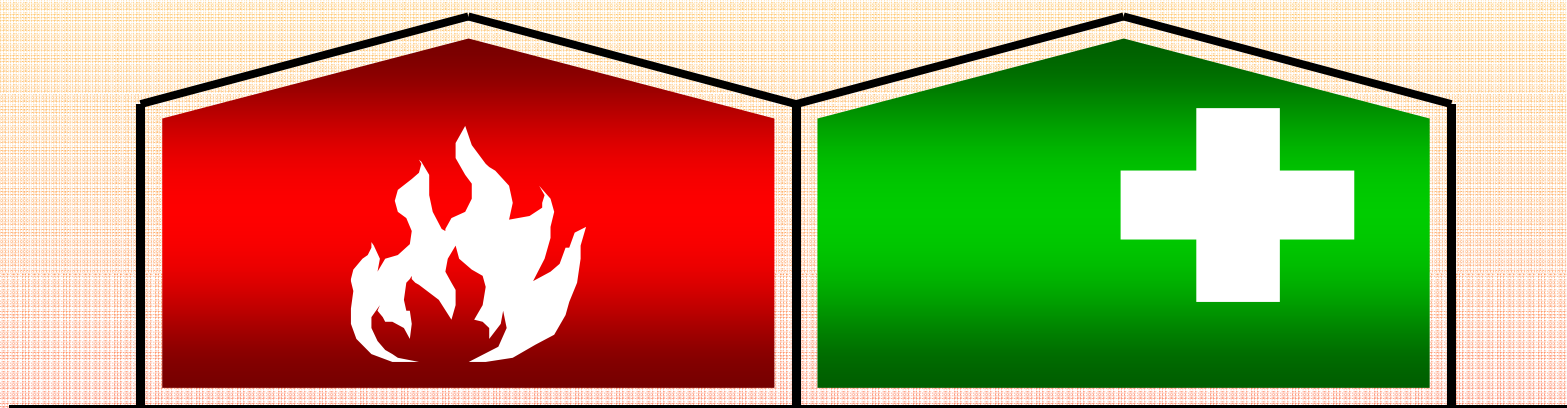


# Presentatie « software LUCA »



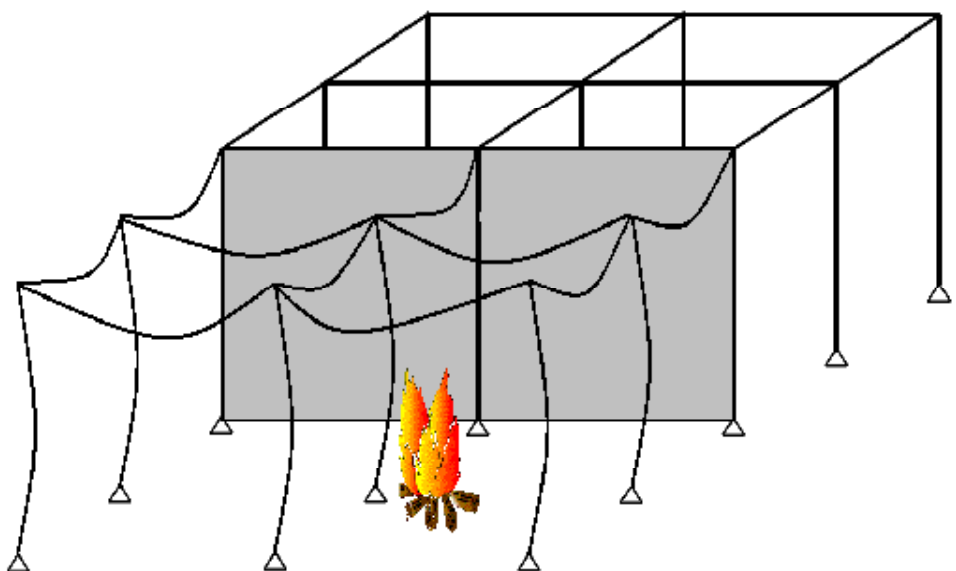
## Brandveiligheid in industriegebouwen



RFS2-C2-2007-00032



# Welcome to the FS+ Project



Please choose a language

- FRANCAIS
- ENGLISH**
- ESPAÑOL



Fire Safety of Industrial Hall

Add a Language

Exit

# ***LUCA***



# Welcome to the FS+ Project

## How to add a language.

To add another language, please follow the succeeding procedure :

