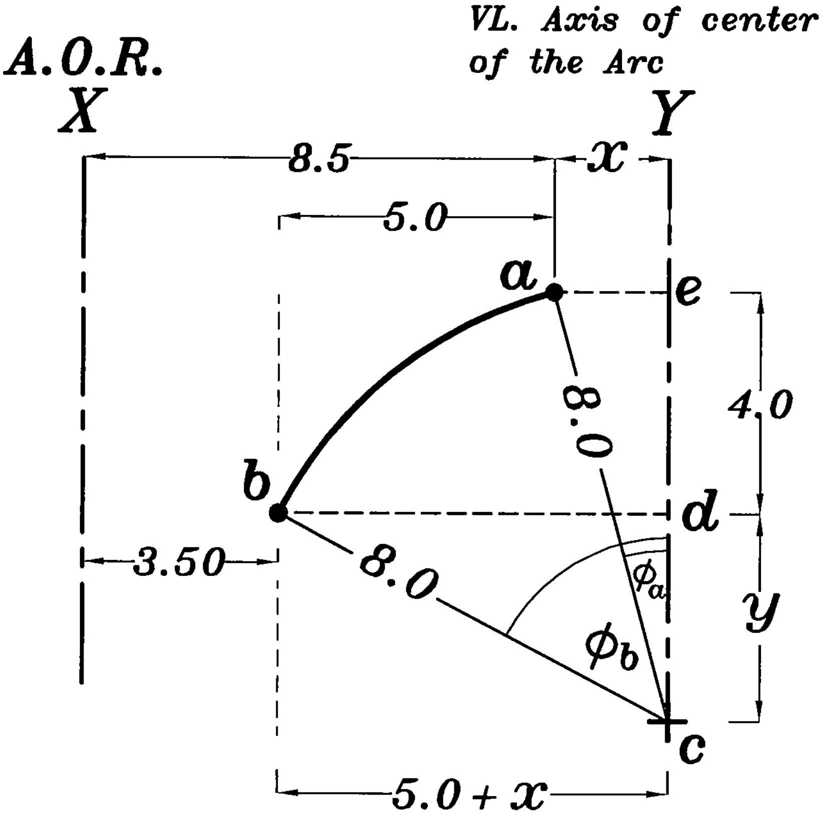
Example.

Fined The surface Area For the Given Dome.









For Triangle b c d

$$8.0^2 = y^2 + (x+5.0)^2$$

$$64 = y^2 + (x+5.0)^2$$

$$\therefore y^2 = 64 - (x+5.0)^2 \quad \text{-----} \; x, y \; \text{-----} \; (1)$$

For Triangle a c e

$$8.0^2 = x^2 + (y+4)^2$$

$$\therefore 64 = x^2 + (y+4)^2 \quad \text{----} \; x, y \; \text{----} \; (2)$$

Subtitution From (1) in (2)

$$\therefore 64 = x^2 + (y+4)^2 = x^2 + y^2 + 8y + 16$$

$$\therefore \cancel{64} = x^2 + \cancel{64} - (x+5)^2 + 8 * \sqrt{64-(x+5)^2} + 16$$

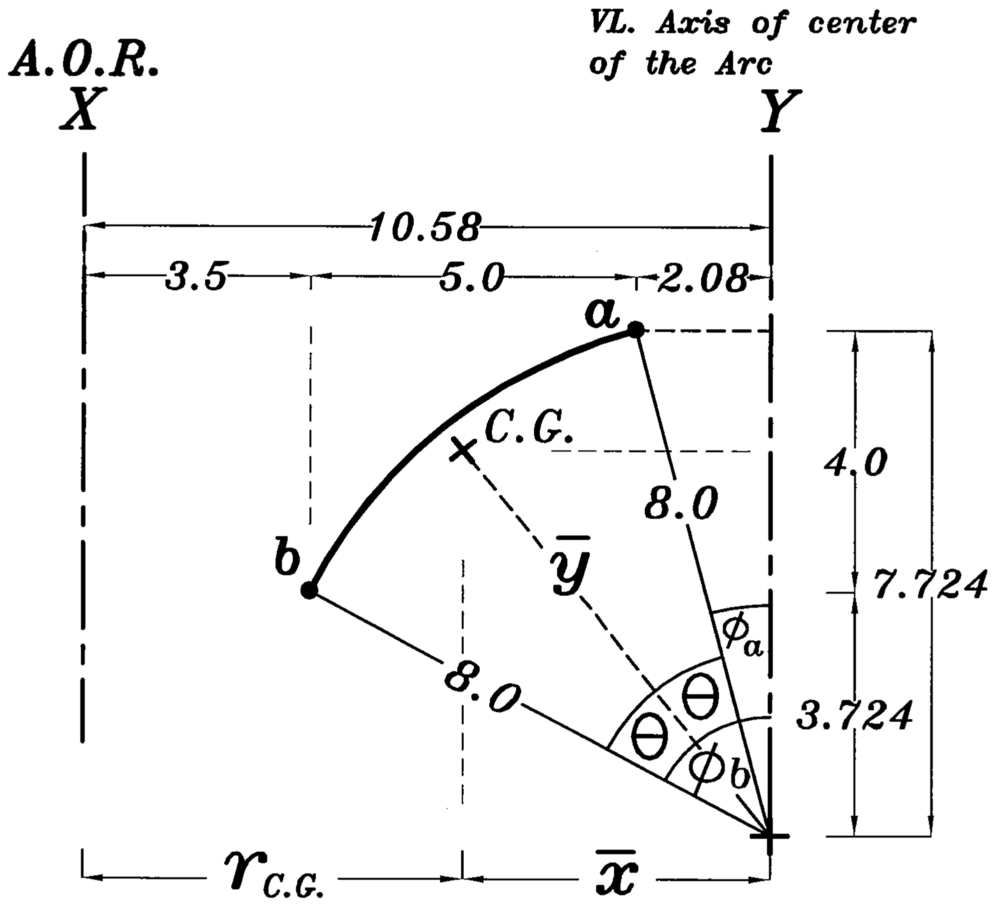
$$0.0 = x^2 - (x^2 + 10x + 25) + 8 * \sqrt{64-(x+5)^2} + 16$$

$$0.0 = \cancel{x^2} - \cancel{x^2} - 10x - 25 + 8 * \sqrt{64-(x+5)^2} + 16$$

$$0.0 = -10x - 9.0 + 8 * \sqrt{64-(x+5)^2} \longrightarrow \boxed{x = 2.08\ m}$$

$$\because y^2 = 64 - (x+5)^2 = 64 - (2.08+5)^2$$

$$\therefore y^2 = 13.873 \longrightarrow \boxed{y = 3.724\ m}$$



$$\sin\phi_a = \frac{2.08}{8.0} \longrightarrow \boxed{\phi_a = 15.07^\circ}$$

$$\cos\phi_b = \frac{3.724}{8.0} \longrightarrow \boxed{\phi_b = 62.257^\circ}$$

$$\text{Centeral Angle } \theta = \frac{\phi_b - \phi_a}{2} = \frac{62.257 - 15.07}{2} = 23.59^\circ$$

$$\bar{y} = \frac{R * \sin\theta}{\theta} = \frac{8.0 * \sin 23.59^\circ}{23.59 * \pi \backslash 180} = 7.775\ m$$

$$\because \sin(\phi_a + \theta) = \frac{\bar{x}}{\bar{y}} \quad \therefore \sin(15.07 + 23.59) = \frac{\bar{x}}{7.775} \longrightarrow \bar{x} = 4.857\ m$$

$$r_{C.G.} = \text{Distance between the Two axes} - \bar{x}$$

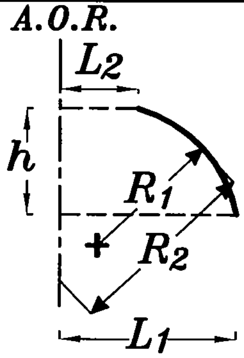
$$r_{C.G.} = 10.58 - 4.857 = 5.723\ m$$

$$\text{Arc Length} = 2 * R * \theta = 2 * 8.0 * 23.59 * \frac{\pi}{180} = 6.587\ m$$

$$S.A. = \text{Arc Length} * 2\pi * r_{C.G.} = 6.587 * 2\pi * 5.723 = 236.86\ m^2$$

Special Case.

ممكن تأجيل قراءه هذه الحاله حتى الانتهاء من الدرس و بدء حل الامثله



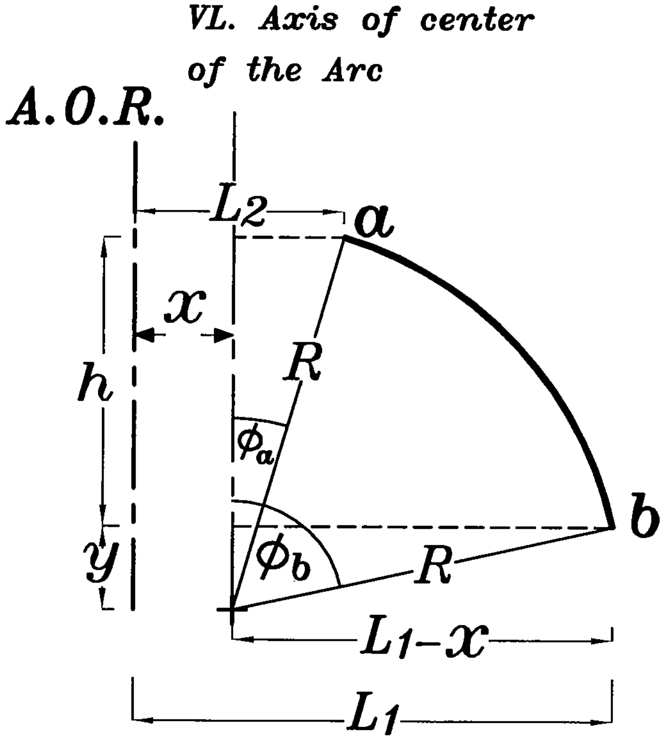
اذا كان المنحنى للداخل لكن مركزه ليس على الـ .A.O.R

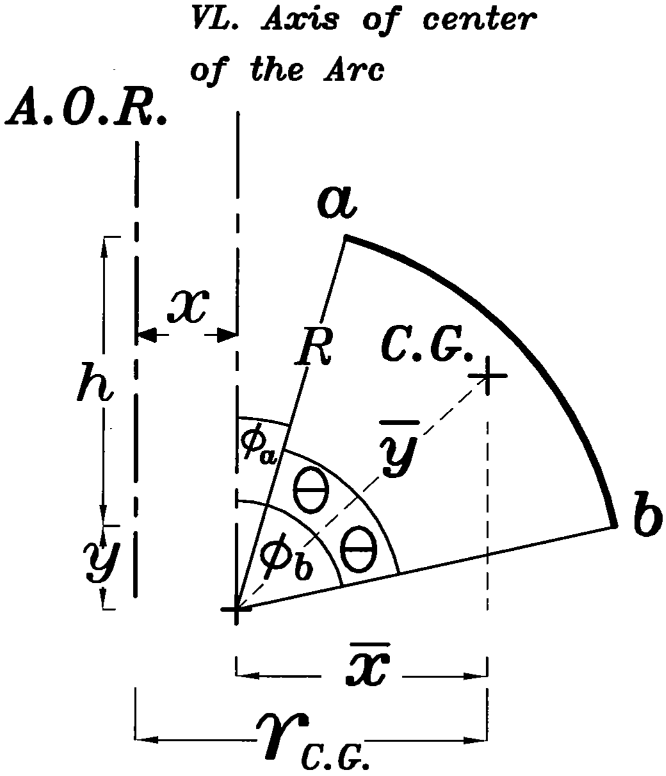
ستكون $\boxed{R_1 \neq R_2}$

و يجب ان يكون نصف قطر المنحنى (R_1) معطى لكى نستطيع تكمله حسابات المسأله.

