* System Of Energy Absorbing

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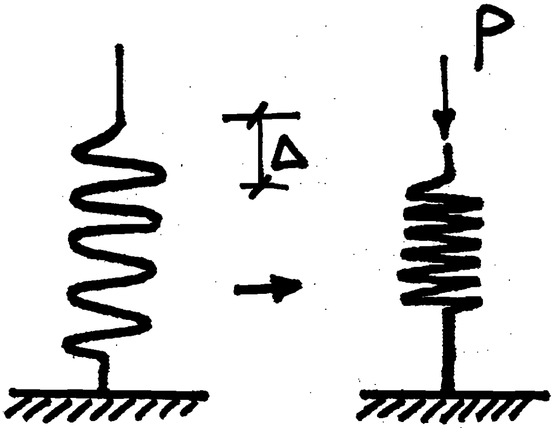
نظم إمتصاص الطاقة



قبل الإنضغاط — بعد الإنضغاط

لتخفيف حمل الصدم الواقع على الكمرات والأعمدة

Look

يتم إستخدام نظاماً (الزنبرك) سستم

لتحمل قوى الصدم الناتجة وتقليل تأثيرها على الأجسام

- Stiffness of Spring «K» = $\frac{P}{\Delta}$:

P : الحمل المؤثر

Δ : الإنضغاط من الزنبرك

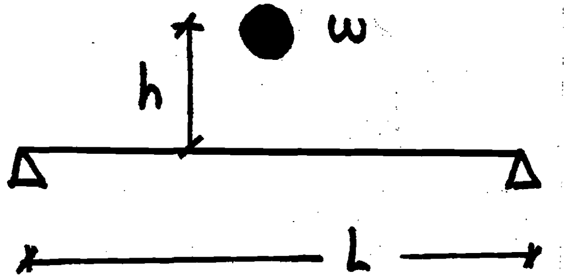
Look

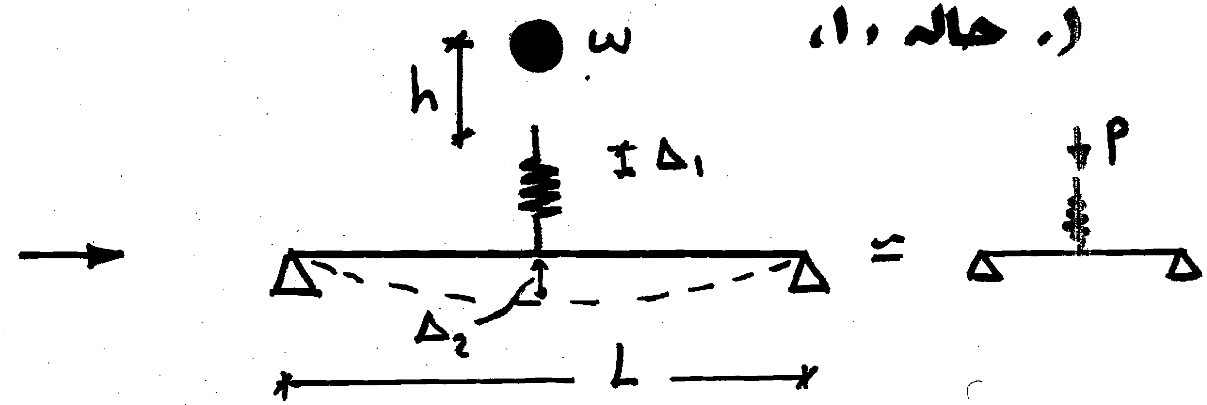
Book

- يوجد أكثر من نظام لوضع الزنبرك على حسب المصمم: سيادتك

1. Case "1"

1. حالة "1"





- الزنبرك يتحمل الصدمة مباشرةً :

$$W(h+\Delta) = \frac{1}{2} P \Delta$$

الطاقة الخارجية نتيجة السقوط

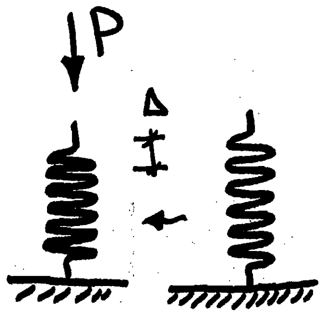
الطاقة الداخلية

$$\therefore W(\underbrace{h+\Delta_1+\Delta_2}_{\text{(ارتفاع السقوط)}}) = \frac{1}{2} P \Delta_1 + \frac{1}{2} P \Delta_2$$

: $\Delta_1 = P/k$ & $\Delta_2 = \dfrac{PL^3}{48EI}$

→ System of energy absorbing:

" نظام إمتصاص الطاقة "



بعد   قبل الإنضغاط

- لتخفيف حمل الصدمة الواقع على الكمرة

يتم إستخدام نظام " الزنبرك " (سستم القلم)

Look

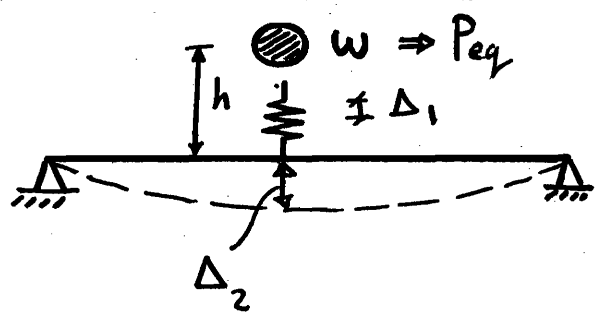
- Stiffness of spring "K" $= \dfrac{P}{\Delta}$ $\Delta = \dfrac{P}{K}$

$\therefore$ P : الحمل المؤثر على الزنبرك

Δ : الإنضغاط فى الزنبرك

- يوجد أكثر من نظام لوضع الزنبرك على حسب قوة الصدمة:

Case "1"



- الزنبرك يتحمل الصدمة " مباشرةً "

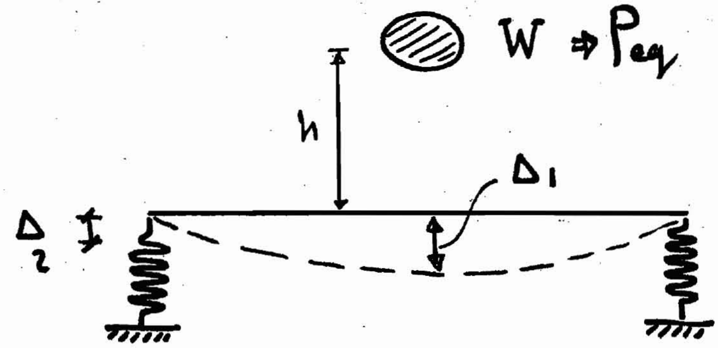
$$\therefore \Delta_1 = P/K \rightarrow (1)$$

$$\therefore \Delta_2 = \frac{PL^3}{48\,EI} \rightarrow (2)$$

- المعادلة العامة:

$$w(h+\Delta_1+\Delta_2) = \frac{1}{2}P(\Delta_1+\Delta_2)$$

Case "2"



