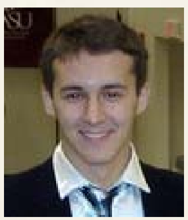
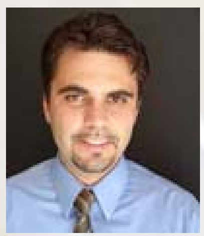
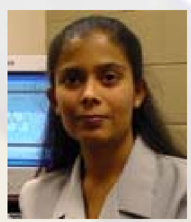
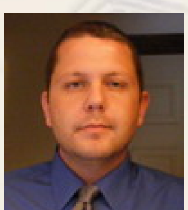
NEWS Network Enabled WorkSpaces

A Different VIEW :
Virtual Interactive Engineering on the Web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Computer Science & Engineering Studies

Outline

- Why Materials Engineering?
- Web3D Engineering Labs
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  - Graphical User Interface
  - Simulation Functionality
  - Machine and Material Sample Modeling
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- Acknowledgements

Why Materials Engineering ?

- Engineering courses often seem as abstract concepts difficult to understand and apply.
- Laboratory experience is an essential part of engineering education.
- Possible issues:
  - no space for large equipment in labs
  - lab setups are too costly
  - students have no time to finish the experiments during labs
- Virtual Interactive Engineering on the Web (VIEW) is Web3D-based laboratories accessible from any computer with Internet connection.
- Tensile Testing Laboratory (TTL) is a part of Engineering Materials course which introduces students to the analysis of mechanical properties of materials.

Related Work

Non-Web3D:

- The department of Mechanical Engineering at the University of Colorado, Boulder – Integrated Teaching and Learning Online Lab [1], including the tensile test, the torsion test, beam deflection, heat treatments experiments, etc.
  - Drawback: 2D Flash movies, reduced interactivity.
- The faculty at Rutgers University and the University of Illinois at Urbana-Champaign – Instructional Remote Laboratory Environment [2], including combustion and jet thrust labs
- M. Karweit at John Hopkins University – virtual laboratory for experiments showing the diffusion process, a robotic arm control [3]
- Bhargava et. al – a virtual torsion laboratory [4]
  - Drawback: reduced interactivity, no 3D perspective
- Demidov et. al. – crystal models for an engineering materials course [5]
- Rehan et. al. – teaching the Solid State course at Mansoura University, Egypt [6]
- Liarokapis et al. – broad engineering education [7]
  - A few ideas, no implementation

Technologies for Web Simulation

Technologies for Web3D:

- *VRML*
- *Java 3D*
- *WireFusion*
- *Adobe Shockwave*
- X3D – new, XML based

X3D vs. VRML

- Compatible with the next generation of graphics files - e.g. Scalable Vector Graphics.
- Open source, so no licensing issues.
- Has been officially incorporated within the MPEG-4 multimedia standard.
- XML support makes it easy to expose 3D data to Web Services and distributed applications.
- 3D objects can be manipulated in C or C++, as well as Java