سنحتاج لتحديد مكان المحور (Y) الذى يوجد عنده مركز الدائره المكونه لهذا المنحنى .

ثم نحدد المسافه الافقيه بين المحور (Y) و محور الدوران (X) .





$$\boxed{S.A. = Arc\ \ Length * 2\pi * r_{C.G.}}$$

$$\boxed{Arc\ \ Length = 2 * R * \Theta}$$

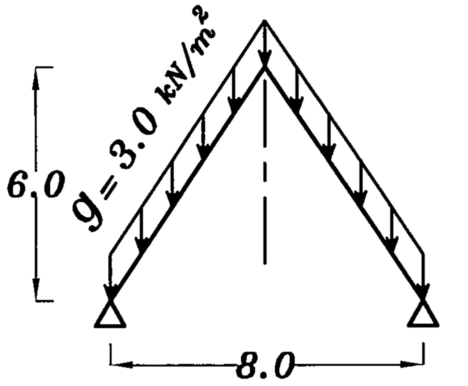
$$\boxed{\bar{y} = \frac{R * Sin\,\Theta}{\Theta}}$$

Training To Calculate T_1 & T_2

Example.

Draw T_1 & T_2 distribution on the vertical projection of the Cone due to dead load only.

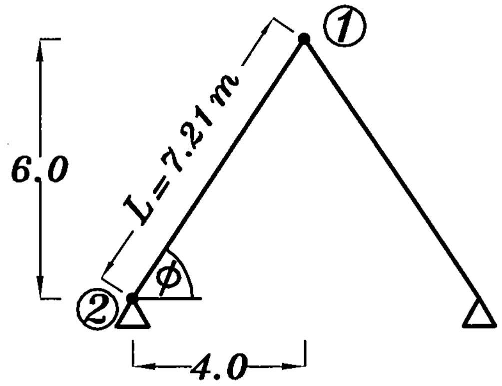
$g = 3.0$ kN/m^2



$$\tan\phi = \frac{6.0}{4.0} \longrightarrow \boxed{\phi = 56.31^\circ}$$

$$L^2 = 6.0^2 + 4.0^2 \longrightarrow \boxed{L = 7.21\ m}$$

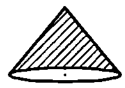
$$R_1 = \infty$$



Sec. ① $T_1 = T_2 = Zero$

Sec. ② $r = 4.0\ m$

$$S.A. = \pi * r * L = \pi * 4.0 * 7.21 = 90.60\ m^2$$



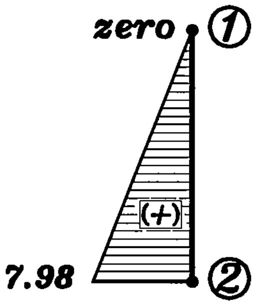
$$W_\phi = g * S.A. = 3.0 * 90.60 = +271.8\ kN$$

$$T_1 = \frac{W_\phi}{2\pi r \sin\phi} = \frac{+271.8}{2\pi * 4.0 * \sin 56.31^\circ} = +13.0\ kN/m\ \text{Comp.}$$

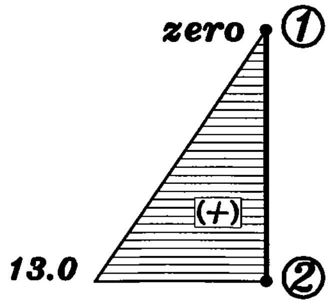
$$Z = g \cos\phi = 3.0 * \cos 56.31^\circ = +1.664\ kN/m^2$$

$$R_2 = \frac{r}{\sin\phi} = \frac{4.0}{\sin 56.31^\circ} = 4.80\ m$$

$$\because\ T_2 = Z * R_2 = 1.664 * 4.80 = +7.98\ kN/m\ \text{Comp.}$$



T_2 Diagram (kN/m)

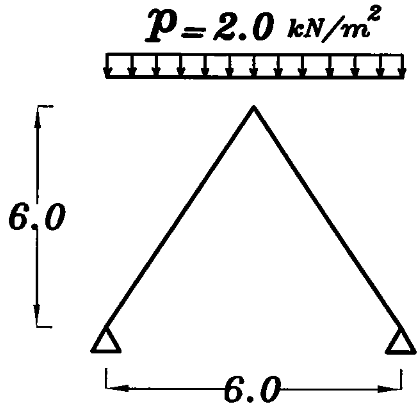


T_1 Diagram (kN/m)

Example.

Draw T_1 & T_2 distribution on the vertical projection of the Cone due to live load only.

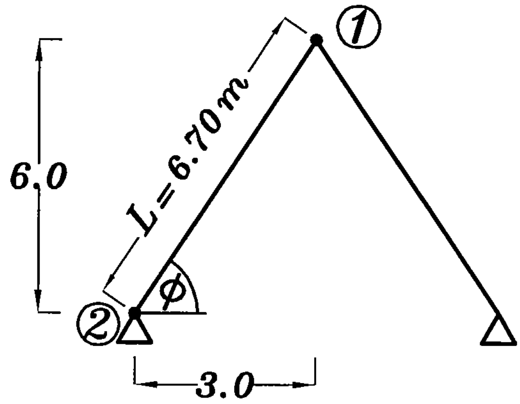
$p = 2.0 \ kN/m^2$



$$\tan\phi = \frac{6.0}{3.0} \longrightarrow \boxed{\phi = 63.43^\circ}$$

$$L^2 = 6.0^2 + 3.0^2 \longrightarrow \boxed{L = 6.70\,m}$$

$$R_1 = \infty$$



Sec. ① $\quad T_1 = T_2 = Zero$

Sec. ② $\quad r = 3.0 \ m$

Projected area $= \pi * r^2$  $= \pi * 3.0^2 = 28.27 \ m^2$

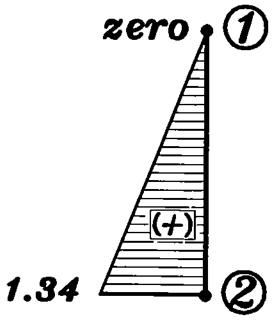
$W_\phi = p *$ Projected area $= 2.0 * 28.27 = +56.54 \ kN$

$$T_1 = \frac{W_\phi}{2\pi r \ \sin\phi} = \frac{+56.54}{2\pi * 3.0 * \sin 63.43^\circ} = +3.35 \ kN/m \ \text{Comp.}$$

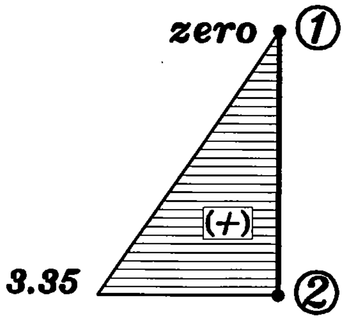
$$Z = p\cos^2\phi = 2.0 * \cos^2 63.43^\circ = +0.40 \ kN/m^2$$

$$R_2 = \frac{r}{\sin\phi} = \frac{3.0}{\sin 63.43^\circ} = 3.35 \ m$$

$$\because \ T_2 = Z * R_2 = 0.40 * 3.35 = +1.34 \ kN/m \ \text{Comp.}$$



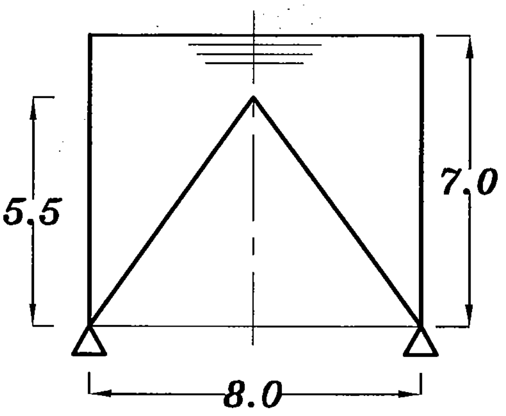
T_2 Diagram (kN/m)



T_1 Diagram (kN/m)

Example.

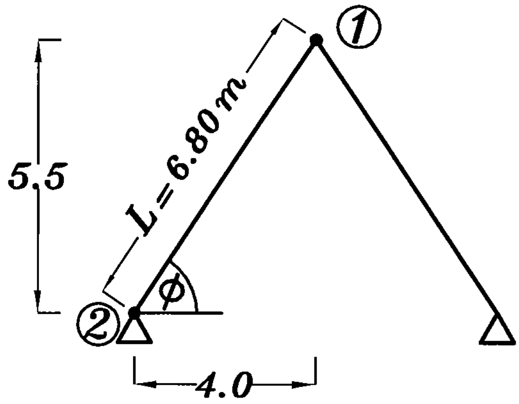
Draw T_1 & T_2 distribution on the vertical projection of The Cone due to water pressure.



$$\tan\phi = \frac{5.5}{4.0} \longrightarrow \boxed{\phi = 53.97^\circ}$$

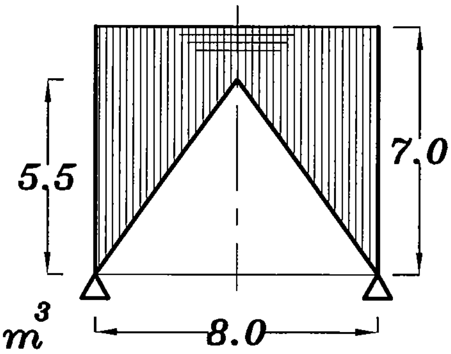
$$L^2 = 6.0^2 + 4.0^2 \longrightarrow \boxed{L = 6.80\,m}$$

$$R_1 = \infty$$



Sec. ① $\quad T_1 = T_2 = Zero$

Sec. ② $\quad r = 4.0\ m$



Volume of Cylinder $= \pi * r^2 * h$ 

$= \pi * 4.0^2 * 7.0 = 351.85\ m^3$

Volume of Cone $= \frac{1}{3} * \pi * r^2 * h$ 

$= \frac{1}{3} * \pi * 4.0^2 * 5.5 = 92.15\ m^3$

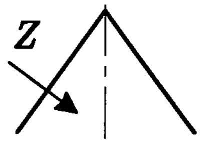
Volume of Water  $=$   $351.85 - 92.15 = 259.7\ m^3$

$W_\phi = \gamma_w * Volume = 10.0 * 259.7 = +2597.0\ kN \downarrow$

$$T_1 = \frac{W_\phi}{2\pi r \ Sin\phi} = \frac{+2597.0}{2\pi * 4.0 * Sin\,53.97^\circ} = +\mathbf{127.77}\ kN/m \quad Comp.$$