1. Open the file wich is called « langues » ;
2. Make the translation of the different texts ;
3. Save it and close it.

Remarks :

- Your text must be under 60 characters
- Take care to respect the number of column of the first character for every line (1, 61, 121, 181, 241, 301, 361...).

De manière à ajouter votre propre langue, suivez les instructions suivantes

1. Ouvrez le fichier appelé « langues » ;
2. Faites la traduction de l'ensemble des textes ;
3. Enregistrez et fermez la fenêtre.

Remarque :

- Votre texte doit contenir un maximum de 60 caractères
- Prêter attention à respecter le numéro de colonne du premier caractère pour chaque ligne (1, 61, 121, 181, 241, 301, 361...).

Please choose a language

FRANCAIS

ENGLISH

ESPAÑOL

ArcelorM



Add a Language

Exit

# LUCA

# Introduction



## Field of application

This Software is applicable to industrial halls the fulfill the following conditions:

- Buildings with steel structure, either steel portal frames with cross section in standard H or I hot rolled profiles or equivalent welded plate girders, or steel frames based on lattices beams with columns in H or I;
- Buildings divided in one or several compartments separated one from another by fire walls. These walls can be either parallel to the steel frames, or perpendicular to the steel frames.

The sizes considered in the project are as listed :

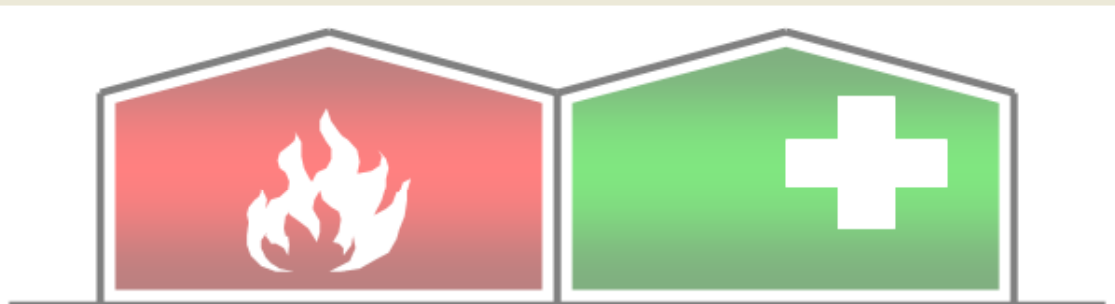
- Length of a span for simple bay : 15 m, 20 m and 30 m
- Length of a span for multiple bay : 20 m, 30 m and 40 m
- Height - simple bay : 5 m, 7.5 m, and 12.5 m
- Height - multiple bay : 7.5 m, 12.5 m and 20 m  
( $H < 20$  m [Collapse toward the inside])
- Slope of the roof : 5°
- Number of bays : 1, 3 and 5
- Lattice beam : equal angles 50x50x5 till 120x120x12

Design beyond the scope of analysis will not be recommended unless treated as preliminary design, which will be farther validated.

