

Story by

다이빙대의 최적화

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기계공학부 김명준
양종문

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Project Statement





Project Statement

최적설계



**설계 조건에 맞는 다이빙대를 최소
비용으로 제작하기 위한 최적설계**



2. Data and Information

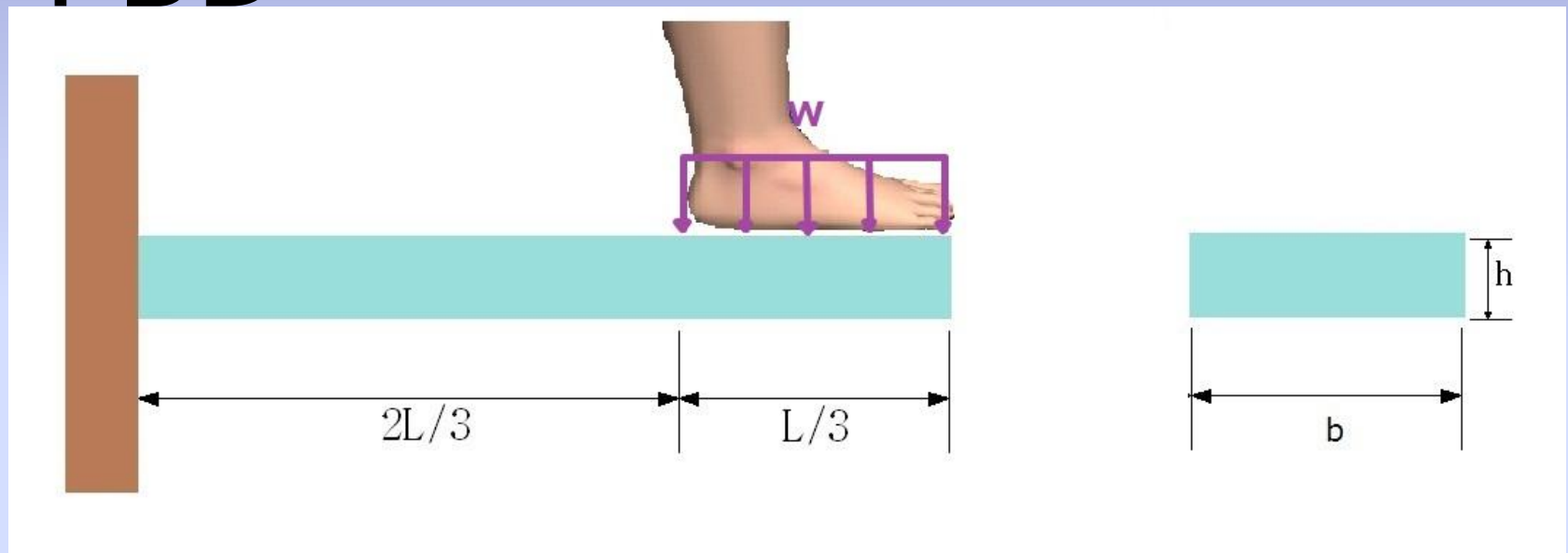
2

Data and information

최적설계



FBD



$$L = 0.9m \quad w = 700N/m \quad E = 65 \times 10^6 N/m^2 \quad \text{cost} = 2000\$/m^3$$

$$\sigma_a = 23 \times 10^4 N/m^2$$

$$\theta_a = 1^\circ = 0.01745 \text{ rad}$$

2

Data and information

$$\sum M_A = M_A - W \left(\frac{L}{3} \right) \left(\frac{5L}{6} \right)$$

$$M_A = \frac{5WL^2}{18}$$

$$Z = \frac{I}{C} = \frac{\frac{bh^3}{12}}{\frac{h}{2}} = \frac{bh^2}{6}$$

$$\sigma = \frac{M}{Z} = \frac{\frac{5WL^2}{18}}{\frac{bh^2}{6}} = \frac{5WL^2}{3bh^2}$$

