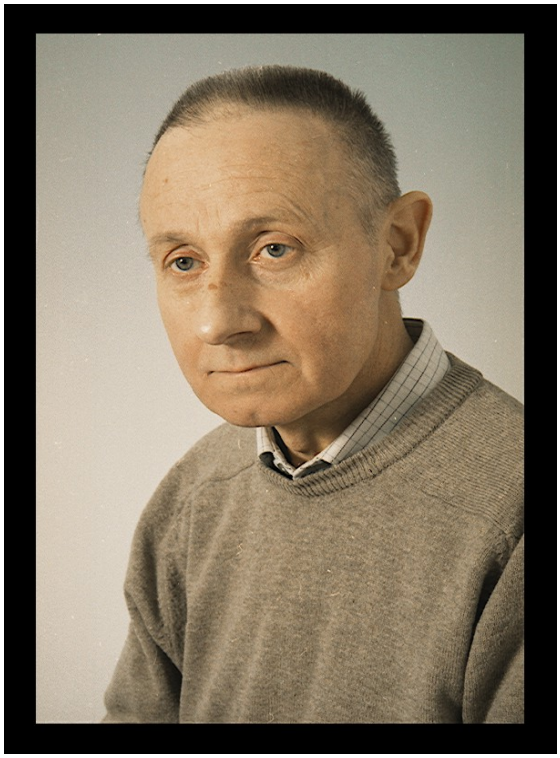
IN MEMORIAM



Józef Joachim Telega
(1943-2005)

J. Joachim Telega was born at Przeszowice in Poland on March 24, 1943. He got two Master's degrees : in 1968 at Technological Department of Silesian University and in 1970 at Mathematics, Physics and Chemistry Department of the same University. Here he had been working until 1977 and he had got there PhD. in 1972. Since 1977 until last days of his life he had permanent position at IFTR PAS. Since 2001 he was the head of the Division of Variational Methods and Biomechanics within the Department of Mechanics of Materials and Biomechanics. He was engaged in various kinds of scientific cooperation, in Poland, as well as abroad. The teamwork was his preferable method of scientific activity.

Telega was editor-in-chief of the Polska Bibliografia Analityczna Mechaniki (Polish Analytical Reviews of Mechanics) in the years 1984-1991. He was a member of numerous scientific societies and served in the editorial boards of scientific journals : Applied Mechanics Reviews, since 1992 (technical editor and associate editor), Archives of Mechanics (Archiwum Mechaniki Stosowanej) since 1999, Matematyka Stosowana (Applied Mathematics) since 2000,Acta Bioengineering and Biomechanics, since 2000, Russian Journal of Biomechanics, since 2000. During last years he edited five volumes of the

„Conference Proceedings" of the Centre of Excellence for Advanced Materials and Structures AMAS series and twenty volumes of AMAS „Lecture Notes". He was editor-in-chief of the series: Reports of Institute of Fundamental Technological Research, in abbreviation IFTR Reports (in Polish: Prace IPPT) since 1991, and a member of the editorial board of Biblioteka Mechaniki Stosowanej (Series on Applied Mechanics), since 1999.

J. Joachim Telega was a member of several scientific committees of international conferences and during the last decade he organized numerous workshops, seminars and courses mainly on biomechanics. Since 1996 he had actively contributed to Ukrainian-Polish Conferences, where he also presented (together with his coworkers) the following papers:

1. S. Jemioło, J.J. Telega, An alternative approach to the representation of orthotropic tensor functions in the three - dimensional case, 1996.
2. S. Jemioło, J.J. Telega, Fabric tensors in cancellous bone mechanics, 1997.
3. A. Gałka, J.J. Telega, S. Tokarzewski, Determination of effective conductivity of nonlinear composites: homogenization and approximation, 1997.
4. J.J. Telega, A. Gałka, Augmented Lagrangian methods and applications to contact problems, 1998.
5. A. Gałka, J.J. Telega, S. Tokarzewski, R. Wojnar, Overall properties of elastic composites with temperature - dependent coefficients, 1999.
6. S. Jemioło, J.J. Telega, Implementation of isotropic hyperelastic models of soft tissues in FEM ABAQUS, 1999.
7. S. Tokarzewski, J.J. Telega, A. Gałka, Effective moduli of trabecular bones with regular microstructures, 1999.
8. J. Telega, T. Lewiński, Theory of plates and shells with locking and application to optimization, 2000.
9. S. Jemioło, J.J. Telega, On finite anisotropic elasticity and applications to soft tissue modelling, 2000.
10. J.J. Telega, S. Tokarzewski, A. Gałka, Hydraulic stiffening of cancellous bone due to the presence of marrow: the application of multipoint Padé approximants, 2000.
11. A. Gałka, J.J. Telega, S. Tokarzewski, Determination of macroscopic elastic moduli of cancellous bonewith honeycomb microstructure, 2001.
12. A. Gałka, J.J. Telega, Augmented Lagrangian methods for frictionless contact problems and nonconvex duality, 2001.
13. S. Tokarzewski, J.J. Telega, A. Gałka Torsional creep and relaxation of cancellousbone filled with marrow, 2001.
14. A. Sławianowska, J.J. Telega, A contribution to asymptotic modelling of linear elastic orthotropic plates, 2001.
15. J.J. Telega, S. Jemioło, Polyconvexity for anisotropic materials undergoing finite deformations. Part I. General setting and existence theorem, 2002.
16. J.J. Telega, S. Jemioło, Polyconvexity for anisotropic materials undergoing finite deformations. Part II. Incompressibility, injectivity, internal and boundary unilateral constrains, 2002.
17. J.J. Telega, T. Lewiński, Relaxation of the minimum compliance problem within plate theories of Kirchhoff and Reissner, 2002.
18. S. Tokarzewski, J. J. Telega, General inequalities for effective transport coefficient of two-phase media, 2002.
19. A. Sławianowska, J. J. Telega, Asymptotic-variational approach to modelling of piezoelectric plates, 2002.
20. W. Bielski, E. Kruglenko, J. J. Telega, Non-convex minimization problems and microstructures, 2002.

21. J. J. Telega, W. Bielski, Formulation of extremum principles for adaptive elasticity. Part I. General setting for nonpotential static problems, 2003.
22. J. J. Telega, W. Bielski, Formulations of extremum principles for adaptive elasticity. Part II. Quasistatic coupled problems, 2003.
23. A. Gałka, B. Gambin, J. J. Telega, Multi-layered piezocomposites: homogenization and optimization, 2003.
24. S. Tokarzewski, J. J. Telega, B. Gambin, A. Gałka, Constraints on anisotropic Stieltjes measures determining the effective transport coefficients of two-phase media, 2003.
25. J.J. Telega, S. Jemioło, New approach to limit analysis theorems for incompressible and compressible materials with non-associated flow rules, 2004.
26. W. Bielski, J.J. Telega, Transversally isotropic hyperelasticity with stored energy function exhibiting nonpolynomial growth, 2004.
27. B. Gambin, A. Gałka, J.J. Telega and S. Tokarzewski, Influence of anisotropy induced by microcracks on effective elastic properties, 2004.
28. J.J. Telega, B. Gambin, A. Gałka and S. Tokarzewski, Exact internal controllability of perforated linear elastic solid, 2004.
29. S. Tokarzewski, J.J. Telega, B. Gambin and A. Gałka, Linear fractional transformation as a tool for generating bounds on macroscopically isotropic two-phase media, 2004.

He was a cochairman of the NATO Advanced Research Workshop " Nonlinear Homogenization and Its Applications to Composites, Polycrystals and Smart Materials, 2003. The most recent was the workshops: „Modelling in Biomechanics" and „Advanced Course on Tissue Remodelling", both held in Warsaw in 2004. He delivered his lectures during both these events and prepared exhaustive Lecture Notes which will soon be published.

Telega was active in various fields of science. His broad interests and expertise enabled him to contribute to many domains such as: applications of mathematical programming to limit analysis, shakedown and optimization, plasticity, nonlinear elasticity, Cosserat and polar media theory, mathematical, and particularly variational methods in solid and structural mechanics, the invariant theory and tensor functions and their applications to the formulations of constitutive relationships, micromechanics and homogenization (deterministic and stochastic), effective properties of composites including piezoelectric and fissured composites, porous media, thermodiffusion, electrokinetics, coupled fields, geological faults, contact mechanics, variational inequalities, exact controllability and stabilization of structures and to various fields of biomechanics. He authored or coauthored 13 books and over 350 scientific papers.