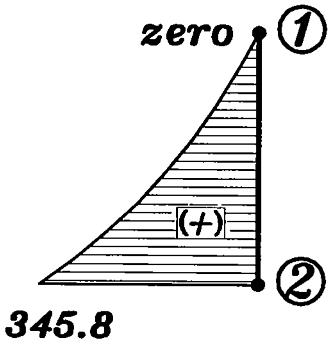
$$Z = \gamma_w * h = 10.0 * 7.0 = +70\ kN/m^2$$

اشاره Z $(+Ve)$ لان اتجاهها داخل الى المحور

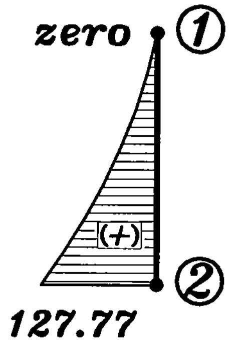


$$R_2 = \frac{r}{Sin\phi} = \frac{4.0}{Sin\,53.97^\circ} = 4.94\ m$$

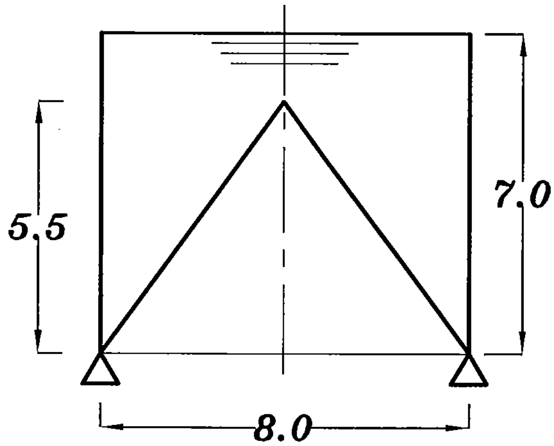
$$\because \quad T_2 = Z * R_2 = 70.0 * 4.94 = +\mathbf{345.8}\ kN/m \quad Comp.$$



T_2 Diagram (kN/m)



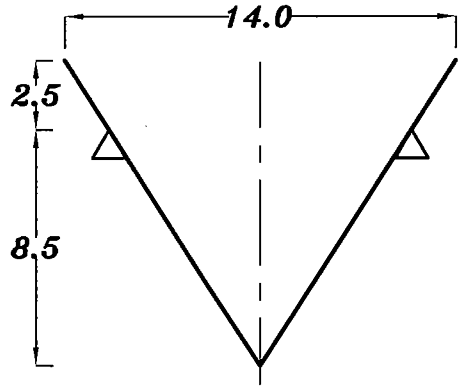
T_1 Diagram (kN/m)



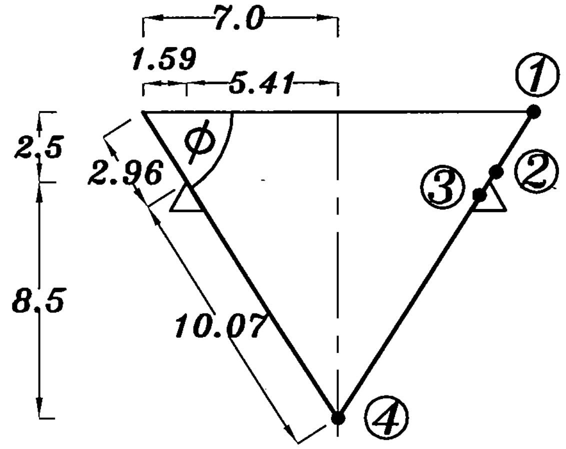
Example.

Draw T_1 & T_2 distribution on the vertical projection. due to dead load only.

$g = 3.0\ kN/m^2$



$\tan\phi = \frac{11}{7.0} \longrightarrow \boxed{\phi = 57.53^\circ}$



$R_1 = \infty$

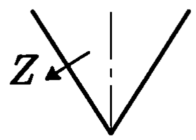
Sec. ①

$r = 7.0\ m$

$W_\phi = Zero \longrightarrow T_1 = Zero$

$Z = g\cos\phi = 3.0 * \cos 57.53^\circ = -1.61\ kN/m^2$

اشاره Z $(-Ve)$ لان اتجاهها خارج من المحور



$R_2 = \frac{r}{\sin\phi} = \frac{7.0}{\sin 57.53^\circ} = 8.297\ m$

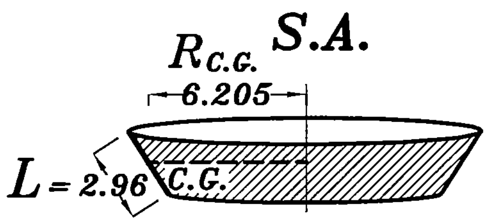
$T_2 = Z * R_2 = -1.61 * 8.297 = -13.35\ kN/m$ Ten.

Sec. ②

$r = 5.41 m$

$S.A. = L * 2\pi * R_{C.G.}$

$= 2.96 * 2\pi * 6.205 = 115.4\ m^2$



$W_\phi = g * S.A. = 3.0 * 115.4 = +346.2\ kN$

$T_1 = \frac{W_\phi}{2\pi r \sin\phi} = \frac{+346.2}{2\pi * 5.41 * \sin 57.53^\circ} = +12.07\ kN/m$ Comp.

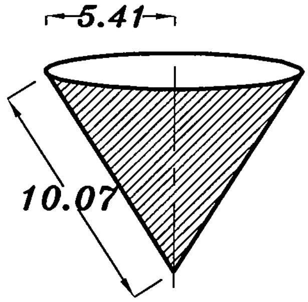
$Z = g\, Cos\phi = -1.61\ kN/m^2$

$$R_2 = \frac{r}{Sin\phi} = \frac{5.41}{Sin\, 57.53^\circ} = 6.41\ m$$

$T_2 = Z * R_2 = -1.61 * 6.41 = -\mathbf{10.32}\ kN/m$ Ten.

Sec. ③ $r = 5.41 m$

S.A.



$S.A. = \pi * L * r = \pi * 10.07 * 5.41 = 171.15\ m^2$

$W\phi = g * S.A. = 3.0 * 171.15 = -513.45\ kN$

اشاره $W\phi$ (-Ve) لان اتجاهها خارج من ال Support

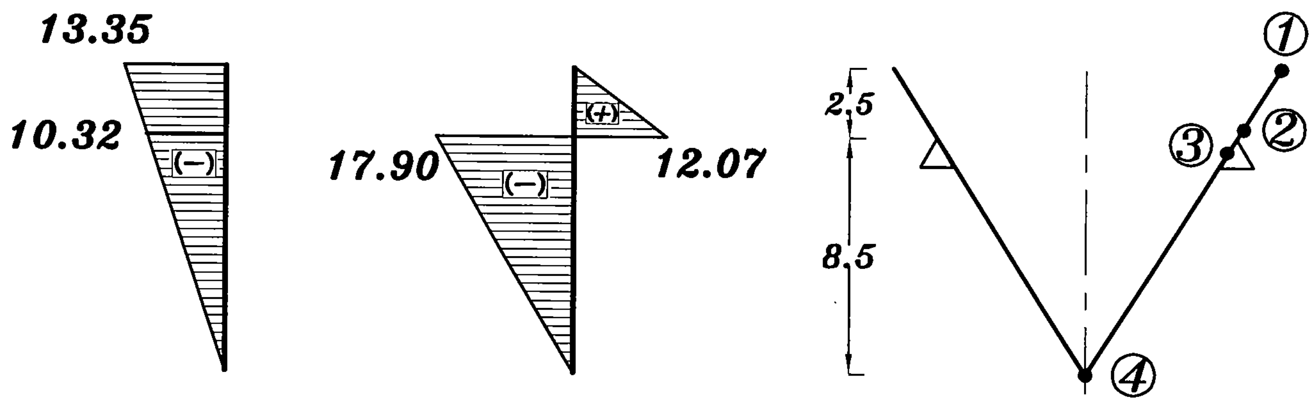
$$T_1 = \frac{W\phi}{2\pi r\ Sin\phi} = \frac{-513.45}{2\pi * 5.41 * Sin\, 57.53^\circ} = -\mathbf{17.90}\ kN/m \text{ Ten.}$$

$$R_2 = \frac{r}{Sin\phi} = \frac{5.41}{Sin\, 57.53^\circ} = 6.41\ m$$

$T_2 = Z * R_2 = -1.61 * 6.41 = -\mathbf{10.32}\ kN/m$ Ten.

Sec. ④ Vertex of the Cone.

$T_1 = T_2 = Zero$

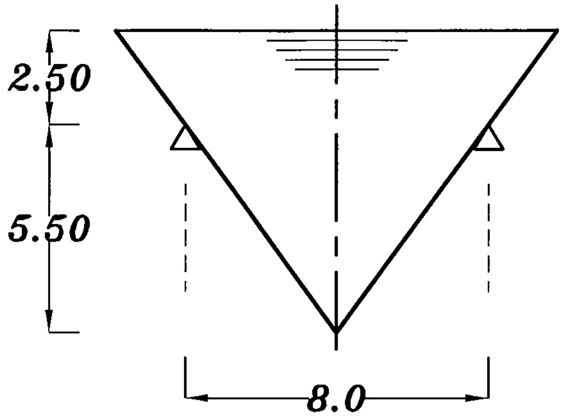


T_2 Diagram (kN/m)

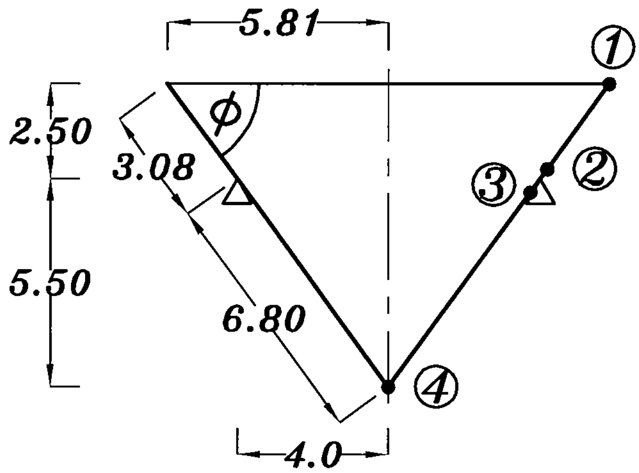
T_1 Diagram (kN/m)

Example.

