PC Stress Analysis Tools for Engineers

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Abstract

A complete stress analysis package for engineers using IBM PCs has been redesigned and released by The MacNeal-Schwendler Corporation. New features and enhancements have been implemented into MSC/pal 2 Version 3.5, MSC/cal version 2.5 and MSC/mod 1.5. Special versions of these products for the 80386 based machines have also been released. These new products take advantage of the 32-bit data structure and the extended memory beyond the 640K boundary. Timing comparison among the products are given in this paper.

Introduction

Since the introduction of MSC/pal in the Fall of 1984, several versions of MSC/pal 2 have been released. Many new features and improvements have been added to take advantage of the more powerful PC hardware. The latest release of MSC/pal 2 version 3.5 provides an extensive element library, improves analysis performance and increases maximum problem size. A revised MSC/cal version 2.5, a PC Heat Transfer Analysis program, has also been updated to reflect the latest improvements in computer hardware. A new pre-processor program, MSC/mod, has been released to support MSC/pal 2 and MSC/cal, as well as the powerful mainframe MSC/NASTRAN and the popular PC CAD programs, completing the links to provide a complete mechanical Computer Aid Design tool for different fields of engineers and designers.

MSC/pal 2

MSC/pal 2 version 3.5 contains an extensive element library that will support designers and engineers in many fields; aerospace, civil, mechanical and medical, to name a few. The library includes 3-D beams, curved beams, triangular and quadrilateral plates, 3-D solid elements; hexa, penta and tetra, axisymmetric elements, and scalar springs, masses and dampers. All these elements can be used for either static stress or dynamic vibration analyses. Dynamic vibration analyses include normal mode analysis, transient analysis, and frequency analysis.

Any structural models can be comprised of different combinations of elements and external applied forces can be loaded. MSC/pal 2 provide different kind of loads to aid the application of applied forces. Loads include concentrated loads, pressure loads, gravity loads, line loads, centripetal loads, and temperature loads. Output includes applied forces, reaction forces, nodal displacements, velocities and accelerations, and element stresses. The location of the center of gravity (CG) and the moment of inertia about the origin and the CG can be computed

MSC/pal 2 version 3.5 has employed a better solution algorithm, better data structure and I/O, so that the performance has been increased by 100-400% for static and 20-50% for dynamics as compared to version 3.0 for large problems. As better graphics devices are offered by different vendors (a noticeable one is VGA), MSC/pal 2 version 3.5 has supported these devices.

Two special versions of the MSC/pal 2 supporting 80386 based machines have been released; one for the 80387 (Version 3.5/N) and the other for the Weitek math co-processor chips (Version 3.5/W). These versions take advantage of the 386 32-bit data structure and the extended memory beyond the 640K boundary under the MS-DOS environment. The programs run in the 386 protected mode and require 2M memory minimum. The program dynamically allocates the maximum available memory when the program is invoked. A larger available memory size reduces the number of I/O operations, increasing performance accordingly. These versions support larger problem sizes with 2000 nodes and 12000 DOFs limits, whereas the corresponding DOS version is 1000 nodes and 6000 DOFs.

A few benchmarks are shown in Figure 1. In Table 1, different versions of MSC/pal 2 are compared to Version 3.5. It can be seen that V3.5/N is about 3 times faster than V3.5. Also, V3.5/W is about four times faster than V3.5 for the machines and problems shown. For the larger problems, the 6000 degree of freedom HEXA and the 12000 DOF QUAD static models, V3.5/W is about 1.5 times faster than the V3.5/N. The amount of performance improvement depends on the type of analyses, the problems, the type of co-processors, and the amount of available memory space; the comparison in Table 1 should be treated as a guideline only. Two applications of MSC/pal 2 are shown in Figures 1 and 2. The model geometry, the deformed shapes, and the displacement and stress contours are also shown.

MSC/cal

MSC/cal is a PC based finite element for Heat Transfer analysis. It provides discrete model creation, element generation, system equation solution, and tabular and graphical postprocessing for steady state and transient analyses problems in heat conduction.

The element library is composed of one dimensional bar (beam), two dimensional planar, plate, axisymmetric triangular and quadrilateral, and three dimensional tetrahedral, pentahedral, and hexahedral elements. Element material properties can be assigned for thermal conductivity, specific heat, density, and volumetric internal heat generation. The elements are generated by connecting nodes.

The boundary conditions are applied to the model in terms of convection boundary condition, flux boundary condition, nodal power, temperature boundary condition, and nodal convection commands. The radiation transport is applied through the linearized radiation condition that the radiation heat transfer coefficient or radiative film coefficient is expressed as a convection heat transfer boundary condition. Thermal contact resistance of 2-D or 3-D geometry is specified by slide-line or slide-plane technology. For transient analysis, the initial temperature of each node must be specified.

MSC/cal can be coupled with MSC/pal 2 for thermal stress analysis and can transmit files directly to MSC/pal 2. It performs an iterative nonlinear analysis for nonlinear steady state problems and a segmented piecewise linear analysis for nonlinear transient problems. With the key philosophies of versatility and simplicity, MSC/cal provides the heat transfer designer a powerful, yet easy to use, analysis capability in a desktop environment.

