DefleX®

DIGITAL IMAGE CORRELATION
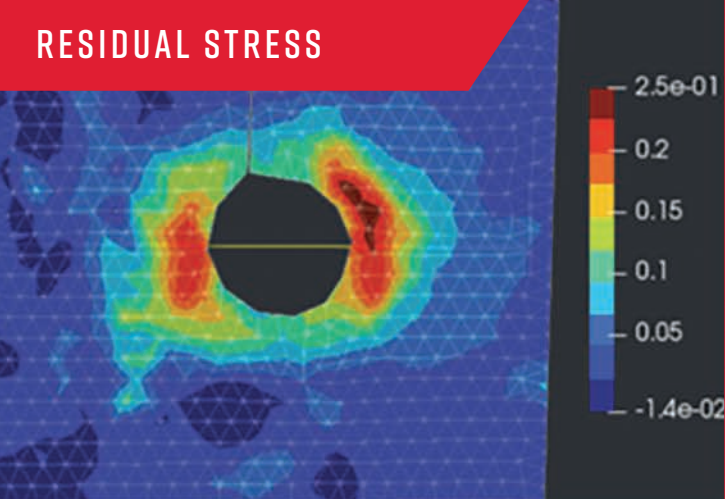
TQ TECQUIPMENT
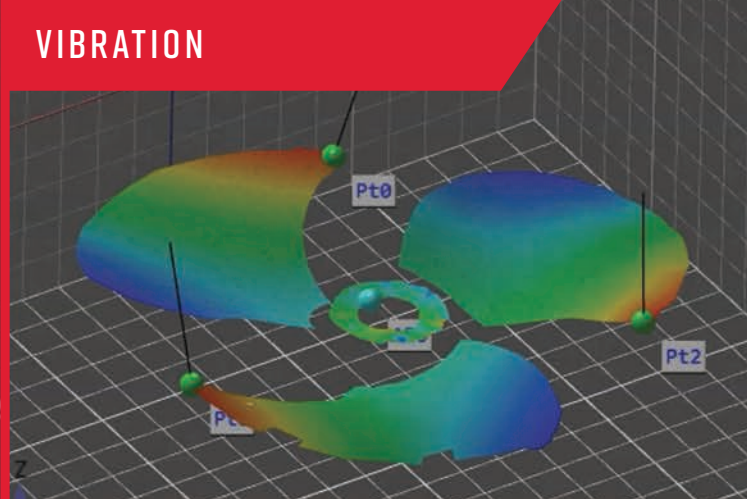

DefleX®-2D

DefleX®-3D

P=0 | 1.1752 | mm

RESIDUAL STRESS

2.5e-01	
0.2	
0.15	
0.1	
0.05	
-1.4e-02	

VIBRATION

Pt0

Pt2
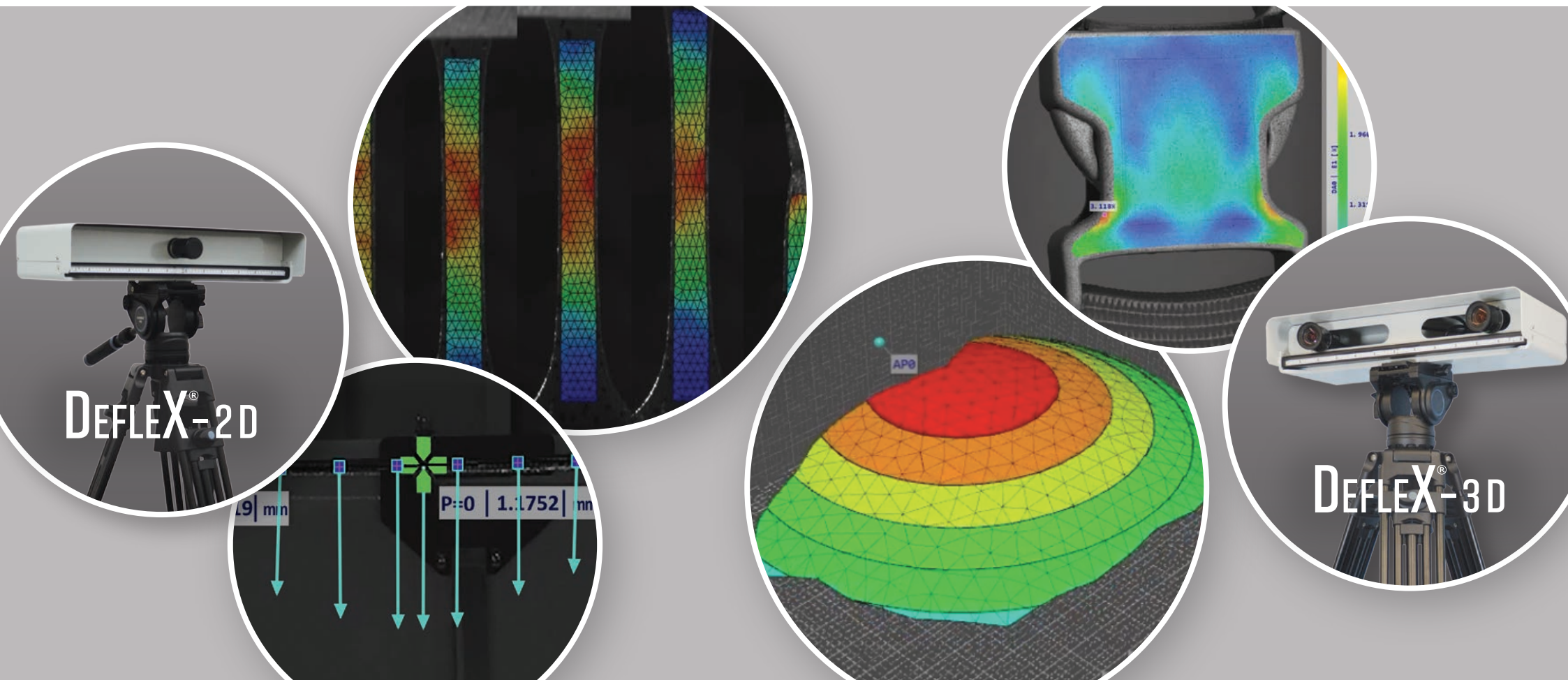
TORSION
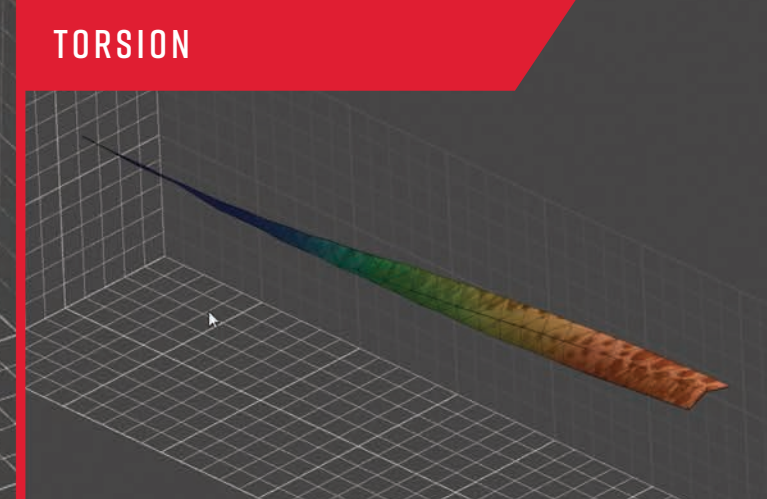
DEFLECTION