- الزنبركين عبارة عن ركائز

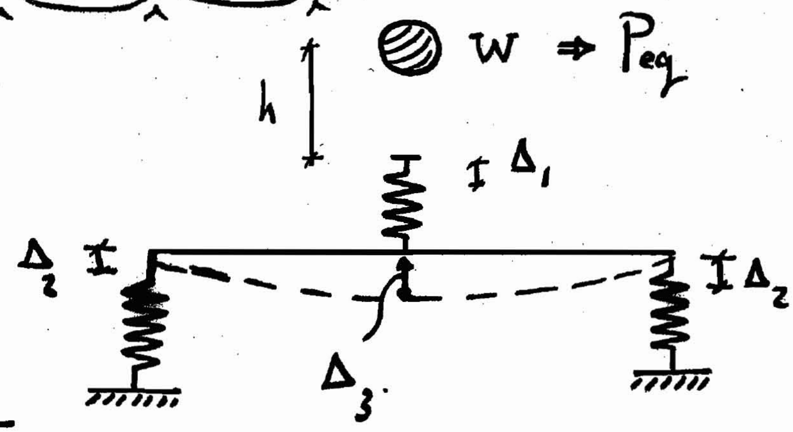
$$\Delta_1 = \frac{PL^3}{48\,EI} \quad , \quad \Delta_2 = \frac{P/2}{K}$$

- نصف الحمل بيروح للركيزه " رد الفعل ".

المعادلة العامة

$$W\,(h + \Delta_1 + \Delta_2) = \frac{1}{2}\cdot P \cdot (\Delta_1 + \Delta_2)$$

Case "3"



Case (1) + Case (2)

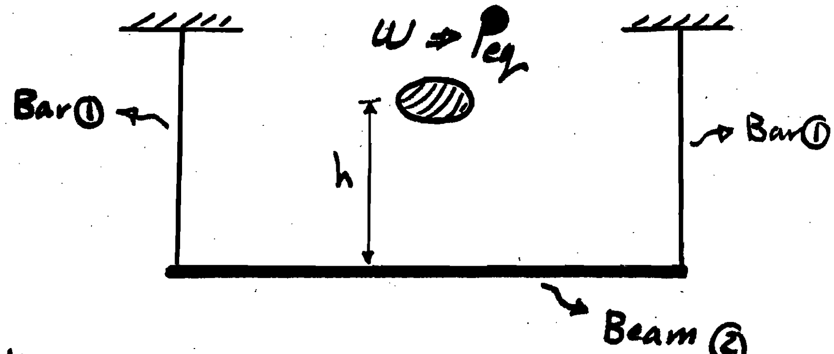
$$\Delta_1 = P/K \quad , \quad \Delta_2 = \frac{P/2}{K}$$

$$\Delta_3 = \frac{PL^3}{48\,EI}$$

- المعادلة العامة :

$$W\,(h + \Delta_1 + \Delta_2 + \Delta_3) = \frac{1}{2}\cdot P \cdot (\Delta_1 + \Delta_2 + \Delta_3)$$

Case "4"

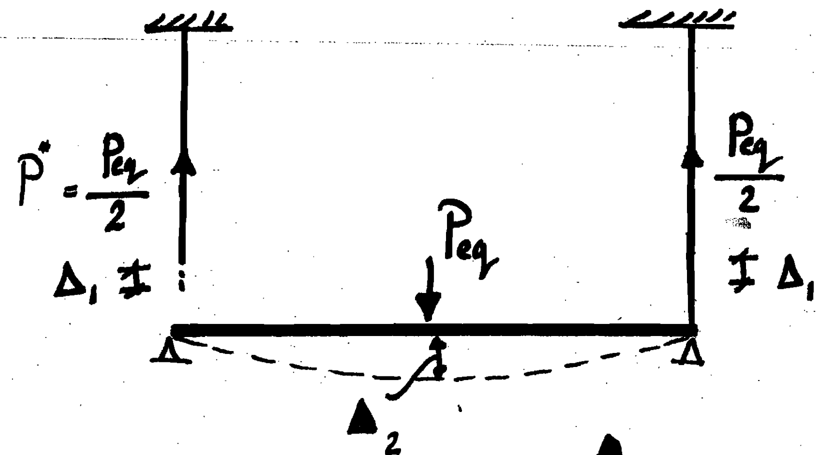


* Bar ①

معرض لقوة شد

" Axial load "

$\therefore\ f = \dfrac{P^*}{A}$ — P^* → الحمل الذي يتحمله ; A → مساحة مقطع ال ① ; f → ((Stress))



$\therefore\ P^* = f \cdot A =$

$\boxed{P_{eq} = 2P^*} \rightarrow ①$

+ Beam ②

- معرض لقوة إنثناء

$\therefore\ f = \dfrac{M}{I} \cdot y \Rightarrow M = \dfrac{PL}{4}$

$\boxed{\therefore\ P_{eq} =} \rightarrow ②$

Look

$\Delta_1 = ?\ \&\ \Delta_2 = ?$

from ① & ②

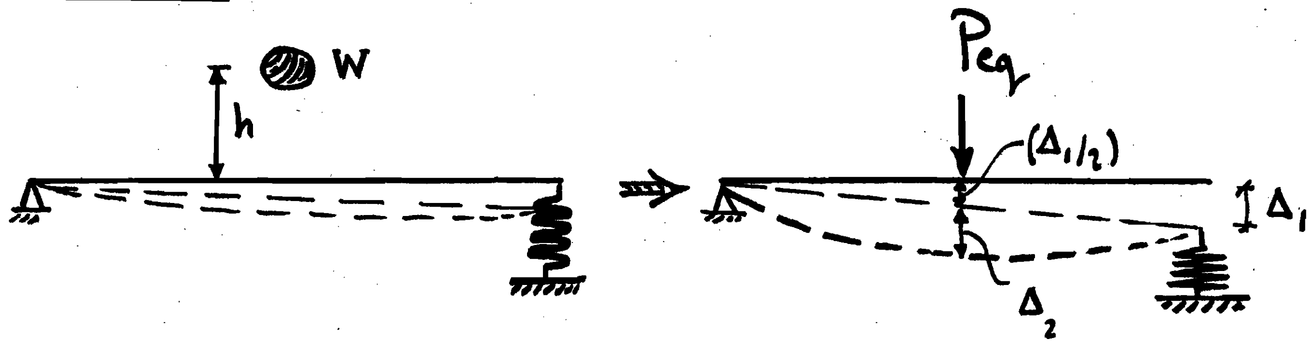
Use " P_{eq} " small الأصغر

- المعادلة العامة :

$$\boxed{W\,(h + \Delta_1 + \Delta_2) = \frac{1}{2}\cdot(P_1)\cdot(\Delta_1 + \Delta_2)}$$

