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The present article provides a basic overview on wind design pressures and seismic hazard design factors in Brazil. For reference purposes, comparisons between Brazilian and US norms are presented (*i.e.* NBR vs. UBC) where possible.

Wind Design

According to Local Standard NBR 6123, Brazil is divided in five wind hazard regions, as shown in Fig. 1. For example, the North-East region of Brazil is mostly located in Region I, with a recommended minimum basic wind speed of 30 m/s (approx. 108 km/h or 67 mph).

Calculation of Dynamic Wind Pressure P

According to *NBR 6123*	According to UBC-97
$P = 0.613\,(V_K)^2\,(C_e - C_i)$ *where:* *$V_K = V_o\,S_1\,S_2\,S_3$* *and:* *V_o: basic wind speed (defined at a height of 10m, with 3 s gust and on open flat field)* *S_1: Topography factor;* *S_2: Combined Height Exposure factor;* *S_3: stochastic factor;* *Ce; Ci: external and internal pressure coefficient*	*$P = C_E * Cq * qs * Iw$* *where:* *C_E: Combined height, exposure and gust factor;* *Cq: Pressure coefficient;* *qs: Basic design wind pressure (at a height of 10m, 3 s gust on open flat field);* *Iw: Importance factor*

Table 1: *Calculation of dynamic wind pressures according to Brazil Norm NBR 6123 (left) and UBC-97 (right).*

Table 1 summarizes the different calculation approaches for the static wind pressure, according to NBR and UBC norms. From a practical point of view, the question arises how the results of these procedures compare when calculated for a specific common case.

In a first approach, static wind pressures P were calculated according to both NBR 6123 and UBC-97 (Chapter 16) for the two examples depicted in Fig. 2, namely a flat wall located on an open flat field, and a cylinder with a diameter of 6 meters located on an open flat field:

Fig. 2: Schematic view of the two structure examples *for which static wind pressures were calculated according to both NBR and UBC norms. Left: flat wall. Right: cylinder with a diameter of 6 meters. Both structures were asumed to be located on an open flat field. No pressures resulting from dynamic effects have been considered.*

Calculation results for both examples are depicted in Fig. 3. The results indicate that static wind pressures calculated according to UBC result higher than if calculated according to NBR norms.

According to these first indicative results, the wind design performed for structures according UBC results more conservative, and hence more costly, than if performed according to NBR.

It must be clearly stated however that, for the case of aforementioned calculations, no dynamic wind effects were taken into consideration. Especially for the case of the cylindrical structure however, wind pressures resulting from dynamic effects have a substantial impact on total wind pressures and have thus to be accounted for in more thorough studies.

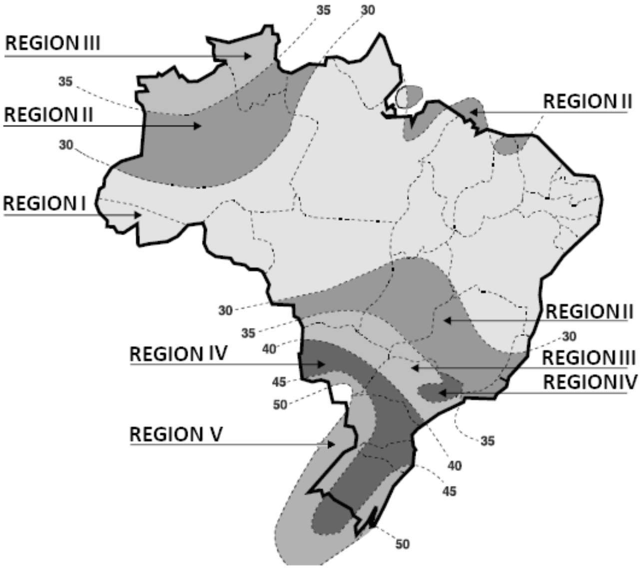


Fig. 1: Wind Speeds in Brazil. *Wind regions in Brazil are categorized according to the wind hazard. The territory is divided into different wind regions which are numbered from I through V, with increasing wind hazard. Contour lines mark the regions with different recommended basic wind speeds. Corresponding wind speed values range between 30 and 50 m/s (108 - 180 Kmph or 67 to 112 mph).*

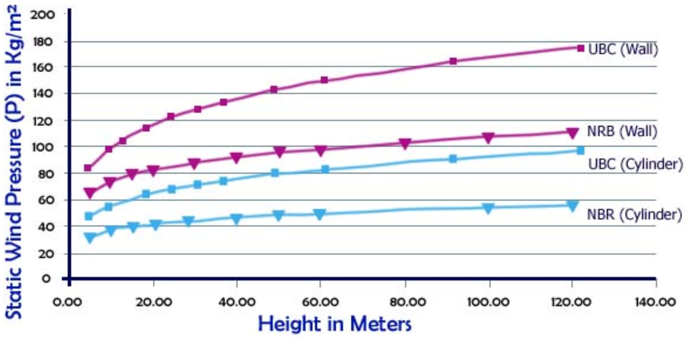


Fig. 3**: **Wind pressure calculation results for a flat wall (marked in purple) and cylindrical structure (marked in blue), located on an open flat field.
Calculation results according to UBC are marked with squares whereas calculation results according to Brazilian norm NBR 6123 are marked with triangles. Special care was taken in applying identical conditions for both approaches (basic design parameter as wind velocity, type of exposure, etc). For the the particular examples, the P-values obtained according to UBC are clearly higher than those corresponding P-values that were calculated according to NBR. The calculation input values are given in Table 2, below.