Draw T_1 & T_2 distribution on the vertical projection. due to water pressure.



$$\tan\phi = \frac{5.5}{4.0} \longrightarrow \boxed{\phi = 53.97^\circ}$$



$$R_1 = \infty$$

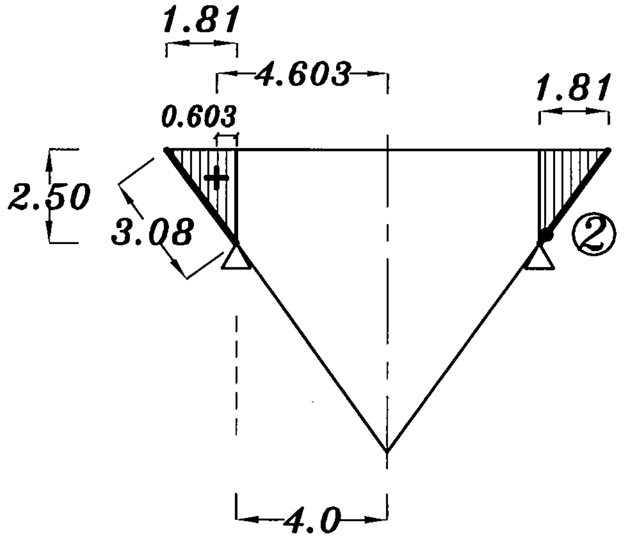
Sec. 1

$r = 5.1\ m$

$$W_\phi = Zero \longrightarrow T_1 = Zero$$

$$Z = \gamma_w * h = \gamma_w * Zero = Zero$$

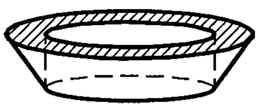
$$T_2 = Z * R_2 = Zero$$

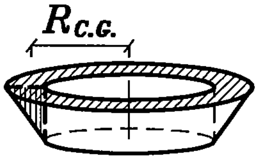


Sec. 2

$r = 4.0\ m$

Volume of water =





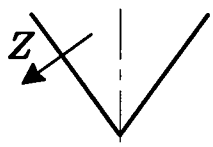
$= Area * 2\pi * R_{C.G.}$

$$Volume\ of\ water = \left(\frac{1}{2} * 1.81 * 2.5\right) * 2\pi * 4.603 = 65.43\ m^3$$

$$W_\phi = \gamma_w * Volume = 10.0 * 65.43 = +654.3\ kN$$

$$T_1 = \frac{W_\phi}{2\pi r \sin\phi} = \frac{+654.3}{2\pi * 4.0 * \sin 53.97^\circ} = +\mathbf{32.19}\ \ kN/m\ \ Comp.$$

$$Z = \gamma_w * h = 10.0 * 2.5 = -25\ kN/m^2$$



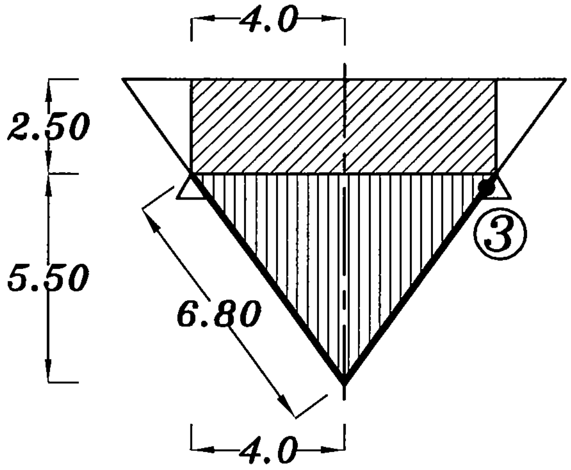
اشاره Z $(-Ve)$ لان اتجاهها خارج من المحور

$$R_2 = \frac{r}{Sin\phi} = \frac{4.0}{Sin\,53.97^\circ} = 4.94\ m$$

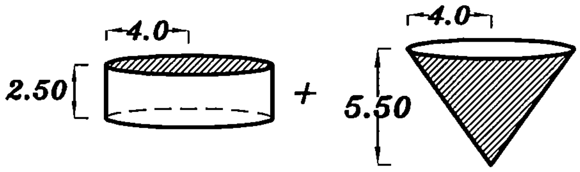
$$\because\ T_2 = Z * R_2 = -25 * 4.94 = -\mathbf{123.5}\ kN/m\ \ Ten.$$

Sec. ③

$r = 4.0\ m$



Volume of water =



$$Volume\ of\ water = \pi r^2 * h + \frac{1}{3} * \pi * r^2 * h$$

$$= \pi * 4.0^2 * 2.5 + \frac{1}{3} * \pi * 4.0^2 * 5.5 = 217.82\ m^3$$

$$W_\phi = \gamma_w * Volume = 10.0 * 217.8 = -2178.2\ kN$$

اشاره W_ϕ $(-Ve)$ لان اتجاهها خارج من ال Support

$$T_1 = \frac{W_\phi}{2\pi r\ Sin\phi} = \frac{-2178.2}{2\pi * 4.0 * Sin\,53.97^\circ} = -\ 107.17\ kN/m\ \ Comp.$$

$$Z = \gamma_w * h = 10.0 * 2.5 = -25\ kN/m^2$$

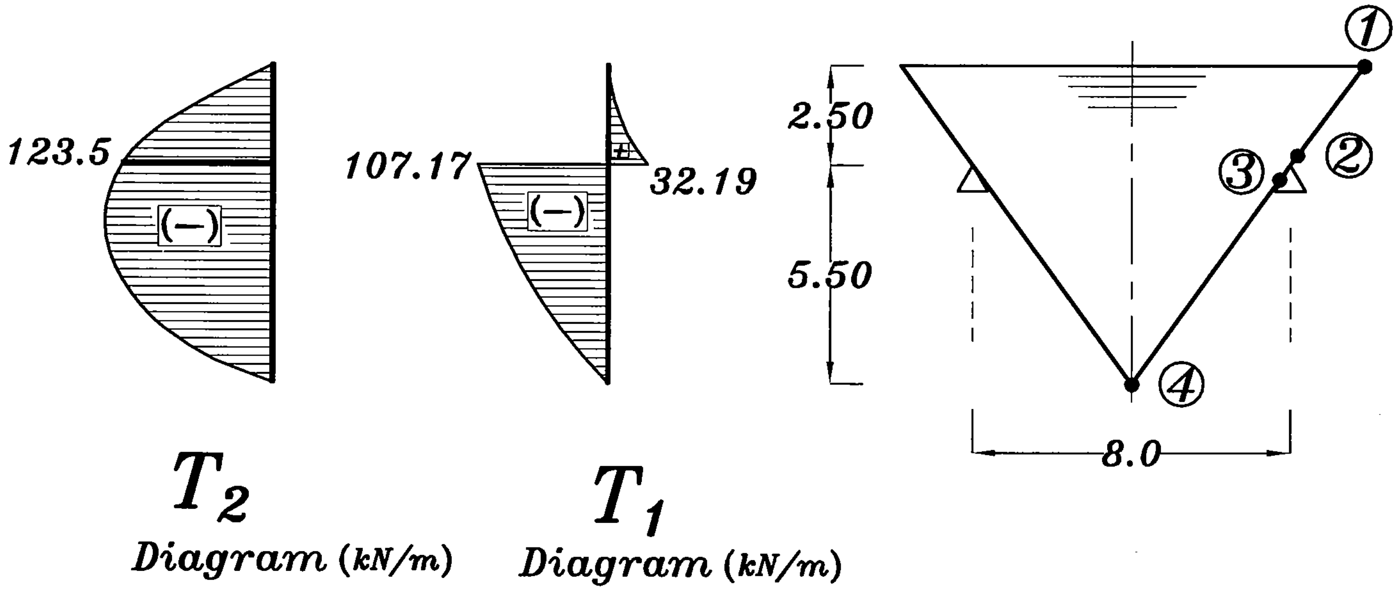
اشاره Z $(-Ve)$ لان اتجاهها خارج من المحور

$$R_2 = \frac{r}{Sin\phi} = \frac{4.0}{Sin\,53.97^\circ} = 4.94\ m$$

$$\because\ T_2 = Z * R_2 = -25 * 4.94 = -\mathbf{123.5}\ kN/m\ \ Ten.$$

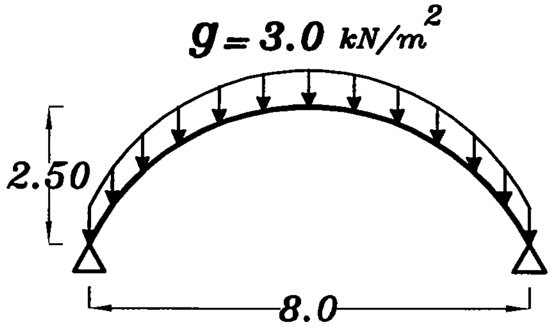
Sec. ④ Vertex of the Cone.

$$T_1 = T_2 = Zero$$



Example.

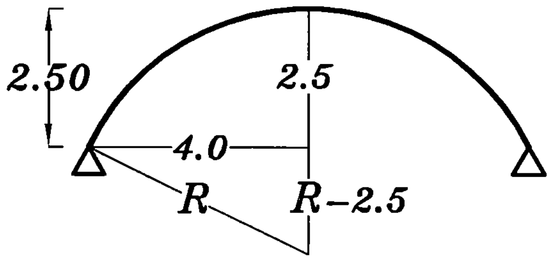
Draw T_1 & T_2 distribution (at least 3 points) on the vertical projection of the Dome due to Dead load only. $g = 3.0\ kN/m^2$



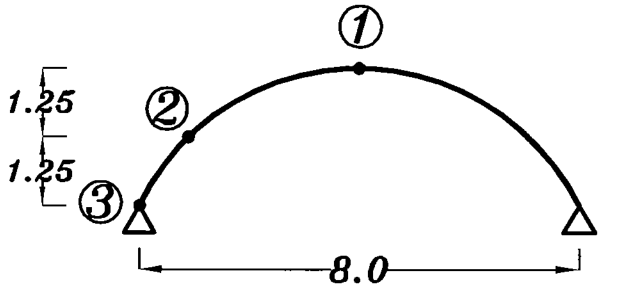
$$R^2 = 4.0^2 + (R - 2.5)^2$$

$$R^2 = 16 + R^2 - 5R + 6.25$$

$$5R = 22.25 \longrightarrow \boxed{R = 4.45\,m}$$



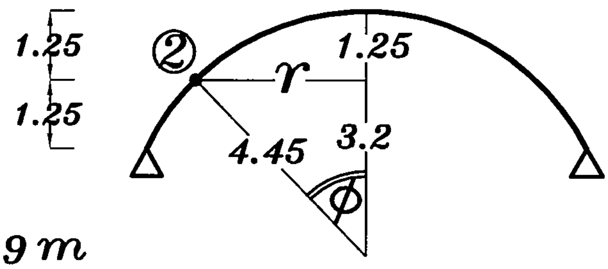
Sec. ① $\qquad \phi = Zero$



$$Z = g\,Cos\,\phi = 3.0 * Cos\,0.0$$
$$= +\,3.0\ kN/m^2$$

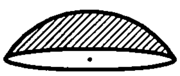
$$T_1 = T_2 = \frac{RZ}{2} = \frac{4.45 * 3.0}{2} = +\ 6.675\ kN/m\ \ Comp.$$

Sec. ②



$$Cos\,\phi = \frac{3.2}{4.45} \longrightarrow \boxed{\phi = 44.02^\circ}$$

$$r = R\,Sin\phi = 4.45 * Sin\,44.02^\circ = 3.09\,m$$

$S.A. = 2\pi * R * h$  $= 2\pi * 4.45 * 1.25 = 34.95\ m^2$

$$W_\phi = g * S.A. = 3.0 * 34.95 = +104.85\ kN$$

$$T_1 = \frac{W\phi}{2\pi r\ Sin\phi} = \frac{+104.85}{2\pi * 3.09 * Sin\,44.02^\circ} = +\ 7.77\ kN/m\ \ Comp.$$

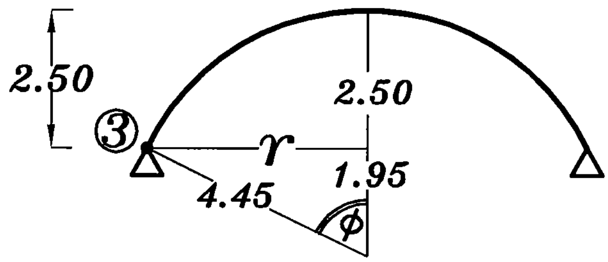
$R_1 = R_2 = R = 4.45\ m$

$Z = g\ Cos\phi = 3.0 * Cos 44.02^\circ = +\ 2.157\ kN/m^2$

$\because T_1 + T_2 = Z * R \quad \therefore +7.77 + T_2 = 2.157 * 4.45$

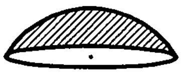
$\therefore T_2 = +\ \mathbf{1.83}\ kN/m$ Comp.

