Sistema de suspensão rocker-bogie

PEF-3208 - Fundamentos em Mecânica das Estruturas

27 de junho de 2020

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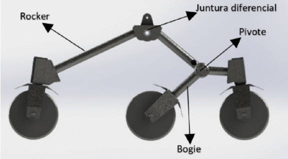
Escola Politécnica - Universidade de São Paulo

Introdução

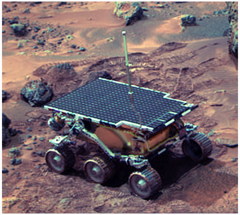
Sobre o sistema rocker-bogie

- Desenvolvido em 1988 para o uso da NASA na exploração de Marte.
- Usado para movimentar robôs de 6 rodas.

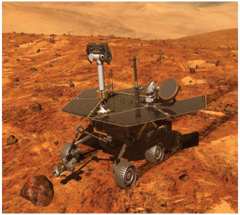


Uso do sistema de suspensão

Sojourner (1996)

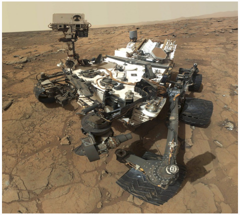


Spirit (2003)



Opportunity (2003)

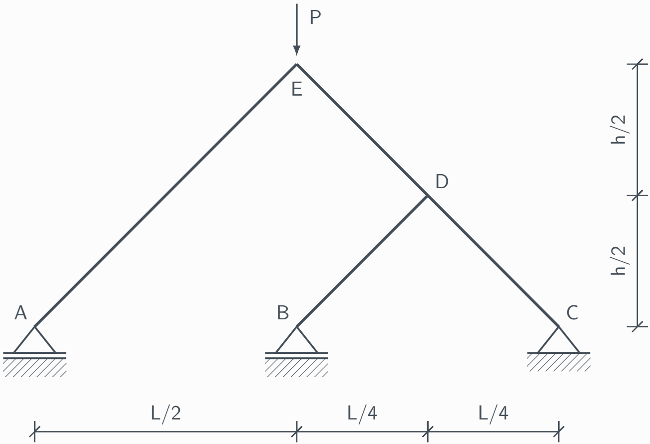
Curiosity (2011)



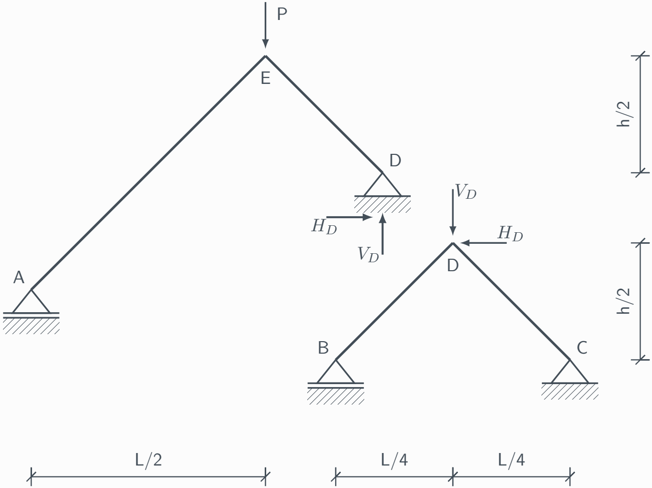
Perseverance (2020)