$\Delta_1 = \dfrac{P \cdot L}{E\,A}$ & $\Delta_2 = \dfrac{PL^3}{48\,E\,I}$

Case "5"



حيث $\Delta_1 = \dfrac{P_{eq}/2}{K}$ ، $\Delta_2 = \dfrac{P_{eq}\, L^3}{48\, E I}$

- المعادلة العامة :

$$W\left(h + \frac{\Delta_1}{2} + \Delta_2\right) = \frac{1}{2} \cdot P_{eq} \cdot \left(\Delta_{1/2} + \Delta_2\right)$$

Look

- كل الحالات السابقة تعتبر تطبيق من المعادلة العامة

وخطوات الحل كالآتي :

① نوجد Δ بدلالة P .   ① Δ = —

② نعوض في المعادلة العامة ⇐ P = — نحصل على "P" .

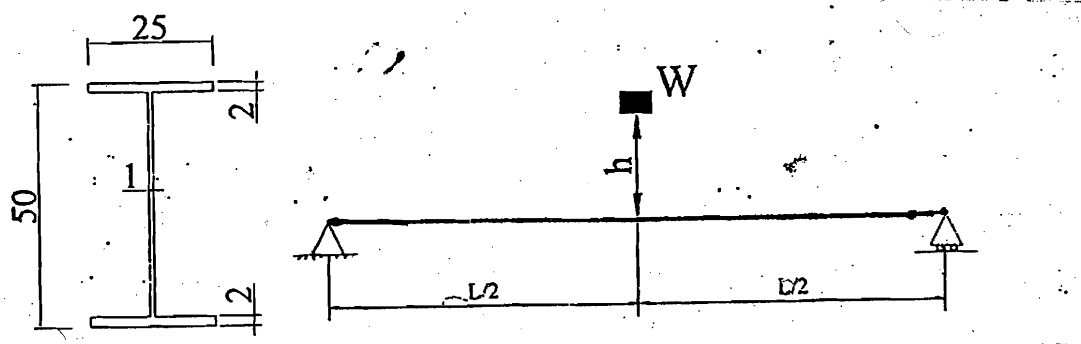
③ نحصل على Δ = — .

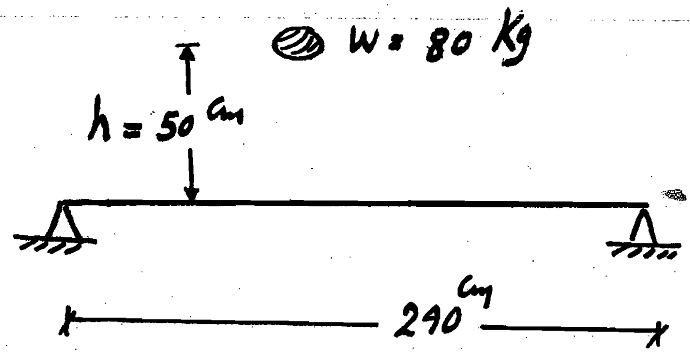
إزاي !!

Look

لو حد ممكن يجيب أي شكل تاني !؟

C. The following beam is made of steel and has an I-section as shown in the figure. The beam span is 240 cm and its elastic modulus is 1800 t/cm2. The beam is subject to a falling weight of 80 kg from a height of 50 cm. It is required to calculate the stress and deformation of the beam due to this impact loading. Also, calculate the dynamic factor k_d in this case.





* Given :

$E = 1800 \ t/cm^2$

Sol

$$\because \quad \Delta = \frac{PL^3}{48\,EI}$$

$$\because \quad I = \frac{25 \cdot (50)^3}{12} - 2 \cdot \left[\frac{12 \cdot (46)^3}{12} \right]$$

$$= 65744.67 \ cm^4$$

$$\therefore \quad \Delta = \frac{P \cdot (240)^3}{48 \cdot 1800 \cdot 1000 \cdot 65744.67} = \frac{6\,P}{2465425} \rightarrow (1)$$

التحويل لـ "Kg".

(7)

- المعادلة العامة :

$$\therefore \quad W(h+\Delta) = \frac{1}{2} \cdot P \cdot \Delta$$

Look

$$\therefore \quad 80\left(50 + \frac{6P}{2465425}\right) = \frac{1}{2} \cdot P \cdot \frac{6P}{246525}$$

معادلة من الدرجة الثانية

$$\therefore \quad 1.217 \cdot 10^{-6} P^2 - 1.947 \times 10^{-4} P - 4000 = 0.0$$

$$\therefore \quad P = 57414.5 \text{ Kg}$$

from ① $\quad \Delta = \frac{6}{2465425} \cdot 57414.5 = 0.14 \text{ cm}$

$$\therefore \quad \text{Stress } (f) = \frac{M}{I} \cdot y$$

$$\Rightarrow M = \frac{PL}{4} = \frac{57414.5 \times 240}{4} = 3444870 \text{ Kg.cm}$$

$$\therefore \quad f = \frac{3444870}{65744.67} \cdot (25)$$

$$\therefore \quad f = 1304 \text{ Kg/cm}^2$$

∴ Deformation "Δ" ⇒ from ①

$$\therefore \Delta = \frac{6P}{2465425} = \frac{2 * 57414.5}{2465425}$$

$$\therefore \underline{\underline{\Delta = 0.05 \ Cm}}$$

∴ Dynamic factor = $K_d = \frac{f_d}{f_s} =$

$$\therefore K_d = \frac{P}{\omega} = \frac{57414}{80} = 717$$

$$\therefore \underline{K_d = 717}$$

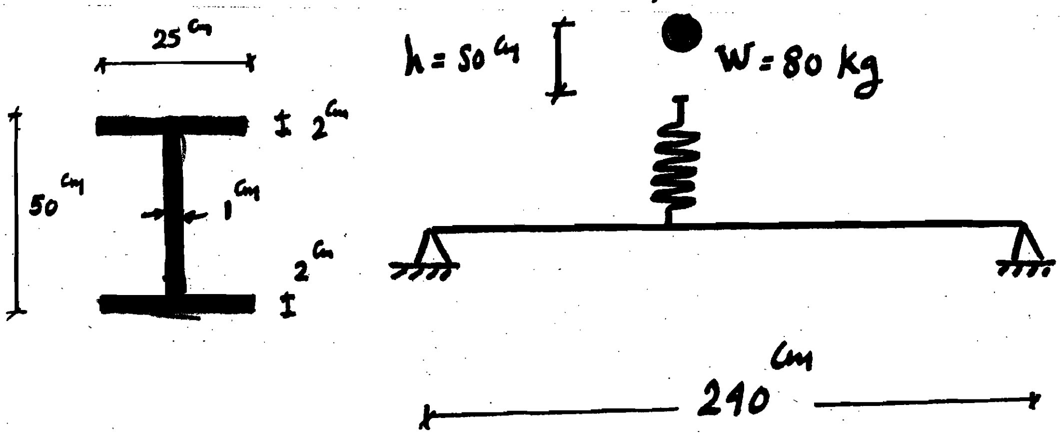
For the same problem, if the allowable stress of the beam material is 900 kg/cm2 and only this beam is available to resist the impact, the following suggestions are proposed:

i. To use a spring at the top of the beam at the location of the impact to receive the weight first, calculate the required stiffness of this spring.