## How to treat the results

The displacements that will be obtained must be used to verify the stability of the interior and exterior walls :

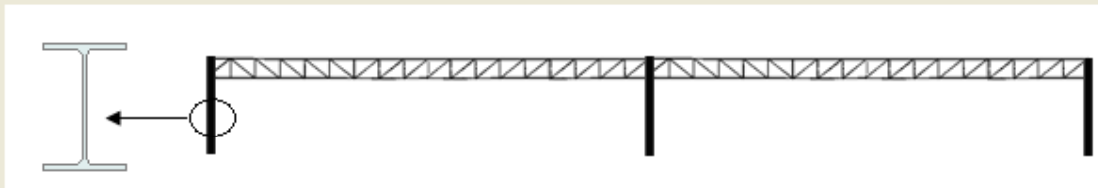
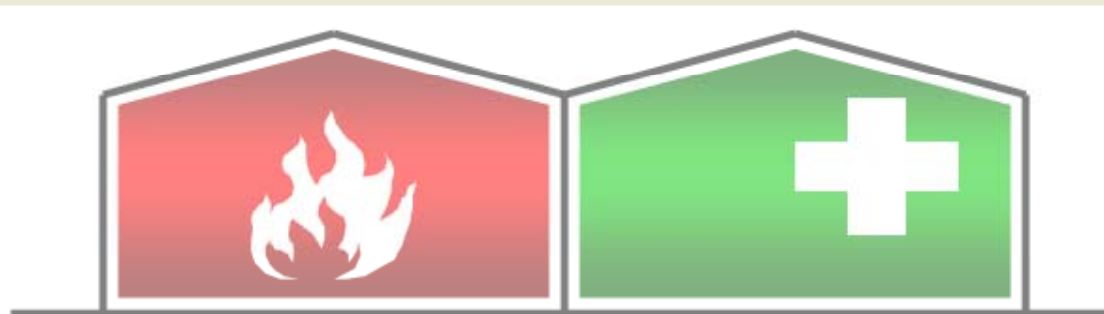
The force that will be obtained in stage of pull must be used to verify the stability of the cold part (force located at the top of the column).



Fire Safety of Industrial Hall

Single bay frame Multiple frames with cross section in H or I sections

\*

 Multiple frames with lattice beams and columns in H or I sections\* With an height  $H < 20$  m (collapse toward the inside)

Fire Safety of Industrial Hall

OK

Previous

Quit



## Enter the following parameters

### Column

#### Steel Profile

Type : IPE

Profile : IPE 360

Depth (h) : 360 mm

Width (b) : 170 mm

Thickness of the flanges (tf) : 12.7 mm

Thickness of the web (tw) : 8 mm

Radius of the root filet(r) : 18 mm

Inertia : 16270 cm<sup>4</sup>

### Beam

#### Steel Profile

Type : IPE

Profile : IPE 330

Depth (h) : 330 mm

Width (b) : 160 mm

Thickness of the flanges (tf) : 11.5 mm

Thickness of the web (tw) : 7.5 mm

Radius of the root filet(r) : 18 mm

Inertia : 11770 cm<sup>4</sup>

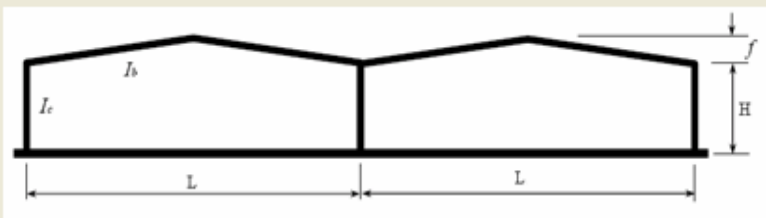
Fire wall parallel to the frames

Fire Wall perpendicular to the frames

Fire compartment in the centre of the building

Fire compartment at the edge of the building

Total design value of the load on the roof (fire situation)  N/m



Length (L) :  mm

Height (H) :  mm

Ridging (f) :  mm

Number of span in the cold compartment located to the left of the fire compartment

Number of span in the fire compartment

Number of span in the cold compartment located to the right of the fire compartment