Tensile Testing Experiment

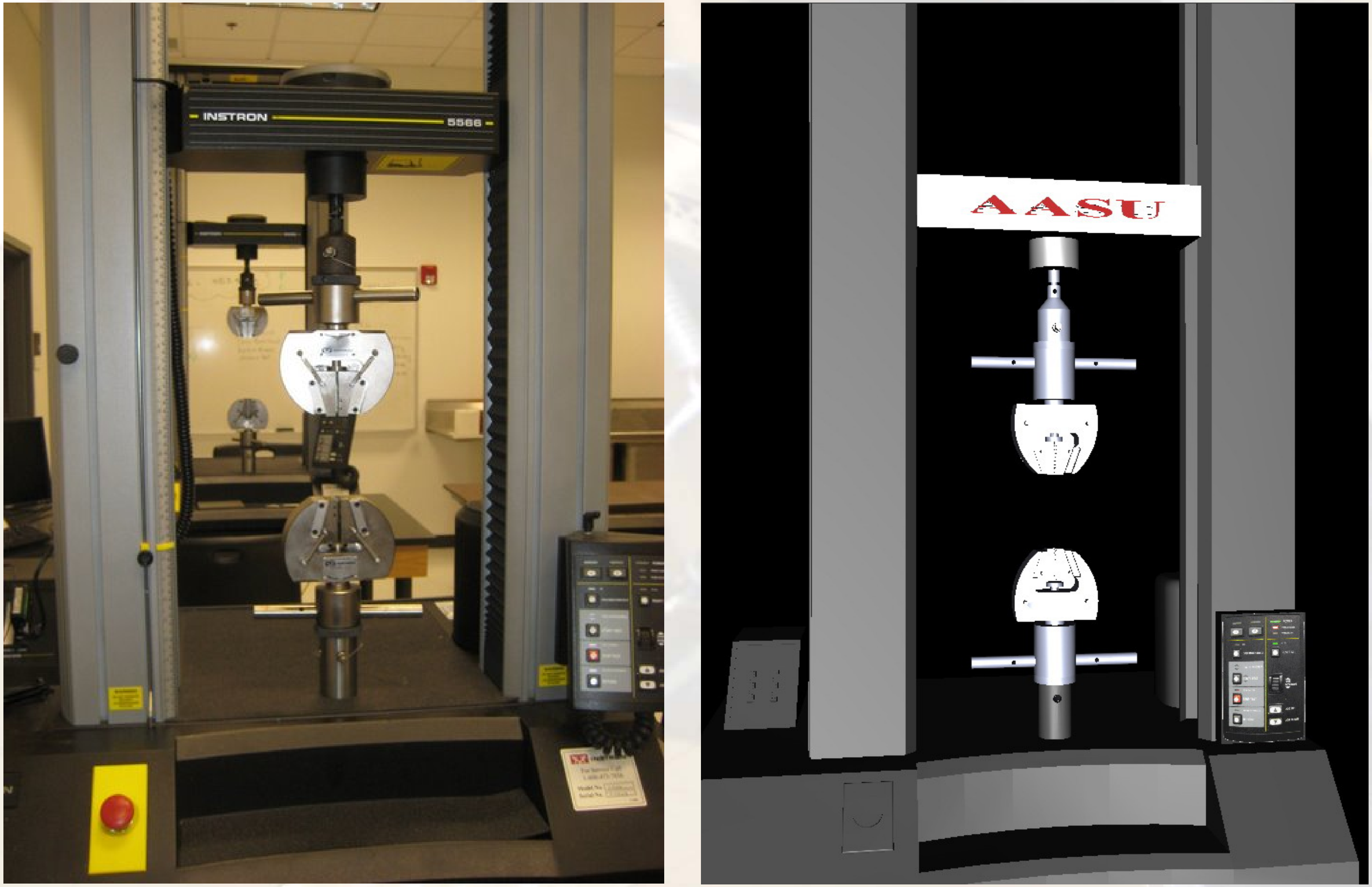


Figure 1: *InstronTM 5566 real TTM (left) and simulator (right)*

Tensile Testing Experiment

- Objective – introduce basic testing techniques required to evaluate mechanical properties of materials (hardness, ductility, and stiffness)
- Setup involves a Tensile Testing Machine (TTM); our Virtual TTL (VTTL) models an InstronTM 5566 TTM (figure 1).
- Sample of a certain material is mounted into the holding grips of the TTM, and the upper grip pulls the sample upward (figure 2).

