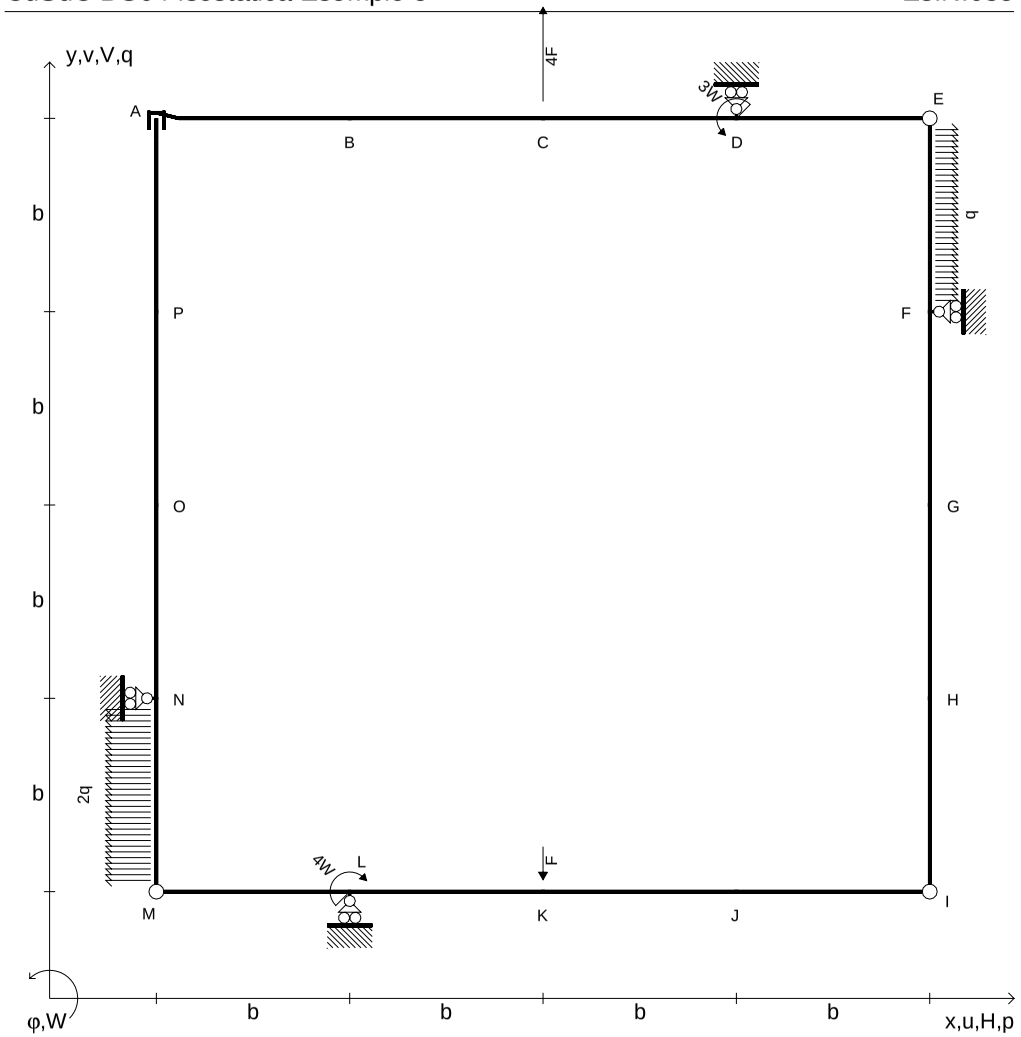
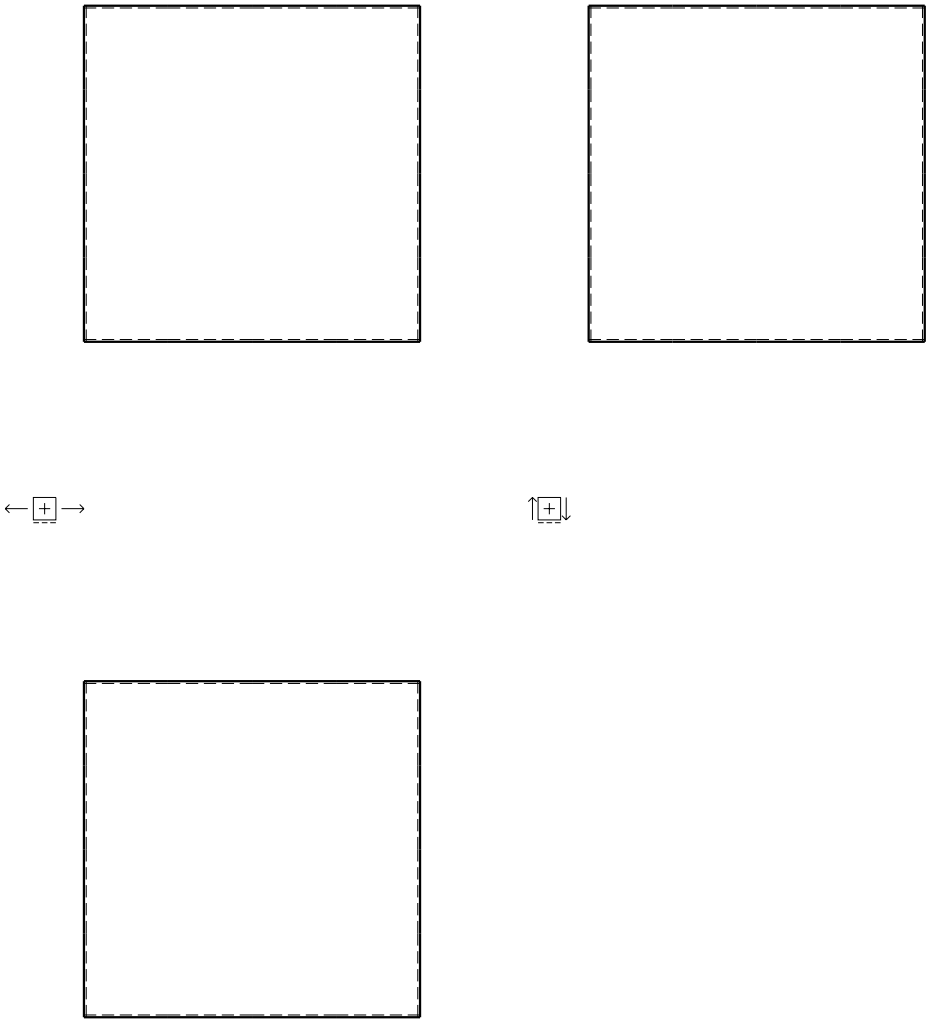


$V_C = 4F$ $W_D = 3W = 3Fb$ $p_{EF} = q = F/b$

$V_K = -F$ $W_L = -4W = -4Fb$ $p_{MN} = -2q = -2F/b$

Svolgere l'analisi cinematica.
Determinare matrice di congruenza e di equilibrio.
Determinare le reazioni vincolari a terra col PLV (Le=0).
Determinare le azioni interne in D col PLV (Le=0).
Carichi e deformazioni date hanno verso efficace in disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.



@ Adolfo Zavelani Rossi, Politecnico di Milano

Schema grafico non rappresentabile

REAZIONI

V_D =
H_F =

V_L =
H_N =

H_{AB} =
V_{AB} =
W_{AB} =
H_{BA} =
V_{BA} =
W_{BA} =

H_{BC} =
V_{BC} =
W_{BC} =
H_{CB} =
V_{CB} =
W_{CB} =

H_{CD} =
V_{CD} =
W_{CD} =
H_{DC} =
V_{DC} =
W_{DC} =

H_{DE} =
V_{DE} =
W_{DE} =
H_{ED} =
V_{ED} =
W_{ED} =

H_{EF} =
V_{EF} =
W_{EF} =
H_{FE} =
V_{FE} =
W_{FE} =

H_{FG} =
V_{FG} =
W_{FG} =
H_{GF} =
V_{GF} =
W_{GF} =

H_{GH} =
V_{GH} =
W_{GH} =
H_{HG} =
V_{HG} =
W_{HG} =

H_{HI} =
V_{HI} =
W_{HI} =
H_{IH} =
V_{IH} =
W_{IH} =

H_{IJ} =
V_{IJ} =
W_{IJ} =
H_{JI} =
V_{JI} =
W_{JI} =

H_{JK} =
V_{JK} =
W_{JK} =
H_{KJ} =
V_{KJ} =
W_{KJ} =

H_{KL} =
V_{KL} =
W_{KL} =
H_{LK} =
V_{LK} =
W_{LK} =

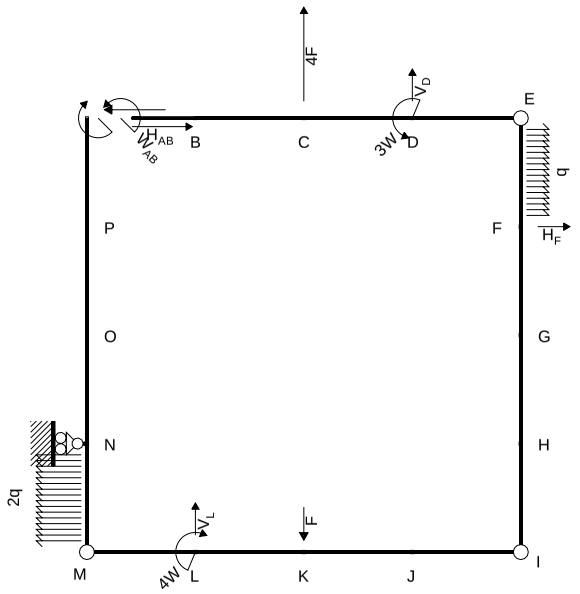
H_{LM} =
V_{LM} =
W_{LM} =
H_{ML} =
V_{ML} =
W_{ML} =

H_{MN} =
V_{MN} =
W_{MN} =
H_{NM} =
V_{NM} =
W_{NM} =

H_{NO} =
V_{NO} =
W_{NO} =
H_{ON} =
V_{ON} =
W_{ON} =

H_{OP} =
V_{OP} =
W_{OP} =
H_{PO} =
V_{PO} =
W_{PO} =

H_{PA} =
V_{PA} =
W_{PA} =
H_{AP} =
V_{AP} =
W_{AP} =



EQUAZIONI DI EQUILIBRIO
Traslazione verticale globale
$V_D + V_L = -3F$
Rotazione globale intorno a N
$3V_Db - 2H_Fb + V_Lb = -6Fb + W + 7/2qb^2$
Rotazione intorno a M: aste ML LK KJ JI IH HG GF FE ED DC CB BA
$3V_Db - 3H_Fb + V_Lb - 4H_{AB}b + W_{AB} = -6Fb + W + 7/2qb^2$
Rotazione intorno a I: aste IH HG GF FE ED DC CB BA
$-V_Db - 3H_Fb - 4H_{AB}b + W_{AB} = 8Fb - 3W + 7/2qb^2$
Rotazione intorno a E: aste ED DC CB BA
$-V_Db + W_{AB} = 8Fb - 3W$

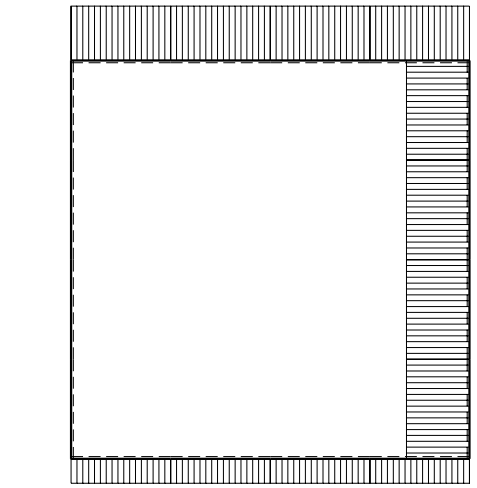
Matrice di equilibrio

	V_Db	H_Fb	V_Lb	$H_{AB}b$	W_{AB}		Fb	W	qb^2
v_N	1	0	1	0	0		-3	0	0
φ_N	3	-2	1	0	0		-6	1	7/2
φ_{ML}	3	-3	1	-4	1	=	-6	1	7/2
φ_{IJ}	-1	-3	0	-4	1		8	-3	7/2
φ_{ED}	-1	0	0	0	1		8	-3	0

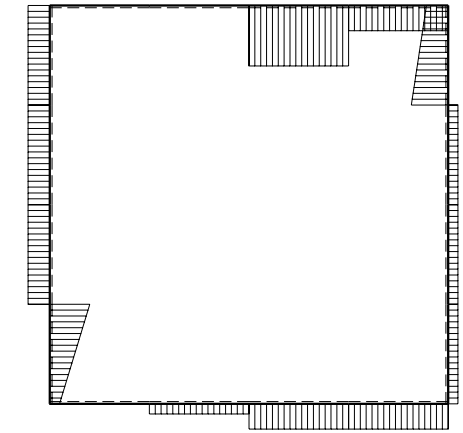
Soluzione del sistema

		Fb	W	qb^2
V_Db		-11/3	4/3	0
H_Fb		-13/6	5/6	-7/4
V_Lb	=	2/3	-4/3	0
$H_{AB}b$		13/8	-5/8	7/16
W_{AB}		13/3	-5/3	0

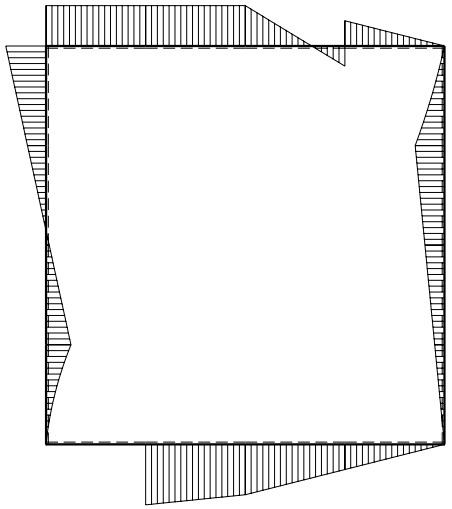
Schema grafico non rappresentabile



2 F



5 F



5 Fb

REAZIONI

$V_D = -11/3F +4/3(W/b) = -7/3F$
$H_F = -13/6F +5/6(W/b) -7/4qb = -37/12F$

$V_L = 2/3F -4/3(W/b) = -2/3F$
$H_N = 13/6F -5/6(W/b) +11/4qb = 49/12F$

$H_{AB} = 13/8F -5/8(W/b) +7/16qb = 23/16F$
$V_{AB} = 0$
$W_{AB} = 13/3Fb -5/3W = 8/3Fb$
$H_{BA} = -13/8F +5/8(W/b) -7/16qb = -23/16F$
$V_{BA} = 0$
$W_{BA} = -13/3Fb +5/3W = -8/3Fb$

