

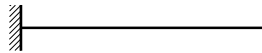
Složeniji statički određeni štapni sistemi u ravnini

K. F.

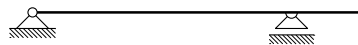
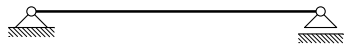
Elementarni statički određeni sistemi

jedno tijelo \mathcal{E} podloga:

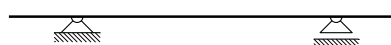
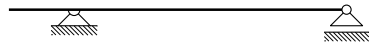
- (punostjena) konzola



- (punostjena) jednostavno oslonjena greda (s varijacijama)

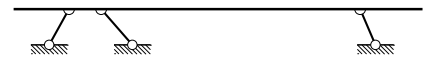


greda s prepustom

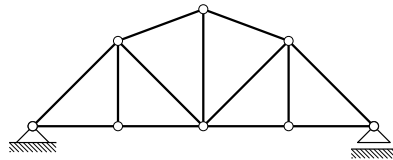


greda s prepustima

- (punostjena) greda spojena s pomoću tri zglobna štapa

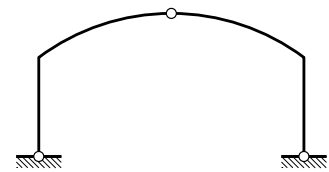
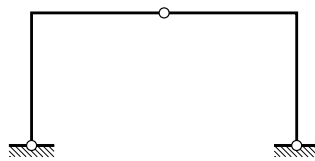
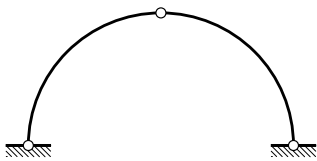


- rešetkasta jednostavno oslonjena greda

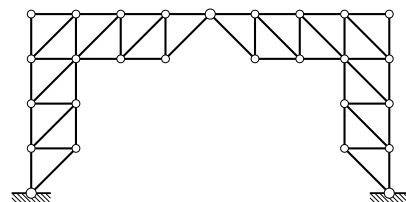
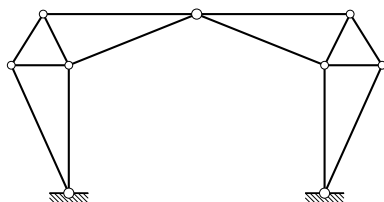


dva tijela \mathcal{E} podloga:

- (punostjeni) trozglobni lukovi \mathcal{E} okviru:



- rešetkasti trozglobni okviru:



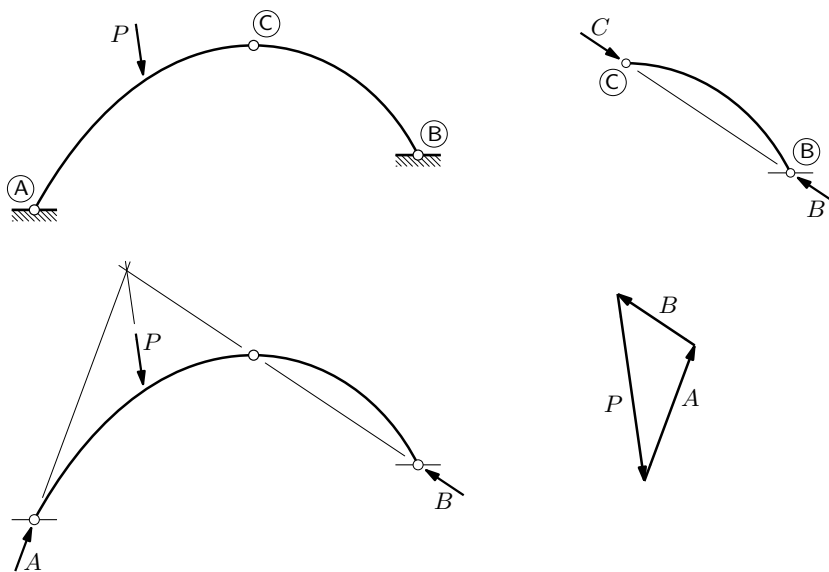
Trozglobni lukovi & okviri



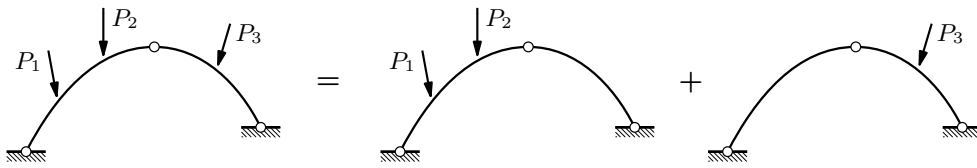
Pont Alexandre III, Pariz, 1896.–1900.

grafički način određivanja sila u spojevima:

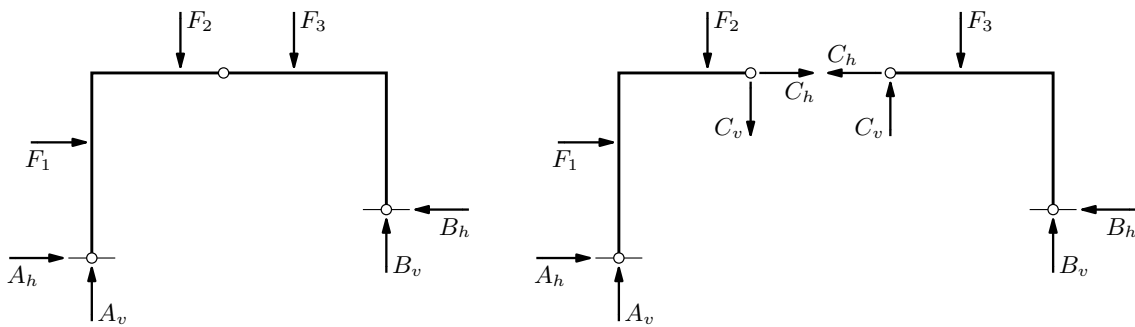
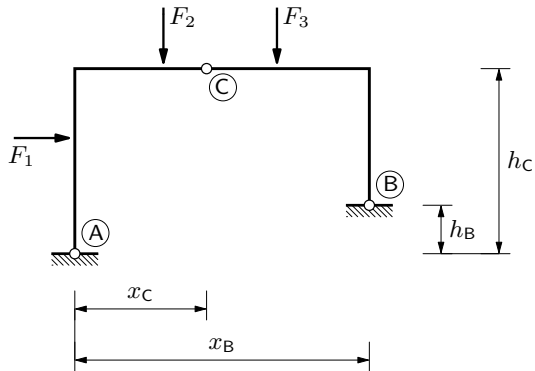
opterećeno jedno tijelo:



opterećena oba tijela:



analitički način izračunavanja sila u spojevima:



$$\sum_{[A,C]} F_x = \underline{A_h} + F_1 + \underline{C_h} = 0$$

$$\sum_{[C,B]} F_x = -\underline{C_h} - \underline{B_h} = 0$$

$$\sum_{[A,B]} F_x = \underline{A_h} + F_1 - \underline{B_h} = 0 \quad \Rightarrow \quad \sum_{[A,B]} F_x = \sum_{[A,C]} F_x + \sum_{[C,B]} F_x$$

$$\sum_{[A,C]} F_z = -\underline{A_v} + F_2 + \underline{C_v} = 0$$

$$\sum_{[C,B]} F_z = -\underline{C_v} + F_3 - \underline{B_v} = 0$$

$$\sum_{[A,B]} F_z = -\underline{A_v} + F_2 + F_3 - \underline{B_v} = 0 \quad \Rightarrow \quad \sum_{[A,B]} F_z = \sum_{[A,C]} F_z + \sum_{[C,B]} F_z$$

$$\sum_{[A,C]} M_{/A} = -h_1 F_1 - x_2 F_2 - x_C \underline{C}_v - h_C \underline{C}_h = 0$$