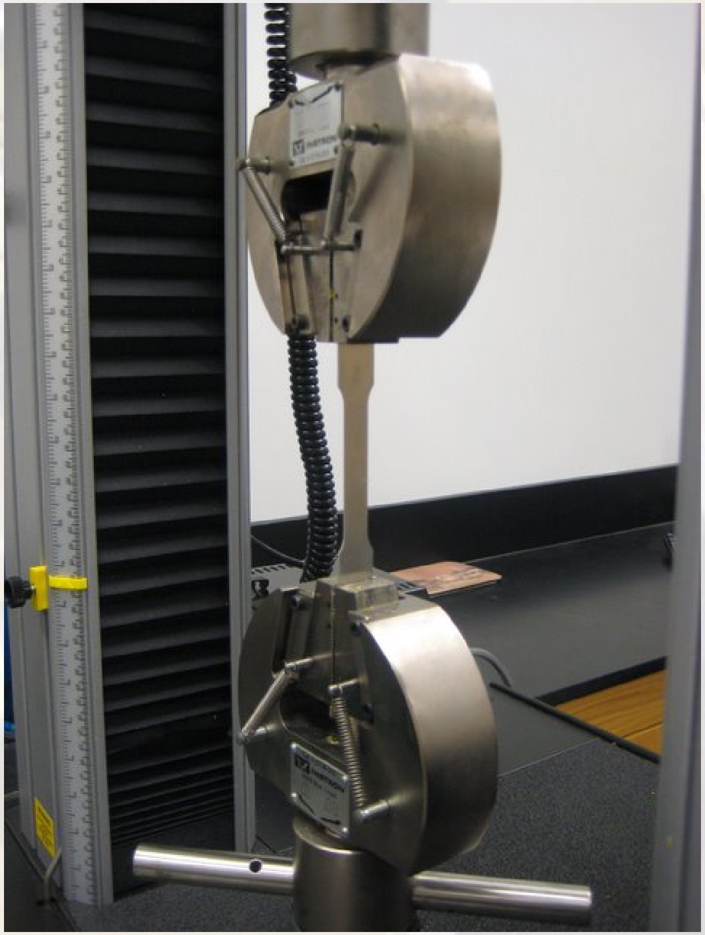


Figure 2: *Sample fixation in the grips of TTM*

Tensile Testing Experiment

- TTM controller measures load and strain and transmits the information to the computer.
- A load-strain linear graph with the results is obtained.
- These data can be used for further analyses with MATLAB™ and other software.

Simulator Implementation

- Three key components:
  - PHP
  - X3D
  - JavaScript

- PHP is the web scripting language of choice for generating web pages.

- X3D [8] is an ISO standard - real-time graphics processing.

- JavaScript provides the interaction between the elements of the graphical user interface (GUI).

- Additional components:
  - ECMAScript
  - AJAX (Asynchronous JAvascript and Xml)

