Advanced Computing for Automotive Applications Engineering Mechanics

by

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ENGINEERING MECHANICS OVERVIEW

- Background
- Parallel Computing
- Computational Steering/Remote Computing
- Concurrent Engineering
- Models of Composite Materials
- Welding Simulation

ENGINEERING MECHANICS

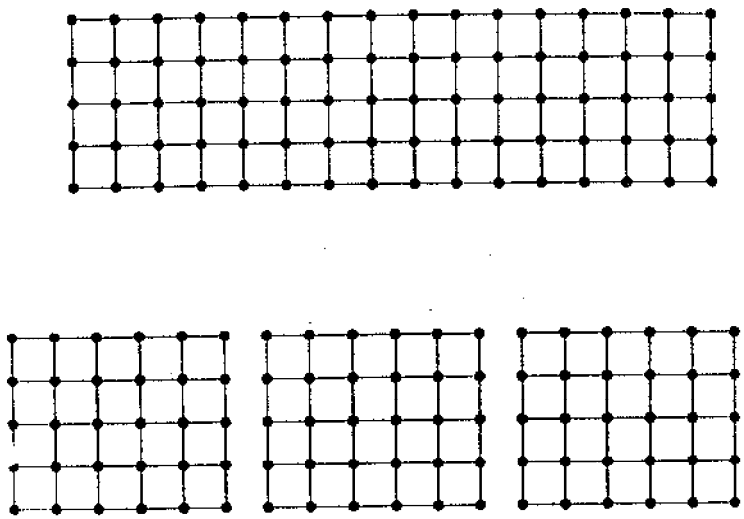
- Argonne's engineering mechanics research team has spent several decades developing finite element methods for the solution of highly nonlinear transient solid/structural mechanics problems.
- In the past 5 years, this research team has focused on the development of finite element algorithms for use on advanced computing architectures including a single workstation, a cluster of workstations (e.g., SUN, HP, SGI), scalable systems (e.g., IBM-SP2), and massively parallel computers (e.g., Intel Paragon). Recent work has been done in the virtual reality arena.
- By using these state-of-the-art algorithms on advanced computing platforms, existing modeling capability, as measured by problem size and execution speed, will be enhanced by orders of magnitude allowing the use of refined models with more physics in numerical simulations.

ENGINEERING MECHANICS (cont.)

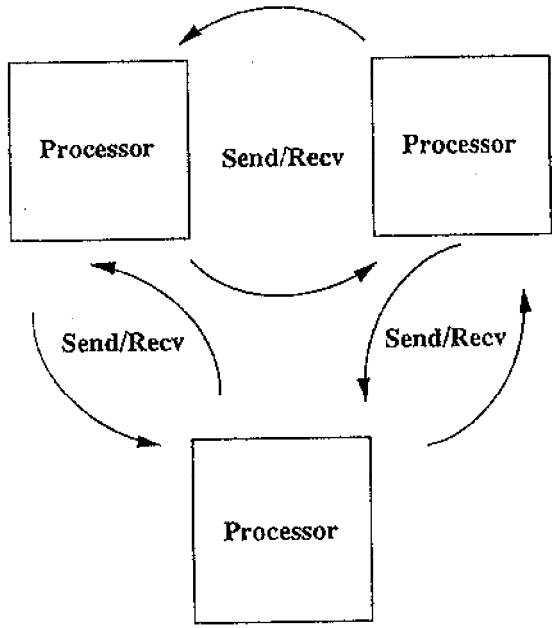
- Recently, research has focused on using virtual reality tools, such as Argonne's immersive virtual reality CAVE, to display computational mechanics results for enhancing the interpretation of numerical simulations and for developing concurrent engineering applications.
- Development of numerical methods for evaluating the structural integrity of modern lightweight materials, such as fiberglass composites, for use in automobiles and civil structures is an active research area.