Sec. ③



$Cos\phi = \dfrac{1.95}{4.45} \longrightarrow \boxed{\phi = 64.01^\circ}$

$r = 4.0\ m$

$S.A. = 2\pi * R * h$  $= 2\pi * 4.45 * 2.50 = 69.90\ m^2$

$W_\phi = g * S.A. = 3.0 * 69.90 = +209.7\ kN$

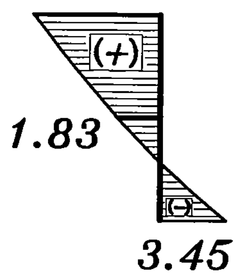
$T_1 = \dfrac{W\phi}{2\pi r\ Sin\phi} = \dfrac{+209.7}{2\pi * 4.0 * Sin\ 64.01^\circ} = +\ \mathbf{9.28}\ kN/m$ Comp.

$R_1 = R_2 = R = 4.45\ m$

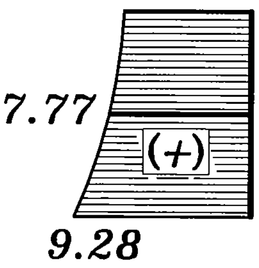
$Z = g\ Cos\phi = 3.0 * Cos\ 64.01^\circ = +\ 1.31\ kN/m^2$

$\because T_1 + T_2 = Z * R \quad \therefore +9.28 + T_2 = 1.31 * 4.45$

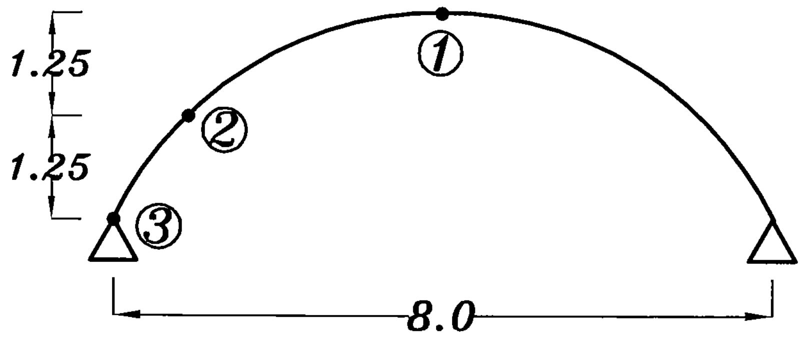
$\therefore T_2 = -\ \mathbf{3.45}\ kN/m$ Ten.



T_2 Diagram (kN/m)

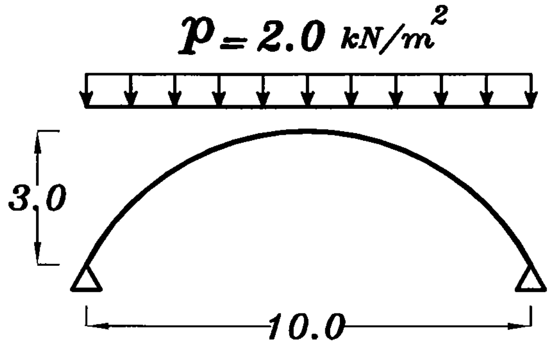


T_1 Diagram (kN/m)



Example.

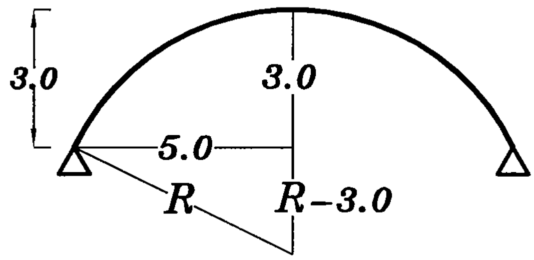
Draw T_1 & T_2 distribution (at least 3 points) on the vertical projection of the Dome due to Live load only. $p = 2.0\ kN/m^2$



$$R^2 = 5.0^2 + (R-3.0)^2$$

$$R^2 = 25 + R^2 - 6R + 9.0$$

$$6R = 34.0 \longrightarrow \boxed{R = 5.66\,m}$$

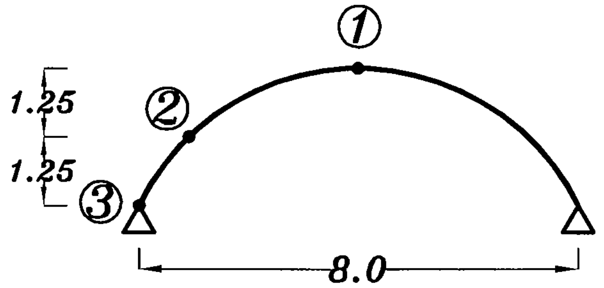


Sec. ①

$\phi = Zero$

$$Z = p\,Cos^2\phi = 2.0 * Cos^2 0.0$$

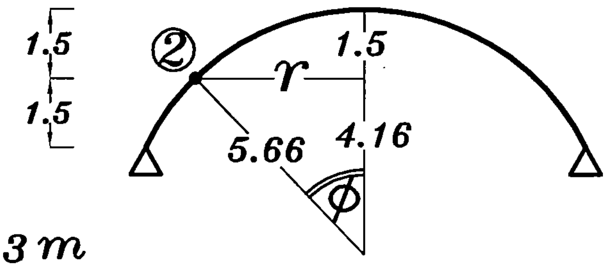
$$= +\,2.0\ kN/m^2$$



$$T_1 = T_2 = \frac{RZ}{2} = \frac{5.66 * 2.0}{2} = +\,5.66\ \ kN/m\ \ Comp.$$

Sec. ②

$$Cos\,\phi = \frac{4.16}{5.66} \longrightarrow \boxed{\phi = 42.69^\circ}$$



$$r = R\,Sin\phi = 5.66 * Sin\ 42.69^\circ = 3.83\ m$$

Projected area $= \pi * r^2$  $= \pi * 3.83^2 = 46.08\ m^2$

$$W_\phi = p * \text{Projected area} = 2.0 * 46.08 = +92.16\ kN$$

$$T_1 = \frac{W\phi}{2\pi r\ Sin\phi} = \frac{+92.16}{2\pi * 3.83 * Sin\ 42.69^\circ} = +\,5.66\ kN/m\ \ Comp.$$

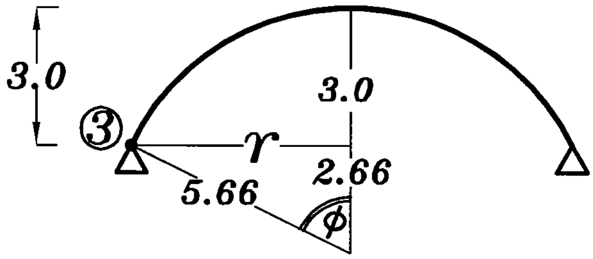
$$R_1 = R_2 = R = 5.66\ m$$

$$Z = p\,Cos^2\phi = 2.0 * Cos^2 42.69^\circ = +\ 1.08\ \ kN/m^2$$

$$\because\ T_1 + T_2 = Z * R \qquad \therefore\ +5.65 + T_2 = 1.08 * 5.66$$

$$\therefore\ T_2 = +\ \mathbf{0.46}\ kN/m\ \ Comp.$$

Sec. ③



$$Cos\,\phi = \frac{2.66}{5.66} \longrightarrow \boxed{\phi = 61.96^\circ}$$

$$r = 5.0\ m$$

$$Projected\ \ area = \pi * r^2 \ = \pi * 5.0^2 = 78.54\ m^2$$

$$W_\phi = p * Projected\ \ area = 2.0 * 78.54 = +157.08\ \ kN$$

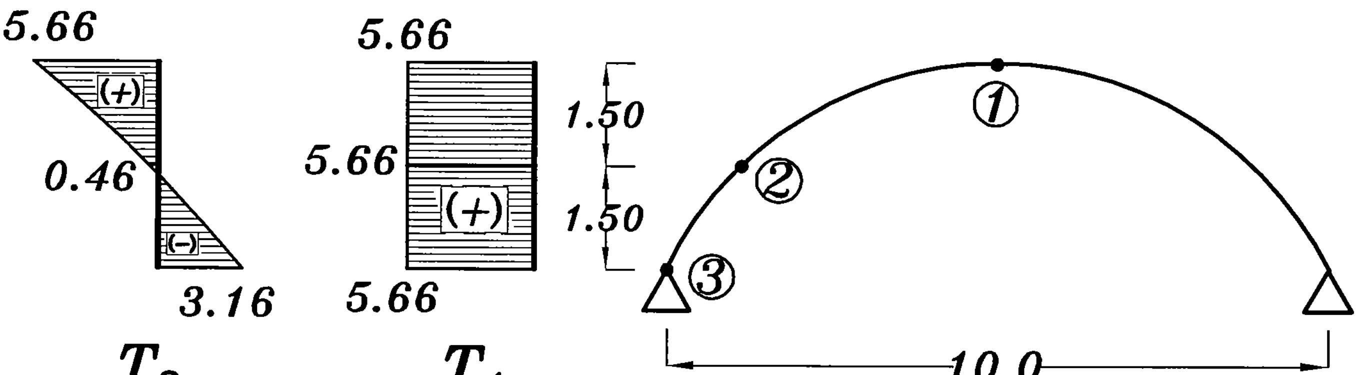
$$T_1 = \frac{W_\phi}{2\pi r\ \ Sin\phi} = \frac{+157.08}{2\pi * 5.0 * Sin\ 61.96^\circ} = +\ \mathbf{5.66}\ \ kN/m\ \ Comp.$$

$$R_1 = R_2 = R = 5.66\ m$$

$$Z = p\,Cos^2\phi = 2.0 * Cos^2 61.96^\circ = +\ 0.442\ kN/m^2$$

$$\because\ T_1 + T_2 = Z * R \qquad \therefore\ +5.66 + T_2 = 0.442 * 5.66$$

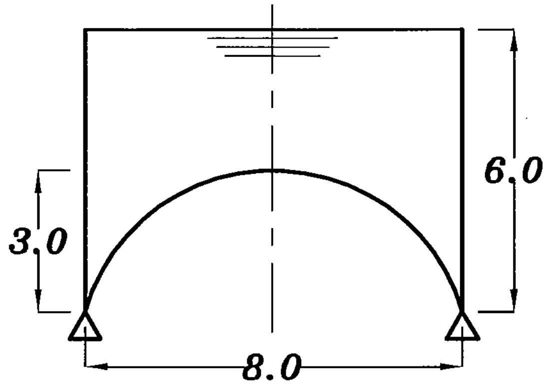
$$\therefore\ T_2 = -\ \mathbf{3.16}\ kN/m\ \ Ten.$$



T_2 Diagram (kN/m) $\qquad$ T_1 Diagram (kN/m)

Example.