Graphical User Interface

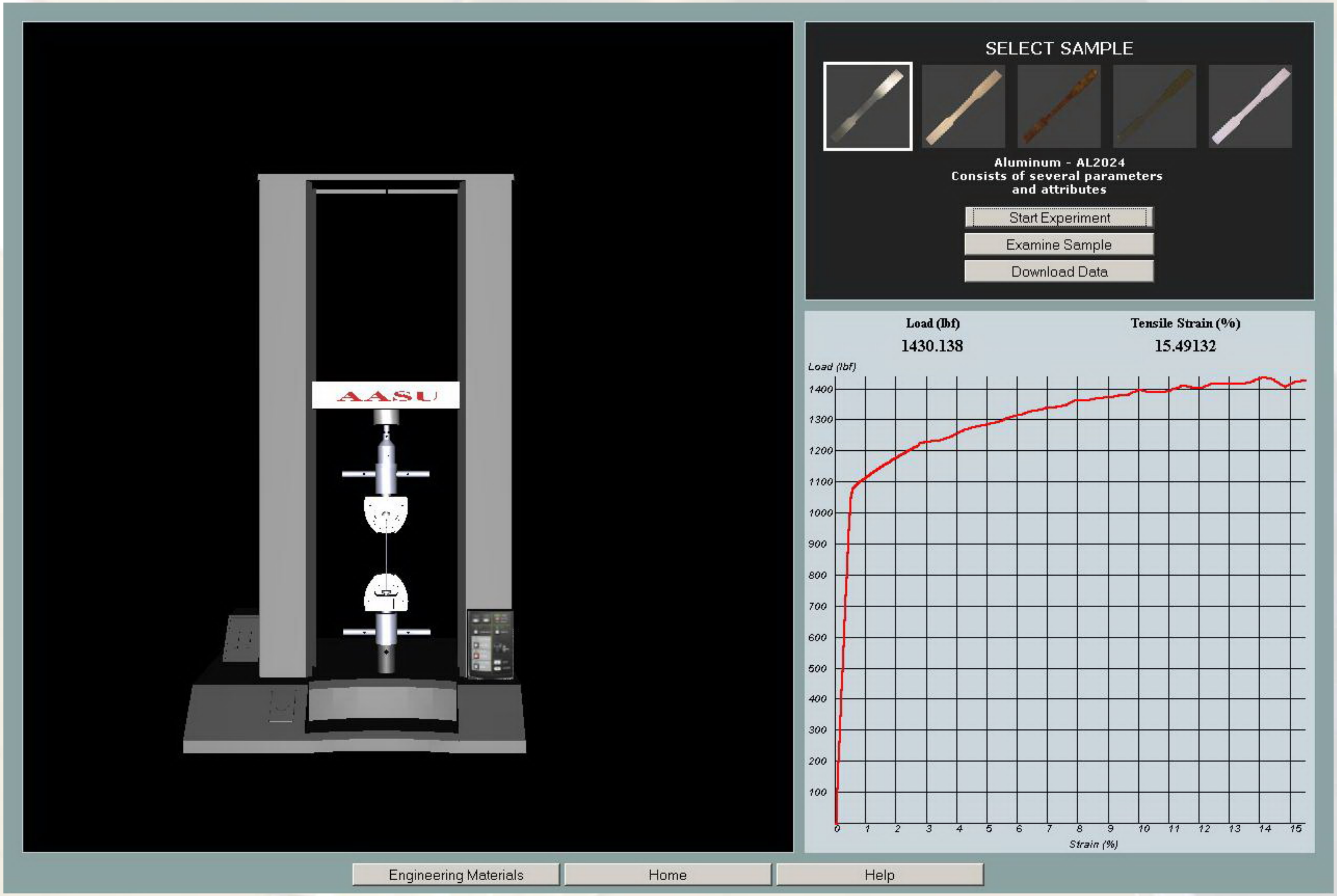


Figure 3: *VTTL's GUI*

Multimodal
Graphical User Interface (3D & sound)

- GUI components (figure 3):
  - HTML controls
  - virtual 3D scene
  - graph/displays panel

- HTML controls:
  - clickable images to choose a material sample
  - “Start Experiment” button for starting the experiment
  - “Examine Specimen” button for examining the current sample in a close view
  - “Download Data” button for downloading experimental data in an MS Excel™file

- Experiment is initiated using button once a sample is selected.

- During the experiment the TTM motion is simulated, and the graph of load-strain dependence is drawn.

- Audio imitating the hum of the real machine and the breaking sound of the sample

Simulation Functionality

- A special plug-in is needed to show X3D graphics (we chose BitManagement Contact™ Player).
- Scene Authoring Interface (SAI) enables the developer to dynamically modify or create X3D worlds.
- The experimental data is preloaded unnoticeably using AJAX – not affected by the fluctuations of the network delay.
- JavaScript function reads pairs of strain-load values and updates the scene and the graph.