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# Report

## Input Data

Type of beam	<input type="text" value="IPE 330"/>	Fire Wall perpendicular to the frames	L	<input type="text" value="24"/>	m	Design Load Q	<input type="text" value="3572"/>	N/m	Number of spans (cold part) located to the left of the fire	<input type="text" value="0"/>
Inertia	<input type="text" value="11770"/>		cm <sup>4</sup>	H	<input type="text" value="7"/>				m	Number of spans in the fire
Type of column	<input type="text" value="IPE 360"/>	Fire compartment at the edge part of the building	f	<input type="text" value="1.2"/>	m			Number of spans (cold part) located to the right of the fire	<input type="text" value="3"/>	
Inertia	<input type="text" value="16270"/>		cm <sup>4</sup>							

## Intermediare results

Slope of the roof	<input type="text" value="10"/>	%	$\alpha$	<input type="text" value="0.177"/>	k	<input type="text" value="97024"/>	Kt	<input type="text" value="12049"/>
Coefficient Cp/Cth	<input type="text" value="0.015"/>		Cg	<input type="text" value="1"/>	Kg	<input type="text" value="12613"/>		
			Cd	<input type="text" value="2.779"/>	Kd	<input type="text" value="269597"/>		

## Results

### *Stage of Push*

Displacement to the left	<input type="text" value="688"/>	mm
Displacement to the right	<input type="text" value="32"/>	mm

### *Pull Stage*

Displacement	<input type="text" value="350"/>	mm
Pull Force	<input type="text" value="94301"/>	N

Print

Show the equations

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**Case 1 : Fire in a compartment located at the middle of the Hall**

**Stage of Push :** displacements at fire compartment ends



Displacements  $\delta_i$  [m] :

$$\delta_i = \frac{C_p \cdot n \cdot q \cdot l}{K_i}$$

Roof slope	$C_p$
0%	1,19
5%	1,16
10%	1,1

$C_p$  is an empirical coefficient (function of the slope of the roof) (\*) linear interpolation may be used

$n$  is the span number of the compartment submitted to fire ( $n \leq 2$ )

$q$  is the linear load on roof (fire situation)

$l$  is the span length [m]

$K_i$  are the equivalent lateral stiffness of the steel frames of cold compartments [N/m]

$m_i$  is the span number of the neighboring cold compartments

$$\begin{cases} K_i = k \text{ for } m_i = 1 \text{ [1]} \\ K_i = c \cdot k \text{ for } m_i \geq 2 \text{ [2]} \end{cases}$$

With,

$$\begin{cases} k = \frac{\alpha}{1+2\alpha} \cdot \frac{12 \cdot E \cdot I_b}{(h+f)^3} \text{ [N/m]} \\ \alpha = \frac{I_b}{I_c} \cdot \frac{h+f}{l} \left(1 - \frac{f}{0.6h}\right) \text{ [3]} \\ c = 1 + \sum_{i=1}^m \frac{i}{2} \cdot \frac{2\alpha+1}{1+2i\alpha} \end{cases}$$

$h$  height of the portal frame [m]

$f$  ridding [m]

$I_b$  second moment of area of the beam [m<sup>4</sup>]

$I_c$  second moment of area of columns [m<sup>4</sup>]

$E$  modulus of elasticity of steel [N/mm<sup>2</sup>]



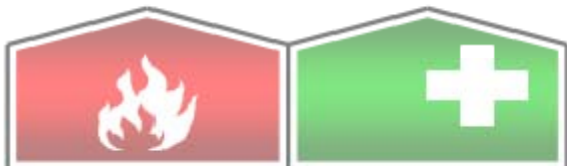
**Stage of Traction :** Stability of the cold part of the structure and displacement at fire compartment end

