Customer: Philippe-Auguste – Project reference: Musée du Louvre
Executed by Vincent Juhel Ouaip, on Friday, 22 March 2019.
Generated with Lisa.blue software version 18.11.04.

Global data

Building address: Musée du Louvre, 75001 Paris, France
Altitude: 34 m Gravity: 9.81 N/kg
Eurocodes standards :

- *basis : EN 1990 (03/2003) + FR NA (12/2011)*
  (Consequences class CC3 = High consequence for loss of human life, or economic, social or environmental consequences very great.)
- *snow loads : EN 1991-1-3 (07/2003) + FR NA (05/2007)*
- *wind actions : EN 1991-1-4 (2005) + FR NA (03/2008)*
- *seismic actions : EN 1998-1 (12/2004) + FR NA (12/2013)*
- *fire actions : EN 1991-1-2 (11/2002) + FR NA (02/2007)*

Snow

The building is located in snow zone A1 at an altitude of 34 m .

Snow standard

The standard applicable for snow load calculation on this building is *EN 1991-1-3 (07/2003)* and its national annex *FR NA (05/2007)*.

Characteristic snow load on the ground

The values of surfacic loads of snow on the ground $s_{k,0}$, corresponding to lower altitudes, are specified by the national annex.
This one provides a country map divided into climatic zones.
For the zone A1, the specified value of the load is : $s_{k,0} = 0.450$ kN/m^2.

Characteristic snow load on the ground of the site

The load $s_{k,34\ m}$ incorporates the influence of altitude here equal to 0.000 kN/m^2 :
$s_{k,A}$ = *(NF EN 1991-1-3 /NA)*
$s_{k,34\ m}$ =
$s_{k,34\ m} = 0.450$ kN/m^2

Normal snow load on the ground of the site

The National Annex does not give the elements for adjusting the snow load on the ground with the return period.
So we will just have: $s_n = s_{k,34\ m} = 0.45$ kN/m^2

Accidental snow load on the ground of the site

The values of s_{Ad} are given by the map attached to this standard. These values are independent of altitude.
$s_{Ad} = 0$ kN/m^2 *(NF EN 1991-1-3 /NA Clause 4.3)*

Equivalent snow depth on the ground of the site

For checkings at serviceability limit states:

- fresh snow depth = 45 cm,
- settled snow depth = 22 cm,
- old snow depth = 12 cm,
- wet snow depth = 11 cm.
- with: snow depth = —

For checkings at ultimate limit states:

- fresh snow depth = 67 cm,
- settled snow depth = 33 cm,
- old snow depth = 19 cm,
- wet snow depth = 16 cm.
- with: snow depth = ————

with: *(Annex E)*

- fresh snow density = 1 kN/m^3,
- settled snow density = 2 kN/m^3,
- old snow density = 3.5 kN/m^3,
- wet snow density = 4 kN/m^3

Wind

The building is located in wind zone 2.

Wind standard

The standard applicable for wind load calculation on this building is *EN 1991-1-4 (2005)* and its national annex *FR NA (03/2008)*.

Fundamental values of the basic wind velocity

The fundamental value of the basic wind velocity, v_{b0}, is the characteristic 10 minutes mean wind velocity, irrespective of wind direction and time of year, at 10 m above ground level in terrain of 'open country' type.
The fundamental values of the basic wind velocity are specified by the National Annex.
This one provides a country map divided into climatic zones.
For the zone 2, the specified value of the velocity is: $v_{b0} = 24$ m/s .

Basic wind velocity v_b on the building site during a period of 100 years

Probability coefficient of exceeding

The probability p of exceedance is considered on the useful life of the project, itself based on the use of the project.
The design working lives are given in the NF EN 1990 /NA Tableau 2.1(NF) depending on the use.
For our building project, the use is "ERP", the recommended duration of use, necessary for determining the return period, is therefore 100 years.
The 10 minutes mean wind velocity having the probability p for an annual exceedence is determined by multiplying the basic wind velocity v_b by the probability factor of severe wind c_{prob}:

$$c_{prob} = \frac{\quad}{\quad} \quad \textit{(NF EN 1991-1-4 Equation 4.2)}$$

$$c_{prob} = \frac{\quad}{\quad}$$

$$c_{prob} = 1.0325$$

Directional factor of wind

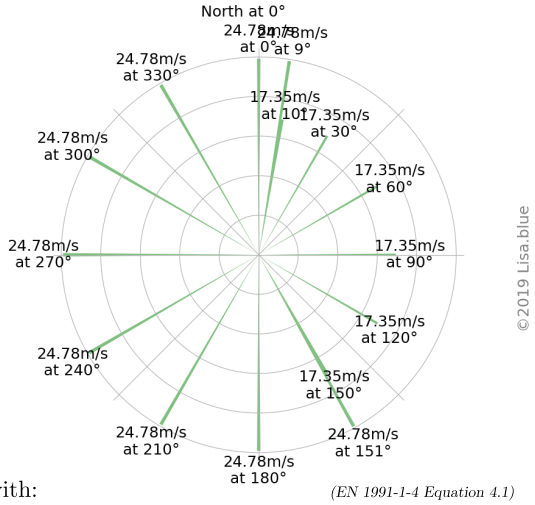
'wind direction' means the direction from which the wind comes.
By convention, this direction is indicated by the angle it forms with the North, increasing from 0° to 360° in the direction of clockwise.
High velocities of wind are observed more frequently in some sectors directions; the directional factor allows a reduction when the wind comes from a direction where the probability of occurrence of severe winds is lesser.
The envisaged reduction should be permitted in all the nominal wind sector considered to be validly adopted.
The impact of this reduction is important because the coefficient c_{dir} is taken into account when calculating the velocity and that the wind pressure is evaluated from the square of this velocity.

The values of the directional factor of wind $c_{dir,\ zone\ 1}$ for different wind directions are indicated in the NF EN 1991-1-4 Figure 4.4(NA).

Season factor

The value of the season factor c_{season} is given in the NF EN 1991-1-4 Figure 4.5(NA).
It is considered here that the project duration is longer than 1 year and does not allow for seasonal decrease in the risk of strong winds, therefore $c_{season} = 1$.

The basic wind velocity v_b on the building site, defined for each direction of the wind at 10 m above ground level in terrain of 'open country' type falling into the terrain category II, is shown in the graph below:



with: *(EN 1991-1-4 Equation 4.1)*

Orography

The altitudes are arbitrarily identified at 150m, 500m and 1000m around the construction.
A 3D interpolation of these points allows to evaluate the shape of the terrain in the vicinity of the construction shown in the graph below:

Peak velocity pressure q_p

For each surfaces of the building, wind effects are observed in 4 nominal angular sectors of 90°:

- the highest basic wind velocity v_b contained in each of its sectors is retained
- this velocity is amplified by the orography factor c_o taking into account the relief of the terrain.
- it is then adjusted taking account of the impact of terrain roughness on the variability of the mean wind velocity.
- the peak velocity pressure q_p is finally calculated with taking account of the density of air and the rapid fluctuations in velocity.

Niveau 1

- Wind from 25° :
  - Effect from orography
    Orographic profile = Flat land
    The effects of orography may be neglected when the mean slope of the upwind terrain is less than 5%. *(EN 1991-1-4 §4.3.3(2))*
    Here, the upwind terrain slope is 0 % : $c_o = 1$

  - Effect from terrain roughness:
    Terrain category IV *(National annex to EN 1991-1-4 §4.3.2(1))*
    Urban areas with at least 15% of the surface is covered with buildings whose average height is greater than 15 m; forests
    - terrain factor:
      $k_r =$ *(EN 1991-1-4 equation 4.5)*
      $k_r =$
      $k_r = 0.2343$
    - height above ground level or the minimum height depending on the terrain category:
      $z = 20.000$ m
    - roughness factor:
      $c_r(z) =$ *(EN 1991-1-4 equation 4.4)*
      $c_r(z) =$
      $c_r(z) = 0.702$

  - Peak velocity pressure:
    $q_p(z) =$ *(NF EN 1991-1-4 equation 4.8)*
    $q_p(z) =$
    $q_p(z) = 0.555$ kN/m²

    with:
    - mean wind velocity:
      $v_m(z) =$ *(NF EN 1991-1-4 equation 4.3)*
      $v_m(z) =$
      $v_m(z) = 17.395$ m/s