$H_{BC} = 13/8F -5/8(W/b) +7/16qb = 23/16F$
$V_{BC} = 0$
$W_{BC} = 13/3Fb -5/3W = 8/3Fb$
$H_{CB} = -13/8F +5/8(W/b) -7/16qb = -23/16F$
$V_{CB} = 0$
$W_{CB} = -13/3Fb +5/3W = -8/3Fb$

$H_{CD} = 13/8F -5/8(W/b) +7/16qb = 23/16F$
$V_{CD} = 4F = 4F$
$W_{CD} = 13/3Fb -5/3W = 8/3Fb$
$H_{DC} = -13/8F +5/8(W/b) -7/16qb = -23/16F$
$V_{DC} = -4F = -4F$
$W_{DC} = -1/3Fb +5/3W = 4/3Fb$

$H_{DE} = 13/8F -5/8(W/b) +7/16qb = 23/16F$
$V_{DE} = 1/3F +4/3(W/b) = 5/3F$
$W_{DE} = 1/3Fb +4/3W = 5/3Fb$
$H_{ED} = -13/8F +5/8(W/b) -7/16qb = -23/16F$
$V_{ED} = -1/3F -4/3(W/b) = -5/3F$
$W_{ED} = 0$

$H_{EF} = 13/8F -5/8(W/b) +7/16qb = 23/16F$
$V_{EF} = 1/3F +4/3(W/b) = 5/3F$
$W_{EF} = 0$
$H_{FE} = -13/8F +5/8(W/b) -23/16qb = -39/16F$
$V_{FE} = -1/3F -4/3(W/b) = -5/3F$
$W_{FE} = 13/8Fb -5/8W +15/16qb^2 = 31/16Fb$

$H_{FG} = -13/24F +5/24(W/b) -5/16qb = -31/48F$
$V_{FG} = 1/3F +4/3(W/b) = 5/3F$
$W_{FG} = -13/8Fb +5/8W -15/16qb^2 = -31/16Fb$
$H_{GF} = 13/24F -5/24(W/b) +5/16qb = 31/48F$
$V_{GF} = -1/3F -4/3(W/b) = -5/3F$
$W_{GF} = 13/12Fb -5/12W +5/8qb^2 = 31/24Fb$

$H_{GH} = -13/24F +5/24(W/b) -5/16qb = -31/48F$
$V_{GH} = 1/3F +4/3(W/b) = 5/3F$
$W_{GH} = -13/12Fb +5/12W -5/8qb^2 = -31/24Fb$
$H_{HG} = 13/24F -5/24(W/b) +5/16qb = 31/48F$
$V_{HG} = -1/3F -4/3(W/b) = -5/3F$
$W_{HG} = 13/24Fb -5/24W +5/16qb^2 = 31/48Fb$

$H_{HI} = -13/24F +5/24(W/b) -5/16qb = -31/48F$
$V_{HI} = 1/3F +4/3(W/b) = 5/3F$
$W_{HI} = -13/24Fb +5/24W -5/16qb^2 = -31/48Fb$
$H_{IH} = 13/24F -5/24(W/b) +5/16qb = 31/48F$
$V_{IH} = -1/3F -4/3(W/b) = -5/3F$
$W_{IH} = 0$

$H_{IJ} = -13/24F +5/24(W/b) -5/16qb = -31/48F$
$V_{IJ} = 1/3F +4/3(W/b) = 5/3F$
$W_{IJ} = 0$
$H_{JI} = 13/24F -5/24(W/b) +5/16qb = 31/48F$
$V_{JI} = -1/3F -4/3(W/b) = -5/3F$
$W_{JI} = -1/3Fb -4/3W = -5/3Fb$

$H_{JK} = -13/24F +5/24(W/b) -5/16qb = -31/48F$
$V_{JK} = 1/3F +4/3(W/b) = 5/3F$
$W_{JK} = 1/3Fb +4/3W = 5/3Fb$
$H_{KJ} = 13/24F -5/24(W/b) +5/16qb = 31/48F$
$V_{KJ} = -1/3F -4/3(W/b) = -5/3F$
$W_{KJ} = -2/3Fb -8/3W = -10/3Fb$

PROCEDIMENTO E RISULTATI Nome: Es.N.035

$H_{KL} = -13/24F +5/24(W/b) -5/16qb = -31/48F$
$V_{KL} = -2/3F +4/3(W/b) = 2/3F$
$W_{KL} = 2/3Fb +8/3W = 10/3Fb$
$H_{LK} = 13/24F -5/24(W/b) +5/16qb = 31/48F$
$V_{LK} = 2/3F -4/3(W/b) = -2/3F$
$W_{LK} = -4W = -4Fb$

$H_{LM} = -13/24F +5/24(W/b) -5/16qb = -31/48F$
$V_{LM} = 0$
$W_{LM} = 0$
$H_{ML} = 13/24F -5/24(W/b) +5/16qb = 31/48F$
$V_{ML} = 0$
$W_{ML} = 0$

$H_{MN} = -13/24F +5/24(W/b) -5/16qb = -31/48F$
$V_{MN} = 0$
$W_{MN} = 0$
$H_{NM} = 13/24F -5/24(W/b) +37/16qb = 127/48F$
$V_{NM} = 0$
$W_{NM} = 13/24Fb -5/24W +21/16qb^2 = 79/48Fb$

$H_{NO} = 13/8F -5/8(W/b) +7/16qb = 23/16F$
$V_{NO} = 0$
$W_{NO} = -13/24Fb +5/24W -21/16qb^2 = -79/48Fb$
$H_{ON} = -13/8F +5/8(W/b) -7/16qb = -23/16F$
$V_{ON} = 0$
$W_{ON} = -13/12Fb +5/12W +7/8qb^2 = 5/24Fb$

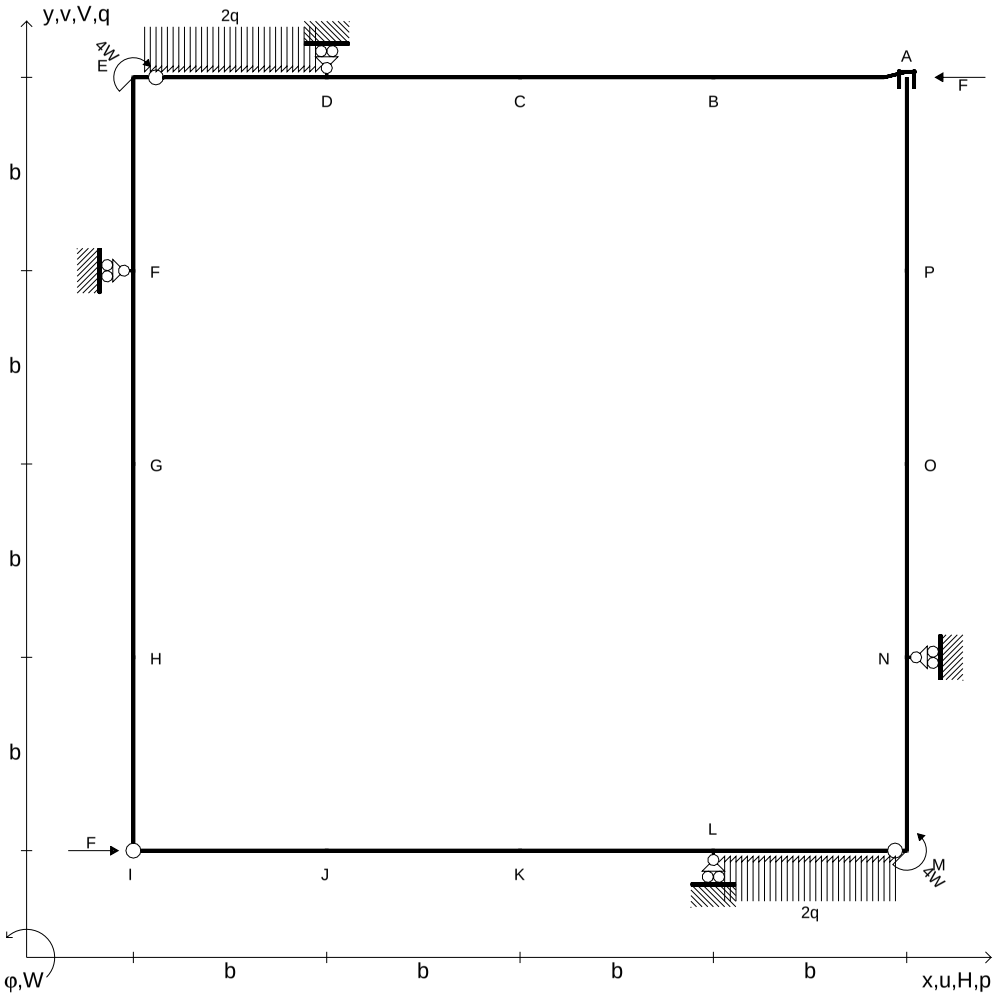
$H_{OP} = 13/8F -5/8(W/b) +7/16qb = 23/16F$
$V_{OP} = 0$
$W_{OP} = 13/12Fb -5/12W -7/8qb^2 = -5/24Fb$
$H_{PO} = -13/8F +5/8(W/b) -7/16qb = -23/16F$
$V_{PO} = 0$
$W_{PO} = -65/24Fb +25/24W +7/16qb^2 = -59/48Fb$

$H_{PA} = 13/8F -5/8(W/b) +7/16qb = 23/16F$
$V_{PA} = 0$
$W_{PA} = 65/24Fb -25/24W -7/16qb^2 = 59/48Fb$
$H_{AP} = -13/8F +5/8(W/b) -7/16qb = -23/16F$
$V_{AP} = 0$
$W_{AP} = -13/3Fb +5/3W = -8/3Fb$

@ Adolfo Zavelani Rossi, Politecnico di Milano

Es.N.035

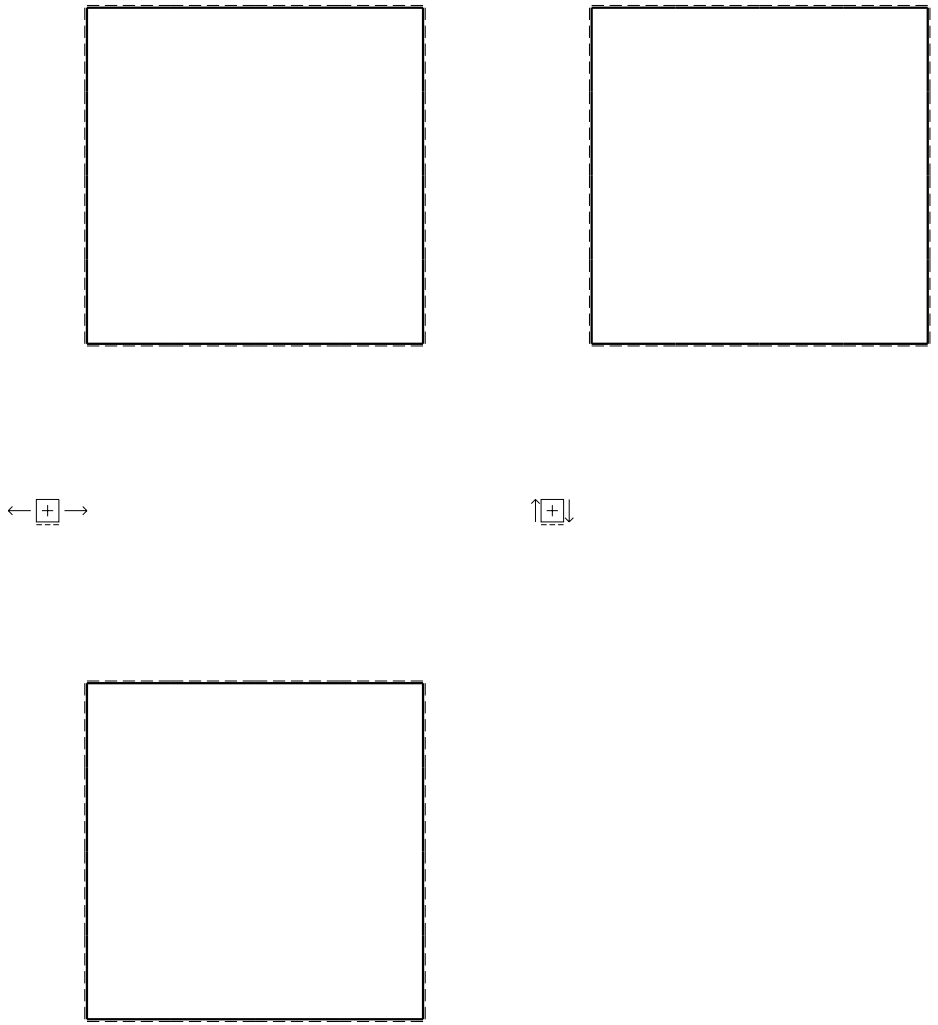
@ Adolfo Zavelani Rossi, Politecnico di Milano



$H_A = -F$ $W_E = -4W = -4Fb$ $q_{DE} = -2q = -2F/b$

$H_I = F$ $W_M = 4W = 4Fb$ $q_{LM} = 2q = 2F/b$

Svolgere l'analisi cinematica.
Determinare matrice di congruenza e di equilibrio.
Determinare le reazioni vincolari a terra col PLV (Le=0).
Determinare le azioni interne in D col PLV (Le=0).
Carichi e deformazioni date hanno verso efficace in disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.



