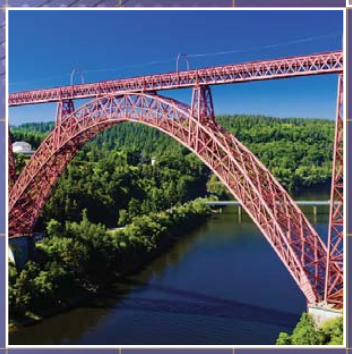
Structures



“ The School of Engineering at the University of Lincoln is the first new Engineering School in the UK for more than 20 years and collaborates closely with industry to produce graduates who are not only academically excellent, but ‘industry ready’.
TecQuipment products form the practical basis of our Static Mechanics and Dynamic Mechanics curriculum and help to demonstrate fundamental aspects of thermodynamic theory to our undergraduate students. ”

Daniel Stones, Technician, University of Lincoln

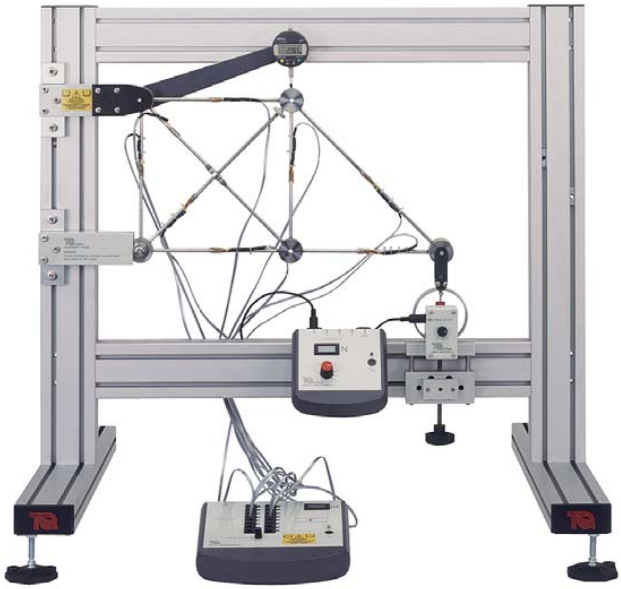
Structures

Our modular Structures range offers a cost-effective, flexible teaching system that we believe is the most advanced in its field.

The range teaches basic principles to more advanced theory for students of mechanical, civil and structural engineering. It has 19 desk-mounting hardware experiment modules supported by full automatic data acquisition, and TecQuipment's powerful and popular Structures Software (STRS).

You can use the hardware modules and the Structures Software together or as stand-alone products. However, using both with automatic data acquisition gives a powerful teaching solution.

In addition, the products include a full selection of user guides, student guides, lecturer guides, textbook and other supporting material.



Flexible and modular

- Experiment modules and instrumentation fix easily to the test frame.
- Easily removed and changeable experiments, making good use of laboratory space.
- The modularity of the range allows for expansion at your convenience.

Authentic software simulation

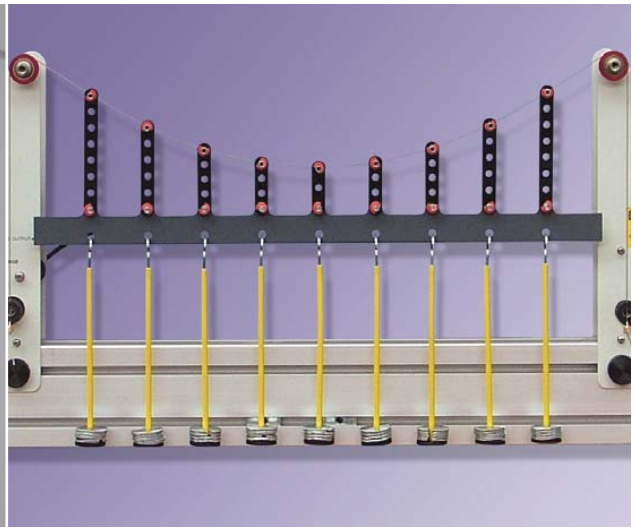
- The Structures Software offers an affordable and effective method for students to quickly learn structures principles by performing virtual experiments on a computer.
- Allows students the flexibility of working away from the laboratory.
- Expands experiments beyond the limits of the hardware.

Automatic data acquisition

- The use of automatic data acquisition and digital instrumentation means students can get quick and accurate results, optimising laboratory time.
- There are no difficult-to-read instruments or abstract experiment set-ups to distract students.

High functionality, affordably priced

- One experiment can show several principles, for excellent value.
- Extensive experiment capabilities and choice of hardware and software, mean our Structures range provides an unsurpassed teaching solution at an unbeatable price.



The Structures Test Frame (STR1)

This strong, sturdy and bench-mounting test frame holds the interchangeable experiment modules and instruments of TecQuipment's Structures range.

Includes textbook

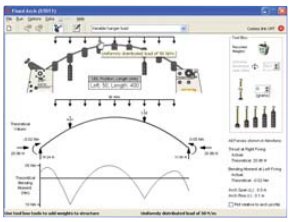
Automatic Data Acquisition Unit (STR2000)

Links to load cells and other instruments in the Structures range to send data to a suitable computer.

Includes Structures Software (STRS)

Structures Software (STRS)

The software accurately simulates all 19 experiment modules on a suitable computer without the need of the Structures hardware.



Includes extensive user guides and example experiments

The Experiment Modules (STR2–STR20)

Interchangeable experiment modules give realistic and verifiable experiment results.

Code	Experiment Module
STR2	Bending Moments in a Beam
STR3	Shear Force in a Beam
STR4	Deflection of Beams and Cantilevers
STR5	Bending Stress in a Beam
STR6	Torsion of Circular Sections
STR7	Unsymmetrical Bending and Shear Centre
STR8	Pin-Jointed Frameworks
STR9	Three-Pinned Arch
STR10	Two-Pinned Arch
STR11	Fixed Arch
STR12	Buckling of Struts
STR13	Continuous and Indeterminate Beams
STR14	Curved Bars and Davits
STR15	Plastic Bending of Beams
STR16	Plastic Bending of Portals
STR17	Redundant Truss
STR18	Frame Deflections and Reactions
STR19	Simple Suspension Bridge
STR20	Bending Moments in a Portal Frame

Ordering

The modular nature of our Structures range means you can choose the right combination of products that best suits your teaching needs.

Software (STRS) = **VIRTUAL EXPERIMENTS**

Test Frame (STR1) + **Experiment Modules** (STR2–STR20) = **HARDWARE EXPERIMENTS**

Test Frame (STR1) + **Experiment Modules** (STR2–STR20) + **ADA Unit** (STR2000 – includes STRS Software) =
HARDWARE EXPERIMENTS
VIRTUAL EXPERIMENTS
AUTOMATIC DATA ACQUISITION

Structures Test Frame (STR1)

A strong frame that holds the experiments of TecQuipment's Structures range

- Holds the interchangeable experiment modules and instruments of TecQuipment's Structures range
- Strong, bench-mounting frame
- Easy-to-use fixings and slots so students can quickly set up, remove or change experiments
- Also ideal for holding experiments during storage
- Includes textbook with full theory and explanations of different structures

A lightweight yet strong bench-mounting frame that holds interchangeable experiment modules and instrumentation from the TecQuipment Structures range.

The frame has specially designed slots and self-positioning nuts that hold the Structures experiments and instruments. This fixing system is quick and easy to use. It allows students to change, position and secure each experiment. Adjustable feet support the frame to allow students to level the apparatus before use.

Supplied in kit form with instructions for use and a textbook.

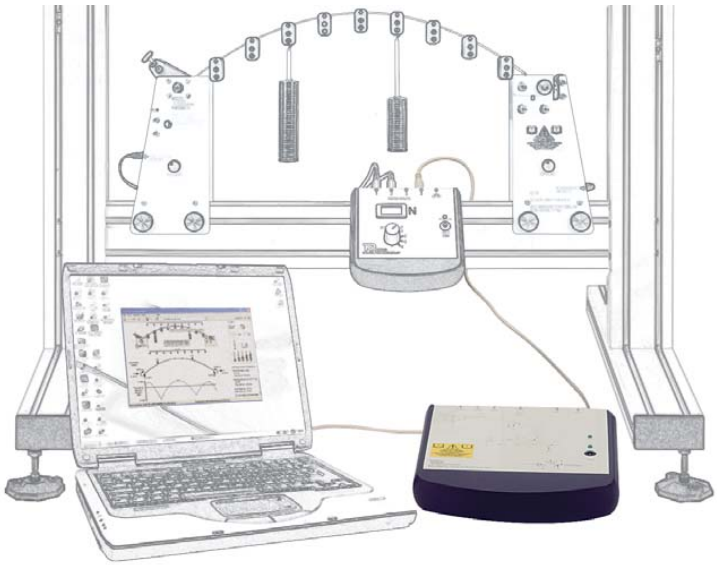
Available Experiment Modules:	Page
• One or more Structures experiment modules (STR2–STR20)	201–220

Test Frame (STR1) fitted with the experiment module Bending Stress in a Beam (STR5) and Digital Force Display (STR1a)

Automatic Data Acquisition Unit (STR2000)

Connects any of the Structures range experiments to a computer – includes TecQuipment's Structures Software for automatic data acquisition and virtual experiments

- Interface unit links to load cells and other instruments in the Structures range to send data to a suitable computer
- Allows students to compare results from actual experiments with results from simulation software
- Fully automatic and simple connection to most modern computers – no need to add any extra circuit boards



The STR2000 computer interface unit shown transmitting data from one of the Structures hardware experiment modules to the Structures Software

The Automatic Data Acquisition Unit is an interface box with software that connects experiments from the TecQuipment Structures range to a suitable computer (computer not included). It allows data logging, analysis and extra 'virtual' simulated experiments. It accepts inputs from a digital force display, a digital strain display, an angular sensor and digital deflection indicators. It converts these inputs into the correct data signals for the computer. The software can then analyse the data and create tables and charts. The software can also simulate experiments which students can perform using the hardware, so they can compare simulated and real results.