MOTION

40 4.8e+01
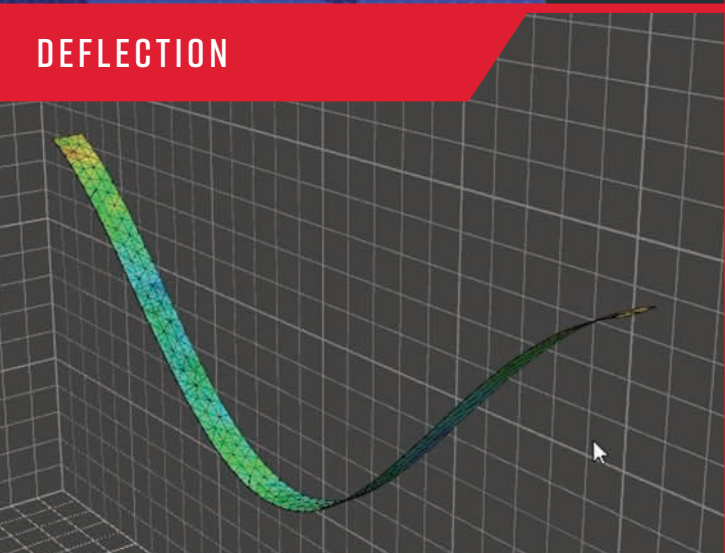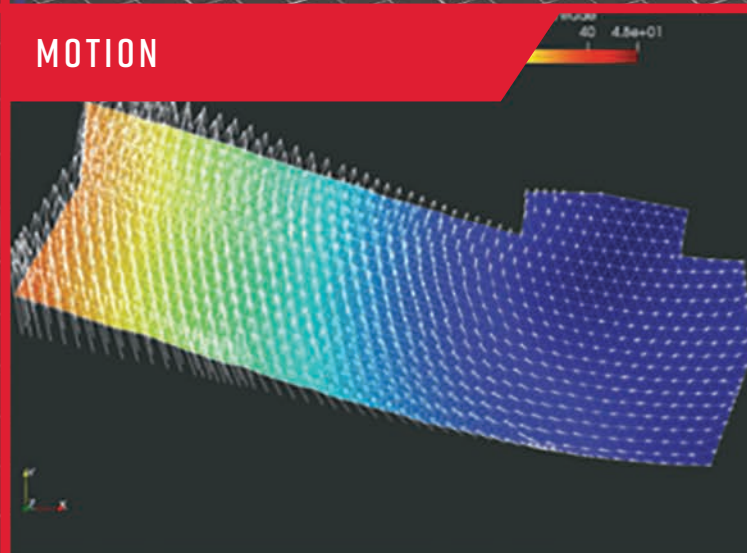
ADHESION

CRACK PROPAGATION

DA0 | E1 [%]

| 3.548 |
| 2.826 |
| 2.104 |
| 1.382 |
| 0.660 |
| -0.062 |

EXTENSION/COMPRESSION

DA0 | DeltaY

| -0.734 |
| -1.467 |
| -2.201 |
| -2.935 |
| -3.668 |

BLC Strain Distribution X

| -0.074 |
| -2.489 |
| -5.052 |
| -7.615 |
| -10.178 |
| -12.741 |
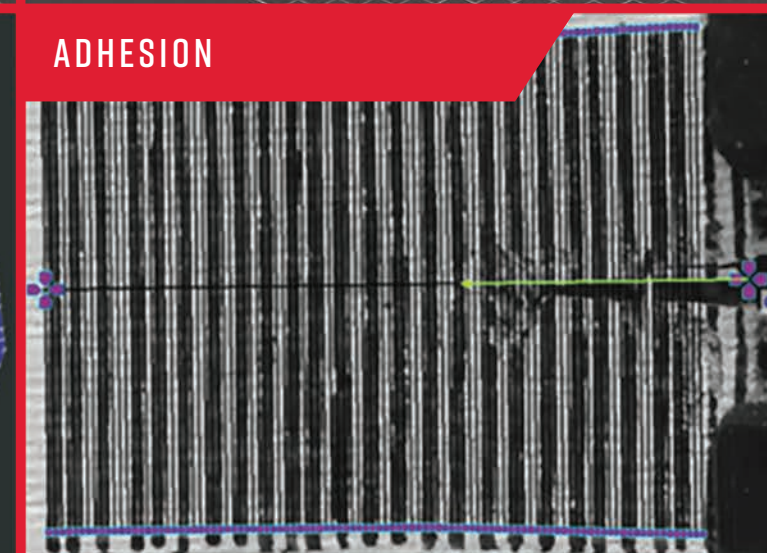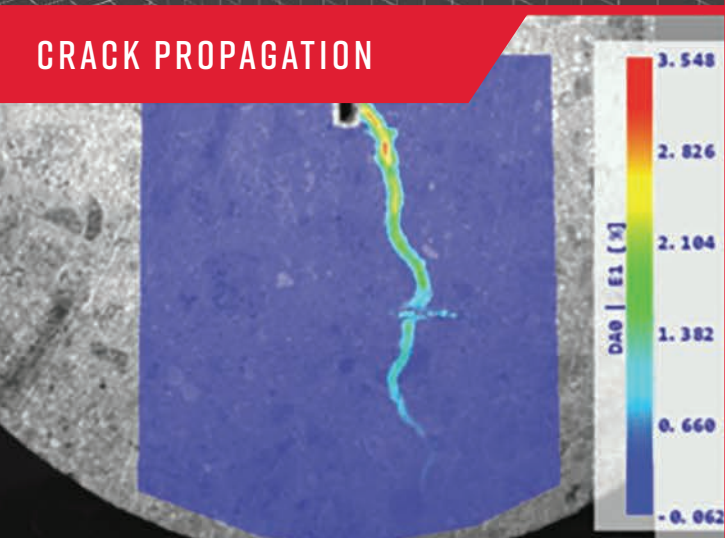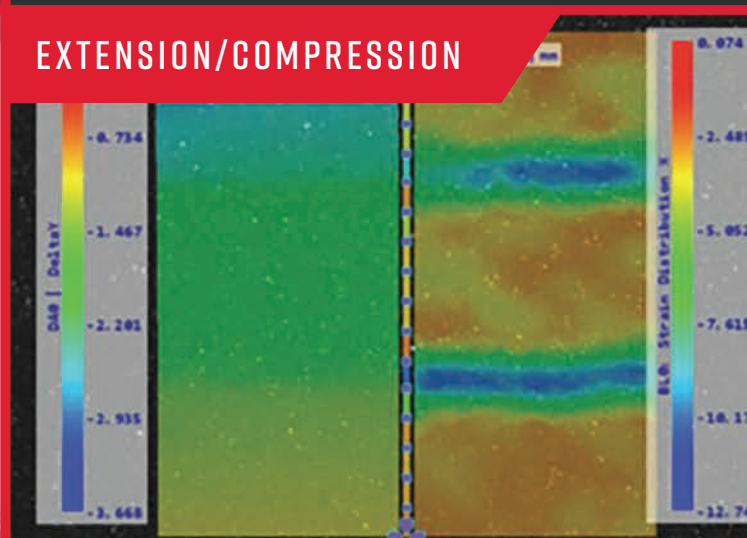
DEFORMATION
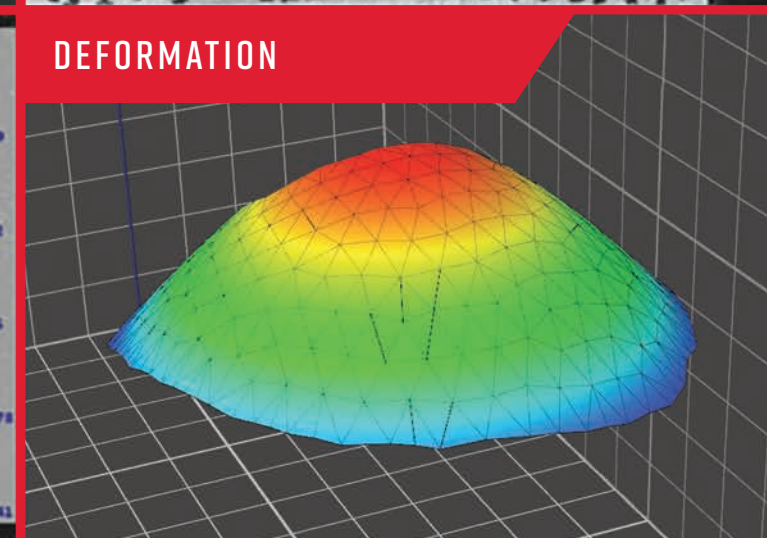
INTRODUCING DIGITAL IMAGE CORRELATION

Today digital image correlation (DIC) is used in industry, as well as in research and development at universities and research facilities. It can be used to aid product and material development, and used to test and validate finite element models (FEA) at a more advanced level.

The skills acquired by learning how to use DIC as part of an engineering curriculum means that students can apply the technique to a variety of fields of engineering. This can help students develop a greater understanding of how different materials, or structures, behave under different loads and in different environments.