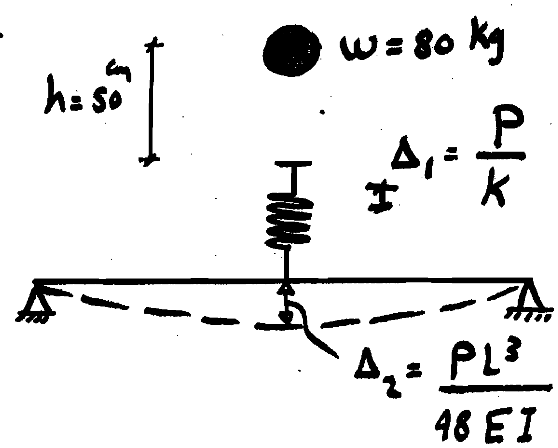
ii. To use two identical springs at the supports, calculate the required stiffness of each spring.

"H.W" iii. To use both systems together (i.e. i and ii), calculate the required stiffness of each spring.

Case "i" Use a spring at the top of the beam at the location of the impact to receive the weight.



- Find : Stiffness (K)



Sol

- الترخيم من الزنبرك :

$$\Delta_1 = P/K \rightarrow ①$$

- الترخيم من الكمرة :

$$\Delta_2 = \frac{PL^3}{48EI} = \frac{6}{2465425} P \rightarrow ②$$

- المعادلة العامة :

$$\therefore \quad W(h + \Delta_1 + \Delta_2) = \frac{1}{2} P (\Delta_1 + \Delta_2)$$

$$\therefore \quad 80 \left(50 + \frac{P}{K} + \frac{6P}{2465425}\right) = \frac{1}{2} P \left(\frac{P}{K} + \frac{6P}{2465425}\right)$$

Look

معادلة بها مجهولين

- لازم نحصل على واحد منهم ؟!

$\Leftarrow P = ??$

- بمعلومية الإجهاد المسموح به " f_{all} " :

$$\therefore \quad f_{all} = \frac{M}{I} \cdot y$$

لاحظ : $M = \frac{PL}{4}$

$$\therefore \quad 900 = \frac{P \cdot (240)}{4 \cdot 65749.67} \cdot (25)$$

$$\therefore \quad P = 39446.8 \text{ kg}$$

- بالتعويض في المعادلة العامة :

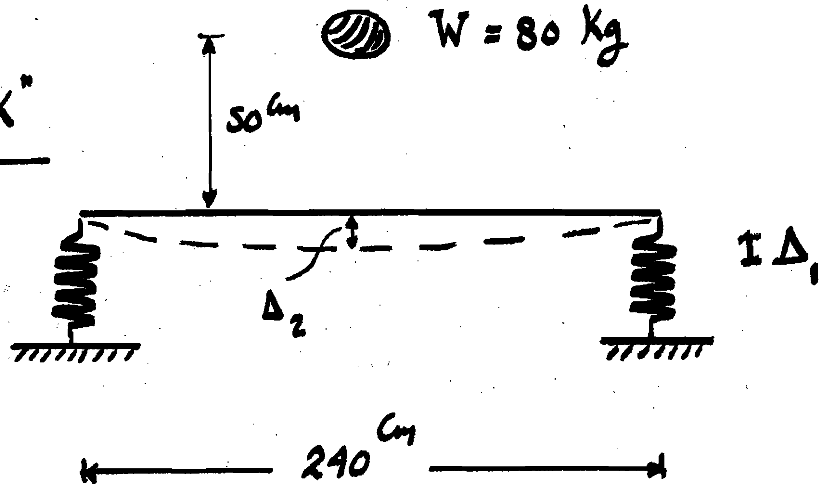
$$\therefore \quad K = 366501 \ \text{kg/cm}$$

Look

لازم يضع على الكمرة زنبرك جساءه (366501) يشيل الصدمة حتى لا تنكسر الكمرة

Case "ii" Use two spring at the supports:

- Find : Stiffness "K"



Sol

- الترخيم في الزنبرك :

$$\Delta_1 = \frac{P/2}{k}$$

لاحظ : نصف "P" = $\frac{P}{2}$ لأن الحمل يروح يمين وشمال

$$\Delta_2 = \frac{P L^3}{48 EI} = \frac{6}{2465425} P$$

- المعادلة العامة :

$$W (h + \Delta_1 + \Delta_2) = \frac{1}{2} P (\Delta_1 + \Delta_2)$$

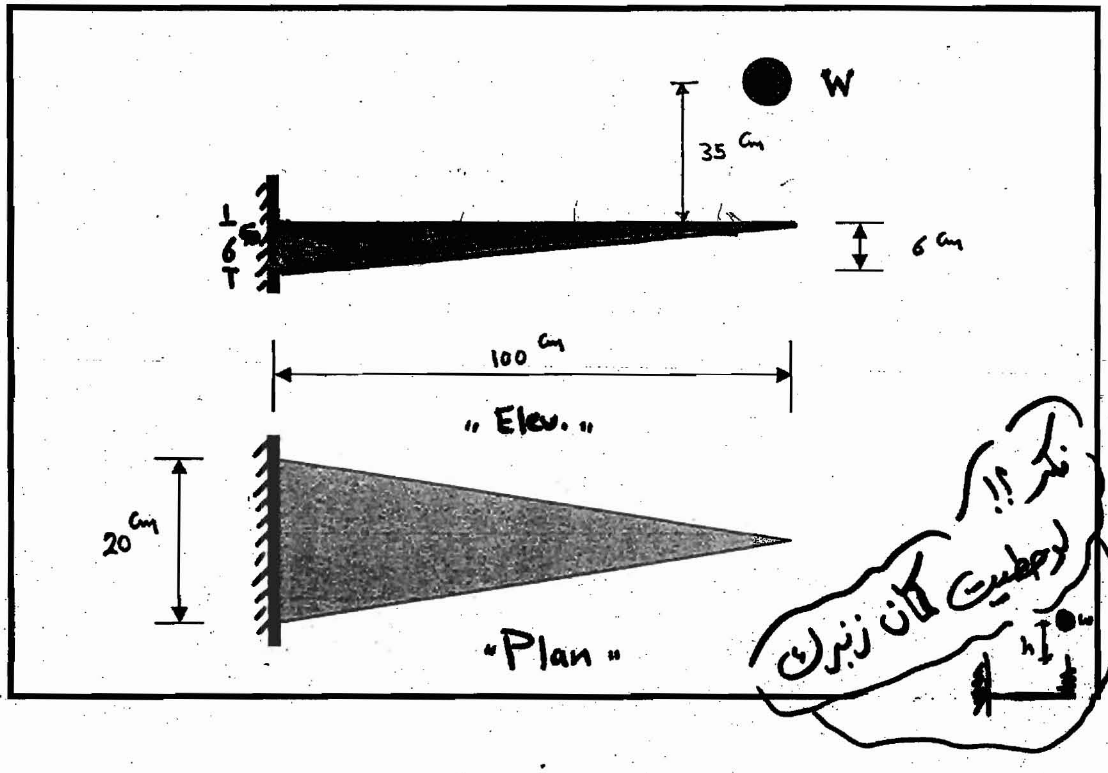
$$\therefore \quad 80 \left(50 + \frac{P/2}{k} + \frac{6P}{2465425}\right) = \frac{1}{2} P \left(\frac{P/2}{k} + \frac{6P}{2465425}\right)$$