Essential Ancillary:

- Suitable computer (not supplied by TecQuipment)

Ancillary for:	Page
• One or more experiment modules from the Structures range (STR2–STR20)	201–220

Digital Force Display (STR1a)

For use with TecQuipment's Structures range, this display shows the forces from up to four force sensors on the Structures experiments

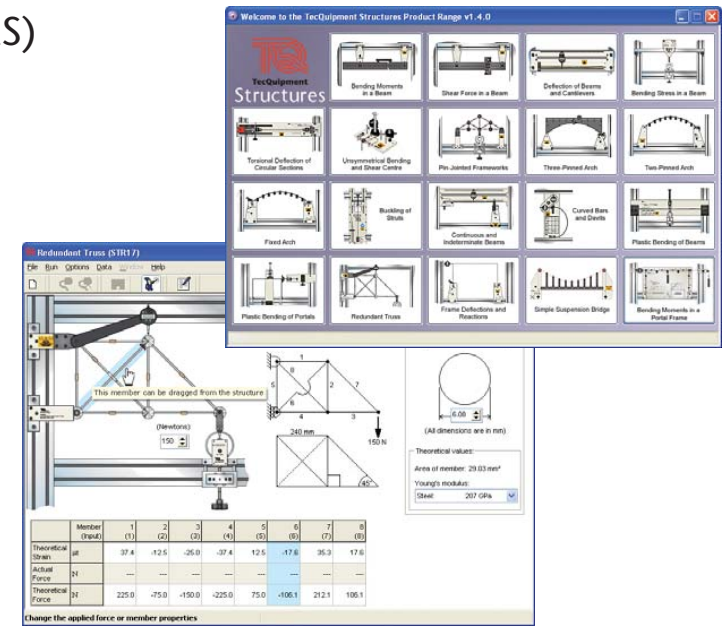
- Fits onto the Structures Test Frame (STR1) to give a tidy work area
- Real-time display of each of up to four forces
- Can connect to TecQuipment's Automatic Data Acquisition Unit (STR2000) to automatically measure all four forces at the same time

The Digital Force Display fixes to a Structures Test Frame (STR1, available separately). This keeps the experiments tidy and saves space around the work area. The display measures up to four forces from sensors on many of the experiments in the TecQuipment Structures range.

A four-way selector switch selects the displayed force. The display automatically adjusts its range to the force. Includes an output to the Automatic Data Acquisition Unit (STR2000, available separately). When used with the STR2000, the Digital Force Display outputs all four force signals at the same time to the Structures Software.

Ancillary for:	Page
• One or more Structures experiment modules (STR2–STR20)	201–220

Structures Software (STRS)



Software that allows computer simulation of structures. Simulates and extends TecQuipment's Structures range

- Accurately simulates all 19 of TecQuipment's Structures range experiments
- Includes user guides with suggested experiments and typical answers
- Gives virtual experiments that extend beyond the limits of the experiment hardware
- Single-user and networked options available

SEE FOR YOURSELF!

Request a copy of our FREE demonstration CD

EXPERIMENTS:

Computer-simulated examination of a wide variety of structures principles, including:

- **Bending moments in a beam**
- **Shear force in a beam**
- **Deflection of beams and cantilevers**
- **Bending stress in a beam**
- **Torsional deflection of circular sections**
- **Unsymmetrical bending and shear centre**
- **Pin-jointed frameworks**
- **Three-pinned arch**
- **Two-pinned arch**
- **Fixed-arch**
- **Buckling of struts**
- **Continuous and indeterminate beams**
- **Curved bars and davits**
- **Plastic bending of beams**
- **Plastic bending of portals**
- **Redundant truss**
- **Frame deflections and reactions**
- **Simple suspension bridge**
- **Bending moments in a portal frame**

TecQuipment's Structures Software is ideal for students of civil, mechanical and structural engineering. It allows them to perform computer-simulated experiments which study the principles of structures.

The Structures Software is the ideal companion to TecQuipment's hardware modules (STR2 to STR20). It includes a simulated form of each hardware module. The software is a useful tool when used on stand-alone or networked computers. TecQuipment offers different network licences, determined by your needs.

The Structures Software expands the scope of each experiment beyond the limits of the hardware. It mimics the hardware but allows students to change and extend many parts of the experiment. Depending on the experiment module, the student can alter different parts of each experiment, including the:

- type and number of supports;
- shape of the structure or specimen;
- material of the structure or specimen;
- Young's modulus of the structure or specimen.

The software also allows students to apply a greater range of loads, often including uniformly distributed loads (which the students cannot apply in many of the hardware experiments). Students can see, tabulate and graph data, reducing the time needed for them to get, process and show results. They can study and compare the properties of a wide variety of different structures.

Note: You can buy the Structures Software (STRS) by itself, but it is also included free with the Automatic Data Acquisition Unit (STR2000).

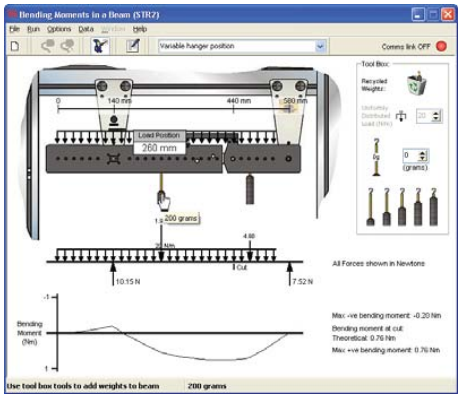
Included are a student guide, with suggested experiments, and a lecturer guide with typical answers.

Essential Ancillary:

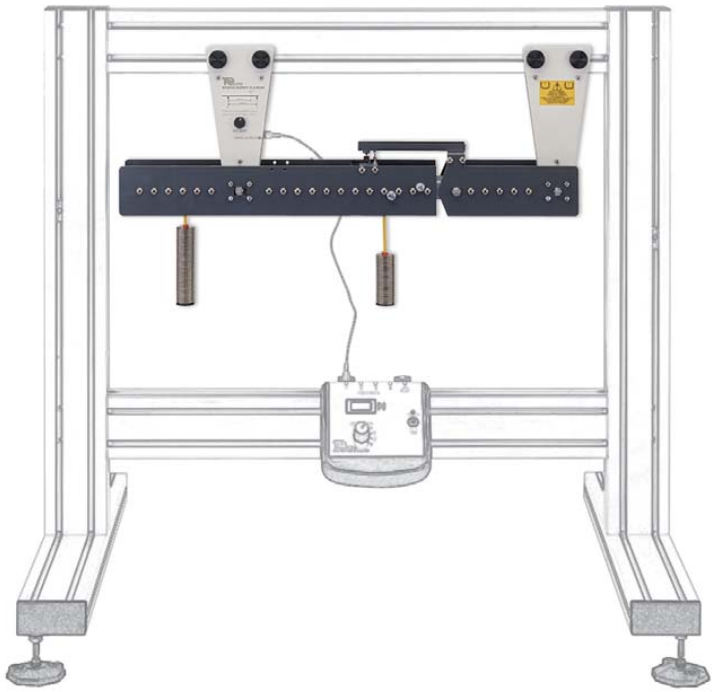
- Suitable computer (not supplied by TecQuipment)

Bending Moments in a Beam (STR2)

Shows and proves the basic theory of bending moments in a beam



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Bending moment variation at the point of loading**
- **Variation of bending moment away from the point of loading**
- **Examination of various other loading cases, including loads traversing the beam**

The experiment hardware is a simply supported beam 'cut' by a pivot. The beam fixes to the Structures Test Frame (STR1, available separately). Students apply loads at set positions using hangers holding various masses. To stop the beam collapsing, a moment arm bridges the cut onto a load cell thus reacting (and measuring) the bending moment force. A Digital Force Display (STR1a, available separately) displays forces during experiments.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software which displays and logs your experiment results and gives the extra virtual experiments.