PARALLEL COMPUTING

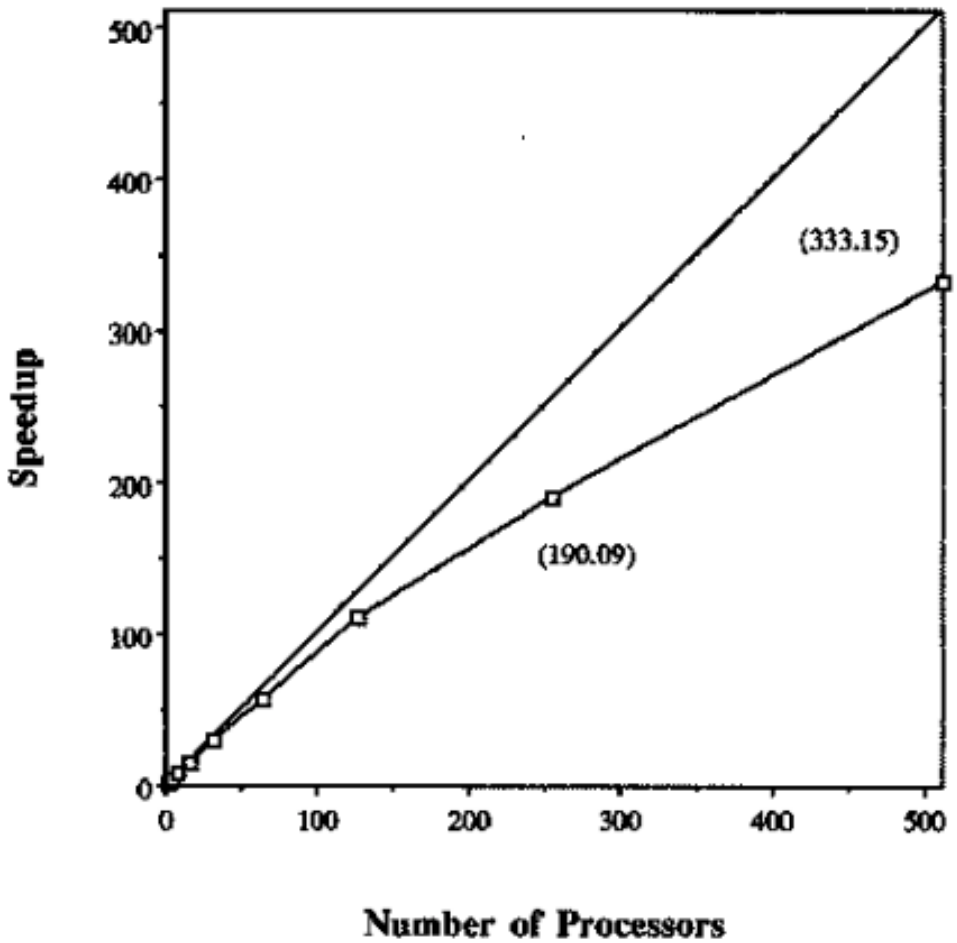
Domain Decomposition



Message Passing



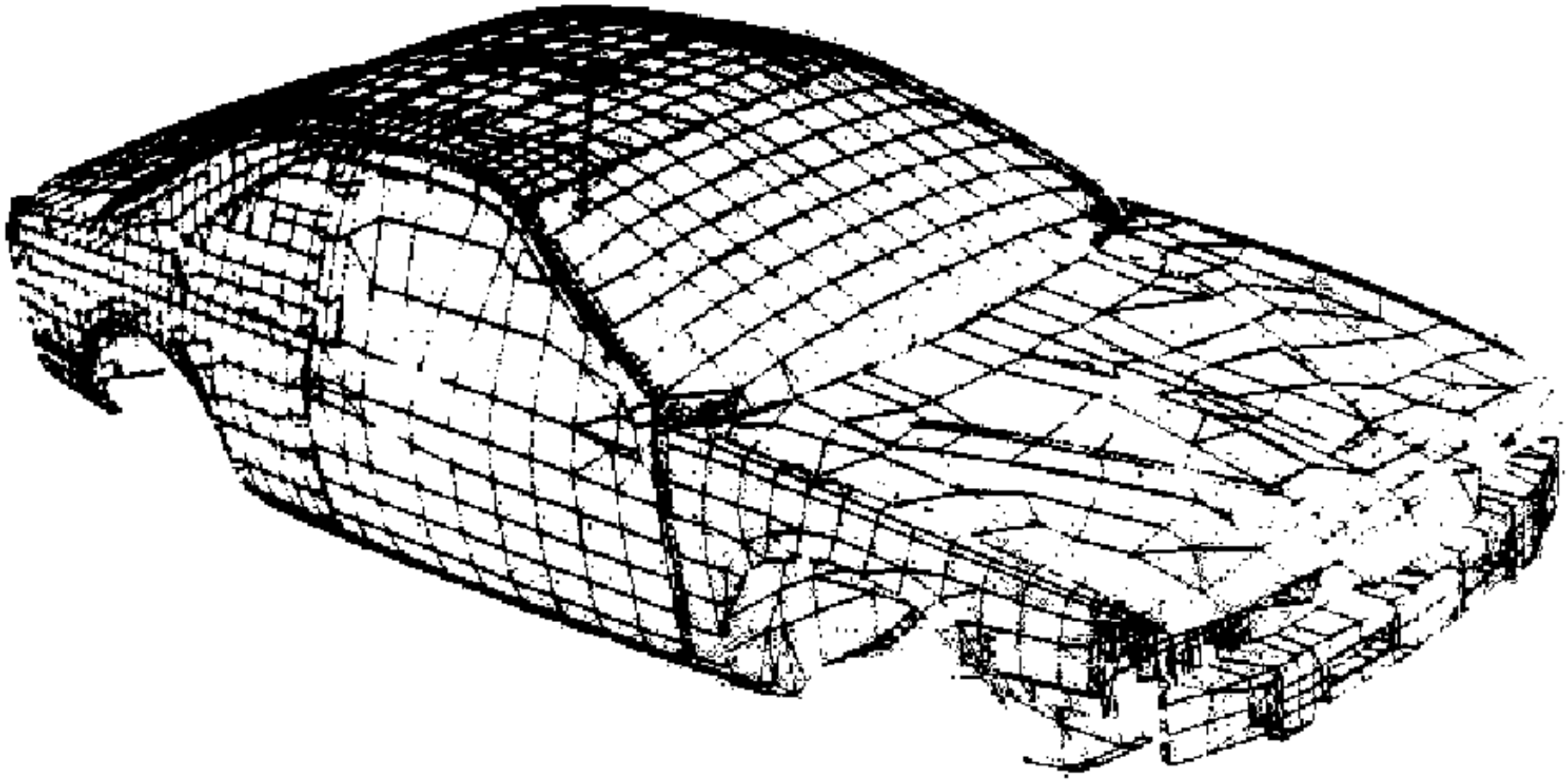
Parallel Computing Impulsively Loaded Cylindrical Panel Base Time = 68927.7 sec



Distributed Parallel Computing (Cylindrical Panel on HP Workstation Cluster)

Number of Processors	Time (sec)	Speed-up	Efficiency (%)
1	922	1.00	100
2	575	1.60	80
3	400	2.32	77
4	303	3.04	76
5	245	3.76	75
6	208	4.43	74
7	185	4.98	71
8	163	5.65	71

