節点移動がない場合
対称条件

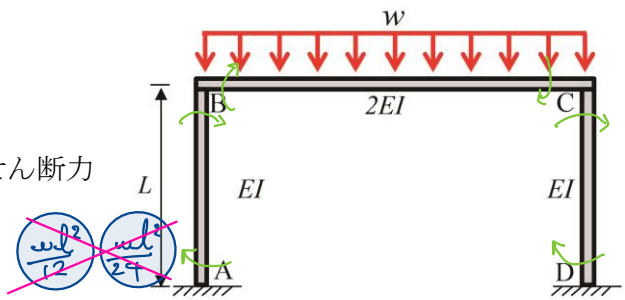
構造力学演習　第 11 章　演習問題

学年：＿＿＿学籍番号：＿＿＿＿＿＿＿＿名前：＿＿＿＿＿＿＿＿

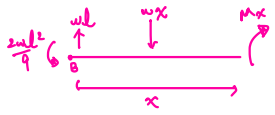
1．図 1 に示すラーメン構造に対して、

① 不静定次数を判定せよ。

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 図と変型図を描け。



① $3+6+2-4\times2=$ 3次の不静定



② ①

$$M_{AB}=k_{AB}(2\varphi_A+\varphi_B+\psi_{AB})+C_{AB}$$
$$M_{BA}=k_{AB}(\varphi_A+2\varphi_B+\psi_{AB})+C_{BA}$$
$$M_{BC}=k_{BC}(2\varphi_B+\varphi_C+\psi_{BC})+C_{BC}$$
$$M_{CB}=k_{BC}(\varphi_B+2\varphi_C+\psi_{BC})+C_{CB}$$
$$M_{CD}=k_{CD}(2\varphi_C+\varphi_D+\psi_{CD})+C_{CD}$$
$$M_{DC}=k_{CD}(\varphi_C+2\varphi_D+\psi_{CD})+C_{DC}$$

② $K_{AB}=\frac{I}{L}$　$K_{BC}=\frac{2I}{2L}=\frac{I}{L}$　$K_{CD}=\frac{I}{L}$

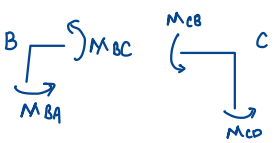
$K_0=\frac{I}{L}$　$k_{AB}=1$　$k_{BC}=1$　$k_{CD}=1$

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

④ $C_{AB}=0$　$C_{BA}=0$　$C_{BC}=-\frac{wl^2}{12}=-\frac{wl^2}{3}$　$C_{CB}=\frac{wl^2}{12}=\frac{wl^2}{3}$　$C_{CD}=0$　$C_{DC}=0$

⑤ $M_{AB}=\varphi_B$　$M_{BA}=2\varphi_B$　$M_{BC}=2\varphi_B+\varphi_C-\frac{wl^2}{3}$　$M_{CB}=\varphi_B+2\varphi_C+\frac{wl^2}{3}$　$M_{CD}=2\varphi_C$　$M_{DC}=\varphi_C$