- air density:
  $\rho = 1.225 kg/m^3$ *(NF EN 1991-1-4 clause 4.5(1) NOTE 2)*
- turbulence factor:
  $k_l =$ *(NF EN 1991-1-4 equation 4.20-NA)*
  $k_l =$
  $k_l = 0.854$
- turbulence intensity:
  $i_v =$ *(NF EN 1991-1-4 equation 4.7)*
  $i_v =$
  $i_v = 0.285$

- Wind from 115° :
  - Effect from orography
    Orographic profile = Flat land
    The effects of orography may be neglected when the mean slope of the upwind terrain is less than 5%. *(EN 1991-1-4 §4.3.3(2))*
    Here, the upwind terrain slope is 0 % : $c_o = 1$

  - Effect from terrain roughness:
    Terrain category II *(National annex to EN 1991-1-4 §4.3.2(1))*
    Open field, with or without a few isolated obstacles (trees, buildings, etc.) separated from each other by more than their height x40
    - terrain factor:
      $k_r =$ *(EN 1991-1-4 equation 4.5)*
      $k_r =$
      $k_r = 0.1900$
    - height above ground level or the minimum height depending on the terrain category:
      $z = 20.000$ m
    - roughness factor:
      $c_r(z) =$ *(EN 1991-1-4 equation 4.4)*
      $c_r(z) =$
      $c_r(z) = 1.138$

  - Peak velocity pressure:
    $q_p(z) =$ *(NF EN 1991-1-4 equation 4.8)*
    $q_p(z) =$
    $q_p(z) = 1.054$ kN/m²

    with:
    - mean wind velocity:
      $v_m(z) =$ *(NF EN 1991-1-4 equation 4.3)*
      $v_m(z) =$
      $v_m(z) = 28.209$ m/s
    - air density:
      $\rho = 1.225 kg/m^3$ *(NF EN 1991-1-4 clause 4.5(1) NOTE 2)*
    - turbulence factor:
      $k_l =$ *(NF EN 1991-1-4 equation 4.20-NA)*
      $k_l =$
      $k_l = 0.995$
    - turbulence intensity:
      $i_v =$ *(NF EN 1991-1-4 equation 4.7)*
      $i_v =$
      $i_v = 0.166$

- Wind from 205° :
  - Effect from orography

Orographic profile = Flat land
The effects of orography may be neglected when the mean slope of the upwind terrain is less than 5%. *(EN 1991-1-4 §4.3.3(2))*
Here, the upwind terrain slope is 0 % : $c_o = 1$

- Effect from terrain roughness:
  Terrain category II *(National annex to EN 1991-1-4 §4.3.2(1))*
  Open field, with or without a few isolated obstacles (trees, buildings, etc.) separated from each other by more than their height x40
  - terrain factor:
    $k_r =$ *(EN 1991-1-4 equation 4.5)*
    $k_r =$
    $k_r = 0.1900$
  - height above ground level or the minimum height depending on the terrain category:
    $z = 20.000$ m
  - roughness factor:
    $c_r(z) =$ *(EN 1991-1-4 equation 4.4)*
    $c_r(z) =$
    $c_r(z) = 1.138$

- Peak velocity pressure:
  $q_p(z) =$ *(NF EN 1991-1-4 equation 4.8)*
  $q_p(z) =$
  $q_p(z) = 1.054$ kN/m²

  with:
  - mean wind velocity:
    $v_m(z) =$ *(NF EN 1991-1-4 equation 4.3)*
    $v_m(z) =$
    $v_m(z) = 28.209$ m/s
  - air density:
    $\rho = 1.225 kg/m^3$ *(NF EN 1991-1-4 clause 4.5(1) NOTE 2)*
  - turbulence factor:
    $k_l =$ *(NF EN 1991-1-4 equation 4.20-NA)*
    $k_l =$
    $k_l = 0.995$
  - turbulence intensity:
    $i_v =$ *(NF EN 1991-1-4 equation 4.7)*
    $i_v =$
    $i_v = 0.166$