Horizontal tensile force  $F$  at the compartment ends

$$F = C_p \cdot n \cdot q \cdot l$$

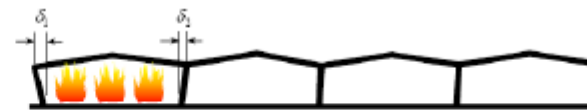
Maximum displacements induced at the top of columns

$$\delta_{max,i} = \frac{F}{K_i} \quad K_i \text{ given by [1]}$$



**Case 2 : Fire compartment at edge part of the storage building**

**Stage of Push :** displacements at fire compartment ends



Displacements  $\delta_i$  [m] :

$$\delta_i = \frac{K_2}{K_i} \cdot n \cdot C_{th} \cdot l$$

$$\text{With, } K_i = \frac{K_1 \cdot K_2}{K_1 + K_2}$$

$K_1$  et  $K_2$  equivalent lateral stiffness of the steel frames

$l$  is the span length [m]

$n$  is the span number of the compartment submitted to fire

$C_{th}$  empirical coefficient (function of the slope of the roof) linear interpolation may be used

Roof slope	$C_{th}$
0%	0,01
5%	0,011
10%	0,015

$K_2$  given by [1] or [2]

$$\begin{cases} K_1 = 0,065 \cdot k \text{ for } n = 1 \\ K_1 = 0,13 \cdot k \text{ for } n = 2 \\ K_1 = 0,13 \cdot c \cdot k \text{ for } n > 2 \end{cases}$$

$c$  and  $k$  given by [3] with  $m = n - 1$

**Stage of Traction :** Stability of the cold part of the structure and displacement at fire compartment end

Horizontal tensile force  $F$  at the compartment ends

$$\begin{cases} F = 0,5 \cdot C_p \cdot q \cdot l \text{ pour } n = 1 \\ F = C_p \cdot q \cdot l \text{ pour } n \geq 2 \end{cases}$$

Maximum displacements induced at the top of columns

$$\delta_{max,i} = \frac{F}{K_i} \quad K_i \text{ given by [1]}$$

# Report FS+

-----

## 1] Introduction

Multiple frames with cross section in H or I sections

### 1.1] Field of application

This Software is applicable to industrial halls the fulfill the following conditions:

- Buildings with steel structure, either steel portal frames with cross section in standard H or I hot rolled profiles or equivalent welded plate girders, or steel frames based on lattices beams with columns in H or I ;
- Buildings divided in one or several compartments separated one from another by fire walls. These walls can be either parallel to the steel frames, or perpendicular to the steel frames.

The sizes considered in the project are as listed :

Length of a span for simple bay : 15 m, 20 m and 30 m  
Length of a span for multiple bay : 20 m, 30 m and 40 m  
Height - simple bay : 5 m, 7.5 m, and 12.5 m  
Height - multiple bay : 7.5 m, 12.5 m and 20 m  
(H < 20 m [Collapse toward the inside])  
Slope of the roof : 5°  
Number of bays : 1, 3 and 5  
Lattice beam : equal angles 50x50x5 till 120x120x12

Design beyond the scope of analysis will not be recommended unless treated as preliminary design, which will be farther validated.

### 1.2] How to treat the results

The displacements that will be obtained must be used to verify the stability of the interior and exterior walls ;

The force that will be obtained in stage of pull must be used to verify the stability of the cold part (force located at the top of the column).

## 2] Input Data

### 2.1] Type and inertia of the columns and beams of the frames

Type of beam  
IPE 330  
Inertia  
11770 cm<sup>4</sup>

Type of column  
IPE 360  
Inertia  
16270 cm<sup>4</sup>

### 2.2] Position of the fire wall and location of the fire in the building :

Fire Wall perpendicular to the frames

Fire compartment at the edge part of the building

### 2.3] Geometry of the frames :

Length :  
L = 24 m  
Height :  
H = 7 m  
Ridging :  
f = 1.2 m

0 : Number of spans (cold part) located to the left of the fire  
2 : Number of spans in the fire compartment  
3 : Number of spans (cold part) located to the right of the fire

