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Some considerations on material sensitivity to their microstructure to design effective computational models dependent on really measurable parameters

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It is well-known and worldwide shared that modeling material microstructure is unavoidable to investigate separate or coupled phenomena on which the expected response depends. This is the case of biomaterials broadly understood, namely living materials, usually called tissues, which follow often coupled mechanical, chemical, electromagnetic and biological behavioral laws strongly dependent on intimate architecture at different scale, from Micro to Nano.

Two main points should be taken into consideration: a suitable theoretical approach and a reliable implementation that does not mean fulfilling classical convergence criteria only but also measuring parameters consistent with the model and able to be taken from feasible experimental tests ad hoc designed or suitably selected among those which can give information on the material microstructure on which the expected or unexpected material behavior is dependent.

Basically such theories range from macro to micro and Nano-scale, thus implying in some cases different constitutive or physical laws. For engineering application searching for theories as much as possible simple and at the same time reliable with respect to the research target is still a fundamental criteria, provided that approximations introduced do not prevent from analyzing features to predict.

Classical Micromechanics of solids is a meaningful example of theories well founded but subject to severe limitations. In fact Micromechanics extends fundamental principles of continuum mechanics to bodies embedding heterogeneous particles, as micro-composites typically do, provided that linear elastic constitution be considered only and continuity of the 'mother' theory be preserved. In other words Micromechanics, even if appealing for elegant formulations, suffers limitations due to its basic hypotheses.

Its extension to take into account any kind of discontinuities, as plastic strains or fracturing debonding, require so much integrations and modifications that numerical methods based on discretization of the field- body seem to be preferable because their essential capacity to model local phenomena, whatever be the scale at which they develop, as long as behavioral laws assumed be consistent with them.

Unfortunately also experimental tests must change the scale consistently, thus requiring sophisticated testing techniques, sometimes based micro-Nano image-based devices. Micro-Nanoindentation, coupled with particular microscopes, is one of the above techniques that is focused on for its real power to characterize micro-composites, aided by mathematical methods as identification does.

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