節点移動がある場合 構造力学演習　第 11 章　演習問題

逆対称条件

学年：＿＿＿学籍番号：＿＿＿＿＿＿＿＿名前：＿＿＿＿＿＿＿＿

1．図 1 に示すラーメン構造に対して、

① 不静定次数を判断せよ。

② たわみ角法を使って、曲げモーメント分布 M 図、せん断力 Q 図、軸力 N 図と変形図を描け。

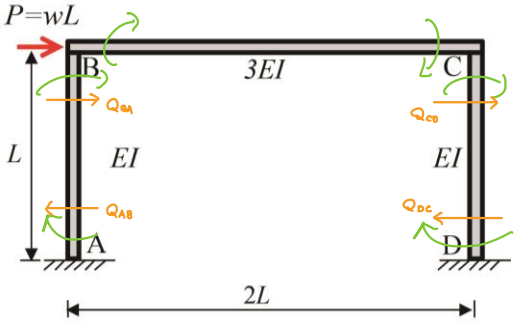


図 1

① 3 + 6 + 2 - 2×4 = 3次の不静定

② ①

$M_{AB} = k_{AB}(2\varphi_A + \varphi_B + \psi_{AB}) + C_{AB}$

$M_{BA} = k_{AB}(\varphi_A + 2\varphi_B + \psi_{AB}) + C_{BA}$

$M_{BC} = k_{BC}(2\varphi_B + \varphi_C + \psi_{BC}) + C_{BC}$

$M_{BC} = k_{BC}(\varphi_B + 2\varphi_C + \psi_{BC}) + C_{CB}$

$M_{CD} = k_{CD}(2\varphi_C + \varphi_D + \psi_{CD}) + C_{CD}$

$M_{DC} = k_{CD}(\varphi_C + 2\varphi_D + \psi_{CD}) + C_{DC}$

②

$K_{AB} = \frac{I}{L}$　$k_{AB} = 1$

$K_{BC} = \frac{3I}{2L}$　$k_{BC} = \frac{2}{3}$

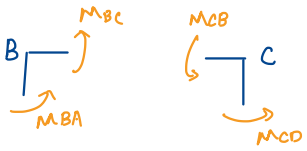
$K_{CD} = \frac{I}{L}$　$k_{CD} = 1$

$K_0 = \frac{I}{L}$

③ $\varphi_A = 0$, $\varphi_D = 0$, $\psi_{BC} = 0$, $\psi_{AB} = \psi_{CD}$

④ $C_{AB} = 0$, $C_{BA} = 0$, $C_{BC} = 0$, $C_{CB} = 0$, $C_{CD} = 0$, $C_{DC} = 0$

⑥



$M_{BA} + M_{BC} = 0$

$M_{CB} + M_{CD} = 0$

⑤

$M_{AB} = (\varphi_B + \psi_{AB})$

$M_{BA} = (2\varphi_B + \psi_{AB})$

$M_{BC} = \frac{3}{2}(2\varphi_B + \varphi_C)$

$M_{CB} = \frac{3}{2}(\varphi_B + 2\varphi_C)$

$M_{CD} = (2\varphi_C + \psi_{AB})$

$M_{DC} = (\varphi_C + \psi_{AB})$

⑦ 水平方向のつり合いより

$wL - Q_{AB} - Q_{DC} = 0$

M_B まわり $Q_{AB}h + M_{AB} + M_{BA} = 0$

$Q_{AB} = \frac{-M_{AB} - M_{BA}}{L}$

M_C まわり $Q_{DC}h + M_{CD} + M_{DC} = 0$

$Q_{DC} = \frac{-M_{CD} - M_{DC}}{L}$

⑧

$2\varphi_B + \psi_{AB} + \frac{6}{2}\varphi_B + \frac{3}{2}\varphi_C = 0$　（-20 - 6 +3 +3 -17 -3）

$\psi_{AB} = -\frac{10}{2}\varphi_B - \frac{3}{2}\varphi_C$ …①

$\frac{3}{2}\varphi_B + \frac{6}{2}\varphi_C + 2\varphi_C + \psi_{AB} = 0$

$\psi_{AB} = -\frac{3}{2}\varphi_B - \frac{10}{2}\varphi_C$ …②

$4wL + \varphi_B + \psi_{AB} + 2\varphi_B + \psi_{AB} + 2\varphi_C + \psi_{AB} + \varphi_C + \psi_{AB} = 0$