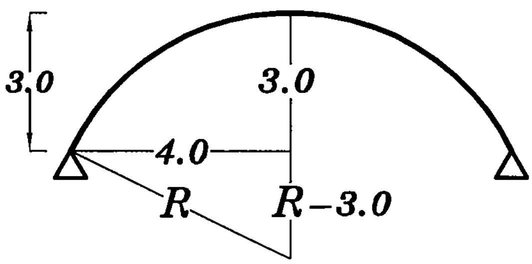
Draw T_1 & T_2 distribution (at least 3 points) on the vertical projection of the Dome due to water pressure only.



$$R^2 = 4.0^2 + (R-3.0)^2$$

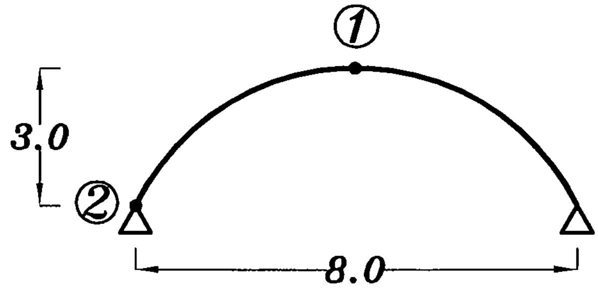
$$R^2 = 16 + R^2 - 6R + 9.0$$

$$6R = 25.0 \longrightarrow \boxed{R = 4.17\ m}$$



Sec. ①

$$\phi = Zero$$

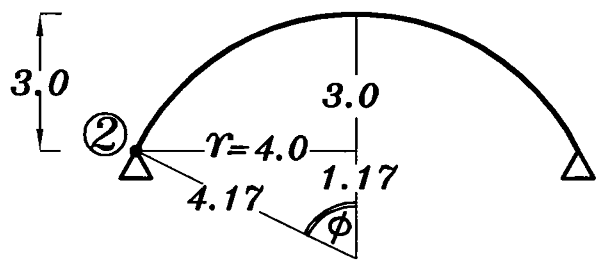


$$Z = \gamma_w * h = 10.0 * 3.0 = +30\ kN/m^2$$

$$T_1 = T_2 = \frac{RZ}{2} = \frac{4.17 * 30}{2} = +62.55\ kN/m\ Comp.$$

Sec. ②

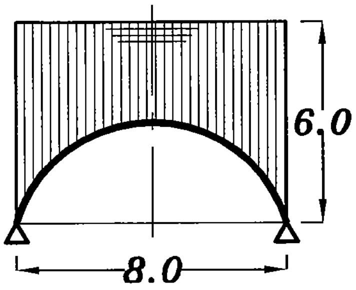
$$Cos\,\phi = \frac{1.17}{4.17} \longrightarrow \boxed{\phi = 73.70^\circ}$$



$$r = 4.0\ m$$

Volume of Cylinder $= \pi * r^2 * h$

$= \pi * 4.0^2 * 6.0 = 301.6\ m^3$



Volume of Dome $= \dfrac{\pi * h}{6}(3r^2 + h^2)$

$= \dfrac{\pi * 3.0}{6}(3 * 4.0^2 + 3.0^2) = 89.53\ m^3$

Volume of Water $= 301.6 - 89.53 = 212.07\ m^3$

$W_\phi = \gamma_w * Volume = 10.0 * 212.07 = +2120.7\ kN$

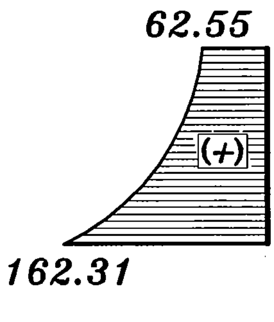
$T_1 = \dfrac{W\phi}{2\pi r\ Sin\phi} = \dfrac{+2120.7}{2\pi * 4.0 * Sin\ 73.70^\circ} = \mathbf{+87.89}\ kN/m\ Comp.$

$R_1 = R_2 = R = 4.17\ m$

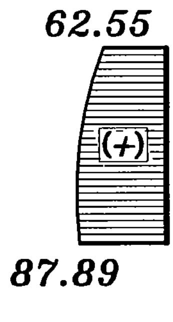
$Z = \gamma_w * h = 10.0 * 6.0 = +60\ kN/m^2$

$\because T_1 + T_2 = Z * R \quad \therefore +87.89 + T_2 = 60 * 4.17$

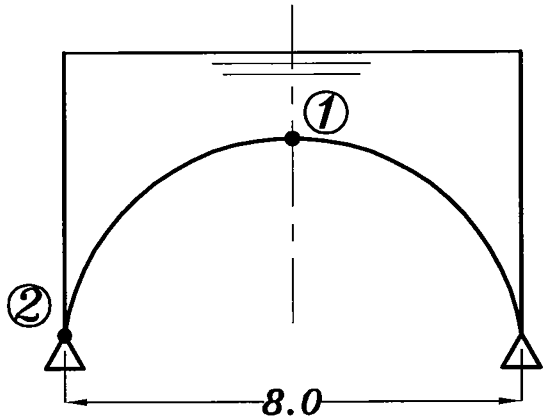
$\therefore T_2 = \mathbf{+162.31}\ kN/m\ Comp.$



T_2 Diagram (kN/m)



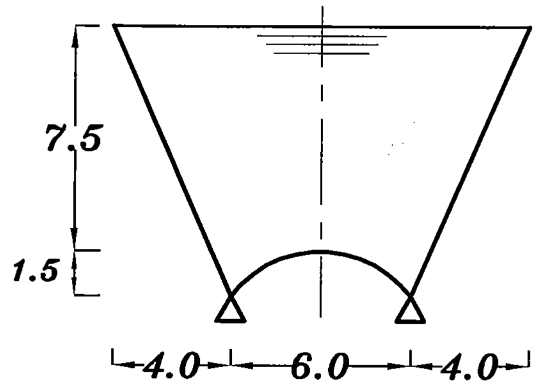
T_1 Diagram (kN/m)



Example.

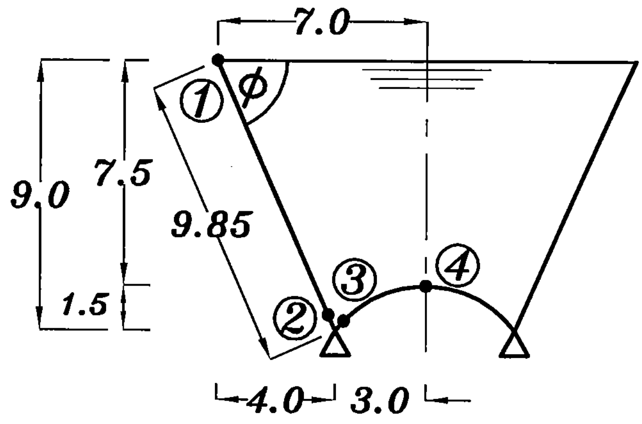
Draw T_1 & T_2 distribution on the vertical projection. due to dead load & water pressure.

$t_s = 0.16\ m$



Deal Load $= g = t_s\,\gamma_c = 0.16 * 25 = 4.0\ \ kN/m^2$

For Cone



$$\tan\phi = \frac{9.0}{4.0} \longrightarrow \boxed{\phi = 66.03^\circ}$$

Sec. ①

$r = 7.0\ m$

$W_\phi = Zero \longrightarrow T_1 = Zero$

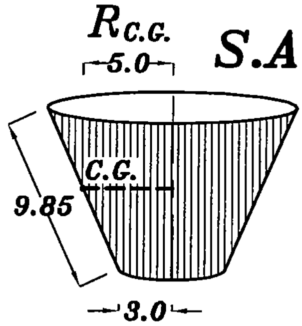
$Z = g\,Cos\,\phi + \gamma_w * h = 4.0 * Cos\,66.03^\circ + \gamma_w * Zero = -1.62\ kN/m^2$

اشاره Z $(-Ve)$ لان اتجاهها خارج من المحور

$$R_2 = \frac{r}{Sin\phi} = \frac{7.0}{Sin\,66.03^\circ} = 7.66\ m$$

$T_2 = Z * R_2 = -1.62 * 7.66 = -12.41\ kN/m$ Ten.

S.A.



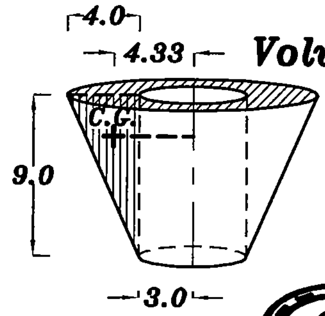
Sec. ②

$r = 3.0\ m$

$S.A. = L * 2\pi * R_{C.G.}$

$= 9.85 * 2\pi * 5.0 = 309.44\ m^2$

Volume



Volume of water $= Area * 2\pi * R_{C.G.}$

$$= \left(\frac{1}{2} * 4.0 * 9.0\right) * 2\pi * 4.33$$

$$= 489.71\ m^3$$

$$W_\phi = g * S.A. + \gamma_w * Volume$$

$$= 4.0 * 309.44 + 10.0 * 489.71 = 6134.86 \ kN$$

$$T_1 = \frac{W_\phi}{2\pi r \ Sin\phi} = \frac{+6134.86}{2\pi * 3.0 * Sin \ 66.03^\circ} = +\mathbf{356.18} \ kN/m \ \ Comp.$$

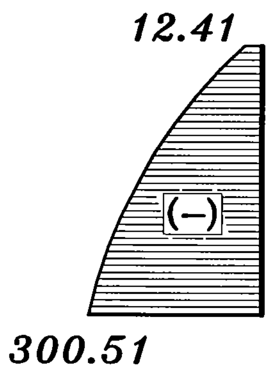
$$Z = g \ Cos\phi + \gamma_w * h = 4.0 * Cos \ 66.03^\circ + 10 * 9.0 = -91.62 \ kN/m^2$$

اشاره Z $(-Ve)$ لان اتجاهها خارج من المحور

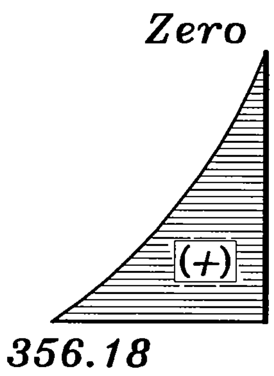
$$R_2 = \frac{r}{Sin\phi} = \frac{3.0}{Sin \ 66.03^\circ} = 3.28 \ m$$

$$\because \ T_2 = Z * R_2 = -91.62 * 3.28 = -\mathbf{300.51} \ kN/m \ \ Comp.$$

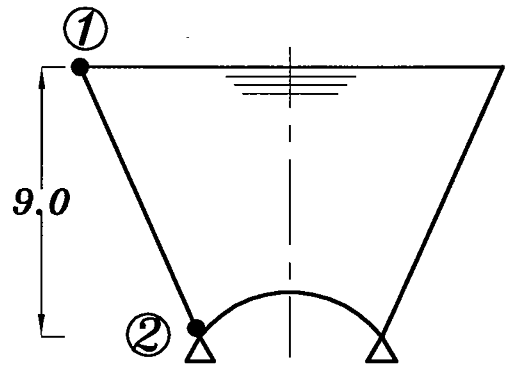
T_1 & T_2 distribution For the Cone.