Since early nineties Telega has turned his scientific interests into biomechanics. He noted that the methods developed for modeling deformations of engineering structures and materials can be, albeit with some necessary care, applied to the mathematical modeling of living structures (tissues, bone structures, muscles) as well as to figure out the phenomena taking place therein. While dealing with biomechanics Telega has enlarged his knowledge by further studies in the fields of biology, biochemistry and biophysics, as well as in more specific fields like physiology or histology. Being severely handicapped by ill-health, having experienced introduction of four joint implants, he initiated at the Institute of Fundamental Technological Research of Polish Academy of Sciences the organization of a laboratory for research into modeling of various biomechanical aspects of joints implantations. Due to his high mathematical education, knowledge of modern tools of mechanics and uncommon ability in comprehending the complexity of scientific information from various fields of science, including biology, he was able to play the role of a competent head of many research projects conducted, of interdisciplinary profile, linking the results of research done by clinicians,

experimental biologists and specialists in continuum and computational mechanics. The projects concerned the biomechanics of bones, muscles and articular cartilages, orthopaedic biomechanics and electromechanical effects in living tissues (bones, cartilage, etc.). This activity has been continued within the framework of the Centre of Excellence for Applied Biomedical Modelling and Diagnostics ABIOMED formed in 2002 within the IFTR. Telega became the scientific coordinator of the Centre.

Let us look at his scientific outcome, from the very beginning. The first papers by Joachim Telega, published in years 1970-1971, inspired to some extent by Antoni Sawczuk, his cordial friend, concern the limit load theory of skeletal structures and plates, see e.g.[Mech.Teoret.Stos. **9**, 1971, 7-52]. The Author concentrates on the mathematical approach which, without going into engineering technicalities, reduces the mechanical problems considered to the linear programming problem. The problems of limit load of frames involve not only displacements but also the rotations as unknowns. This could be the reason why J.J.Telega turned soon his attention into generalizing the limit load theorems to incorporate independent rotations in the continuum formulation by considering the limit load problems for micropolar media [Mech.Teoret.Stos. **10**, 1972, 411-427]. Then, in years 1973-1975, the papers by Telega went in two directions. One, purely mathematical stream of works concerns selected problems of shifter spaces and on covariant derivatives of product tensors. On the other hand Telega compiled an extensive bibliography of applications of the finite element method in solid mechanics, with particular attention being paid on soil and rock mechanics [Mech.Teoret.Stos.**11**, 1973, 195-210]. The next years, 1976-1982, bring new results of determination of potential form of operators thus completing the known works by M.Krener (1933) and E.Tonti (1973). Telega generalizes the method of F.Magri (1974) to the broader class of nonlinear operators; in this respect Telega's paper ["On variational formulations for nonlinear, non-potential operators", J.Inst.Maths.Applics. **24**, 1978, 175-195] is frequently cited. The methods worked out by him made it possible to derive new variational principles on deformations of rigid-plastic solids obeying non-associated flow laws; the relevant two-part paper by Telega was published in [Int.J.Eng.Sci. **20**. 1982, 913-933; 935-946]. This publication, along with further papers (joint with A.Gałka) on variational formulations of finite elasticity in the presence of non-potential loadings [Bull.Acad.Pol.Sci. Ser.Sc.Tech. 30, 1982, 121-128; 129-135] strengthened the authority of Joachim Telega among specialists in the continuum mechanics. In these papers one notes a peculiar feature of his works: getting to the core of the mathematical essence of the problem, abstracting it and then solving by appropriate, modern, sometimes advanced methods, yet without any escape into mathematical abstruseness. Such method of work is characteristic for the most distinguished scientists whom solid mechanics owes its progress.

In eighties, the scientific interests of J.J. Telega were directed to the theory of representation of tensor functions, with a special emphasis put on its applications in plasticity. His survey paper : "Theory of invariants: from Boole to the present" was published in the book edited by him: "Methods of Functional Analysis in Plasticity", published by Ossolineum in 1981. This paper, due to its high level of competence, played an important didactic role, at least in our country. The topic of invariant theory will come back in nineties in Telega's papers joint with S.Jemioło. Their joint report: "Representations of tensor functions and applications in continuum mechanics", IFTR Reports, 3/1997, pp.112, deserves a special attention. This book is widely used by specialists in continuum mechanics, not only by PhD students in Poland.

