COURS
STRUCTURES EN MÉTAL

TGC 11, chapitres 3, 4, 14: CV, stabilisation

RESSLab
Resilient Steel Structures Laboratory

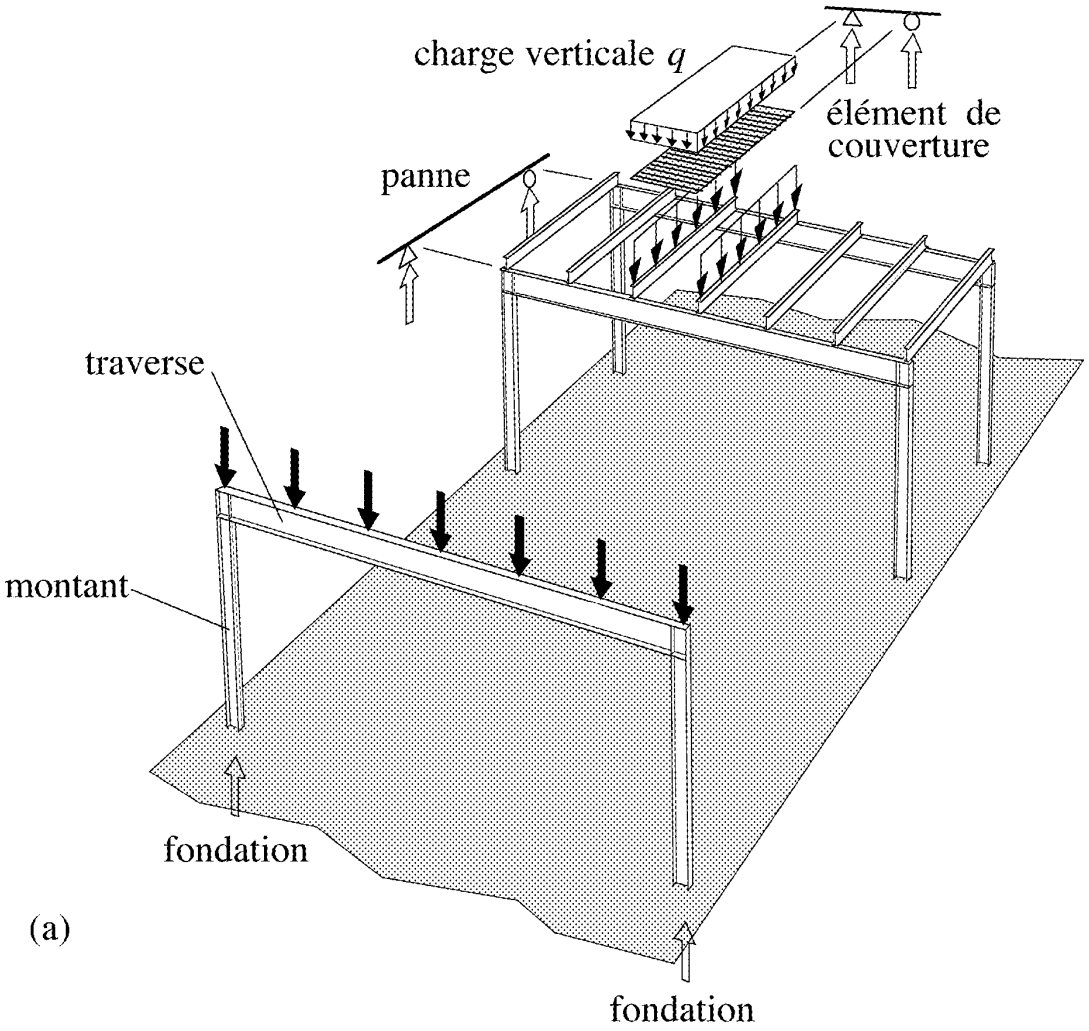
Présentation en partie reprise de celle de l'APK

APK
ASSOCIATION POUR LA PROMOTION DE L'ENSEIGNEMENT DE LA CONSTRUCTION ACIER

Pourquoi et comment faut-il contreventer une structure ?

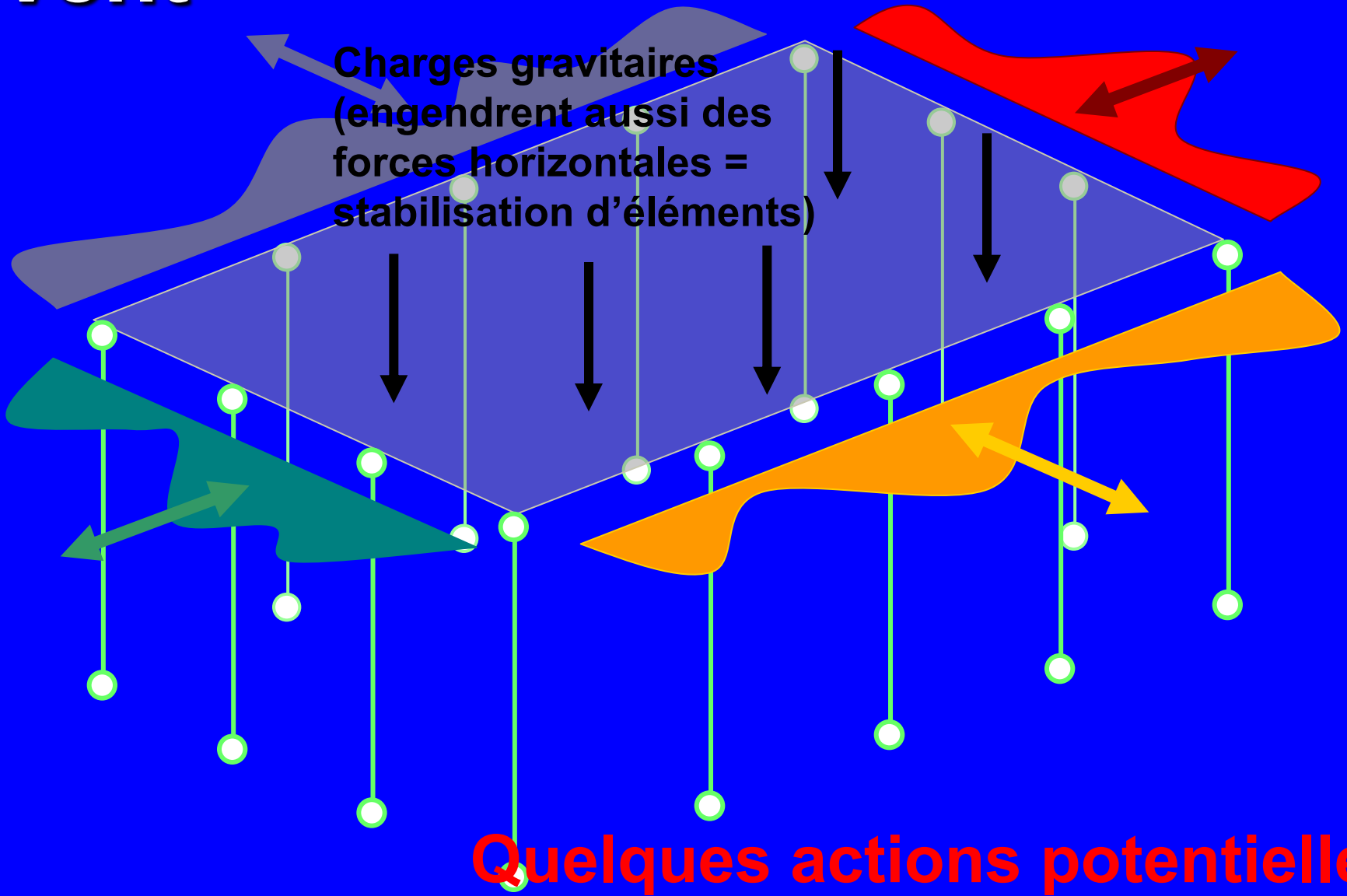
CUST Polytech'Clermont-Ferrand

TGC11, Fig. 3.3a: Cheminement forces verticales

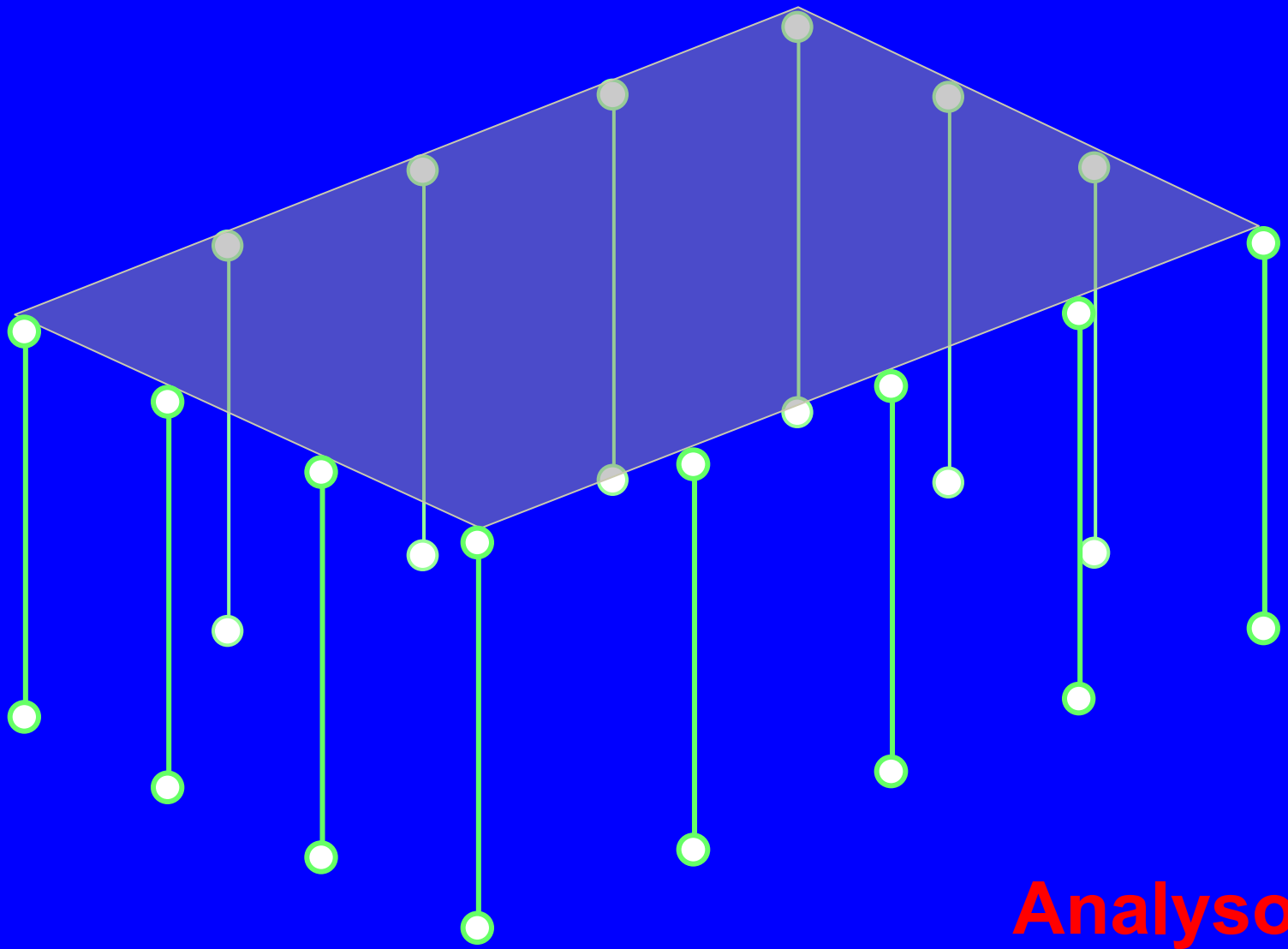


Et cheminement des forces horizontales ?