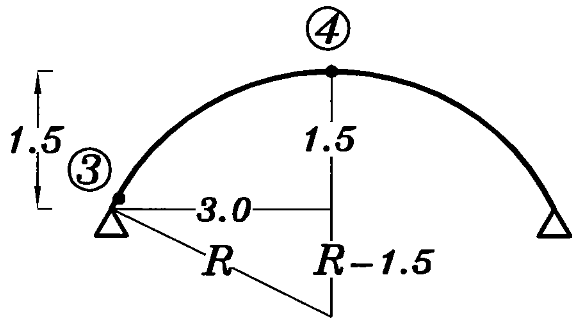
T_2
Diagram (kN/m)



T_1
Diagram (kN/m)



Dome.



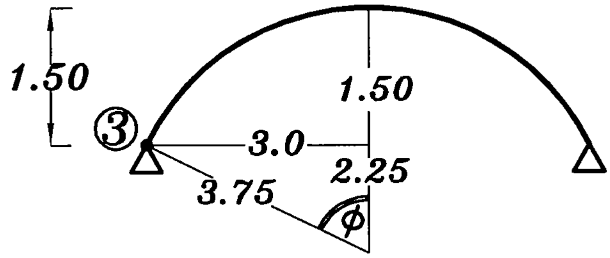
$$R^2 = 3.0^2 + (R - 1.5)^2$$

$$R^2 = 9.0 + R^2 - 3R + 2.25$$

$$3R = 11.25 \longrightarrow \boxed{R = 3.75 \, m}$$

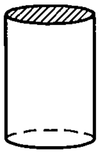
Sec. 3

$$\cos\phi = \frac{2.25}{3.75} \longrightarrow \boxed{\phi = 53.13^\circ}$$

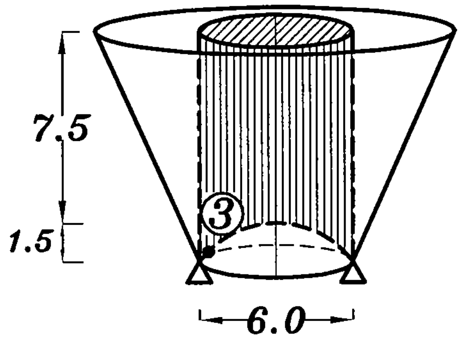


$r = 3.0\ m$

$$S.A. = 2\pi * R * h$$  $$= 2\pi * 3.75 * 1.50 = 35.34\ m^2$$

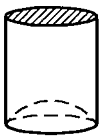
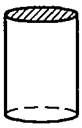
Volume of Cylinder $= \pi * r^2 * h$ 

$$= \pi * 3.0^2 * 9.0 = 254.47\ m^3$$



Volume of Dome $$= \frac{\pi * h}{6}(3r^2 + h^2)$$ 

$$= \frac{\pi * 1.5}{6}(3 * 3.0^2 + 1.5^2) = 22.97\ m^3$$

Volume of Water  $=$   $= 254.47 - 22.97 = 231.5\ m^3$

$$W_\phi = g * S.A. + \gamma_w * Volume$$

$$= 4.0 * 35.34 + 10.0 * 231.5 = 2456.36\ kN$$

$$T_1 = \frac{W_\phi}{2\pi r \sin\phi} = \frac{+2456.36}{2\pi * 3.0 * \sin 53.13^\circ} = +162.90\ kN/m\ \text{Comp.}$$

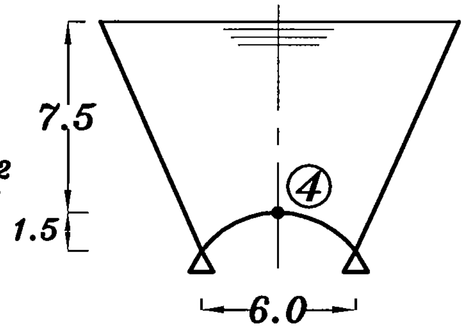
$$R_1 = R_2 = R = 3.75\ m$$

$$Z = g\cos\phi + \gamma_w * h = 4.0 * \cos 53.13^\circ + 10 * 9.0 = +92.40\ kN/m^2$$

$$\because T_1 + T_2 = Z * R \qquad \therefore +162.90 + T_2 = 92.40 * 3.75$$

$$\therefore T_2 = +183.6\ kN/m\ \text{Comp.}$$

Sec. ④ $\phi = Zero$

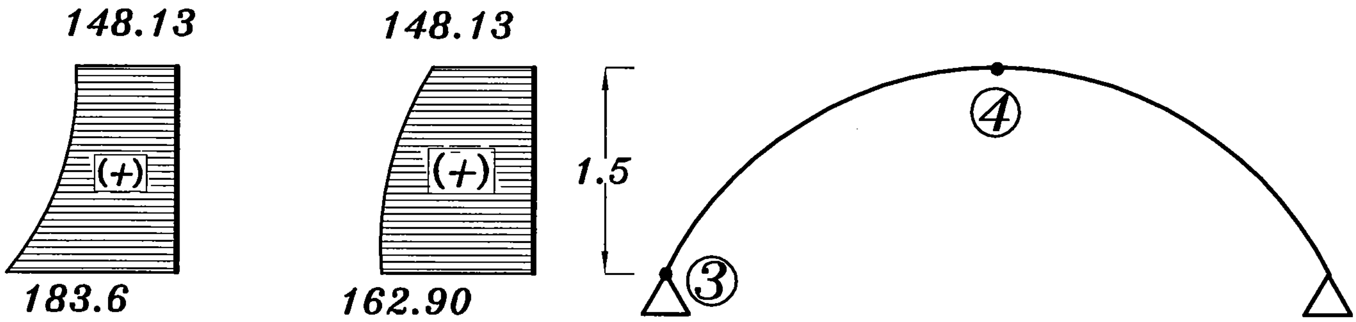


$$Z = g\,Cos\,\phi + \gamma_{w} * h$$

$$= 4.0 * Cos\,0.0 + 10 * 7.5 = +79.0 \ kN/m^2$$

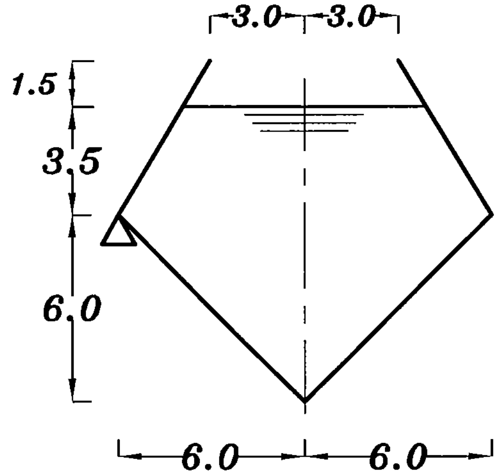
$$T_1 = T_2 = \frac{RZ}{2} = \frac{3.75 * 79.0}{2} = +148.13 \ kN/m \ Comp.$$

T_1 & T_2 distribution For the Dome.



T_2 Diagram (kN/m) T_1 Diagram (kN/m)

Example.

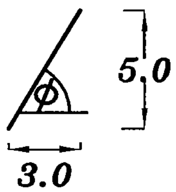


Draw T_1 & T_2 distribution
on the vertical projection.
due to dead load & water pressure.

$t_s = 0.20\ m$

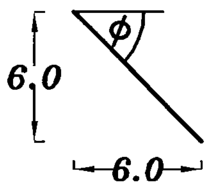
Deal Load $= g = t_s\, \gamma_c = 0.20 * 25 = 5.0\ kN/m^2$

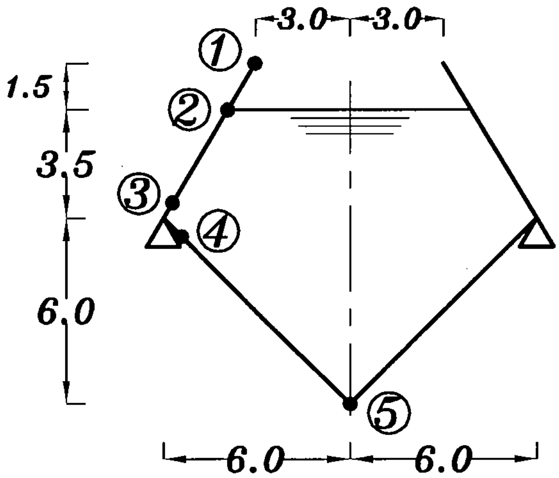
First Cone.



$\tan\phi = \dfrac{5.0}{3.0} \longrightarrow \boxed{\phi = 59.04^\circ}$

Second Cone.





$\tan\phi = \dfrac{6.0}{6.0} \longrightarrow \boxed{\phi = 45.0^\circ}$

Sec. ① $r = 3.0\ m$

$W_\phi = Zero \longrightarrow T_1 = Zero$

$Z = g \cos\phi = 5.0 * \cos 59.04^\circ = +2.572\ kN/m^2$

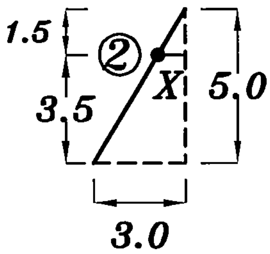
$R_2 = \dfrac{r}{\sin\phi} = \dfrac{3.0}{\sin 59.04^\circ} = 3.50\ m$

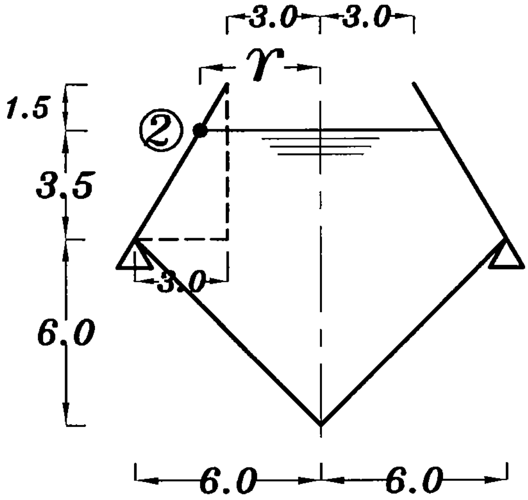
$T_2 = Z * R_2 = +2.572 * 3.50 = +9.0\ kN/m$ *Comp.*

