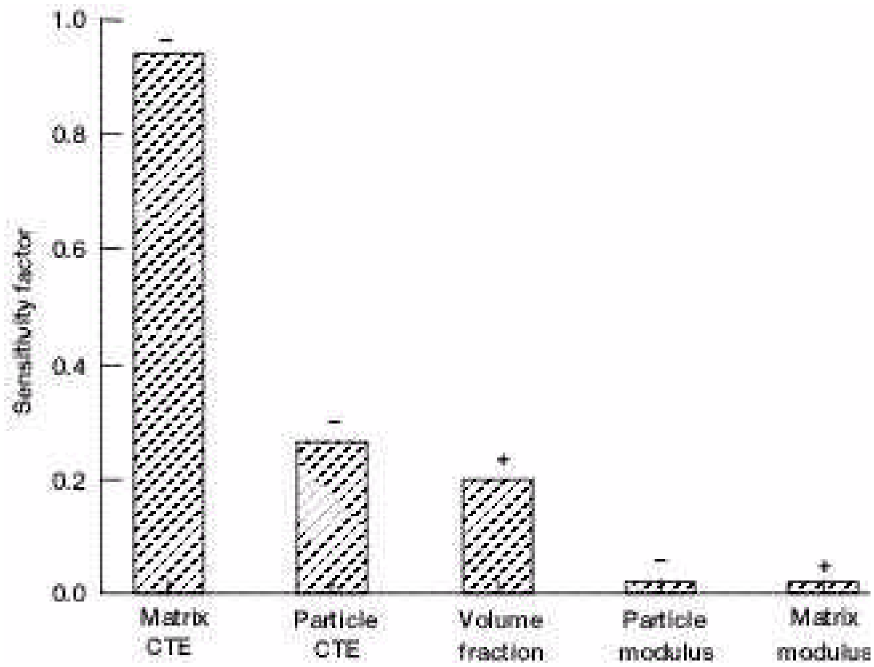
# Uncertainties in the Thermal and Mechanical Properties of Particulate Composites Quantified

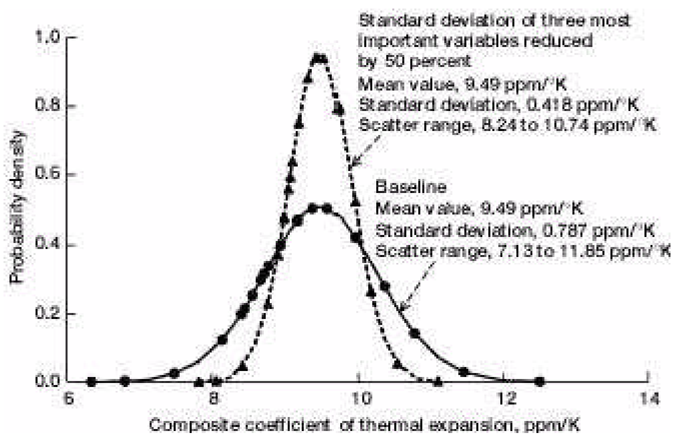
Particle-reinforced composites are candidate materials for a wide variety of aerospace and nonaerospace applications. The high costs and technical difficulties involved with the use of many fiber-reinforced composites often limit their use in many applications. Consequently, particulate composites have emerged as viable alternatives to conventional fiber-reinforced composites. Particulate composites can be processed to near net shapepotentially reducing the manufacturing costs. They are candidate materials where shock or impact properties are important. For example, particle-reinforced metal matrix composites have shown great potential for many automotive applications. Typically, these materials are aluminum matrix reinforced with SiC or TiC particles. Reinforced concrete can also be thought of as a particle-reinforced composite. In situ ceramics can be modeled as particulate composites and are candidate materials for many high-temperature applications. The characterization of these materials is fundamental to their reliable use. It has been observed that the overall properties of these composites exhibit scatter because of the uncertainty in the constituent material properties, and fabrication-related parameters.

The observed scatter in the global composite behavior or "response" is usually caused by the existence of uncertainties in the basic or "primitive" variables. Primitive variables are properties or parameters that participate at the lowest or micromechanics level in defining a global or homogenized property. Volume fractions and individual constituent properties such as moduli, thermal expansion coefficients, thermal conductivities, and strengths are examples of primitive variables. They are assumed to be independent and have their own statistical distributions. Response variables are those that characterize such composite behavior as the composite moduli, thermal properties, and strengths.

This approach to quantify probabilistic composite behavior, which was developed at the NASA Glenn Research Center, combines the micromechanics of particulate composites with a fast probability integration technique. The role of micromechanics equations that are programmed in a computer code ICAN/PART, is to provide functional relationships that tie the constituent properties to the equivalent composite behavior. The role of the fast probability integration technique is to perform probabilistic analyses by utilizing the properties generated by the micromechanics equations. The combined procedure yields probabilistic distribution and density functions of global composite properties. Furthermore, the procedure also identifies and ranks the sensitivities of the various primitive variables on the global composite property and its scatter. This technique is far more efficient than a standard Monte-Carlo tech-nique where a large number of simulations are needed to generate such information. The figures show sample results from the analysis.




*Sensitivity factors of composite coefficients of thermal expansion.*




*Probability density function of composite thermal expansion coefficient.*

# Bibliography

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**Glenn contact:** Dr. Pappu L.N. Murthy, 216-433-3332, Pappu.L.Murthy@grc.nasa.gov
**University of Toledo contact:** Subodh K. Mital, 216-433-3261, Subodh.K.Mital@grc.nasa.gov
**Authors:** Dr. Pappu L.N. Murthy and Subodh K. Mital
**Headquarters program office:** OAT
**Programs/Projects:** Base R&T