@ Adolfo Zavelani Rossi, Politecnico di Milano

Schema grafico non rappresentabile

REAZIONI

V_D = H_F = V_L = H_N =

H_{AB} =
V_{AB} =
W_{AB} =
H_{BA} =
V_{BA} =
W_{BA} =

H_{BC} =
V_{BC} =
W_{BC} =
H_{CB} =
V_{CB} =
W_{CB} =

H_{CD} =
V_{CD} =
W_{CD} =
H_{DC} =
V_{DC} =
W_{DC} =

H_{DE} =
V_{DE} =
W_{DE} =
H_{ED} =
V_{ED} =
W_{ED} =

H_{EF} =
V_{EF} =
W_{EF} =
H_{FE} =
V_{FE} =
W_{FE} =

H_{FG} =
V_{FG} =
W_{FG} =
H_{GF} =
V_{GF} =
W_{GF} =

H_{GH} =
V_{GH} =
W_{GH} =
H_{HG} =
V_{HG} =
W_{HG} =

H_{HI} =
V_{HI} =
W_{HI} =
H_{IH} =
V_{IH} =
W_{IH} =

H_{IJ} =
V_{IJ} =
W_{IJ} =
H_{JI} =
V_{JI} =
W_{JI} =

H_{JK} =
V_{JK} =
W_{JK} =
H_{KJ} =
V_{KJ} =
W_{KJ} =

H_{KL} =
V_{KL} =
W_{KL} =
H_{LK} =
V_{LK} =
W_{LK} =

H_{LM} =
V_{LM} =
W_{LM} =
H_{ML} =
V_{ML} =
W_{ML} =

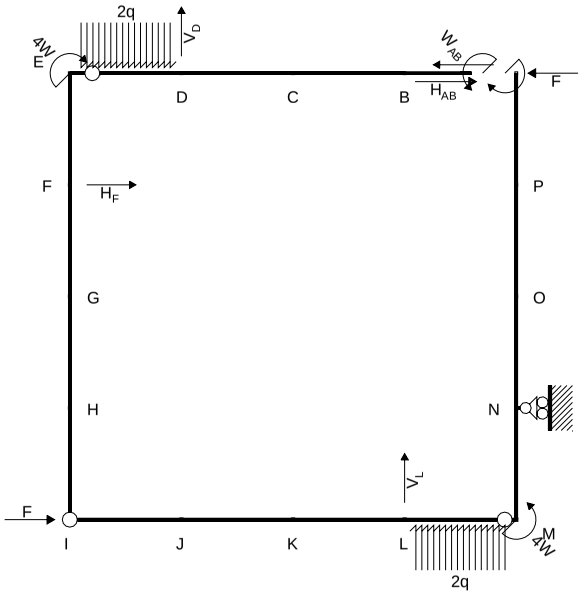
@ Adolfo Zavelani Rossi, Politecnico di Milano

H_{MN} =
V_{MN} =
W_{MN} =
H_{NM} =
V_{NM} =
W_{NM} =

H_{NO} =
V_{NO} =
W_{NO} =
H_{ON} =
V_{ON} =
W_{ON} =

H_{OP} =
V_{OP} =
W_{OP} =
H_{PO} =
V_{PO} =
W_{PO} =

H_{PA} =
V_{PA} =
W_{PA} =
H_{AP} =
V_{AP} =
W_{AP} =



EQUAZIONI DI EQUILIBRIO
Traslazione verticale globale
$V_D + V_L = 0$
Rotazione globale intorno a N
$-3V_D b - 2H_F b - V_L b = -4Fb - 6qb^2$
Rotazione intorno a M: aste ML LK KJ JI IH HG GF FE ED DC CB BA
$-3V_D b - 3H_F b - V_L b - 4H_{AB} b + W_{AB} = 4W - 6qb^2$
Rotazione intorno a I: aste IH HG GF FE ED DC CB BA
$V_D b - 3H_F b - 4H_{AB} b + W_{AB} = 4W + qb^2$
Rotazione intorno a E: aste ED DC CB BA
$V_D b + W_{AB} = qb^2$

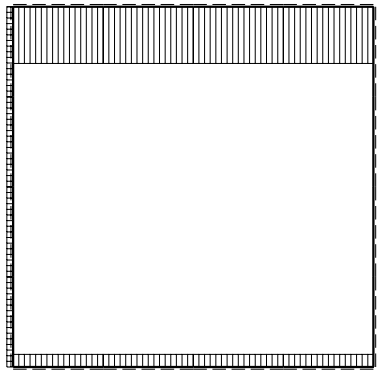
Matrice di equilibrio

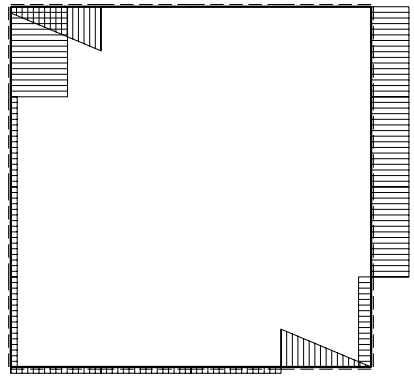
	$V_D b$	$H_F b$	$V_L b$	$H_{AB} b$	W_{AB}		Fb	W	qb^2
v_N	1	0	1	0	0		0	0	0
φ_N	-3	-2	-1	0	0		-4	0	-6
φ_{ML}	-3	-3	-1	-4	1	=	0	4	-6
φ_{IJ}	1	-3	0	-4	1		0	4	1
φ_{ED}	1	0	0	0	1		0	0	1

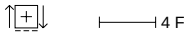
Soluzione del sistema

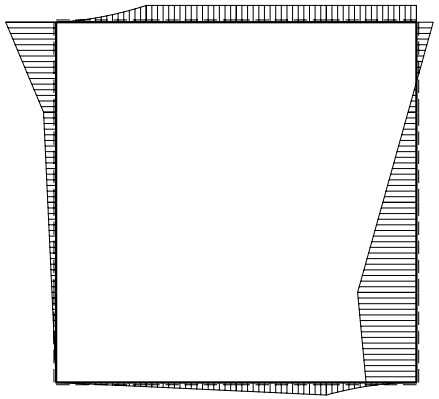
		Fb	W	qb^2
$V_D b$		0	0	7/3
$H_F b$		2	0	2/3
$V_L b$	=	0	0	-7/3
$H_{AB} b$		-3/2	-1	-1/2
W_{AB}		0	0	-4/3

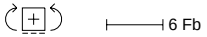
Schema grafico non rappresentabile











REAZIONI

$V_D = 7/3qb = 7/3F$ $H_F = 2F +2/3qb = 8/3F$ $V_L = -7/3qb = -7/3F$ $H_N = -2F -2/3qb = -8/3F$

$H_{AB} = -3/2F -(W/b) -1/2qb = -3F$
$V_{AB} = 0$
$W_{AB} = -4/3qb^2 = -4/3Fb$
$H_{BA} = 3/2F +(W/b) +1/2qb = 3F$
$V_{BA} = 0$
$W_{BA} = 4/3qb^2 = 4/3Fb$

$H_{BC} = -3/2F -(W/b) -1/2qb = -3F$
$V_{BC} = 0$
$W_{BC} = -4/3qb^2 = -4/3Fb$
$H_{CB} = 3/2F +(W/b) +1/2qb = 3F$
$V_{CB} = 0$
$W_{CB} = 4/3qb^2 = 4/3Fb$

$H_{CD} = -3/2F -(W/b) -1/2qb = -3F$
$V_{CD} = 0$
$W_{CD} = -4/3qb^2 = -4/3Fb$
$H_{DC} = 3/2F +(W/b) +1/2qb = 3F$
$V_{DC} = 0$
$W_{DC} = 4/3qb^2 = 4/3Fb$

$H_{DE} = -3/2F -(W/b) -1/2qb = -3F$
$V_{DE} = 7/3qb = 7/3F$
$W_{DE} = -4/3qb^2 = -4/3Fb$
$H_{ED} = 3/2F +(W/b) +1/2qb = 3F$
$V_{ED} = -1/3qb = -1/3F$
$W_{ED} = 0$

$H_{EF} = -3/2F -(W/b) -1/2qb = -3F$
$V_{EF} = 1/3qb = 1/3F$
$W_{EF} = -4W = -4Fb$
$H_{FE} = 3/2F +(W/b) +1/2qb = 3F$
$V_{FE} = -1/3qb = -1/3F$
$W_{FE} = -3/2Fb +3W -1/2qb^2 = Fb$

$H_{FG} = 1/2F -(W/b) +1/6qb = -1/3F$
$V_{FG} = 1/3qb = 1/3F$
$W_{FG} = 3/2Fb -3W +1/2qb^2 = -Fb$
$H_{GF} = -1/2F +(W/b) -1/6qb = 1/3F$
$V_{GF} = -1/3qb = -1/3F$
$W_{GF} = -Fb +2W -1/3qb^2 = 2/3Fb$

$H_{GH} = 1/2F -(W/b) +1/6qb = -1/3F$
$V_{GH} = 1/3qb = 1/3F$
$W_{GH} = Fb -2W +1/3qb^2 = -2/3Fb$
$H_{HG} = -1/2F +(W/b) -1/6qb = 1/3F$
$V_{HG} = -1/3qb = -1/3F$
$W_{HG} = -1/2Fb +W -1/6qb^2 = 1/3Fb$

$H_{HI} = 1/2F -(W/b) +1/6qb = -1/3F$
$V_{HI} = 1/3qb = 1/3F$
$W_{HI} = 1/2Fb -W +1/6qb^2 = -1/3Fb$
$H_{IH} = -1/2F +(W/b) -1/6qb = 1/3F$
$V_{IH} = -1/3qb = -1/3F$
$W_{IH} = 0$

$H_{IJ} = 3/2F -(W/b) +1/6qb = 2/3F$
$V_{IJ} = 1/3qb = 1/3F$
$W_{IJ} = 0$
$H_{JI} = -3/2F +(W/b) -1/6qb = -2/3F$
$V_{JI} = -1/3qb = -1/3F$
$W_{JI} = 1/3qb^2 = 1/3Fb$

$H_{JK} = 3/2F -(W/b) +1/6qb = 2/3F$
$V_{JK} = 1/3qb = 1/3F$
$W_{JK} = -1/3qb^2 = -1/3Fb$
$H_{KJ} = -3/2F +(W/b) -1/6qb = -2/3F$
$V_{KJ} = -1/3qb = -1/3F$
$W_{KJ} = 2/3qb^2 = 2/3Fb$

$H_{KL} = 3/2F -(W/b) +1/6qb = 2/3F$
$V_{KL} = 1/3qb = 1/3F$
$W_{KL} = -2/3qb^2 = -2/3Fb$
$H_{LK} = -3/2F +(W/b) -1/6qb = -2/3F$
$V_{LK} = -1/3qb = -1/3F$
$W_{LK} = qb^2 = Fb$

$H_{LM} = 3/2F -(W/b) +1/6qb = 2/3F$
$V_{LM} = -2qb = -2F$
$W_{LM} = -qb^2 = -Fb$
$H_{ML} = -3/2F +(W/b) -1/6qb = -2/3F$
$V_{ML} = 0$
$W_{ML} = 0$

PROCEDIMENTO E RISULTATI Nome: Es.N.036

$H_{MN} = 3/2F -(W/b) +1/6qb = 2/3F$
$V_{MN} = 0$
$W_{MN} = 4W = 4Fb$
$H_{NM} = -3/2F +(W/b) -1/6qb = -2/3F$
$V_{NM} = 0$
$W_{NM} = -3/2Fb -3W -1/6qb^2 = -14/3Fb$

$H_{NO} = -1/2F -(W/b) -1/2qb = -2F$
$V_{NO} = 0$
$W_{NO} = 3/2Fb +3W +1/6qb^2 = 14/3Fb$
$H_{ON} = 1/2F +(W/b) +1/2qb = 2F$
$V_{ON} = 0$
$W_{ON} = -Fb -2W +1/3qb^2 = -8/3Fb$

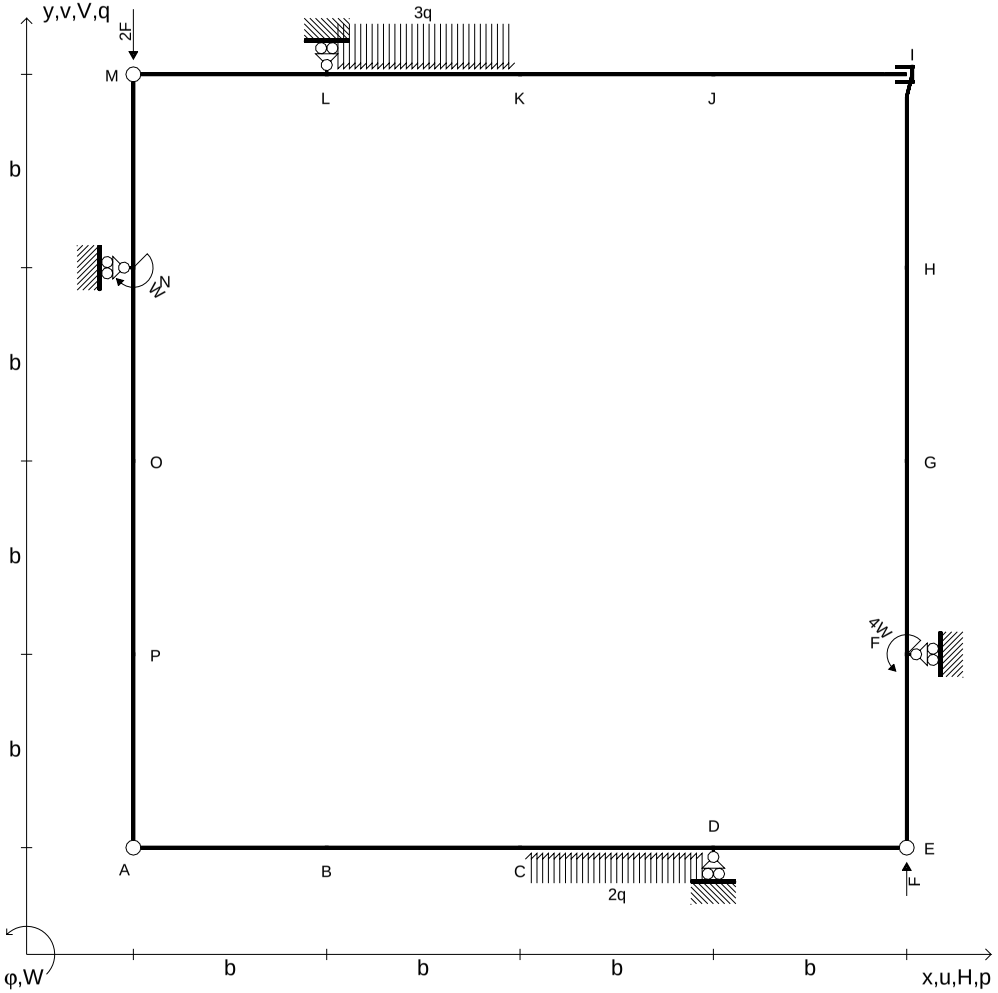
$H_{OP} = -1/2F -(W/b) -1/2qb = -2F$
$V_{OP} = 0$
$W_{OP} = Fb +2W -1/3qb^2 = 8/3Fb$
$H_{PO} = 1/2F +(W/b) +1/2qb = 2F$
$V_{PO} = 0$
$W_{PO} = -1/2Fb -W +5/6qb^2 = -2/3Fb$

$H_{PA} = -1/2F -(W/b) -1/2qb = -2F$
$V_{PA} = 0$
$W_{PA} = 1/2Fb +W -5/6qb^2 = 2/3Fb$
$H_{AP} = 1/2F +(W/b) +1/2qb = 2F$
$V_{AP} = 0$
$W_{AP} = 4/3qb^2 = 4/3Fb$

@ Adolfo Zavelani Rossi, Politecnico di Milano

Es.N.036

@ Adolfo Zavelani Rossi, Politecnico di Milano



$V_E = F$ $W_F = 4W = 4Fb$ $q_{CD} = 2q = 2F/b$

$V_M = -2F$ $W_N = -W = -Fb$ $q_{KL} = -3q = -3F/b$

Svolgere l'analisi cinematica.
Determinare matrice di congruenza e di equilibrio.
Determinare le reazioni vincolari a terra col PLV (Le=0).
Determinare le azioni interne in D col PLV (Le=0).
Carichi e deformazioni date hanno verso efficace in disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.