Simulation Functionality

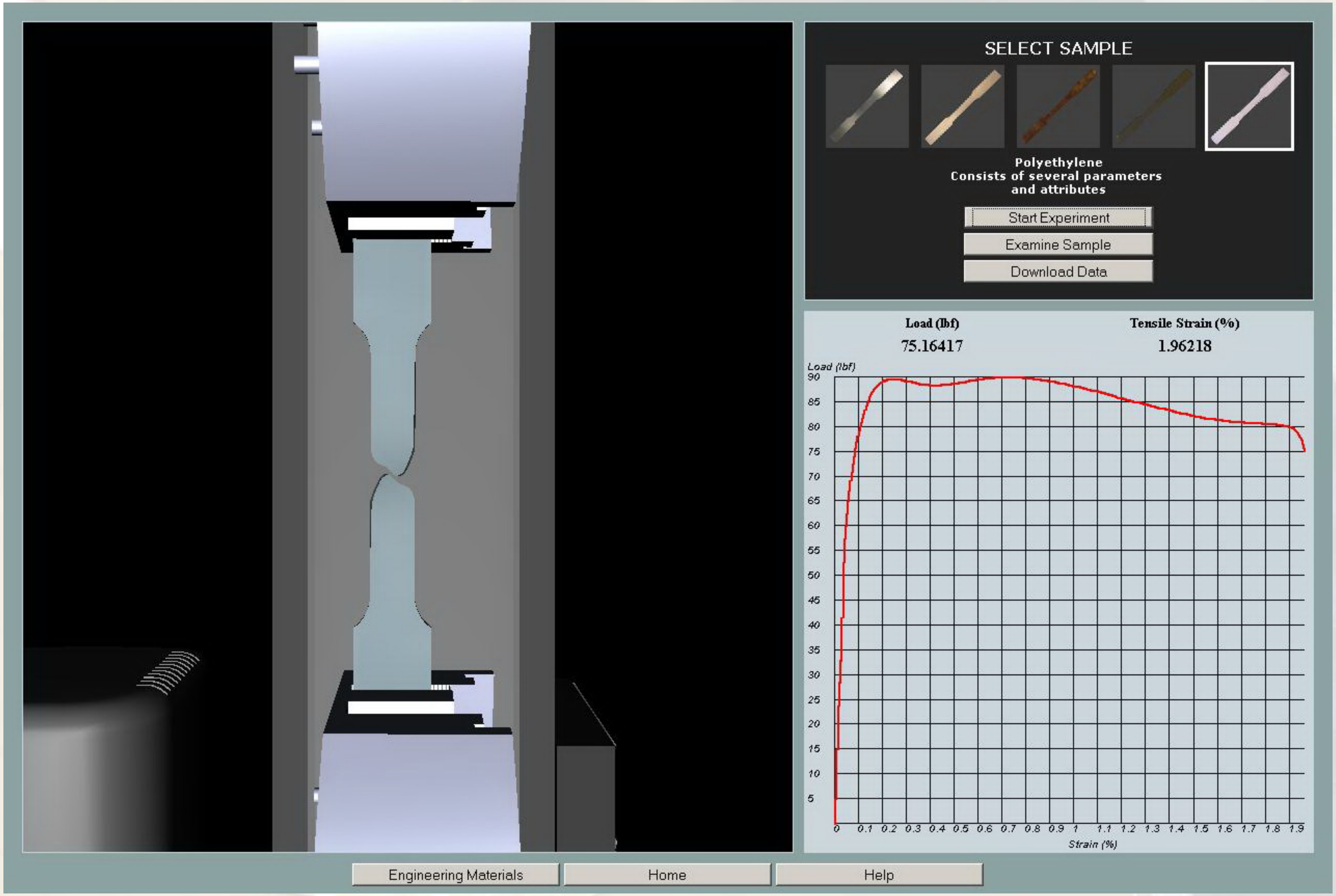


Figure 4: *Polyethylene sample breakage*

Simulation Functionality

- The virtual material sample has three parts:
  - two ends that are held by the grips
  - the middle part that brakes
- Upper grip moves upward based on the strain values from the data set.
- Upper grip's shift equals *gauge* x *strain (%)* / *100:*
  - Upper end of the sample is translated along with the upper bar.
  - Middle part is lifted half that distance and elongated to appear as a single piece with the other parts.
  - Lower end remains static.
- To "brake" the sample, we replace it with a preloaded "broken" elongated version.

Simulation Functionality

- Graph is calibrated based on the experimental values (figure 4):
  - Plotting area adjusts automatically to fit the functional curve.
  - Grating period is such that a reasonable number of graduation marks is displayed.