2

Data and information

<Boundary Condition>

$$x = 0 \quad \frac{dy}{dx} = 0$$

$$x = 0 \quad y = 0$$

<Differential equations for the deflection of beam>

$$EI \frac{d^2 y}{dx^2} = M(x) = M_1(x) = \frac{wL}{3}x - \frac{5wL^2}{18} \quad (0 \leq x \leq \frac{2}{3}L)$$

$$EI \frac{d^2 y}{dx^2} = M(x) = \frac{wL}{3}x - \frac{5wL^2}{18} - w(x - \frac{2L}{3})(\frac{x - 2L/3}{2}) \quad (\frac{2}{3}L \leq x \leq L)$$

$$EI \frac{d^2 y}{dx^2} = \frac{wL}{6}x^2 - \frac{5wL^2}{18}x + C_1 \quad (0 \leq x \leq \frac{2}{3}L)$$

$$EI \frac{dy}{dx} = \frac{wL}{6}x^2 - \frac{5wL^2}{18}x - \frac{w}{6}(x^3 - 2Lx^2 + \frac{4L^2}{3}x) + C_2 \quad (\frac{2}{3}L \leq x \leq L)$$

2

Data and information

$$x = \frac{2L}{3} \quad \text{에서 연속조건에 의하여} \quad C_2 = \frac{4wL^3}{81} \quad \text{이므로}$$

$$\frac{dy}{dx} = \frac{1}{EI} \left[\frac{wL}{6} x^2 - \frac{5wL^2}{18} x - \frac{w}{6} (x^3 - 2Lx^2 + \frac{4L^2}{3} x) + \frac{4wL^3}{81} \right]$$

$$\left(\frac{2}{3} L \leq x \leq L \right)$$

이때의 처짐각은

$$\theta \approx \tan \theta = \left(\frac{dy}{dx} \right)_L = - \frac{23wL^3}{81EI} = - \frac{23wL^3}{81E \frac{bh^3}{12}} = - \frac{92wL^3}{27Eb h^3}$$

3.

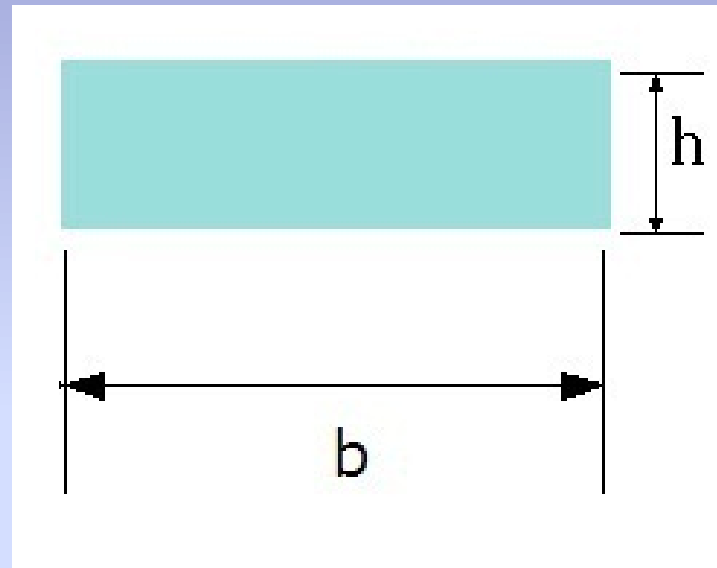
Design Variables



3

Design variables

최적설계



b: 폭

h: 두께

A photograph of two divers in mid-air, performing a synchronized dive. They are wearing red and white striped swimsuits. The background is a blurred blue, suggesting an outdoor pool setting.

4. Criterion

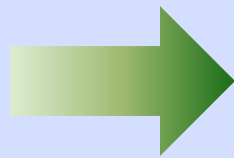
4

Criterion

최적설계



$$\text{COST} = 2000\text{BHL}$$



최소화

5.