Schema grafico non rappresentabile

REAZIONI

V_D =
H_F =

V_L =
H_N =

H_{AB} =
V_{AB} =
W_{AB} =
H_{BA} =
V_{BA} =
W_{BA} =

H_{BC} =
V_{BC} =
W_{BC} =
H_{CB} =
V_{CB} =
W_{CB} =

H_{CD} =
V_{CD} =
W_{CD} =
H_{DC} =
V_{DC} =
W_{DC} =

H_{DE} =
V_{DE} =
W_{DE} =
H_{ED} =
V_{ED} =
W_{ED} =

H_{EF} =
V_{EF} =
W_{EF} =
H_{FE} =
V_{FE} =
W_{FE} =

H_{FG} =
V_{FG} =
W_{FG} =
H_{GF} =
V_{GF} =
W_{GF} =

H_{GH} =
V_{GH} =
W_{GH} =
H_{HG} =
V_{HG} =
W_{HG} =

H_{HI} =
V_{HI} =
W_{HI} =
H_{IH} =
V_{IH} =
W_{IH} =

H_{IJ} =
V_{IJ} =
W_{IJ} =
H_{JI} =
V_{JI} =
W_{JI} =

H_{JK} =
V_{JK} =
W_{JK} =
H_{KJ} =
V_{KJ} =
W_{KJ} =

H_{KL} =
V_{KL} =
W_{KL} =
H_{LK} =
V_{LK} =
W_{LK} =

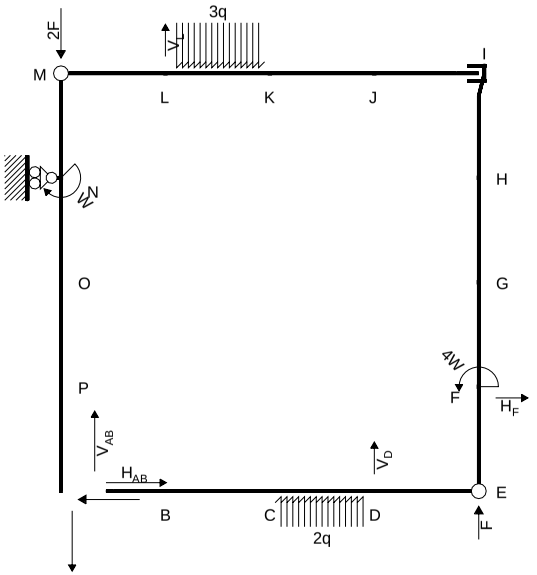
H_{LM} =
V_{LM} =
W_{LM} =
H_{ML} =
V_{ML} =
W_{ML} =

H_{MN} =
V_{MN} =
W_{MN} =
H_{NM} =
V_{NM} =
W_{NM} =

H_{NO} =
V_{NO} =
W_{NO} =
H_{ON} =
V_{ON} =
W_{ON} =

H_{OP} =
V_{OP} =
W_{OP} =
H_{PO} =
V_{PO} =
W_{PO} =

H_{PA} =
V_{PA} =
W_{PA} =
H_{AP} =
V_{AP} =
W_{AP} =



EQUAZIONI DI EQUILIBRIO
Traslazione verticale globale
$V_D + V_L = F + qb$
Rotazione globale intorno a N
$3V_D b + 2H_F b + V_L b = -4Fb - 3W - 1/2qb^2$
Rotazione intorno a M: aste ML LK KJ JI IH HG GF FE ED DC CB BA
$3V_D b + 3H_F b + V_L b + 4H_{AB} b = -4Fb - 4W - 1/2qb^2$
Traslazione orizzontale: aste IH HG GF FE ED DC CB BA
$H_F + H_{AB} = 0$
Rotazione intorno a E: aste ED DC CB BA
$-V_D b - 4V_{AB} b = 3qb^2$

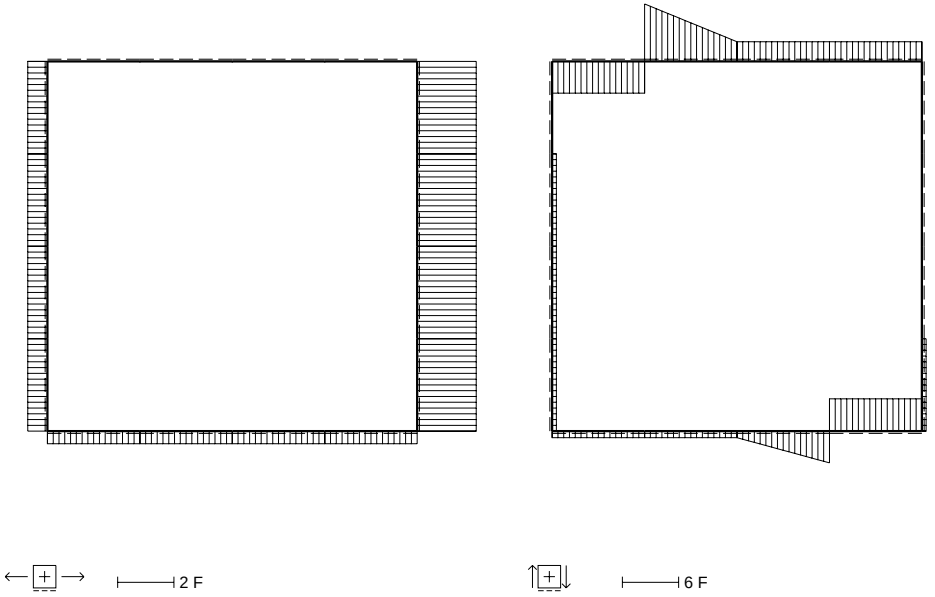
Matrice di equilibrio

	$V_D b$	$H_F b$	$V_L b$	$H_{AB} b$	$V_{AB} b$		Fb	W	qb^2
v_N	1	0	1	0	0		1	0	1
φ_N	3	2	1	0	0		-4	-3	-1/2
φ_{ML}	3	3	1	4	0	=	-4	-4	-1/2
u_{IJ}	0	1	0	1	0		0	0	0
φ_{ED}	-1	0	0	0	-4		0	0	3

Soluzione del sistema

		Fb	W	qb^2
$V_D b$		-5/2	-11/6	-3/4
$H_F b$		0	1/3	0
$V_L b$	=	7/2	11/6	7/4
$H_{AB} b$		0	-1/3	0
$V_{AB} b$		5/8	11/24	-9/16

Schema grafico non rappresentabile



REAZIONI

$V_D = -5/2F -11/6(W/b) -3/4qb = -61/12F$
$V_L = 7/2F +11/6(W/b) +7/4qb = 85/12F$
$H_F = 1/3(W/b) = 1/3F$
$H_N = -1/3(W/b) = -1/3F$

$H_{AB} = -1/3(W/b) = -1/3F$
$V_{AB} = 5/8F +11/24(W/b) -9/16qb = 25/48F$
$W_{AB} = 0$
$H_{BA} = 1/3(W/b) = 1/3F$
$V_{BA} = -5/8F -11/24(W/b) +9/16qb = -25/48F$
$W_{BA} = 5/8Fb +11/24W -9/16qb^2 = 25/48Fb$

$H_{BC} = -1/3(W/b) = -1/3F$
$V_{BC} = 5/8F +11/24(W/b) -9/16qb = 25/48F$
$W_{BC} = -5/8Fb -11/24W +9/16qb^2 = -25/48Fb$
$H_{CB} = 1/3(W/b) = 1/3F$
$V_{CB} = -5/8F -11/24(W/b) +9/16qb = -25/48F$
$W_{CB} = 5/4Fb +11/12W -9/8qb^2 = 25/24Fb$

$H_{CD} = -1/3(W/b) = -1/3F$
$V_{CD} = 5/8F +11/24(W/b) -9/16qb = 25/48F$
$W_{CD} = -5/4Fb -11/12W +9/8qb^2 = -25/24Fb$
$H_{DC} = 1/3(W/b) = 1/3F$
$V_{DC} = -5/8F -11/24(W/b) -23/16qb = -121/48F$
$W_{DC} = 15/8Fb +11/8W -11/16qb^2 = 41/16Fb$

$H_{DE} = -1/3(W/b) = -1/3F$
$V_{DE} = -15/8F -11/8(W/b) +11/16qb = -41/16F$
$W_{DE} = -15/8Fb -11/8W +11/16qb^2 = -41/16Fb$
$H_{ED} = 1/3(W/b) = 1/3F$
$V_{ED} = 15/8F +11/8(W/b) -11/16qb = 41/16F$
$W_{ED} = 0$

$H_{EF} = -1/3(W/b) = -1/3F$
$V_{EF} = -7/8F -11/8(W/b) +11/16qb = -25/16F$
$W_{EF} = 0$
$H_{FE} = 1/3(W/b) = 1/3F$
$V_{FE} = 7/8F +11/8(W/b) -11/16qb = 25/16F$
$W_{FE} = 1/3W = 1/3Fb$

$H_{FG} = 0$
$V_{FG} = -7/8F -11/8(W/b) +11/16qb = -25/16F$
$W_{FG} = 11/3W = 11/3Fb$
$H_{GF} = 0$
$V_{GF} = 7/8F +11/8(W/b) -11/16qb = 25/16F$
$W_{GF} = -11/3W = -11/3Fb$

$H_{GH} = 0$
$V_{GH} = -7/8F -11/8(W/b) +11/16qb = -25/16F$
$W_{GH} = 11/3W = 11/3Fb$
$H_{HG} = 0$
$V_{HG} = 7/8F +11/8(W/b) -11/16qb = 25/16F$
$W_{HG} = -11/3W = -11/3Fb$

$H_{HI} = 0$
$V_{HI} = -7/8F -11/8(W/b) +11/16qb = -25/16F$
$W_{HI} = 11/3W = 11/3Fb$
$H_{IH} = 0$
$V_{IH} = 7/8F +11/8(W/b) -11/16qb = 25/16F$
$W_{IH} = -11/3W = -11/3Fb$

$H_{IJ} = 0$
$V_{IJ} = -7/8F -11/8(W/b) +11/16qb = -25/16F$
$W_{IJ} = 11/3W = 11/3Fb$
$H_{JI} = 0$
$V_{JI} = 7/8F +11/8(W/b) -11/16qb = 25/16F$
$W_{JI} = 7/8Fb -55/24W -11/16qb^2 = -101/48Fb$

$H_{JK} = 0$
$V_{JK} = -7/8F -11/8(W/b) +11/16qb = -25/16F$
$W_{JK} = -7/8Fb +55/24W +11/16qb^2 = 101/48Fb$
$H_{KJ} = 0$
$V_{KJ} = 7/8F +11/8(W/b) -11/16qb = 25/16F$
$W_{KJ} = 7/4Fb -11/12W -11/8qb^2 = -13/24Fb$

PROCEDIMENTO E RISULTATI Nome: Es.N.037

$H_{KL} = 0$
$V_{KL} = -7/8F -11/8(W/b) +11/16qb = -25/16F$
$W_{KL} = -7/4Fb +11/12W +11/8qb^2 = 13/24Fb$
$H_{LK} = 0$
$V_{LK} = 7/8F +11/8(W/b) +37/16qb = 73/16F$
$W_{LK} = 21/8Fb +11/24W -9/16qb^2 = 121/48Fb$

$H_{LM} = 0$
$V_{LM} = 21/8F +11/24(W/b) -9/16qb = 121/48F$
$W_{LM} = -21/8Fb -11/24W +9/16qb^2 = -121/48Fb$
$H_{ML} = 0$
$V_{ML} = -21/8F -11/24(W/b) +9/16qb = -121/48F$
$W_{ML} = 0$

$H_{MN} = 0$
$V_{MN} = 5/8F +11/24(W/b) -9/16qb = 25/48F$
$W_{MN} = 0$
$H_{NM} = 0$
$V_{NM} = -5/8F -11/24(W/b) +9/16qb = -25/48F$
$W_{NM} = 0$

$H_{NO} = -1/3(W/b) = -1/3F$
$V_{NO} = 5/8F +11/24(W/b) -9/16qb = 25/48F$
$W_{NO} = -W = -Fb$
$H_{ON} = 1/3(W/b) = 1/3F$
$V_{ON} = -5/8F -11/24(W/b) +9/16qb = -25/48F$
$W_{ON} = 2/3W = 2/3Fb$

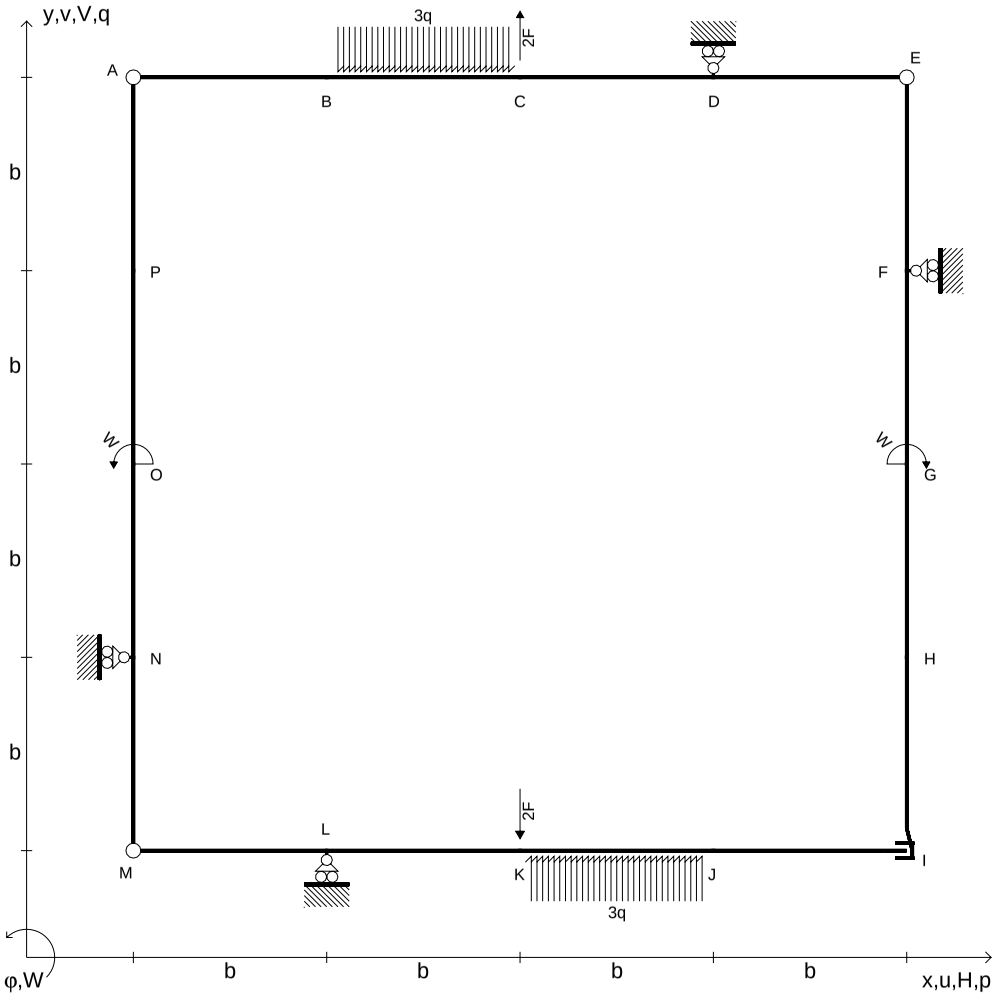
$H_{OP} = -1/3(W/b) = -1/3F$
$V_{OP} = 5/8F +11/24(W/b) -9/16qb = 25/48F$
$W_{OP} = -2/3W = -2/3Fb$
$H_{PO} = 1/3(W/b) = 1/3F$
$V_{PO} = -5/8F -11/24(W/b) +9/16qb = -25/48F$
$W_{PO} = 1/3W = 1/3Fb$