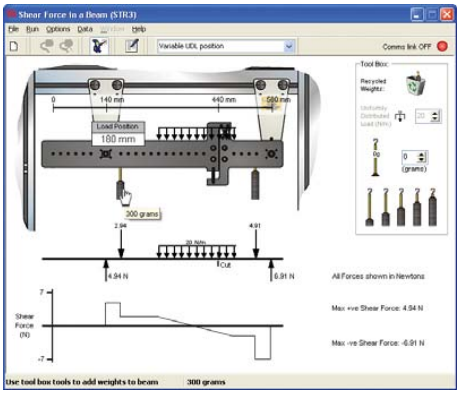
Essential Base Unit:	Page
• Structures Test Frame (STR1)	198

Essential Ancillary:	Page
• Digital Force Display (STR1a)	199

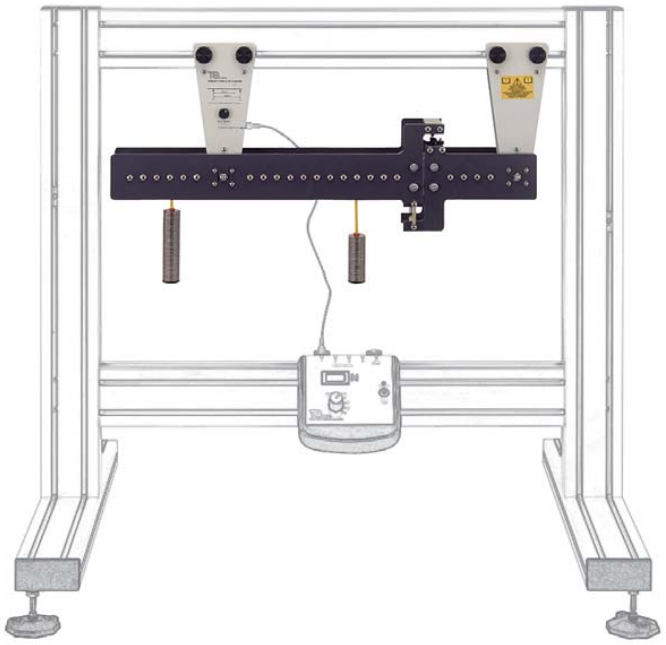
Recommended Ancillary:	Page
• Structures Software (STRS) for virtual experiments	200
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

Shear Force in a Beam (STR3)

Shows and proves the basic theory of shear force in a beam



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Shear force variation with an increasing point load**
- **Variation of shear force for various loading conditions**
- **Examination of various other loading cases and their effect on shear force, including loads traversing the beam**

The experiment hardware is a simply supported beam with a 'cut'. The beam fits onto a Structures Test Frame (STR1, available separately).

A mechanism bridges the cut, which stops the beam collapsing and allows movement in the shear direction only. An electronic load cell measures the force, and connects to a Digital Force Display (STR1a, available separately). Students apply loads at set positions using hangers holding various masses.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software which displays and logs your experiment results and gives the extra virtual experiments.

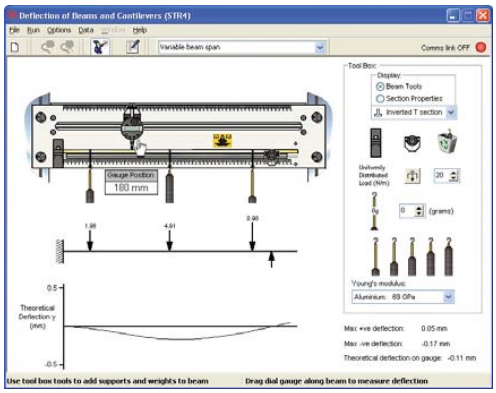
Essential Base Unit:	Page
• Structures Test Frame (STR1)	198

Essential Ancillary:	Page
• Digital Force Display (STR1a)	199

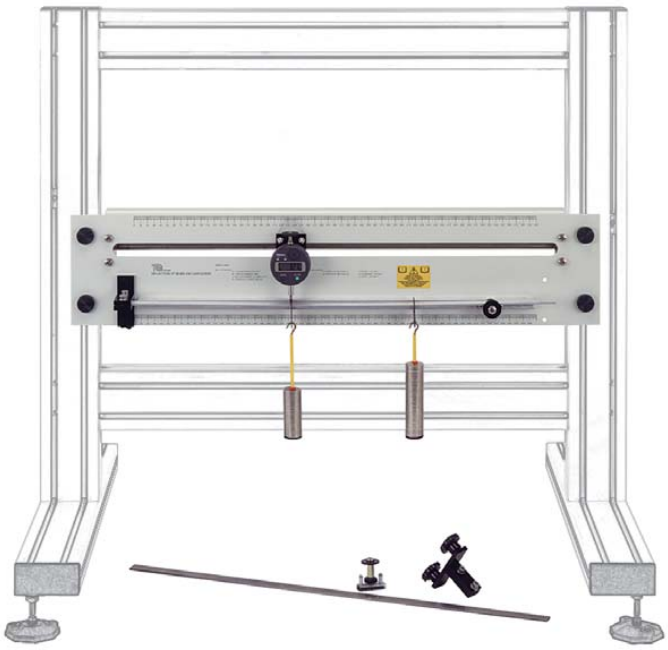
Recommended Ancillary:	Page
• Structures Software (STRS) for virtual experiments	200
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

Deflection of Beams and Cantilevers (STR4)

For study of beam deflection under different loads and fixing conditions



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

Examination of:

- **Beam deflections**
- **General bending formulae**
- **Beam end rotations**
- **Elastic moduli (Young's modulus) for various materials**

Typical conditions are:

- **Cantilever**
- **Propped cantilever**
- **Encastré beam**
- **Simply supported beam**

The experiment hardware consists of a backboard that fixes to the Structures Test Frame (STR1, available separately). Test beams fit onto the backboard using a rigid clamp and knife-edge supports. Students apply loads at any position using hangers holding various masses. Mounted on a trammel, a digital deflection indicator traverses the beam. The indicator measures beam deflection. Scales on the backboard show the position of the indicator, the loads and supports.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

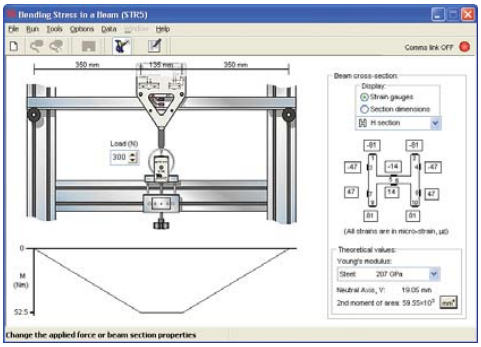
Essential Base Unit:	Page
• Structures Test Frame (STR1)	198

Recommended Ancillary:	Page
• Structures Software (STRS) for virtual experiments	200
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

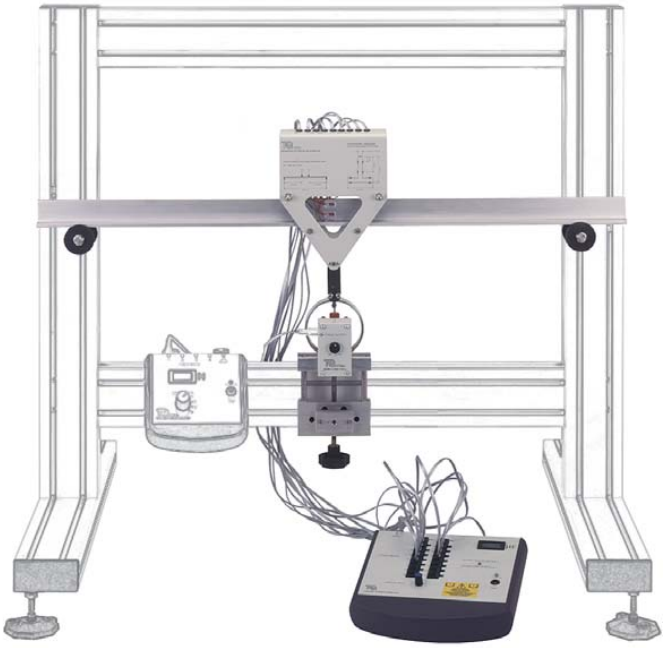
Alternative Products:	Page
• Stiffness of Materials and Structures (TE16)	156
• Continuous and Indeterminate Beams (STR13)	212
• Beam Apparatus (SM1004)	178
• Beam and Leaf Spring (SM1000g)	172
• Deflection of Beams Kit (ES4)	12

Bending Stress in a Beam (STR5)

For study of stress distribution across the section of a beam



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

Study of:

- **Second moment of area**
- **Converting strains to stresses**
- **Strain gauges**
- **The neutral axis**
- **The bending equation**

The experiment hardware is a T-beam that fits onto a Structures Test Frame (STR1, available separately).