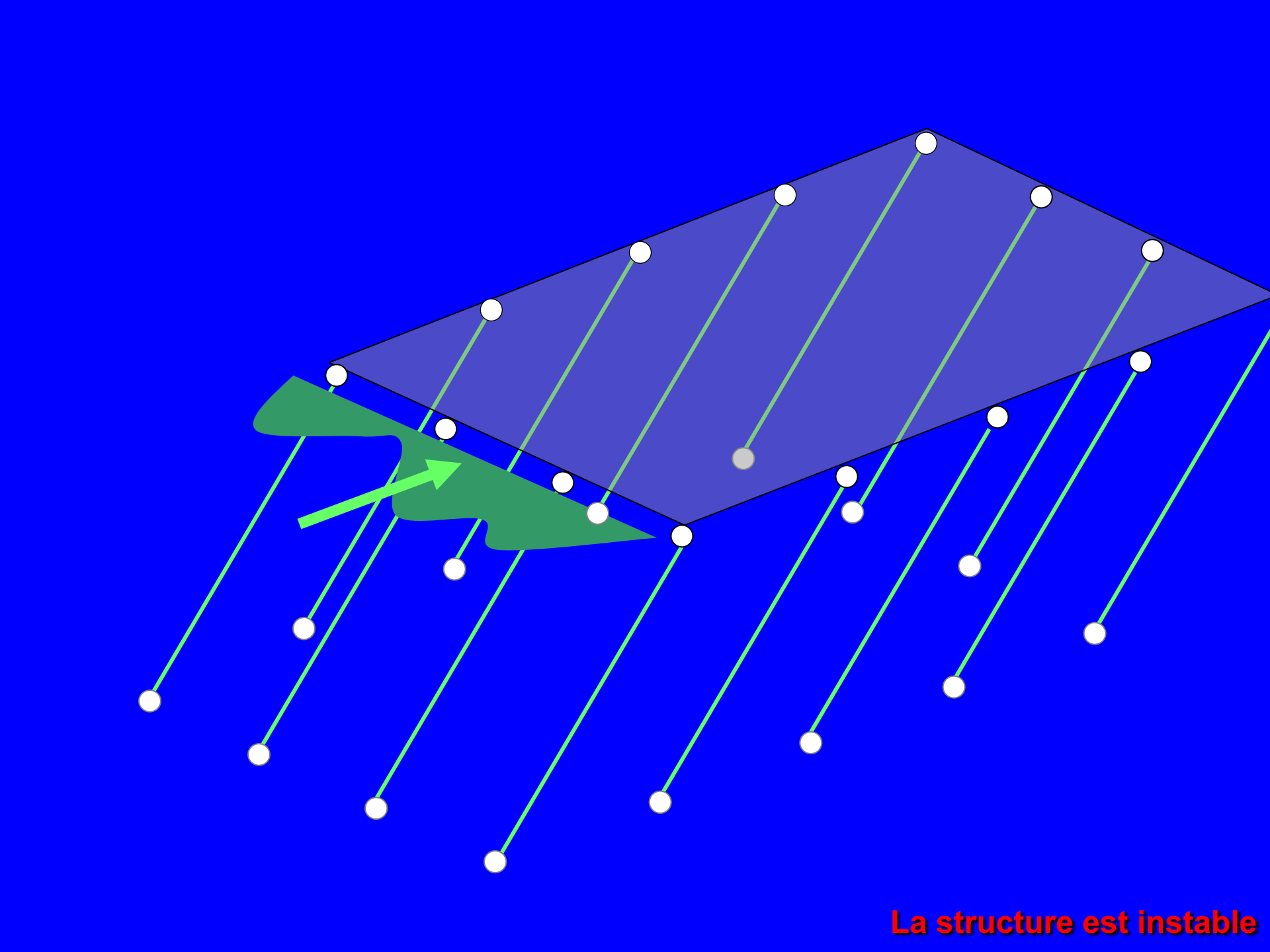
Vent

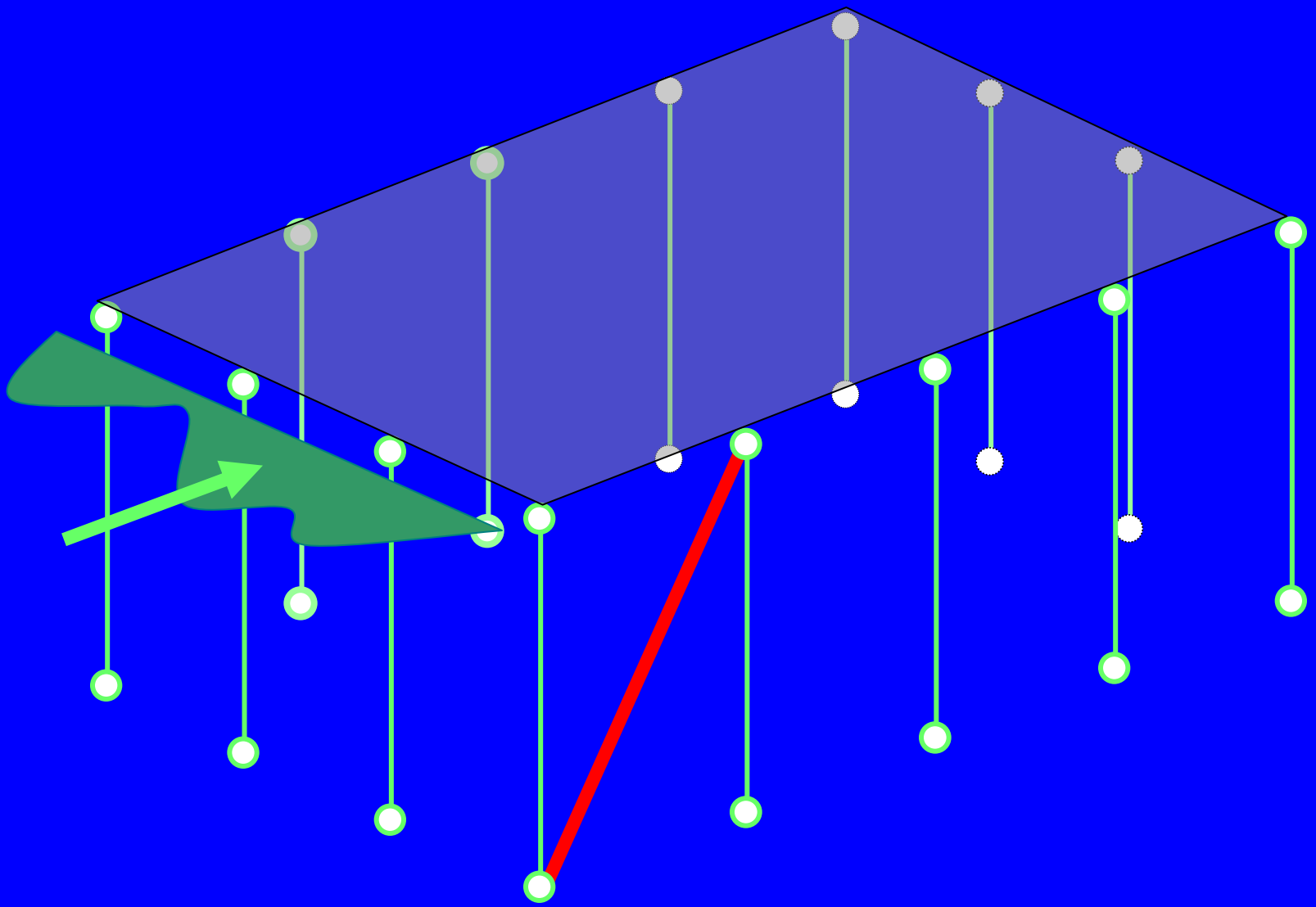


Quelques actions potentielles verticales, horizontales

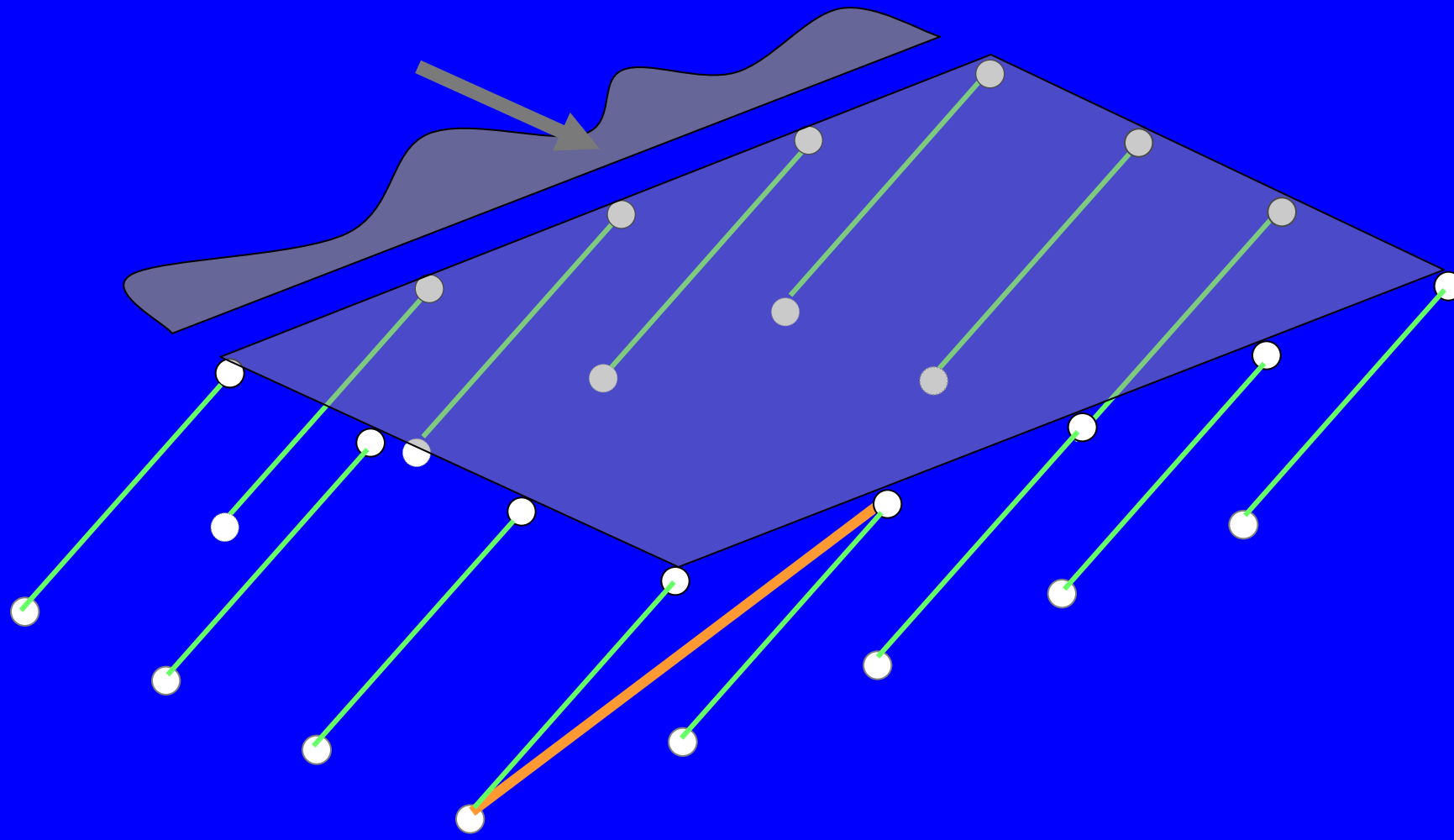


Analysons le fonctionnement face par face

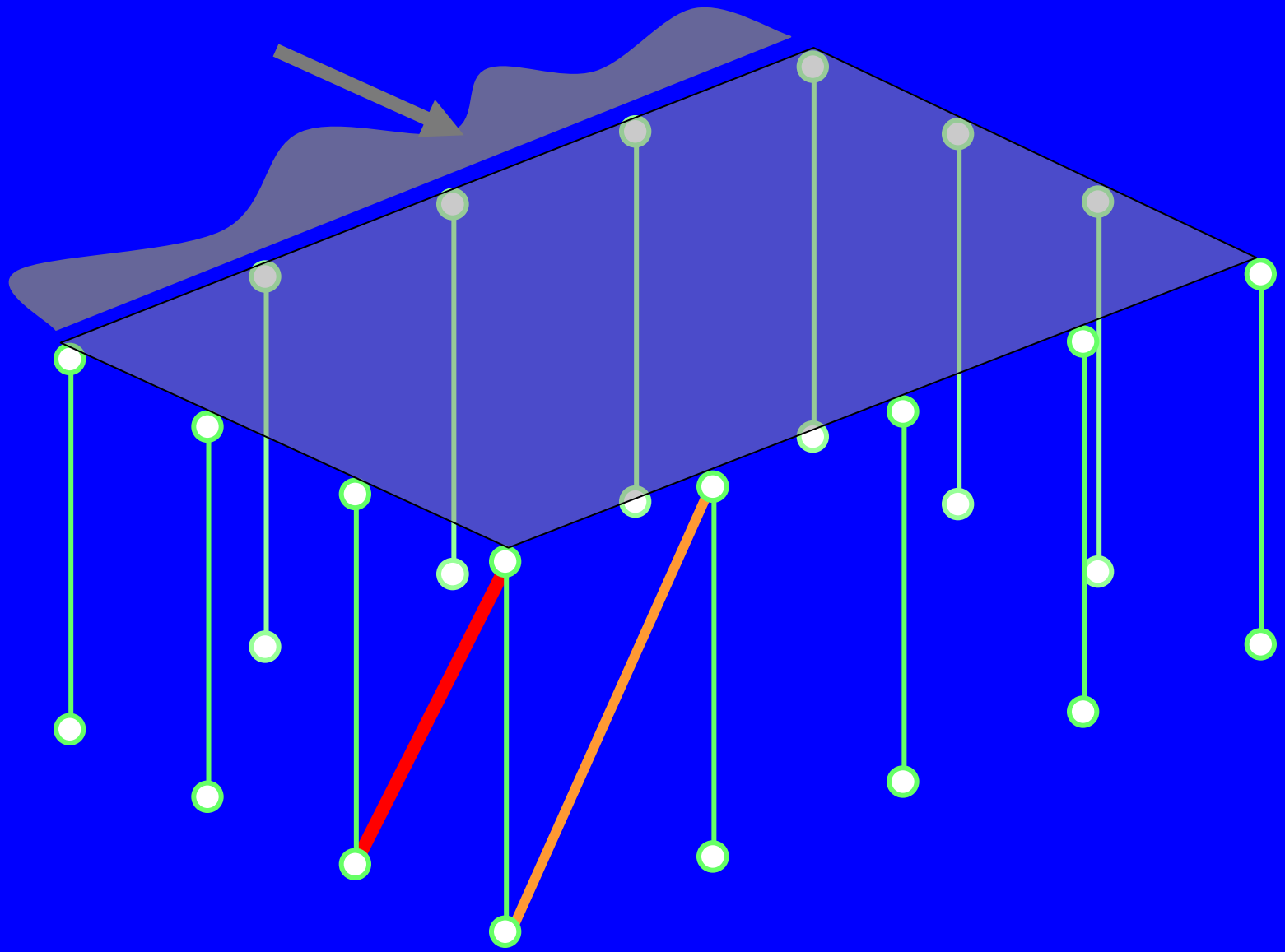

La structure est instable



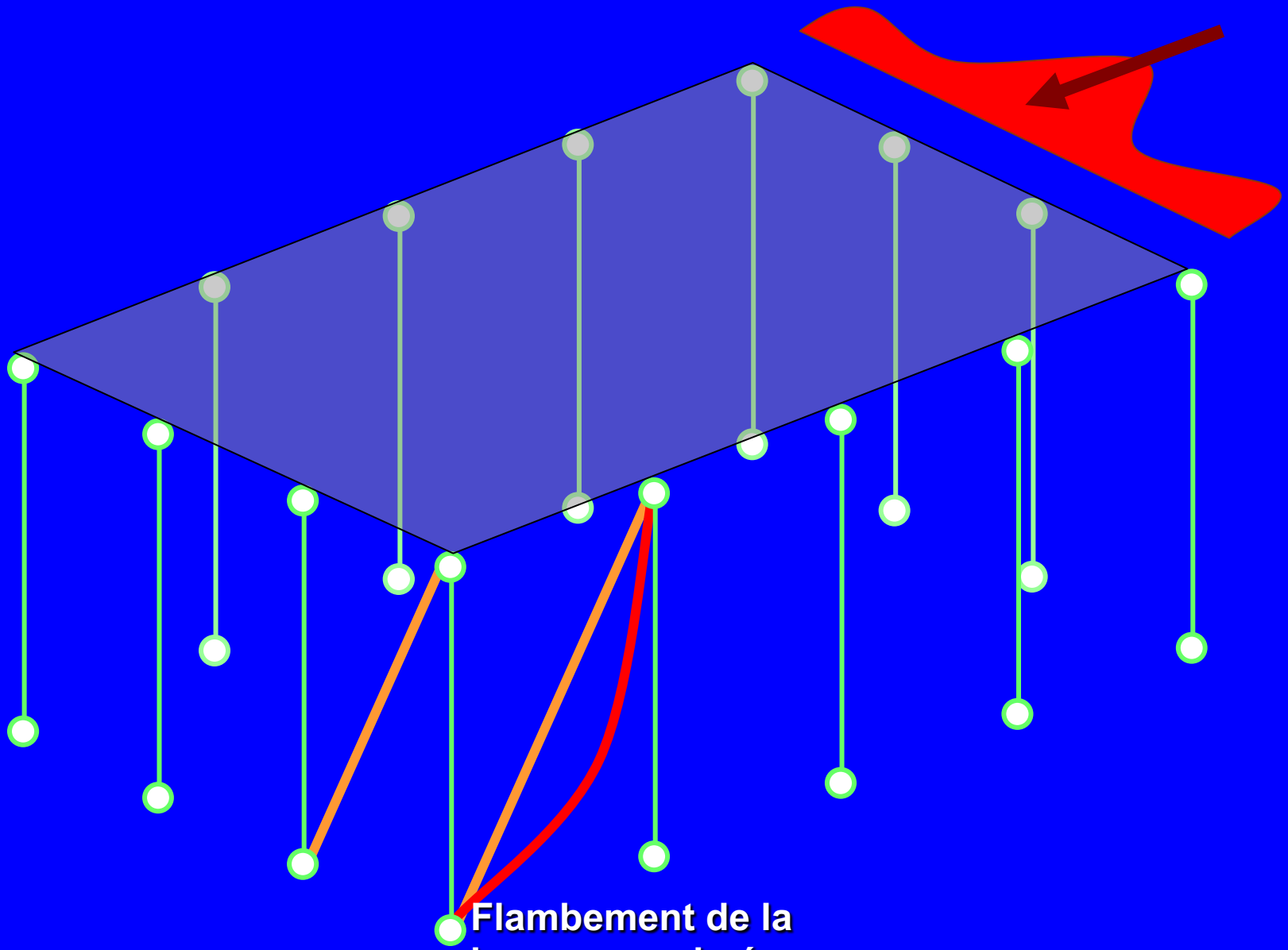
Solution pour ce cas