$\therefore P = 39446.8$ Kg ⇐ الحمل : من الجزء السابق -

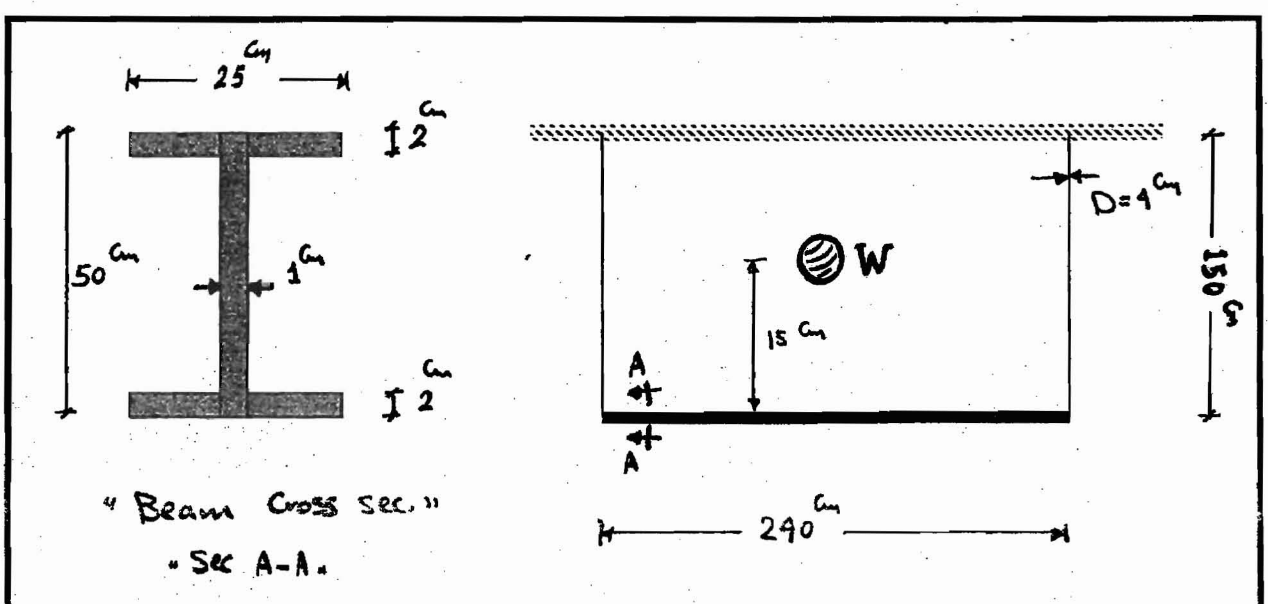
$\therefore k = 183250$ Kg/cm ـ بالتعويض في المعادلة العامة :

" H. W. "

a. Calculate the maximum weight W that can be dropped from a height of 35 cm on a cantilever beam in the configuration shown next to cause a allowable stress 1200 kg/cm² knowing that the modulus of elasticity for the material is 2000 t/cm² and a cross section of beam is available.

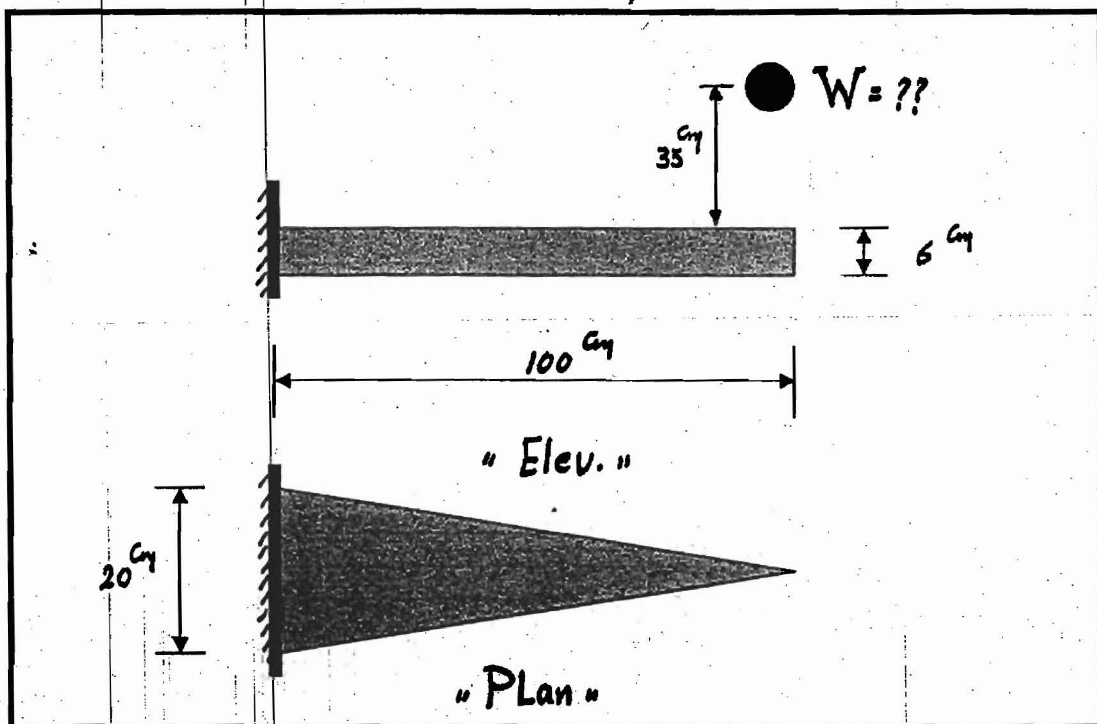


b. Calculate the maximum weight W that can be dropped from a height of 15 cm on a beam in the configuration shown next to cause a allowable stress 1200 kg/cm² knowing that the modulus of elasticity for the material is 2000 t/cm² and it is hanged at both ends with two inclined wires of 4 cm diameter as shown and the allowable stress in wire 2000 kg/cm².