Structural Analysis of Automobiles

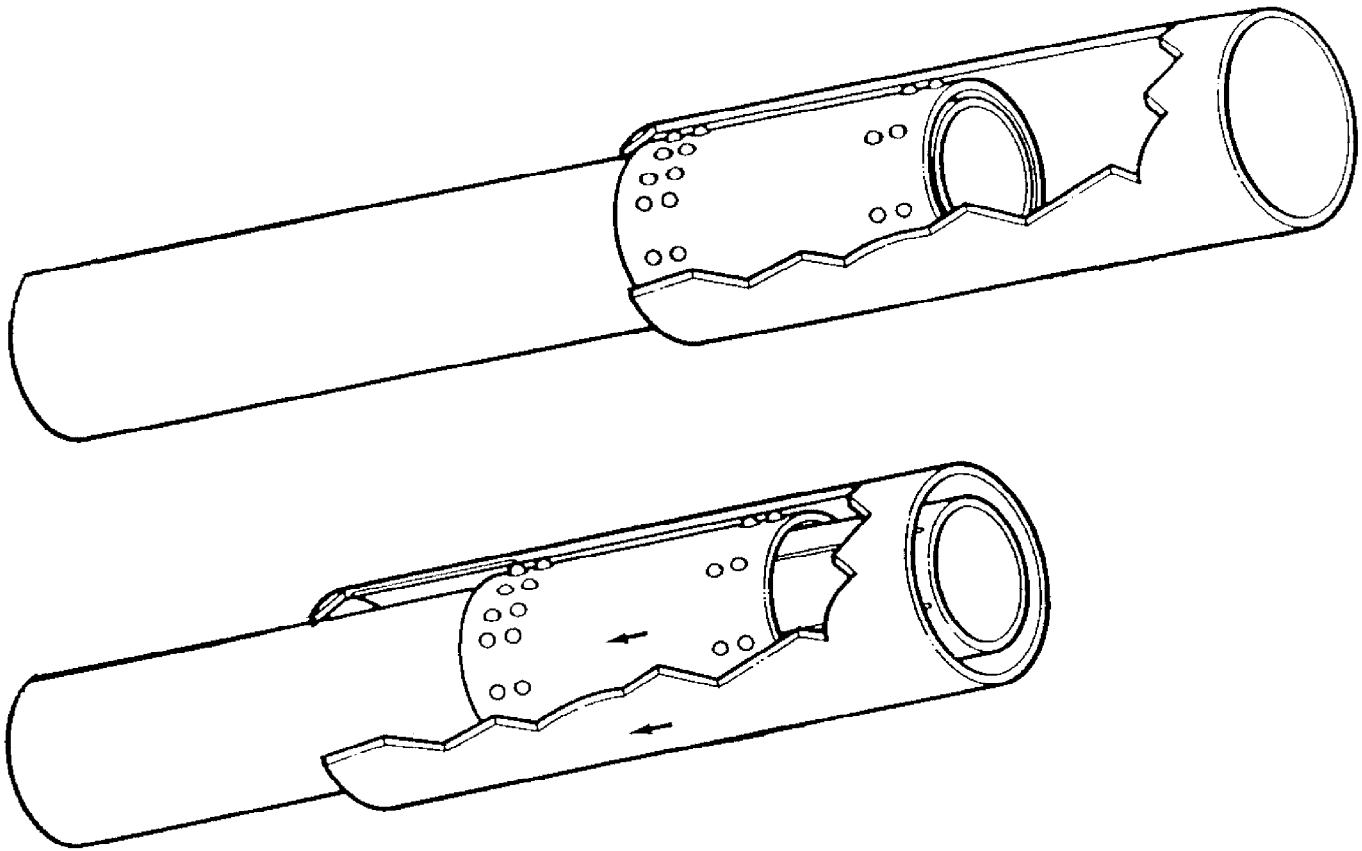


Argonne National Laboratory
Transportation Technology R&D Center

Numerical Simulation of Energy Absorption by Metal Deformation

- ANL is applying engineering mechanics and parallel computing expertise to solve problems for Delphi Steering (formally Saginaw Division of General Motors).
- Controlled large deformation of metallic components are used to absorb energy in structural safety systems, such as steering columns.
- Delphi wants to replace costly trial-and-error methods with computer simulations.
- ANL is developing a 3D nonlinear finite-element code to allow rapid design of steering columns on parallel computing platforms. A beta test version was installed at Delphi for testing.