## WHAT IS DIGITAL IMAGE CORRELATION?

DIC is a non-contact optical technique that offers a highly accurate method of measuring strains, deformations or vibrations of materials as they undergo loading conditions.

It is ideal for students studying materials science, mechanical and structural engineering, and other related disciplines, since DIC helps them visualise how materials behave when subject to various loads that would not be apparent to the naked eye.

HOW DOES DIC WORK?

The DIC technique works by taking images of the object before any strains are applied, then continually tracking deformations in the material whilst the load is being added.

DIC uses one or more high-speed video cameras to track the movement of materials during a dynamic event. Images are collected and advanced computer processing is used to reconstruct the images to enhance visualisation. The surface is tracked by using a random surface pattern, either naturally occurring on the material, or applied using a 'speckled' pattern.
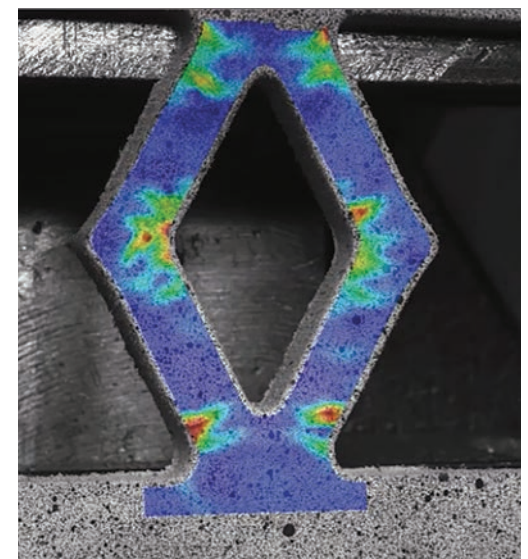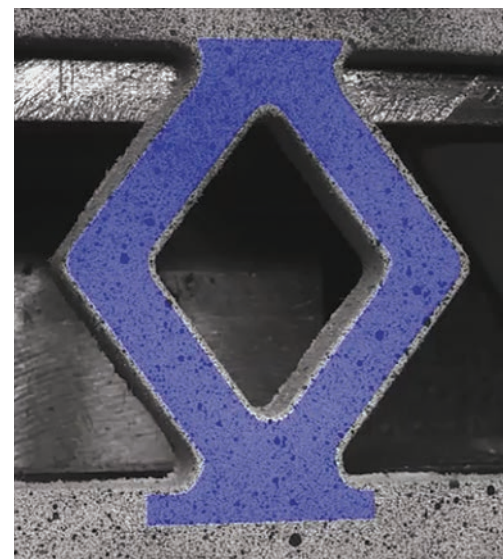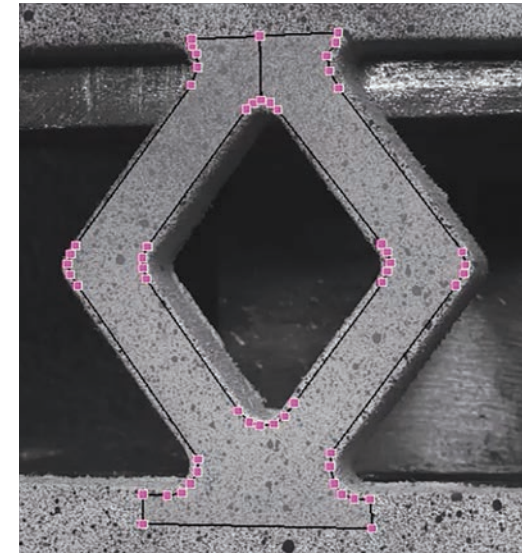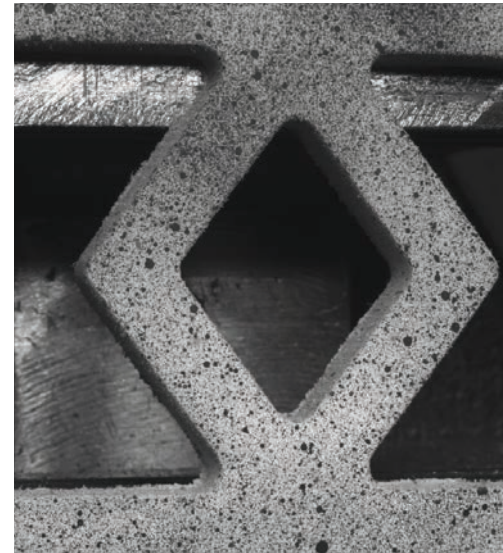

2D DIC USED TO MEASURE STRAIN ON A COMPLEX CONCRETE SHAPE

WORKING WITH DIFFERENT MATERIALS AND SURFACES

DIC works by tracking small changes to unique features on the surface of an object. These features can either be natural, such as wood grain, or they can be created artificially using a speckle pattern (a high-contrast series of marks applied to the specimen surface, such as dots or lines, by a pen, stamp or paint).

Some surfaces that don't need "speckling":

- Non-polished metals
- Wood
- Textiles
- Composites
- Concrete
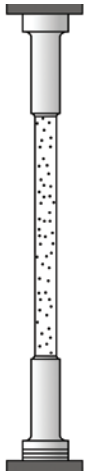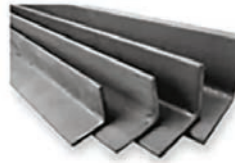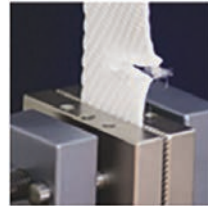
WHEN YOU NEED A SPECKLED PATTERN

The most important thing in DIC measurements is to have a clear, contrasting pattern for the software to track.

Speckled patterns are needed for surfaces featuring smooth and shiny finishes. Generally, in DIC, this takes the form of a randomly distributed series of dots called a "speckle pattern".

Ideally the target area should be given a black or white undercoat using a thin layer of matt paint. A contrasting pattern of speckles is then applied using, for example, either a rocker stamp, roller or printed directly onto the surface area.

SPECIMEN WITH
APPLIED SPECKLED
PATTERN

FIND OUT MORE ABOUT DEFLEX® ON OUR WEBSITE

TECQUIPMENT.COM/OPTICAL-EXTENSOMETRY

SPECKLING KIT COMING SOON

A compact kit designed to teach students how to apply a speckle pattern to a variety of surfaces for DIC measurements. The kit includes a set of rocker stamps and rollers covered in flexible studs.
It allows the user to easily create patterns to cover a range of different surface profiles from flat area, curved surfaces and small intricate areas, helping the DefleX® camera capture and track material deformations.

+44 115 972 2611   SALES@TECQUIPMENT.COM

MEASUREMENT PROBES

MEASUREMENT AND ANALYTICAL TOOLS

The DefleX® software offers students a number of probes or sensors, which can be used individually or in combination to customise the measurement of specimens being tested.

- **Line** is an elementary measuring probe for strain and length determination.

- **Extreme line** is the probe for axial neck detection.

- **Trans line** analyses the change in width along a specimen.

- **Torsion line** enables dual position angular twist and strain measurement.

- **Bend line** is a probe designed for bending tests. Measures strain over a curved shape and enables the visualisation of the real-time strain distribution.

- **Crack probe** measures crack length during static or dynamic tests.

- **DIC area** is the full-field probe for strain and displacement distribution mapping.