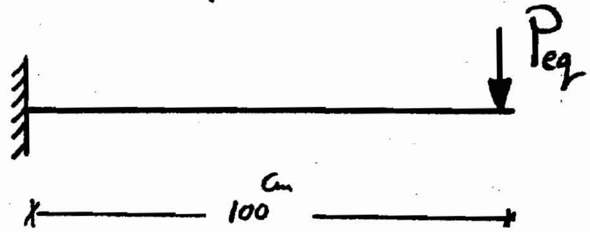
"H.W." مذكرة ؟

Calculate the maximum weight W that can be dropped from a height of 35 cm on a cantilever beam in the configuration shown next to cause a allowable stress 1200 kg/cm² knowing that the modulus of elasticity for the material is 2000 t/cm² and a cross section of beam is available.



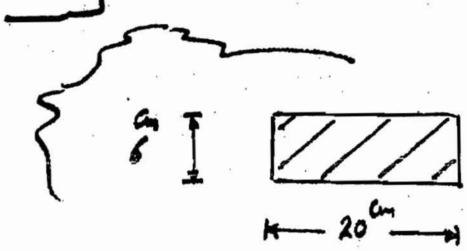
حل

- يوجد تغير في قطاع الكمرة ← القانون العام



$\because \; f_{all} = 1200 \; Kg/cm^2$

$\therefore \; f = \frac{M}{I} \cdot y$ $\quad$ $M = P.L$ لاحظ



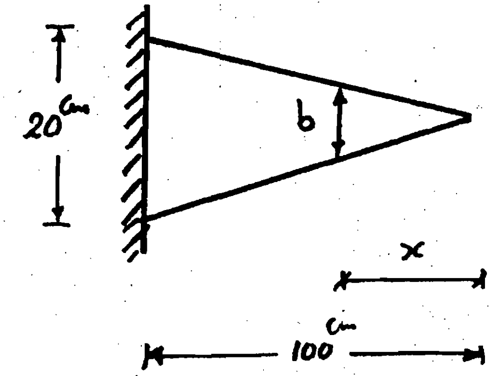
$\therefore \; 1200 = \frac{P * 100}{360} * \left(\frac{6}{2}\right)$

$\therefore \; P = 1440 \; kg$ $\qquad$ $I = \frac{20\,(6)^2}{12} = 360 \; cm^4$

Look

ـ للحصول على $\Delta = ??$ "متغير القطاع ← القانون العام"

$$\therefore \quad U = \int_0^L \frac{(M_x)^2}{2EI} \cdot dx$$



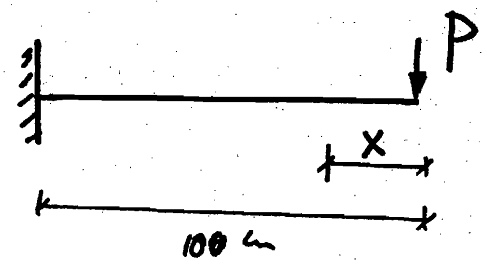
* from shape : $\frac{b}{20} = \frac{x}{100}$

$$\therefore \boxed{b = \frac{20}{100} x = \frac{x}{5}} \rightarrow ①$$

from ①

$$\therefore \quad I = \frac{b\,h^3}{12} = \frac{(x/5)\cdot(6)^3}{12} = 3.6\,x$$

$$\& \quad M_x = P \cdot x$$



$$\therefore M_x = 1440\,x \qquad (0 \rightarrow 100^{cm})$$

$\therefore$ Use General equ. :

$$U = \int_0^{100} \frac{(1440\,x)^2}{2\,E\,I} = \int_0^{100} \frac{(1440)^2 \cdot x^{\cancel{2}}}{2 \cdot 2000 \cdot 1000 \cdot 3.6\,\cancel{x}} \cdot dx$$

"Kg" لل

$$= \frac{(1440)^2}{2 \cdot 2000 \cdot 1000 \cdot 3.6} \left[\frac{x^2}{2}\right]_0^{100}$$

Look

$$\therefore \quad U = 720 \quad Kg.cm$$

فاكر "$U = \frac{1}{2} P.\Delta$"

$$\therefore \quad U = \frac{1}{2} \cdot P \cdot \Delta$$

$$\therefore \quad 720 = \frac{1}{2} \cdot 1440 \cdot \Delta$$

$$\therefore \quad \Delta = 1.0 \ cm$$

- معادلة الصدم العامة :

$$\therefore \quad W\,(h + \Delta) = \frac{1}{2} \cdot P \cdot \Delta$$

$$\therefore \quad W\,(35 + 1) = \frac{1}{2} \cdot 1440 \cdot 1$$

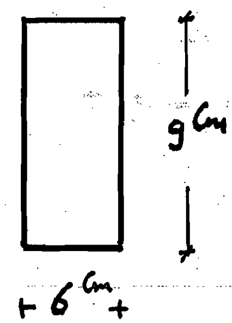
$$\therefore \quad W = 20 \ kg$$

Final 2007

d) A three- point bending test is performed on a metallic beam that is made of steel and has a span of 150 cm and a rectangular cross section of width of 6.0 cm and depth of 9.0 cm. The load is applied at mid span of the beam. The mid span deflection is 0.20 cm of 2.0 ton concentrated load. This beam is subjected to impact bending due to dropped weight (w) of 10.0 kg from a height of 80.0 cm in the middle of span. Determine the maximum stress due to the impact load and also the absorbed energy of beam providing that the stress due to the two cases is less than the proportional limit stress of material beam.