$4\psi_{AB} + 4wL = -3\varphi_B - 3\varphi_C$ …③

①-②より　$0 = -\frac{7}{2}\varphi_B + \frac{7}{2}\varphi_C$

$\varphi_B = \varphi_C$ …④

①×4-③より　$-4wL = -17\varphi_B - 3\varphi_C$ …⑤

④より　$-4wL = -20\varphi_C$

$\psi_{AB} = -\frac{10}{40} - \frac{3}{40} = -\frac{13}{40}wL^2$

$\varphi_B = \varphi_C = \frac{wL^2}{20}$, $\psi_{AB} = -\frac{13}{40}wL^2$

⑨

$M_{AB} = \frac{1}{20} - \frac{13}{40} = -\frac{11}{40}wL^2$

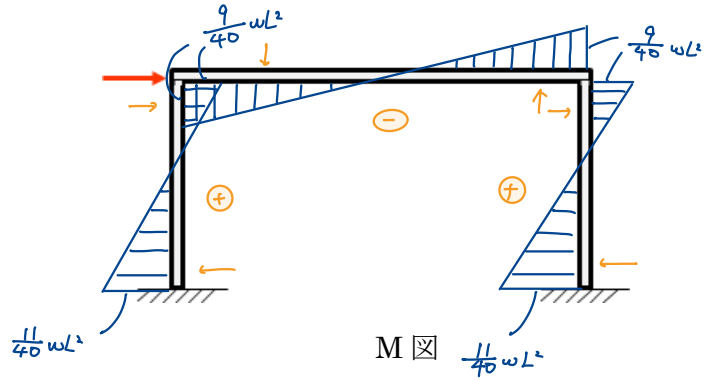
$M_{BA} = \frac{2}{20} - \frac{13}{40} = -\frac{9}{40}wL^2$

$M_{BC} = \frac{6}{40} + \frac{3}{40} = \frac{9}{40}wL^2$

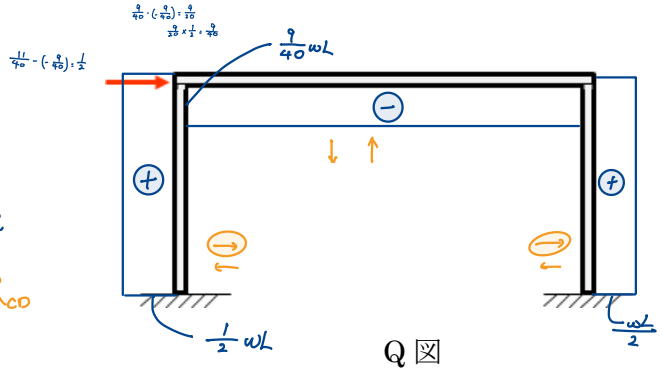
$M_{CB} = \frac{3}{40} + \frac{6}{40} = \frac{9}{40}wL^2$

$M_{CD} = \frac{2}{20} - \frac{13}{40} = -\frac{9}{40}wL^2$

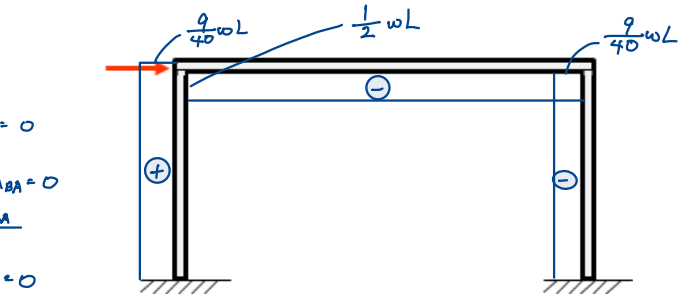
$M_{DC} = \frac{1}{20} - \frac{13}{40} = -\frac{11}{40}wL^2$



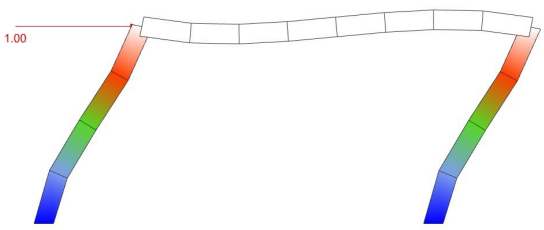
M 図



Q 図



N 図



変形図