LINE

EXTREME LINES

TORSION LINE

CRACK PROBE

TRANS LINE

BEND LINE

POINT
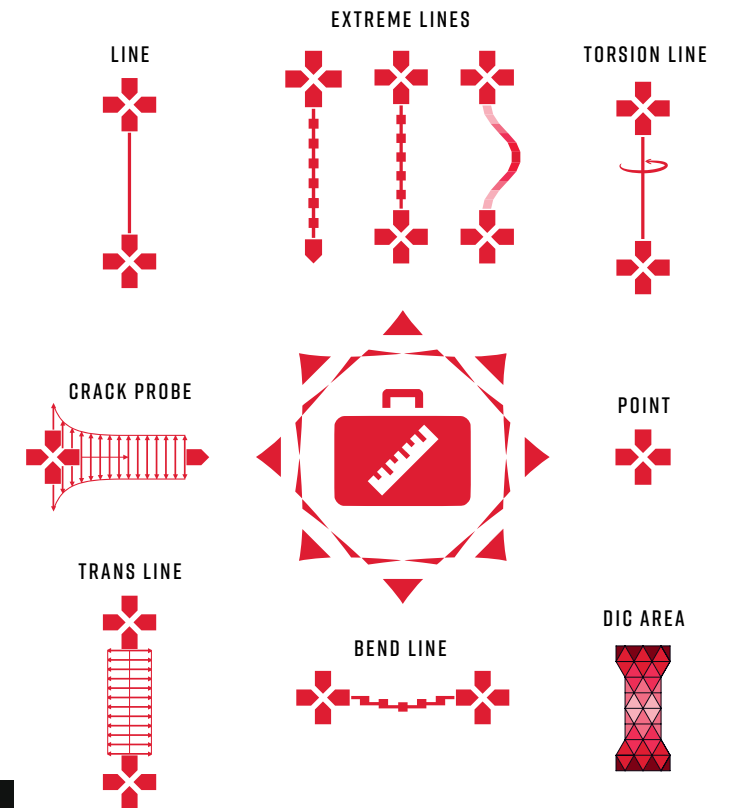
DIC AREA

EXAMPLES OF SOME OF THE MEASUREMENT PROBES:
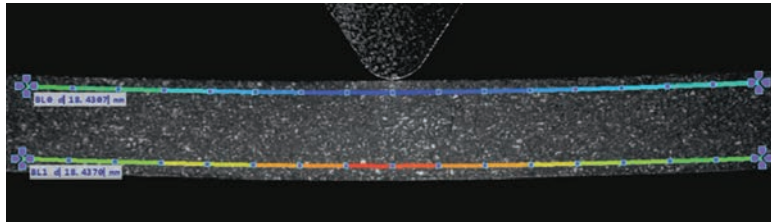
BEND LINE
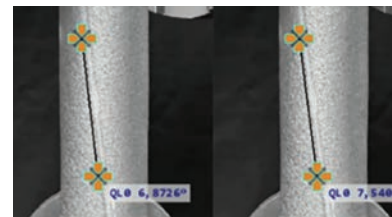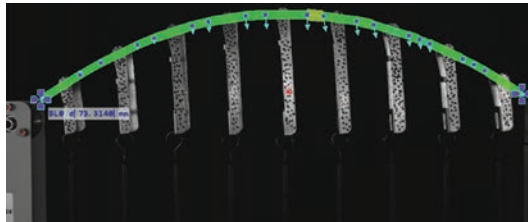
TORSION LINE*

DIC AREA

CRACK PROBE

LINE

EXTREME LINE*

*Deflex®-2D only

DEFLEX®-2D

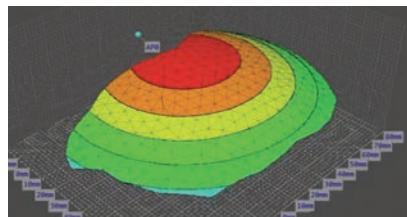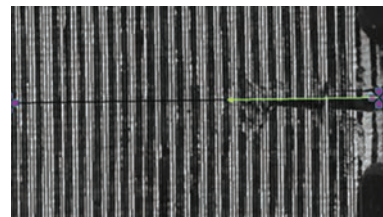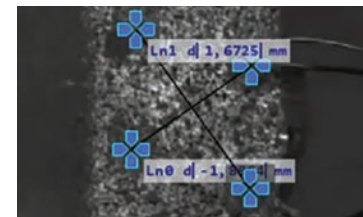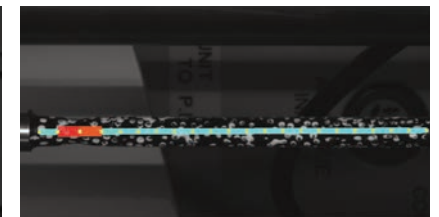DefleX®-2D is an entry-level system designed to introduce students to the concept and technique of digital image correlation. As a complete and compact system, DefleX®-2D offers students a digital blended learning experience as part of their engineering courses.

DOWNLOAD DATASHEET
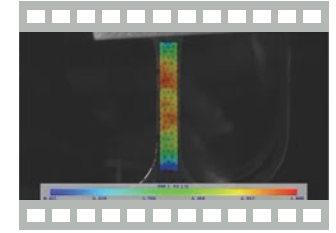
BENEFITS OF DEFLEX®-2D FOR STUDENTS

- Fast and easy to set up
- Great visual learning aid
- Teaches students about the DIC technique
- Encourages learning by experimenting
- Real time concept demonstration
- Deeper scientific understanding of behaviour of materials under strain
- Enhances theory with practical use
- Provides real-time experiment results
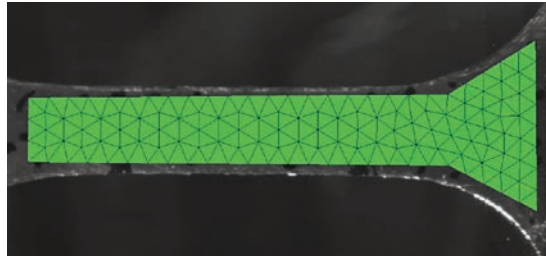
PRE-STRAIN: BEFORE ANY LOADING IS APPLIED TO THE SURFACE MATERIAL
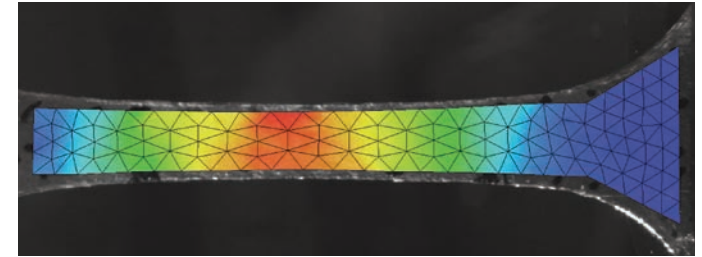
POST-STRAIN: STRAIN DISTRIBUTION ACROSS THE FULL SURFACE OF MATERIAL

SETTING UP THE SYSTEM

The single-lens compact DefleX®-2D camera unit uses an interchangeable set of single lenses offering students the flexibility to measure objects at different distances.

WORKING DISTANCE

DEFLEX® SYSTEM SET UP

+44 115 972 2611   SALES@TECQUIPMENT.COM

APPLICATIONS OF 2D DIGITAL IMAGE CORRELATION

RESIDUAL STRESS

2D DIC is used to help visualise strain distribution around a drilled hole in the surface of a part containing residual stresses. Combined with finite element simulation, DIC can helps students assess residual stresses in the part.

Benefits of DIC:

- Study of residual stresses to understand material performance and structural integrity
- Prevent failures
- Ensure quality control
- Optimise design

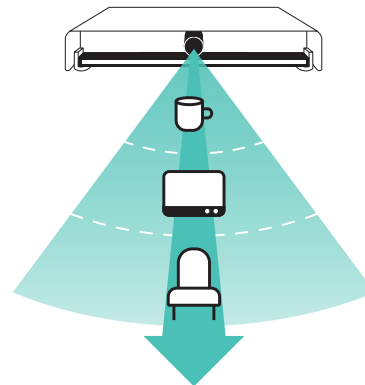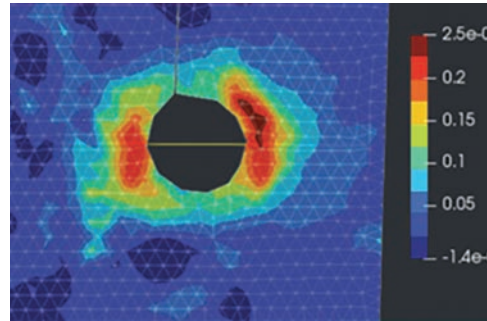## STRAIN CONCENTRATION

2D DIC is used to identify strain distribution on a loaded shear-test sample. Identifies strain concentration which can indicate weak points in a component's design. These are potential failure points under static loading, or crack initiation sites under cyclic loading.

