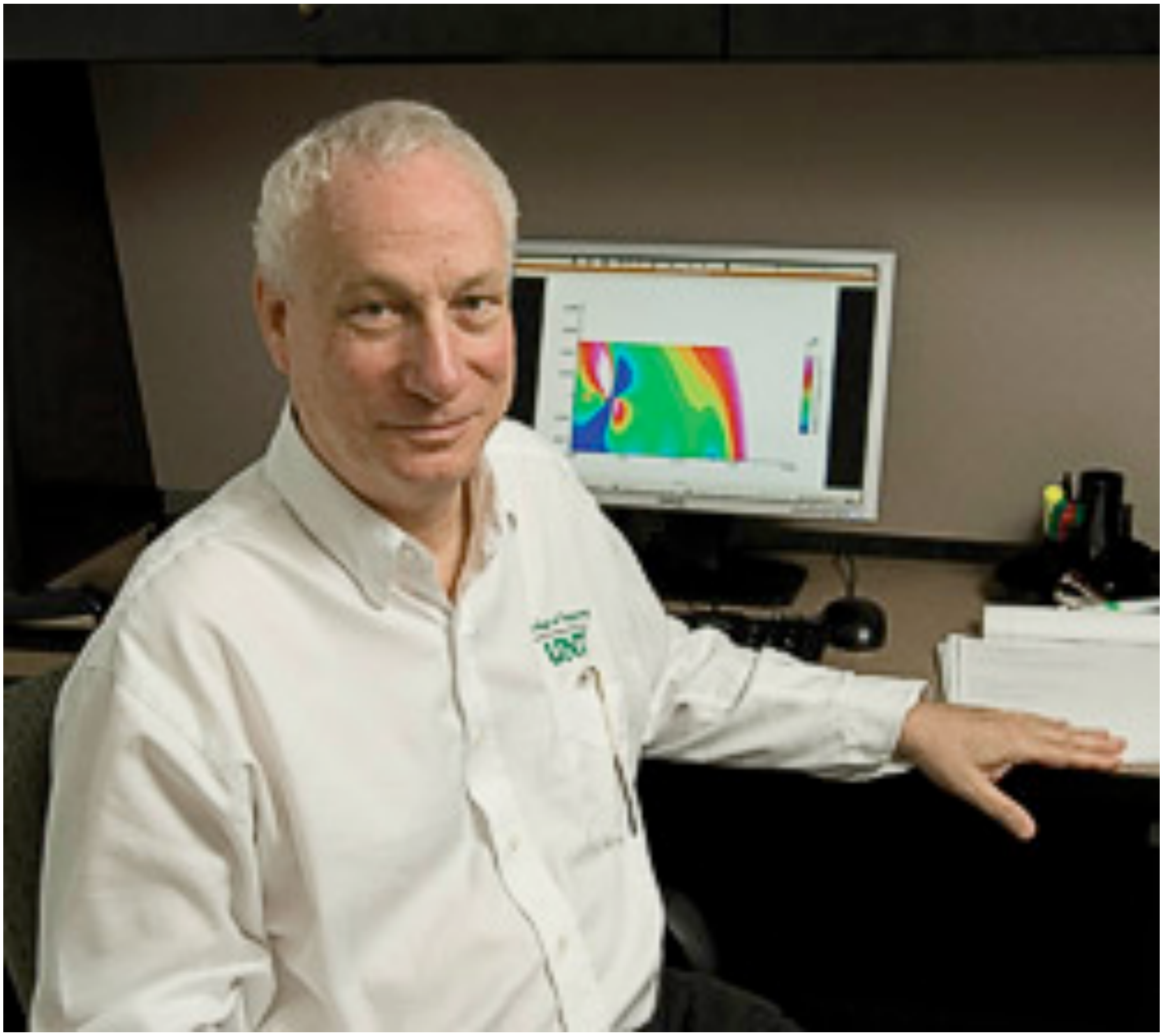

Professor Alan Needleman

See:
http://www.mtse.unt.edu/Needleman/
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http://www.worldcat.org/identities/lccn-n85-819658
http://www.journalogy.net/Author/10680567/alan-needleman