Sec. ②

$$\frac{1.5}{5.0} = \frac{X}{3.0} \longrightarrow X = 0.9\,m$$

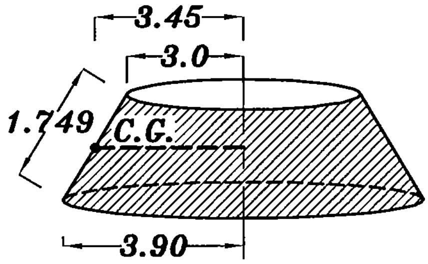
$$r = 3.0 + 0.9 = 3.90\ m$$





$$S.A. = L * 2\pi * R_{C.G.}$$

$$= 1.749 * 2\pi * 3.45 = 37.91\ m^2$$



$$W_\phi = g * S.A. = 5.0 * 37.91 = +\ 189.55\ kN$$

$$T_1 = \frac{W_\phi}{2\pi r\ Sin\phi} = \frac{+\ 189.55}{2\pi * 3.90 * Sin\ 59.04^\circ} = +\ \mathbf{9.02}\ kN/m\ \ Comp.$$

$$Z = g\ Cos\,\phi = 5.0 * Cos\ 59.04^\circ = +\ 2.572\ kN/m^2$$

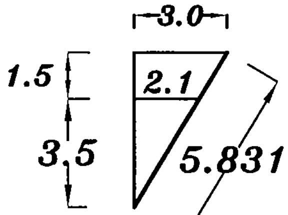
$$R_2 = \frac{r}{Sin\phi} = \frac{3.90}{Sin\ 59.04^\circ} = 4.548\ m$$

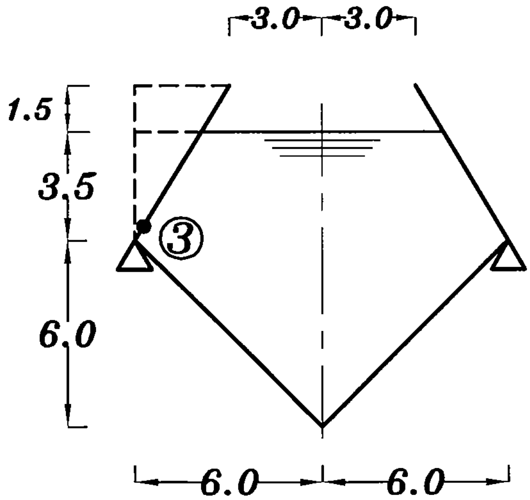
$$T_2 = Z * R_2 = 2.572 * 4.548 = +\ \mathbf{11.70}\ kN/m\ \ Comp.$$

Sec. ③

$$r = 6.0\ m$$

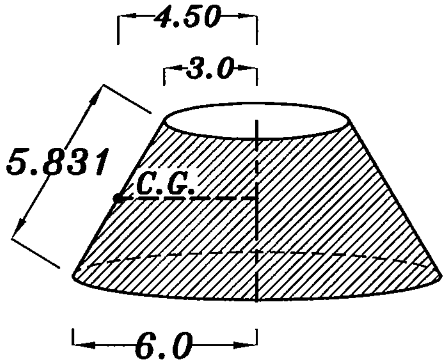
$$\phi = 59.04^\circ$$



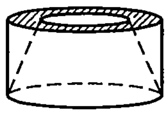


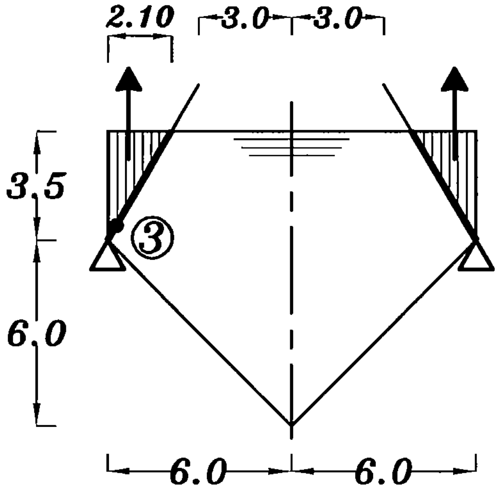
$S.A. = L * 2\pi * R_{C.G.}$

$= 5.831 * 2\pi * 4.50 = 164.86\,m^2$

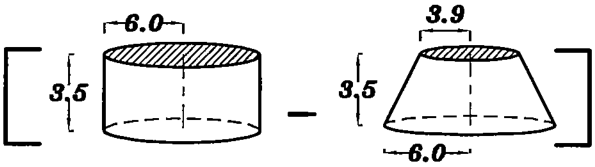


Volume





Volume of



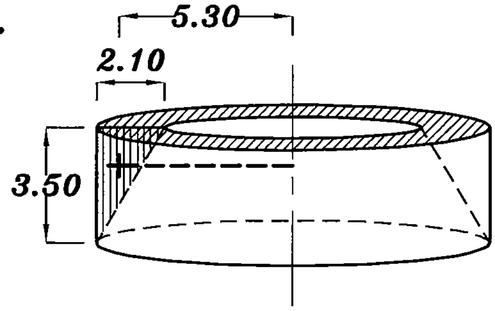
$$Volume = \left[\pi r^2 * h - \frac{\pi h}{3}(a^2 + b^2 + ab)\right]$$

$$= \left[\pi * 6.0^2 * 3.5 - \frac{\pi * 3.5}{3}\left(3.9^2 + 6.0^2 + 3.9 * 6.0\right)\right]$$

$$= 122.38\ m^3$$

Or we can get the volume From.

$Volume = Area * 2\pi * R_{C.G.}$



$$Volume = \left(\frac{1}{2} * 2.10 * 3.5\right) * 2\pi * 5.30 = 65.43\ m^3$$

$$= 122.38\ m^3$$

$$W_\phi = g * S.A. \downarrow - \gamma_w * Volume \uparrow$$

$$= 5.0 * 164.86 - 10.0 * 122.38 = -399.5 \ kN \uparrow$$

تم طرح القيمتين من بعضهما لان وزن السطح $(g * S.A.)$ يؤثر رأسيا لاسفل بينما ضغط الماء $(\gamma_w * Volume)$ يؤثر رأسيا لاعلى .

$$T_1 = \frac{W_\phi}{2\pi r \ Sin\phi} = \frac{-399.5}{2\pi * 6.0 * Sin\, 59.04^\circ} = -12.36 \quad kN/m \ Comp.$$

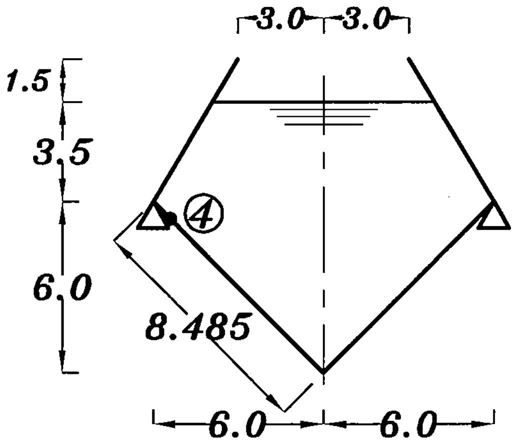
$$Z = g \, Cos\phi \searrow - \gamma_w * h \nwarrow$$

$$= 5.0 * Cos\, 59.04^\circ - 10 * 3.5 = -32.43 \quad kN/m^2$$

$$R_2 = \frac{r}{Sin\phi} = \frac{6.0}{Sin\, 59.04^\circ} = 7.0 \ m$$

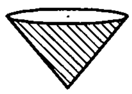
$$\because \quad T_2 = Z * R_2 = -32.43 * 7.0 = -227.0 \ kN/m \ \ Ten.$$

Sec. ④

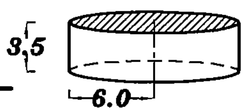
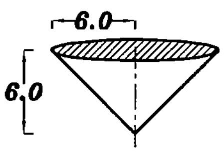


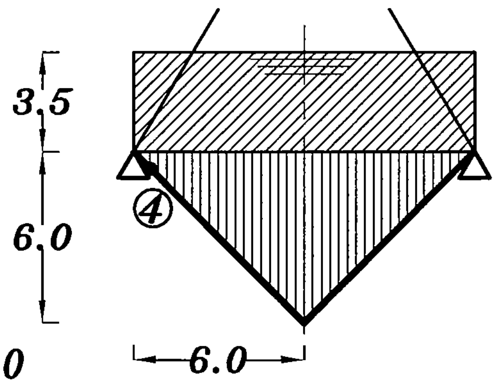
$r = 6.0 \ m$

$\phi = 45.0^\circ$

$S.A. = \pi * r * L$ 

$$= \pi * 6.0 * 8.485 = 159.93 \ m^2$$

Volume [ + ]



$$Volume = \pi r^2 * h + \frac{1}{3} * \pi * r^2 * h$$

$$= \pi * 6.0^2 * 3.5 + \frac{1}{3} * \pi * 6.0^2 * 6.0$$

$$= 622.03 \quad m^3$$

$$W_\phi = g * S.A. + \gamma_w * Volume$$

$$= 5.0 * 159.93 + 10.0 * 622.03 = -7019.95\ kN$$

اشاره W_ϕ $(-Ve)$ لان اتجاهها خارج من ال Support

$$T_1 = \frac{W_\phi}{2\pi r\ Sin\phi} = \frac{-7019.95}{2\pi * 6.0 * Sin\ 45^\circ} = -\mathbf{263.36}\ kN/m\ Ten.$$

$$Z = g\ Cos\phi + \gamma_w * h$$

$$= 5.0 * Cos\ 45^\circ + 10 * 3.5 = -38.53\ kN/m^2$$

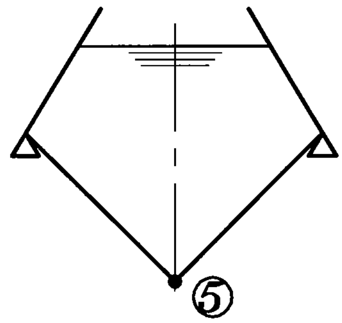
اشاره Z $(-Ve)$ لان اتجاهها خارج من المحور

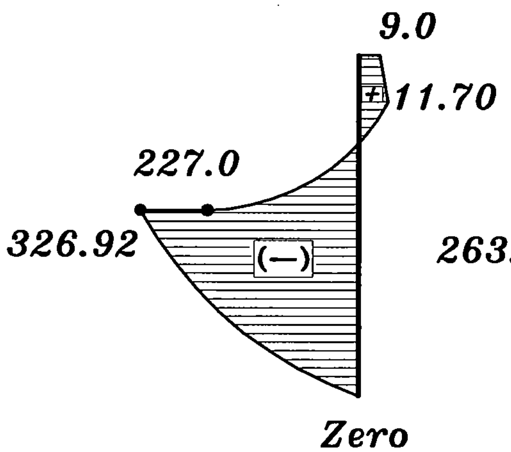
$$R_2 = \frac{r}{Sin\phi} = \frac{6.0}{Sin\ 45^\circ} = 8.485\ m$$

$$\because\ T_2 = Z * R_2 = -38.53 * 8.485 = -\mathbf{326.92}\ kN/m\ Ten.$$

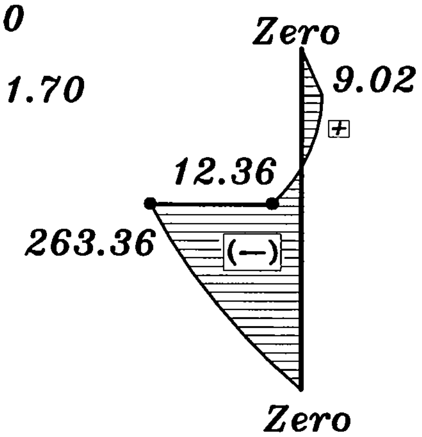
Sec. ⑤ Vertex of the Cone.

$$T_1 = T_2 = Zero$$





T_2 Diagram (kN/m)



T_1 Diagram (kN/m)