Numerical Simulation of Energy Absorption by Metal Deformation



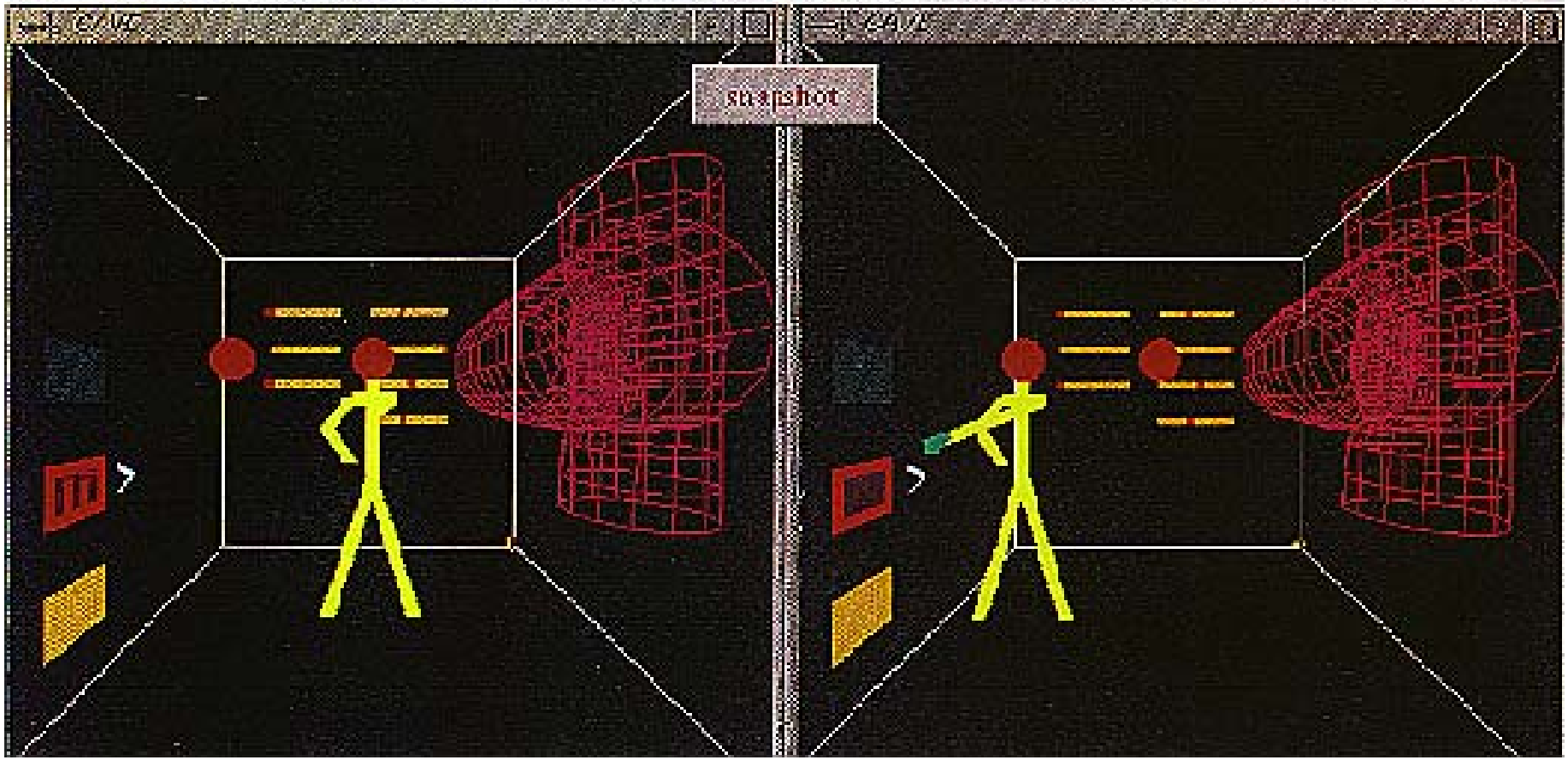
COMPUTATIONAL STEERING/ REMOTE COMPUTING

- Computational steering will allow engineers using a graphics workstation to interact with computations as they proceed on a compute server, which may be remotely located.
- Unfruitful designs can be terminated and parameters can be altered midstream in response to visualizing the numerical simulation.
- A GUI (graphical user interface) has been developed to provide interaction with
  - graphical display
  - numerical simulation
  - communications control

CONCURRENT ENGINEERING

- The capability to simultaneously display engineering analysis models at several geographical locations has been identified by ANL and industry as key need to reduce the time from design to manufacture.
- Engineering simulations will create a visual model that can be studied simultaneously by the designer, analysts, and manufacturer.
  - Progress can be checked
  - Unfruitful design directions can be terminated midstream
  - Parameters may be altered and tuned in response to observations
- ANL is developing software for use in the Cave Automatic Virtual Environment (CAVE). The CAVE programming tools will simplify the task of designing, implementing, and testing a CAVE application.