Benefits of DIC:

- Identify weak points, optimise design and manufacturing processes
- Assess structural integrity
- Enhance safety
- Conduct fatigue studies
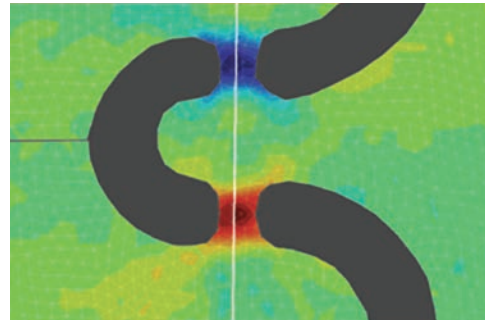
DEFLECTION

Visualisation of strain distribution during a three-point bending test, showing compression on the top side and tension on the bottom side of the beam. The deflection distribution can also be observed in this setup.
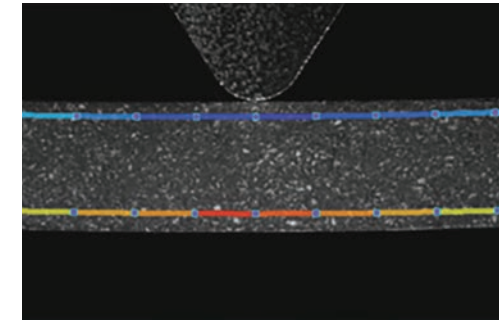
2D DIC can be used to evaluate three/four-point bending tests and visualise fundamental principles of beam bending, which is a critical and potentially dangerous deformation mode.

Benefits of DIC:

- Material selection
- Component sizing
- Design optimisation
- Component validation
- Assessment and maintenance of existing structures
- Damage prevention
- Ensure compliance with standards

READ OUR BLOG TO FIND OUT MORE

Unlocking the world of digital image correlation (DIC) with the DefleX® solution.

TECQUIPMENT.COM/KNOWLEDGE

MOTION

2D DIC provides a comprehensive view and understanding of the behaviour of the component or structure.

Displacement field displayed using both a colour map and a vector field in a motion study of the component.

Benefits of DIC:

- Assess the safety and stability of structures
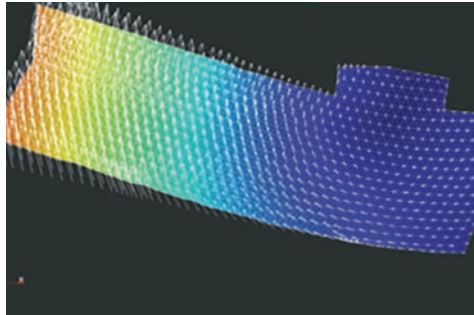- Evaluate the performance and functionality of mechanisms
- Analyse and control vibrations
- Predict dynamic responses and noise
- Assess durability
- Optimise or validate design and simulations

ADHESION

Measures the strength of the bond between two materials and assesses the uniformity and durability of adhesive applications.

2D DIC shows crack length progression during an adhesion test, such as a peel test or a pull-off test.
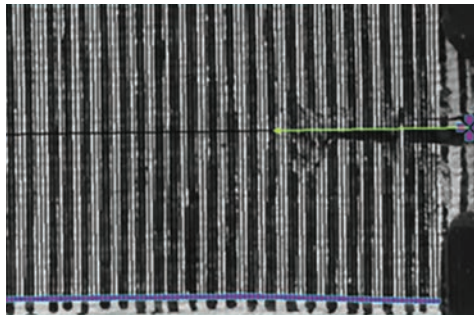
Benefits of DIC:

- Ensure product performance and reliability
- Test material compatibility and selection
- Quality control and compliance with standards
- Understand and prevent adhesive failures
- Enhance user safety and experience
- Optimise manufacturing processes

CRACK PROPAGATION

2D DIC is ideal to help students understand the material's fracture behaviour and toughness, characterise anisotropy and heterogeneity in the material, and evaluate stress concentration effects.

An illustration of the principal strain distribution during a notched Brazilian disc test of concrete.
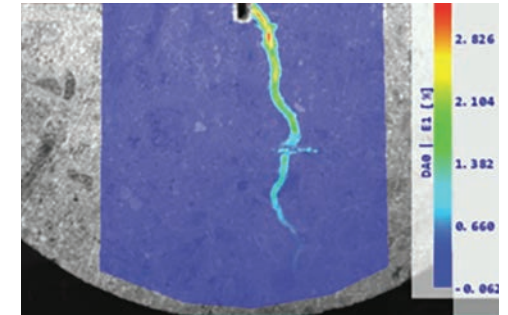
Benefits of DIC:

- Predict and analyse component failure
- Design optimisation
- Select materials with appropriate crack-resistant properties
- Extend the service life of components/structures
- Maintenance planning

EXTENSION/COMPRESSION

2D DIC helps to provide a comprehensive understanding of the deformation of non-standard materials (e.g. composites, foams).

Displacement (left) and strain (right) distribution during the compression test of a foam-like structure.
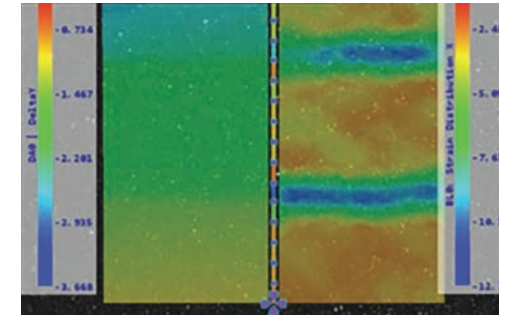
Benefits of DIC:

- Determine material properties such as elastic modulus, yield strength, ultimate strength, ductility and Poisson's ratio
- Design of structures and components
- Ensure safety and reliability
- Quality control and standard compliance
- Analyse and prevent failures

PRACTICAL APPLICATION EXAMPLES OF 2D DIGITAL IMAGE CORRELATION

STRUCTURES AND CIVIL ENGINEERING

MEASUREMENT PROBE WITH BEND LINES

DIC can be used for monitoring the behaviour of large structures. In the image above, using the bend line, the deformation curve is visualised with scaled vectors and shows a deflection of 2 mm caused by the locomotive. The colour coding represents the relative change in the distance between neighbouring points.

This data can be used to validate the structure's design, confirm compliance with regulations and standards, or enhance structural safety by detecting unexpected responses within the system.
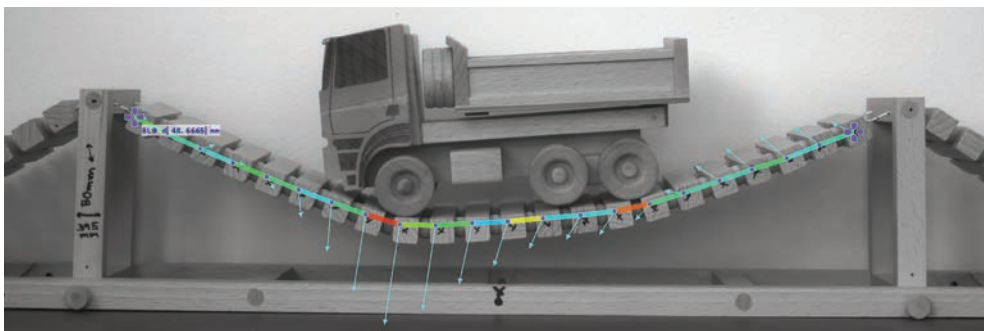
MEASUREMENT PROBE WITH BEND LINES

DIC visualises vectors in real time to show how loading has changed the shape of the original catenary curve, and a colour map shows how much the transverse beams have moved relative to one another.

MATERIALS TESTING AND PROPERTIES
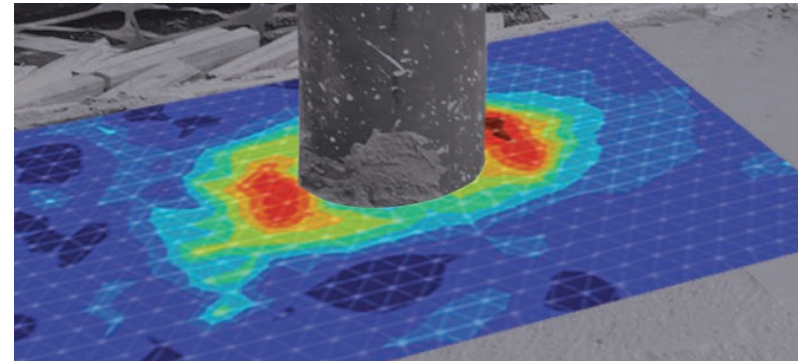
MEASUREMENT PROBE WITH DIC AREA

DIC can be used to examine factors affecting residual stresses around an object in concrete caused by uneven drying. This helps identify crack formation during construction and reduces the risk of failure under anticipated loading conditions. DIC could also be used to quantify concrete shrinkage and settlement.

