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CONTROL OF INSTABILITY PROBLEM UNDER NON-CONSERVATIVE LOAD

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The structural instability in dynamics (yet called flutter) and corresponding vibrations control are of great interest for many applications in engineering [1] [4]. Namely, the continuous innovation in intelligent materials, with better performance at a more accessible price, allow for constructing slender structures that become more sensitive to instability, under various loads with the most important here as non-conservative loading, some examples are: highrise buildings, bridges, aeroplane wings, wind-turbines flexible blades, or other kind of slender with high sensitivity to instability phenomena. One such example that we studied recently [5] but not from the stand point of structural instability, comes from the domain of wind turbine technology used as renewable power generation that can help meet the sustainable development goals through provision of access to clean, secure, reliable and affordable energy. The progressive electrification of the transport and heating sectors is becoming a tangible reality that should be further enabled by efficient green energy assets. The latter may help with capped costs, and at the same time, it should be virtuously balanced by the flexible demand of these sectors. If we try to motivate the used for instability studies, we can say that the wind turbine technology has made significant advances over the past decade. Larger and more reliable turbines, along with higher heights and larger rotor diameters, have combined to increase capacity factors. This also makes them more and more sensitive for instability phenomena. Today, virtually all onshore wind turbines are horizontal axis turbines, predominantly using three blades. In the future design of a wind turbine different factors intervene, variations may include different land-use and transportation requirements.

Wind turbines have been built in optimal locations like the ocean front. If we want to ensure an enlarged number of turbines and put the wind turbine technology in any other location, we have to play with increasing the flexibility of blades, making easy to start moving with slow wind, like leaves in the tree. If a flexible blade is easy to start moving, contrary to the stiff wind turbine, it is easy to have excessively large motion and the instability. The correct design of wind turbines is very important because a bad design might have catastrophic consequences. Structures behaviour under dynamic loads control is very important for preventing their instability phenomena that can lead to the turbine collapse. One kind of structure control under dynamic loads can be achieved by adding damping (see Fig.2) provided by some kind of external damping mechanism to the structure, such as simple dampers or a smart shape memory alloy. This kind of control is equivalent to the well-known concept of passivity [7] [6] .

Lightweight structures may lead to loss of structural stability. The later can be produced by applying critical forces on structures, which are classified into two categories: conservative forces and non-conservative forces such as follower force (see Fig. 3). Wind forces acting on wind turbines, buildings on bridges, these forces are non-conservative (e.g. fluid flow exerted pressure). The stability of structures under fluid flow should generally be placed in the category of non-conservative stability problems, which are of main interest for our present studies. Structures under non-conservative forces represent a special

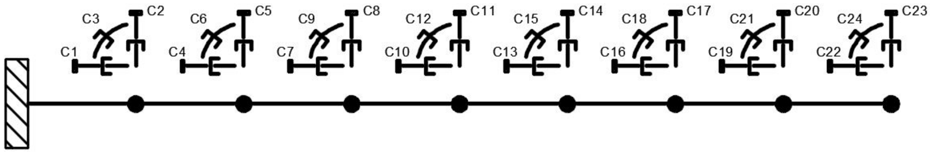

Figure 1: Dampers in each degree of freedom of a beam

class of problems that are prone to losing their stability dynamically.

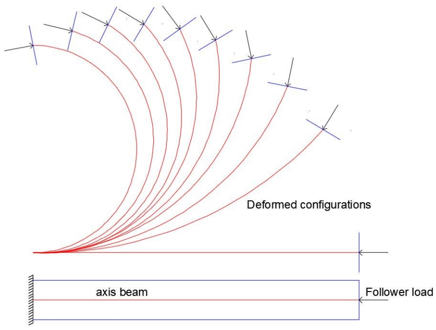

Figure 2: Follower load

We propose numerical solution procedures for solving the instability problems under both conservative and non-conservative loads. The details of theoretical developments are given in terms of the non-linear dynamical equations obtained by using the principle of virtual work [1][2]. All the structural models used for solving more complex problems are built with a numerical approach based upon the finite-element method and the geometrically exact beam models capable of describing finite rotations. It is show as well that the proposed models can successfully handle large overall motion under static and dynamic instability (or flutter) under both conservative and non-conservative loads.

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