Análise da Estrutura

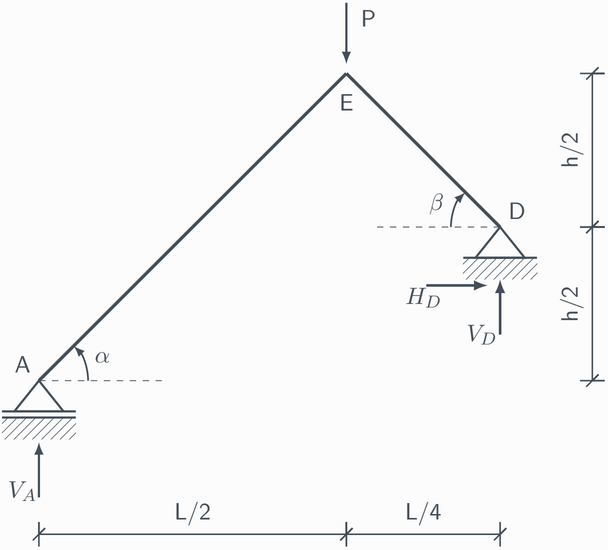
Diagrama da Estrutura



Simplificação

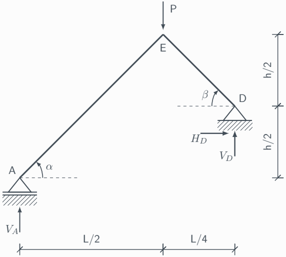


Análise da Primeira Estrutura



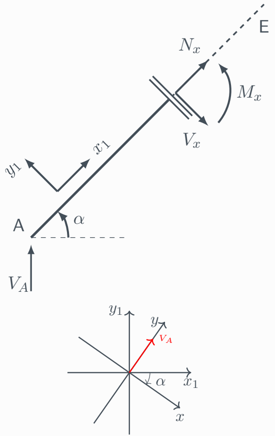
Equações de Equilíbrio

$$
\begin{cases}
\sum F_H = 0 \ \Rightarrow \ H_D = 0 \\
\sum F_V = 0 \ \Rightarrow \ V_A + V_D - P = 0 \\
\sum M_A = 0 \ \Rightarrow \ \left(\frac{L}{2} + \frac{L}{4}\right) V_D - \frac{L}{2} P - \frac{h}{2} H_D = 0 \\
\sum M_D = 0 \ \Rightarrow \ \left(\frac{L}{2} + \frac{L}{4}\right) V_A + \frac{L}{4} P = 0
\end{cases}
$$



$$\boxed{H_D = 0} \qquad \boxed{V_A = \frac{P}{3}} \qquad \boxed{V_D = \frac{2P}{3}}$$

Teorema do Corte: A-E

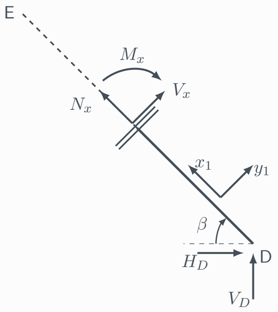


$$\begin{cases} \sum F_H = 0 \;\Rightarrow\; V_A \sin\alpha + N_x = 0 \\ \sum F_V = 0 \;\Rightarrow\; V_A \cos\alpha + V_x = 0 \\ \sum M_x = 0 \;\Rightarrow\; -V_A \cos(\alpha) x + M_x = 0 \end{cases}$$

$$\boxed{N_x = -\frac{P}{3}\sin\alpha} \qquad \boxed{V_x = \frac{P}{3}\cos\alpha}$$

$$\boxed{M_x = \frac{P}{3}\cos(\alpha)\; x}$$

Teorema do Corte: D-E

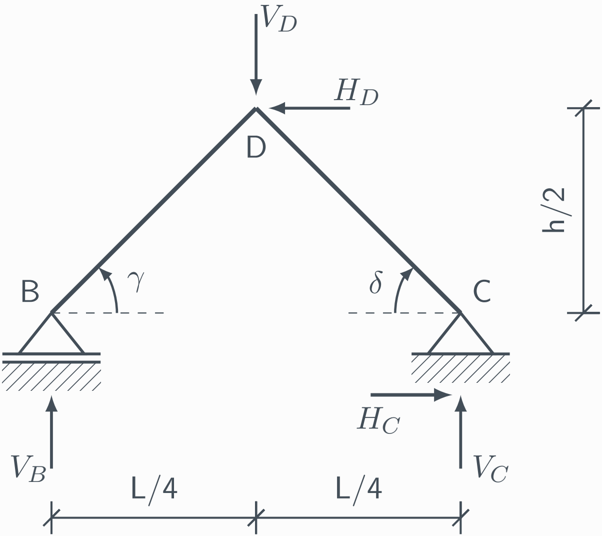


$$
\begin{cases}
\sum F_H = 0 \;\Rightarrow\; V_D \sin\beta - H_D \cos\beta + N_x = 0 \\
\sum F_V = 0 \;\Rightarrow\; V_D \cos\beta + H_D \sin\beta + V_x = 0 \\
\sum M_x = 0 \;\Rightarrow\; (V_D \cos\beta + H_D \sin\beta)x - M_x = 0
\end{cases}
$$

$$\boxed{N_x = -\frac{2P}{3}\sin\beta} \qquad \boxed{V_x = -\frac{2P}{3}\cos\beta}$$

$$\boxed{M_x = \frac{2P}{3}\cos(\beta)\; x}$$

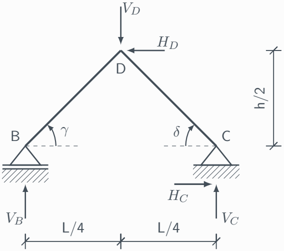
Análise da Segunda Estrutura



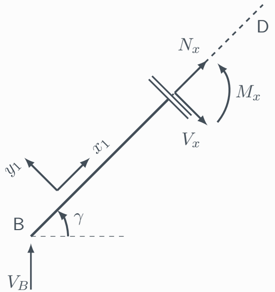
Equações de Equilíbrio

$$
\begin{cases}
\sum F_H = 0 \;\Rightarrow\; -H_D + H_C = 0 \\
\sum F_V = 0 \;\Rightarrow\; V_B + V_C - V_D = 0 \\
\sum M_B = 0 \;\Rightarrow\; \dfrac{L}{2}V_C - \dfrac{L}{4}V_D = 0 \\
\sum M_C = 0 \;\Rightarrow\; -\dfrac{L}{2}V_B + \dfrac{L}{4}V_D = 0
\end{cases}
$$

$$\boxed{H_C = 0} \qquad \boxed{V_B = \frac{P}{3}} \qquad \boxed{V_C = \frac{P}{3}}$$