MEASUREMENT OF TENSILE STRAIN DUE TO WEIGHT OF CLIMBER

This illustrates the practical application of tensile loading on the ropes due to the climber's weight. Visualising tensile loading of equipment in extreme environments is made easier with digital image correlation.

DEFLEX®-3D

An integrated digital image correlation system for measuring full-field displacements and strains over a material's surface in three dimensions. DefleX®-3D is ideal for materials science, structural engineering and general mechanical engineering courses.

DefleX®-3D is a three-dimensional digital image correlation (DIC) system designed to teach students how to accurately measure full-field 3D surface deformations, strains and displacements in materials and objects. This cutting-edge technology is a powerful tool for gaining insights that are difficult or even impossible to achieve with traditional measurement techniques.

KEY BENEFITS OF 3D DIC

- 3D visualisation of strain measurement and surface deformations
- Non-contact method: no contact between the camera and the object/surface
- Enhances students' learning experience
- Fast and easy to set up
- Teaches students principles of digital image correlation
- A non-destructive method to assess the quality of materials and objects by identifying hidden material defects
- Enables precision-driven product development allowing for innovative product design validation and reduced prototype testing
- Great potential in vibration and other structural dynamic tests

THE DEFLEX®-3D SYSTEM

DefleX®-3D features two stereoscopic cameras that simultaneously view the surface of a specimen. The software matches the subset pattern between the two cameras in a process known as stereo-matching. The triangulation of the DIC point between two cameras of known separation and orientation allows deformations and displacements to the surface in the Z-axis (towards and away from the camera) to be calculated.
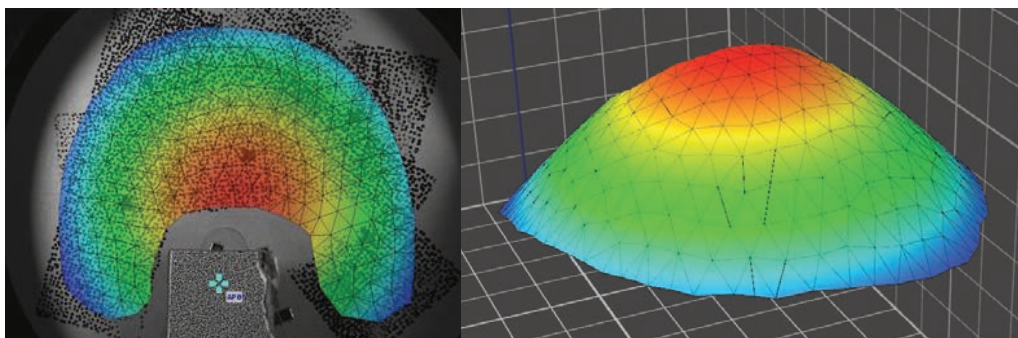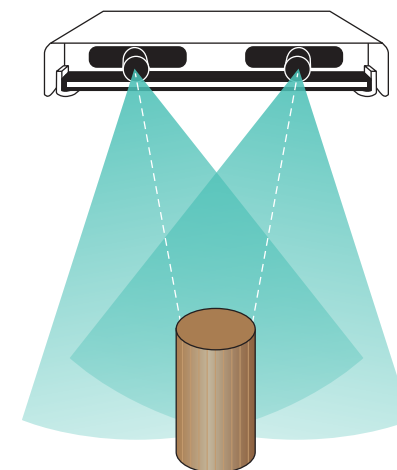
DEFLEX®-3D VISUALISATION OF THE EFFECT OF PRESSURE ON THE SURFACE PROFILE OF THE DIAPHRAGM (SM1008)
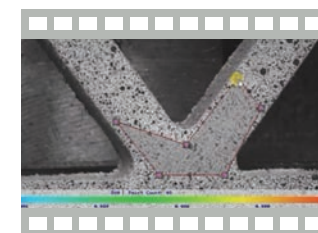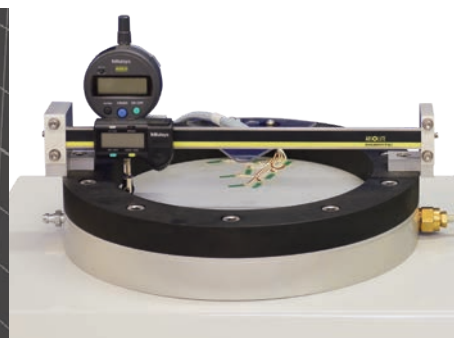
# APPLICATIONS OF 3D DIGITAL IMAGE CORRELATION

DEFLECTION OF A FAN BLADE

DefleX®-3D can be used to investigate the response of a component to external vibration. This helps to visualise the deflections that describe the mode shapes (vibration patterns) of fan blades under various loading frequencies. With two cameras, DefleX®-3D can measure contour, displacement and vibration of the propeller blades.
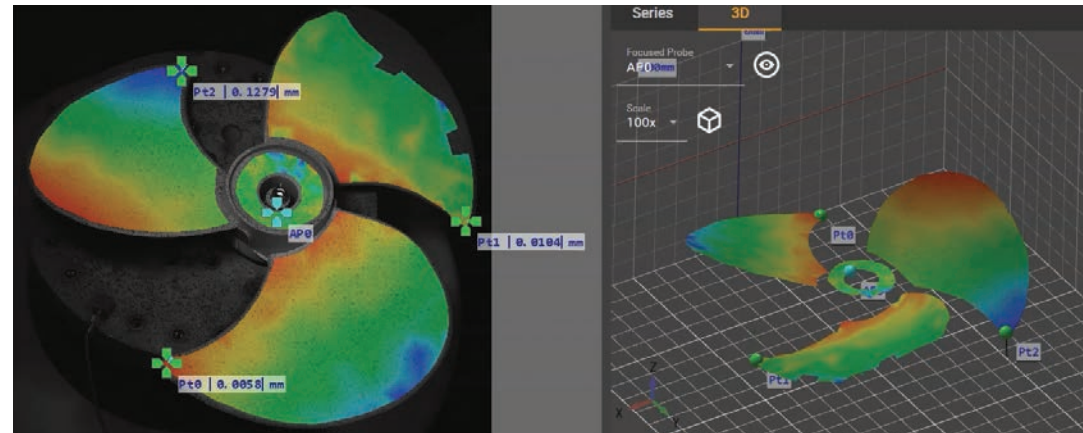
VISUALISATION OF VIBRATION OF PROPELLER BLADE

COMPONENT TESTING

Component testing of a belt buckle subjected to tensile loading in 3D. The distribution of the first principal strain is shown, along with the underlying mesh of elements used for its calculation. The red areas indicate potential locations for stiffening to prevent excessive deformation. Additionally, this analysis can serve as a basis for calibrating the finite element model.
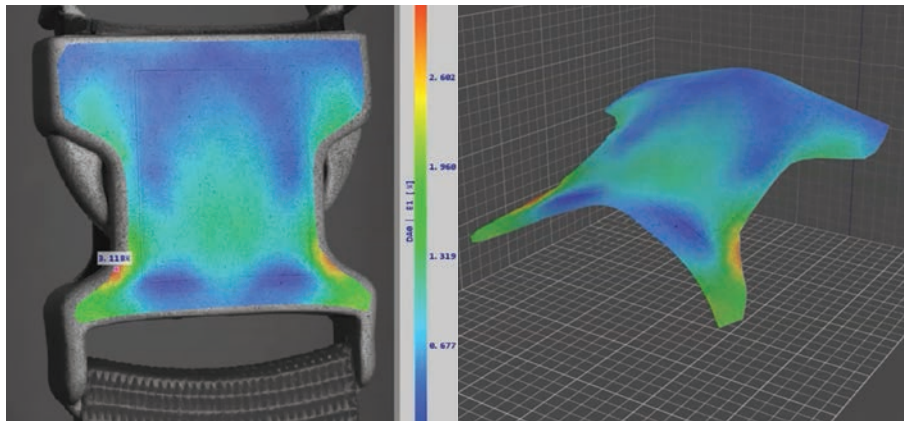

COMPONENT TESTING OF A BELT BUCKLE SUBJECTED TO TENSILE LOADING IN 3D

BIOMECHANICS AND SOFT MATERIALS ANALYSIS

DefleX®-3D delivers precise, full-field deformation measurements for soft materials, such as soft polymers or skin, enabling everything from non-invasive, real-time monitoring to advanced analysis of material behaviour.