From Wikipedia: Alan Needleman was born September 2, 1944, in Philadelphia, PA and is currently Professor of Materials Science & Engineering, University of North Texas. Prior to 2009, he was Florence Pirce Grant University Professor of Mechanics of Solids and Structures at Brown University in Providence, RI. Professor

Needleman received his B.S. from the University of Pennsylvania in 1966, a M.S. and Ph.D. from Harvard University in 1967 and 1970 respectively, advised by John W. Hutchinson. He was an Instructor and Assistant Professor in the Department of Applied Mathematics at the Massachusetts Institute of Technology from 1970 to 1975. He has been a Professor of Engineering at Brown University since 1975, and served as the Dean of the Engineering Department from 1988 to 1991. He was the chair of the Applied Mechanics Division.

Professor Needleman's main research interests are in the computational modeling of deformation and fracture processes in structural materials, in particular metals. A general objective is to provide quantitative relations between the measurable (and hopefully controllable) features of the materials' micro-scale structure and its macroscopic mechanical behavior. Ongoing research projects involve studies of ductile fracture and ductile-brittle transitions; crack growth in heterogeneous microstructures with particular emphasis on the role of interfaces; nonlocal and discrete dislocation plasticity; fatigue crack growth; and fast fracture in brittle solids.

Professor Needleman is a Member of the National Academy of Engineering, a Fellow of the American Society of Mechanical Engineers, a Fellow of the American Academy of Mechanics, an Honorary Member of MECAMAT (Groupe Français de Mecanique des Matériaux) and a Foreign Member of the Danish Center for Applied Mathematics and Mechanics. He has been recognized by Institute for Scientific Information (ISI) Science Citation Index as a highly cited author both in Engineering and in Materials Science. In 1994, his work on 3D modeling of metallic fracture was a finalist in the Science Category for the Computerworld-Smithsonian Award. In 2006 he was the recipient of both the William Prager Medal and the Drucker Medal and received an Honorary Doctorate from Technical University of Denmark (DTU).

Some of his most highly cited publications (taken from ISI Web of Knowledge) include:

Needleman, A. and J. R. Rice (1980). "Plastic Creep Flow Effects In The Diffusive Cavitation Of Grain-Boundaries." Acta Metallurgica 28(10): 1315-1332.

Christman, T., A. Needleman, et al. (1989). "An Experimental And Numerical Study Of Deformation In Metal Ceramic Composites." Acta Metallurgica 37(11): 3029-3050.

Asaro, R. J. and A. Needleman (1985). "Overview.42. Texture Development And Strain-Hardening In Rate Dependent Polycrystals." Acta Metallurgica 33(6): 923-953.

Peirce, D., R. J. Asaro, Needleman, A. (1983). "Material Rate Dependence And Localized Deformation In Crystalline Solids." Acta Metallurgica 31(12): 1951-1976.

Pierce, D., C. F. Shih, Needleman, A. (1984). "A Tangent Modulus Method For Rate Dependent Solids." Computers & Structures 18(5): 875-887.

Xu, X. P. and A. Needleman (1994). "Numerical Simulations Of Fast Crack-Growth In Brittle Solids." Journal Of The Mechanics And Physics Of Solids 42(9): 1397-&.

Needleman, A. (1987). "A Continuum Model For Void Nucleation By Inclusion Debonding." Journal Of Applied Mechanics-Transactions of the ASME 54(3): 525-531.

Chu, C. C. and A. Needleman (1980). "Void Nucleation Effects In Biaxially Stretched Sheets." Journal Of Engineering Materials And Technology-Transactions of the ASME 102(3): 249-256.

Needleman, A. and V. Tvergaard (1987). "An Analysis Of Ductile Rupture Modes At A Crack Tip." Journal Of The Mechanics And Physics Of Solids 35(2): 151-183.

Vandergiessen, E. and A. Needleman (1995). "Discrete Dislocation Plasticity - A Simple Planar Model." Modelling And Simulation In Materials Science And Engineering 3(5): 689-735.

Professor Needleman often collaborates with Viggo Tvergaard, John Hutchinson, Subra Suresh, and Eric Van der Giessen among others in both materials science and mechanics.