- Wind from 295° :
  - Effect from orography
    Orographic profile = Flat land
    The effects of orography may be neglected when the mean slope of the upwind terrain is less than 5%. *(EN 1991-1-4 §4.3.3(2))*
    Here, the upwind terrain slope is 0 % : $c_o = 1$

  - Effect from terrain roughness:
    Terrain category II *(National annex to EN 1991-1-4 §4.3.2(1))*
    Open field, with or without a few isolated obstacles (trees, buildings, etc.) separated from each other by more than their height x40
    - terrain factor:
      $k_r =$ *(EN 1991-1-4 equation 4.5)*
      $k_r =$
      $k_r = 0.1900$
    - height above ground level or the minimum height depending on the terrain category:
      $z = 20.000$ m
    - roughness factor:
      $c_r(z) =$ *(EN 1991-1-4 equation 4.4)*

$c_r(z) =$

$c_r(z) = 1.138$

- Peak velocity pressure:
  $q_p(z) =$ *(NF EN 1991-1-4 equation 4.8)*
  $q_p(z) =$
  $q_p(z) = 1.054\ kN/m^2$

  with:
  - mean wind velocity:
    $v_m(z) =$ *(NF EN 1991-1-4 equation 4.3)*
    $v_m(z) =$
    $v_m(z) = 28.209\ m/s$
  - air density:
    $\rho = 1.225 kg/m^3$ *(NF EN 1991-1-4 clause 4.5(1) NOTE 2)*
  - turbulence factor:
    $k_l =$ *(NF EN 1991-1-4 equation 4.20-NA)*
    $k_l =$
    $k_l = 0.995$
  - turbulence intensity:
    $i_v =$ *(NF EN 1991-1-4 equation 4.7)*

    $i_v =$

    $i_v = 0.166$

- The peak velocity pressures q_p, applied on the surface Niveau 1 at a level of 20m, are drawn on this graph for each sector of wind:

Maximum equivalent peak wind velocity (at the ridge Lvl +20.0m)

- 149 km/h to control the vibrations and the deformations of the structure at serviceability limit states (SLS).
  $v =$ $=$ $= 149\ km/h$
- 183 km/h to control the resistance of the structure at ultimate limit state (ULS).
  $v =$ $=$ $= 183\ km/h$

Seism

Seism standard

The standard *EN 1998-1 (12/2004)* and its national annex *FR NA (12/2013)* define the design rules and design methods for seismic actions on buildings.

Legislative texts about seism

- Zoning: *Art. D563-8-1, Décret N°2010-1255 (22/10/2010)*
  - The construction is located at Paris in a very low seismicity zone (zone 1).
- Classification: *Art. 2, Arrêté du 22/10/2010 modifié par Art.1, Arrêté du 15/09/2014*

Reference peak ground acceleration

The intensity of the acceleration a_{gr} is function of the seismic zone. Its value of $0.4\ m/s^2$ is specified in Art. 4, Arrêté du 22/10/2010 modifié par Art.1, Arrêté du 15/09/2014.

Use for importance classification:

The building's use is of type "establishment open to the public of 1st category" (Public establishment classification according to *Article R*123-19 du code de la construction et de l'habitation*)

According to Art. 2, Arrêté du 22/10/2010 modifié par Art.1, Arrêté du 15/09/2014, the importance category associated to seism is III.

Importance factor of the building

The factor γ_I is function of the importance category of the building. Its value of 1.2 is specified in Art. 2 §III, Arrêté du 22/10/2010 modified by Art.1, Arrêté du 15/09/2014.

Paraseismic checking

A building located in seismic zone 1 does not require the application of Eurocode 8.

Fire

Legislative texts about fire

The reference document, *Arrêté du 25 juin 1980* , indicate the security arrangements against the risk of fire, including fire resistance durations structures.

Fire standard

The standard *EN 1991-1-2 (11/2002)* and its national annex *FR NA (02/2007)* define the design rules and design methods for fire actions to buildings.

Use for fire classification

establishment open to the public of 1st category with the bottom floor of the last level accessible to the public less than 8 meters above the ground
(Public establishment classification according to *Article R*123-19 du code de la construction et de l'habitation*)

Fire resistance of structures

Required fire resistance

- Vertical support: 60 minutes
- Floors: 60 minutes
- Roof: 60 minutes