MSC/mod

Not only is MSC/mod an efficient and easy to use finite element model generator (pre-processor), it completes the MSC PC analysis software package by providing a common link between MSC/pal 2, MSC/cal, and even MSC/NASTRAN. This is done by its ability to create, edit and translate models made with powerful automatic element meshing commands. In addition to the support of full range of element types, MSC/mod allows load and boundary input and material property input. All of this is done with an easy to use, graphical, menu-driven user interface. The two applications were generated in MSC/mod (Figures 1 and 2).

Future Developments

New releases of the PC products will be continually developed, enhanced and supported in the future. Ongoing development topics include orthotropic material properties, composite elements, larger size problem, a gap element for static analysis, and other dynamic capabilities. Other efforts are expanding the hardware flatform for the PC Products, including better support for the Apple Macintosh machines and exploring the OS/2 operating system for the IBM PCs. MSC will continue to offer the best computer-aided engineering software for the personal computer environment in years to come.

TIMING COMPARISONS AMONG VARIOUS VERSIONS OF MSC/pal 2

Machine Type	Analysis	MSC/pal 2			
		V 3.0	V3.5	V3.5 /N	V3.5/W
Compaq 386/25	Static 3000 DOF HEXA	5483 1.75	3137 1.00	1238 0.39	774 0.25
Compaq 386/25	Static 6000 DOF QUAD	9251 2.22	4175 1.00	1077 0.26	731 0.18
Compaq 386/20	Dynamic 6000 DOF BEAM	5837 2.60	2245 1.00	963 0.43	864 0.38
Compaq 386/25	Static 6000 DOF HEXA	- -	- -	2822 1.00	1870 0.66
Compaq 386/25	Static 12000 DOF QUAD	- -	- -	1854 1.00	1345 0.73

Notes: 1. Top numbers are timing is in seconds;
lower numbers are ratio with respect to V3.5 or V3.5/N