Speech of Acceptance of the 2011 Timoshenko Medal by Alan Needleman

at the Applied Mechanics Division Honors & Awards Banquet, 15 November 2011

Thank you, Ares, for your kind introduction. I am greatly honored to have my name added to the list of Timoshenko Medalists. However, receiving the Timoshenko Medal has a down side. I'll describe the down side through a story told by Jean-Baptiste Leblond. At the circus in Imperial Rome a slave was thrown to the lions. The lion stalked the slave and then attacked. As the lion jumped on him the slave grabbed the lion's mane and whispered in its ear. To the crowd's amazement the lion slinked off into a far corner of the arena and sat down. The Emperor called the slave over and said “If you tell me what magic you worked I'll give you your freedom.” The slave replied “It wasn't magic. I just told the lion if he ate me he'd have a good meal but then he'd have to give an after dinner speech. “

Fortunately for me, many previous Timoshenko after dinner speeches are available on iMechanica. I will follow several of those and talk about my life in mechanics. Before I start on that, I want to mention four mechanicians who have had an enormous influence on my professional life as well as having greatly enriched my personal life: John Hutchinson, Viggo Tvergaard, Jim Rice and Erik van der Giessen. There is not enough time to detail my debt to them.

My life in mechanics began my senior year at the University of Pennsylvania. I took a course in continuum mechanics from Hsuan Yeh who was Dean of the Towne School. The course was so interesting that I decided that was what I wanted to study in graduate school. I went to graduate school at Harvard and was very lucky that a young faculty member named John Hutchinson agreed to be my thesis adviser. My PhD thesis involved the finite strain, finite element analysis of a two dimensional periodic array of circular holes (motivated by the pioneering ductile fracture studies of Frank McClintock and Jim Rice). This initiated me into two emerging developments in solid mechanics: finite element methods and materials mechanics. As John Hutchinson remarked in his Timoshenko Medal address, we did not realize we were participating in a revolution.

At that time finite element methods were not well regarded by much of the solid mechanics community. Too many years passed before computational mechanics was accepted and integrated into mainstream solid mechanics. I am pleased that the situation is very different now as evidenced by the Timoshenko Medal having been awarded to Oleg Zienkiewicz, Tinsley Oden, Ted Belytschko and Tom Hughes. Materials mechanics was more readily accepted and became a source of wonderfully challenging problems. It has stimulated the development of new mechanics theories and experimental methods, particularly those aimed at understanding small size scale phenomena. Conversely, it has led to solid mechanics having a significant impact on materials science and engineering.

I finished my PhD work at Harvard in the summer of 1970 and got a job as an Instructor in Applied Mathematics at MIT. To start my research career, I decided to build on my expertise and proposed analyzing a two dimensional array of elliptical holes. You can imagine my disappointment when no one showed any interest in this or any willingness to support it. So I dropped it and decided to work on something that excited me which was an idea in the literature that tensile necking, like buckling, could be regarded as a bifurcation. I thought it would be fun to do the bifurcation analysis and calculate the subsequent neck development using finite elements. That worked out well and I was asked to give a seminar on this work by Harvey Greenspan, then the head of Applied Math. He gave me some sage advice "No one every complained that a lecture was too short." I have tried, not always successfully, to follow his advice. The title of my talk was "Necking in Bars." To the best of my knowledge it is the only MIT Applied Math talk ever listed in the entertainment section of the local paper.

Midway through my stay at MIT I had a leave of absence at the Technical University of Denmark and began my collaboration with Viggo Tvergaard. Viggo and I worked on buckling and when I came back from Denmark I got excited about a plastic buckling issue. My idea was that the so-called plastic buckling paradox could be resolved by considering three dimensional effects. I mentioned my idea to John Hutchinson who knew I was clearly wrong but didn't try to dampen my enthusiasm. I am grateful for that. Eventually I realized I was wrong, learned how to differentiate between excitement and insight, and to accept being wrong and then move on. During my time at MIT I was free to pursue whatever excited me and was able to develop my own research style.