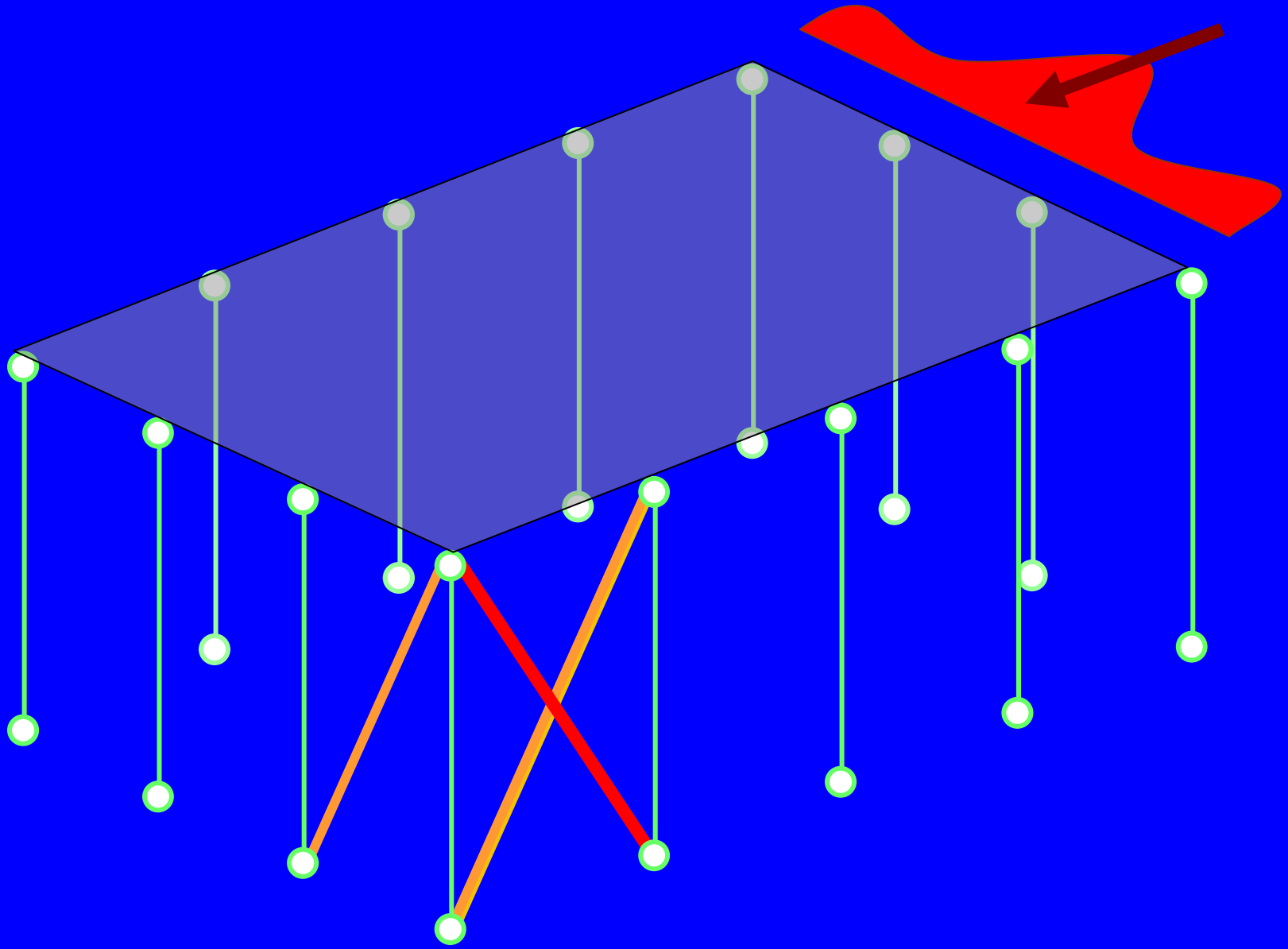
La structure est également instable



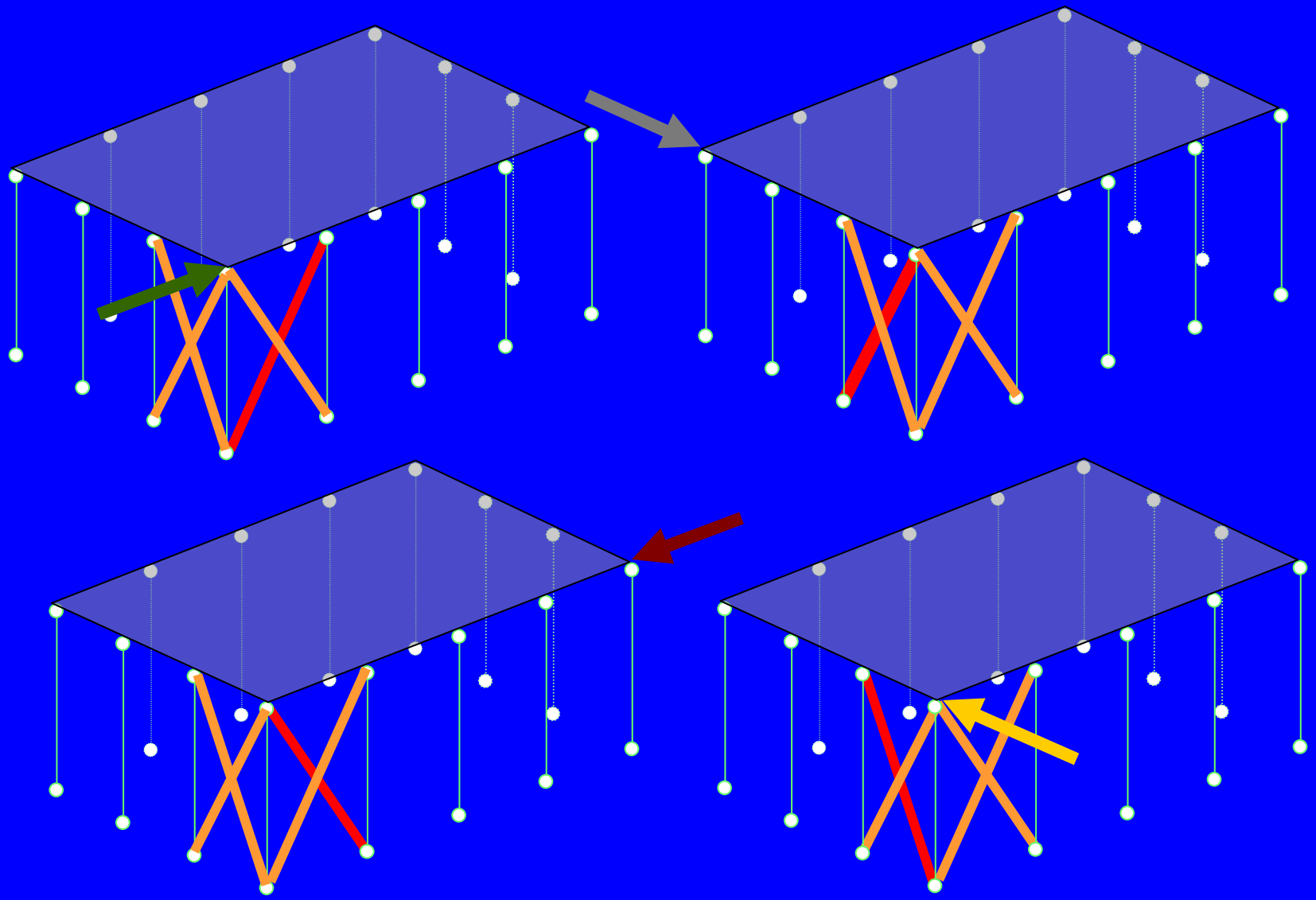
Solution pour ce cas



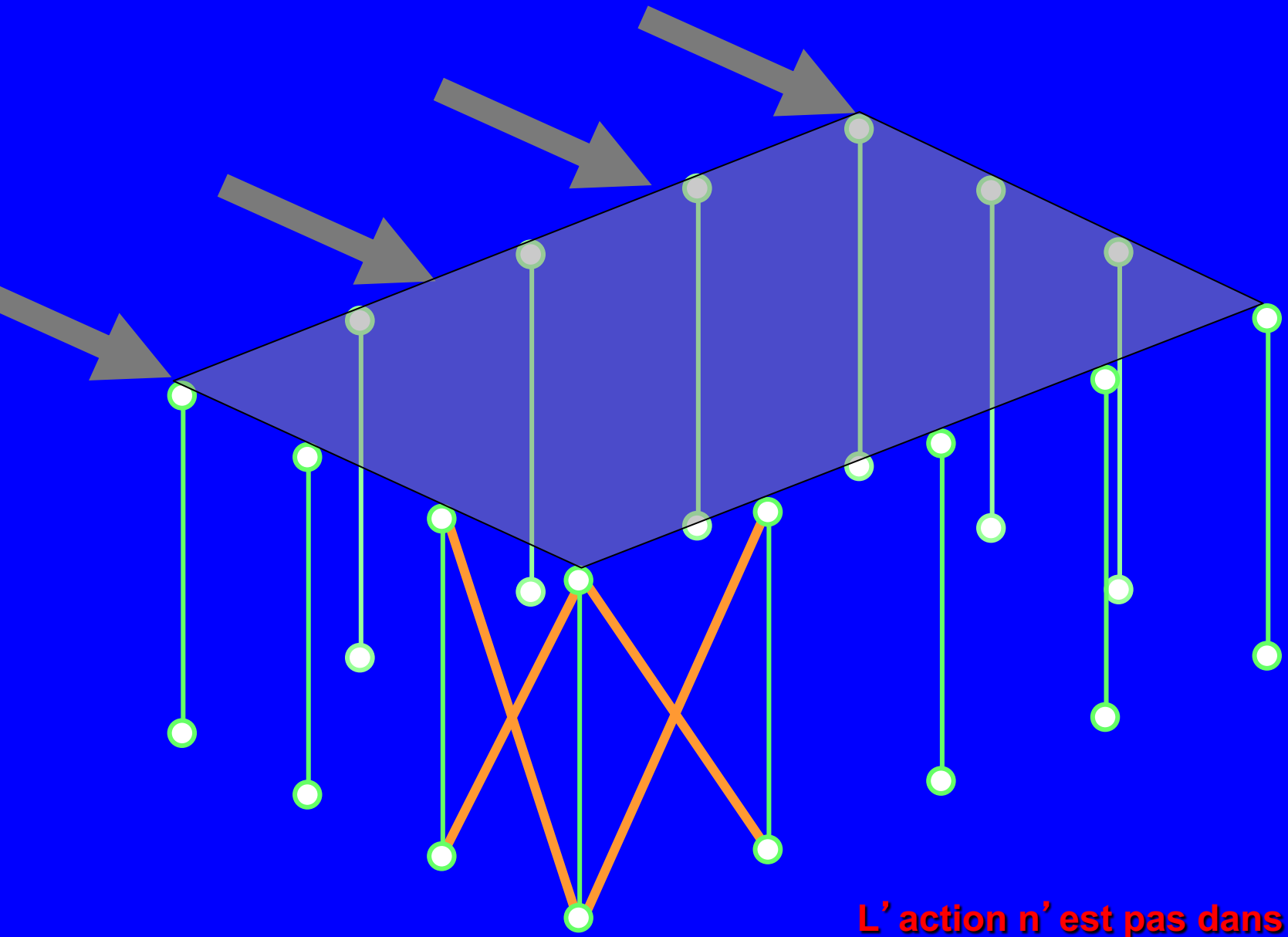
Autre cas



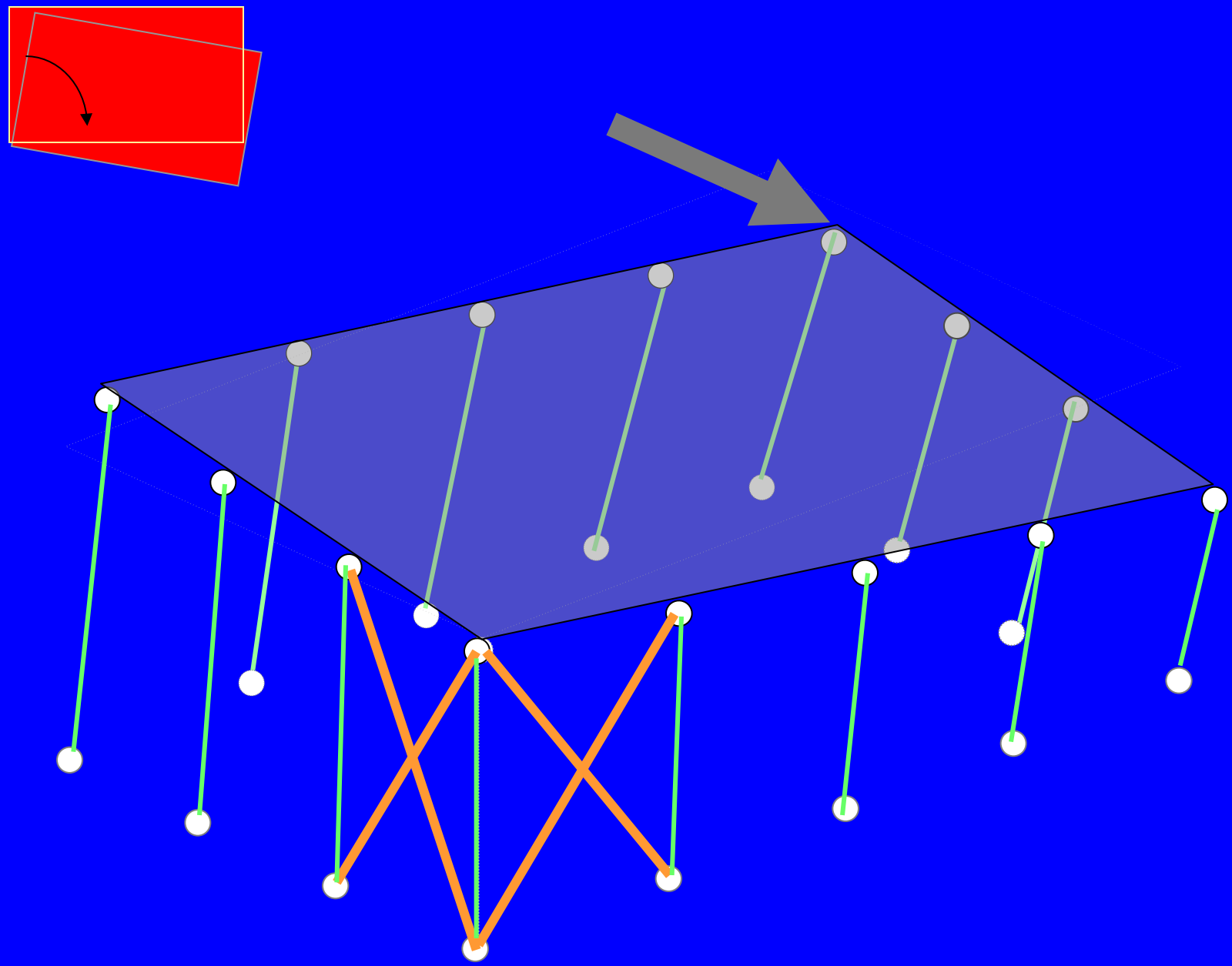
Solution pour ce cas



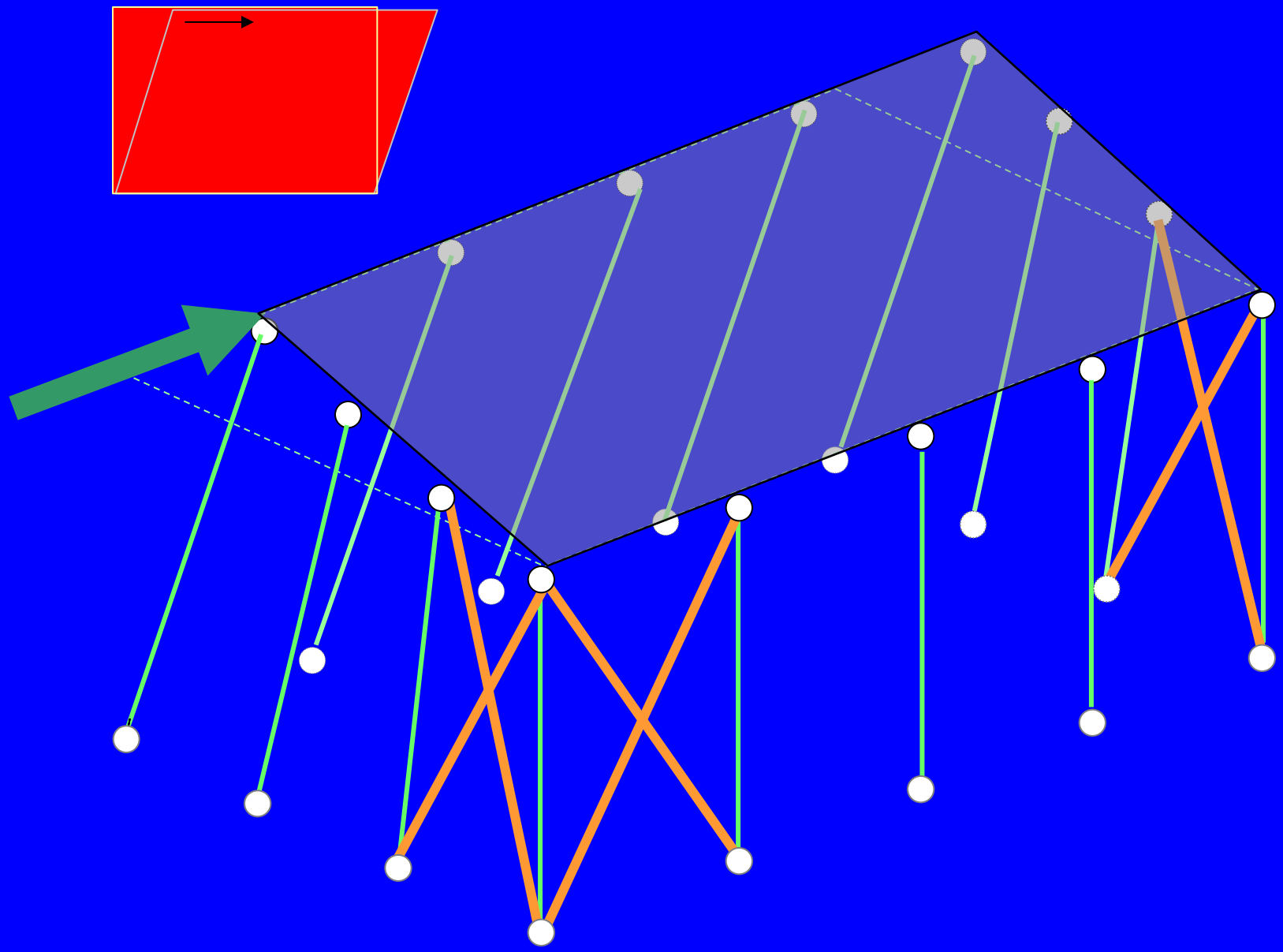
Solutions successives selon la face concernée