	Input parameters NBR	**Input parameters UBC**
Wall example	V_o=30ms-1, S_1=1.0, S_2: eq. to Category II, class A, S_3=0.95, C_e=0.8, Ci=-0.7 .	V_0=30m/s, qs=61.5Kgm^2, Iw=1, Cq=1.3, and C_E acc. to 6-G UBC-97, exposition C.
Cylinder example	V_o=30m/s, S_1=1.0, S_2: eq. to Category II, class A, S_3=0.95, C_e=0.77, Ci=0	V_0=30m/s, qs=61.5 Kgm^2, Iw=1, Cq=0.8, C_E acc. to 6-G UBC-97, exposition C.

Table 2: *Calculation input values used for determining the static wind pressures for the two structure examples, according to NBR and UBC norms.*

Seismic Hazard

Brazil is located in an intraplate area where seismic activity is not significant compared with the activity occurring at the borders of tectonic plates.

The seismic map depicted in Fig. 4 shows that most of the territory can be classified as UBC Zone Factor 1, with exception of areas that border the Andes mountain chain and a well-defined region in the northeastern part of the country. These two regions however do not exceed UBC Zone 2B.

Aforementioned classification has been performed by translating the values for the Maximum Horizontal Ground Acceleration (Z-values) of Fig. 4, according to the UBC equivalents given in Table 3 hereafter:

UBC Zone	1	2A	2B	3	4
Z (in g)	0.075	0.15	0.20	0.30	0.40

Table 3: *UBC Seismic Zone Factors in accordance with the effective maximum horizontal ground acceleration Z, expressed in fractions of the earth gravity g (1g ≈ 9.8 m/s^2). Each UBC Zone is assigned with a maximum Z-value, that can be exceeded in 50 years with a probability of 10%. Source: Uniform Building Code 1997, Division IV.*

Seismic Design Strategies

The following two general approaches are being used for seismic design of a specific structure:

1. Performance within the elastic range (elastic approach)

In this approach, structures are designed to resist seismic forces within the elastic range of their elements. This translates into the none-occurrence of plastic deformations in reinforced concrete elements and that the individual elements of a steel structure will not reach the yield limit state. A variation of this case occurs when seismic basic isolation devices are introduced, see Fig. 5. The main goal of this technology is to avoid the development of the seismic horizontal (inertial) forces on the building, by allowing significant relative displacements at the foundation level. This approach, however, can only be applied to low- and mid-rise buildings.

Fig. 5: *Example of an isolation device manufactured by Maurer Söhne, Germany. This device allows relative displacements between the foundation and the structure.*

2. Performance within post-elastic range (ductile approach)

This approach relies on the dissipation of seismic energy on a given structure through post-elastic deformations of its elements (controlled, post-elastic deformation located mainly at intersection points between main structural elements, connections and neighbor areas). This so called ductility criterion is usually applied for the case of multi-stories buildings. Depending on the required post-earthquake functionality of the building in question, additional safety factors may be considered for major earthquake shocks.

In general terms, the seismic design objective varies according to seismicity of the site and to the project specific technical/economical constraints.

For the case of none-seismic areas (UBC Zone 1 or less), the design objective is to provide the structure with the resistance and stiffness needed to resist the maximum combination of loads resulting from operation and environment. In such case the design is performed according to standard constraints given by applicable international and local norms.

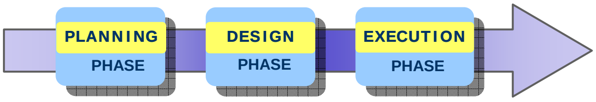
***Fig. 4. Seismic Hazard Map of Brazil**. Contour lines indicate the expected Maximum Horizontal Ground Acceleration Z, expressed in g (1g≈9.8 m/s^2), according to an extrapolation from the Global Seismic Hazard Map, produced by the Global Seismic Assessment Program. Arrows indicate the classification of the different areas into UBC Zones according to the correspondance indicated in table 3.*
Results show that most of the Brazil territory can be classified as UBC Zone 1, with exeption of the eastern regions (bordering the Andes Mountain Chain) and a defined region in the northeastern part of the country.

In areas of high seismicity (UBC Zones 3, 4 or above), the main structural design objective is to resist the maximum combination of standard operation loads and minor earthquakes within the elastic range. Forces induced by the design earthquake (major event) are to be absorbed through post-elastic deformations of the structural components (ductile approach). Since the explicit incorporation of ductility into the design process is a very complex task, design codes use simplified design rules to prevent shear failure mechanism on the structure.

Concrete and Steel structures, located in seismic prone areas, have to be designed as systems with the special detailing approach. Buildings designed according to the American Concrete Institute (ACI 318), have to comply with specific seismic provisions. For the case of steel structures, the American Institute of Steel Construction (AISC LRFD) provides the design guidelines that include the use of prequalified connections. In zones 3 or 4, the intermediate detailing approach is limited to steel buildings not exceeding 48 meters of height. For the case of areas with medium seismicity (UBC Zones 2a and 2b) the design rules to follow are the same as those applicable for zones of high seismicity, however, intermediate detailing can be used.

SCOPE OF SERVICES

Engineering support from EC is given during different project stages, reaching from the planning phase until the construction execution phase. A few examples are given hereafter:



Scope of services during Planning Phase:
Coordination or execution of site studies, (topographical, geophysical, geotechnical, seismic hazard). Preliminary multidisciplinary engineering. Tendering of local works.

Scope of services during Design/Engineering Phase:
Civil and structural design of buildings, industrial plants and infrastructure, based on local and international standards. Multidisciplinary detail design of thermo-electrical power plants.

Scope of services during Execution Phase:
Construction management assistance, including on-site supervision.