

Tools for Designing and Analyzing Structures

Structural Design and Analysis Toolset is a collection of approximately 26 Microsoft Excel spreadsheet programs, each of which performs calculations within a different subdiscipline of structural design and analysis. These programs present input and output data in user-friendly, menu-driven formats. Although these programs cannot solve complex cases like those treated by larger finite element codes, these programs do yield quick solutions to numerous common problems more rapidly than the finite element codes, thereby making it possible to quickly perform multiple preliminary analyses — e.g., to establish approximate limits prior to detailed analyses by the larger finite element codes. These programs perform different types of calculations, as follows:

1. determination of geometric properties for a variety of standard structural components;
2. analysis of static, vibrational, and thermal-gradient loads and deflections in certain structures (mostly beams and, in the case of thermal-gradients, mirrors);
3. kinetic energies of fans;
4. detailed analysis of stress and buckling in beams, plates, columns, and a variety of shell structures; and
5. temperature dependent properties of materials, including figures of merit that characterize strength, stiffness, and deformation response to thermal gradients.

This program was written by Paul L. Luz of Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31797.

Interactive Display of Scenes With Annotations

ThreeDView is a computer program that enables high-performance interactive display of real-world scenes with annotations. ThreeDView was developed primarily as a component of the Science Activity Planner (SAP) software, wherein it is to be used to display annotated images of terrain acquired by exploratory robots on Mars and possibly other remote

planets. The images can be generated from sets of multiple-texture image data in the Visible Scalable Terrain (ViSTa) format, which was described in “Format for Interchange and Display of 3D Terrain Data” (NPO-30600) *NASA Tech Briefs*, Vol. 28, No. 12 (December 2004), page 25. In ThreeDView, terrain data can be loaded rapidly, the geometric level of detail and texture resolution can be selected, false colors can be used to represent scientific data mapped onto terrain, and the user can select among navigation modes. ThreeDView consists largely of modular Java software components that can easily be reused and extended to produce new high-performance, application-specific software systems for displaying images of three-dimensional real-world scenes.

This program was written by Marsette Vona, Mark Powell, Paul Backes, Jeffrey Norris, and Robert Steinke of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30675.

Solving Common Mathematical Problems

Mathematical Solutions Toolset is a collection of five software programs that rapidly solve some common mathematical problems. The programs consist of a set of Microsoft Excel worksheets. The programs provide for entry of input data and display of output data in a user-friendly, menu-driven format, and for automatic execution once the input data has been entered. The programs perform the following calculations:

1. “Definite Integral Evaluator 1.0” calculates the definite integral of a user-specified function $y = f(x)$ between user-specified limits for the lower and upper bands. The program will also plot the function.
2. Solve for X in the matrix equation $AX = B$, where A is a 2×2 , 3×3 , or 6×6 matrix of constant coefficients, X is the matrix of unknown independent values, and B is the matrix of dependant values.
3. “Cubic Equation Solver” calculates the real and imaginary roots, x , of the cubic equation $x^3 + ax^2 + bx + c = 0$.

4. Given a pair of vectors specified in terms of their Cartesian components, the Vector Calculator program calculates their scalar product, their vector product, the unit vectors, and the angle between the vectors.
5. “Unit Conversions” will convert between the English and metric values of the most commonly used units for length, volume, velocity, mass, density, force, pressure, energy, power, temperature, and thermal energy.

This program was written by Paul L. Luz of Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31794.

Tools for Basic Statistical Analysis

Statistical Analysis Toolset is a collection of eight Microsoft Excel spreadsheet programs, each of which performs calculations pertaining to an aspect of statistical analysis. These programs present input and output data in user-friendly, menu-driven formats, with automatic execution. The following types of calculations are performed:

- Descriptive statistics are computed for a set of data $x(i)$ ($i = 1, 2, 3 \dots$) entered by the user.
- “Normal Distribution Estimates” will calculate the statistical value that corresponds to cumulative probability values, given a sample mean and standard deviation of the normal distribution.
- “Normal Distribution from two Data Points” will extend and generate a cumulative normal distribution for the user, given two data points and their associated probability values.
- Two programs perform two-way analysis of variance (ANOVA) with no replication or generalized ANOVA for two factors with four levels and three repetitions.
- “Linear Regression-ANOVA” will curve-fit data to the linear equation $y=f(x)$ and will do an ANOVA to check its significance.
- Two multiple regression programs will do statistical analysis on test data that includes more than one predictor and will perform curve-fitting of the data to either the equation $y = f(x_1, x_2)$ or $y = f(x_1, x_2, x_3, x_4)$.

This program was written by Paul L. Luz of Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31796.

Program Calculates Forces in Bolted Structural Joints

A FORTRAN 77 computer program calculates forces in bolts in the joints of structures. This program is used in conjunction with the NASTRAN finite-element structural-analysis program. A mathematical model of a structure is first created by approximating its load-bearing members with representative finite elements, then NASTRAN calculates the forces and moments that each finite element contributes to grid points located throughout the structure. The user selects the finite elements that correspond to structural members that contribute loads to the joints of interest, and identifies the grid point nearest to each such joint. This program reads the pertinent NASTRAN output, combines the forces and moments from the contributing elements to determine the resultant force and moment acting at each proximate grid point, then transforms the forces and moments from these grid points to the centroids of the affected joints. Then the program uses these joint loads to obtain the axial and

shear forces in the individual bolts. The program identifies which bolts bear the greatest axial and/or shear loads. The program also performs a "fail-safe" analysis in which the foregoing calculations are repeated for a sequence of cases in which each fastener, in turn, is assumed not to transmit an axial force.

This program was written by Daniel A. Buder of The Boeing Company for Johnson Space Center.

Title to this invention, covered by U.S. Patent No. 5,884,232 has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)). Inquiries concerning licenses for its commercial development should be addressed to:

*The Boeing Company
Rocketdyne Propulsion & Power
6633 Canoga Avenue
P.O. Box 7922*

*Canoga Park, CA 91309-7922
Phone: (818) 586-1367*

Fax: (818) 586-2833

E-mail: danielle.bartoli@boeing.com

Refer to MSC-23121, volume and number of this NASA Tech Briefs issue, and the page number.

Integrated Structural Analysis and Test Program

An integrated structural-analysis and structure-testing computer program is being developed in order to:

- Automate repetitive processes in testing and analysis;
- Accelerate pre-test analysis;
- Accelerate reporting of tests;
- Facilitate planning of tests;
- Improve execution of tests;
- Create a vibration, acoustics, and shock test database; and
- Integrate analysis and test data.

The software package includes modules pertaining to sinusoidal and random vibration, shock and time replication, acoustics, base-driven modal survey, and mass properties and static/dynamic balance. The program is commanded by use of ActiveX controls. There is minimal need to generate command lines. Analysis or test files are selected by opening a Windows Explorer display. After selecting the desired input file, the program goes to a so-called analysis data process or test data process, depending on the type of input data. The status of the process is given by a Windows status bar, and when processing is complete, the data are reported in graphical, tubular, and matrix form.

This work was done by Daniel Kaufman of Goddard Space Flight Center. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-14775-1.