Experimental Stress Analysis and the Mechanical Engineers Courses


*Professor of Mechanical of Materials and Experimental Stress Analysis at UniFEI, Sao Bernardo do Campo, Sao Paulo, Brazil Av. Humberto de Alencar Castelo Branco, 3.972 Sao Bernardo do Campo — ZipCode 09850-901

** UniFEI Mechanical of Materials Students and Monitors

e-mail: renatcos@fei.edu.br , fetieghi@yahoo.com.br , alanis.cunha@terra.com.br

ABSTRACT

This work present an alternative to the theoretical classic teaching methods generally used in Strength of Materials. It is introduced a dynamic, interactive process, emphasizing the use of Experimental Stress Analysis. The activities developed in the Strength of Materials Laboratory of UniFEI and their influence in the teaching process of the future mechanical engineers are also presented. Some undergraduate students works using these techniques are described, in order to illustrate this application.

INTRODUCTION

Many Brazilian Mechanical Engineering schools still use a teaching and learning instructor-based process for Strength of Materials. This process presents low student s participation and interaction, which leads to their small motivation and high failure indexes.

We also recognize the importance and the need to encourage practical activities, specially in laboratory, as a mean to help the future engineer to absorb new theoretical concepts, to increase his sensibility, to get acquainted with measuring equipment, to develop a critical vision, to work in a team, to stimulate creativity, to acquire abilities for preparing reports, to compare experimental results with those obtained from classical, analytical and numerical methods, and, finally, to arrive to the correct conclusions for the solution of modern engineering problems.

Looking from this viewpoint, it is imperious that engineering schools introduce experiments, research and services in the many knowledge areas.

We understand that all subjects should be related to a lab center and maintain systematic activities throughout the course.
In the case of UniFEI, the Strength of Materials Laboratory, also called Experimental Stress Analysis Laboratory has been inaugurated in 1984, after some years of researches made by professors and students in Brazil and abroad, specially through an agreement between UniFEI and ENSAM — Ecole Nationale Superieure d Arts et Metiers, Paris, France.

The Laboratory is related to the Strength of Materials II subject, with two obligatory hours a week, in which all the 3rd year Mechanical Engineering Students have a global vision of the Experimental Stress Analysis techniques, mainly Electric Extensometry and Photo-elasticity.

All the students participate in an average of five didactic experiments, illustrating stress concentration, cantilever beams, internal pressure tubes, composed loading and shear center.

Besides the didactic experiments, the students use all their energy and creativity, under the professors and instructors orientation, to develop interesting works.

The best projects are presented in a Strength of Materials Annual General Seminar.

The Strength of Materials Lab is in constant updating, and together with the Materials Lab and other Labs, constitute the CLM — Mechanical Laboratories Center, which provides conditions for scientific initiation projects, undergraduation projects, researches and services.

To summarize, the Lab has many equipments related to the MM and KYOWA manufacturers Electric Extensometry, the MM’s photo-elasticity, the Tec Equipment didactic experiments and the MM’s and HBM’s data acquisition systems. Besides this, we use the various equipment of the Materials Lab, such as: the recently acquired MTS 810 traction machine, with a 250kN capacity for static and dynamic tests. We also develop dozens of experiments, research, transducers, prototypes, etc.

We also present some features of the interconnection between the Experimental Stress Analysis technique and other methods, giving a global vision of engineering to our students.

Considering the beginning of the 21st century we comment on the growing importance of Internet and general Multimedia to make dynamic and integrate classroom and laboratory activities and research through the e-learning techniques.

SOME WORKS DEVELOPED

Mini Baja — UniFEI always ahead!

UniFEI - Centro Universitario da FEI is the main Brazilian institution to maintain, since 1964, an Automotive Engineering Course, which has prepared thousands of engineers for the vehicle industry.

A great number of projects were and still are developed by students, faculty and instructors, starting with the TALAV, an aerial high velocity train, and keeping on today with the FEI X series, whose main characteristic is the very low fuel consumption.

During the last years UniFEI invested heavily on the famous Mini Baja race, sponsored by SAE- Society of Automotive Engineering. These races have been carried out for more than forty years in USA and for the last seven years in Brazil.