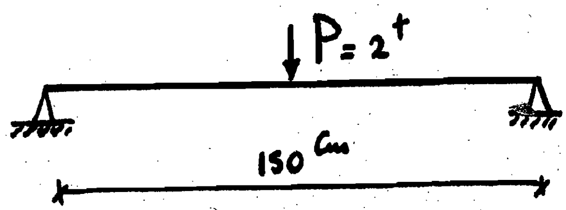
* Given: - $L = 150^{cm}$, $b = 6^{cm}$

$h = 9^{cm}$



$\Delta = 0.2^{cm} \rightarrow P = 2^{ton}$

$w = 10^{kg}$, $h = 80^{cm}$



Sol ∴ $\Delta = \dfrac{PL^3}{48EI}$

∴ $0.2 = \dfrac{2 * (150)^3}{48 * E * \frac{(6)(9)^3}{12}}$

∴ $\boxed{E = 1929 \ t/cm^2}$

∴ $\dfrac{1}{2} P_{eq} \Delta = w(h + \Delta) \rightarrow ①$

$$\therefore \quad \Delta = \frac{P_{eq} * L^3}{48 EI}$$

$$= \frac{P_{eq} * (150)^3 * 12}{48 * 1929 * (6)(9)^3}$$

$$\therefore \quad \Delta = 0.1 P_{eq}$$

<u>from</u> ①

$$\therefore \quad \frac{1}{2} * P_{eq} * 0.1 P_{eq} = \frac{10}{1000} * (80 + 0.1 P_{eq})$$

$$\therefore \quad 0.05 P_{eq}^2 - 0.001 P_{eq} - 0.8 = 0.0$$

$$\therefore \quad P_{eq} = 4.00 \text{ ton}$$

$$= \underline{4000 \text{ Kg}}$$

$$\therefore \quad f_{max} = \frac{M}{I} * y = \frac{P_{eq} \cdot L}{4 * I} * y$$

$$= \frac{4000 * 150 * 12}{4 * 6 * (9)^3} * \left(\frac{9}{2}\right)$$

$$\therefore \quad f_{max} = 1852 \quad \text{Kg/cm}^2$$

- Absorbed Energy $= \frac{1}{2} \cdot P_{eq} \cdot \Delta$

$$= \frac{1}{2} * 4000 * 0.1\,(4000)$$

$$= 800000 \ \text{Kg.Cm}$$

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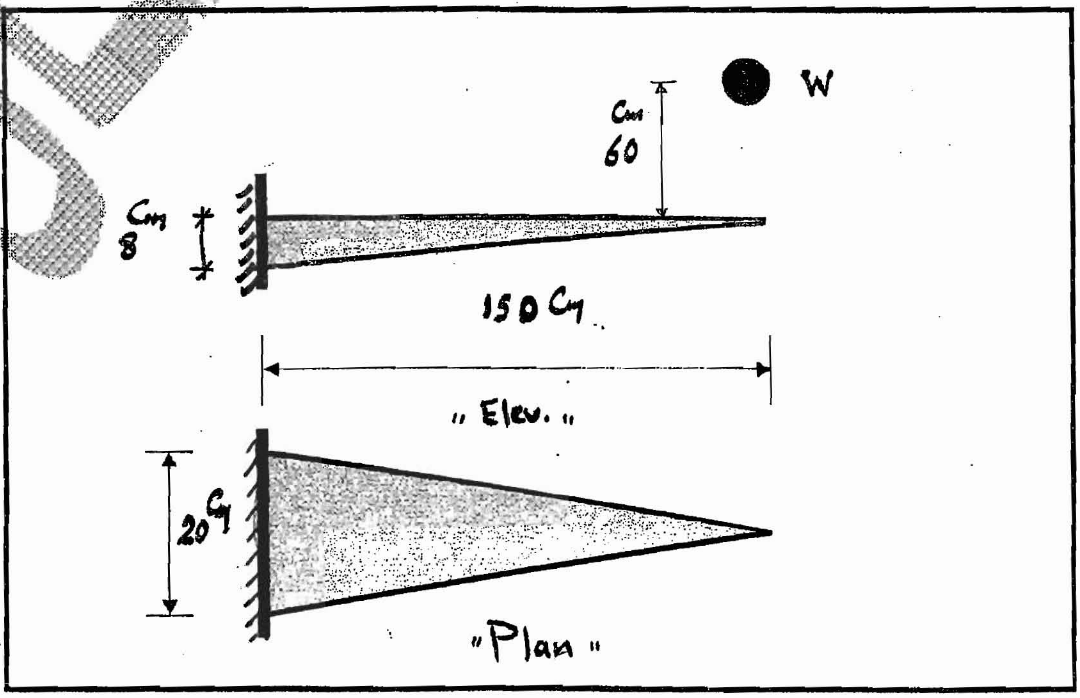
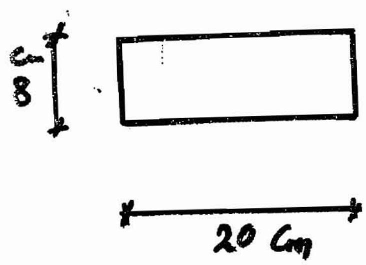
④ تمرين «س: ٤»

a. Calculate the maximum weight W that can be dropped from a height of 60 cm on a cantilever beam in the configuration shown next to cause a allowable stress 1200 kg/cm² knowing that the modulus of elasticity for the material is 2000 t/cm² and a cross section of beam is available.



$\because f_{all} = 1200 \ kg/Cm^2 \quad , \quad E = 2000 \ t/Cm^2$

$\because f_{all} = 1200 = \dfrac{M}{I} \cdot y$



$$1200 = \frac{P * 150}{\frac{(20)(8)^3}{12}} * \left(\frac{8}{2}\right)$$

$$\therefore P = 1707 \ kg$$

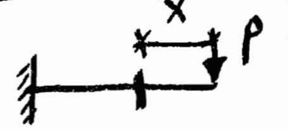
$$\therefore \; W(h+\Delta) = \frac{1}{2} P \Delta$$

$$\therefore \; W(60+\Delta) = \frac{1}{2}(1707) * \Delta \quad \rightarrow ①$$

$$\therefore \; \Delta = ?? \quad \boxed{\frac{PL^3}{3EI}}$$

ده غلط ?? لازم يكون I ثابت

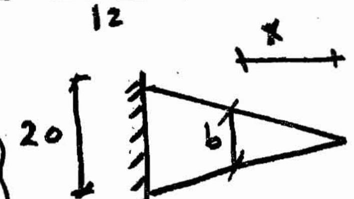
*** From Energy :-**



$$M_x = P.x$$

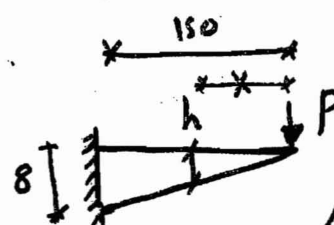
$$(0 \longrightarrow L)$$

$$I = \frac{b.h^3}{12}$$



$$\therefore \frac{b}{20} = \frac{X}{150}$$

$$\left(b = \frac{X}{7.5}\right)$$



$$\frac{h}{8} = \frac{X}{150}$$

$$h = \frac{X}{18.75}$$

$$U = \int_0^L \frac{(M_x)^2}{2EI} . dx$$

$$= \int_0^{150} \frac{P^2 X^2}{2E * \frac{bh^3}{12}} . dx$$

$$= \int_0^{150} \frac{(12) P^2 X^{\cancel{2}}}{2E * \frac{X}{7.5} * \left(\frac{X}{18.75}\right)^{\cancel{3}}} dx$$