Whether testing biological tissues, soft polymers or other flexible materials, DefleX®-3D provides unparalleled insights with high-resolution imagery.
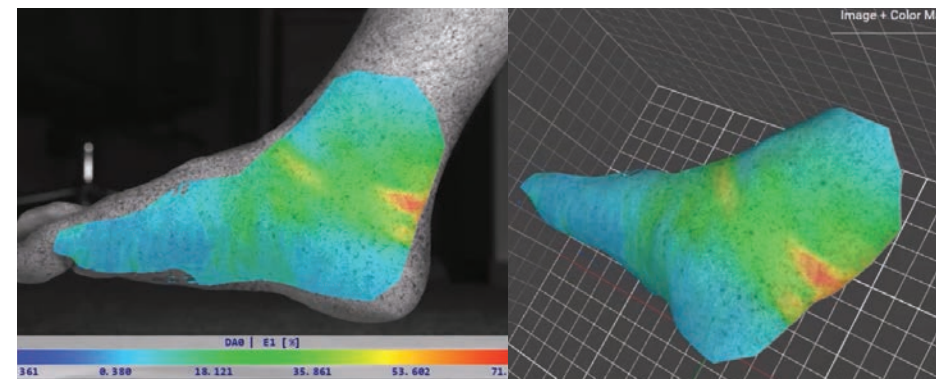

VISUALISING THE STRAIN FIELD IN SKIN AS IT STRETCHES AND COMPRESSES DURING FOOT MOVEMENT

DEFORMATION OF METAL DIAPHRAGM

3D DIC can be used to visualise the effect of pressure on the surface profile of a diaphragm and measure the distribution of circumferential and radial strains.

DefleX®-3D can be used to show deformation of a metal diaphragm due to the increasing pressure of an oil reservoir beneath it.

In this instance, using DefleX®-3D is a great way to visualise how digital technology can be used to measure material behaviours under high pressure.
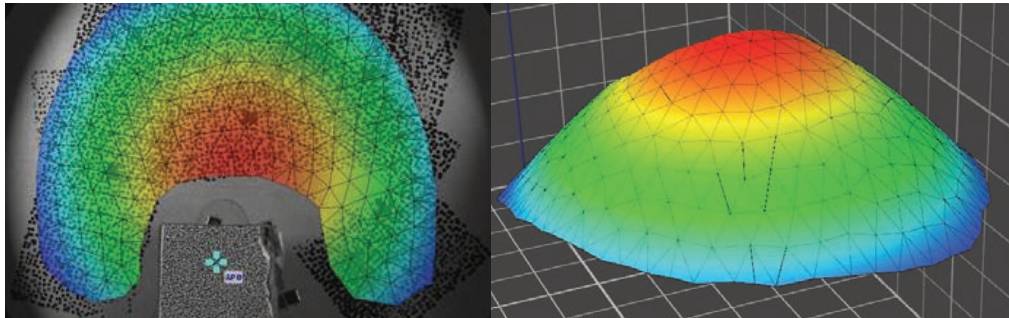
DEFLEX®-3D VISUALISATION OF THE EFFECT OF PRESSURE ON THE SURFACE PROFILE OF A DIAPHRAGM (SM1008)

DEFLECTION PROFILES OF STRUTS UNDER EULER BUCKLING

Uniaxial compression of a slender strut with fixed ends. This example illustrates visual representation of bending that has been exaggerated 20 times to show the shape of the deformation. This is used whenever columns or struts are under axial compression.
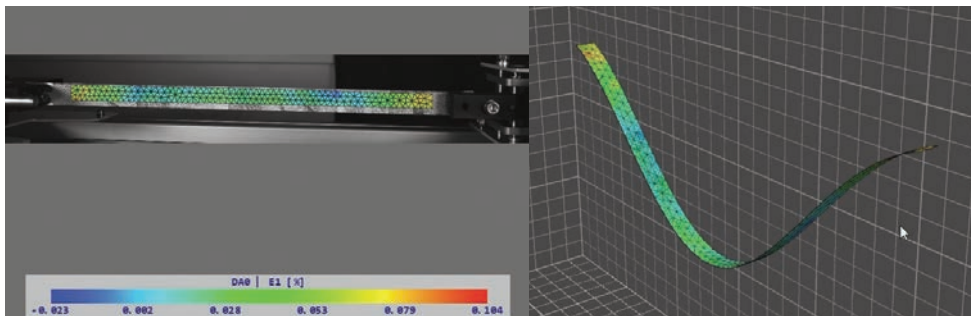

BUCKLING OF A SLENDER STRUT UNDER AXIAL COMPRESSIVE STRAIN USING THE EULER BUCKLING APPARATUS (SM1005)

COMPLEX SHAPE INVESTIGATION

Utilise DefleX®-3D's non-contact measurement capabilities to study complex-shaped components under various loading conditions. Gain deeper insights into their behaviour, identify strain concentration areas and optimise designs for enhanced durability and reliability.

DefleX®-3D shows how a concrete structure will handle tensile strains, which is important for materials design and civil engineering. The heat maps show where the tensile strains are the greatest.
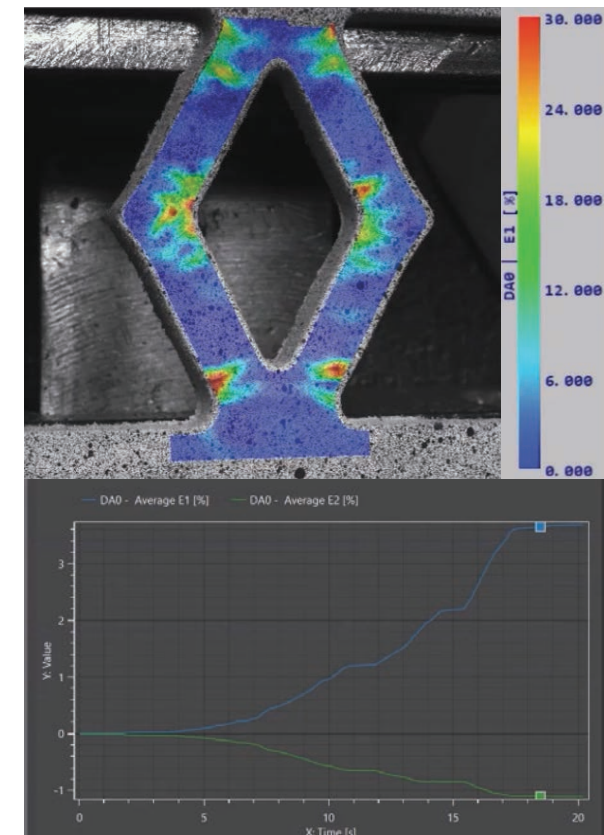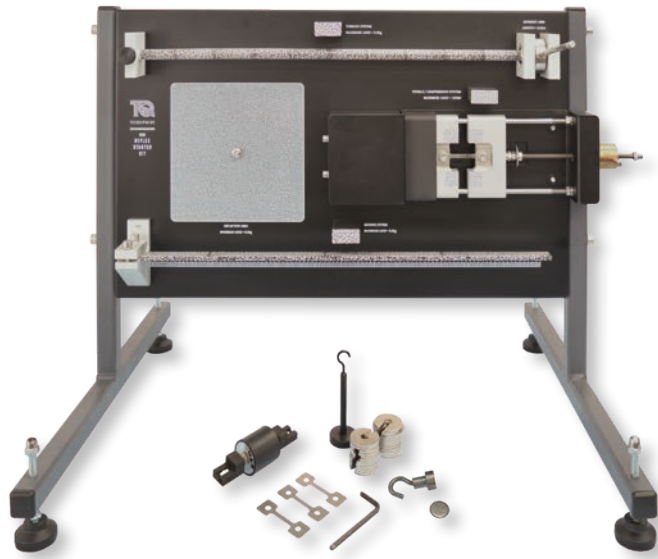

STRAIN DISTRIBUTION IN A COMPLEX CONCRETE STRUCTURE

DEFLEX® STARTER KIT NEW

A simple system designed to introduce students to the concept of digital image correlation and teach them how to take basic measurements using the DefleX®-2D and DefleX®-3D systems.