After five years at MIT I was told my services were no longer needed and I was extremely fortunate to wind up at Brown. One area I worked on when I started at Brown was necking problems related to sheet metal forming. I gave a presentation on some of that work at a Canadian Applied Mechanics Conference. I don't remember my talk but I do remember that, at least in one respect, my presentation was the hit of the conference. The speaker at the conference dinner was the Minister of Education of British Columbia. She began her speech by saying that she had been looking through the book of abstracts during dinner and the titles meant nothing to her until she came across "Necking in Thin Sheets." That title she could relate to. But she had one question, "Why do the sheets have to be thin?" Fortunately, I was sitting too far in the back to be expected to provide an answer.

There was a great deal of intellectual excitement in solid mechanics at Brown in the late 1970s. Much of it stemmed from Jim Rice who had many original and deep ideas, and was generous in sharing them. One topic was the coupling of grain boundary diffusion and plastic creep in polycrystalline metals. Plastic deformation could effectively shorten diffusion lengths so there could be a synergistic effect. Quantifying this required numerical calculations. That's where I came in. The finite element formulation of this problem involved creating a stiffness matrix with surface terms accounting for grain boundary diffusion in addition to the usual volumetric terms. The calculations quantified a significant synergistic effect. Years later the idea of a finite element formulation with separate constitutive descriptions for volumes and surfaces was to play a prominent role in my research.

In the 1960s and 70s computations were carried out at a central university computer center and CPU time was a scarce resource. Programs were written on punch cards and submitted to computer operators over a counter not unlike the counter at a fast food restaurant. However, the turn around time was measured in hours rather than minutes. What came back was a stack of paper that either contained error messages or a print out of numbers that hopefully corresponded to a meaningful result. Draftsmen were employed to turn the numbers into pictures. Computer terminals replaced cards toward the end of this period but the rest of the process was pretty much the same.

A huge change came at the end of the 70s when the solid mechanics group at Brown acquired a dedicated computer for computational mechanics, a DEC VAX 780. This acquisition provided me with a lesson in humility. The DEC salesman mentioned that the standard VAX configuration included one 67 MByte disk. He asked if I wanted to purchase a second disk. I answered “No, we'll never fill up 67 MBytes.” The VAX 780 consisted of several refrigerator size cabinets and could do double precision floating point operations at about 0.14 MFlops. To put this in perspective it is less than 1/100 the speed of a modern smartphone. But we were thrilled with its performance and it opened up new possibilities for simulation.

Again largely stimulated by Jim Rice's interests, I became involved in research on plastic flow localization (a seminal paper on that topic was co-authored by Jim and this years' Drucker Medalist John Rudnicki). The conditions for initiation were established but determining the evolution required computation. Viggo was visiting Brown and our first project on the VAX was calculating shear band development using the J2-corner theory that John Hutchinson and Jes Christoffersen had developed. I found it exciting to be able to simulate the evolution of such complex deformation patterns. I was so pleased with the resulting pictures that I brought a reprint home and proudly showed it to our 6 and 8 year old children saying “Look what I did.” One of them (I don't remember which) said “No, you didn't. You're not smart enough. Mommy probably did it.” Another lesson in humility.

At about the time Viggo and I were doing our calculations Bob Asaro was investigating localized deformation in single crystals experimentally. In work with Bob and Dan Peirce we found that rate independent single crystal calculations completely broke down for a certain range of parameters of interest. Eventually we found that accounting for material rate dependence could eliminate the pathological behavior. Rate dependent single crystal calculations were able to simulate observed deformation responses remarkably well.

An issue with the rate independent localization calculations with Viggo and Bob was that the formulation did not contain a material length scale. The band thickness and hence the post-localization response were essentially determined by the finite element discretization rather than by any mechanism embedded in the modeling. Material rate dependence in effect led to the introduction of a length scale. Whether or not this is the governing length scale in a specific situation is another matter but we found that rate dependence can regularize localization problems. I like to think that our computations of localized deformation modes played a role in stimulating at least some of the subsequent work on incorporating a material length scale into continuum plasticity theories.