$H_{PA} = -1/3(W/b) = -1/3F$
$V_{PA} = 5/8F +11/24(W/b) -9/16qb = 25/48F$
$W_{PA} = -1/3W = -1/3Fb$
$H_{AP} = 1/3(W/b) = 1/3F$
$V_{AP} = -5/8F -11/24(W/b) +9/16qb = -25/48F$
$W_{AP} = 0$

@ Adolfo Zavelani Rossi, Politecnico di Milano

Es.N.037

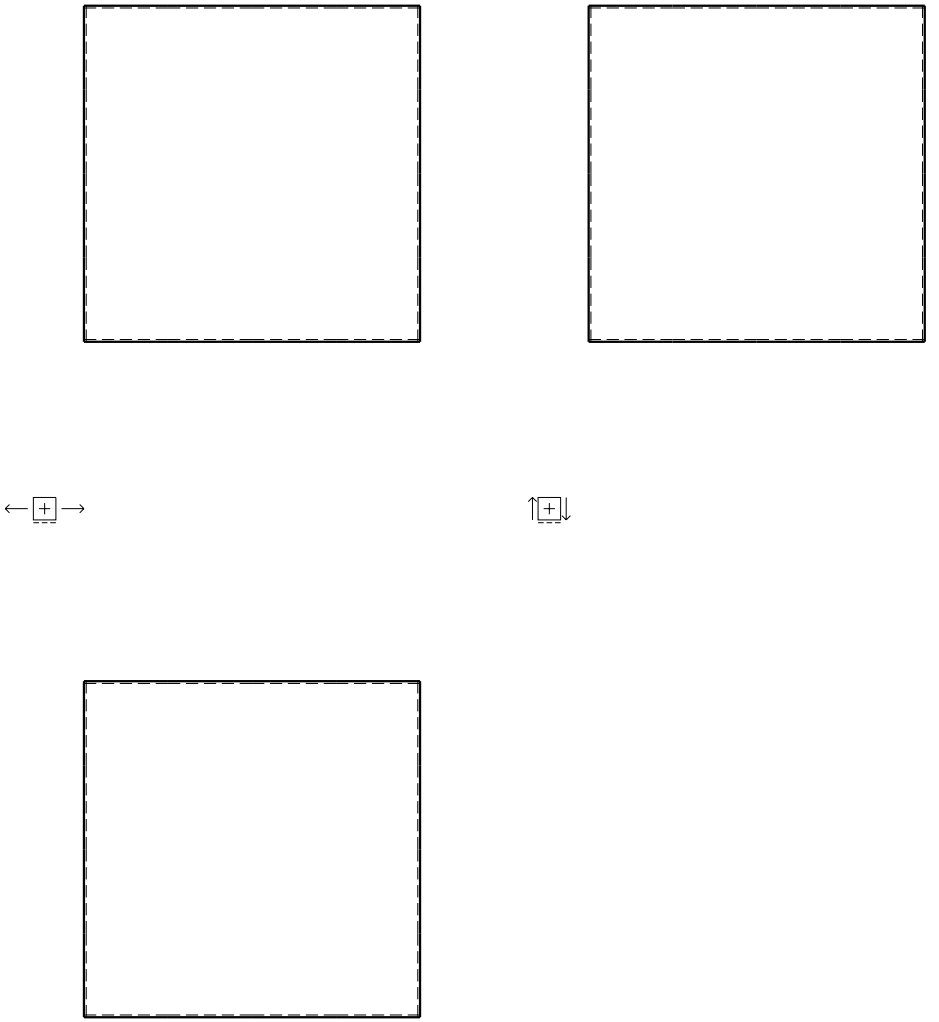
@ Adolfo Zavelani Rossi, Politecnico di Milano



$V_K = -2F$ $W_G = -W = -Fb$ $q_{BC} = -3q = -3F/b$

$V_C = 2F$ $W_O = W = Fb$ $q_{JK} = 3q = 3F/b$

Svolgere l'analisi cinematica.
Determinare matrice di congruenza e di equilibrio.
Determinare le reazioni vincolari a terra col PLV (Le=0).
Determinare le azioni interne in D col PLV (Le=0).
Carichi e deformazioni date hanno verso efficace in disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.



Schema grafico non rappresentabile

REAZIONI

V_D = V_L =

H_F = H_N =

H_{AB} = H_{BC} =

V_{AB} = V_{BC} =

W_{AB} = W_{BC} =

H_{BA} = H_{CB} =

V_{BA} = V_{CB} =

W_{BA} = W_{CB} =

H_{CD} = H_{DE} =

V_{CD} = V_{DE} =

W_{CD} = W_{DE} =

H_{DC} = H_{ED} =

V_{DC} = V_{ED} =

W_{DC} = W_{ED} =

H_{EF} = H_{FG} =

V_{EF} = V_{FG} =

W_{EF} = W_{FG} =

H_{FE} = H_{GF} =

V_{FE} = V_{GF} =

W_{FE} = W_{GF} =

H_{GH} = H_{HI} =

V_{GH} = V_{HI} =

W_{GH} = W_{HI} =

H_{HG} = H_{IH} =

V_{HG} = V_{IH} =

W_{HG} = W_{IH} =

H_{IJ} = H_{JK} =

V_{IJ} = V_{JK} =

W_{IJ} = W_{JK} =

H_{JI} = H_{KJ} =

V_{JI} = V_{KJ} =

W_{JI} = W_{KJ} =

H_{KL} =
V_{KL} =
W_{KL} =
H_{LK} =
V_{LK} =
W_{LK} =

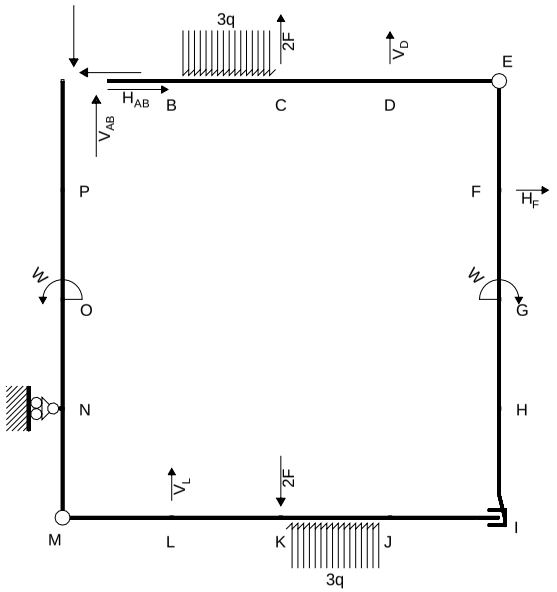
H_{LM} =
V_{LM} =
W_{LM} =
H_{ML} =
V_{ML} =
W_{ML} =

H_{MN} =
V_{MN} =
W_{MN} =
H_{NM} =
V_{NM} =
W_{NM} =

H_{NO} =
V_{NO} =
W_{NO} =
H_{ON} =
V_{ON} =
W_{ON} =

H_{OP} =
V_{OP} =
W_{OP} =
H_{PO} =
V_{PO} =
W_{PO} =

H_{PA} =
V_{PA} =
W_{PA} =
H_{AP} =
V_{AP} =
W_{AP} =



EQUAZIONI DI EQUILIBRIO
Traslazione verticale globale
$V_D + V_L = 0$
Rotazione globale intorno a N
$3V_Db - 2H_Fb + V_Lb = -3qb^2$
Rotazione intorno a M: aste ML LK KJ JI IH HG GF FE ED DC CB BA
$3V_Db - 3H_Fb + V_Lb - 4H_{AB}b = W - 3qb^2$
Traslazione orizzontale: aste IH HG GF FE ED DC CB BA
$H_F + H_{AB} = 0$
Rotazione intorno a E: aste ED DC CB BA
$-V_Db - 4V_{AB}b = 4Fb - 15/2qb^2$

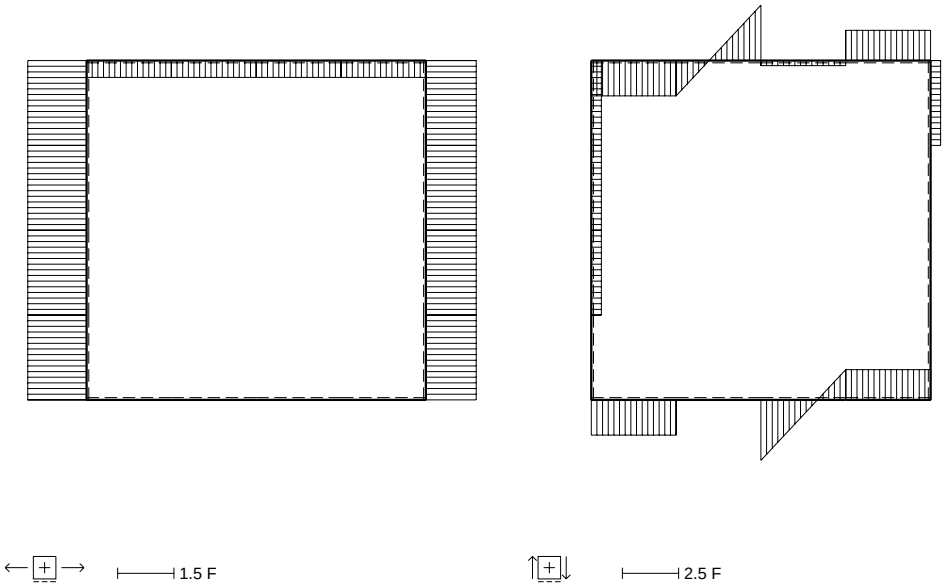
Matrice di equilibrio

	V_Db	H_Fb	V_Lb	$H_{AB}b$	$V_{AB}b$		Fb	W	qb^2
v_N	1	0	1	0	0		0	0	0
φ_N	3	-2	1	0	0		0	0	-3
φ_{ML}	3	-3	1	-4	0	=	0	1	-3
u_{IJ}	0	1	0	1	0		0	0	0
φ_{ED}	-1	0	0	0	-4		4	0	-15/2

Soluzione del sistema

		Fb	W	qb^2
V_Db		0	1/3	-3/2
H_Fb		0	1/3	0
V_Lb	=	0	-1/3	3/2
$H_{AB}b$		0	-1/3	0
$V_{AB}b$		-1	-1/12	9/4

Schema grafico non rappresentabile



REAZIONI

$V_D = 1/3(W/b) - 3/2qb = -7/6F$ $V_L = -1/3(W/b) + 3/2qb = 7/6F$

$H_F = 1/3(W/b) = 1/3F$ $H_N = -1/3(W/b) = -1/3F$

$H_{AB} = -1/3(W/b) = -1/3F$
$V_{AB} = -F - 1/12(W/b) + 9/4qb = 7/6F$
$W_{AB} = 0$
$H_{BA} = 1/3(W/b) = 1/3F$
$V_{BA} = F + 1/12(W/b) - 9/4qb = -7/6F$
$W_{BA} = -Fb - 1/12W + 9/4qb^2 = 7/6Fb$

$H_{BC} = -1/3(W/b) = -1/3F$
$V_{BC} = -F - 1/12(W/b) + 9/4qb = 7/6F$
$W_{BC} = Fb + 1/12W - 9/4qb^2 = -7/6Fb$
$H_{CB} = 1/3(W/b) = 1/3F$
$V_{CB} = F + 1/12(W/b) + 3/4qb = 11/6F$
$W_{CB} = -2Fb - 1/6W + 3qb^2 = 5/6Fb$

$H_{CD} = -1/3(W/b) = -1/3F$
$V_{CD} = F - 1/12(W/b) - 3/4qb = 1/6F$
$W_{CD} = 2Fb + 1/6W - 3qb^2 = -5/6Fb$
$H_{DC} = 1/3(W/b) = 1/3F$
$V_{DC} = -F + 1/12(W/b) + 3/4qb = -1/6F$
$W_{DC} = -Fb - 1/4W + 9/4qb^2 = Fb$

$H_{DE} = -1/3(W/b) = -1/3F$
$V_{DE} = F + 1/4(W/b) - 9/4qb = -F$
$W_{DE} = Fb + 1/4W - 9/4qb^2 = -Fb$
$H_{ED} = 1/3(W/b) = 1/3F$
$V_{ED} = -F - 1/4(W/b) + 9/4qb = F$
$W_{ED} = 0$

$H_{EF} = -1/3(W/b) = -1/3F$
$V_{EF} = F + 1/4(W/b) - 9/4qb = -F$
$W_{EF} = 0$
$H_{FE} = 1/3(W/b) = 1/3F$
$V_{FE} = -F - 1/4(W/b) + 9/4qb = F$
$W_{FE} = -1/3W = -1/3Fb$

$H_{FG} = 0$
$V_{FG} = F + 1/4(W/b) - 9/4qb = -F$
$W_{FG} = 1/3W = 1/3Fb$
$H_{GF} = 0$
$V_{GF} = -F - 1/4(W/b) + 9/4qb = F$
$W_{GF} = -1/3W = -1/3Fb$

$H_{GH} = 0$
$V_{GH} = F + 1/4(W/b) - 9/4qb = -F$
$W_{GH} = -2/3W = -2/3Fb$
$H_{HG} = 0$
$V_{HG} = -F - 1/4(W/b) + 9/4qb = F$
$W_{HG} = 2/3W = 2/3Fb$