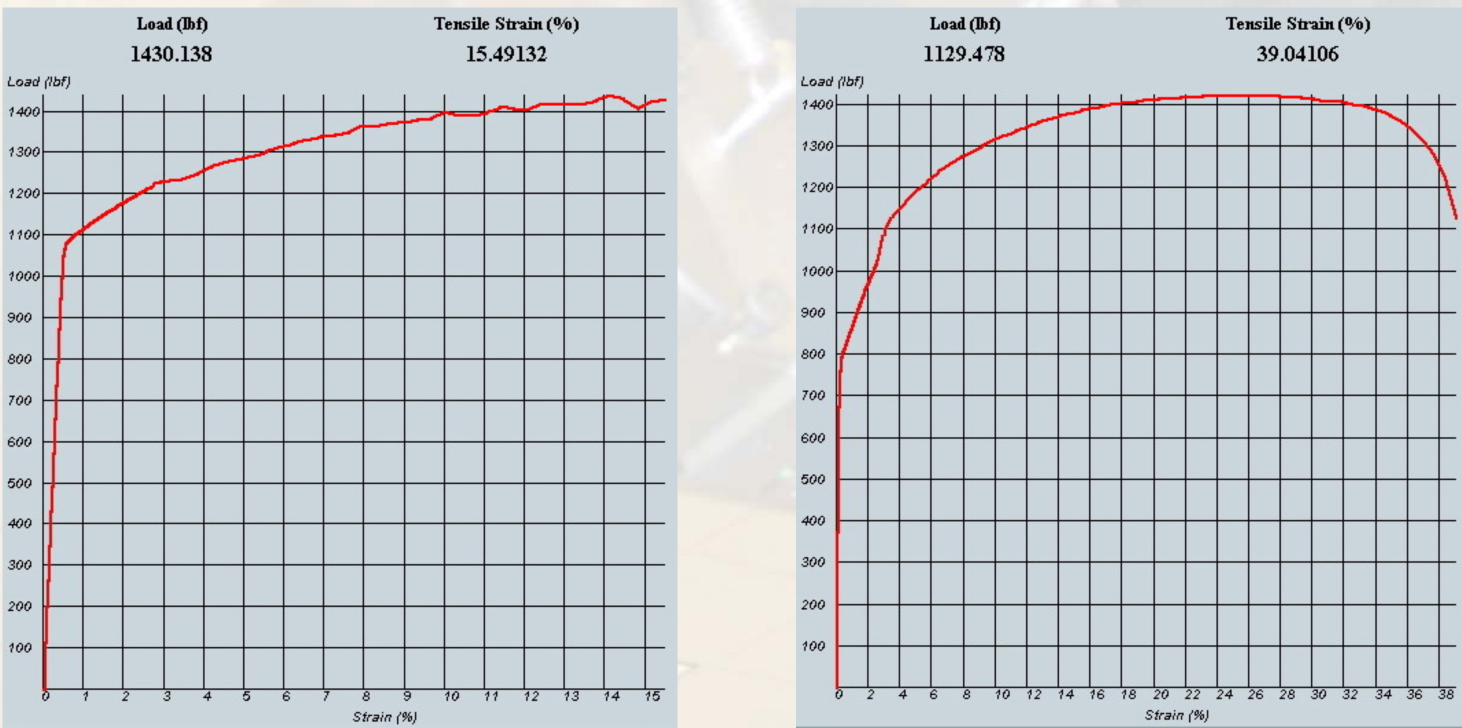


Figure 5: *VTTL experimental graphs for Aluminum 2024 (left) and Steel 1006 (right)*

Machine and Material Sample Modeling

- We use SolidWorks™ to model the TTM and material samples.
- Each part was measured with a digital caliper.
- All elements were assembled into a single part; colors and surface textures were added.
- Five samples of different material types were modeled: Aluminum 2024, Aluminum 6061, Steel 1006, Polycarbonate, and Polyethylene.