Every year the UniFEI prototypes, designed by our students, are submitted to a series of tests in the Strength of Materials Laboratory, where are analyzed the stresses and deformations on critical points, and, through the use of moving transducers, are measured the main displacements. The results are always compared to those obtained from analyses, made from the standpoints of basic strength of materials and the more detailed finite elements method.

This event has enhanced our teams technical development and the cordial relationship between Brazilian and students from other countries.
On 2002 UniFEI hosted the Rochester Institute of Technology (USA) team, which came to participate in the Brazilian competition.

The results have been the best possible. On 2002, UniFEI participated with two teams in the 7th Brazilian Mini Baja Race, with a wonderful performance, obtaining the First and Second Places. The race took place in Interlagos, Sao Paulo, with the participation of 70 Brazilian and 2 foreign schools. As a reward, 15 UNIFEI students and 2 professors have participated on the 2002 Midwest Mini Baja, in Milwaukee, USA, which is the most important world event in this category. Our teams obtained the third and sixth positions, showing once more the importance of using Experimental Stress Analysis for vehicles development.

Experimental and Numerical Analysis on a Main Body Truck

This work presents an alternative contribution to truck structural analysis, considering the influence of the connection rigidity between the fuel tank and chassis and the non-uniform torsion effect on thin wall profiles, considering the dual momentum effect previewed by Vlasov’s Theory.

A Ford Cargo truck was tested at the Mechanical of Material Laboratory of UniFEI and IPEI — Institute for Industrial Studies and Research. By the use of strain gauges, being determined the stress on the critical points of the chassis and, using dislocation transducers, were measured the displacement and rotations for variable load.

The numerical analysis, made through the Finite Elements Method, compared the many types of modeling with and without the dual momentum effect. The COSMOS/M and MSC/NASTRAN software were used.

This work was presented, with great repercussion, in the 1991’s COBEM — Brazilian Congress on Mechanical Engineering, promoted by ABCM— Brazilian Association for Mechanical Sciences.
The use of Extensometry on Orthopedics

This work describes a broad cooperation agreement between IPEI — Institute for Industrial Studies and Research, belonging to UniFEI, a College institution which is maintained by the Jesuitical Teaching Foundation, and the University of Sao Paulo Clinical Hospital, through its Orthopedics Institute, which represent the largest medical and academic facilities in Latin America.

The agreement was established in 2002. This first work, from the UniFEI’s Mechanical of Materials Laboratory, is developing for the Institute’s Walking Laboratory, a special weighting board that, using several transducers, will monitor the main efforts to which the patients’ feet are submitted, by simulating the many striding ways on a rolling matting.

The mechanical system works through electric extensometers and has a complete interface with a modern computational system of data acquisition.

The board allows the measurement of 6 spatial strains, i.e.: a normal force, two shear forces, and three moments around the axes x, y and z.

The project is finished in which refers to its mechanical and electronic parts, and is at the final stage of implementation. It represents an important application for the Experimental Stress Analysis at Bioengineering, that certainly will make it possible for engineers, doctors, physiotherapists and students to help handicapped persons, thus fulfilling the main mission of our institution, which is to serve community.

Photo-elastics Analysis on Teeth in Normal Occlusion

As it was mentioned in the beginning of this work, UniFEI maintains several research lines on Bioengineering, having developed during the last years several studies and applications, such as femur prosthesis, mechanical knees, monitoring of patients’ efforts, and others.

Specially in the dentistry area are in development several researches on experimental and numerical analysis application. We selected for this Congress a summary of a work developed in the Strength of Materials Laboratory studying the distribution of the strain on a teeth, when it is subjected to the pressure of the jaws during mastication.
The method used was the "freezing of the tensions", being built a three-dimensional model of teeth, with photo-elastic material.

After the heating of the model, by simulation of the efforts made by the jaws, the piece returned to room temperature, being appropriately sliced and analyzed by the Transmission by Photo Elasticity method.

The experimental and numerical results were then compared. The conclusions are available for interested engineers, doctors, dentists, students or patients.

The use of transducers for the measurement of drilling and metal cutting strains

On this line of research for the use of load cells and transducers, were already designed and built a great number of prototypes of variable types, sizes and complexity.

Two of the more recent works in this area were a transducer which allows the measurement of penetration and drilling strain, and another which measures drilling strain during lathe operation (cutting, advancing and penetration).

These transducers operate with various strain gage electrical extensometers, which are bridge connected, so as to increase sensibility.