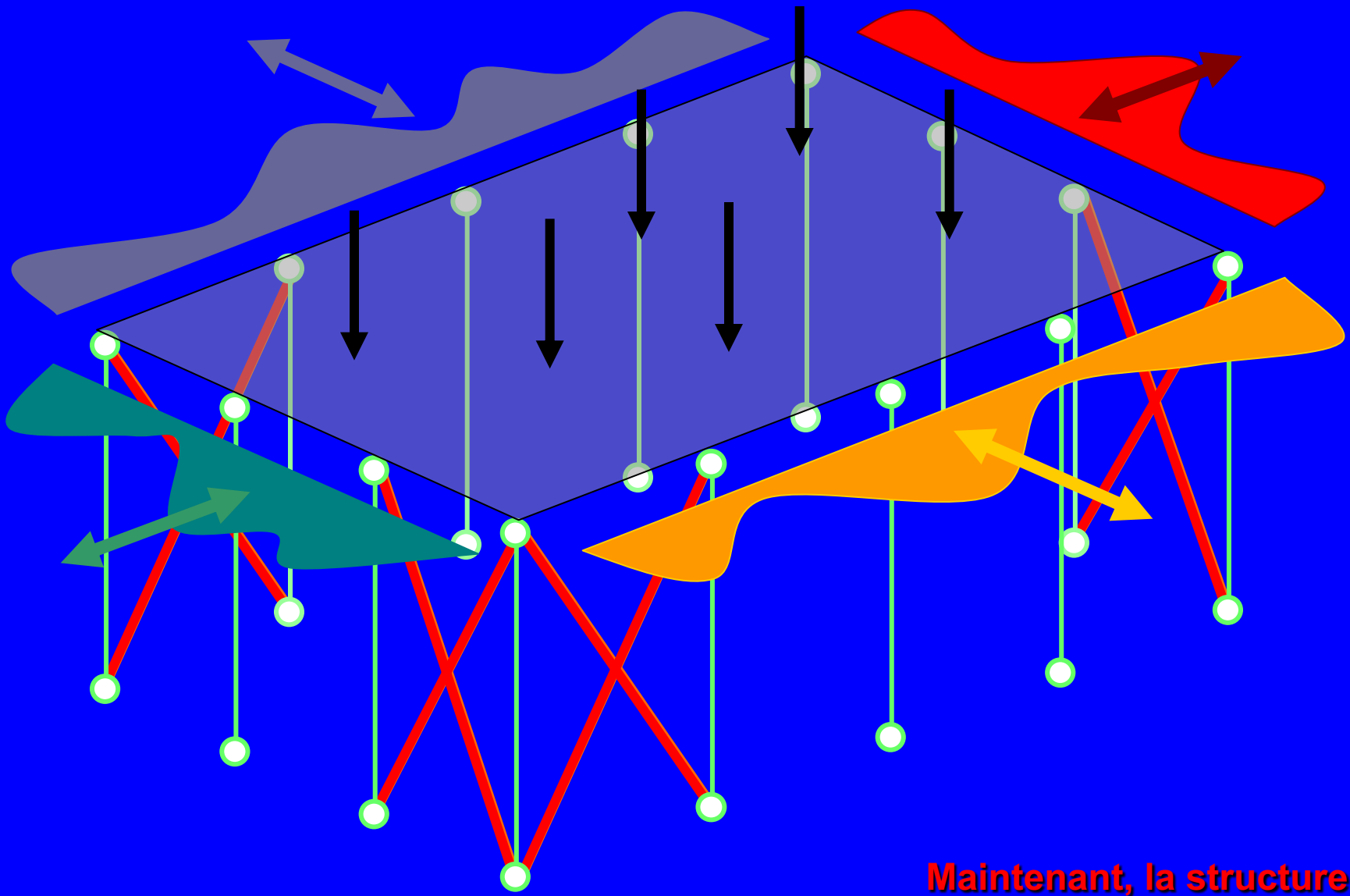
L’ action n’ est pas dans le plan du panneau contreventé



La structure est toujours instable

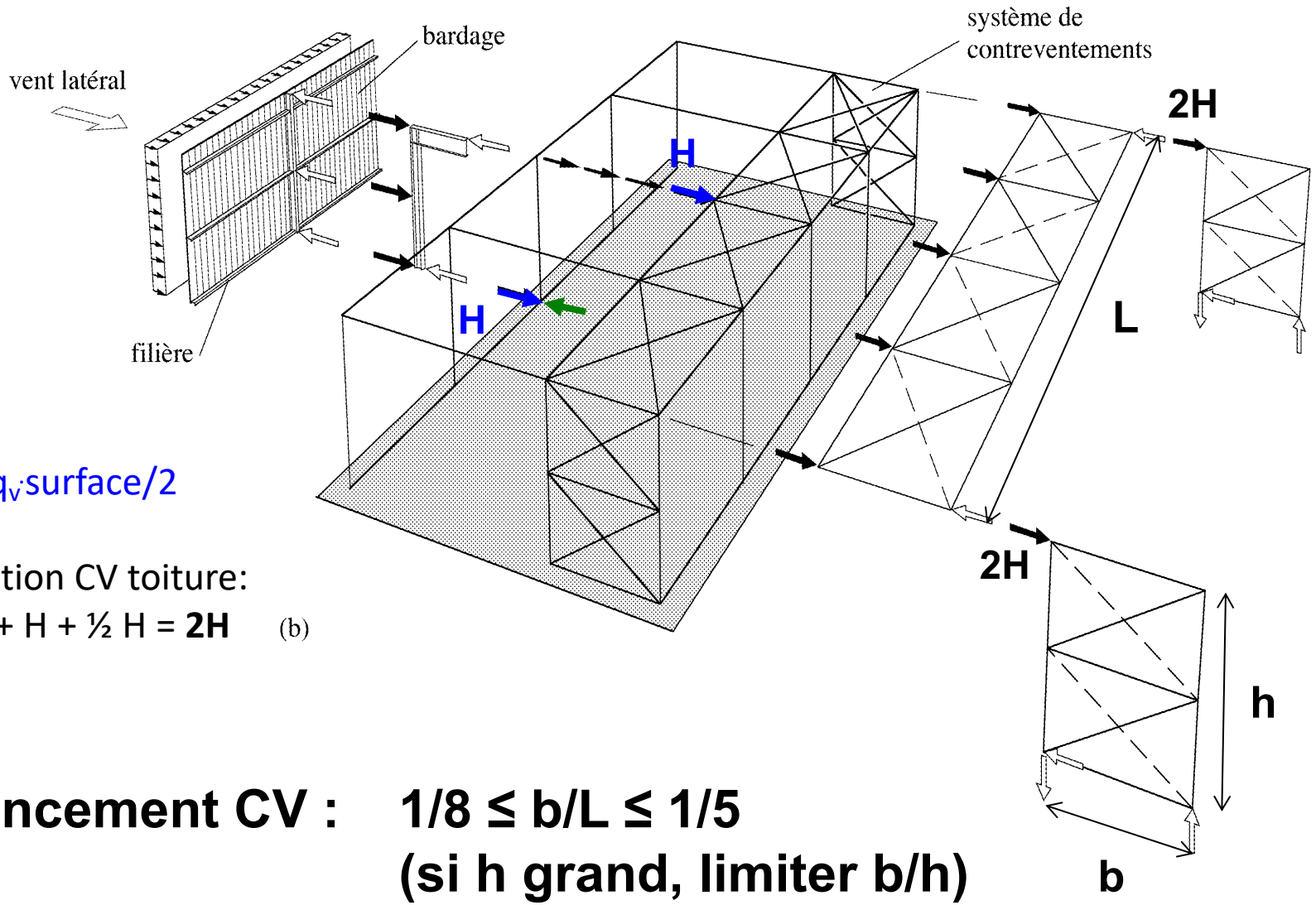


La structure est encore instable



Maintenant, la structure est complètement stabilisée

Cheminement forces horizontales (transv.)

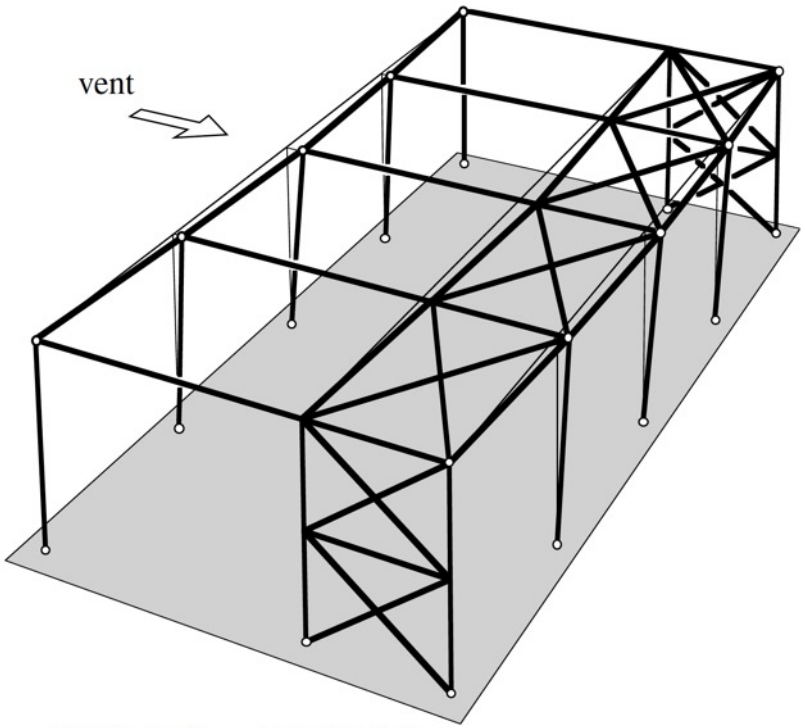


H = q_v·surface/2

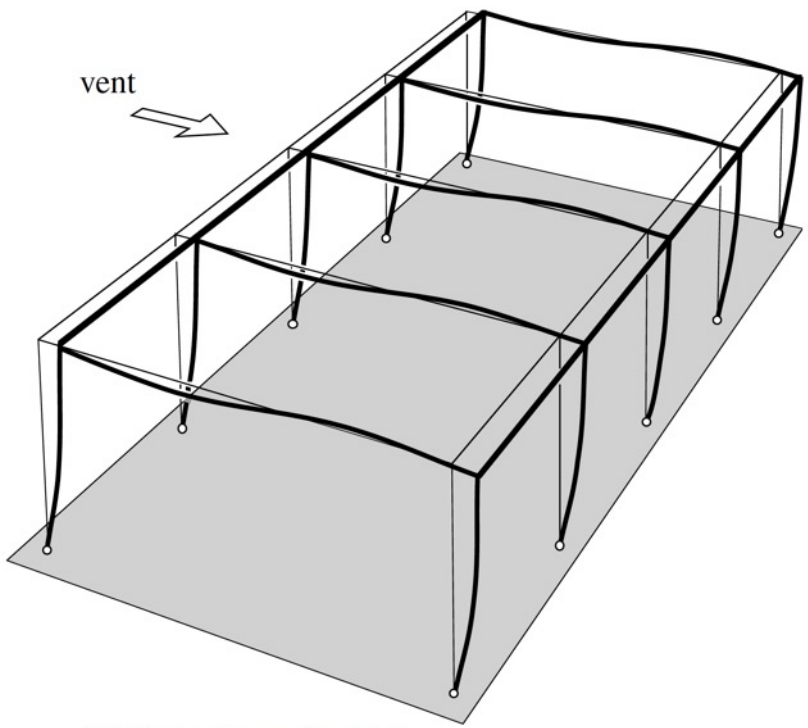
Réaction CV toiture:
½ H + H + ½ H = **2H**

Elancement CV : 1/8 ≤ b/L ≤ 1/5
(si h grand, limiter b/h)

Fig. 3.22: stabilisation de cadres articulés vs rigides

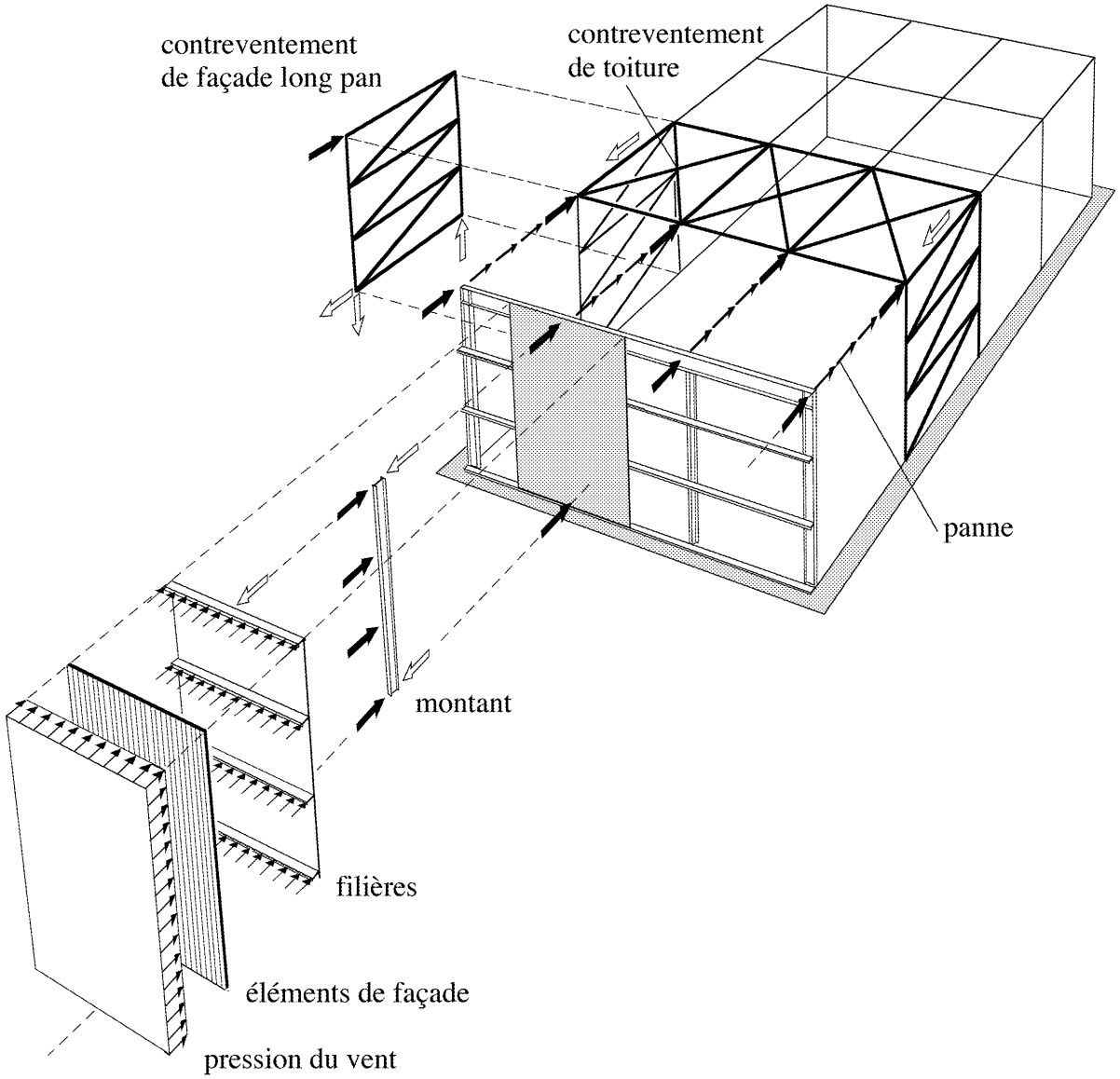


(a) Cadre à quatre articulations
(stabilisation par contreventements)

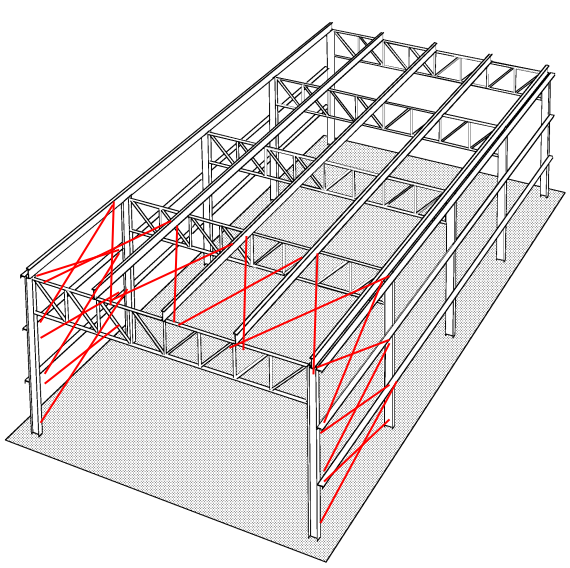


(b) Cadre à nœuds rigides
(stabilisation par effet cadre)

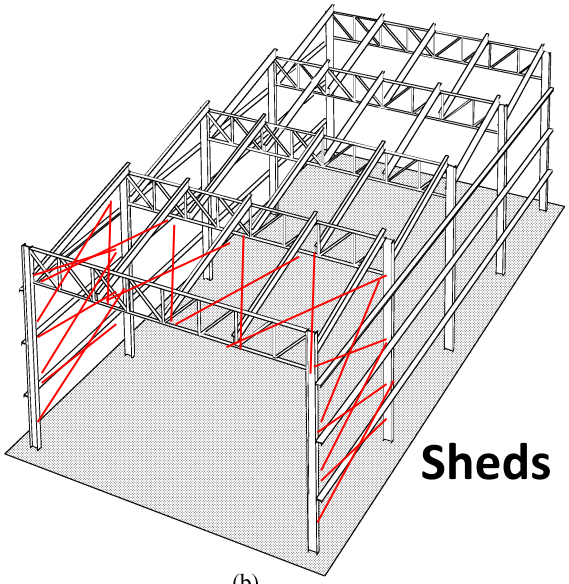
Fig. 3.20: cheminement forces horizontales (longi.)