Students adjust a load cell that bends the beam and, when connected to the optional Digital Force Display (STR1a, available separately), it measures the bending force (load). Strain gauges and a digital strain bridge measure the strains in the beam. Dummy strain gauges compensate for temperature variation and balance the strain bridges. The equipment includes a lead for connection to the Digital Force Display (STR1a, available separately).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests that you do with the hardware. They also extend the choice of tests than that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

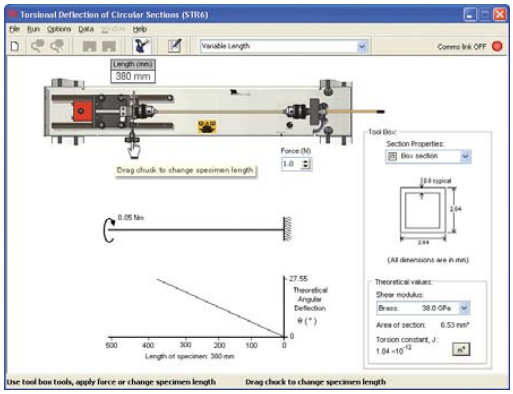
Essential Base Unit:	Page
• Structures Test Frame (STR1)	198

Essential Ancillary:	Page
• Digital Force Display (STR1a)	199

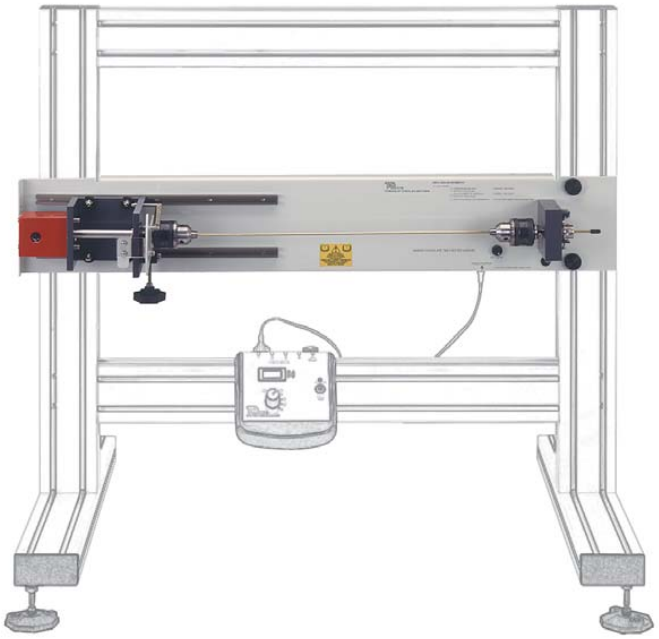
Recommended Ancillary:	Page
• Structures Software (STRS) for virtual experiments	200
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

Torsion of Circular Sections (STR6)

For study of torque and deflection in different materials with circular section



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

Study of:

- **The relationship between specimen length, torque and angular deflection**
- **The behaviour of specimens of different material and sections**
- **General torsion theory**
- **Shear modulus**
- **Polar moment of inertia**

The experiments hardware fits onto a Structures Test Frame (STR1, available separately). It examines the behaviour in the elastic region of solid and tubular-section specimens.

Two chucks on a backboard hold a test specimen. A mechanism on one chuck applies torque manually to the specimen. A protractor scale on this chuck measures angular movement. A load cell on the other chuck measures torque. The equipment includes a lead to connect the load cell to a Digital Force Display (STR1a, available separately). To vary the test length of a specimen, one chuck can traverse the backboard. Included is an electronic angular transducer for use with the optional Automatic Data Acquisition Unit (STR2000).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software which displays and logs your experiment results and gives the extra virtual experiments.

Essential Base Unit:	Page
• Structures Test Frame (STR1)	198

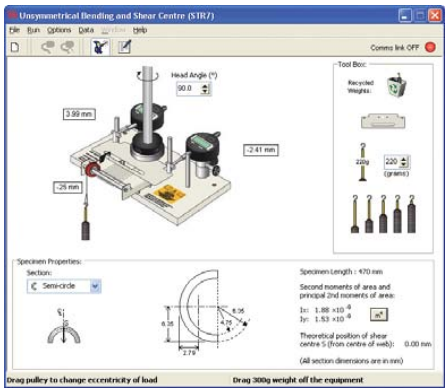
Essential Ancillary:	Page
• Digital Force Display (STR1a)	199

Recommended Ancillary:	Page
• Structures Software (STRS) for virtual experiments	200
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

Alternative Products:	Page
• Additional Torsion Testing Kit (TE16b)	156
• Torsion Testing Machine (SM1001)	164
• Torsion of Circular Sections Kit (ES5)	13

Unsymmetrical Bending and Shear Centre (STR7)

For study of vertical and horizontal deflection of different asymmetric (unsymmetrical) sections



Screenshot of the optional TecQuipment Structures Software

EXPERIMENTS:

Study of:

- **Horizontal and vertical deflection of different asymmetrical sections at various angles**
- **Horizontal and vertical deflection of different asymmetrical sections under various loads**
- **Relationship between the vertical and horizontal deflections and the principal moments of area of each section**
- **Shear centre of various asymmetrical sections**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). It examines the vertical and horizontal deflection of different asymmetrical sections at various angles and loads.

Two multi-way chucks hold a test specimen vertically. One chuck has an indexing system for rotating the beam in set increments. This changes the angle of loading. The other chuck and a weight hanger applies a variable load. Two digital deflection indicators measure deflection in the x and y directions. An interchangeable plate allows students to find the shear centre of the specimen.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Essential Base Unit:	Page
• Structures Test Frame (STR1)	198

Recommended Ancillary:	Page
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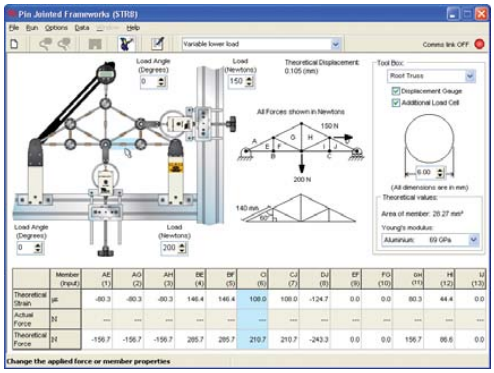
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

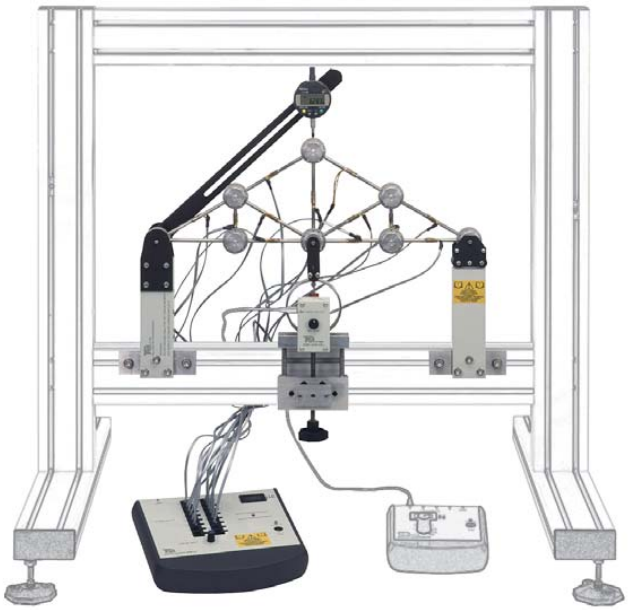
Alternative Product:	Page
• Unsymmetrical Cantilever (SM1003)	177

Pin-Jointed Frameworks (STR8)

For study of the strains, stresses, forces and deflections in various pin-jointed frameworks



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Study of Bow's notation, strains, stresses, forces and deflections in various frameworks, including a Warren girder and roof truss**
- **Comparison of different frameworks**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students use stainless-steel members to build different pin-jointed frameworks. The members join by slotting the ends into bosses.

The equipment includes two framework supports: a pivoting support, and a pivoting and rolling support. Each member has a strain gauge attached that connects to a digital strain bridge. A load cell applies loads to the structure at various angles. When connected to the optional Digital Force Display (STR1a), the load cell measures the applied load. To apply loads simultaneously, extra load cells are available (STR8a).

A digital deflection indicator measures the deflection and the digital strain bridge shows the strains in the members. From this, students can calculate the forces in the members.

TecQuipment supplies the members in a custom-made storage tray to avoid accidental damage. A second tray stores the joint bosses and other loose items.