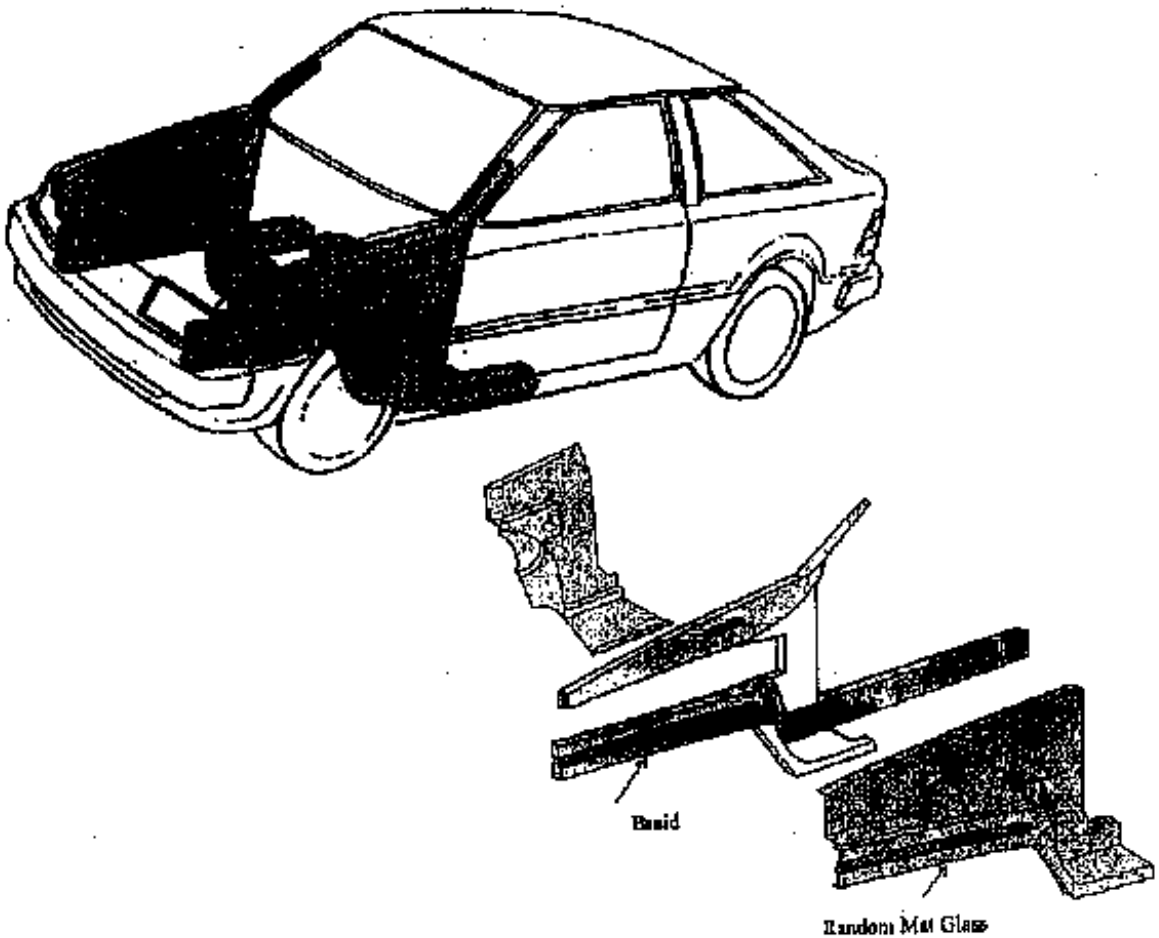
Cave Automatic Virtual Environment (CAVE)



USCAR High-Performance Computing (Composite Modeling)