An independent stream of works by Telega concerned the non-classical contact problems, in particular the contact with friction. The first papers, joint with W.Bielski, appeared in Archives of Mechanics in 1985. There a new dual formulation (in the sense of U.Mosco) of contact problems with Signorini conditions, including friction, was put forward. Additionally,

the dual form of the obstacle problem for von Kármán plates was dealt with. Once again Telega devoted his time to compile a new survey paper, now on contact problems, this time written in Russian: "Variational methods in contact problems of mechanics", Adv.Mech. (Uspekhi Mekhaniki) **10**, 1987, 3-95. This work provides a competent description of more than 400 works on contact problems. The survey was met with a very good response from the side of Russian and Russian-language scientists. The problems of contact with friction were the subject of Telega's lectures in CISM, Udine, published in: J.J.Moreau and P.D.Panagiotopoulos, Eds., Nonsmooth Mechanics and Applications", Springer, Wien-New York, 1988. The dual approach to the contact problem with friction was a part of Telega's Habilitation Thesis: "Variational methods and convex analysis in contact problems and homogenization", IFTR Reports 38/ 1990, pp 209. Just recently, Telega has come back to the contact mechanics problems; his newest results have been published in the book: M. Shillor, M. Sofonea, J. J. Telega, *Models and Analysis of Quasistatic Contact, Variational Methods,* Series: Lecture Notes in Physics, Vol. 655, Springer, Berlin 2004, XII, 262 p. This book includes also the results found in joint papers with A.Curnier and Qi-Chang He of 1992.

Since late 70^{th} the progress of the homogenization theory inspired Joachim Telega to extend the method to the problems concerning structures, i.e. arches, plates, laminates and shells and to the coupled fields problems of composites. The paper joint with A.Lutoborski [J.Elasticity **14**, 1984, 65-77] opens a long series of his papers on homogenization. The effective stiffnesses were found by the energy method of L.Tartar. By using the variational-asymptotic method one can perform homogenization not only of arches but in general, of shells, as was shown in a joint paper with T.Lewiński [Arch.Mech. **40**, 1988, 705-723]. These results were later justified by Telega and Lewiński [Bull.Polon.Acad.Sci.Tech.Sci. **46**, 1998, 1-9; 11-21] by using the Γ-convergence technique, also in the dual setting.

The homogenization process for shells and plates of repetitive structure should be bonded with the process of formation of the two-dimensional model. Telega showed that such a passage to a limit can be examined by Γ-convergence. This derivation as well as other original results by Telega are included in the book: T. Lewiński , J.J. Telega, *Plates, Laminates and Shells. Asymptotic Analysis and Homogenization.* World Scientific Publishing; Series on Advances in Mathematics for Applied Sciences vol.52, pp 768, 2000, Singapore, New Jersey, London, Hong Kong. This book summarizes the outcome of J.J.Telega of the years 1985-2000 within the topic of homogenization of plates and shells. In particular, the book comprises the original contribution of Telega concerning homogenization of plates of moderate thickness, von Kármán plates, elasto-plastic plates and thin shells. The advanced results on homogenization of plastic plates were based on the work by J.J.Telega: "Epi-limit on HB and homogenization of heterogeneous plastic plates", Nonlin.Anal.Th.Meth.Appl. **25**, 1995, 499-529. This paper deserves a special attention since the results important for the mechanics of plates were found with using very subtle methods of epi-convergence in the sense of H.Attouch.

Homogenization of cracked plates and laminates requires special asymptotic techniques, see Ch.III of the book cited above. A specially difficult justification by Γ-convergence have been developed by Telega. The effective properties of elastic solids with randomly distributed cracks were the subject of the contribution by B.Gambin and J.J.Telega [Mech.Res.Comm. 27, 2000, 697-706].