Included is a lead to connect the load cell to a Digital Force Display (STR1a, available separately). The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

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Essential Ancillary:	Page
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Recommended Ancillaries:	Page
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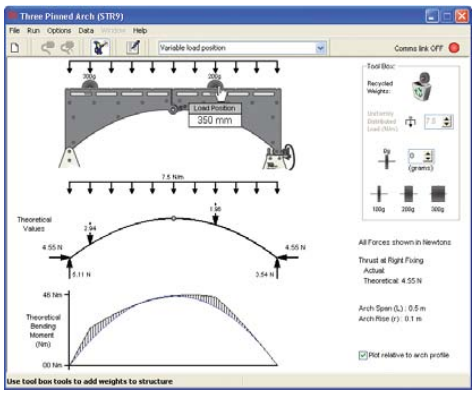
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199
• Additional Load Cell (STR8a)	

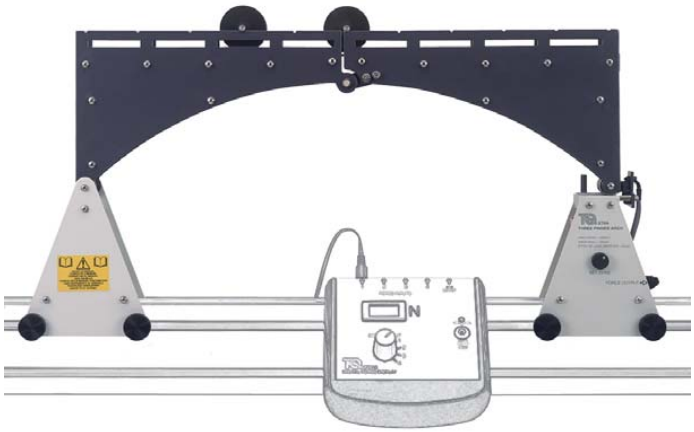
Alternative Product:	Page
• Redundant Truss (STR17)	217

Three-Pinned Arch (STR9)

For studying the characteristics of a three-pinned arch under various load conditions



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

Studies of:

- **The characteristics of a three-pinned arch**
- **The relationship between applied loads and horizontal thrust produced from a simple determinate arched structure**

Also:

- **Appreciation of footing stability and economy.**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students apply various loads at set positions along the top of a simple 'determinate' three-pinned arched structure. They can also apply a uniformly distributed load (UDL).

The structure has a pivot at one end and at the crown. The arch rolls against a load cell at the opposite end. The load cell connects to a Digital Force Display (STR1a, available separately) to measure and display the thrust reaction. The equipment includes a lead to connect the load cell to a Digital Force Display (STR1a).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

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Recommended Ancillary:	Page
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or	
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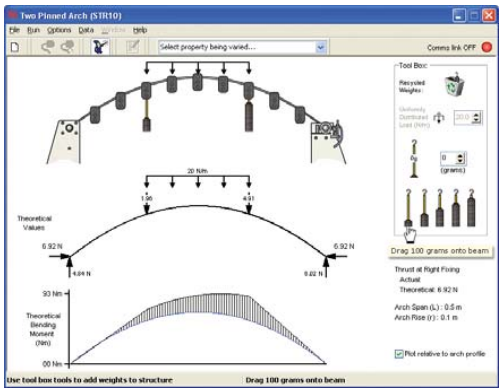
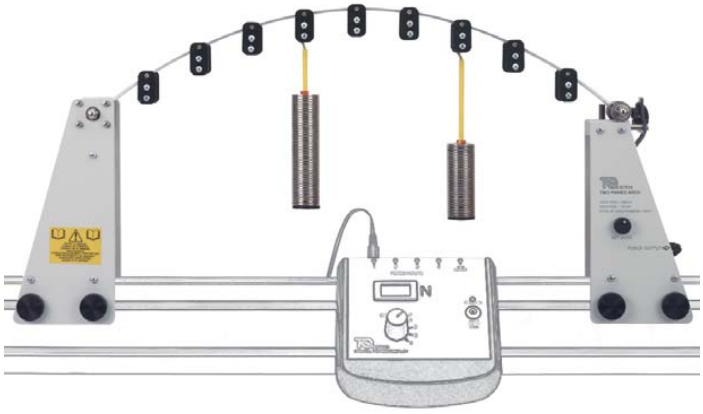
Alternative Products:	Page
• Two-Pinned Arch (STR10)	209
• Fixed Arch (STR11)	210

Two-Pinned Arch (STR10)

For studies of the characteristics of a two-pinned arch under various load conditions



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Demonstration of the characteristics of a two-pinned arch**
- **Examination of the relationship between applied loads and horizontal thrust produced from a redundant (in one degree) arched structure**
- **Comparison of behaviour to simplified theory based on the Secant assumption**

The experiment hardware fits onto the Structures Test Frame (STR1, available separately). Students use masses on weight hangers to apply various loads to the arch at set positions along its span.

One end of the arch is pivoted, the other end rolls against a load cell. When connected to a Digital Force Display (STR1a, available separately), the load cell measures the thrust reaction. The equipment includes a lead to connect the load cell to a Digital Force Display (STR1a).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

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Recommended Ancillary:	Page
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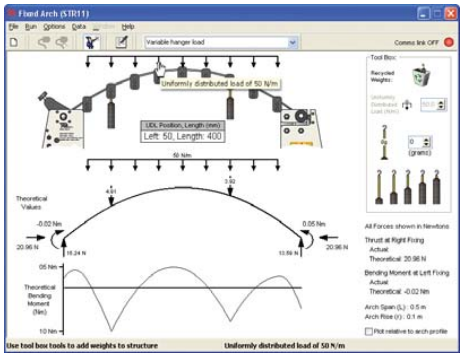
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

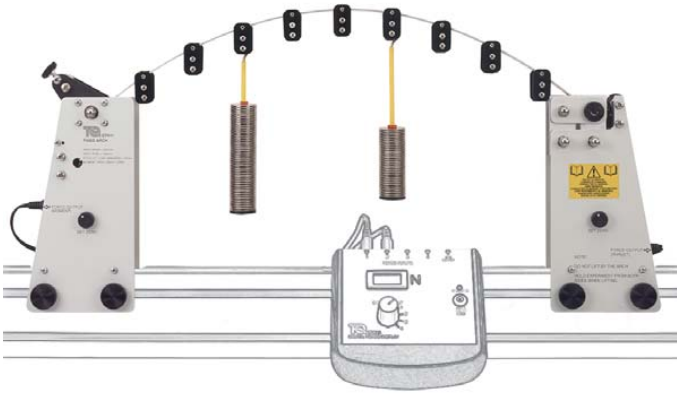
Alternative Products:	Page
• Three-Pinned Arch (STR9)	208
• Fixed Arch (STR11)	210

Fixed Arch (STR11)

For studying the characteristics of a fixed arch under various load conditions



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Demonstration of the characteristics of a fixed arch**
- **Examination of the relationship between applied loads, horizontal thrust and fixing moment produced from a fixed (thus redundant in three degrees) arched structure.**
- **Comparison of behaviour to simplified theory based on the Secant assumption.**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). To load the arch, students fit masses on weight hangers to set positions along the arch span.

Both ends of the arch are fixed. At one end of the arch, a moment arm rests on a load cell. This measures the fixed moment reaction. At the other end, a load cell measures the horizontal thrust. The equipment includes leads to connect the load cells to a Digital Force Display (STR1a, available separately).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

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Recommended Ancillary:	Page
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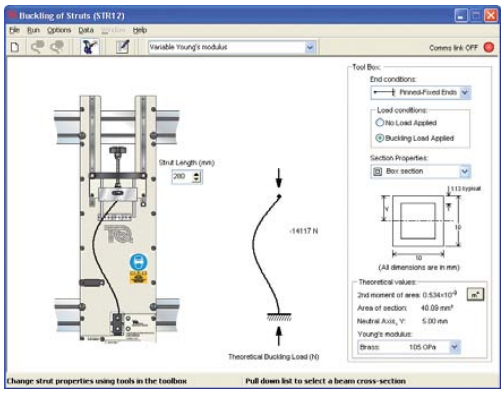
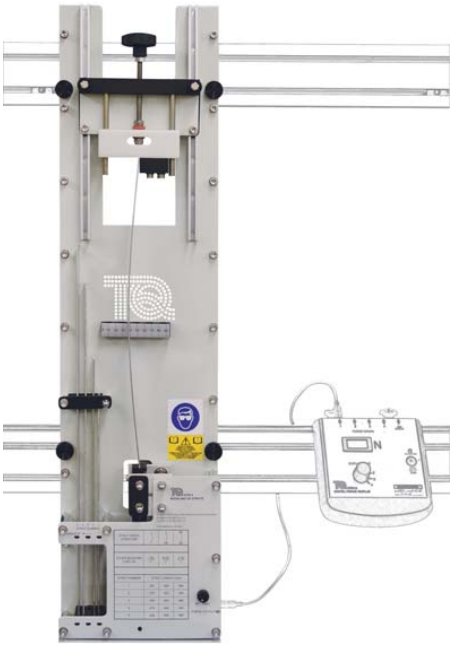
Alternative Products:	Page
• Three-Pinned Arch (STR9)	208
• Two-Pinned Arch (STR10)	209

Buckling of Struts (STR12)

For studying buckling of slender columns and relationships between length, end-fixing conditions and buckling load



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Euler buckling loads**
- **Relationship between strut length and collapse load**
- **Relationship between various end-fixing conditions and collapse load**
- **Nature of deflection and deflected shapes with various end-fixing conditions**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students compress aluminium columns (struts) using a screw mechanism. The equipment uses chucks to hold the struts and allows different end-fixing conditions. An integral load cell connected to a Digital Force Display (STR1a, available separately) displays the load on the strut as it is compressed. A magnetic deflection scale shows how much the strut buckles. Students continue compressing the strut until reaching the critical buckling load. They then repeat the experiment using different strut lengths or fixing conditions, analysing their results.

