

# DIMENSIONS



## College of Engineering and Applied Science

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### EXPERIMENTAL STRESS ANALYSIS AT UWM

When dealing with real engineering structures, it is not always sufficient or advisable to rely on analysis alone. Stresses, strains and/or displacements may have to be determined experimentally to validate the design and, in some difficult or complex situations, may actually provide the only practical approach to the solution of the problem. This is where experimental stress analysis enters. Most of the prior work in this field carried out in the Milwaukee area has relied on conventional techniques such as brittle coatings or strain gages. Recently, however, Associate Professor John A. Gilbert of the College's Civil Engineering Department has shed new "light" on this field by developing laser-based stress analysis techniques.

The invention of the laser has stimulated such novel techniques as holographic interferometry, speckle interferometry, and laser speckle photography. Optical methods now allow for the quantitative measurements of motion (translation, rotation and deformation) on any surface that can be properly illuminated and viewed. There are numerous advantages of optical systems over conventional techniques. Lasers permit non-contact and non-destructive evaluation. This allows for the testing of prototypes or finished parts without fear that their structural characteristics or their performance will be impaired. By using the wavelength of laser light as the basic measurement unit, these techniques are also very accurate. Finally, they can be applied in unique situations, including relatively inaccessible areas or in hostile environments where conventional stress analysis approaches would not be suitable.

Dr. Gilbert has been working for over a decade on a fundamental understanding and on applications of laser-based techniques. However, recently incorporating fiber optics and adding numerical processing to data acquisition and analysis have opened completely new opportunities.

Fiber optics, which were originally developed for use in communications systems, have been adapted to guide laser light to a test surface and to transmit images of that surface back to a recording system for analysis. The use of fiber optics promises many advantages. From an experimental point of view, the number of optical components (mirrors, lenses, etc.) is reduced thereby simplifying the laboratory set-up. The flexibility and small size of optical fibers permits investigation of remote areas that would otherwise not be optically accessible. Fiber bundles are flexible and can be inserted into many areas of an enclosed structure or, possibly, even into the human body for observation. The use of photo-electric-numerical data processing provides greater speed in analyzing data compared to previous tech-

niques, such as photographic recording, which also required total darkness. On-line data reduction also suggests that fiber optics may work for objects whose surface moves fairly rapidly or vibrates.

Dr. Gilbert has been sponsored in his work by the Army Research Office as well as by the College from internal funds. Under his Army grant, Gilbert records and analyzes surface deformation patterns; the first successful application of the recording of holograms through optical fibers. He also works closely with the Bell Telephone Laboratories of Murray Hill, New Jersey, on data reduction techniques and with the American Cystoscope Makers, Inc. of Stamford, Connecticut, on possible medical applications. He initially demonstrated the feasibility of using a vidicon camera-digitizer system to analyze data captured through fiber optics at the Bell Laboratories. This work has also led to a grant by the National Science Foundation for the equipment necessary to further this research in photo-electronic-numerical data acquisition and analysis here at UWM.

Professor Gilbert anticipates that the technology now being developed will not only pioneer new avenues in fiber optics and optical metrology but will also have practical applications. For example, a fiber optic network would enable displacement or deformation, recorded at several test sites throughout an industrial test floor, to be rapidly processed at a central location by interfacing with computational facilities. Other applications might include analysis in remote areas of a structure; such as inside an airplane wing, on the walls of a submerged pipeline or within the human body.

According to Professor Gilbert, he worked his way through school as an undergraduate, playing "rock and roll" in a group called "Your Mutha." He recalls that he took up a lot of "space" in the Polytechnic Institute of Brooklyn before graduating with a B.S. in Aerospace and Engineering. Graduate studies for his M.S. in Applied Mechanics at Polytech were funded through several fellowships but Dr. Gilbert notes

that, "It was necessary to minor in poker to make ends meet." Following his Ph.D. from the Illinois Institute of Technology in 1975 he joined the faculty at UWM. When Gilbert is not in class, in his office or in the labs, there is a good chance that he can be found chasing a Penn at the Klotsche Center or a Titelist at Brown Deer Park.

Gilbert is quick to point out that his research is a joint effort which involves and, to a large degree, depends on his six full-time graduate students. He encourages both undergraduate and graduate students to inquire about the opportunity to become a part of his research team or to enroll in 240-502, Experimental Stress Analysis.