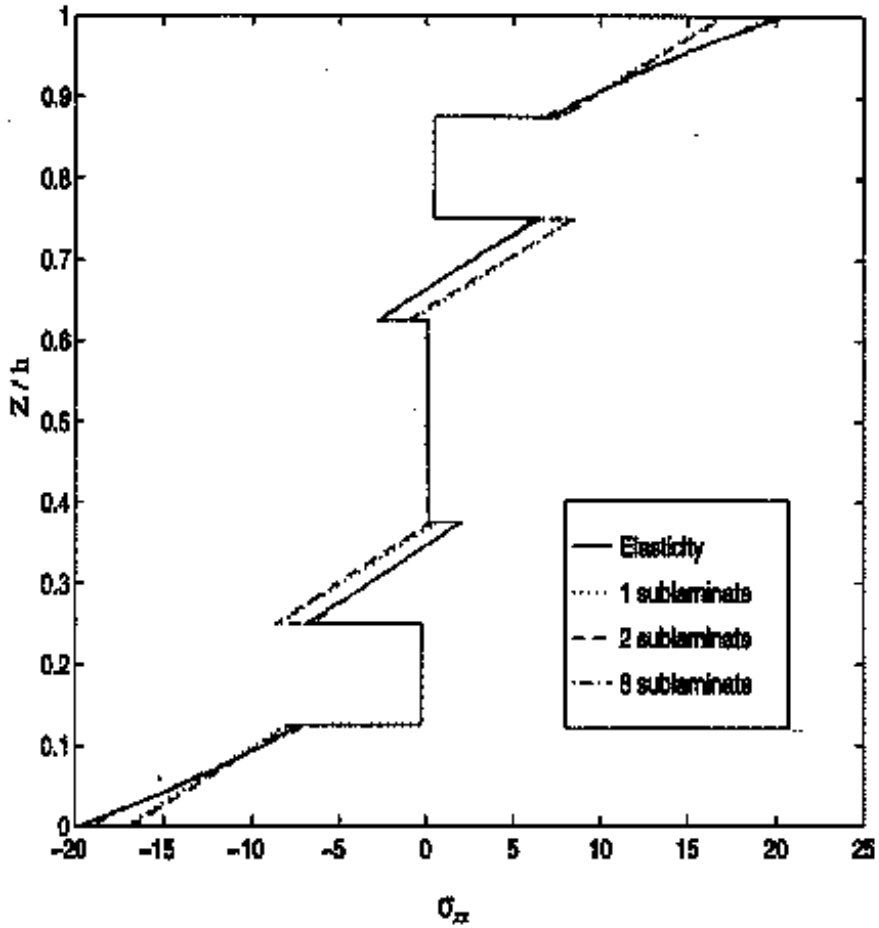
- The PNVG Goal 3 is to achieve fuel economies up to three times those of 1994 family sedans by 2004. The use of strong light-weight composites is a key part of the strategy. Crash-worthiness of these "composite" vehicles is a prime consideration.
- ANL and several other National Labs (LANL, LLNL, ORNL and SNL) are working with USCAR (a consortia formed by Chrysler, Ford, and GM) to develop efficient computational models of lightweight fiberglass composites that will result in the economical design and manufacturing of lighter, crashworthy vehicles.
- ANL's task is to develop element technology to represent the behavior of laminated composites during crash events.