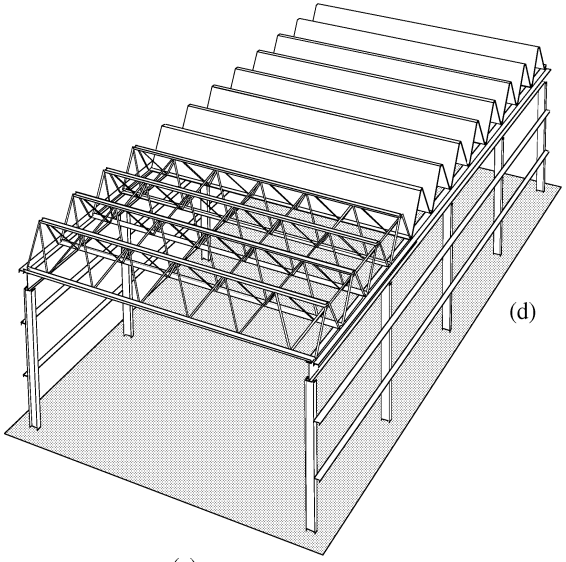
Cadres et différents types de halles, stabilisation



(a)

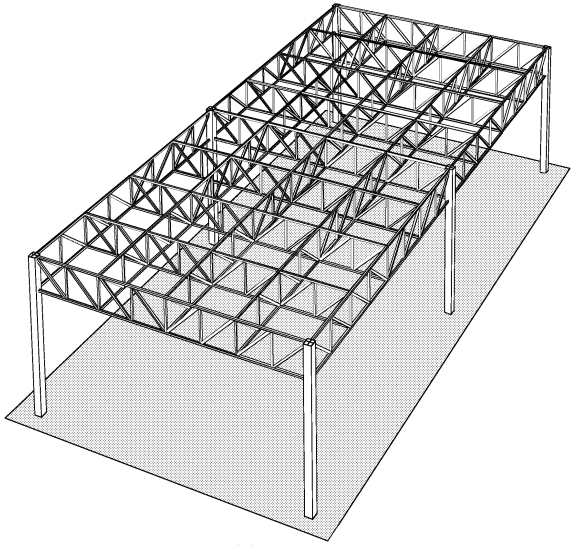


(b)



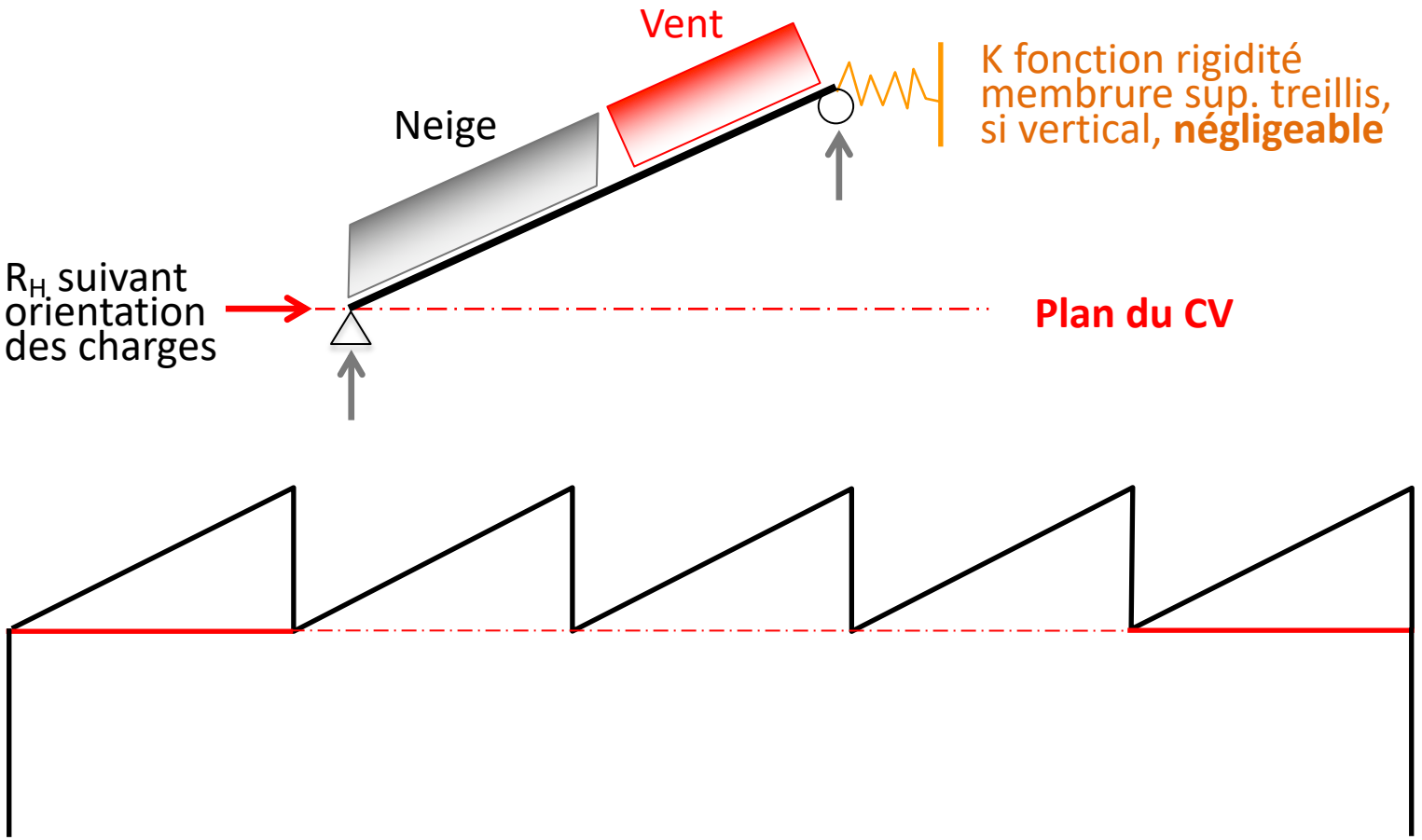
(c)

(d)



(e)

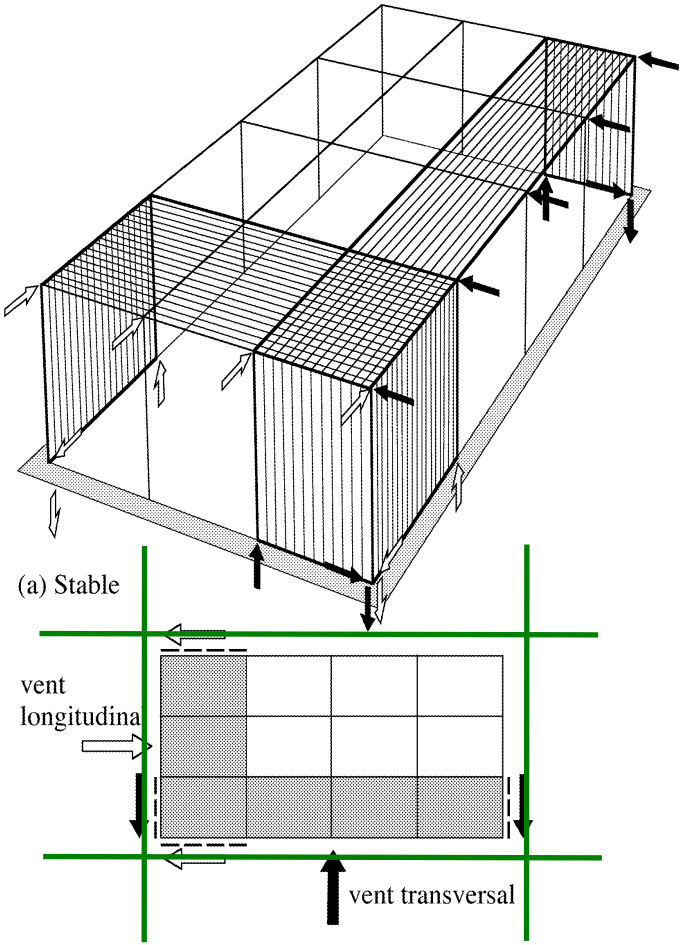
Cas particulier des sheds

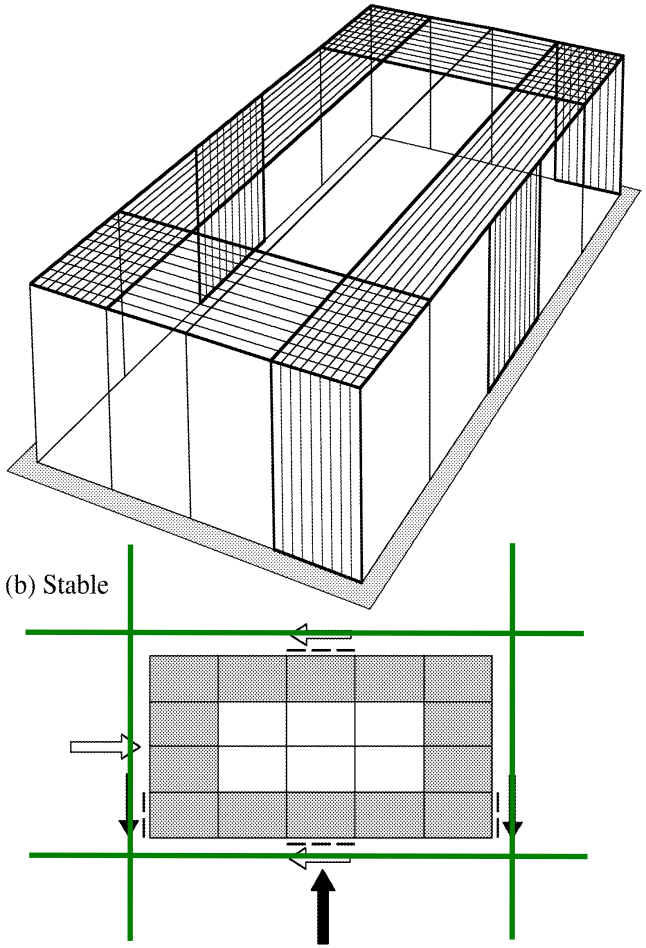


Disposition des contreventements

Pour pouvoir équilibrer une force agissant dans n'importe quelle direction :

1. il faut disposer d'au moins trois lignes d'action de forces,
2. les lignes d'action de forces ne doivent pas être concourantes en un point,
3. les lignes d'action de forces ne doivent pas être toutes parallèles entre elles.





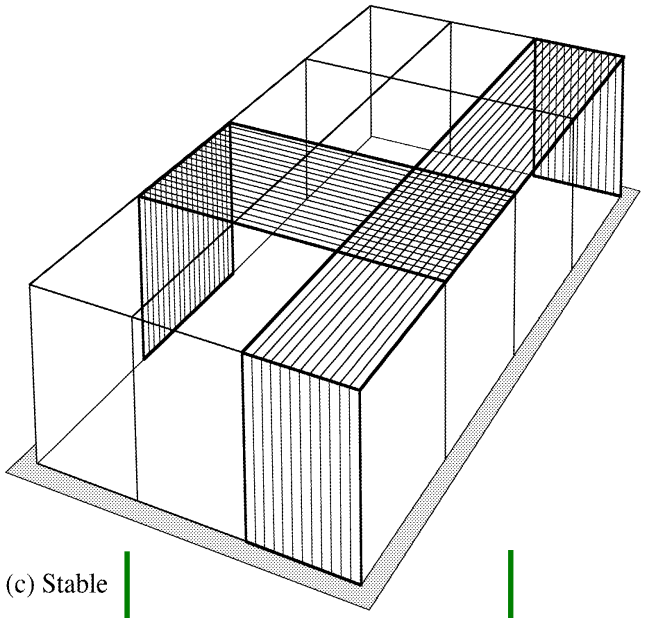
Disposition des contreventements

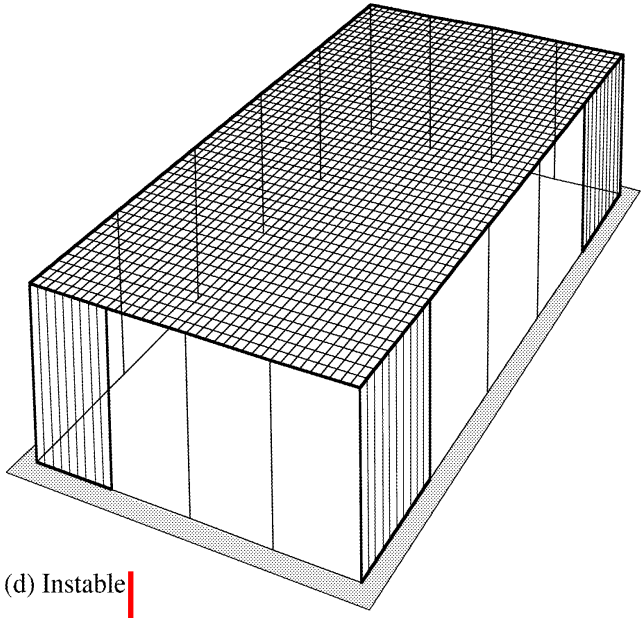
Les contreventements ont 3 fonctions:

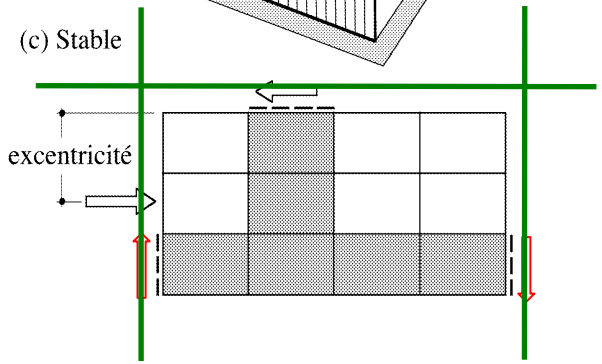
1. Transmettre les efforts horizontaux,
2. Limiter les déformations,

} Stabilisation de l'ensemble

3. Contribuer à stabiliser les éléments (poutres contre déversement, poteau contre flambage)







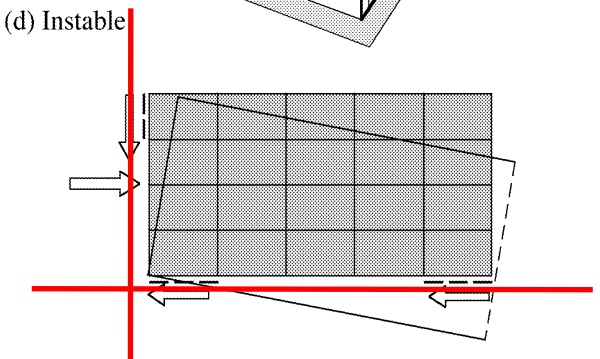
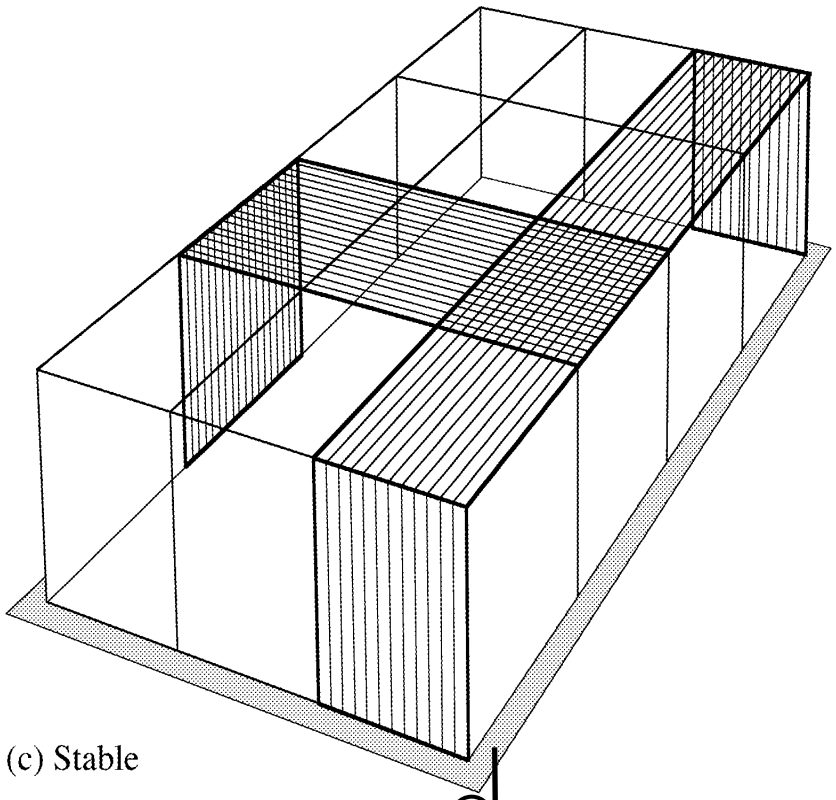
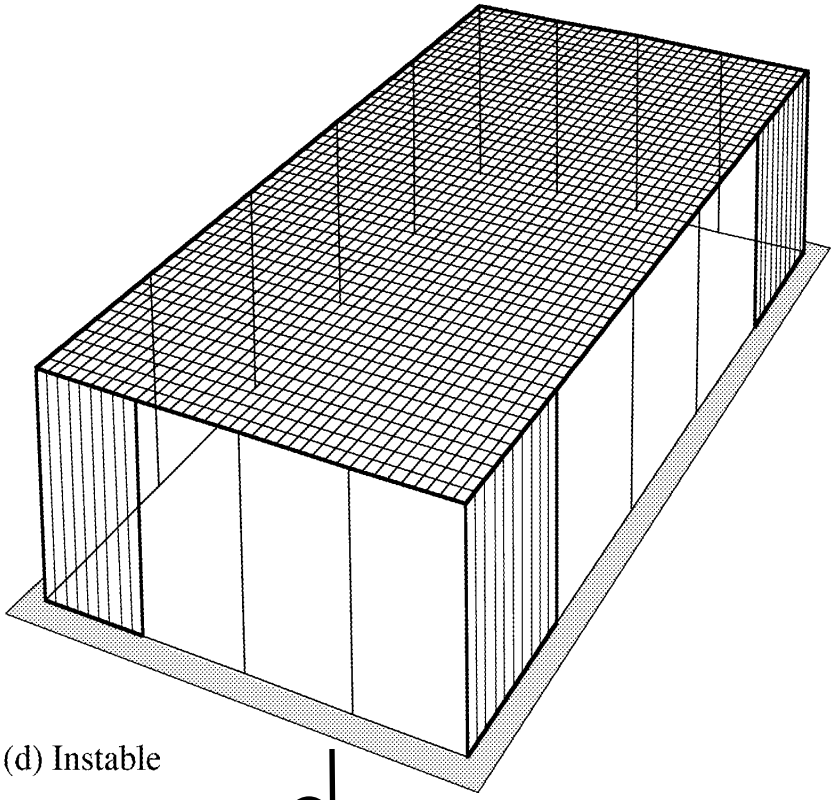