Table 1. Timing Comparison

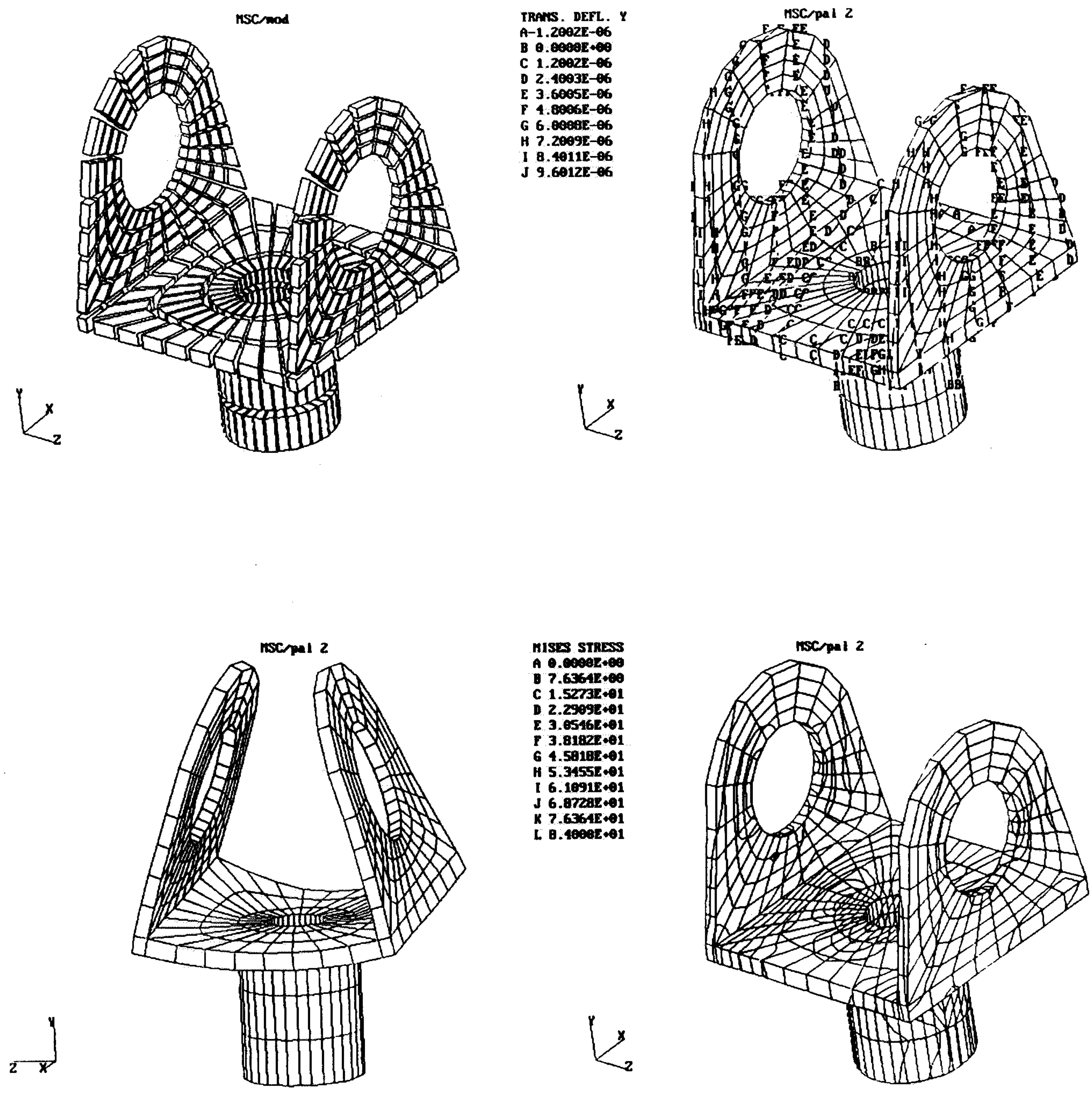

Figure 1. Stress Analysis of Clevis

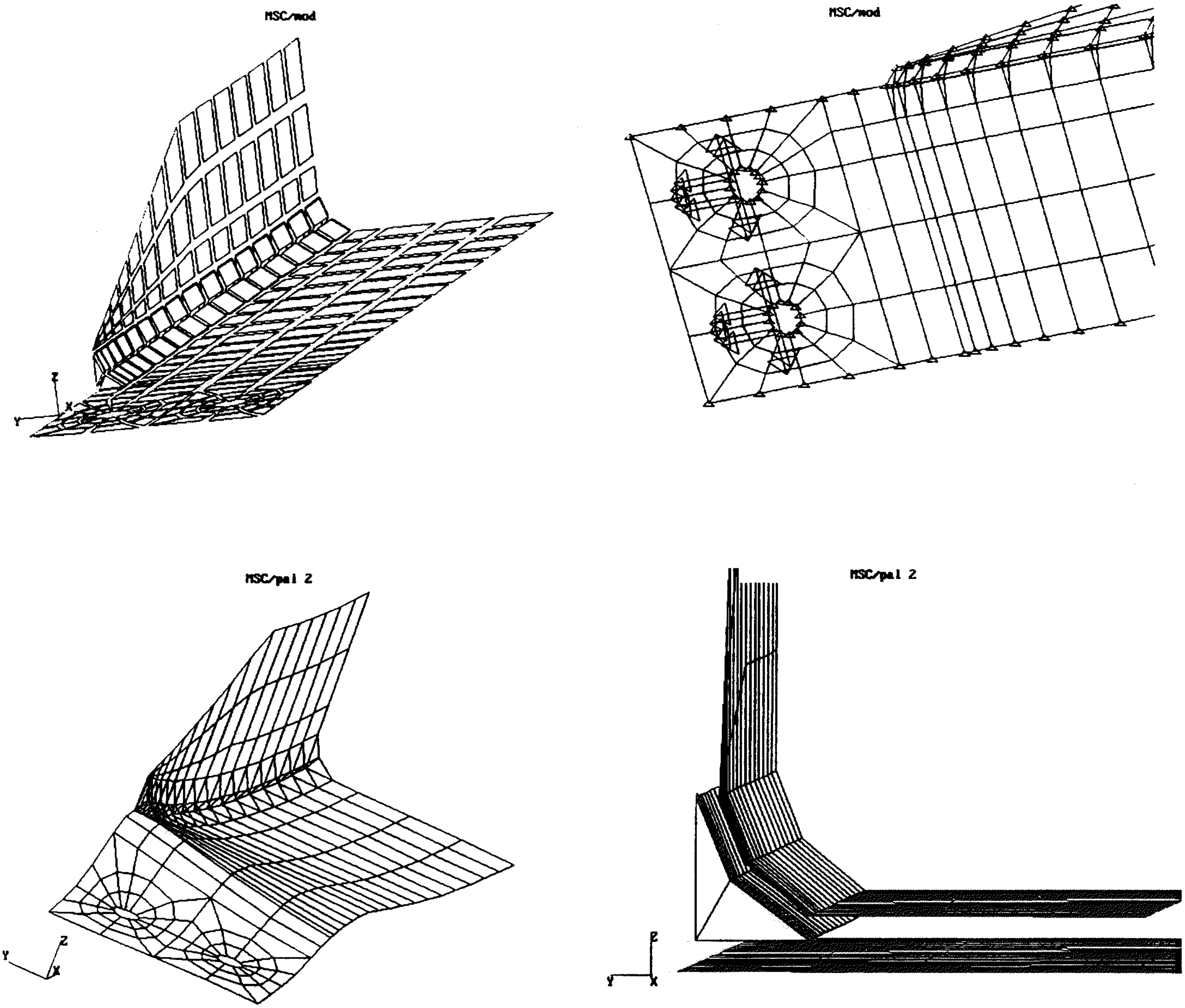

Figure 2. Stress Analysis of Stiffened Panel