Abstract

At the present time the computation in limit analysis is taking more and more relevance by the necessity to obtain more realistic results. Actually the capacity of the computers causes that they are tried to solve more complex problems that years back. Certain present problems of engineering need calculation models that are able to efficiently model the physical reality of the problem. The linear elasticity theory it’s very simple to approach, apply and calculate, but it offers great simplifications of the real behavior of the materials, underestimating his resistant capacity and offering non realistic results in multitude of occasions. From this point the necessity arises to complement the results in linear elasticity with more complex models of calculation, than they allow, for example, a plastified region of the solid before the collapse, approaching much more to the real behavior of the solid. These engineering necessities combined with the great advances of the computers and the sprouting of new, efficient and robust algorithms of nonlinear optimization make of the limit analysis problem a reasonable field, reason why it is in great study and expansion process.

We work with a solid, rigid and perfectly plastic and submissive to a distribution of fixed load. The basic problem that approaches the limit analysis problem is the attainment of the minimum multiple of this distribution of fixed load that causes the collapse of the solid. This multiple of the load distribution comes from the resolution of a saddle point problem in an infinite dominion. Knowing that this continuous saddle point problem has great properties of duality and restricting the flow condition to a convex cone, we can to raise the well-known static and kinematic principles of the limit analysis problem. An efficient mathematical procedure is developed to discretize the static and kinematic principles. These principles are discretized in suitable interpolation spaces that assure to us the attainment of strict bounds for the exact collapse multiplier. One has worked at any moment with a suitable and convex yield condition for geomaterials as it is the Drucker-Prager collapse model. Thanks to use this collapse model we obtained great results for materials that have great resistive differences to traction and compression as is the case of concrete.

The process has two clearly differentiated stages. At the first stage, discretize the static principle of limit analysis by means of two different interpolation spaces. One of them is a purely static interpolation space for the tensions and the plastic flow field, to guarantee strict an inferior bound of the collapse multiplier. The other interpolation space used is purely kinematic as well for the tensions and the flow field, guaranteeing the obtaining of strict and superior bound of the exact collapse multiplier.

The second step is based on reformulating these principles to a canonical form, so that they can be solved by means of the algorithms of second order cone programming based on the interior point method. This algorithm is able to solve, at the same time, the primal and the dual, taking advantage of the duality-convexity properties of the problem, optimizing the calculation effort and assuring in most of occasions a global convergence of the solution. We will obtain at the end of the process two values, that will limit inferior and superior the exact collapse multiplier, obtaining a measurement of the error committed in the discretization process.

A very novel adaptive refinement takes advantage of throughout the work, only employee previously in a doctoral thesis of Héctor Ciria, based on a measurement of local error to solve satisfactorily and very efficiently problems with concentrated collapse mechanisms in reduced zones of the geometry, like the Brazilian test.

Another great advantage of the calculation process used in this work is that we can certify later the validity of the results without the necessity to have the program used on the calculation process. Solely with the solution fields and the geometric characteristics of the mesh, it is enough to verify in them its static and kinematic nature, and already we’ll be able to assure its validity like strict bounds to the limit analysis problem. Therefore will not be had the necessity to know the program used nor to have programming knowledge to verify the validity of the results.

Finally one demonstrates to the reliability and robustness of the method with diverse numerical examples between which is the Brazilian test, widely used to calculate the tensile strenght of the concrete.