Meanwhile Jim Rice, Ben Freund and their collaborators were carrying out pioneering studies in fracture mechanics. What got me excited was the possibility of using computation to directly simulate fracture. This led to a series of micromechanical fracture studies with Viggo. Again, a key issue is how to incorporate a length scale into the formulation. A main aim of the fracture simulations that Viggo and I (and now many others) are engaged in is to relate measurable and (hopefully) controllable features of a material's microstructure to its fracture resistance to provide a basis for designing more fracture resistant material systems. Rather than quantitative predictions these simulations seek to provide trends, scaling relations and insight into the mechanisms controlling toughness and ductility.

Throughout my time at Brown there was a wonderful spirit of cooperation and interaction. Many of the projects I worked on came from discussions in the hallways or over lunch or coffee. Just to mention one example: my work on cohesive modeling started after an informal talk Steve Nutt gave where he showed some pictures of void nucleation at a fiber end in an Al-SiC composite. The combination of Steve's micrographs and my earlier work with Jim Rice on grain boundary diffusion led to the idea to regard a continuum as consisting of both surfaces and volumes, with a constitutive relation for each. Hence, an initial crack was not needed to use a Barenblatt/Dugdale type cohesive relation. A cohesive framework introduces a length scale and can be used to create new free surface thus modeling crack initiation. The computer code from the grain boundary diffusion work had the infrastructure to implement this. In subsequent work, with Ares Rosakis and later with Yehuda Ben-Zion, we analyzed rupture propagation along surfaces described by frictional constitutive relations using basically the same computational infrastructure.

There were group grants at Brown that made it possible to explore new areas of research without worrying about financial support (if you were not an experimentalist). Because of this I was able to develop my collaboration with Erik van der Giessen on discrete dislocation plasticity. Discrete dislocation plasticity also introduces a length scale (in fact several length scales). So now instead of no length scale, identifying the governing length scale in a problem can be an issue. One of my favorite projects in this area was our work with Vikram Deshpande on fatigue crack growth that gave a fatigue threshold and a Paris law as natural outcomes of the simulations. Another was our work with Lucia Nicola and Joost Vlassak of Harvard which involved a direct comparison of our simulations for stress evolution in thin films with Joost's experiments.

Quite generally, I regard what I do as solid mechanics simulation: an idealized model is created that is governed by the equations of mechanics which are then solved computationally. Such simulations can be a powerful tool for gaining insight into features that are not directly accessible experimentally. Comparison of predicted observables with experiment is a win-win situation: agreement gives confidence in the predictions while disagreement can point the way to the development of improved theories and models. Another role for such simulations is to identify regions of parameter space that merit experimental exploration. I find it gratifying that this actually happened in work with Ares and Demir Coker. What has typically been missing from solid mechanics simulations is a statistical perspective. I will venture a prediction that a statistical perspective will become more prevalent in the future.

Over my years at Brown I benefited enormously from collaborations with many people in addition to those named already. There isn't time to name them all but I will mention a sampling: extraordinary colleagues including Fong Shih, Subra Suresh, Michael Ortiz, K.S. Kim, Ben Freund, Rod Clifton and Bill Curtin; wonderful collaborators from around the world including Yves Bréchet, Mort Gurtin, Norman Fleck, Xavier Oliver and René de Borst; and an excellent group of students and post-doc visitors including Nick Triantafyllidis, Rich Becker, Xiaopeng Xu, Amine Benzerga and Alfredo Huespe.

I retired from Brown after being a faculty member for 34 years to be closer to grandchildren. I was very fortunate to get a position in the University of North Texas (UNT) Materials Science and Engineering Department which is in an exciting stage of development. Quite a few of my recent collaborators have been women researchers including Julia Greer, Elisabeth Bouchaud, Cate Brinson and Linda Schadler. I hope to be in the audience when the first female Timoshenko Medalist delivers her address.

Finally, I'd like to thank my wife Wanda who has had her own career as an accomplished psychiatrist and psychoanalyst. Because of her work schedule I had to be involved with family as well as pursue my career. I am very proud to be a Timoshenko Medalist. I am also proud that when our children were small I was known as a nursery school mommy. Those nursery school children are now both faculty members; Deborah in English Literature at UNT and Daniel in Engineering and Applied Sciences at Harvard (where I got my PhD).

I close by expressing my appreciation for this extraordinary honor and thank everyone who made it happen.