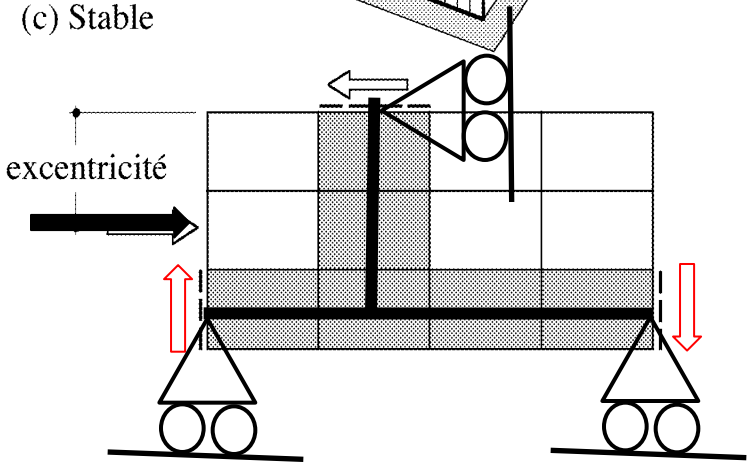
Fig. 3.19: Disposition des contreventements, suite



(c) Stable



(d) Instable



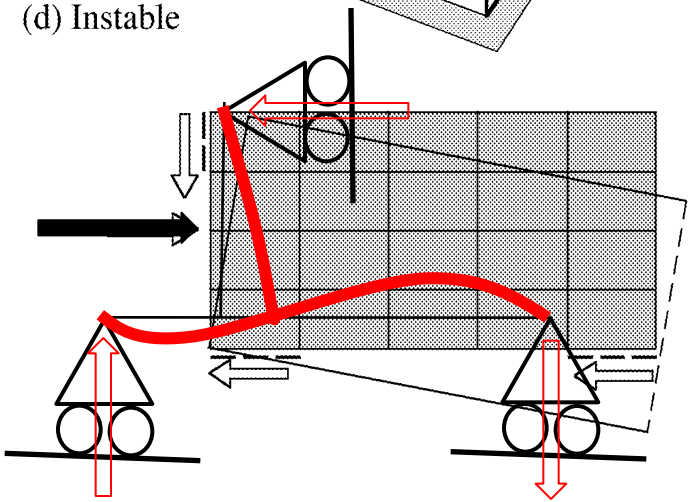
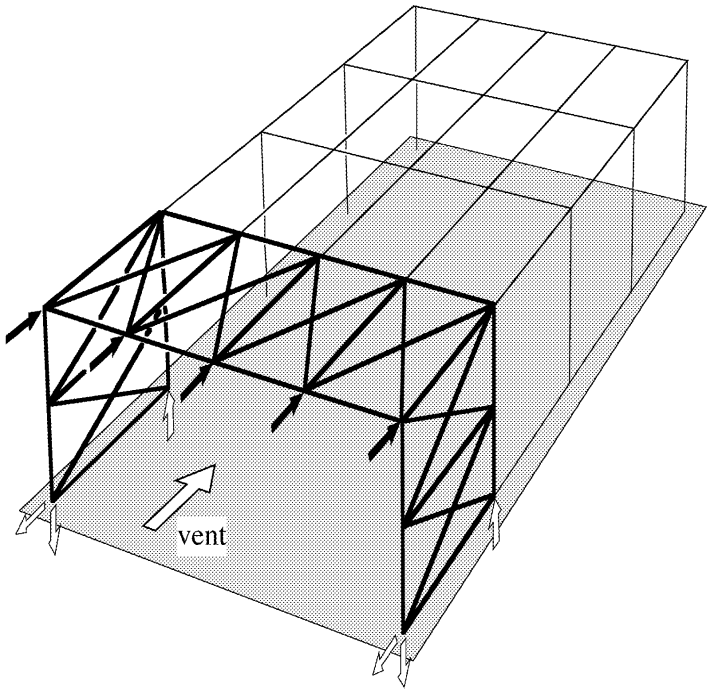


Fig. 3.25a: Transmission des efforts horizontaux

La direction du vent n'est pas constante …



(a)

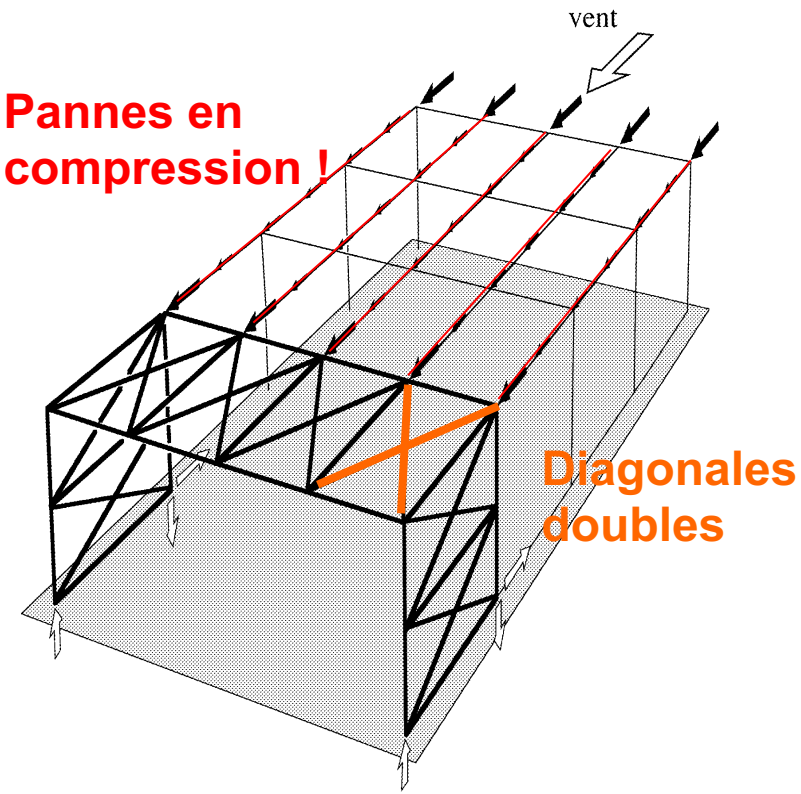
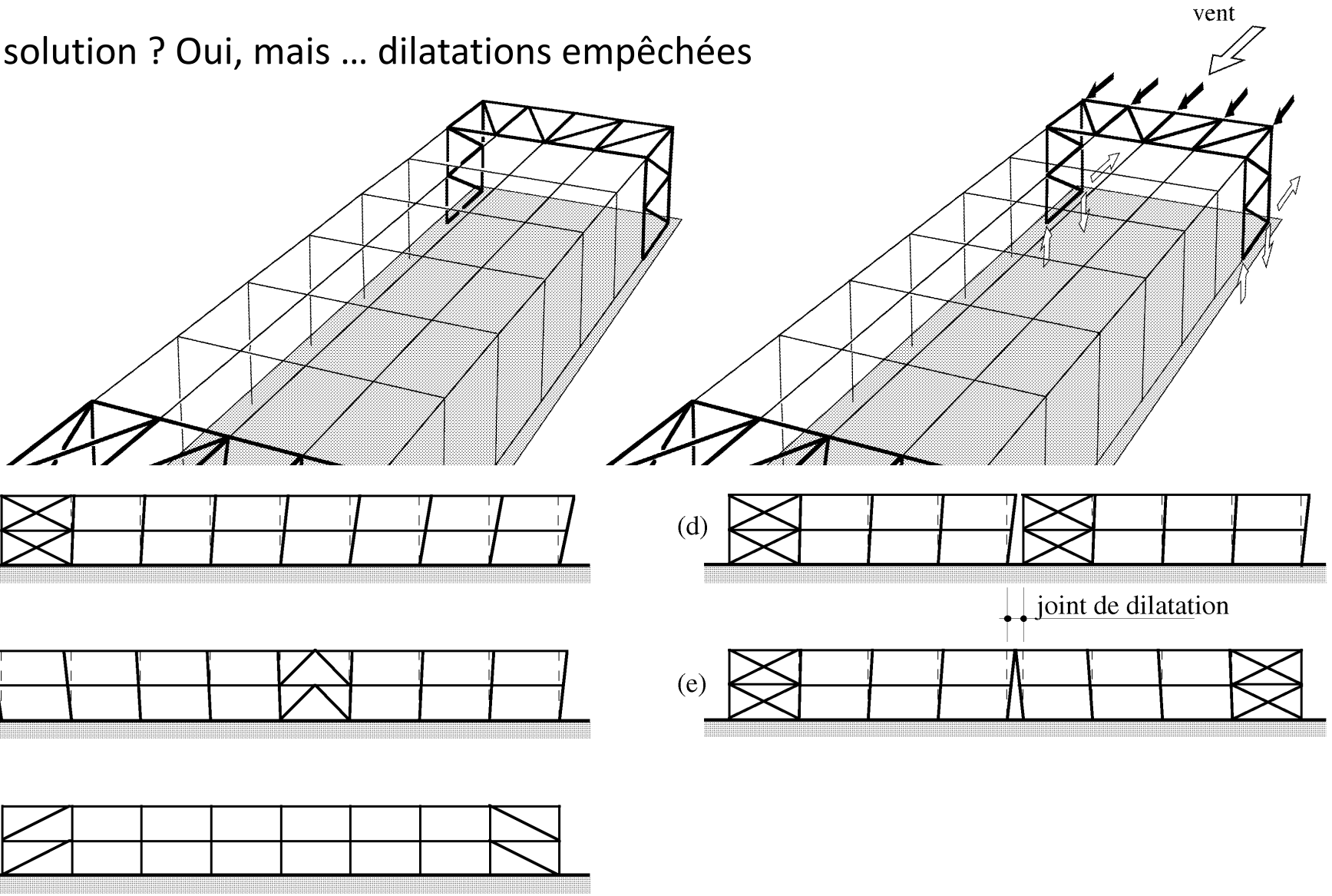
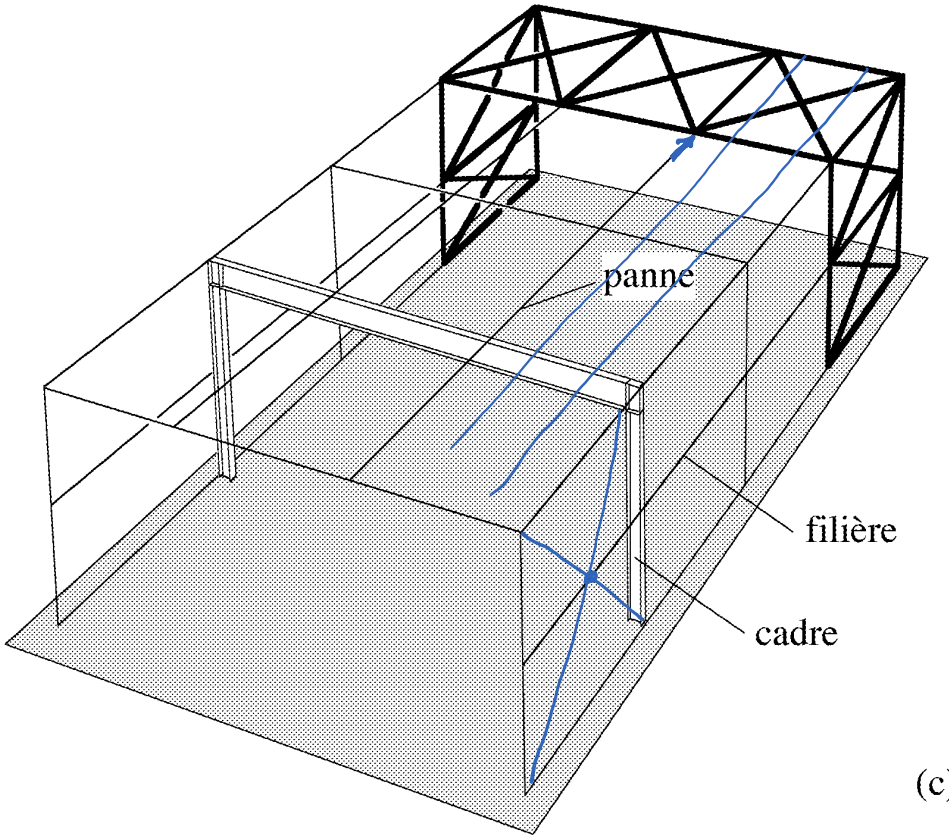


Fig. 3.25b: Transmission des efforts horizontaux

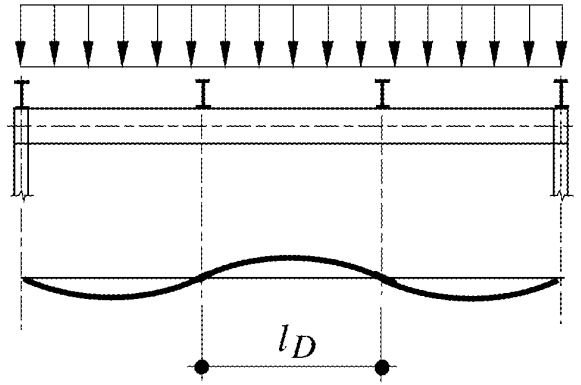
La solution ? Oui, mais … dilatations empêchées



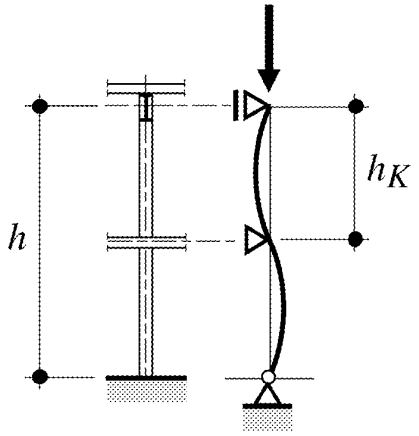
Autres rôles du CV, contribuer à stabiliser les éléments



(c)

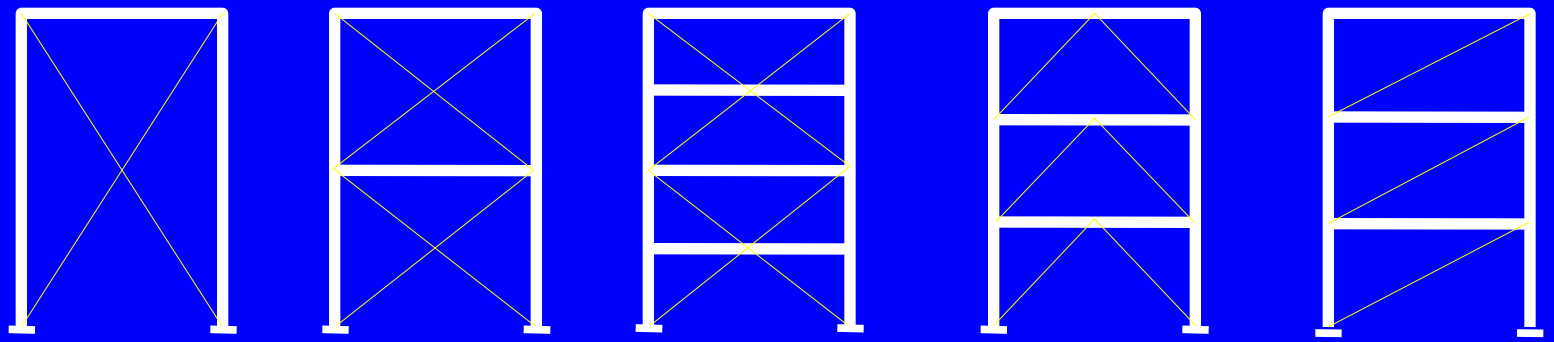


Déversement de la traverse



Flambage hors plan du montant

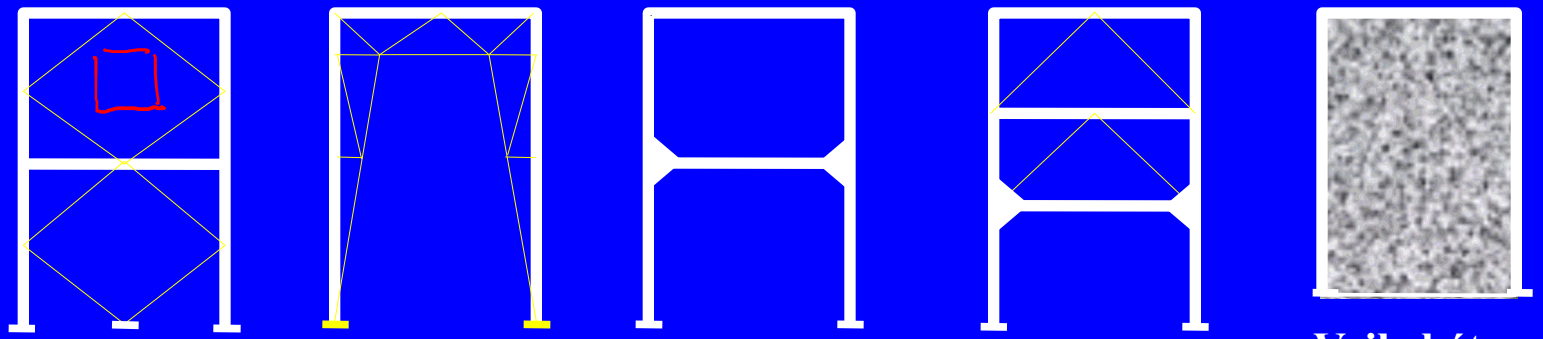
Types de contreventements



En croix de Saint -André

En V

En N



En losange

En treillis

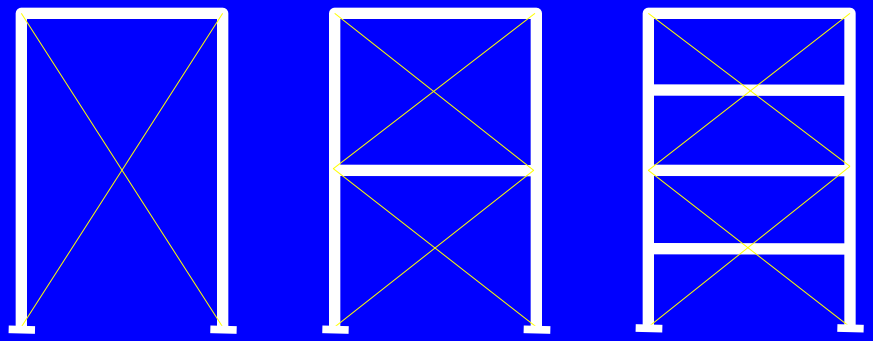
Cadres

Combiné (portique+V)

