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Foreword / *Avant-propos*

Recent advances in finite fracture mechanics—a tribute to Dominique Leguillon’s scientific achievements

Progrès récents en mécanique finie de la rupture — un hommage à l’œuvre scientifique de Dominique Leguillon

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On the scene of contemporaneous French fracture mechanics, Dominique Leguillon stands as a singular and most remarkable character. Indeed, after the completion of his PhD thesis undertaken and pursued at the Laboratoire de Modélisation en Mécanique of Université Pierre et Marie Curie (Paris VI) (now part of Sorbonne Université), he was appointed as Ingénieur de Recherches in the CNRS (Centre National de la Recherche Scientifique). His already heavy task, which he managed to perform alone, consisted in the organization and maintenance of the ensemble and network of computers of the Laboratoire de Modélisation en Mécanique. But he would not limit his activities to such aspects and undertook scientific cooperations with various researchers, and notably our illustrious colleague Evariste Sanchez-Palencia. With him, he dedicated numerous and fruitful efforts to various important issues in mechanics of deformable solids, such as periodic homogenization, matched asymptotic expansions, and occurrence of singularities. The popularity and impact of these studies allowed him to successfully apply for a post of Directeur de Recherches at the CNRS. This highly improbable passage from a position of engineer in charge of computers to one of researcher is exceptional enough in the CNRS to deserve a very special mention.

But it was in the 2000’s that Dominique’s career and scientific reputation really started to take off. In order to explain the nature of his essential contribution, it is first necessary to provide some elements of context.

The aim of the classical theory of fracture mechanics is to study and predict propagation of cracks in materials. It is of utmost practical importance, and serves as a basis to avoid crack-induced failure of various mechanical objects and structures. But in spite of its very numerous and important successes, it is still prone to notable shortcomings. For instance, it permits to predict crack propagation from some small pre-existing crack, but not in a sound structure devoid of any pre-crack. Even more critically, it fails to predict crack initiation from a notch root, in spite of the frequent occurrence of such a situation, notably in welded joints.

The essential contribution of Dominique, which no longer owed anything to anyone else, was to overcome these limitations by proposing an extended theory, nowadays known as “finite fracture mechanics”. This new approach of this type of problems requires the definition of some

“double” or “coupled” criterion, involving two necessary conditions for crack propagation, one on the opening stress before propagation, the other on the energy-release-rate. The new theory is termed *finite* fracture mechanics because it does not split crack propagation into infinitesimal steps, each governed by the double criterion, but into steps that may be finite, over some distance determined by the criterion.

Dominique's proposal immediately drew attention from numerous researchers in the field at various places in the world, and met with very important success; experimenters active in France, Europe, Israël and the USA, embarked on the experimental verification of this proposal and its practical applications. Dominique collaborated with them and accompanied them in his typically friendly way, thus weaving a large web of international cooperations.

These features permit to state that Dominique's new theory of finite fracture mechanics stands as one of the major additions brought to fracture mechanics in the last few decades.

Having retired, Dominique changed almost nothing in his working habits, and went on coming to his research institution every day, pursuing the development of his ideas with his colleagues and friends. However, having reached the age of 75 in full command of his intellectual means, and although nothing permitted to foresee such an event, Dominique suddenly succumbed to a heart attack while he was walking in the street. He leaves an immense emptiness behind him, but also appealing scientific perspectives, because his ideas, being so simple, elegant and straightforwardly applicable to problems of both scientific and technical nature, can still motivate numerous and important developments; so true it is that fracture mechanics cannot possibly be content with predicting and depicting the propagation of cracks while forgetting about their initiation.

For those who had the privilege of knowing Dominique, he will remain an exceptional colleague and friend. The aim of this special issue of *Comptes-Rendus Mécanique* dedicated to him is to fittingly honor his memory, by showing how his ideas still give rise and stimulate diverse and interesting works.

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