### 2.4] Design Load Q

q = 3572 N/m

## 3] Intermediate results

### 3.1] Slope of the roof, Coefficient (function of the slope)

10 % : Slope of the roof  
0.015 : Coefficient Cp/Cth

### 3.2] Coefficients a and c :

a : 0.177  
Cg : 1  
Cd : 2.779

### 3.3] Equivalent stiffness for lateral displacements :

k : 97024 N/m  
Kg : 12613 N/m  
Kd : 269597 N/m  
Kt : 12049 N/m

## 4] Results

### 4.1] Stage of Push

Horizontal displacements in the top of the columns :

- 688 mm : Displacement to the left
- 32 mm : Displacement to the right

### 4.2] Pull Stage

Maximum horizontal force in the top of the columns :

94301 N : Pull Force

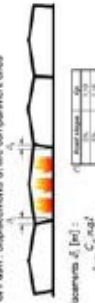
Horizontal displacements in the top of the columns :

350 mm : Displacement

Made with the Software LUCA

Case 1 : Fire in a compartment located at the middle of the Hall

Stage of Push : displacements at fire compartment ends



Displacements  $\delta_j$  [m] :

$$\delta_j = \frac{C_{p,j} \cdot \Delta T \cdot l_j}{E_j}$$

- $C_{p,j}$  is an empirical coefficient (function of the slope of the roof) (\*)
- $\Delta T$  is the temperature increase in the compartment (K)
- $l_j$  is the span length [m]
- $E_j$  is the equivalent lateral stiffness of the steel frames or cold compartments (kN/m)
- $m_j$  is the span number of the compartment subjected to fire (1, 2, 3)
- $q$  is the linear load on roof (kN/m)
- $r$  is the span length [m]
- $A_c$  are the equivalent lateral stiffness of the steel frames or cold compartments
- $m_j$  is the span number of the neighbouring cold compartments

$$\delta = \frac{q \cdot l^2}{8 \cdot E} \cdot \frac{1 + 2 \cdot \alpha \cdot (1 + \alpha \cdot l^2 / 8 \cdot E)}$$

$$\alpha = \frac{1}{l} \cdot \frac{b \cdot l}{l} \cdot \left( 1 - \frac{r}{0.6 \cdot b} \right)$$

$$c = 1 + \frac{2 \cdot l}{r} \cdot \frac{2 \cdot l \cdot \alpha}{1 + 2 \cdot \alpha \cdot l^2 / 8 \cdot E}$$

- $h$  : height of the steel frame [m]
- $I$  : slapping [m<sup>4</sup>]
- $J_1$  : second moment of area of the beam [m<sup>4</sup>]
- $J_2$  : second moment of area of columns [m<sup>4</sup>]
- $E$  : modulus of elasticity of steel [N/m<sup>2</sup>]

Stage of Traction : Stability of the cold part of the structure and displacement at fire compartment end

Horizontal tensile force  $F$  at the compartment ends

$$F = C_{p,j} \cdot \Delta T \cdot l_j$$

Maximum displacements induced at the top of columns

$$\delta_{max} = \frac{F \cdot h}{E_c}$$

$E_c$  given by [1]

Case 2 : Fire compartment at edge part of the storage building

Stage of Push : displacements at fire compartment ends



Displacements  $\delta_j$  [m] :

$$\delta_j = \frac{C_{p,j} \cdot \Delta T \cdot l_j}{E_j}$$

- with  $E_j = \frac{E_c \cdot I_c}{h_j \cdot (1 + \alpha_j)}$
- $\alpha_j$  et  $E_c$  equivalent lateral stiffness of the steel frames
- $l_j$  is the span length [m]
- $\Delta T$  is the temperature increase in the compartment subjected to fire
- $C_{p,j}$  empirical coefficient (function of the slope of the roof) (these interpretation may be used)

