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Analytical Modeling Occupies a Special Place in the Modeling Effort

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Analytical modeling occupies a special place in the predictive modeling effort [1-5]. This is because it is able not only to come up with relationships that clearly indicate "what affects what" and "what is responsible for what", but, more importantly, can often explain the physics of phenomena and especially various paradoxical situations better than the FEA modeling, or even experiments, can. Since mid-1950s, FEA modeling has become the major research tool for theoretical evaluations in mechanical, structural, aerospace, maritime and other areas of engineering. Since mid-1970s, FEA has become the major modeling tool in electronics and photonics as well. This can be attributed, first of all, to the availability of powerful and flexible computer programs, which enable one to obtain, within a reasonable time, a solution to almost any stress-strain related problem. Broad application of computers, however, has, by no means, made analytical solutions unnecessary or even less important, whether exact, approximate, or asymptotic. Simple and easy-to-use analytical relationships have invaluable advantages, because of the clarity and compactness of the obtained information and clear indication of the role of various factors affecting the given phenomenon or the behavior of the given material or the device. These advantages are especially significant when the parameter under investigation depends on more than one variable. As to the asymptotic techniques, they can be successful in many cases, when there are difficulties in the application of computational methods, e.g., in various problems containing singularities explained in [6-8]. Such problems are often encountered in high-tech engineering, because of wide employment of assemblies comprised of dissimilar materials.

But even when application of FEA encounters no difficulties, it is always advisable to investigate the problem analytically before carrying out FEA analyses. Such a preliminary investigation helps to reduce computer time and expense, develop the most feasible and effective preprocessing model and, in many cases, avoid fundamental errors [9-12]. The FEA has been originally developed for structures with complicated geometry and/or with complicated boundary conditions (such as, e.g., avionics structures), when it might be difficult to apply analytical approaches. As a consequence, FEA has been especially widely used in those areas of engineering, in which structures of complex configuration are typical (aerospace, maritime and offshore structures, some civil engineering structures, etc.). In contrast, electronic and photonic structures are usually characterized by relatively simple geometries and can be easily idealized as beams, flexible rods, rectangular or circular plates, various composite structures of relatively simple geometry, etc. There is an obvious incentive therefore for a broad application of analytical modeling in electronics and photonics materials science and engineering. Additional incentive for that is that adjacent structural elements in materials science and engineering often have dimensions that differ by orders of magnitude. Typical examples are multilayer thin-film structures fabricated on thick substrates and adhesively bonded assemblies, in which the bonding layer is, as a rule, significantly thinner than the bonded components of the assembly. Since the mesh elements in a FEA model must be compatible, FEA of such structures often becomes a problem of itself, especially in regions of high stress concentration. Such a situation does not occur, however, with an analytical approach.

Another consideration in favor of analytical modeling is associated with an illusion of simplicity in applying FEA procedures. Some users of FEA programs believe that they are not even supposed to have any prior knowledge of structural analysis and materials physics, and that the "black box" they deal with will automatically provide the right answer, as long as they push the right keys on the computer. At times, a hasty, thoughtless, and incompetent application of computers can result in more harm than good by creating an impression that a solution has been obtained when, actually, this "solution" is simply wrong. It is well known to those with hands-in experience with FEA that although it is might be easy to obtain a FEA solution; it might be very difficult to obtain the right solution. And how would one know that it is indeed the right solution, if there is nothing to compare it with? In effect, one has to have good background in structural analysis and materials physics to develop an adequate, feasible, and economic preprocessing model and to correctly interpret the obtained information. Clearly, if the FEA data are in good agreement with the results of an analytical modeling, which is usually based on quite different assumptions, then there is a reason to believe that the obtained solution is accurate enough.

A crucial requirement for an effective analytical model is its simplicity and clear physical meaning. A good analytical model, which can be of real help in "high-tech" engineering, should be based on physically meaningful considerations and produce simple and easy-to-use relationships, clearly indicating the role of the major factors affecting the phenomenon or the object of interest. One authority in applied physics remarked, perhaps only partly in jest, that the degree of understanding of a phenomenon is inversely proportional to the number of variables used for its description. The famous $E = mc^2$ relationship is a good illustration to this statement.Although an experimental approach, unsupported by theory, is "blind," theory, not supported by an experiment, is "dead." It is true that it is an experiment that forms a basis for a theoretical model, provides the input data for theoretical modeling, and determines the viability, accuracy, and limits of application of a theoretical model. Limitations of a theoretical model are different in different problems and, in the majority of cases, are not known beforehand. It is the experimental modeling, which is the "supreme and ultimate judge" of a theoretical model. Having said that, it should be pointed out that the limitation of a theoretical model could be also assessed based on a more general theoretical model. E.g., limitations of a linear approach could be determined using a non-linear model. A physical experiment can often be rationally included into a theoretical solution to an applied problem. Even when some relationships and structural characteristics lend themselves, in

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principle, to theoretical evaluation, it is sometimes simpler and more accurate to determine these relationships empirically. E.g., the spring constant of an elastic foundation provided by the primary coating of an optical fiber could be evaluated experimentally and then included into the analytical or a numerical model.

References

1. Suhir E (1989) Analytical Modeling in Structural Analysis for Electronic Packaging: Its Merits Shortcomings and Interaction with Experimental and Numerical Techniques. ASME J Electr Packaging 111: 157-161.
2. Suhir E (1991) Mechanical Behavior of Materials in Microelectronic and Fiber Optic Systems: Application of Analytical Modeling-Review. MRS Symposia Proc 226: 51-59
3. Suhir E (1997) Applied Probability for Engineers and Scientists. McGraw Hill, New York.
4. Suhir E (1997) Dynamic Response of Microelectronics and Photonics Systems to Shocks and Vibrations. Proceedings of the International Conference on Microelectronics and Photonics Packaging INTER Pack, USA.
5. Suhir E (2002) Analytical Stress-Strain Modeling in Photonics Engineering: Its Role Attributes and Interaction with the Finite-Element Method. Laser Focus World.
6. Suhir E (2005) Analytical Thermal Stress Modeling in Physical Design for Reliability of Micro- and Opto-Electronic Systems: Role Attributes Challenges Results. International Workshop on Thermal Investigation of ICs and Systems, USA.
7. Suhir E (2009) Predictive Analytical Thermal Stress Modeling in Electronic and Photonic Systems. ASME App Mech Reviews 62: 01-20.
8. Suhir E, Mahajan R, Lucero A, Bechou L (2013) Probabilistic Design for Reliability (PDfR) and a Novel Approach to Qualification Testing (QT) aerospace electronic Product. IEEE Explore pp: 01-19.
9. Suhir E (2013) Structural Dynamics of Electronics Systems. Modern Physics Letters B 27: 01-32.
10. Suhir E (2014) Reliability Physics and Probabilistic Design for Reliability (PDfR): Role Attributes Challenges. IEEE Explore pp:61-68
11. Suhir E (2015) Analytical Predictive Modeling In Fiber Optics Structural Analysis: Review And Extension. International Society For Optics And Photonics.
12. Suhir E (2015) Analytical Stress Modeling for TSVs in 3D Packaging. IEEE Explore pp: 99-106.

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