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Preface

George J. Dvorak

This special issue of the International Journal of Solids and Structures consists mostly of invited papers presented at the Symposium in Honor of George J. Dvorak, which was held at the 14th U.S. National Congress of Theoretical and Applied Mechanics at the Virginia Polytechnic Institute and State University in June of 2002.

George J. Dvorak was born in Prague, Czech Republic, where he received his primary education. In 1951, after several post-war years spent in Teplice, he returned to Prague and entered the School of Civil Engineering of the Czech Technical University. There, he majored in steel structures under the guidance of Professor František Faltus. During his college years, he also worked as a welding instructor in steel structures courses, and later as a structural design engineer. After graduating with the degree of Civil Engineer, he became in 1957 an Assistant in the Mechanics Department of the Technical University of Liberec, where he taught kinematics, statics and dynamics of mechanisms to mechanical engineering students. He met there a long-time friend and prominent mathematician Alois Švec, with whom he wrote his first book on kinematics-based generation of technical curves, published in Prague in 1962. Returning to Prague in 1959, he started his graduate program under the advisorship of Professor Faltus in the Institute of Theoretical and Applied Mechanics of the Czechoslovak Academy of Science, with a focus on

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experimental investigation of the effect of surface embrittlement on brittle fracture initiation in low-alloy steels. After defending his dissertation entitled "Mechanism of the Greene Effect" he was awarded the Candidate of Science degree in 1964. The same year, he was selected to deliver the opening lecture at the International Institute of Welding Congress, held in Prague. This led to his appointment as Research Associate at Brown University, where he arrived in November of 1964.

In his first year at Brown, George Dvorak worked with Professor Constantine Mylonas, on brittle fracture of ship steels associated with the "exhaustion of ductility" effect caused by hot or cold plastic compression. His investigation identified the heavily deformed surface layer of a rolled steel plate as a major contributor to the observed effect (Dvorak and Mylonas, 1968). Influenced by the impressive research environment at Brown, he commenced an additional Ph.D. program with Professor Daniel C. Drucker. In 1967, he resumed his teaching career, at Duke University, where he initiated his long-time interest in mechanics of composite materials. His contributions during that period include identification of plastic shakedown of the matrix with the saturation damage state in fatigue of metal matrix fibrous composite laminates, and development of an incremental plasticity theory for the MMC materials (Dvorak et al., 1975; Dvorak and Johnson, 1980; Dvorak and Bahei-El-Din, 1982). In later work, cyclic plastic straining and growth of low-cycle matrix fatigue cracks along the fiber direction in metal matrix laminates was found to be responsible for translation and expansion of ply yield surfaces, required for reaching the shakedown state (Dvorak et al., 1994). In 1979, inspired by the example of several generations of his ancestors–administrators and by his fondness of skiing, he became the chairman of the Civil Engineering Department at the University of Utah in Salt Lake City. His main research results achieved in those years laid foundations to the theory of uniform fields in fibrous heterogeneous solids, and to its subsequent applications in formulating the exact connections between the phase and overall elastic moduli and other physical properties, and in thermomechanics of composite materials (Dvorak, 1983, 1990; Dvorak and Chen, 1989). Also, an extensive experimental program on plastic deformation of metal matrix laminates under combined in-plane loads was initiated and completed by Dr. Dvorak and his associates in the laboratory of Professor Aris Phillips at Yale University. The results confirmed the predicted kinematic constraint hardening and lack of normality of the observed plastic strain increment vectors to the experimentally detected loading surfaces, which merely connect vertices of yield cones created by the nonuniform local fields in the matrix. Detailed simulations of the deformation process implementing the normality rule at each integration point reproduced the experimental results with good accuracy (Dvorak et al., 1988, 1991).

In 1984, Dr. Dvorak transferred to Rensselaer Polytechnic Institute in Troy, New York, a leading institution of composite materials research, with over a dozen faculty participating in various projects. For more than 25 years, Rensselaer was the home of a NASA composites center, and since 1986, of sequential University Research Initiative Programs on structural and high-temperature composite materials, which were sponsored by the Defense Advanced Research Projects Agency of the Department of Defense. Dr. Dvorak directed these programs during 1988–1997. Much additional funding was provided over the years by the Air Force Office of Scientific Research, the Army Research Office, the National Science Foundation, the Office of Naval Research, and several federal agencies and industrial sponsors.

His tenure at RPI has been a very productive period for George Dvorak, leading to numerous theoretical and experimental papers and hundreds of lectures on micromechanics of inelastic deformation, damage evolution and fracture of composite materials, and modeling of functionally graded composites. The theory of uniform fields in heterogeneous aggregates and the transformation field analysis (TFA) method were completed in that period (Dvorak and Benveniste, 1992; Dvorak, 1992). Based on a clever use of generalized Green's functions, the TFA method represents local inelastic deformation and damage increments by equivalent eigenstrains that are superimposed with any applied mechanical loads, to create in the original elastic aggregate and/or laminate the same local fields as does the actual deformation and damage process. Many other physical processes can be modeled in this manner, for example, thermal strains, phase transformations, electric polarizations, as well as interface decohesion and transverse cracking. Their representation by local eigenstrains that evolve according to the pertinent constitutive relations allows analysis of interactions of the different processes at several length scales. This work has also identified a family of new methods for estimating the local fields and overall properties of heterogeneous materials, in which the often used self-consistent and Mori–Tanaka methods are special cases (Dvorak and Srinivas, 1999). Dvorak's more recent work led to a theoretical framework for evaluating optimized fiber prestress magnitudes, induced during fabrication and released after matrix cure, and for reducing fiber waviness and improving damage resistance of laminated plates and cylindrical shells (Dvorak et al., 1999; Dvorak and Suvorov, 2000). This research shows that relatively small forces are needed to induce significant prestress magnitudes in the fibers, and thus create either detrimental or beneficial residual stress fields in the interior and at free edges of laminated composite structures.

Dr. Dvorak's accomplishments have been recognized by numerous awards and appointments. Among them are the William Howard Hart Chair in Mechanics at Rensselaer; Visiting Fellowship at Clare Hall in Cambridge, England; Fulbright Research Fellowship at the Technical University of Denmark; the Arpad Nadai Award for pioneering research in modern materials; the Daniel C. Drucker Medal for contributions of broad influence in mechanics from the American Society of Mechanical Engineers; the William Prager Medal for contributions to mechanics of solids from the Society of Engineering Science; the Brown Engineering Alumni Medal; a honorary doctorate of science from the Czech Technical University in Prague; Medal of Merit for contributions to mechanics from the Czech Academy of Sciences; and membership in the National Academy of Engineering.

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