$E_c$  given by [1] or [2]

$$\begin{cases} E_c = 0.083 \cdot E_c \cdot h_j & \text{for } \alpha_j = 1 \\ E_c = 0.13 \cdot E_c \cdot h_j & \text{for } \alpha_j = 2 \\ E_c = 0.11 \cdot E_c \cdot h_j & \text{for } \alpha_j = 3 \end{cases}$$

and  $h_j$  given by [2] with  $m = m - 1$

Stage of Traction : Stability of the cold part of the structure and displacement at fire compartment end

Horizontal tensile force  $F$  at the compartment ends

$$F = 0.5 \cdot C_{p,j} \cdot \Delta T \cdot l_j \cdot m$$

$$F = C_{p,j} \cdot \Delta T \cdot l_j \cdot m \cdot 0.2$$

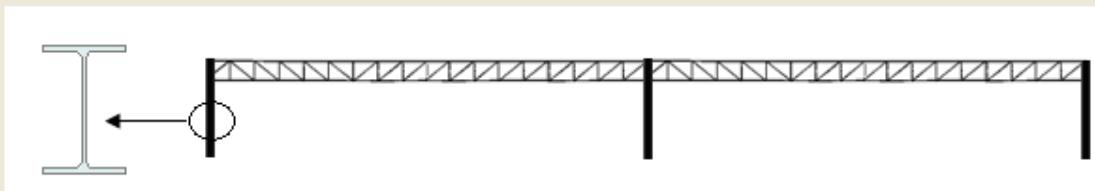
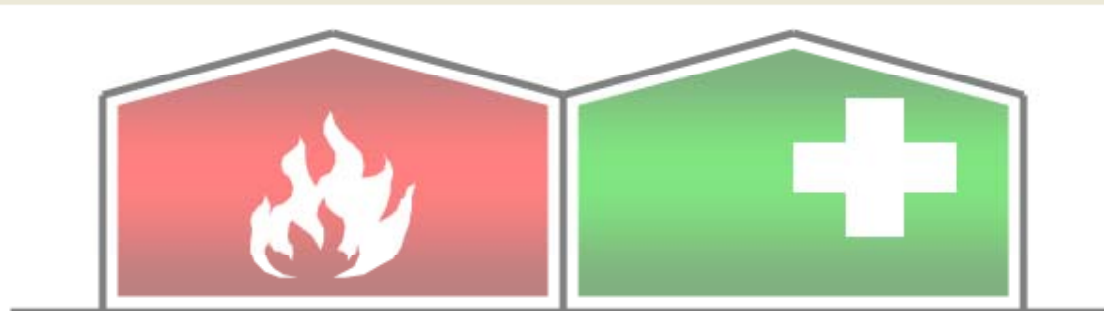
Maximum displacements induced at the top of columns

$$\delta_{max} = \frac{F \cdot h}{E_c}$$

$E_c$  given by [1]

Single bay frame Multiple frames with cross section in H or I sections

\*

 Multiple frames with lattice beams and columns in H or I sections\* With an height  $H < 20$  m (collapse toward the inside)

Fire Safety of Industrial Hall

OK

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## Enter the following parameters:

Number of spans in the fire compartment  
(Max. 6)

Total design value of the load on  
the roof (fire situation)