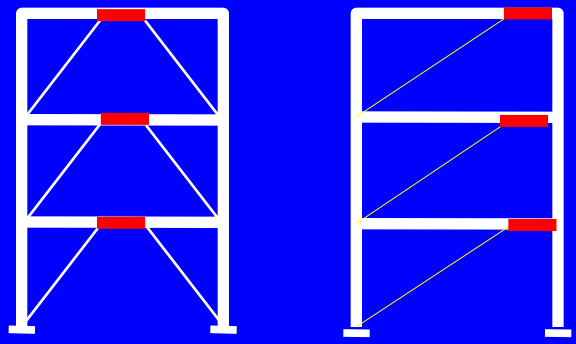
Voile béton (diaphragme vertical)

Types de contreventements

Résistance aux séismes (annexe)

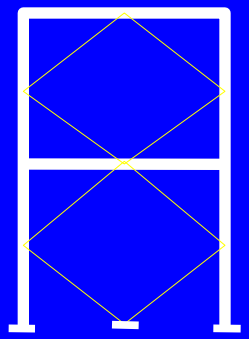


En croix de Saint -André

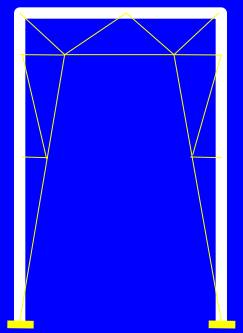


En V

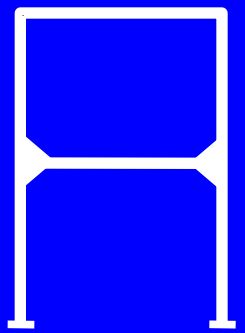
En N



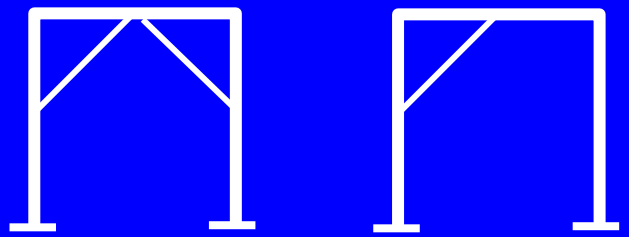
En losange



En treillis



Cadres

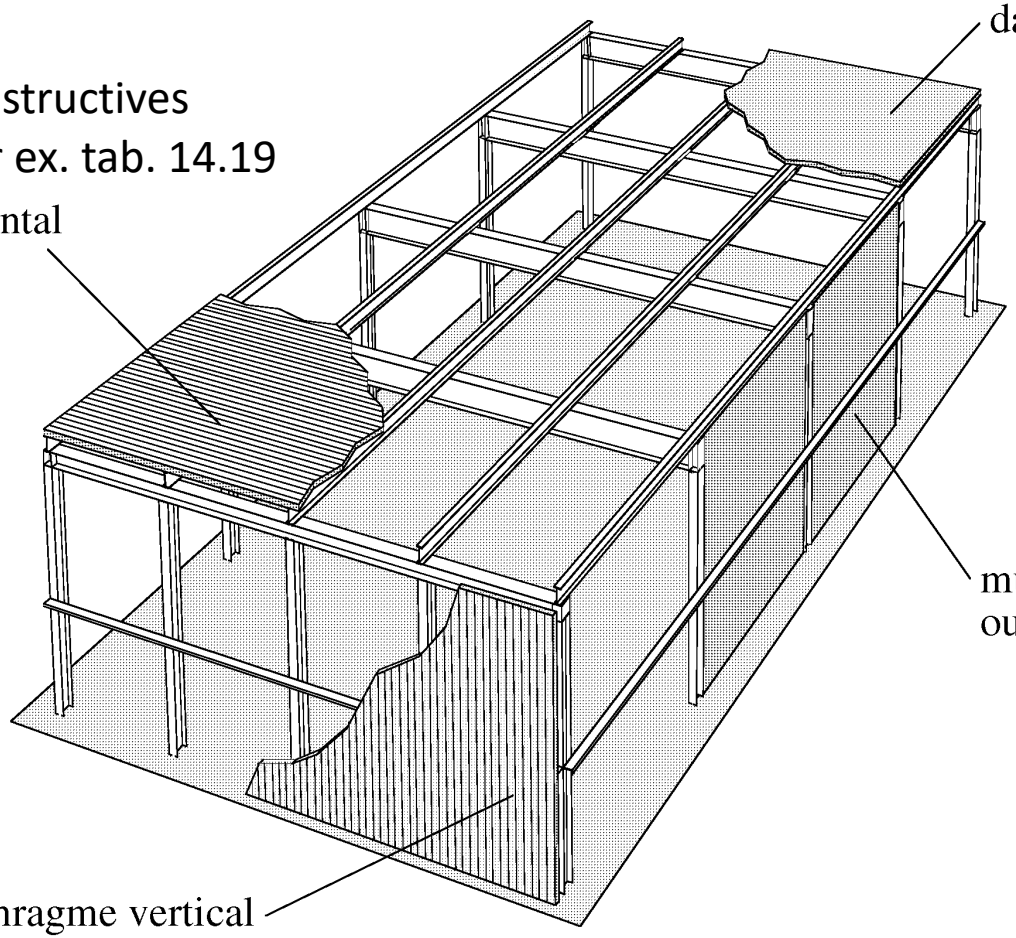


Autres systèmes cadres

Fig. 3.26: Autres éléments servant de stabilisation

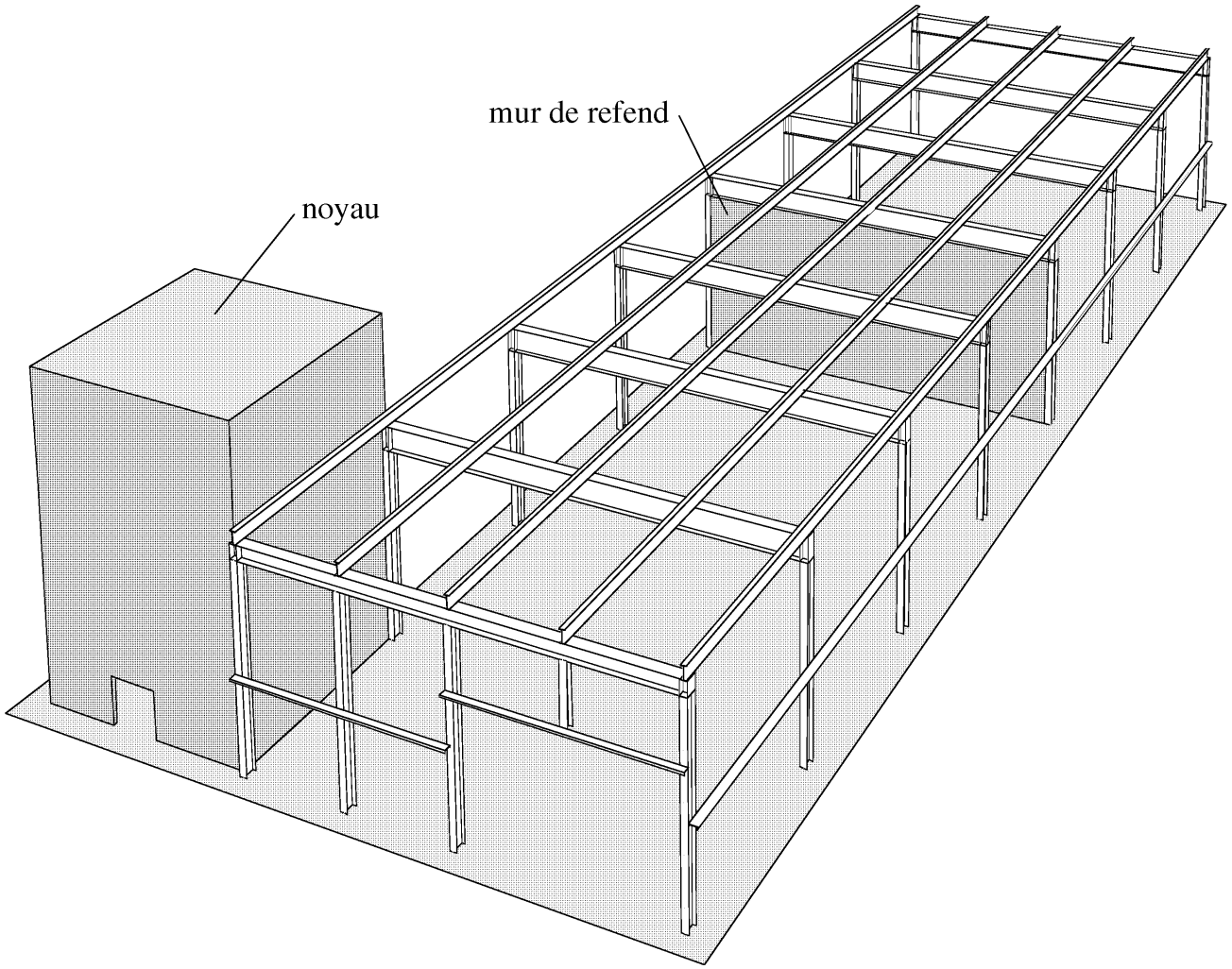
Règles calcul et constructives

TGC 11 § 14.4, par ex. tab. 14.19



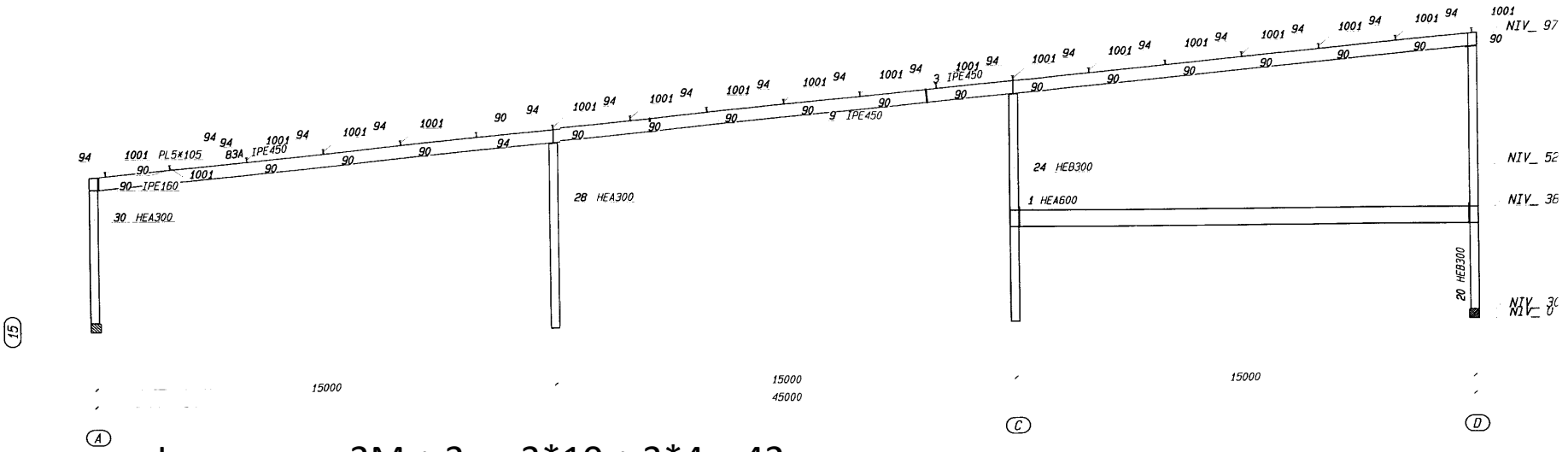
(a)

Fig. 3.26: Autres éléments servant de stabilisation



(b)

Exemple de “notre halle”: cadres autostables

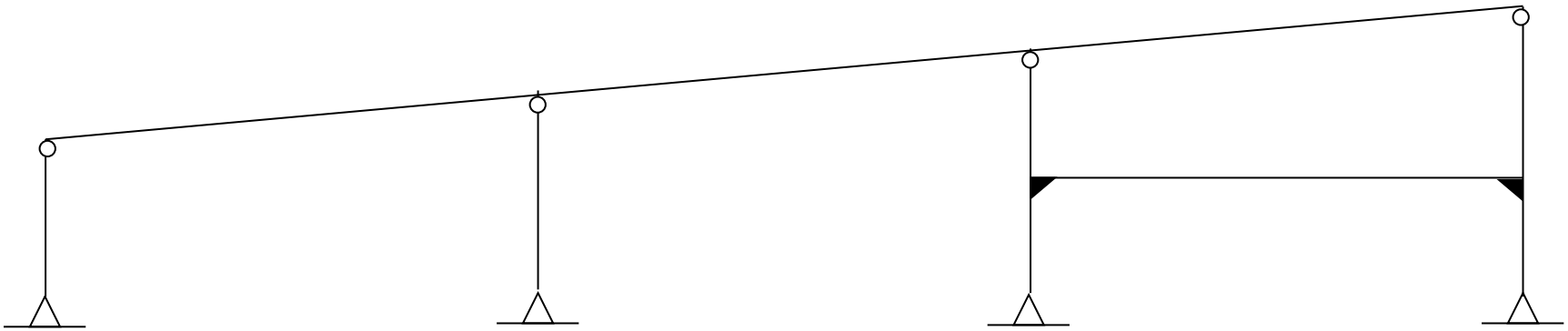


Inconnues: 3M + 3s = 3*10 + 3*4 = 42

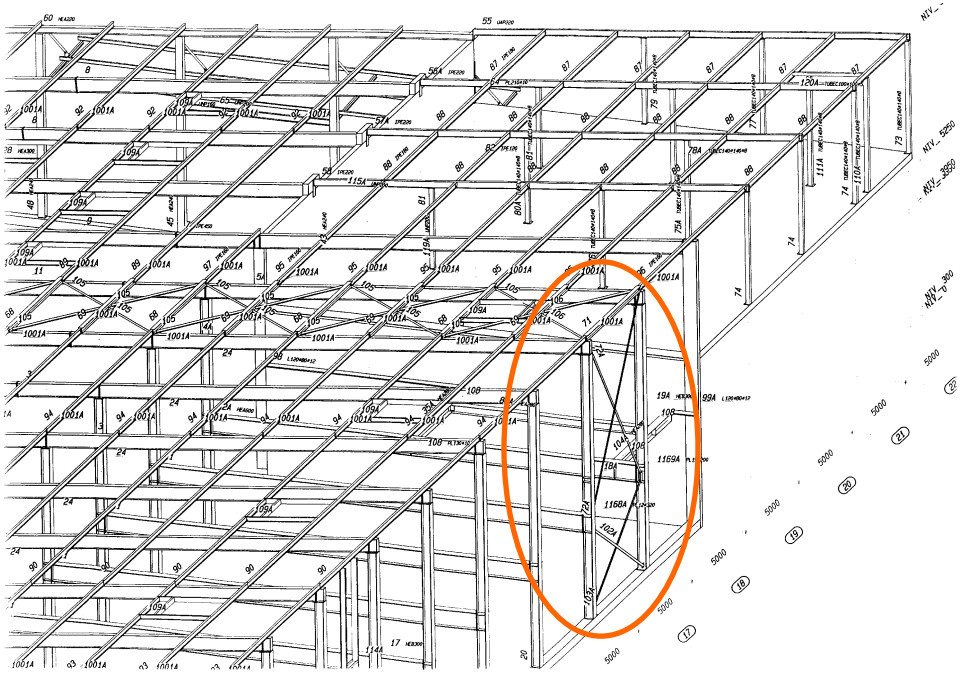
Connues: 3j + r = 3*10 + 4 + 1 + 1 + 1 + 1 = 38

4x hyperstatique intérieur (pour trouver ts les efforts intérieurs)

Seulement 3x hyperstatique cinématique, car alors instable géom.