Machine and Material Sample Modeling

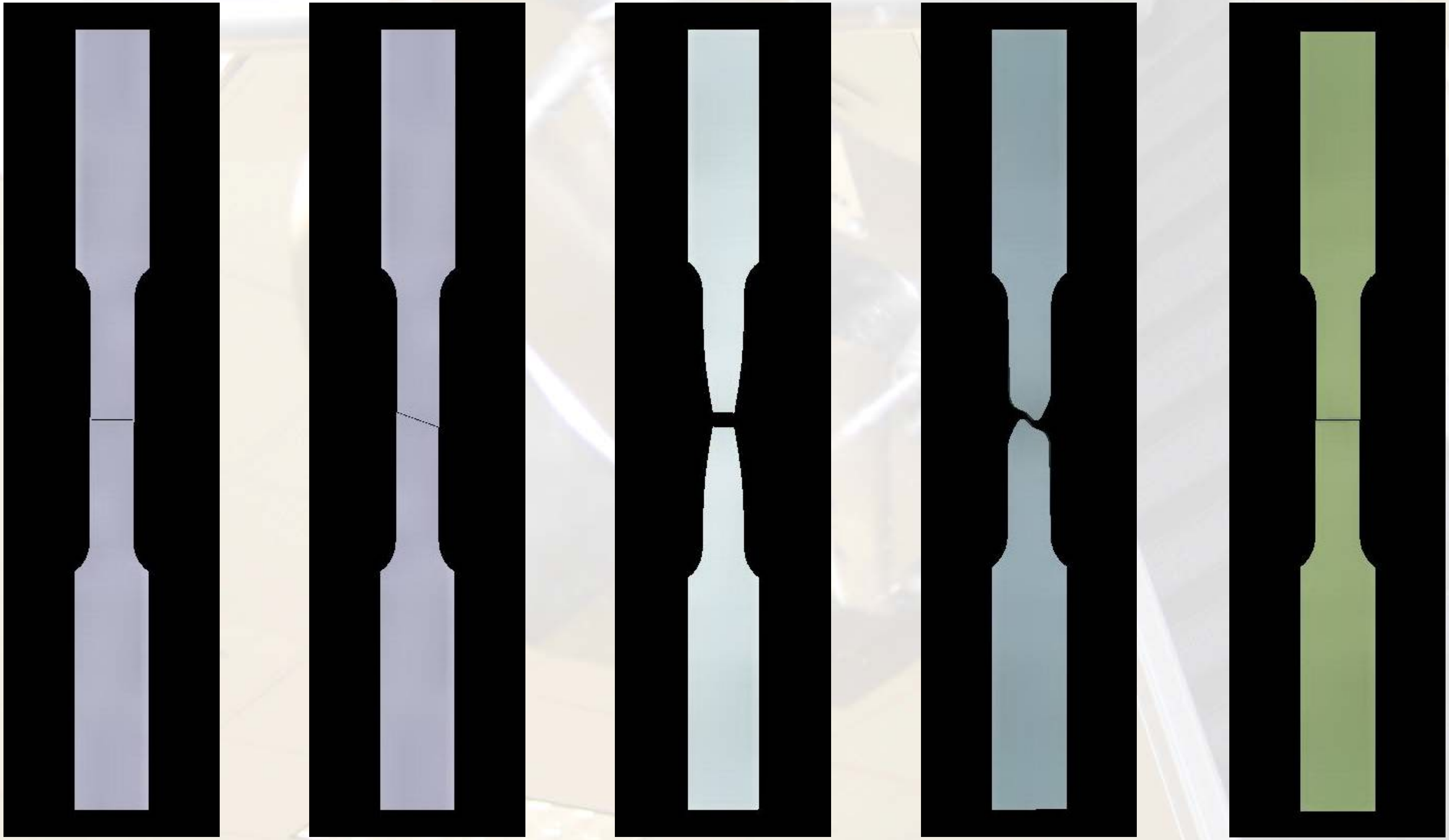
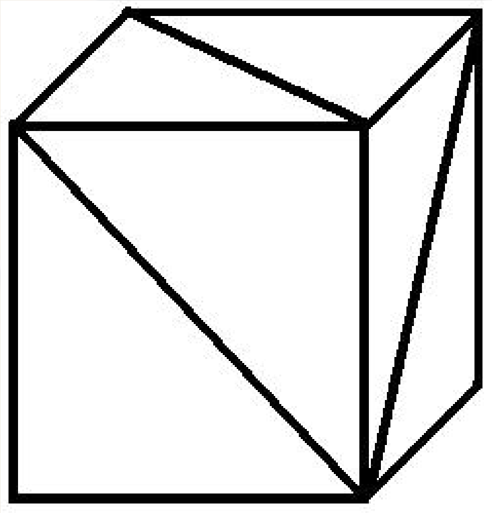


Figure 6: *“Broken” samples of different material types*

Format Conversion Issues

- SolidWorks™ only exports to VRML, not X3D.
- Contact™ player can easily convert the scene from VRML to X3D via saving dialog.
- Graphical objects are downloaded from the website: file sizes grow -> download and visualization time grows.
- Scene can be cached by the X3D client.
- Objects with fewer polygons are desired.
- For instance, a cube could be constructed with 12 triangles instead of hundreds or even thousands.



Expected Impact

- The virtual lab will be assessed in the fall semester in the Introduction to Engineering Materials course (ENGR 2000) at AASU.
- The tool already stimulates the students' interest in the course. (we showed the demo to a few eng. students)
- VTTL will provide the students with an opportunity to transfer and apply knowledge from other courses (e.g., Computing for Engineers using MATLAB™) to complete the virtual lab assignment.

Assessment

- Initial assessment of this tool will be achieved using student surveys and pre/post laboratory quizzes.
- Further modifications will be based on students' and instructors' feedback.
- Other courses in the engineering curriculum such as Engineering Graphics and Introduction to Thermodynamics may benefit from this project.

Conclusions and Future Work

- We have presented the initial stage of a virtual laboratory for engineering materials that uses the X3D standard.
- Models were developed in CAD software and employed in the implementation of a VTTL accessible on the Web.
- This lab will be used by engineering students in the fall 2008 semester.
- We will report the details of our assessment of and modifications to the tool in fall 2008.