$$\sum_{[C,B]} M_{/B} = -(x_B - x_C) \underline{C}_v + (h_C - h_B) \underline{C}_h + (x_B - x_3) F_3 = 0$$

$$\sum_{[A,B]} M_{/A} = -h_1 F_1 - x_2 F_2 - x_3 F_3 + x_B \underline{B}_v + h_B \underline{B}_h = 0$$

$$-h_B \sum_{[C,B]} F_x = h_B \underline{C}_h + h_B \underline{B}_h = 0$$

$$-x_B \sum_{[C,B]} F_z = x_B \underline{C}_v - x_B F_3 + x_B \underline{B}_v = 0$$

$$\begin{aligned} \Rightarrow \quad & \sum_{[A,C]} M_{/A} + \sum_{[C,B]} M_{/B} - h_B \sum_{[C,B]} F_x - x_B \sum_{[C,B]} F_z \\ & = -h_1 F_1 - x_2 F_2 + x_B \underline{B}_v + h_B \underline{B}_h - x_3 F_3 = \sum_{[A,B]} M_{/A} \end{aligned}$$

zaključak: od mogućih devet jednažbi ravnoteže samo ih je šest (ispravno odabranih) linearno nezavisno

uobičajeni redosljed rješavanja:

$$\sum_{[A,B]} M_{/B} = 0 : \quad \underline{A}_h h_B - \underline{A}_v x_B - F_1 (h_1 - h_B) + F_2 (x_B - x_2) + F_3 (x_B - x_3) = 0$$

$$\begin{aligned} \sum_{[A,C]} M_{/C} = 0 : \quad & \underline{A}_h h_C - \underline{A}_v x_C + F_1 (h_C - h_1) + F_2 (x_C - x_2) = 0 \\ \Rightarrow \quad & A_h \text{ \& \# } A_v \end{aligned}$$

$$\sum_{[A,B]} M_{/A} = 0 : \quad -F_1 h_1 - F_2 x_2 - F_3 x_3 + \underline{B}_v x_B + \underline{B}_h h_B = 0$$

$$\begin{aligned} \sum_{[C,B]} M_{/C} = 0 : \quad & -F_3 (x_3 - x_C) - \underline{B}_h (h_C - h_B) + \underline{B}_v (x_C - x_C) = 0 \\ \Rightarrow \quad & B_h \text{ \& \# } B_v \end{aligned}$$

$$\text{provjera } A_h \text{ \& \# } B_h: \quad \sum_{[A,B]} F_x$$

$$\text{provjera } A_v \text{ \& \# } B_v: \quad \sum_{[A,B]} F_z$$

$$\sum_{[A,C]} F_x = 0 : \quad \underline{A}_h + F_1 + \underline{C}_h = 0 \quad \Rightarrow \quad C_h$$

$$\sum_{[A,C]} F_z = 0 : \quad -\underline{A}_v + F_2 + \underline{C}_v = 0 \quad \Rightarrow \quad C_v$$