Automotive Application of Composite Structures

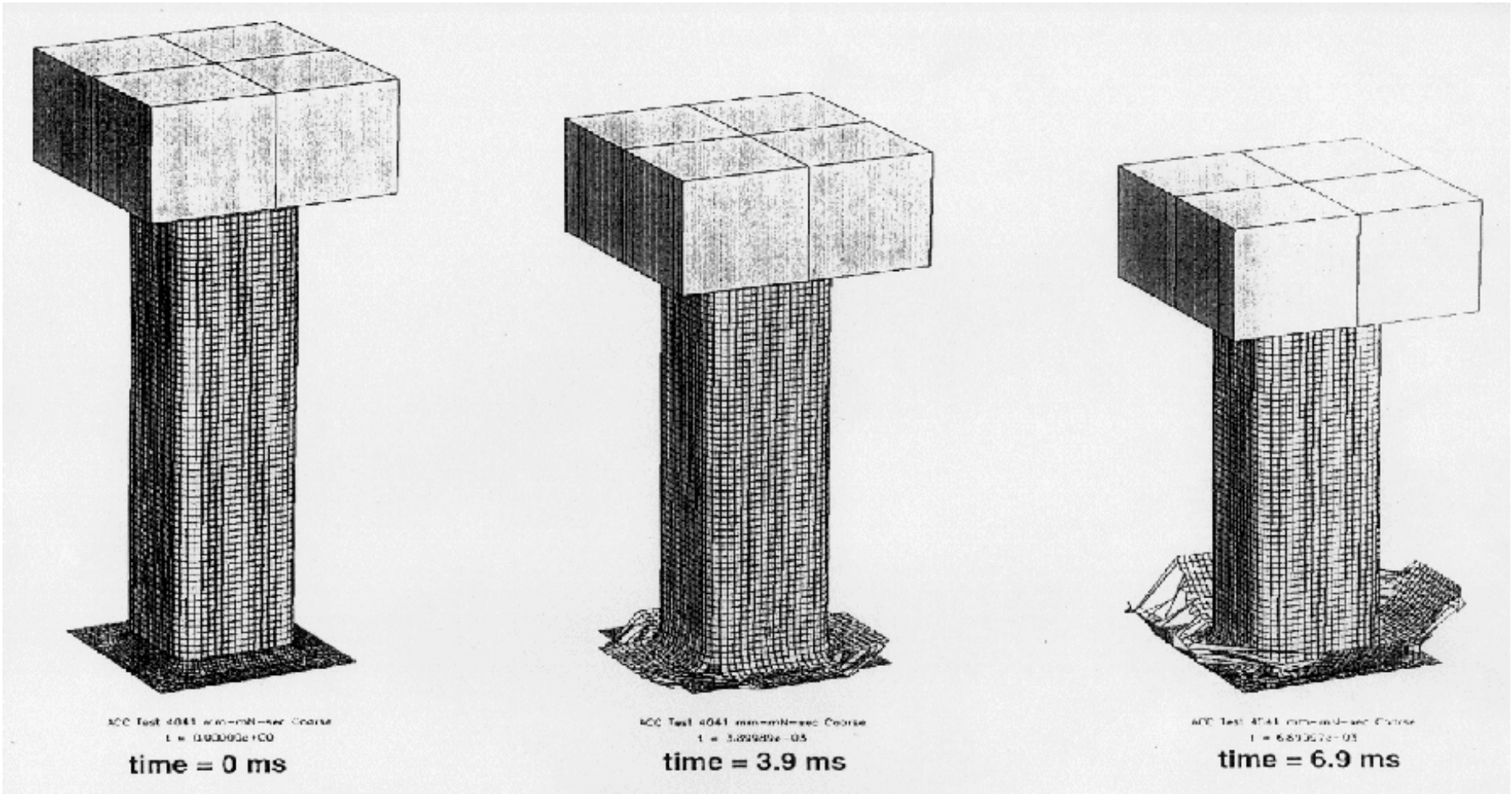


MODELS OF COMPOSITE MATERIALS

- Cooperative research and development for simulating the response of composite materials is being performed by Argonne National Laboratory and Michigan State University as part of a CRADA between the national laboratories and USCAR
- A zig-zag finite element is being developed by ANL/MSU to simulate the complex strain and stress distributions that occur in multilayered composite materials



Composite Modeling Simulation of Experiments



WELDING SIMULATION

- Argonne has a research team working in the welding area
  - modeling and simulation of welding is being performed on parallel computing platforms
  - an experimental welding laboratory was established
  - a materials testing laboratory was established to find material response data for use in constitutive models
  - a weld monitoring device is being developed with potential use for process control

SUMMARY

- Cutting-edge engineering mechanics technology developed at Argonne has found application in the automotive sector.
- Nonlinear finite element methodology and parallel computing have been applied to complex automotive problems at USCAR (Chrysler, Ford, GM) and Delphi Steering.
- Immersive virtual reality can become another tool for use in simulation interpretation and concurrent engineering applications.
- Awareness of the auto industries needs can provide valuable insight into future use of ANL's technology.