⑥

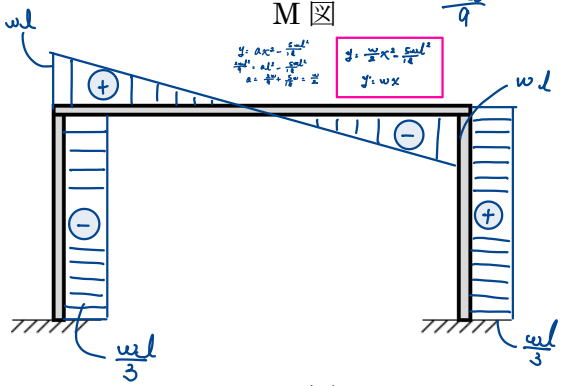


$M_{BC}+M_{BA}=0$

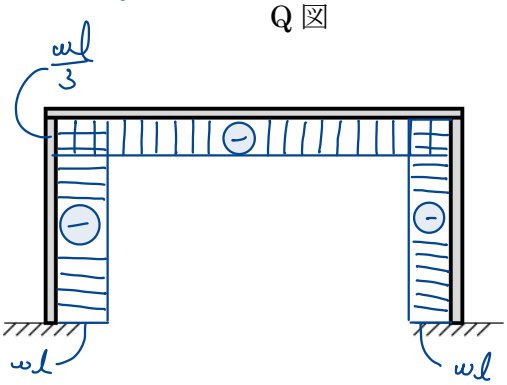
$M_{CB}+M_{CD}=0$

⑦ なし

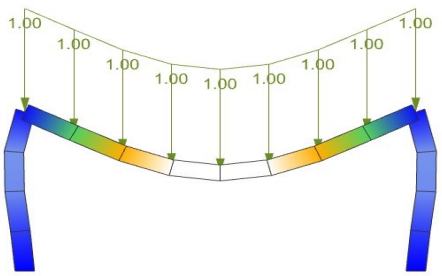
M 図



Q 図



N 図



変形図

(8)

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

$2\varphi_B + \varphi_C - \frac{wl^2}{3} + 2\varphi_B = 0$

$4\varphi_B + \varphi_C = \frac{wl^2}{3}$

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

$\varphi_B + 2\varphi_C + \frac{wl^2}{3} + 2\varphi_C = 0$

$\varphi_B + 4\varphi_C = -\frac{wl^2}{3}$

$4\varphi_B + 16\varphi_C = -\frac{4wl^2}{3}$

$-) \quad 4\varphi_B + \varphi_C = \frac{wl^2}{3}$

$15\varphi_C = -\frac{5wl^2}{3}$

$\varphi_C = -\frac{wl^2}{9}, \quad \varphi_B = \frac{wl^2}{9}$

$M_{AB} = \varphi_B = \frac{wl^2}{9}$

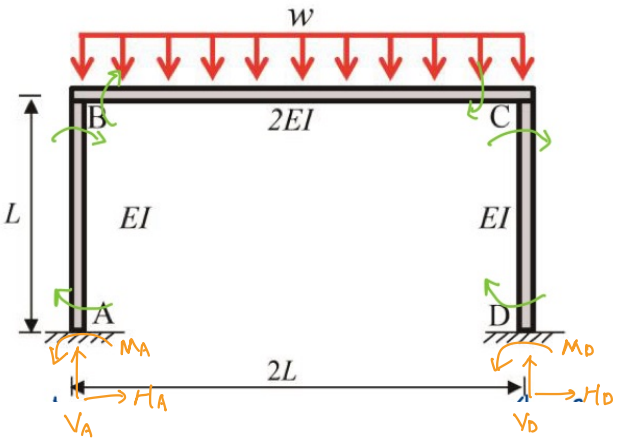
$M_{BA} = 2\varphi_B = \frac{2wl^2}{9}$

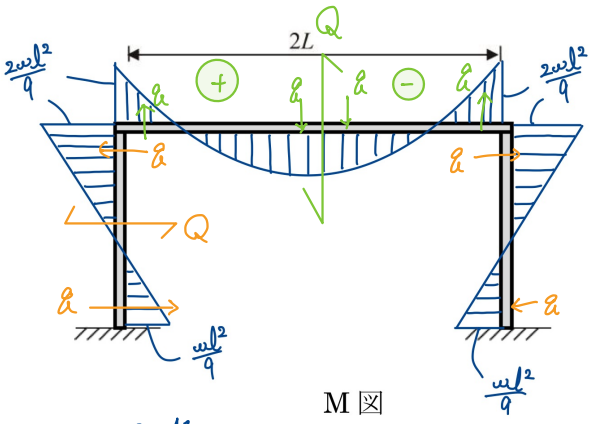
$M_{BC} = 2\varphi_B + \varphi_C - \frac{wl^2}{3} = -\frac{2wl^2}{9}$

$M_{CB} = \varphi_B + 2\varphi_C + \frac{wl^2}{3} = \frac{2wl^2}{9}$

$M_{CD} = 2\varphi_C = -\frac{2wl^2}{9}$

$M_{DC} = \varphi_C = -\frac{wl^2}{9}$





M 図

$Q = \frac{3wl^2}{9} \div L = \frac{wl}{3}$