Conclusions and Future Work

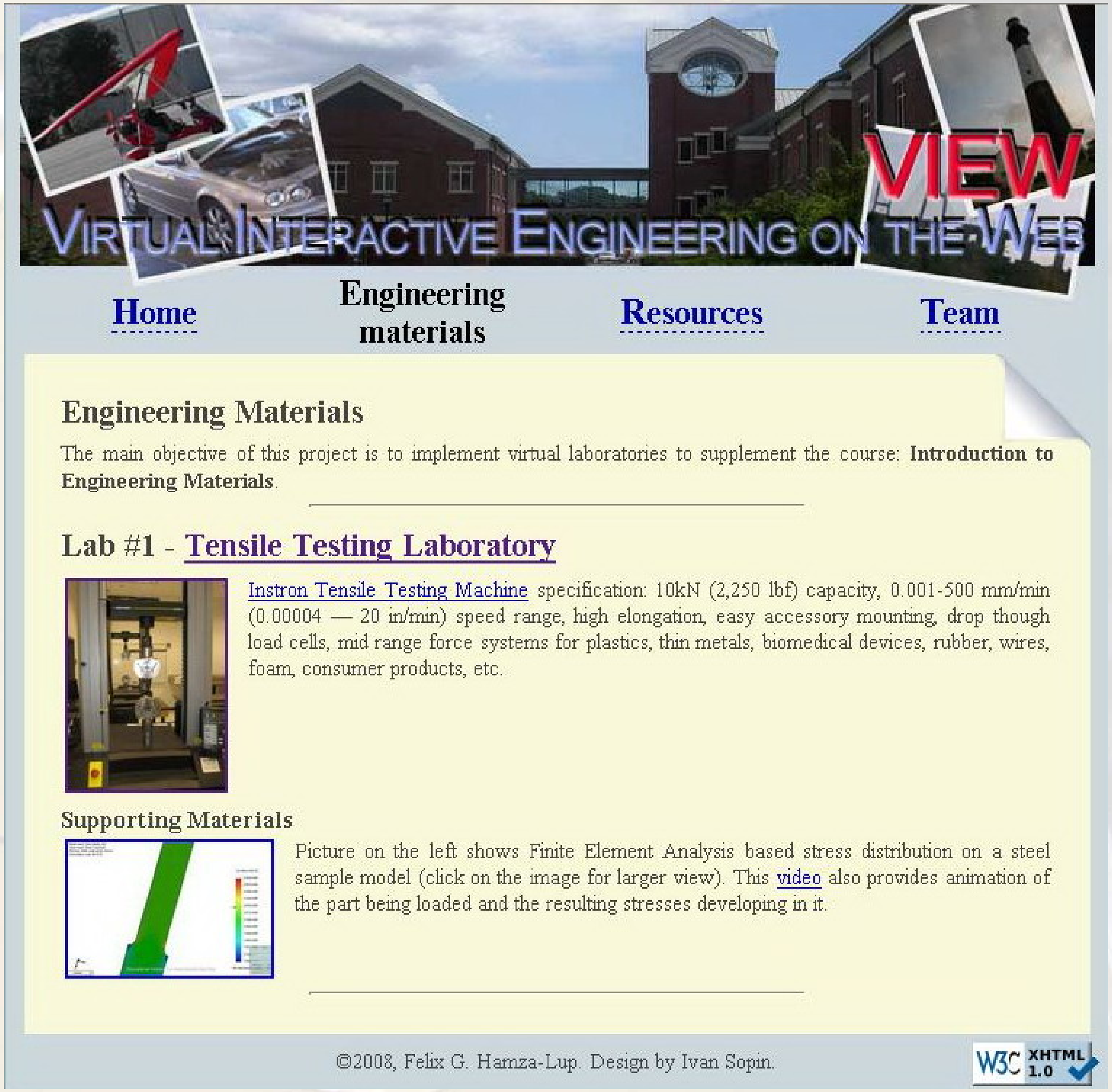


Figure 7: *Project's website*

Teaching and Learning Grant 2007-2008 awarded by AASU's Faculty Development Committee

Team

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and Dr. Priya Goeser

Figure 8: Patrick Hager, Carlos Sanchez, Dr. Wayne Johnson, Dr. Felix Hamza-Lup, Ivan Sopin

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Thank you!
Any questions?