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Limit analysis for civil engineering structures

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Abstract

The analysis of ultimate limit state (ULS) of a structure requires a stability study until failure. This mechanical behaviour is complex to compute with standard tools. Cracking, damage, elastic-plastic law, etc., are phenomena which often lead to numerical problem of convergence and interpretation of results. It is therefore often advised to use codes instead (Eurocodes, AASHTO, etc.), but this solution comes at the expense of accurate analysis of the physical behaviour of failure. An alternate solution is limit analysis, which combines two parallel and complementary methods. Used on a finite element mesh for rigid-plastic calculations, these two methods lead to a full determination of the physical failure: mechanism, stresses distribution and safety factor. Strains presents a software program using limit analysis for steel beam connections nodes, taking into account such phenomena as contact, separation, friction, welding, plasticity and pre-stressed bolts.

Keywords: limit analysis; yield design; civil engineering; failure; safety; steel profiles.

1 Introduction

In order to check the stability of a structure at failure, engineers typically use the concept of ultimate limit state (ULS) as defined in various codes (Eurocodes, AASHTO, SNIP, etc.). This state is often studied under an elastic hypothesis, and doesn't take into account all nonlinear phenomena linked to failure: plasticity, cracking, damage, etc.

When possible, a simplified approach used by engineers is to perform elastic studies mainly by using simple software programs or doing manual calculations. This seldom takes into account nonlinear aspects. Instead, safety is generally built in the computations by increasing loads and by curbing the limit strength of the materials, following rules provided in the codes.

The drawback of this method is that it does not take into account the physical behaviour of the structure. As said previously, failure is typically nonlinear and an elastic analysis, even when safety factors are included, does not account for the real physical behaviour (displacements and stresses).

Hence, if necessary, engineers have to perform elasto-plastic analysis. Not only can this take time in order to create the full 3D model, especially in the field of metallic beam connections, but this

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