Titolo – Modelling of constitutive laws for traditional and innovative building materials

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Descrizione – Constitutive models for various types of building materials may significantly differ from each other since the physical microstructural mechanisms that cause the material deterioration at the macroscopic level, can be completely different. Despite the fact that material properties depend on the kind of microstructure, all the above-mentioned building materials are characterized by the following mechanical parameters: elasticity, yielding, plastic strain, fracture toughness, damage under both monotonic and dynamic loading, fatigue strength under cyclic loading. Therefore, in the present research project, reliable constitutive laws are developed by means of the continuum mechanics theory, without detailed reference to the complexity of the physical microstructure. Today, the scientific progress in the field of material behaviour modelling make it possible to follow the process of deformation and damage of the above building materials even under severe operation conditions, but research work is needed to answer durability issues (safe lifetime) in order to mitigate unexpected events which may have serious consequences such as human victims and environmental catastrophes. Concrete can be conveniently considered like an elastic-plastic-damaged material over a wide class of stress states. Therefore, robust nonlinear numerical models are required by industries and building designers to simulate the constitutive law of concrete, by also taking into account crack growth up to failure under monotonic and dynamic loading. In the field of metallic materials, the challenge is devoted to develop sound models for early crack estimation and fatigue assessment under multiaxial variable amplitude loading. This implies the definition of criteria able to catch their behaviour under generic variable amplitude loading (cyclic or random) both in high-cycle fatigue regime, where cleavage and intergranular fracture are involved (brittle fracture), and in low-cycle fatigue regime (ductile fracture). As far as masonry structures are concerned, the modelling strategies can range from discrete models that simulate the material as a composite made by units (bricks, stones and blocks) and mortar/dry joints, to continuous homogenized texture models. Because of the difficulty to experimentally reproduce their characteristic biaxial stress state and to reliably describe both the anisotropic overall response and the nonlinearities of units and joints, the challenge is addressed to simulate the biaxiality of masonry (periodic and non) up to failure. Nanotechnologies applied to construction industry and building design are certainly one of the most prominent priorities to be investigated, since nanomaterials enhance both the thermal and the mechanical properties of the materials at which they are additivated. In such a context, the use of nano-additives (such as nanosilica and silica fume, nanotitanium dioxide, iron oxide, chromium oxide, nanoclay, $CaCO_3$, Al_2O_3, carbon nanotubes and graphene oxide) in concrete and mortar is catching on, and the development of models able to reproduce the macroscopic failure behaviour of such innovative materials is needed. Natural fibre composites are beginning to stand out as innovative and effective solutions to promote sustainable buildings respecting the human and environmental health. Consequently, it is important to develop robust constitutive models able to simulate the constitutive laws of such composites up to failure, under both monotonic and cyclic loading, by considering several natural fibres nowadays employed in engineering applications. The proposed research project can lead to predictive models able to reproduce the behaviour of the above building materials in order to estimate their durability, giving a feedback of their load-bearing capacity, even in the field of preservation and restoration of existing buildings.

Obiettivi – The proposed research project aims at merging skills and knowledge through a collaborative research activity among the involved Research Units in the field of the analytical and numerical modelling of reliable constitutive laws, in order to predict the response up to failure (collapse) of the most relevant building materials in the Italian context: both traditional materials (such as concrete, metallic materials, masonry) and innovative ones (such as nano-additivated concrete and mortar, and natural fibre composites).