Chapter 4
Miniaturization of Test Specimen for Composites

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ABSTRACT

The objective behind the development of miniaturization or small specimen test technology is to reduce the cost and quantity of material involved during the characterization of the material. The idea of the development of miniaturization took attention when the nuclear industry starts developing as these materials are very costly and it is not economically feasible to waste large amount of these materials for the sole purpose of testing. The second factor which promotes the miniaturization is that the working of machine is not affected while at the same time its material is being tested. At present, the idea of miniaturization is being applied to other materials also. The miniaturization of standards for metals has been done successfully in the past. For composites, not much work has been done. In the chapter, the specimen size effects on tensile properties of glass fiber composite have been identified by varying the length and width simultaneously and have established a relationship between the ASTM standard specimen and the small size specimen.

INTRODUCTION

Background and Motivation

Fiber reinforced composites have an extensive array of applications. They range from structural to recreational use. The aerospace and automotive industries look to composites to improve fuel economy due to their high strength to weight ratio. The sports industry looks to composites to improve sports equipment technologies. The fact that composites offer increased strength without sacrificing additional weight is what gives composites the advantage from most structural and recreational materials. There have been continuous efforts, to miniaturize test specimens for various reasons like scope for deriving

DOI: 10.4018/978-1-5225-5445-5.ch004

more number of specimens from the sample removed, reduction in size of test equipment, saving in waste handling requirements etc. The present work highlights the development of glass fiber composite, layout of miniature test specimens, preparation of test specimens, miniature specimen testing procedures and co-relationship with conventional procedures.

Problem Definition

The more recent introduction of FRP composite technology, together with the large range of materials used and being introduced, brings, a broad design base, which was available for many metals, yet not been compiled for FRP materials, which means, a much testing of composite specimens has to be carried out either on full-scale prototypes, or, in order to save both time and expense, on small-scale models by use of the principles of dimensional analysis. And if any discrepancies encountered whilst scaling from model to full size (i.e. any size effects) should be both identified and understood.

Materials are subjected to various types of tests like tensile, impact and fatigue-fracture characterization. Sub-sized conventional tests, which are essentially a scaled down version of conventional testing, utilize specimens of similar geometry loaded in a similar manner, to produce results equivalent to that obtained from larger specimens. Miniature specimen tests are employed for determination of residual service life of the operating component, by extrapolating the results of evaluation of small specimen.

In a review of literature, it has been shown that the majority of the existing work in the field of small specimen test technology used high quality, pre-preg carbon/epoxy laminates which have been used in the aero- space industries. It is shown that a number of authors have come to the conclusion that the scale/size phenomenon exists. But very few statistical and experimental analyses of the results and trends are reported.

The scaling problem is very complex for composites due to intricate nature of their micro-structure. In addition the many possible material properties that may be considered, such as manufacturing technique and conditions, and fiber and matrix materials, further complicate the problem. Further, the mechanical testing of composite materials is a very wide subject, with many variables that would affect the observed material properties.

The objective of the present study is to identify specimen size effects on tensile properties of glass fiber composite by varying the in-plane dimensions (length and width) simultaneously and establish a relationship between the ASTM standard specimen and the small size specimen. Development of miniature specimen testing technique involves two aspects: namely, development of methods for preparation of miniature specimens and development of techniques to extract useful mechanical properties from such specimens. Hand lay-up method have been used to prepare glass fiber composite. ASTM D3039 standard have been used to prepare standardized specimen and the number of specimens prepared for each size is ten. ASTM standard specimen have been tested on nano plug machine and the sub-specimen have been tested tinius olsen machine. Regression analysis have been done with the help of minitab software.

ORGANIZATION OF CHAPTER

The current report is divided into six parts.