The equipment includes strut storage space and five different sizes of aluminium strut.

The lecturer guide provides details of the equipment including sample experiment results.The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

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Recommended Ancillary:	Page
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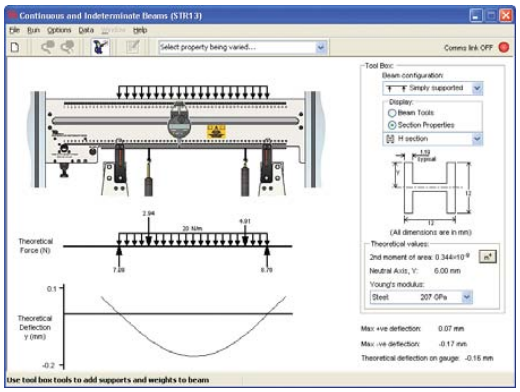
Alternative Product:	Page
• Loading and Buckling of Struts (SM1005)	181

Continuous and Indeterminate Beams (STR13)

Versatile equipment for a wide variety of beam experiments, from simple cases to complex problems



Screenshot of the optional TecQuipment Structures Software

EXPERIMENTS:

- **Reactions of a simply supported beam**
- **Reactions of a two-span continuous beam**
- **Reactions and fixing moments of a fixed beam and a propped cantilever**
- **Reaction and fixing moment of a propped cantilever with a sinking support**
- **Relationship between load and deflection for beams and cantilevers**

This equipment allows many possible experiment configurations, using a stiff (rigid) beam, or a significantly more flexible beam.

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students rest a beam on up to three 'piers'. The piers are movable, so students can arrange them in many different positions under the beam. Students use masses on weight hangers to load the beam.They can also attach the flexible beam to a backboard to measure deflection or fixing moment.

The piers each contain a load cell to measure vertical reactions. These connect to a Digital Force Display (STR1a, available separately). Two of the load cells have knife-edge supports, which students can either fix or allow to sink by a set displacement. The third pier load cell allows students to either clamp the beam (encastré fixing) or rest the beam on a knife edge. The unique design of this equipment allows the load cell to resist the bending moment while accurately measuring the vertical reaction. To measure beam deflection, the backboard has a digital indicator which students move along the beam. The backboard also has a mechanism for measuring the fixing moment of a propped cantilever or a fixed beam.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

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Essential Ancillary:	Page
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Recommended Ancillary:	Page
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or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

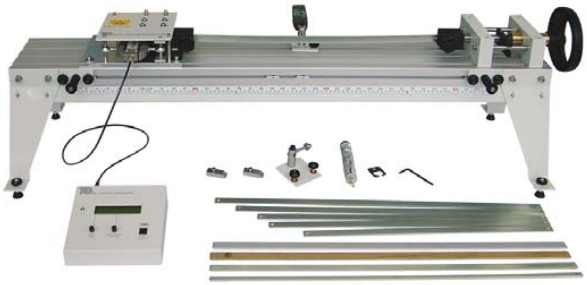
Alternative Products:	Page
• Stiffness of Materials and Structures (TE16)	156
• Beam and Leaf Spring (SM1000g)	172
• Beam Apparatus (SM1004)	178
• Deflection of Beams and Cantilevers (STR4)	203
• Deflection of Beams Kit (ES4)	12

Have you also seen our Materials Testing range?

Our Materials Testing and Properties range (Section 6) also extends into the area of structures and structural elements and includes the following free-standing products:

Unsymmetrical Cantilever Apparatus (SM1003) – Page 177
Examines and displays bending of an unsymmetrical cantilever

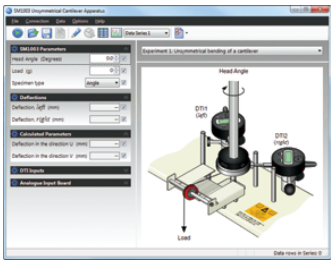
Beam Apparatus (SM1004) – Page 178
Examines the deflection and forces on different types of beams for a wide range of supports and loads



Loading and Buckling of Struts (SM1005) – Page 181
Tests different types of struts and shows how they deflect under load

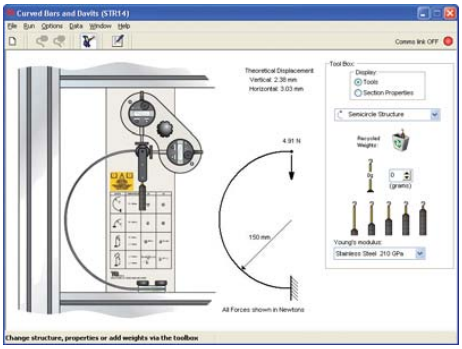
VDAS®

The above equipment is compatible with TecQuipment's Versatile Data Acquisition system (VDAS®). This gives accurate real-time data capture, monitoring and display, calculation and charting of all important readings on a computer – see page 32.



Curved Bars and Davits (STR14)

For students to investigate two common curved structures and two common davit structures



Screenshot of the optional TecQuipment Structures Software

EXPERIMENTS:

Investigation of the relationship between load, horizontal deflection and vertical deflection for:

- **Curved davit**
- **Angled davit**
- **Semicircle structure**
- **Quarter-circle structure**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Included are four different structures. Students attach one of the structures in front of the hardware module, directly onto the test frame. They then apply loads to the structure using masses on hangers.

Two digital deflection indicators, set at 90 degrees to each other on the backboard, contact the structure and so measure horizontal and vertical deflection. The digital deflection indicators are on a magnetic base so students can move them to anywhere on the backboard.

As students load a structure they note the horizontal and vertical deflections, thus investigating the structure behaviour. They then compare this behaviour with theoretical predictions.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

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or	
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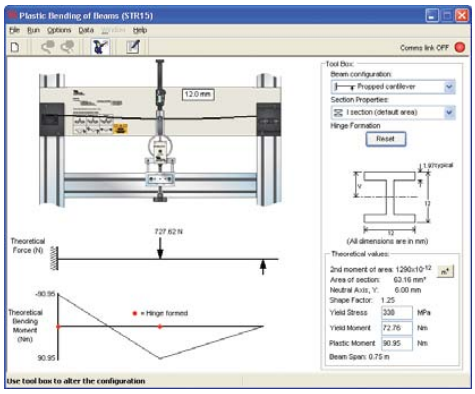
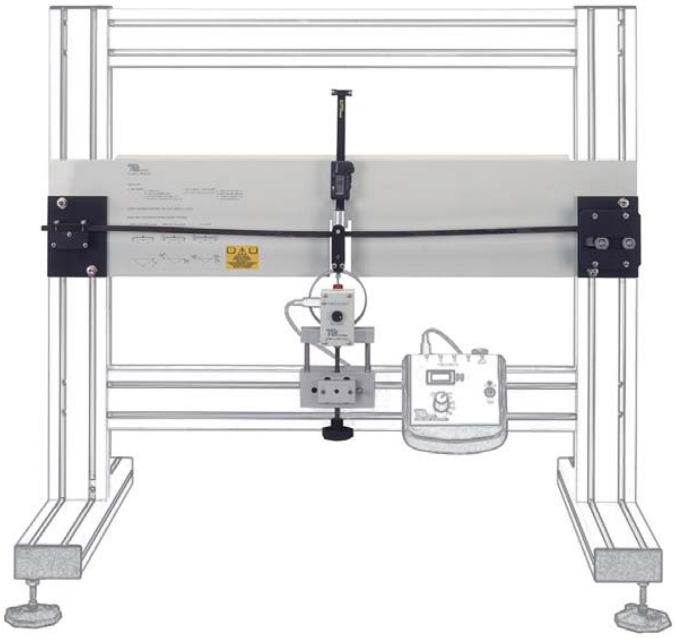
Plastic Bending of Beams (STR15)

Introduces students to plastic theory and limit state design



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Relationship between load and deflection for beams loaded to the plastic condition**
- **Introduction to form factor**
- **Introduction to limit state design**
- **Relationship between maximum loading and plastic hinge formation for a simply supported beam, a propped cantilever and a fixed beam**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students fix a specimen beam in chucks at both ends of a backboard. The chucks can either clamp the beam (encastré fixing), or hold it on a knife-edge. The students then load the beam using a screw mechanism and electronic load cell.

