Overview Annexes E Stability

Introduction

This publication is part of compilation of work of the author to a total rigorous theory, containing the latest developments with goal of a thesis and book. The appended articles are given in full as acknowledgment for the original journal publication.
The developed exact theory is given in the appended publications denoted by E, thus: **E(1990)** and **E(2013)**. Other important derivations and applications are mentioned in these publications. The theory in all appended publications was derived by T.A.C.M. van der Put,

Discussion of annexes "E" about the exact stability criterion of wood

In vdPut **E(1990),** a general approach is given of the buckling and twist-bend buckling problem of symmetrical profiles loaded in bending in the two main directions and at the same time in torsion and compression. The model, according to the second order stress theory, provided a complete extension of the existing models by accounting for eccentrically lateral loading, for instance by purlin hangers, in combination with bending in the horizontal direction (wind loading etc.), with the influence of the initial eccentricities, the warping rigidity and the failure criterion. The limit analysis approach was applied for the start of lateral buckling, based on second order stress theory. Although lateral bifurcation is not possible by 3-dimensional structures, a calculation is possible by first regarding only vertical deformation up to the limit state and then superpose stresses by (the start of) horizontal and rotational movement, up to the ultimate state, which is controlled by a safe failure criterion for the total end-state. For this case, the worst combined failure case is regarded which includes possible shear failure. This design approach is e.g. applied in the Dutch building Code: TGB since 1990, and was proposed for the Eurocode 5 (according to Appendix 3 of **E(1990))**. Although this proposal was accepted by CIB-W18 and members of the Eurocode 5 Committee, it could not be implemented because Germany wanted a year respite. And, although bifurcation is not possible but only a much lower ultimate state, this respite resulted in a sneaky insertion of their inconsistent, unsafe and unreliable quasi eigenvalue rules, in the Eurocode 5 draft, showing again that the Eurocode 5 has no meaning any more for reliable structural design. Official comment did not reach the international Eurocode Committee and could not be published because of a personal censorship. The anti-theory leadership of CIB-W18, formulated this as follows: "Articles of van der Put can no longer be published at CIB-W18, because of the many equations of the complete and controllable derivation that are given, (as is necessary for exact theory). Regrettably this takes too much paper, and thus too much intolerable environmental pollution". Clearly the importance of the, for the Board unreachable, exact new theory is noticed and therefore prohibited, to avoid unmasking of the usual published pseudo-science of CIB-W18. The censorship, by judging the scientific

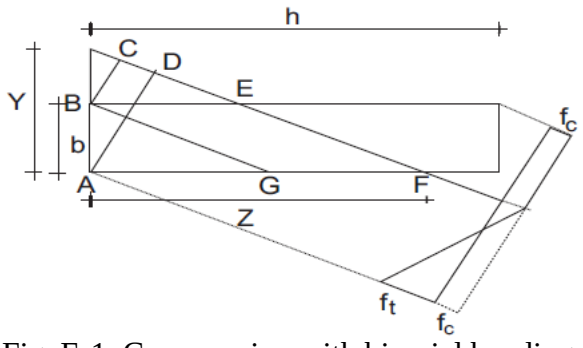

Fig. E-1. Compression with bi-axial bending.

content of an article by a peer review of the abstract (don't laugh) is effective. For that reason is the, in series A to F, developed theory, not generally known and is therefore e-published. In **D(2012b),** is for the first time, the combined, elastic-plastic, compression, shear and biaxial bending strength derived, what can not be found in any other publications. Based on this, is in **E(2013)**, for the first time, a derivation given of exact stability design rules according to limit analysis, applied to timber beam-columns, based on the real bi-axial bending strength criterion. The equilibrium equations, according to the second order stress theory, are solved with aid of virtual work principle. These design rules provide real and calculable reliability as is required according to European pacts and laws. As for other materials, the elastic-full plastic limit design approach is applied, which is already known to precisely explain and predicted uniaxial bending strength behavior **E(1990)**. The strength derivation is based on choosing the location of the neutral line. This provides the stress distribution in the beam cross section in the ultimate state for that case, providing the possibility to calculate the associated ultimate bending moments in both main directions combined with the ultimate normal- and shear forces. The derived general strength and equilibrium equations are simplified to possible elementary design equations, applicable for building regulations. However exact theory is not able to pass the CIB-W18 censorship of the last decades. This lack of a demand of real theory causes, of course, the lack of knowledge of theory, as presented in the Annexes and e.g. of knowledge of elementary standard second order theory of buckling. This is not only demonstrated by the unacceptable Eurocode 5 design rules, but also by thesis work, (see E(2008a,b)) guided, for timber structures, by the CIB-W18 -coordinator. Despite of many written comments and discussions during years, it could not be prevented that the nonsense dissertation was written, what therefore is discussed in **E(2008a,b)** as warning for the chosen way to ridicule and destroy theory (see also D(2010)).

The given equations of the biaxial bending strength are in accordance with the limit analysis method and thus based on elastic-full-plastic behavior. Therefore, the analysis is rigorous and the strength prediction realistic and the result has to be applied in the Building Codes to provide the by Euro-law prescribed sufficient precise reliability calculation (also for the right prediction of behavior of totally new, never occurred and never measured, cases).

For the highest lower bound solution of biaxial bending strength, is necessary, that the neutral axis is a straight line, and that unlimited flow in pure compression occurs. Thus there is bending-tension failure and the shear stress is carried in the elastic part of the cross section. This is an improvement with respect to the thus far applied, (not unique) old model of Johns, and Buchanan, which is based on restricting the ultimate plastic compression strain at failure. The derived general expressions in coordinates of the boundary line of the full compression area provide 3 cases for design. For simplicity of design, is chosen for separate ultimate shear strength and ultimate bending-compression strength equations. The equations contain also the solution for uniaxial bending cases, which are already shown to precisely explain and fit data by the applied elastic full plastic limit analysis. The value of $s = f_t / f_c$ appears to be about constant for all determining load combinations of bending with compression, indicating again (by the data of Johns and Buchanan) that there always is failure by the ultimate tensile strength. A volume effect by stress distribution thus needs not to be regarded as follows from the uniaxial data. The volume effect thus now is caused by the volume alone due to decreasing quality by volume increase.

The solutions of the most general equilibrium equations, eq.(54) and eq.(58) of **E(2013)** are exact, complete and universal, applicable for any material and load combination, based on the virtual work principle, which also is the basis of the lower and upper bound solutions of limit analysis and which always provides an exact solution however complex the equilibrium equations are. The equilibrium equations have to satisfy the mentioned biaxial failure

criterion of the stability problem, which is always a strength problem for full scale timber beams as empirically verified in the past.