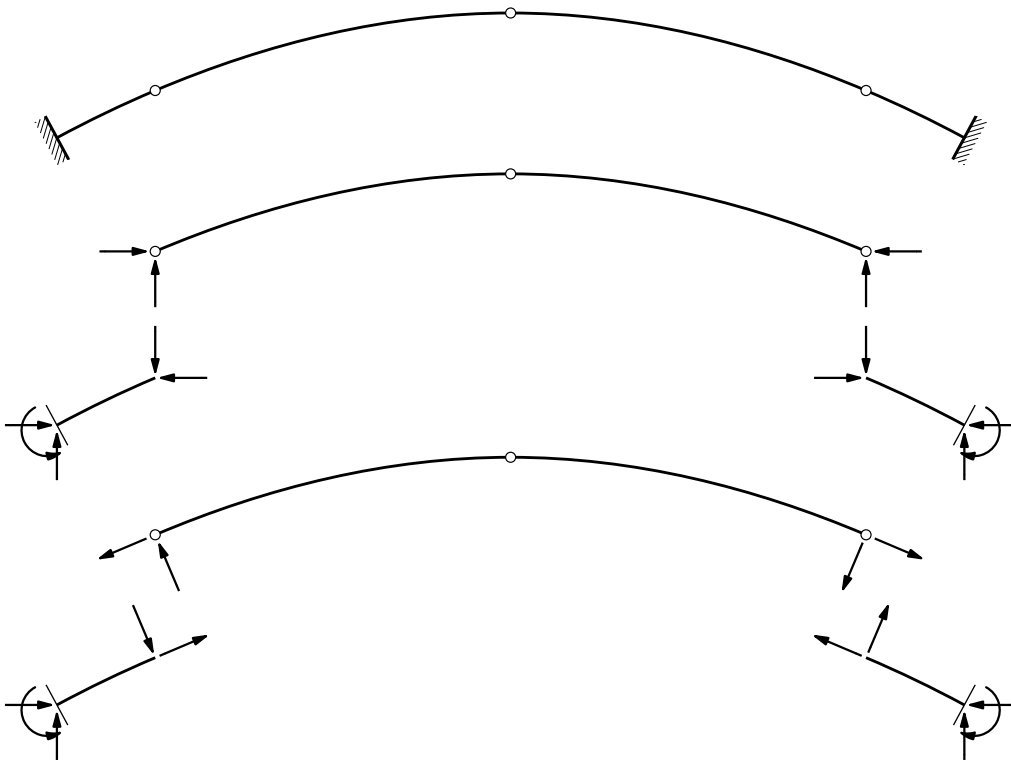
$$\text{provjera } C_h \text{ \& \# } C_v: \quad \sum_{[C,B]} F_x \text{ \& \# } \sum_{[C,B]} F_z$$

Ulančeni sistem koji sadrži trozglobni luk



Viaduc d'Austerlitz, Pariz, 1904.

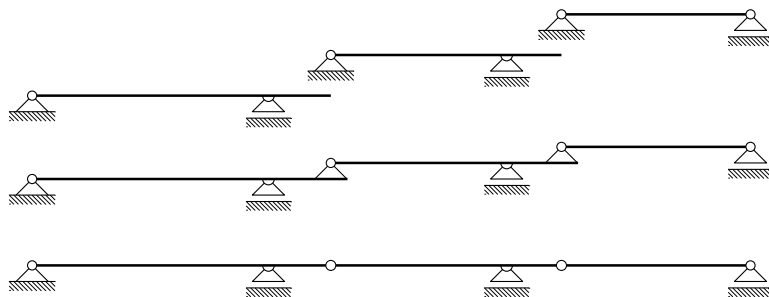
proračunska shema:



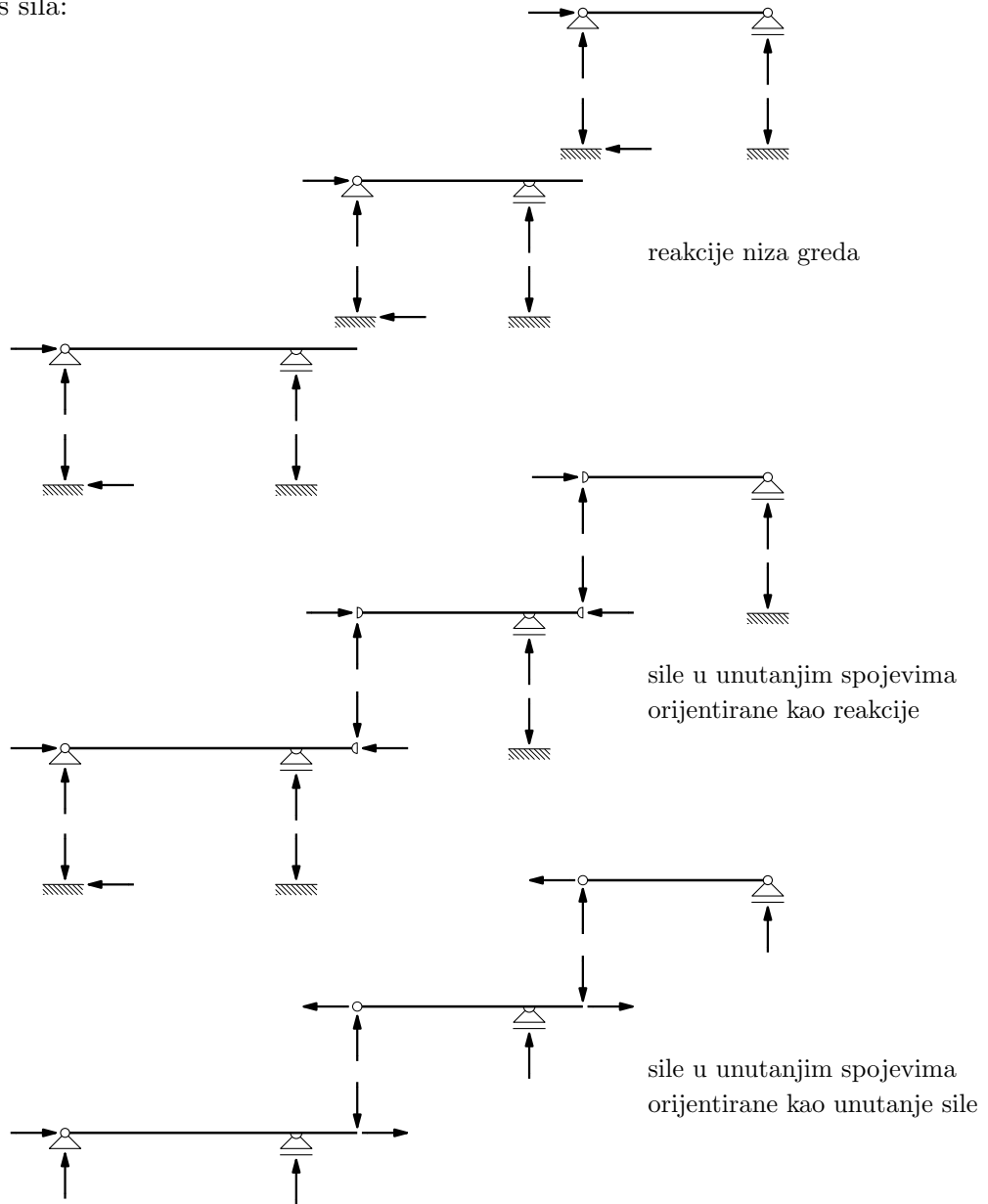
Ulančeni Gerberovi nosači

1. primjer:

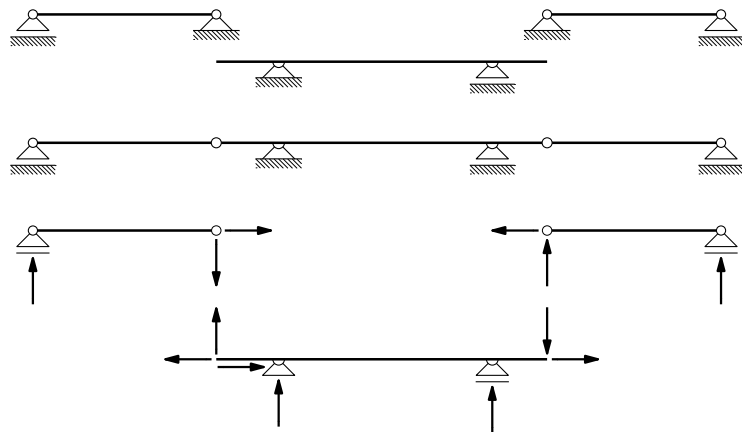
sastavljanje:



prijenos sila:



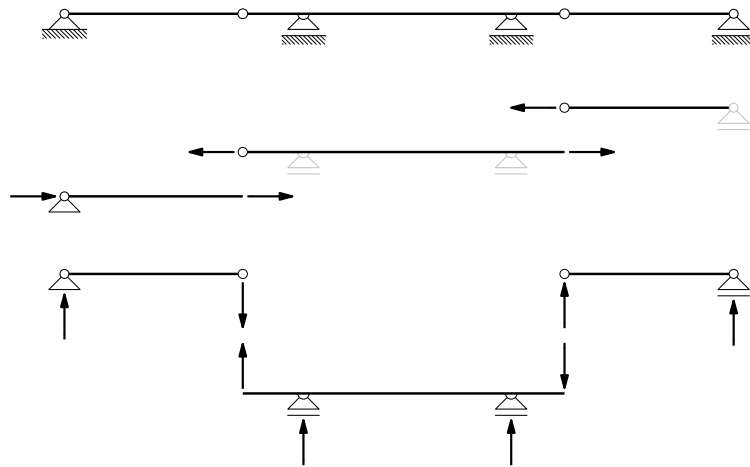
2. primjer:



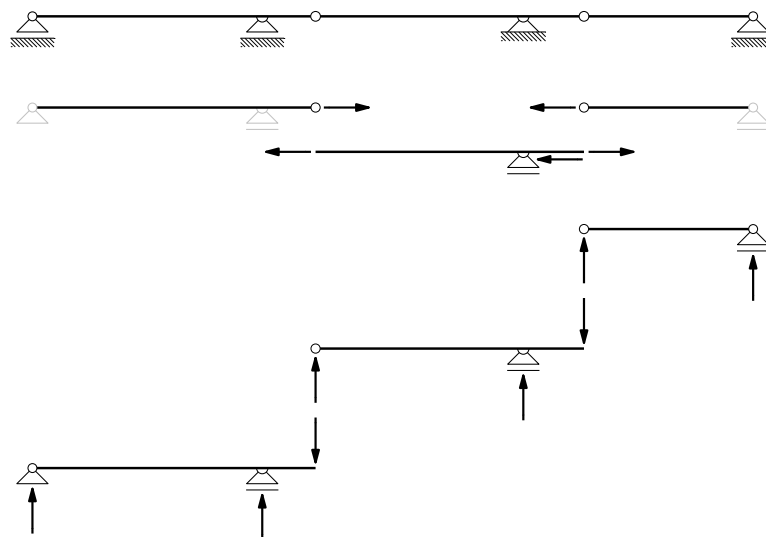
Gerberovi nosači koji nisu ulančeni

- načini prijenosa sila koje djeluju na osi nosača i sila koje djeluju okomito na os razlikuju se

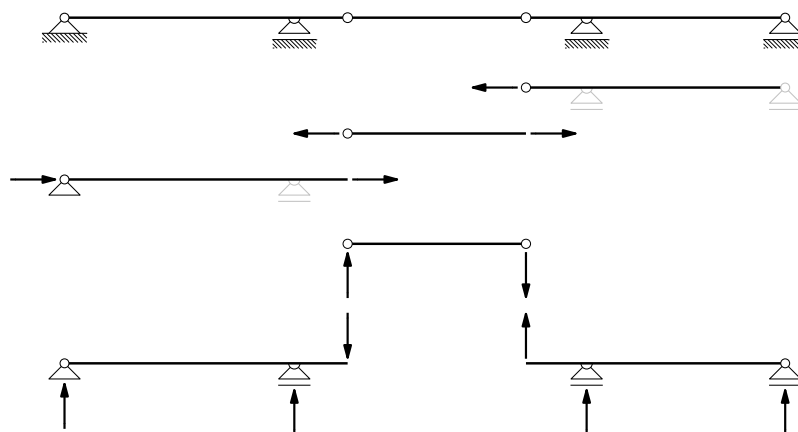
1. primjer:

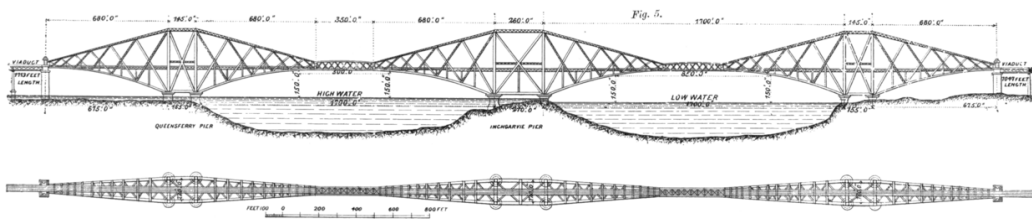
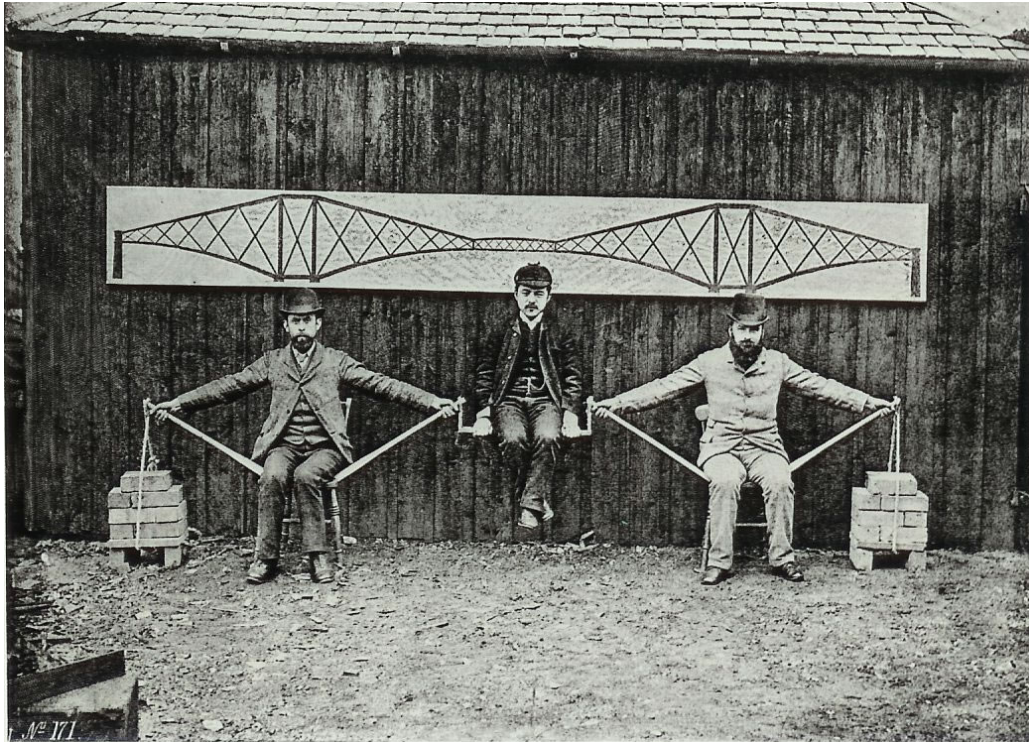


2. primjer:



3. primjer:





THE FORTH BRIDGE. THE LABOUR OF 5000 MEN (DAY AND NIGHT) FOR 7 YEARS.
 ENGINEERS—SIR JOHN FOWLER & SIR BENJAMIN BAKER. COST OVER
 CONTRACTOR—SIR WILLIAM ARROL. OPENED MARCH, 1890. £3,000,000
 LENGTH, INCLUDING APPROACH VIADUCTS, OVER 1½ MILES. TWO SPANS OF 1710 FT. EACH AND
 TWO OF 690 FT. EACH. HIGHEST PART ABOVE SEA LEVEL AT HIGH TIDE, 361 FT. HEIGHT OF
 RAILS ABOVE SEA LEVEL AT HIGH TIDE, 157 FT. 8 INS. DEPTH BELOW WATER LEVEL, 91 FT.
MATERIALS USED:
 STEEL: 54,160 TONS. CONCRETE: 64,300 CUBIC YARDS.
 GRANITE: 740,000 CUBIC FEET. CEMENT: OVER 21,000 TONS.
 ORDINARY STONE: 48,400 CUBIC YARDS. RIVETS: 6,500,000 = 4,200 TONS.

Forth Railway Bridge, Firth of Forth, 1882.–1890.