The load cell connects to a Digital Force Display (STR1a, available separately) which displays the load as the beam deforms. A long-travel digital deflection indicator on the backboard measures specimen deformation. To compensate for the specimen shortening as it deforms, one of the chucks moves along the backboard, relative to the deformation.

Students continue to apply a load until the specimen beam is in the fully plastic condition, that is, the beam has undergone plastic collapse. They then compare the beam behaviour with theoretical predictions based on traditional yield stress theory.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Essential Base Unit:	Page
• Structures Test Frame (STR1)	198

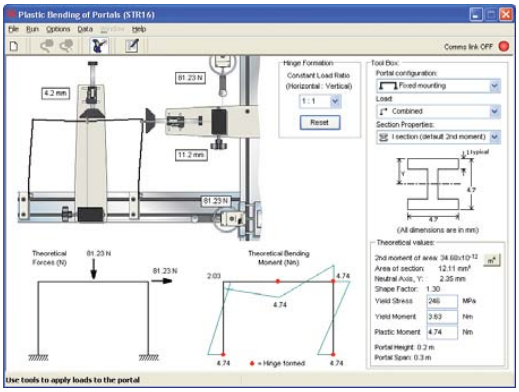
Essential Ancillary:	Page
• Digital Force Display (STR1a)	199

Recommended Ancillary:	Page
• Specimen Beams Pack (STR15a)	
• Structures Software (STRS) for virtual experiments	200
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

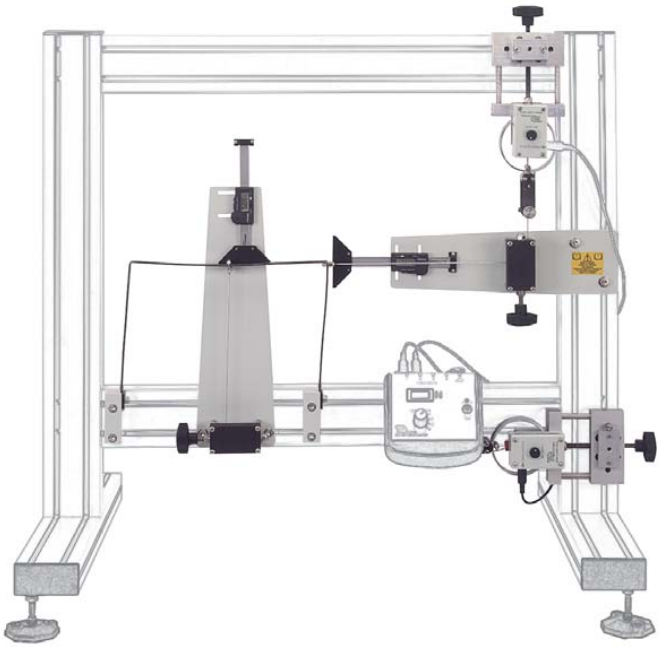
Alternative Product:	Page
• Beam and Leaf Spring (SM1000g)	172

Plastic Bending of Portals (STR16)

For studying plastic theory and limit state design in portal frames



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Relationship between load and deflection for portal frames loaded to the plastic condition**
- **Introduction to limit state design**
- **Relationship between maximum loading and plastic hinge formation in portal frames loaded vertically from the centre, horizontally from one corner, and equally from both positions**
- **Interaction between horizontal and vertical loading in terms of plastic hinge position and mode of collapse**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students fix a specimen portal frame (two uprights with a cross-beam at the top) to the bottom cross-piece of a test frame. The test frame also holds horizontal and vertical screw mechanisms with electronic load cells for loading the portal frame.

Students set the portal frame load conditions by arranging the load cell screw mechanisms to provide either single or combined loads. They then load the portal frame manually by adjusting the screw mechanisms. The electronic load cells connect to a Digital Force Display (STR1a, available separately) that shows the horizontal and vertical loads as the portal frame deforms. Two long-travel digital deflection indicators measure the portal frame deformation.

Students continue to load the portal frame until it is in the fully plastic condition, that is, it has undergone plastic collapse. They monitor the collapse load, deformations, and note where plastic hinges formed during collapse. Packs containing 12 extra specimen portal frames are available separately (STR16a).

Ideally, students should use the Plastic Bending of Beams experiment (STR15) before progressing to Plastic Bending of Portals. The Plastic Bending of Beams experiment provides a basic understanding of underlying principles, such as plastic deformation and form factor.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

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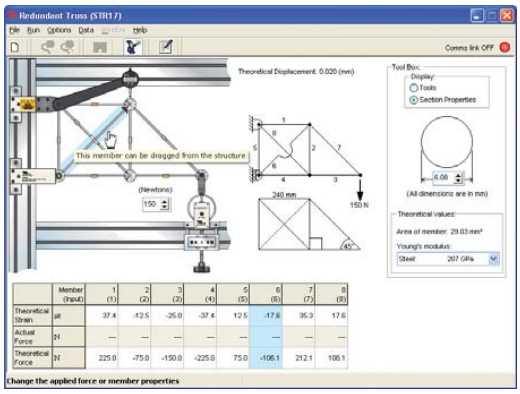
Essential Ancillary:	Page
• Digital Force Display (STR1a)	199

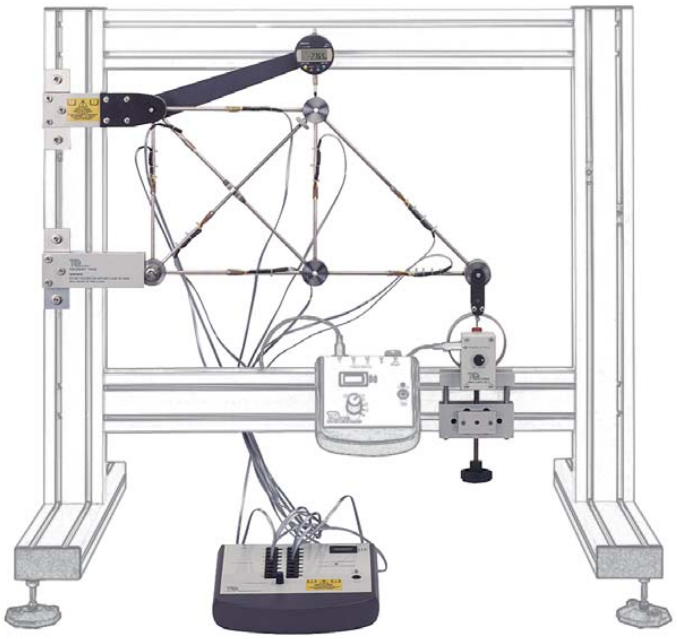
Recommended Ancillaries:	Page
• Specimen Portal Frame Pack (STR16a)	
• Structures Software (STRS) for virtual experiments	200
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	199

Redundant Truss (STR17)

For studying determinate and indeterminate structures



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

Study of strains, stresses, forces and deflections in a:

- **statically determinate structure; and**
- **statically indeterminate structure.**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Two supports hold the top and base of one side of a structure. The top support allows pivoting, the base support allows pivoting and rolling. Initially, one of the members is missing from the structure, making it determinate. To make the structure indeterminate, students refit the missing member.

Students manually apply a load to one end of the determinate framework using a screw-thread and electronic load cell. The load cell connects to a Digital Force Display (STR1a, available separately) which shows the applied load.

Each member of the structure has strain gauges attached. These each connect to a digital strain bridge which shows the member strains. Students use the strains to help them calculate the forces in the structure. A digital deflection indicator measures displacement in the structure.