$H_{HI} = 0$
$V_{HI} = F + 1/4(W/b) - 9/4qb = -F$
$W_{HI} = -2/3W = -2/3Fb$
$H_{IH} = 0$
$V_{IH} = -F - 1/4(W/b) + 9/4qb = F$
$W_{IH} = 2/3W = 2/3Fb$

$H_{IJ} = 0$
$V_{IJ} = F + 1/4(W/b) - 9/4qb = -F$
$W_{IJ} = -2/3W = -2/3Fb$
$H_{JI} = 0$
$V_{JI} = -F - 1/4(W/b) + 9/4qb = F$
$W_{JI} = -Fb + 5/12W + 9/4qb^2 = 5/3Fb$

$H_{JK} = 0$
$V_{JK} = F + 1/4(W/b) - 9/4qb = -F$
$W_{JK} = Fb - 5/12W - 9/4qb^2 = -5/3Fb$
$H_{KJ} = 0$
$V_{KJ} = -F - 1/4(W/b) - 3/4qb = -2F$
$W_{KJ} = -2Fb + 1/6W + 3qb^2 = 7/6Fb$

PROCEDIMENTO E RISULTATI Nome: Es.N.038

$H_{KL} = 0$
$V_{KL} = -F + 1/4(W/b) + 3/4qb = 0$
$W_{KL} = 2Fb - 1/6W - 3qb^2 = -7/6Fb$
$H_{LK} = 0$
$V_{LK} = F - 1/4(W/b) - 3/4qb = 0$
$W_{LK} = -Fb - 1/12W + 9/4qb^2 = 7/6Fb$

$H_{LM} = 0$
$V_{LM} = -F - 1/12(W/b) + 9/4qb = 7/6F$
$W_{LM} = Fb + 1/12W - 9/4qb^2 = -7/6Fb$
$H_{ML} = 0$
$V_{ML} = F + 1/12(W/b) - 9/4qb = -7/6F$
$W_{ML} = 0$

$H_{MN} = 0$
$V_{MN} = -F - 1/12(W/b) + 9/4qb = 7/6F$
$W_{MN} = 0$
$H_{NM} = 0$
$V_{NM} = F + 1/12(W/b) - 9/4qb = -7/6F$
$W_{NM} = 0$

$H_{NO} = -1/3(W/b) = -1/3F$
$V_{NO} = -F - 1/12(W/b) + 9/4qb = 7/6F$
$W_{NO} = 0$
$H_{ON} = 1/3(W/b) = 1/3F$
$V_{ON} = F + 1/12(W/b) - 9/4qb = -7/6F$
$W_{ON} = 1/3W = 1/3Fb$

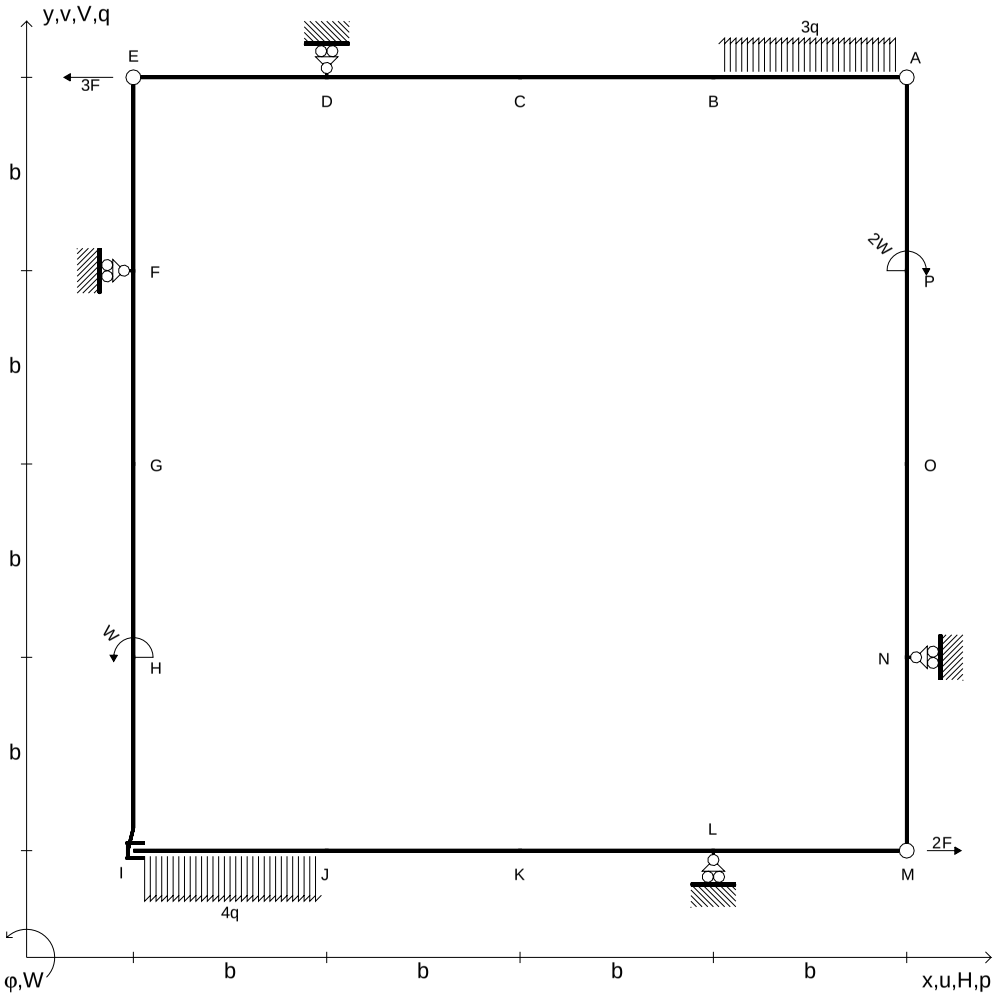
$H_{OP} = -1/3(W/b) = -1/3F$
$V_{OP} = -F - 1/12(W/b) + 9/4qb = 7/6F$
$W_{OP} = 2/3W = 2/3Fb$
$H_{PO} = 1/3(W/b) = 1/3F$
$V_{PO} = F + 1/12(W/b) - 9/4qb = -7/6F$
$W_{PO} = -1/3W = -1/3Fb$

$H_{PA} = -1/3(W/b) = -1/3F$
$V_{PA} = -F - 1/12(W/b) + 9/4qb = 7/6F$
$W_{PA} = 1/3W = 1/3Fb$
$H_{AP} = 1/3(W/b) = 1/3F$
$V_{AP} = F + 1/12(W/b) - 9/4qb = -7/6F$
$W_{AP} = 0$

@ Adolfo Zavelani Rossi, Politecnico di Milano

Es.N.038

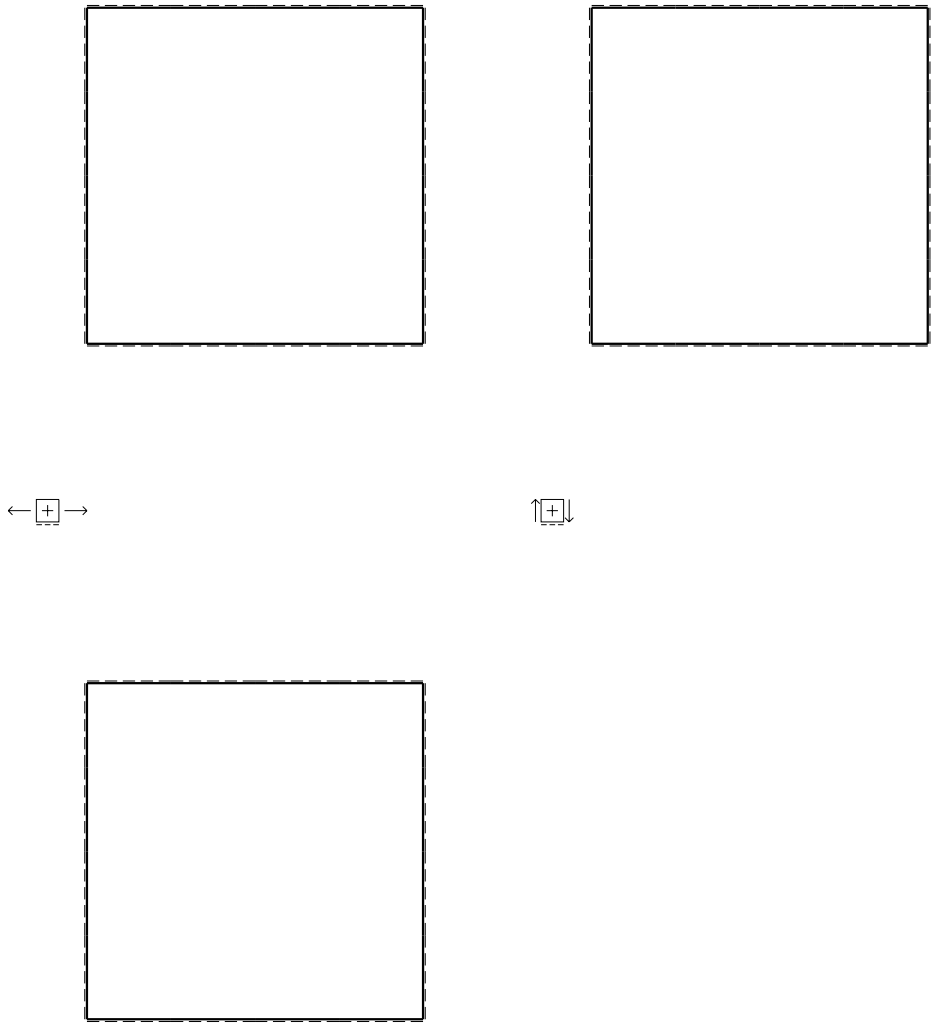
@ Adolfo Zavelani Rossi, Politecnico di Milano



$H_M = 2F$ $W_H = W = Fb$ $q_{AB} = 3q = 3F/b$

$H_E = -3F$ $W_P = -2W = -2Fb$ $q_{IJ} = -4q = -4F/b$

Svolgere l'analisi cinematica.
Determinare matrice di congruenza e di equilibrio.
Determinare le reazioni vincolari a terra col PLV (Le=0).
Determinare le azioni interne in D col PLV (Le=0).
Carichi e deformazioni date hanno verso efficace in disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.



Schema grafico non rappresentabile

REAZIONI

V_D =
H_F =

V_L =
H_N =

H_{AB} =
V_{AB} =
W_{AB} =
H_{BA} =
V_{BA} =
W_{BA} =

H_{BC} =
V_{BC} =
W_{BC} =
H_{CB} =
V_{CB} =
W_{CB} =

H_{CD} =
V_{CD} =
W_{CD} =
H_{DC} =
V_{DC} =
W_{DC} =

H_{DE} =
V_{DE} =
W_{DE} =
H_{ED} =
V_{ED} =
W_{ED} =

H_{EF} =
V_{EF} =
W_{EF} =
H_{FE} =
V_{FE} =
W_{FE} =

H_{FG} =
V_{FG} =
W_{FG} =
H_{GF} =
V_{GF} =
W_{GF} =

H_{GH} =
V_{GH} =
W_{GH} =
H_{HG} =
V_{HG} =
W_{HG} =

H_{HI} =
V_{HI} =
W_{HI} =
H_{IH} =
V_{IH} =
W_{IH} =

H_{IJ} =
V_{IJ} =
W_{IJ} =
H_{JI} =
V_{JI} =
W_{JI} =

H_{JK} =
V_{JK} =
W_{JK} =
H_{KJ} =
V_{KJ} =
W_{KJ} =

H_{KL} =
V_{KL} =
W_{KL} =
H_{LK} =
V_{LK} =
W_{LK} =

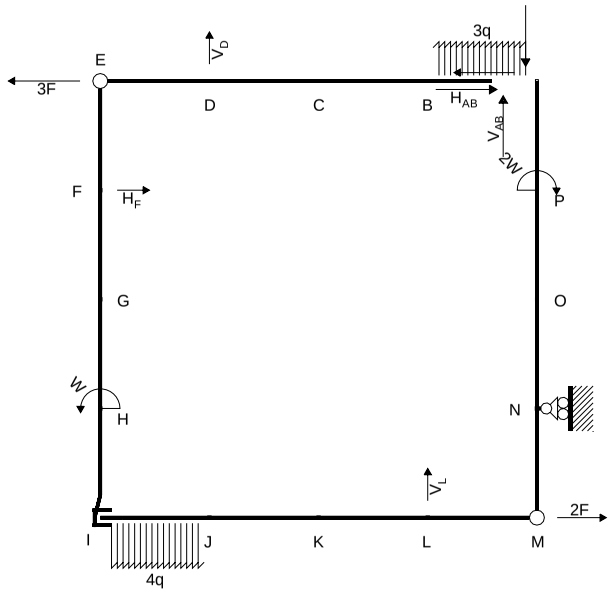
H_{LM} =
V_{LM} =
W_{LM} =
H_{ML} =
V_{ML} =
W_{ML} =

H_{MN} =
V_{MN} =
W_{MN} =
H_{NM} =
V_{NM} =
W_{NM} =

H_{NO} =
V_{NO} =
W_{NO} =
H_{ON} =
V_{ON} =
W_{ON} =

H_{OP} =
V_{OP} =
W_{OP} =
H_{PO} =
V_{PO} =
W_{PO} =

H_{PA} =
V_{PA} =
W_{PA} =
H_{AP} =
V_{AP} =
W_{AP} =



EQUAZIONI DI EQUILIBRIO
Traslazione verticale globale
$V_D + V_L = qb$
Rotazione globale intorno a N
$-3V_Db - 2H_Fb - V_Lb = -11Fb + W - 25/2qb^2$
Rotazione intorno a M: aste ML LK KJ JI IH HG GF FE ED DC CB BA
$-3V_Db - 3H_Fb - V_Lb - 4H_{AB}b = -12Fb - W - 25/2qb^2$
Traslazione orizzontale: aste IH HG GF FE ED DC CB BA
$H_F + H_{AB} = 3F$
Rotazione intorno a E: aste ED DC CB BA
$V_Db + 4V_{AB}b = -21/2qb^2$