$$= \int_0^{150} \frac{12 \; P^2 . \; (7.5)(18.75)^3}{2 \; E \; X^2} . dx$$

$$= \int_0^{150} \frac{12 * 7.5 * 18.75^3 * P^2}{2E * X^2} . dX$$

$$= \frac{12 * 7.5 * 18.75^3 * P^2}{2E} \cdot \int_0^{150} \frac{dx}{x^2}$$

$$= \frac{12 * 7.5 * 18.75^3 * P^2}{2E} * \left[\frac{-1}{x}\right]_0^{150}$$

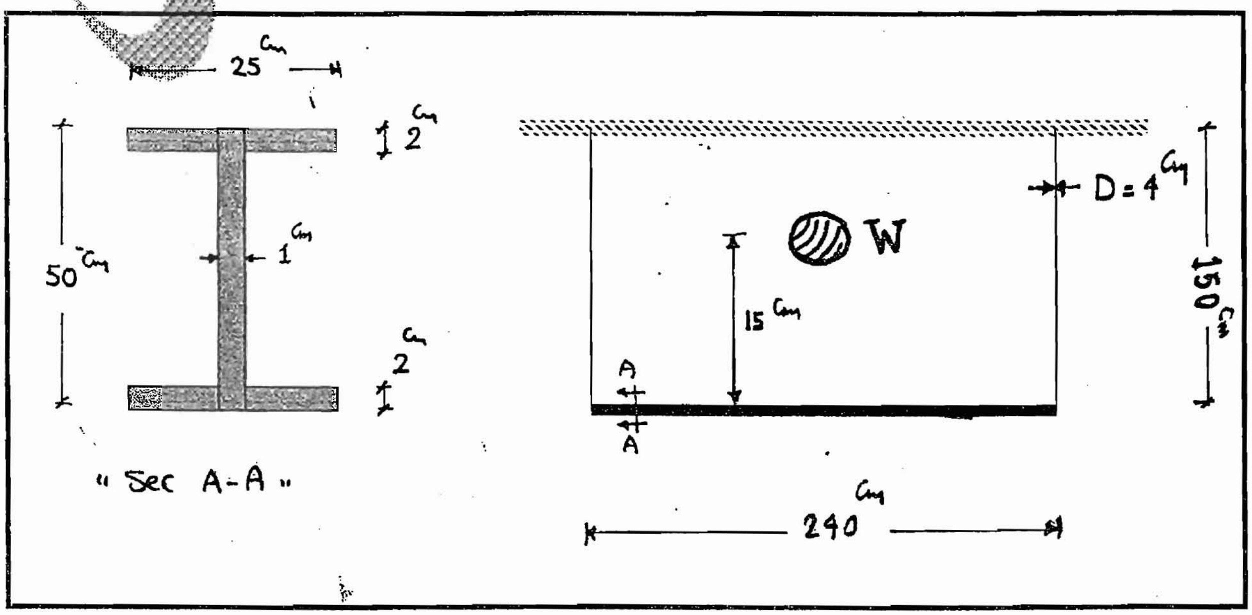
$$U = 2881 \text{ kg.cm} = \frac{1}{2} P \Delta$$

$$\therefore \Delta = 3.4 \text{ cm}$$

$$\therefore W(60 + 3.4) = \frac{1}{2}(1707) * 3.4$$

$$\therefore W = 45.44 \text{ kg}$$

Calculate the maximum weight W that can be dropped from a height of 15 cm on a beam in the configuration shown next to cause a allowable stress 1200 kg/cm² knowing that the modulus of elasticity for the material is 2000 t/cm² and it is hanged at both ends with two inclined wires of 4 cm diameter as shown and the allowable stress in wire 2000 kg/cm².



Sol

$$\therefore \; I = \frac{(50)^3 \cdot 25}{12} - 2 \cdot \frac{12 \cdot (46)^3}{12} = $$

$$= 65744.67 \text{ cm}^4$$

* For Beam : $f_{all} = 1200 \text{ Kg/cm}^2$

$$\therefore \; f_{all} = \frac{M}{I} \cdot y \Rightarrow 1200 = \frac{P \cdot 240}{4 \cdot 65744.67} \cdot (25)$$

$$\therefore \; P = 52596 \text{ Kg} \rightarrow ①$$

* for wire : $f_{all} = 2000\ Kg/cm^2$

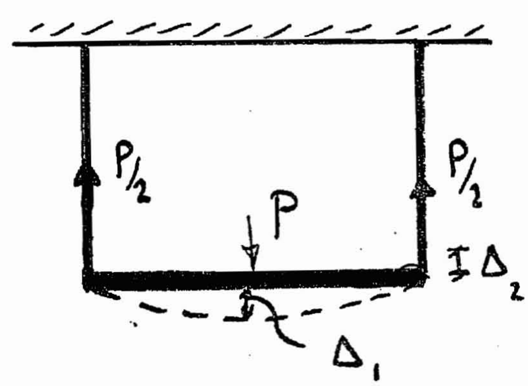
$\therefore f_{all} = \dfrac{P/2}{A} \Rightarrow 2000 = \dfrac{P/2}{\frac{\pi}{4}(4)^2}$

$\therefore P = 50265.5\ kg \rightarrow ②$

take the smallest : ناخذ الأصغر

$$P = 50265.5\ Kg$$

for Beam : $\Delta_1 = \dfrac{PL^3}{48\,EI}$



$\therefore \Delta_1 = \dfrac{50265.5 \times (240)^3}{48 \times 2000 \times 1000 \times 65744.67}$

$\therefore \Delta_1 = 0.11\ cm$

for wire : $\Delta_2 = \dfrac{(P/2) \times L}{E \cdot A}$

$\therefore \Delta_2 = \dfrac{(50265.5/2) \times 150}{2000 \times 1000 \times \frac{\pi}{4}(4)^2} = 0.15\ cm$

خد بالك !!

$\therefore \Delta_2 = 0.15\ cm$

مش موضوع " $\frac{P}{2}$ " خالص !!!!!!!

- المعادلة العامة :

$$W(h+\Delta_1+\Delta_2) = \frac{1}{2}\cdot P\cdot(\Delta_1+\Delta_2)$$

$$\therefore\ W(15+0.11+0.15) = \frac{1}{2}\times 50265.5\times(0.11+0.15)$$

$$\therefore\ W = 428\ ^{kg}$$

لاحظ :

١- عند المقارنه بين حملين P_1 , P_2

نأخذ الحمل الأصغر للأمان .

٢- عند المقارنه بين مساحتين A_1 , A_2 ←

نأخذ المساحة الأكبر للأمان .

- الوزن W أصغر جداً من الحمل المكافئ "P" !

Look

- كلام أوله مهم ←
← مسألة مهمة فكرتها جداً!!