Students note applied load, strains and deflection in a determinate framework. They then repeat the experiment with the frame made indeterminate, and analyse and compare their results.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

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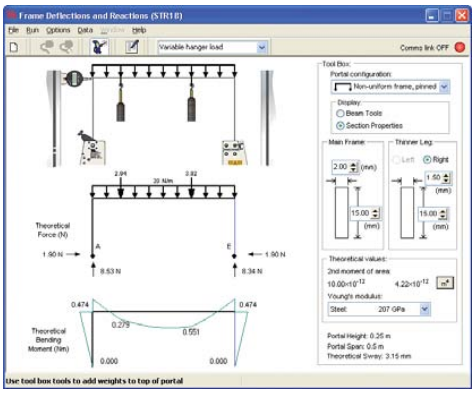
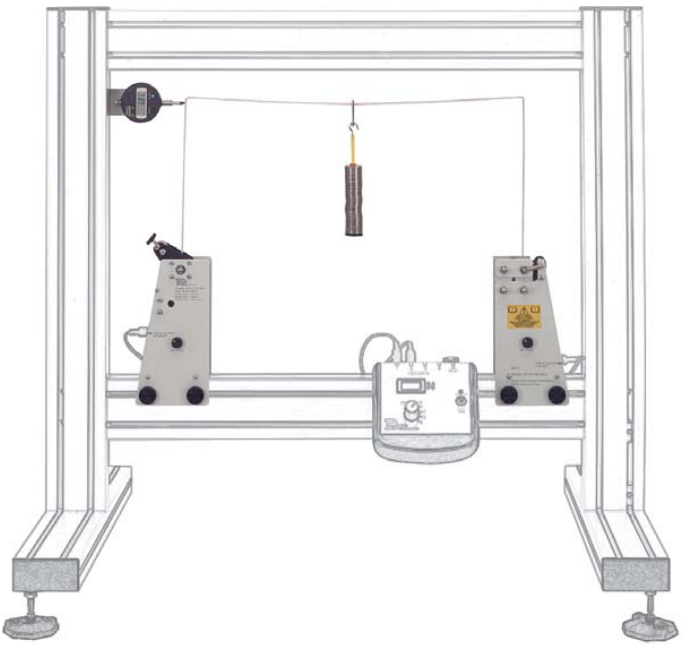
Alternative Product:	Page
• Pin-Jointed Frameworks (STR8)	207

Frame Deflections and Reactions (STR18)

For studying rectangular portals subjected to vertical loads



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

Study and comparison of load, horizontal reactions, fixing moments, sway and shear forces in a:

- **rectangular portal with a uniform section; and**
- **rectangular portal with a non-uniform section.**

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). The hardware includes two rectangular portal frames with the same dimensions. However, one of the frames has a constant second moment of area, while the other has one leg with a smaller second moment of area.

Students clamp each leg of one of the portal frames to supports attached to the test frame. They then load the top of the portal frame using masses on a hanger. Load cells on the supports connect to a Digital Force Display (STR1a, available separately). These measure the moment at one end of the portal frame and the horizontal reaction at the other. A digital deflection indicator measures sway at the top of the portal frame.

Students use the results of moments and reactions to plot bending moment diagrams. They compare the bending moment diagrams, the direction of sway (and its causes) to theoretical calculations. They then repeat the experiment using the other portal frame.

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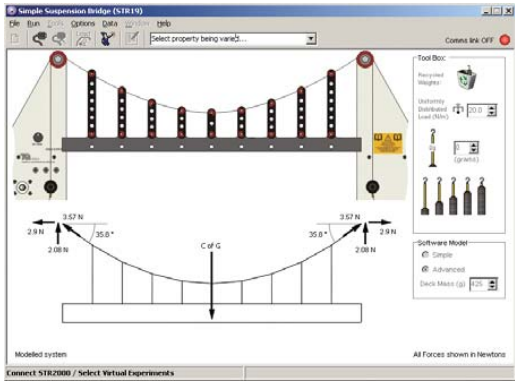
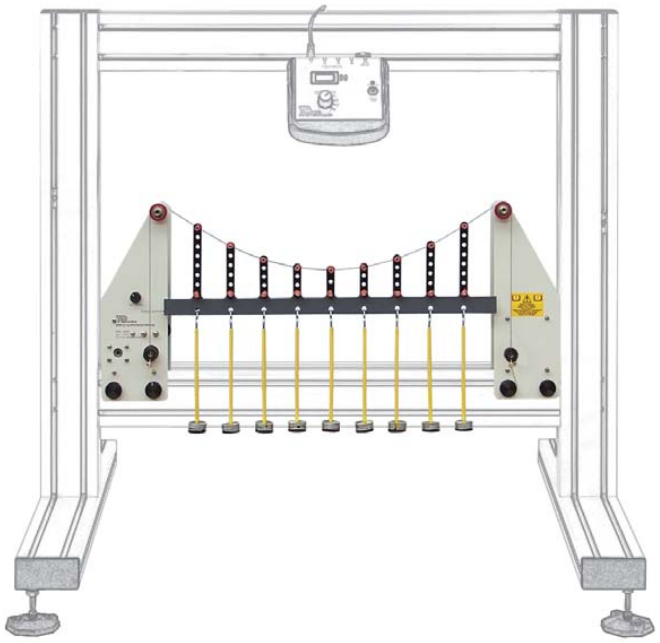
• Bending Moments in a Portal Frame (STR20)	220

Simple Suspension Bridge (STR19)

For studying characteristics of a simple suspension bridge



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Demonstration of the characteristics of a simple suspension bridge**
- **Examination of the relationship between applied loads and the suspension cable tension**
- **Observation of the stability of the structure**
- **Comparison of behaviour to simplified cable theory**

The experiment hardware fits onto the Structures Test Frame (STR1, available separately). Students use masses on weight hangers to apply various loads to a rigid deck, joined to a parabolic cable via hangers.

The suspension cable passes over pulleys at each end. One end is rigidly fixed. The other end connects to a mechanism bearing on a load cell. When connected to a Digital Force Display (STR1a, available separately), the load cell measures the cable tension. The equipment includes a signal cable to connect the load cell to a Digital Force Display (STR1a).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the students' learning experience.

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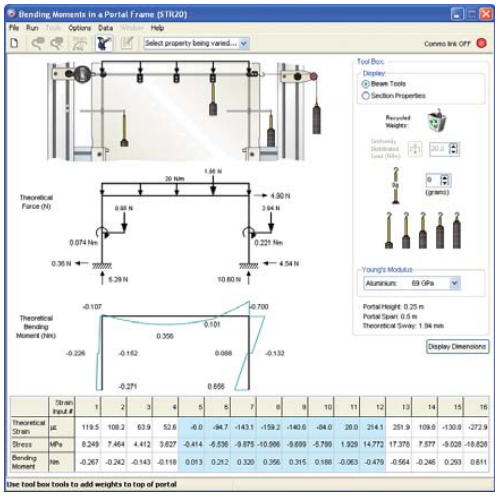
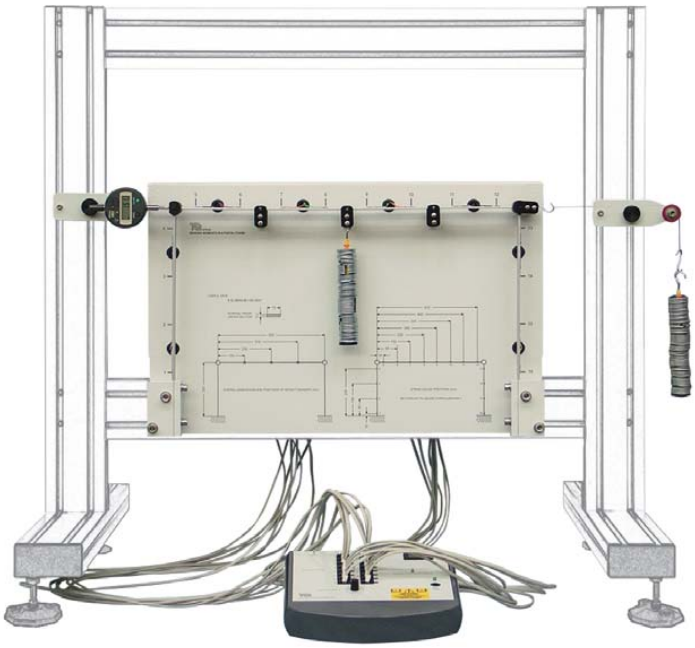
Bending Moments in a Portal Frame (STR20)

For studying bending moments and sway in portal frames



Screenshot of the optional TecQuipment Structures Software



EXPERIMENTS:

- **Strain gauge linearity**
- **Using strain measurement to find the bending moment**
- **Bending moments and sway for vertical and horizontal loads**
- **Bending moments for internal and external moments on vertical members**
- **Comparison of ideal and non-ideal structures**

The experiment hardware fits onto the Structures Test Frame (STR1, available separately). Students use masses on weight hangers to apply various loads to a portal frame. A backplate holding the portal fits to the test frame. The portal has three members: a horizontal beam and two vertical members or 'legs' joined at two upper corners. All members are of the same material and have the same flexural rigidity (IE value).

The backplate holds the bottom of the portal legs to form rigid fixings. The portal has 16 strain gauges: eight along its horizontal member and four along each vertical member. The gauges connect to the Structures digital strain display (supplied) to display their measured strain. As students apply loads, they use the measured strain to find the bending moment at the gauge positions and plot them on a diagram. They can then check the diagram against one created from theory.

The hardware includes a digital indicator to measure horizontal deflection (sway) in the portal. It also includes a pulley bracket so students can apply horizontal loads and compare sway direction with that predicted from theory. The hardware also includes two removable moment arms. Students may fit one or both moment arms to the frame to simulate internal or external floor supports on the sides of a portal structure. Students can find the bending moments caused by these supports and compare with theory.

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