Teorema do Corte: B-D

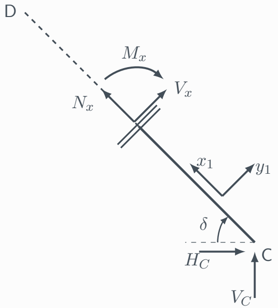


$$\begin{cases} \sum F_H = 0 \;\Rightarrow\; V_B \sin\beta + N_x \\ \sum F_V = 0 \;\Rightarrow\; V_B \cos\beta - V_x \\ \sum M_x = 0 \;\Rightarrow\; -V_B \cos(\beta) x + M_x = 0 \end{cases}$$

$$\boxed{N_x = -\frac{P}{3}\sin\beta} \qquad \boxed{V_x = \frac{P}{3}\cos\beta}$$

$$\boxed{M_x = \frac{P}{3}\cos(\beta)\; x}$$

Teorema do Corte: C-D



$$\begin{cases} \sum F_H = 0 \ \Rightarrow \ V_C \sin\gamma - H_C \cos\gamma + N_x = 0 \\ \sum F_V = 0 \ \Rightarrow \ H_C \sin\gamma + V_C \cos\gamma + V_x = 0 \\ \sum M_x = 0 \ \Rightarrow \ (H_C \sin\gamma + V_C \cos\gamma)x - M_x = 0 \end{cases}$$

$$\boxed{N_x = -\frac{P}{3}\sin\gamma} \qquad \boxed{V_x = -\frac{P}{3}\sin\gamma}$$

$$\boxed{M_x = \frac{P}{3}\cos(\gamma)\ x}$$

Diagrama da Força Normal

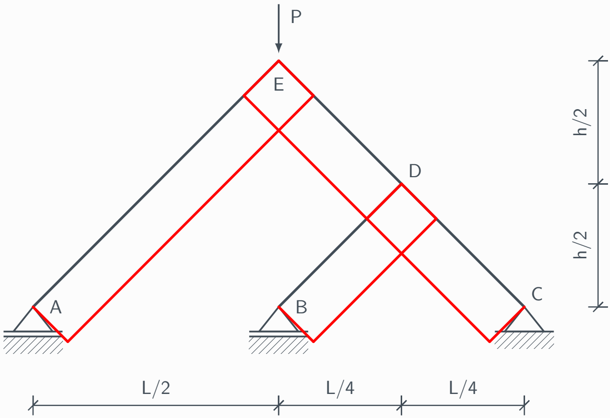


Diagrama da Força Cortante

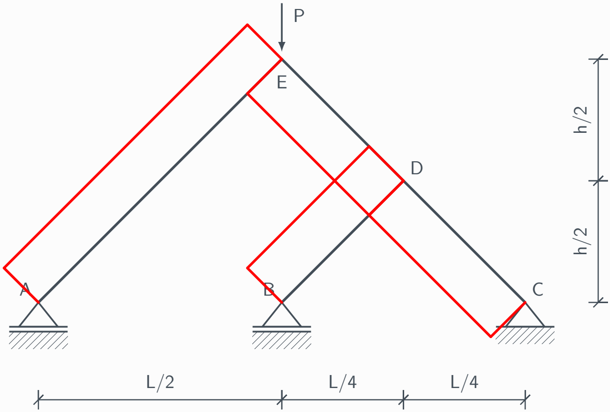
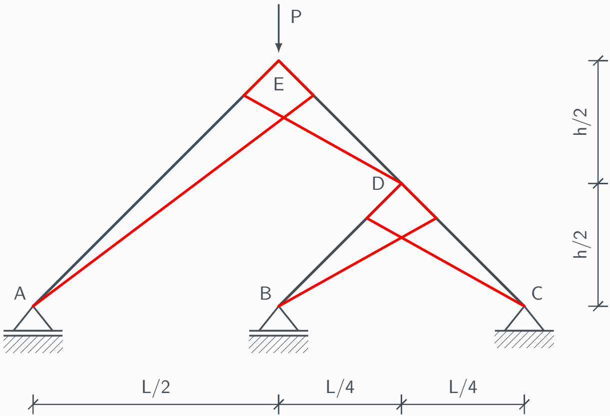


Diagrama do Momento Fletor



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