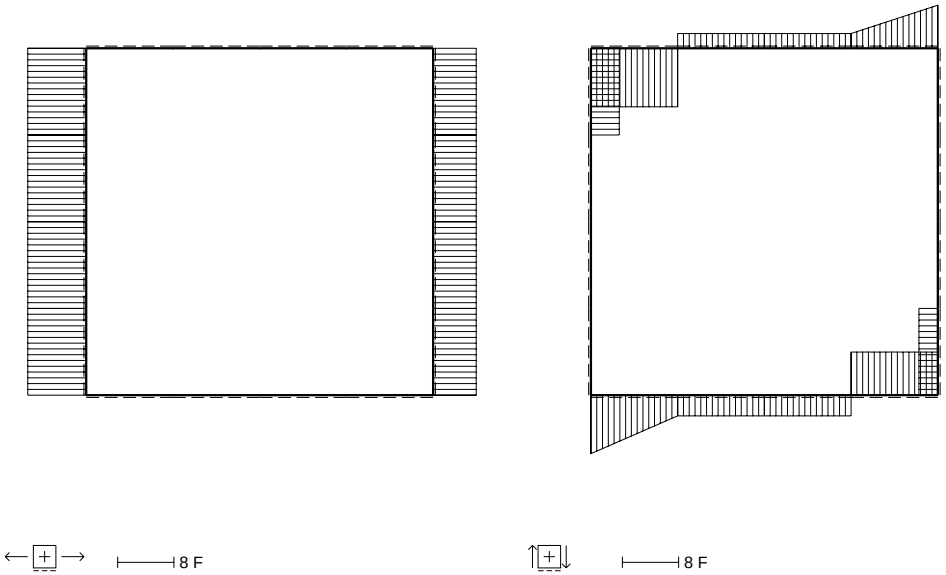
Matrice di equilibrio

$$\begin{array}{c} \\ v_N \\ \varphi_N \\ \varphi_{ML} \\ u_{IJ} \\ \varphi_{ED} \end{array} \begin{bmatrix} V_Db & H_Fb & V_Lb & H_{AB}b & V_{AB}b \\ 1 & 0 & 1 & 0 & 0 \\ -3 & -2 & -1 & 0 & 0 \\ -3 & -3 & -1 & -4 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 4 \end{bmatrix} = \begin{bmatrix} Fb & W & qb^2 \\ 0 & 0 & 1 \\ -11 & 1 & -25/2 \\ -12 & -1 & -25/2 \\ 3 & 0 & 0 \\ 0 & 0 & -21/2 \end{bmatrix}$$

Soluzione del sistema

$$\begin{bmatrix} V_Db \\ H_Fb \\ V_Lb \\ H_{AB}b \\ V_{AB}b \end{bmatrix} = \begin{bmatrix} Fb & W & qb^2 \\ 11/6 & 1/6 & 23/4 \\ 11/3 & -2/3 & 0 \\ -11/6 & -1/6 & -19/4 \\ -2/3 & 2/3 & 0 \\ -11/24 & -1/24 & -65/16 \end{bmatrix}$$

Schema grafico non rappresentabile



REAZIONI

$V_D = 11/6F +1/6(W/b) +23/4qb = 31/4F$
$V_L = -11/6F -1/6(W/b) -19/4qb = -27/4F$
$H_F = 11/3F -2/3(W/b) = 3F$
$H_N = -8/3F +2/3(W/b) = -2F$

$H_{AB} = -2/3F +2/3(W/b) = 0$
$V_{AB} = -11/24F -1/24(W/b) -65/16qb = -73/16F$
$W_{AB} = 0$
$H_{BA} = 2/3F -2/3(W/b) = 0$
$V_{BA} = 11/24F +1/24(W/b) +17/16qb = 25/16F$
$W_{BA} = 11/24Fb +1/24W +41/16qb^2 = 49/16Fb$

$H_{BC} = -2/3F +2/3(W/b) = 0$
$V_{BC} = -11/24F -1/24(W/b) -17/16qb = -25/16F$
$W_{BC} = -11/24Fb -1/24W -41/16qb^2 = -49/16Fb$
$H_{CB} = 2/3F -2/3(W/b) = 0$
$V_{CB} = 11/24F +1/24(W/b) +17/16qb = 25/16F$
$W_{CB} = 11/12Fb +1/12W +29/8qb^2 = 37/8Fb$

$H_{CD} = -2/3F +2/3(W/b) = 0$
$V_{CD} = -11/24F -1/24(W/b) -17/16qb = -25/16F$
$W_{CD} = -11/12Fb -1/12W -29/8qb^2 = -37/8Fb$
$H_{DC} = 2/3F -2/3(W/b) = 0$
$V_{DC} = 11/24F +1/24(W/b) +17/16qb = 25/16F$
$W_{DC} = 11/8Fb +1/8W +75/16qb^2 = 99/16Fb$

$H_{DE} = -2/3F +2/3(W/b) = 0$
$V_{DE} = 11/8F +1/8(W/b) +75/16qb = 99/16F$
$W_{DE} = -11/8Fb -1/8W -75/16qb^2 = -99/16Fb$
$H_{ED} = 2/3F -2/3(W/b) = 0$
$V_{ED} = -11/8F -1/8(W/b) -75/16qb = -99/16F$
$W_{ED} = 0$

$H_{EF} = -11/3F +2/3(W/b) = -3F$
$V_{EF} = 11/8F +1/8(W/b) +75/16qb = 99/16F$
$W_{EF} = 0$
$H_{FE} = 11/3F -2/3(W/b) = 3F$
$V_{FE} = -11/8F -1/8(W/b) -75/16qb = -99/16F$
$W_{FE} = -11/3Fb +2/3W = -3Fb$

$H_{FG} = 0$
$V_{FG} = 11/8F +1/8(W/b) +75/16qb = 99/16F$
$W_{FG} = 11/3Fb -2/3W = 3Fb$
$H_{GF} = 0$
$V_{GF} = -11/8F -1/8(W/b) -75/16qb = -99/16F$
$W_{GF} = -11/3Fb +2/3W = -3Fb$

$H_{GH} = 0$
$V_{GH} = 11/8F +1/8(W/b) +75/16qb = 99/16F$
$W_{GH} = 11/3Fb -2/3W = 3Fb$
$H_{HG} = 0$
$V_{HG} = -11/8F -1/8(W/b) -75/16qb = -99/16F$
$W_{HG} = -11/3Fb +2/3W = -3Fb$

$H_{HI} = 0$
$V_{HI} = 11/8F +1/8(W/b) +75/16qb = 99/16F$
$W_{HI} = 11/3Fb +1/3W = 4Fb$
$H_{IH} = 0$
$V_{IH} = -11/8F -1/8(W/b) -75/16qb = -99/16F$
$W_{IH} = -11/3Fb -1/3W = -4Fb$

$H_{IJ} = 0$
$V_{IJ} = 11/8F +1/8(W/b) +75/16qb = 99/16F$
$W_{IJ} = 11/3Fb +1/3W = 4Fb$
$H_{JI} = 0$
$V_{JI} = -11/8F -1/8(W/b) -11/16qb = -35/16F$
$W_{JI} = -55/24Fb -5/24W +43/16qb^2 = 3/16Fb$

$H_{JK} = 0$
$V_{JK} = 11/8F +1/8(W/b) +11/16qb = 35/16F$
$W_{JK} = 55/24Fb +5/24W -43/16qb^2 = -3/16Fb$
$H_{KJ} = 0$
$V_{KJ} = -11/8F -1/8(W/b) -11/16qb = -35/16F$
$W_{KJ} = -11/12Fb -1/12W +27/8qb^2 = 19/8Fb$

PROCEDIMENTO E RISULTATI Nome: Es.N.039

$H_{KL} = 0$
$V_{KL} = 11/8F +1/8(W/b) +11/16qb = 35/16F$
$W_{KL} = 11/12Fb +1/12W -27/8qb^2 = -19/8Fb$
$H_{LK} = 0$
$V_{LK} = -11/8F -1/8(W/b) -11/16qb = -35/16F$
$W_{LK} = 11/24Fb +1/24W +65/16qb^2 = 73/16Fb$

$H_{LM} = 0$
$V_{LM} = -11/24F -1/24(W/b) -65/16qb = -73/16F$
$W_{LM} = -11/24Fb -1/24W -65/16qb^2 = -73/16Fb$
$H_{ML} = 0$
$V_{ML} = 11/24F +1/24(W/b) +65/16qb = 73/16F$
$W_{ML} = 0$

$H_{MN} = 2F = 2F$
$V_{MN} = -11/24F -1/24(W/b) -65/16qb = -73/16F$
$W_{MN} = 0$
$H_{NM} = -2F = -2F$
$V_{NM} = 11/24F +1/24(W/b) +65/16qb = 73/16F$
$W_{NM} = -2Fb = -2Fb$

$H_{NO} = -2/3F +2/3(W/b) = 0$
$V_{NO} = -11/24F -1/24(W/b) -65/16qb = -73/16F$
$W_{NO} = 2Fb = 2Fb$
$H_{ON} = 2/3F -2/3(W/b) = 0$
$V_{ON} = 11/24F +1/24(W/b) +65/16qb = 73/16F$
$W_{ON} = -4/3Fb -2/3W = -2Fb$

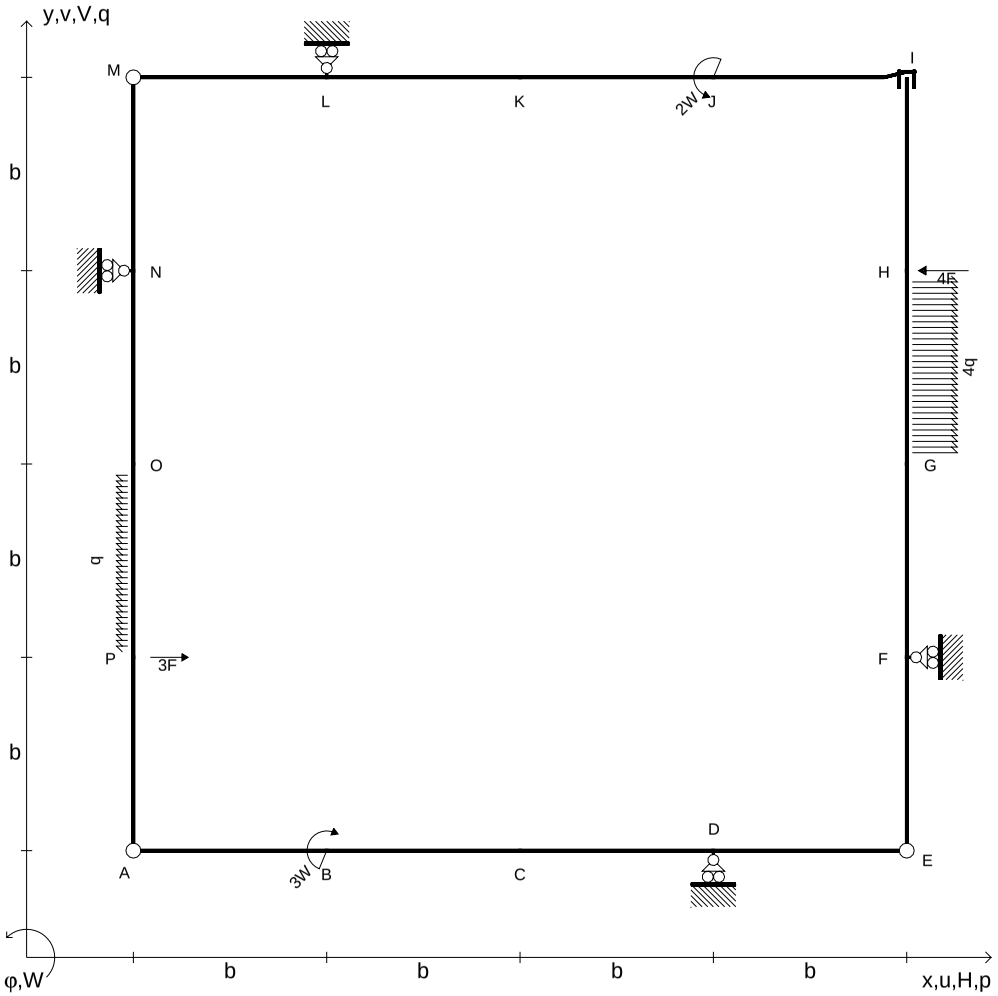
$H_{OP} = -2/3F +2/3(W/b) = 0$
$V_{OP} = -11/24F -1/24(W/b) -65/16qb = -73/16F$
$W_{OP} = 4/3Fb +2/3W = 2Fb$
$H_{PO} = 2/3F -2/3(W/b) = 0$
$V_{PO} = 11/24F +1/24(W/b) +65/16qb = 73/16F$
$W_{PO} = -2/3Fb -4/3W = -2Fb$

$H_{PA} = -2/3F +2/3(W/b) = 0$
$V_{PA} = -11/24F -1/24(W/b) -65/16qb = -73/16F$
$W_{PA} = 2/3Fb -2/3W = 0$
$H_{AP} = 2/3F -2/3(W/b) = 0$
$V_{AP} = 11/24F +1/24(W/b) +65/16qb = 73/16F$
$W_{AP} = 0$

@ Adolfo Zavelani Rossi, Politecnico di Milano

Es.N.039

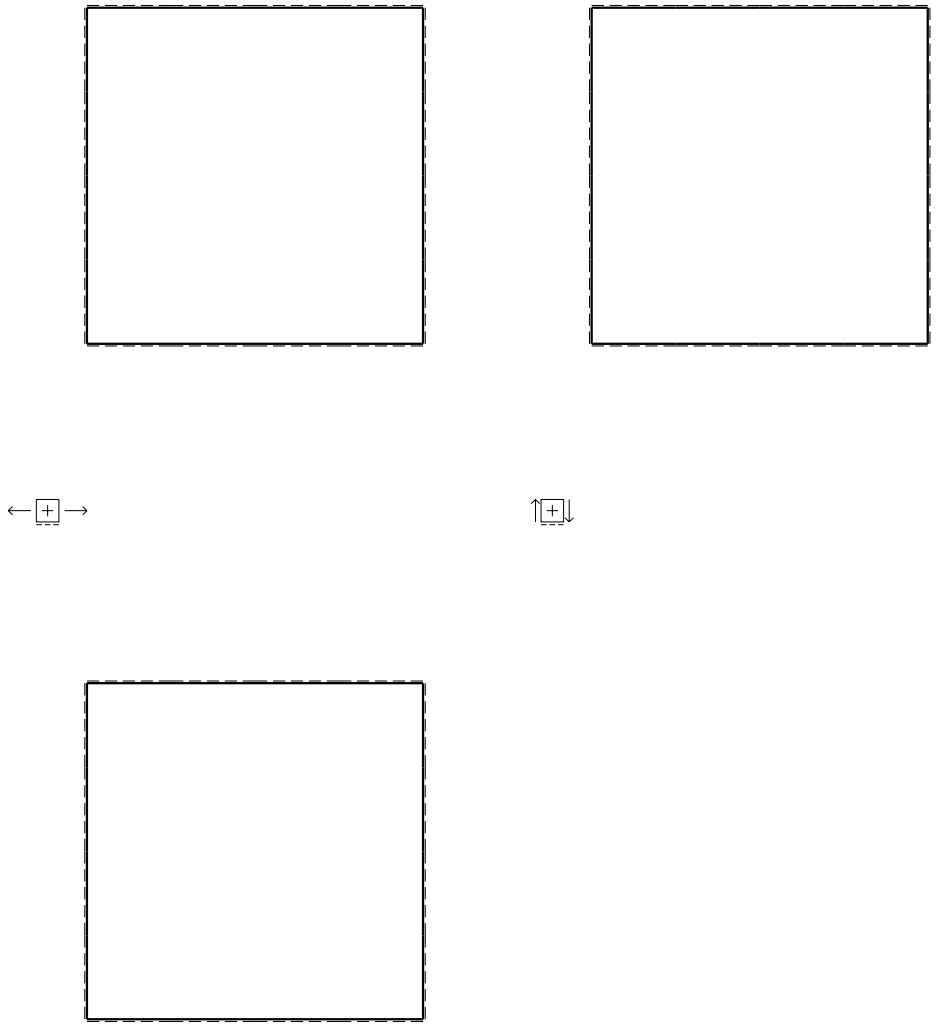
@ Adolfo Zavelani Rossi, Politecnico di Milano



$H_P = 3F$ $W_J = 2W = 2Fb$ $p_{GH} = 4q = 4F/b$

$H_H = -4F$ $W_B = -3W = -3Fb$ $p_{OP} = -q = -F/b$

Svolgere l'analisi cinematica.
Determinare matrice di congruenza e di equilibrio.
Determinare le reazioni vincolari a terra col PLV (Le=0).
Determinare le azioni interne in D col PLV (Le=0).
Carichi e deformazioni date hanno verso efficace in disegno.
Calcolare reazioni vincolari della struttura e delle aste.
Tracciare i diagrammi delle azioni interne nelle aste.