Constraints

KARL MORITZ

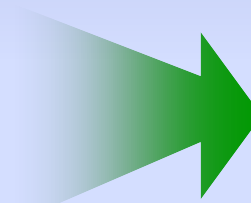
5

Constraints

$$\sigma_a \geq \sigma_{total} = \frac{5 w L^2}{3 b h^2}$$

$$\theta_a \geq |\theta| = \frac{92 w L^3}{27 E b h^3}$$

$$b \geq 3h$$



$$g_1 = \frac{5 w L^2}{3 b h^2} - \sigma_a \leq 0$$

$$g_2 = \frac{92 w L^3}{27 E b h^3} - \theta_a \leq 0$$

$$g_3 = b - 3h \geq 0$$

$$g_4 = -b \leq 0$$

$$g_5 = -h \leq 0$$

6.

Excel을 통한 분석



6

Excel

	A	B	C	D	E
1	Given data				
2	Sig_a	2E+05	Pa		
3	The_a	0.017	rad		
4	L	0.9	m		
5	w	700	N/m		
6	E	7E+07	Pa		
7					
8					
9					
10	Design Variables		Constraints		
11	b	0.3	g1	85000	
12	h	0.1	g2	0.071719231	
13			g3	0	
14			g4	-0.3	
15			g5	-0.1	
16					
17					



$$q_1 = \frac{5wL^2}{3bh^2} - \sigma_a \leq 0$$

$$q_2 = \frac{92wL^3}{27Ebh^3} - \theta_a \leq 0$$

$$q_3 = b - 3h \geq 0$$

$$q_4 = -b \leq 0$$

$$q_5 = -h \leq 0$$

6

Excel

엑셀333 - Microsoft Excel

홈 삽입 페이지 레이아웃 수식 데이터 검토 보기

외부 데이터 가져오기, 모두 새로 고침, 연결, 정렬 및 필터, 정렬, 필터, 지우기, 다시 적용, 고급, 텍스트, 중복된, 나누기, 항목 제거, 데이터 도구, 분석, 해 찾기

해 찾기

해 찾기 모델 설정

목표 셀(E): \$G\$11

해의 조건: ☐ 최대값(M) ☒ 최소값(N) ☐ 지정값(V): 0

값을 바꿀 셀(B): \$B\$11:\$B\$12

제한 조건(U):

- \$E\$11 <= 0
- \$E\$12 <= 0
- \$E\$13 >= 0
- \$E\$14 <= 0
- \$E\$15 <= 0

실행(S), 닫기, 옵션(O)..., 초기화(B), 도움말(H), 추정(G), 추가(A)..., 변경(C)..., 삭제(D)

제한 조건 추가

셀 참조 영역: \$E\$11

제한 조건: <=

확인, 취소, 추가(A)..., 도움말(H)

Given data			
Sig_a	2E+05	Pa	
The_a	0.017	rad	
L	0.9	m	
w	700	N/m	
E	7E+07	Pa	

Design Variables		Constraints		Cost
b	0.3	g1	85000	54
h	0.1	g2	0.071719	
		g3	0	
		g4	-0.3	
		g5	-0.1	

Sheet1 Sheet2 Sheet3

준비

100%

6

Excel

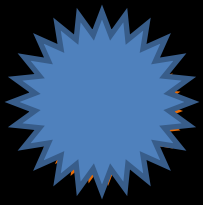
	A	B	C	D	E	F	G	H
1	Given data							
2	Sig_a	2E+05	Pa					
3	The_a	0.017	rad					
4	L	0.9	m					
5	w	700	N/m					
6	E	7E+07	Pa					
7								
8								
	Design Vriables			Constraints			Cost	
	b	0.451		g1	-137319.5		122.0698	
				g2	-3.89E-07			
	h	0.15		g3	0			
14				g4	-0.451054			
15				g5	-0.150351			
16								

7

결론

엑셀의 해찾기를 통해
 $b=0.451\text{m}$, $h=0.15\text{m}$ 의 근사적 치수로
최소비용
 $122.06985\$$ 를 얻을
수 있었다.

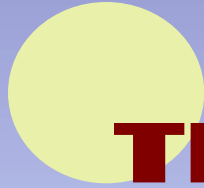




About Next Project..



선천성설계증후군 조



The End

Reference

재료역학 임장근
두산백과사전 Encyber

감사합니다.

Thank you.