Fire walls parallel to the frames

Fire Wall perpendicular to the frames

Fire compartment in the central part of the building

Fire compartment at the edge part of the building

Equivalent stiffness K1  N/m

Equivalent stiffness K2  N/m

L1  mm

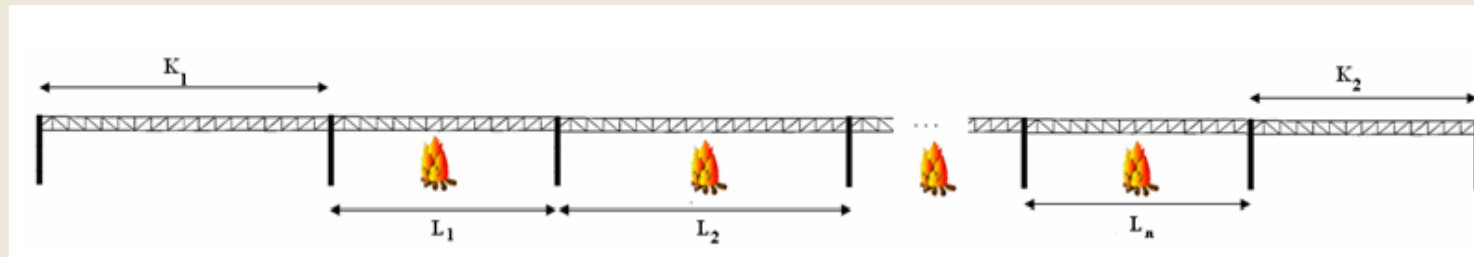
L2  mm

L3  mm

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**Input data**

Multiple frames with lattice beams and columns in H or I sections

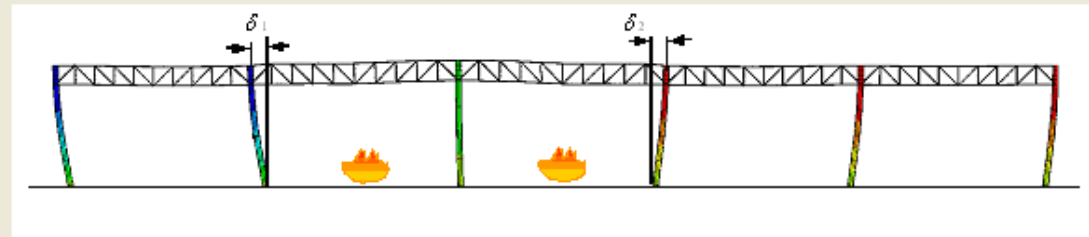
Number of spans in the fire Total design value of the  N/m

Fire walls parallel to the frames

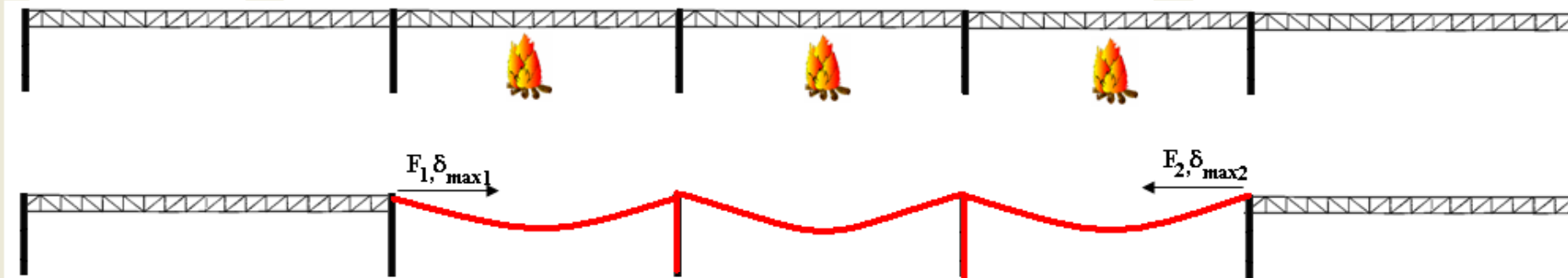
Fire compartment in the central part of the building

L1  mm L2  mm L3  mm**Report**Equivalent stiffness K1  N/mEquivalent stiffness K2  N/mKt (= K1 \* K2 / (K1 + K2))  N/m**Results of the calculations**

Stage of push

**Displacements induced at the ends of the compartment** $\delta_1$   [mm] $\delta_2$   [mm]

Stage of pull

**Horizontal tensile force at the ends compartment ends**F<sub>1</sub>  [N]F<sub>2</sub>  [N]**Maximum displacement(s) induced at the top of the columns** $\delta_1$   [mm] $\delta_2$   [mm]

Print

Show the equations of the calculations

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