The results of Telega published in the paper: "Piezoelectricity and homogenization. Applications to biomechanics" [in: G.A.Maugin, Ed. CMDS Proceedings, Longman 1991] were pioneering in the literature on homogenization of piezocomposites . The formulae found there were soon generalized to the dynamic case and implemented into FEM codes. Much more complex homogenization problems were treated by J.J.Telega, B.Gambin and A.Gałka in: "Non-linear piezoelectric composites: deterministic and stochastic homogenization", [Ed.:

J.Holnicki, J.Rodellar, Smart Structures, 1999, 355-364]. In this paper a random variation of the microstructure has been dealt with. A deep exposition of the subject of stochastic homogenization has been recently given by J.J. Telega in his article: "Stochastic homogenization: convexity and nonconvexity", in: P.P.Castañeda, J.J.Telega, B.Gambin, Eds., Nonlinear Homogenization and its Applications to Composites, Polycrystals and Smart Materials. NATO Science Series. II. Mathematics, Physics and Chemistry, vol.170, Kluwer, Dordrecht, 2004, 305-347.

Homogenization of transport phenomena in the nonlinear range exceeds the classical framework of the homogenization methods. This topic was nevertheless considered in a joint paper (with A.Gałka and S.Tokarzewski) published in Arch.Mech, 1997. One can find there the Hashin-Shtrikman like variational principle as well as the integral representation of type of Golden and Papanicolaou., referred to stochastic media. This representation makes it possible to arrive at reasonable Padé estimates of arbitrary accuracy, see joint papers with S. Tokarzewski of years 1996-1998.

The original results by Telega of 1991 concerning piezoelectric bodies were generalized by J.J. Telega, A. Gałka and R. Wojnar to the dynamic problems of thermopiezoelectricity [Mech.Res.Comm.**19**, 1992, 315-324].

In series of papers (with W. Bielski, R. Wojnar) the flow through various porous media was considered in which different fluids were involved and influence of different physical fields was taken into account. Macroscopic equations governing the dynamic flow of two immiscible viscous fluids through an elastic microperiodic porous medium were derived. To this end homogenization methods were employed and the procedure was justified by the method of two-scale convergence. A general framework for modelling flows of two-ionic species electrolytes through porous piezoelectric media was elaborated. By using the method of two-scale asymptotic expansions, the macroscopic phenomenological equations describing the electrokinetics of such a structure were derived and the formulae for the effective mechanical and nonmechanical coefficients were given.[Telega J.J., Wojnar R., Comptes Rendus de l'Academie des Sciences Serie II Fascicule B-Mecanique Physique Astronomie, vol.328, no.3, March 2000, pp.225-30], [Bielski W., Telega J.J., Wojnar R. , Archives of Mechanics, vol.53, no.4-5, 2001, pp.333-66].

Together with S. Jemioło, J.J. Telega solved a very difficult problem of homogenization of periodic media with locking, see [Bull.Polon. Acad. Sci. Tech.Sci**. 46**, 1998]. The cellular bones can serve as examples of such bodies. The locking problem comes back in Lewiński and Telega's paper on minimal compliance of bending plates[see Arch.Mech. **53**, 2001, 303-331]. The assumption of the volume of the plate material being small degenerates the problem to the Michell-like problem with a functional with an integrand of linear growth. The dual problem was derived and the relevant locking locus found explicitly. Telega stated that the stress fields in Michell-like problems should be treated as stress rates, like in the locking problems of solid mechanics.

Contribution of Telega to the theory of optimization is mainly included in Ch.6 of the book joint with T. Lewiński. This part of the book concerns the problem of minimum of compliance of two-material plates and shells, with the isoperimetric condition imposed on the volume of both the materials. The problem thus posed necessitates relaxation by homogenization. In the book by Lewiński and Telega a particular attention is put on the two-material design for which both the primal and dual formulations are given with all necessary details, in the context of the thin plate theory. The last Telega's contribution on optimization [Lewiński and Telega J.Theoret.Appl.Mech. **41**, 2003, 545-560] deals with optimal design of membrane shells. The subject is linked with the yet unsolved problem of Michell-like surface structures; one known example of Michell's sphere subjected to torsion does not exhaust the topic.