To obtain the mode of variation of strain with time, these transducers are coupled to the HBM S Spider 8, Catman software.

It should be emphasized that, in this and other similar cases, the UniFEI's Strength of Materials Laboratory has given the necessary backing and support to many Undergraduate Scientific Initiation works, as well as to M.Sc. and PHD theses, not only in our institution, but also in other well known universities such as the University of Sao Paulo's School of Engineering.
ANALYTICAL-EXPERIMENTAL-NUMERIC METHOD — WHICH THE MOST RELIABLE?

As it had been shown in the summary of the mentioned works, from the simplest to the most complex structure, we tried to show to our students and future engineers, that in modern, efficient and competitive projects, it s needed the interaction between the several methods such as Analytical, in Strength of Materials and Elasticity Theory; Experimental, in Extensometry and Photo-elasticity and Numerical Computing in Outline Finite Elements. Inside of each method we should make a series of iterations, that is, repetitions with improvements, and refinements, always seeking a necessary convergence and optimization of the results, through the combination of all the available and appropriate tools for the best possible knowledge of the product and the process in discussion.

It should be pointed out that this discussion about the several methods is done in several forums and in spite of the great development of the numeric methods (Finite Elements), the final validation of the pieces of high responsibility is always made through the techniques of the Experimental Analysis of Tensions or by using experimental method.

MULTIMEDIA IN EXPERIMENTAL STRESS ANALYSIS

It is very clear the great development on finite elements programs (CAE), data collecting programs (CAT) and in the Experimental Stress Analysis techniques themselves, which are making possible a more complete, virtual and physical knowledge about the engineering processes and products.

We now intend to emphasize some few advances in the use of multimedia tools in the important teaching and learning process, also applied to Strength of Materials and Experimental Stress Analysis.

The so-called e-learning is being discussed in big companies and universities throughout the world, such as the University of Sao Paulo s School of the Future and in many Brazilian and international congresses (COBENGE, ASEE, ICEE and others).

The Internet use is a reality in many society segments and, in the case of the university, should be adequately integrated to classroom, laboratory and research.

The growing use of electronic resources, such as teaching programs, tutorials, teleconferences, pictures, chat rooms, e-mail exchange, long distance learning, and other communication means generate a greater interactivity with students, making teaching, researching and extension activities more enjoyable and obtaining better results.
CONCLUSION: PASSING INDEXES WENT FROM 20 TO 95%!

We expect to have shown some aspects of Experimental Stress Analysis and Laboratory use as a valid way to improve the learning process in Strength of Materials and Mechanical Engineering.

Even when considered simple low cost models and basic teaching experiments, the student, the central figure in the process, is directly involved, by manipulating pieces and instruments, by measuring the related quantities, by using and preparing statistical hypotheses, by comparing with other methods and, finally, by arriving to his own conclusions.

On this scenery, the instructor is the main actor, not only to store and transmit knowledge, but above all to orient, motivate, facilitate, stimulate, and finally, to organize the many activities, converging to a more complete student formation, both as a man and engineer.

In the case of Strength of Materials II, a subject in UniFEI, we had, before the introduction of Experimental Stress Analysis, very low passing indexes, (around 20%), which, after the inclusion of Strength of Materials Laboratory went to 95%, without lowering the course's level. We intend to get to 100%.

In what refers to the general formation of our mechanical engineers, after the introduction of Experimental Strength of Materials it is very gratifying to notice that tens of our alumni went to work in related areas, intensively using Experimental Stress Analysis techniques, and our students were able to participate in this important congress.

ACKNOWLEDGEMENTS

The authors are grateful for the collaboration of Professors Ayrton Novazzi, Dalton R. Maiuri, Renato Gallina, Rodrigo Magnabosco, Sergio Delijaicov, engineers Leonardo M. Zamboni, Luiz C.H. Ricardo and Instructors Jesus Perlopes, Junior Garcia, Manoel Bento de Souza, Marcos Oliveira Gentil, Wanderlei Soares dos Santos who, directly or indirectly, have contributed to the conclusion of this work. Our special acknowledgement to the Mechanical Engineering Department, to the Head of Teaching Laboratories, to the UniFEI's Rector and to the Presidency of Fundacao Educacional Inaciana, for their support and backing to this work.

REFERENCES