Exemple de “notre halle” : contreventement hors du plan des cadres



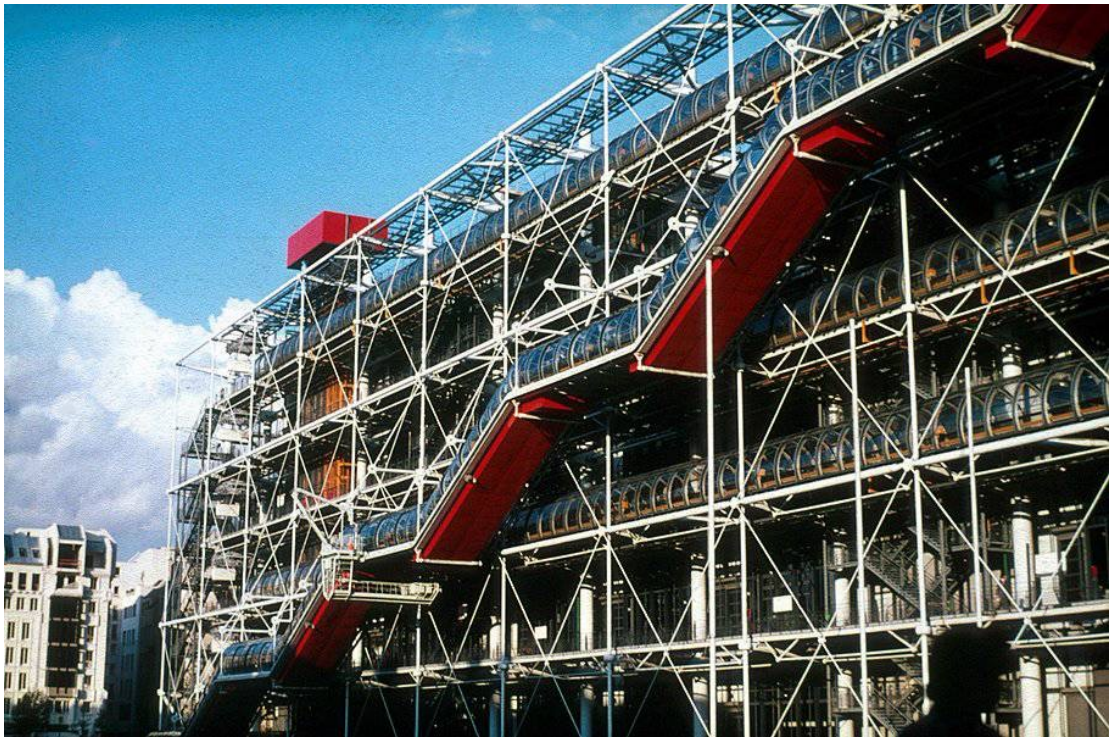
Exemples de contreventements

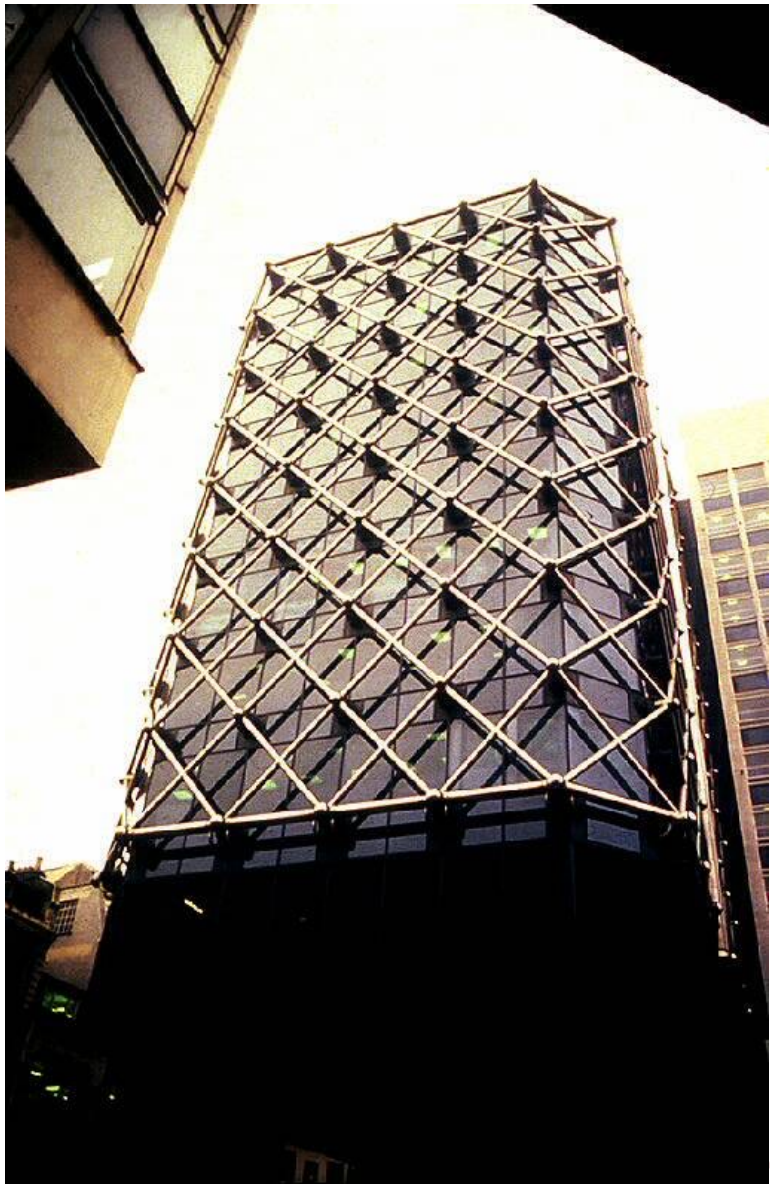
Source: Halle à Ecublens, MP Ingénieurs, 2006 (Eric Tonicello)

Exemples de contreventements

47+7, Sustainable Living Innovations, Seattle, 2015

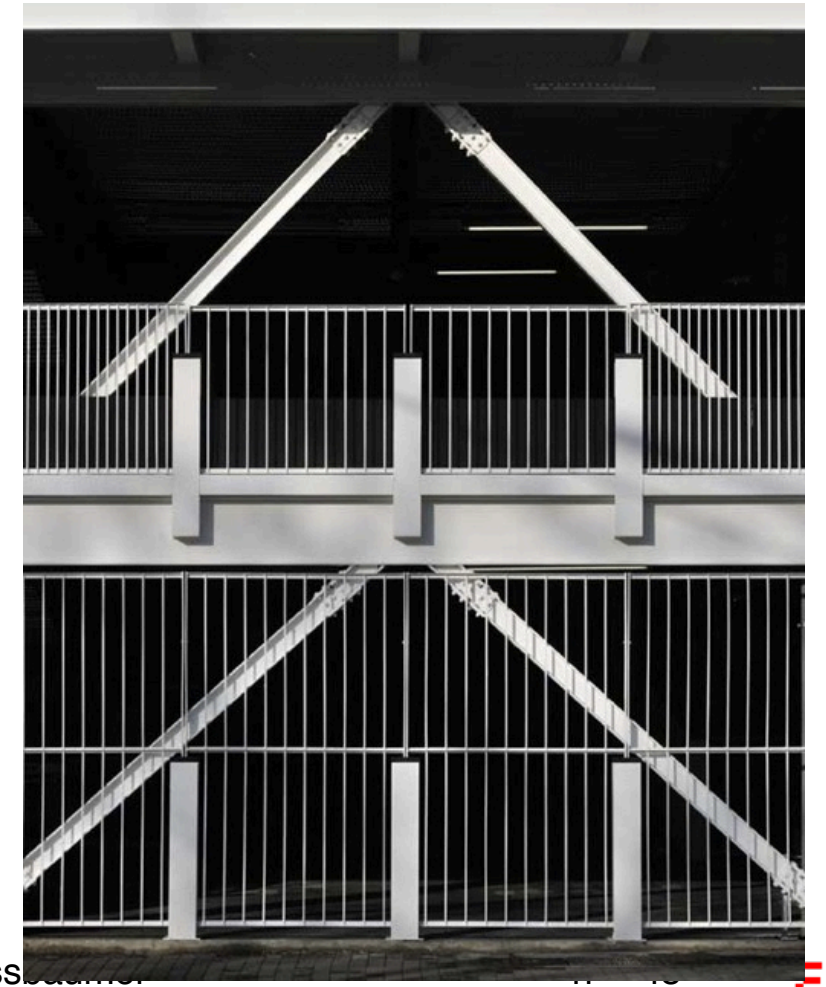
Exemples de contreventements





Exemples de contreventements

Exemples de contreventements



ASSOCIATION POUR LA PROMOTION DE L'ENSEIGNEMENT DE LA CONSTRUCTION ACIER

Exemples de contreventements

Conception : Jean-Pierre Muzeau

Exemples de contreventements

Stadt- und Landesbibliothek Dortmund_Arch. Mario Botta_1999

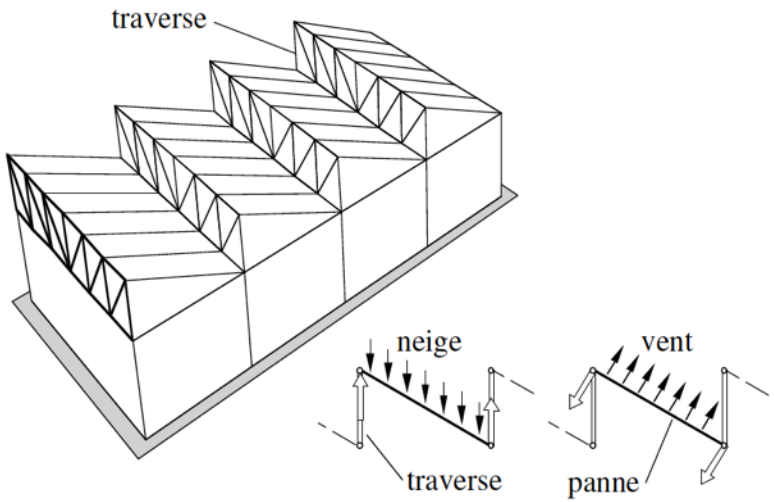
Exemples de contreventements

Tour de la Bank of China, Hong Kong (1990), photos AN

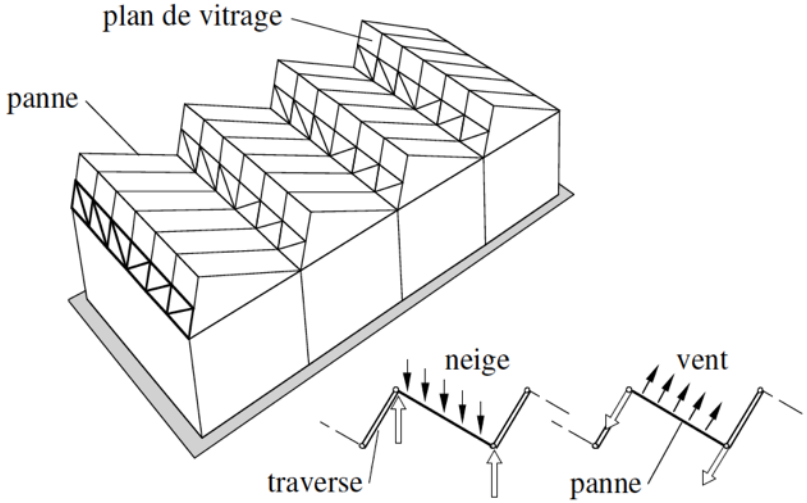
A. Nussbaumer

Contreventement par noyau central

ANNEXE: cas particulier des sheds (TGC 11 § 3.3 et 3.4)

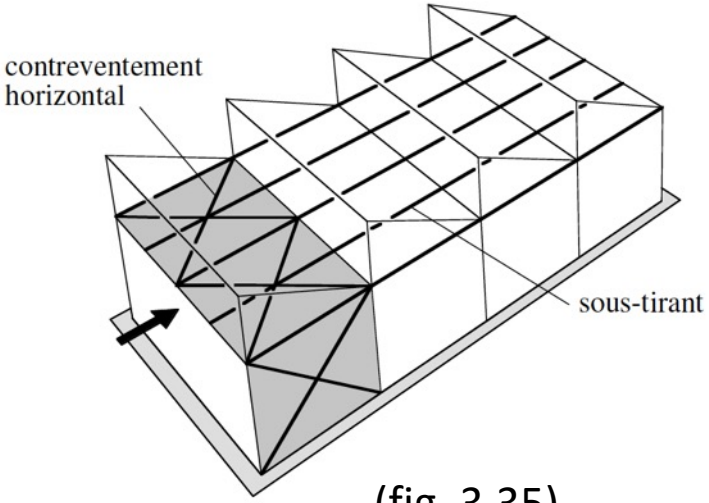


(a) Traverses verticales

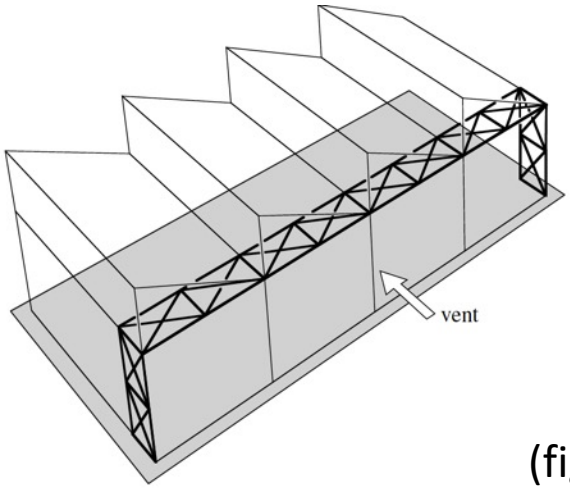


(b) Traverses inclinées

(fig. 3.33)



(fig. 3.35)



(fig. 3.36)

ANNEXE: Coût d'une structure en acier

1. Matière

Achat	tôles	800 frs/t
	profilés	900 frs/t
	tubes	1500 frs/t
Déchets		30 à 50 frs/t
Electrodes, boulons		40 à 60 frs/t
Peinture (deux couches)		150 frs/t

2. Main d'œuvre

Bureau technique		100 à 250 frs/t
Atelier, y.c peinture	profilés	800 frs/t
	poutre à treillis	1800 frs/t

3. Transport en Suisse romande (sans convoi spécial) 50 à 100 frs/t

4. Montage

Main d'œuvre		300 à 600 frs/t
Grues		100 à 300 frs/t

5. Risques et bénéfices si possible ~ 5 %

6. TVA 7.7 %

(dernière actualisation 2019)

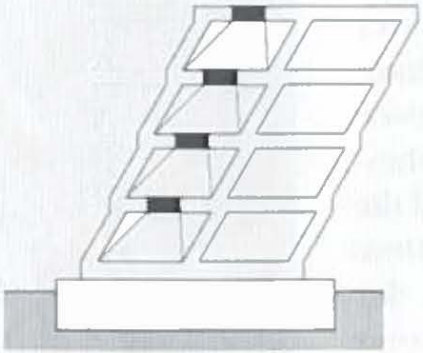
ANNEXE: Coût d'une structure en acier

Exemple comparatif

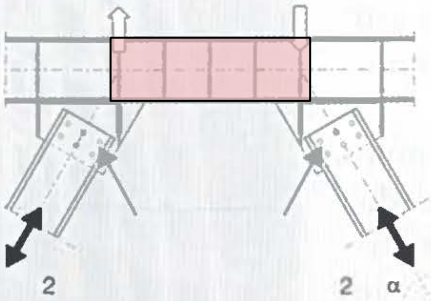
	Structure simple	Structure triangulée	
	construction lourde, min 100 t	profilés tubulaire, léger	construction lourde
1. Matière	1000 frs/t	1800 frs/t	1600 frs/t
2. Bureau technique	100	250	120
Atelier	800	1800	1500
3. Transport	50	100	50
4. Montage	400	900	400
Sous-total	2350	4850	3670
5 + 6 (~12 % du sous-total)	282	582	440
Total	2.60 frs/kg	5.40 frs/kg	4.10 frs/kg

(dernière actualisation 2019)

ANNEXE: Résistance aux séismes et contreventements



Zone de dissipation d'énergie



1 Überfestigkeit (globale Hierarchie)
2 Überfestigkeit (lokale Hierarchie)

Bâtiment à Tokyo (Bauingenieur, 04/2014)

ANNEXE: Résistance aux séismes des contreventements

3 Types de systèmes de CV avec excentricités (zones de plastification, dissipation) selon AISC