The paper: "Topics on deterministic and stochastic controllability and stabilization of distributed parameter systems: theory and numerical approximations" ; in: Advanced Course on Structural Control and Health Monitoring, SMART'01, pp 213-340, Ed.: J.Holnicki-Szulc, AMAS Lecture Notes, Warsaw 2001, was a preparatory step towards the subject of controll and stabilization of *smart* structure. As all his survey papers, this contribution is an excellent introduction to the topic, including competent comments on carefully selected 196 papers on controllability. Telega was also interested in the classical problems of well-posedness and justification of two-dimensional models of homogeneous plates and shells. He formulated criteria of correctness of selected models of plates with transverse shear deformation (see W.R.Bielski and J.J.Telega, J.Elasticity, **42**, 1996, 243-273) and derived asymptotically the dynamic equations of orthotropic plates, see A. Sławianowska and J.J.Telega, Mech.Res.Comm. **27**, 2000, 659-668. His other results in this topic are included in the book co-authored by T. Lewiński.

Telega was a technical editor of Applied Mechanics Reviews. He saw his role as to promote new results emerging in the Eastern Europe. In particular, he intended to make the readers of this Journal acquainted with the Polish contribution to mechanics, sometimes disregarded or not appropriately referred to in the foreign literature. The paper: J.J.Telega, R.Wojnar, Main Polish historical and modern sources on applied mechanics, Appl.Mech.Rev. **49**, 1996, 401-432 fulfilled its predicted role and proves an exceptional orientation of the Authors in the history of mechanics, including earth sciences, beginning from 1870.

Orthopaedic biomechanics has been one of main interests of J.Joachim Telega in his last years. He was involved in research related to mechanical reasons for short- and long-term failure of total joint replacement surgery. Following a common belief that stress concentrations on the bone-implant interface are a significant factor in the tissue degradation, he investigated how the surgery conditions affect the stress distribution in the bone-implant system under natural loads. Finite element techniques enriched with the design sensitivity analysis allowed to investigate the influence of implant shape variations on stress distribution in bone tissue neighbouring the implant [P. Kowalczyk, J.J. Telega , Acta of Bioengineering and Biomechanics, 1: 47-51, 1999].

His special models of contact with adhesion has been developed for interfaces in joints with implants [J. Rojek, J.J. Telega , Journal of Theoretical and Applied Mechanics*,* 37: 659-686, 1999]. This approach allowed to create more realistic model of the interfaces in bone-implant systems which allowed to study loosening of implants due to debonding at the contact interface. Further investigations of the interface has been extended to take into account wear and influence of wear debris on the weakening of adhesive bonds [J. Rojek, J.J. Telega, Journal of Theoretical and Applied Mechanics*, 3,* **39**, pp. 655-677, 2001]. His recent research project included studies on biological aspects of implant loosening caused by the products of wear.

He has published (jointly with M. Stańczyk) four review articles on heat transfer in biomechanics [Russian J. Biomech, 5(4):30-75, 2001; Acta Bioeng. Biomech, **4**(1):31-61, 2002; Acta Bioeng. Biomech, **4**(2):3-31, 2002; Acta Bioeng. Biomech, **5**(2):3-22, 2003;]. The variational formulations and general minimum principles for quasilinear transport and bioheat equations of the bio-heat problems as a specific case of the quasi-linear transport equation are given by Telega in the paper Telega J.J. and Stańczyk M., Comptes Rendus Mecanique, **332**:263-269, 2004.

In his last heroic months of life, being critically ill, having suffered from a serious disability, he prepared hundreds of pages of the monographs envisaged, their titles being:

Young measures and their applications in micromechanics and optimization. Part II. Applications;

Contact Problems for Solids and Structures Undergoing Large Deformations;

Heat Transfer Problems in Biomechanics;

Biomechanical aspects of fracture healing;

Controllability and stabilization of linear and nonlinear plates and shells.

Unfortunately, the untimely death thwarted his plans of finishing these books and hindered from editing of other nearly completed papers.

Joachim Telega had unbelievable reserves of spiritual energy. His life was devoted to work, despite his illness. Yet he coped with it, making up by continual work and perfect organization the time he lost to having medical treatment. Passing away on January 28, 2005, Joachim Telega deprived us of his uncommon personality. Poland lost an outstanding scientist. We lost a sincere friend, a teacher and a guide.

Barbara Gambin and Tomasz Lewiński.
Warsaw, April 2, 2005.