Schema grafico non rappresentabile

REAZIONI

V_D =
H_F =

V_L =
H_N =

H_{AB} =
V_{AB} =
W_{AB} =
H_{BA} =
V_{BA} =
W_{BA} =

H_{BC} =
V_{BC} =
W_{BC} =
H_{CB} =
V_{CB} =
W_{CB} =

H_{CD} =
V_{CD} =
W_{CD} =
H_{DC} =
V_{DC} =
W_{DC} =

H_{DE} =
V_{DE} =
W_{DE} =
H_{ED} =
V_{ED} =
W_{ED} =

H_{EF} =
V_{EF} =
W_{EF} =
H_{FE} =
V_{FE} =
W_{FE} =

H_{FG} =
V_{FG} =
W_{FG} =
H_{GF} =
V_{GF} =
W_{GF} =

H_{GH} =
V_{GH} =
W_{GH} =
H_{HG} =
V_{HG} =
W_{HG} =

H_{HI} =
V_{HI} =
W_{HI} =
H_{IH} =
V_{IH} =
W_{IH} =

H_{IJ} =
V_{IJ} =
W_{IJ} =
H_{JI} =
V_{JI} =
W_{JI} =

H_{JK} =
V_{JK} =
W_{JK} =
H_{KJ} =
V_{KJ} =
W_{KJ} =

@ Adolfo Zavelani Rossi, Politecnico di Milano

H_{KL} =
V_{KL} =
W_{KL} =
H_{LK} =
V_{LK} =
W_{LK} =

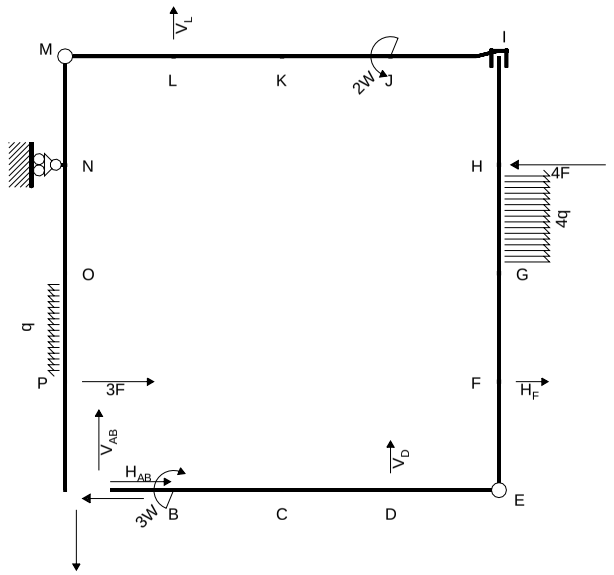
H_{LM} =
V_{LM} =
W_{LM} =
H_{ML} =
V_{ML} =
W_{ML} =

H_{MN} =
V_{MN} =
W_{MN} =
H_{NM} =
V_{NM} =
W_{NM} =

H_{NO} =
V_{NO} =
W_{NO} =
H_{ON} =
V_{ON} =
W_{ON} =

H_{OP} =
V_{OP} =
W_{OP} =
H_{PO} =
V_{PO} =
W_{PO} =

H_{PA} =
V_{PA} =
W_{PA} =
H_{AP} =
V_{AP} =
W_{AP} =



EQUAZIONI DI EQUILIBRIO
Traslazione verticale globale
$V_D + V_L = 0$
Rotazione globale intorno a N
$3V_D b + 2H_F b + V_L b = -6Fb + W - 1/2qb^2$
Rotazione intorno a M: aste ML LK KJ JI IH HG GF FE ED DC CB BA
$3V_D b + 3H_F b + V_L b + 4H_{AB} b = 4Fb + W - 6qb^2$
Traslazione verticale: aste IH HG GF FE ED DC CB BA
$V_D + V_{AB} = 0$
Rotazione intorno a E: aste ED DC CB BA
$-V_D b - 4V_{AB} b = 3W$

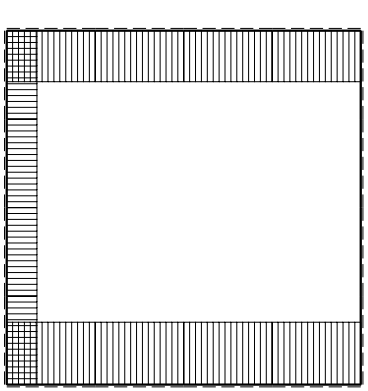
Matrice di equilibrio

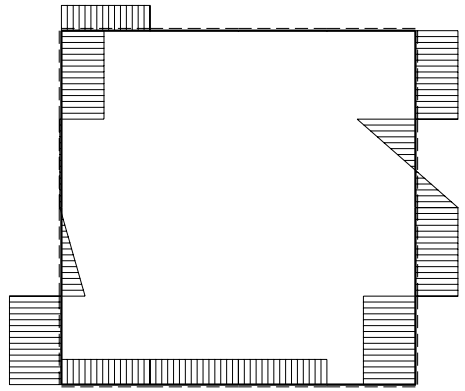
$$\begin{array}{c} \\ v_N \\ \varphi_N \\ \varphi_{ML} \\ v_{IJ} \\ \varphi_{ED} \end{array} \begin{bmatrix} V_D b & H_F b & V_L b & H_{AB} b & V_{AB} b \\ 1 & 0 & 1 & 0 & 0 \\ 3 & 2 & 1 & 0 & 0 \\ 3 & 3 & 1 & 4 & 0 \\ 1 & 0 & 0 & 0 & 1 \\ -1 & 0 & 0 & 0 & -4 \end{bmatrix} = \begin{bmatrix} Fb & W & qb^2 \\ 0 & 0 & 0 \\ -6 & 1 & -1/2 \\ 4 & 1 & -6 \\ 0 & 0 & 0 \\ 0 & 3 & 0 \end{bmatrix}$$

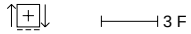
Soluzione del sistema

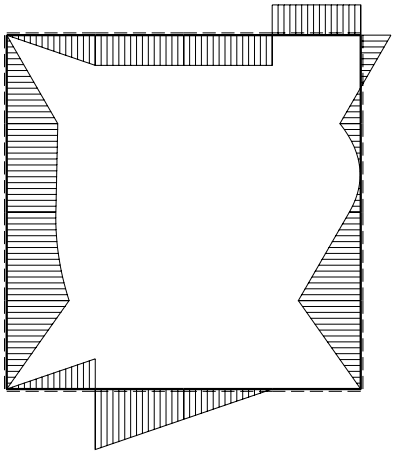
$$\begin{bmatrix} V_D b \\ H_F b \\ V_L b \\ H_{AB} b \\ V_{AB} b \end{bmatrix} = \begin{bmatrix} Fb & W & qb^2 \\ 0 & 1 & 0 \\ -3 & -1/2 & -1/4 \\ 0 & -1 & 0 \\ 13/4 & 1/8 & -21/16 \\ 0 & -1 & 0 \end{bmatrix}$$

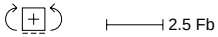
Schema grafico non rappresentabile











REAZIONI

$V_D = (W/b) = F$
$H_F = -3F -1/2(W/b) -1/4qb = -15/4F$

$V_L = -(W/b) = -F$
$H_N = 4F +1/2(W/b) -11/4qb = 7/4F$

$H_{AB} = 13/4F +1/8(W/b) -21/16qb = 33/16F$
$V_{AB} = -(W/b) = -F$
$W_{AB} = 0$
$H_{BA} = -13/4F -1/8(W/b) +21/16qb = -33/16F$
$V_{BA} = (W/b) = F$
$W_{BA} = -W = -Fb$

$H_{BC} = 13/4F +1/8(W/b) -21/16qb = 33/16F$
$V_{BC} = -(W/b) = -F$
$W_{BC} = -2W = -2Fb$
$H_{CB} = -13/4F -1/8(W/b) +21/16qb = -33/16F$
$V_{CB} = (W/b) = F$
$W_{CB} = W = Fb$

$H_{CD} = 13/4F +1/8(W/b) -21/16qb = 33/16F$
$V_{CD} = -(W/b) = -F$
$W_{CD} = -W = -Fb$
$H_{DC} = -13/4F -1/8(W/b) +21/16qb = -33/16F$
$V_{DC} = (W/b) = F$
$W_{DC} = 0$

$H_{DE} = 13/4F +1/8(W/b) -21/16qb = 33/16F$
$V_{DE} = 0$
$W_{DE} = 0$
$H_{ED} = -13/4F -1/8(W/b) +21/16qb = -33/16F$
$V_{ED} = 0$
$W_{ED} = 0$

$H_{EF} = 13/4F +1/8(W/b) -21/16qb = 33/16F$
$V_{EF} = 0$
$W_{EF} = 0$
$H_{FE} = -13/4F -1/8(W/b) +21/16qb = -33/16F$
$V_{FE} = 0$
$W_{FE} = -13/4Fb -1/8W +21/16qb^2 = -33/16Fb$

$H_{FG} = 1/4F -3/8(W/b) -25/16qb = -27/16F$
$V_{FG} = 0$
$W_{FG} = 13/4Fb +1/8W -21/16qb^2 = 33/16Fb$
$H_{GF} = -1/4F +3/8(W/b) +25/16qb = 27/16F$
$V_{GF} = 0$
$W_{GF} = -7/2Fb +1/4W +23/8qb^2 = -3/8Fb$

$H_{GH} = 1/4F -3/8(W/b) -25/16qb = -27/16F$
$V_{GH} = 0$
$W_{GH} = 7/2Fb -1/4W -23/8qb^2 = 3/8Fb$
$H_{HG} = -1/4F +3/8(W/b) -39/16qb = -37/16F$
$V_{HG} = 0$
$W_{HG} = -15/4Fb +5/8W +39/16qb^2 = -11/16Fb$

$H_{HI} = -15/4F -3/8(W/b) +39/16qb = -27/16F$
$V_{HI} = 0$
$W_{HI} = 15/4Fb -5/8W -39/16qb^2 = 11/16Fb$
$H_{IH} = 15/4F +3/8(W/b) -39/16qb = 27/16F$
$V_{IH} = 0$
$W_{IH} = W = Fb$

$H_{IJ} = -15/4F -3/8(W/b) +39/16qb = -27/16F$
$V_{IJ} = 0$
$W_{IJ} = -W = -Fb$
$H_{JI} = 15/4F +3/8(W/b) -39/16qb = 27/16F$
$V_{JI} = 0$
$W_{JI} = W = Fb$

$H_{JK} = -15/4F -3/8(W/b) +39/16qb = -27/16F$
$V_{JK} = 0$
$W_{JK} = W = Fb$
$H_{KJ} = 15/4F +3/8(W/b) -39/16qb = 27/16F$
$V_{KJ} = 0$
$W_{KJ} = -W = -Fb$

PROCEDIMENTO E RISULTATI Nome: Es.N.040

$H_{KL} = -15/4F -3/8(W/b) +39/16qb = -27/16F$
$V_{KL} = 0$
$W_{KL} = W = Fb$
$H_{LK} = 15/4F +3/8(W/b) -39/16qb = 27/16F$
$V_{LK} = 0$
$W_{LK} = -W = -Fb$

$H_{LM} = -15/4F -3/8(W/b) +39/16qb = -27/16F$
$V_{LM} = -(W/b) = -F$
$W_{LM} = W = Fb$
$H_{ML} = 15/4F +3/8(W/b) -39/16qb = 27/16F$
$V_{ML} = (W/b) = F$
$W_{ML} = 0$

$H_{MN} = -15/4F -3/8(W/b) +39/16qb = -27/16F$
$V_{MN} = -(W/b) = -F$
$W_{MN} = 0$
$H_{NM} = 15/4F +3/8(W/b) -39/16qb = 27/16F$
$V_{NM} = (W/b) = F$
$W_{NM} = -15/4Fb -3/8W +39/16qb^2 = -27/16Fb$

$H_{NO} = 1/4F +1/8(W/b) -5/16qb = 1/16F$
$V_{NO} = -(W/b) = -F$
$W_{NO} = 15/4Fb +3/8W -39/16qb^2 = 27/16Fb$
$H_{ON} = -1/4F -1/8(W/b) +5/16qb = -1/16F$
$V_{ON} = (W/b) = F$
$W_{ON} = -7/2Fb -1/4W +17/8qb^2 = -13/8Fb$

$H_{OP} = 1/4F +1/8(W/b) -5/16qb = 1/16F$
$V_{OP} = -(W/b) = -F$
$W_{OP} = 7/2Fb +1/4W -17/8qb^2 = 13/8Fb$
$H_{PO} = -1/4F -1/8(W/b) +21/16qb = 15/16F$
$V_{PO} = (W/b) = F$
$W_{PO} = -13/4Fb -1/8W +21/16qb^2 = -33/16Fb$

$H_{PA} = 13/4F +1/8(W/b) -21/16qb = 33/16F$
$V_{PA} = -(W/b) = -F$
$W_{PA} = 13/4Fb +1/8W -21/16qb^2 = 33/16Fb$
$H_{AP} = -13/4F -1/8(W/b) +21/16qb = -33/16F$
$V_{AP} = (W/b) = F$
$W_{AP} = 0$

@ Adolfo Zavelani Rossi, Politecnico di Milano

Es.N.040

@ Adolfo Zavelani Rossi, Politecnico di Milano