**2**

**Design of lattice towers**

**2.1. General principles**

In this chapter the design verifications carried by the software are detailed including design assumptions required to develop a program with some degree of autonomy.

The software was developed to design lattice steel towers with angle sections according to BS EN 50341-1:2012. Resistance checks are done according to EN 1993-1-1:2005 (EC3) and stability calculations follow the annex G and H of the EN 1993-3-1:2005.

According to BS EN 50341-1 7.3.5 the tower should be checked with a global elastic analysis, the model is usually pin jointed but if the continuity between members is considered the bending moments can be neglected.

The norm identifies three types of elements, leg members, bracing and secondary bracing elements. As the secondary bracing elements – also called redundant members – do not receive direct loads and are in place just to assure local stability of the load bearing members, they can be ignored in the global analysis.

Sections are classified according to EC3 and when class 4 the effective area should be used in the design verifications. The effective area is calculated according to EC3 unless the sections are hot rolled angles, for that case BS En50341-1:2012 7.3.6.2 provides the following expressions to calculate the effective area:

Deformations and vibrations under SLS loads and fatigue and not normally considered unless specified on the project.

Connection design is out of the scope of the software developed in this thesis but is considered according to EC3 part 8.

**2.2. Design loads**

No seismic actions!!

1.2.2. Mancha de impressão

1.2.3. Divisão e Organização do texto

1.2.3.1. Divisão em subcapítulos - terceiro nível em Arial 10 pt normal corrente

**2.3. Resistance verification**

For this type of structure members should be checked according to EC3. There is a provision regarding angles connected through one leg, since the software outputs a structure where the connections are not yet designed this verification is not implemented in the final program.

The software uses the Eurocode 3 checks for both tension and compression elements, as the structure is pin jointed only axial loads are considered on the verification and the area used is the value received by the user, the expression used is:

Mais alguma coisa?

**2.4. Stability verification**

Buckling resistance of members in compression was checked using annex G and H of EC3 part.

The expression used to determine the buckling resistance (Nb,rd) of a member is present on part 1 of the EC3:

The steps needed to determine the reduction factor χ and factor Φ are datailed in annex G of the EC3. A new effective slenderness ratio should be used to calculate both factors, this new slenderness ratio is determined by multiplying the original slenderness ratio (from Eurocode 3) by a factor K that varies with the member being calculated (leg , diagonal or horizontal bracing member).

To determine the , annex H is used to get the buckling length relevant to the member and is calculated according to EC3 part 1.

The effective slenderness factor, K, is calculated from the expressions on tables G.1 to G.3 from the Eurocode 3 that list various values depending on the section type, buckling axis, geometry and member type.

For Leg members table G.1 is used, as the software is intended to design only with angle elements and given the characteristics of the base structure (detailed in chapter 4) geometry of the type described as case (d) on table G.1 is not a possible, as such, the expression used to calculate the effective slenderness factor, K, is given by:

Even though case (d) – discontinuous top end with horizontals – is not allowed as a possible solution case (e) is possible. This case uses the same expression to determine the effective slenderness factor, K, according to another axis, y-y. As the algorithm does not know if the structural solution is symmetrical or unsymmetrical there is function that builds the internal analytical model (IAM) and states the axis in which stability checks need to be carried on Leg members.

[imagem da table G1]

For diagonal bracing annex G states that “k should be determined taking into account of both bracing pattern and the connections of the bracing legs. In the absence of more accurate values of k should be obtained from table G.2”. In a genetic algorithm that automatically iterates through various topologies it is not possible to analyse, without significant computation, the relationship between all the members in each plane to determine a bracing pattern, in fact it is highly likely that some solutions of the GA do not fit a predefined bracing pattern listed in the annex H. Having this into account the “worst case” was adopted and as stated on annex G the k value was obtained from table G.2.

[imagem table g.2]

To extract values for K from table G.2 additional information regarding connection types for bracing members is needed, as previously stated software developed for this thesis is intended to be used in the definition of the tower geometry, as such the connection types are not yet known, in this case an option was made to work with the expressions for the worst-case scenario – higher k values – where bracing members are discontinuous and single bolted at both ends.

Horizontal bracing members have the same rules of diagonal members with the exception of K bracing patterns where the K value needs to be reduced by a ration determined from table G.3 to account for a member with both tension and compression in each half of its length.

(dizer que nao se fez isto porque era impossivel saber se era ou nao k bracing, e como de qualquer forma isto reduz e nao aumenta o k estamos do lado da segurana???)

[table g3]

Pretende-se, com estas regras, estabelecer um conjunto de princípios que assegurem uma uniformidade adequada aos trabalhos a apresentar como Dissertações. Procurou-se que as mesmas não fossem demasiado rígidas e difíceis de entender mas, fundamentalmente, definir regras que deverão ser aplicadas às situações mais correntes e que possam, com sensatez, ser adaptadas para casos mais particulares.

Espera-se que os estudantes dediquem algum zelo à produção gráfica final dos seus documentos. Trata-se de algo que, ao contrário dos trabalhos produzidos no âmbito das restantes disciplinas cuja divulgação raramente ultrapassa o contexto da avaliação, ficará acessível de forma alargada ao meio científico, técnico e profissional, pelo que, depois do esforço na produção de conteúdos válidos, só fará sentido que estes sejam apresentados de forma profissional e graficamente atraente.