The DefleX® Starter Kit (DSK1) is perfectly suited as a teaching aid and demonstration unit for any mechanical, material science, civil or structural engineering course, as it will help students visually understand what happens to materials as they undergo various loading conditions.

The kit guides students through various practical scenarios, enabling them to conduct experiments commonly taught across mechanical engineering courses:

- Torsion testing
- Tensile testing, including extension and compression
- Cantilever beam bending
- Thin plate deflection (3D only)

2D AND 3D DIC EXPERIMENTS AVAILABLE

TORSION TESTING: Can be used with both DefleX®-3D and DefleX®-2D, where a weight is applied on the end of a torque bar, forcing the torsion bar to twist.

TENSILE TESTING: Steel specimens may be used in elastic and plastic regions to determine material tensile strength, yield point and to create a force/extension graph.

EXTENSION AND COMPRESSION: A specifically designed thick rubber specimen is used to explore the elastic region of rubber for extension and compression.


**CANTILEVER BEAM BENDING:** DefleX® enables students to analyse bending of moments, strain distribution and the deflection profile of a cantilever under load.

3D DIC ONLY EXPERIMENTS AVAILABLE

THIN PLATE DEFLECTION: This is an ideal experiment to demonstrate the real power of the DefleX®-3D capabilities, such as measuring the smallest changes in displacements not visible to the naked eye.
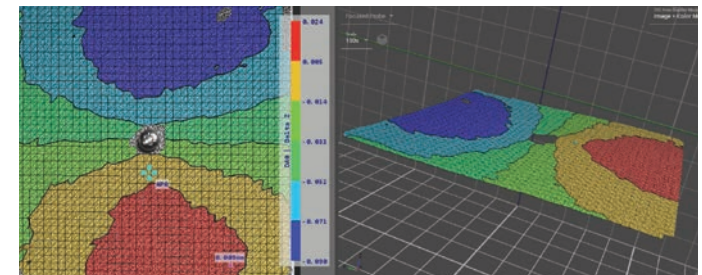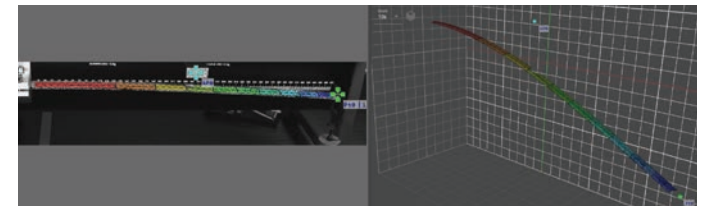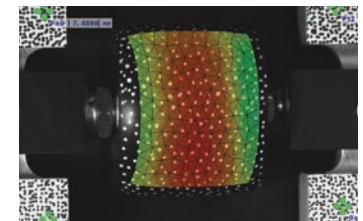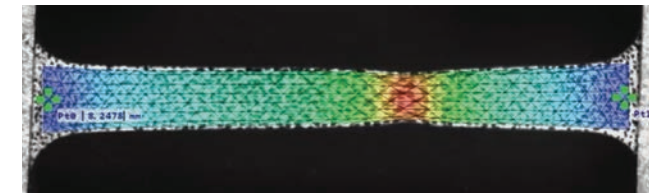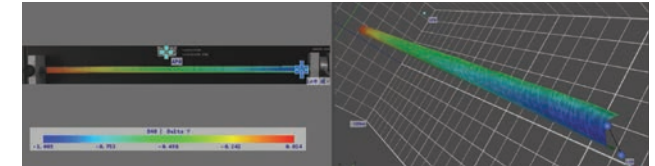
COMPATIBLE TECQUIPMENT PRODUCTS

DefleX® can be used as a complementary learning aid to TecQuipment products (the list below is not definitive) and other suitable third-party lab products.

CODE	PRODUCT NAME	EXPERIMENT TYPE
NEXT GENERATION STRUCTURES		
STS4	Deflection of Beams and Cantilevers	Bending
STS7*	Unsymmetrical Bending and Shear Centre	Bending
STS10	Two-Pinned Arch	Bending
STS11	Fixed Arch	Bending
STS12*	Euler Buckling of Struts	Bending
STS14	Curved Bars and Davits	Bending
STS15	Plastic Bending Beams	Bending, Strain
STS16	Plastic Bending of Portals	Bending
STS18	Frame Deflections and Reactions	Bending
STS19	Simple Suspension Bridge	Bending, Strain
MATERIALS TESTING AND PROPERTIES		
MF40 MkII	Materials Laboratory with Data Capture	Tensile
SM110	Hooke's Law and Spring Rate	Tensile
SM1000	Universal Testing Machine	Tensile
SM1001*	Torsion Testing Machine	Torsion
SM1002	Benchtop Tensile Testing Machine	Tensile
SM1003*	Unsymmetrical Cantilever	Bending
SM1004	Beam Apparatus	Bending
SM1005*	Euler Buckling Apparatus	Bending
SM1006	Creep Machine	Strain, Tensile
SM1008*	Diaphragm	Stress, Strain
TE16	Stiffness, Bending and Torsion	Bending

CODE	PRODUCT NAME	EXPERIMENT TYPE
THEORY OF MACHINES		
TM163*	Centre of Percussion	Vibration
TM164	Free Vibrations of a Mass Spring System	Vibration
TM165	Free Torsional Vibrations	Vibration
TM166	Free Vibrations of a Cantilever	Vibration
TM167	Free Vibrations of a Beam and Spring	Vibration
TM1016V	Free and Forced Vibrations	Vibration

* Only compatible with DefleX®-3D

LICENSING

DefleX® includes a single-user perpetual software licence accessed via the USB licence key. The user installs the software (via the USB flash drive) on the desired number of PCs, but can only use the one with the USB licence key plugged in to access and use the DefleX® software.

The perpetual licence can be extended (optionally if required) by purchasing a perpetual network licence (DefleX®-Net). This allows access of the DefleX® software for up to 20 users on multiple devices while connected to the same network.

The network licence enables the lecturer to record footage and send it to students for them to analyse in the DefleX® software installed on their own computers. (Note: both the network licence and the single-use licence are restricted to educational purposes.)

Both licensing options for DefleX®-2D and DefleX®-3D include one year of technical enhancements, valid from the date of delivery. One year of support is also included for DefleX®-3D licences.

DefleX® is aimed at education for use in universities, colleges and other specialist training centres, and shall only be installed on equipment owned or used by such institutions.
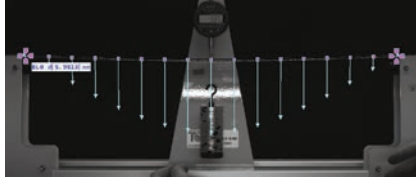
DefleX®

A digital image correlation (DIC) system to teach students how to measure and analyse surface deformations, strains and displacements in materials and shapes.
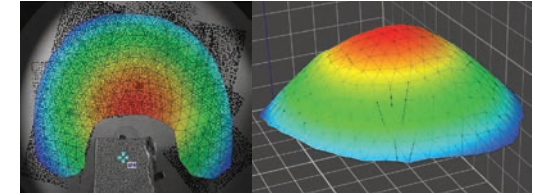
DefleX® is available at entry–level (DefleX®-2D) and for measuring full–field displacements and strains over a material's surface in three dimensions (DefleX®–3D). The units are equipped with camera measurement and image processing software for analysing motions, displacements and strains. Both systems feature the integrated DefleX® software.
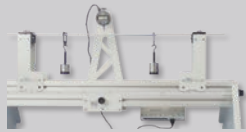

TECQUIPMENT

DEFLEX®-2D

DEFLECTION OF BEAMS AND CANTILEVERS (STS4)

DEFLEX®-3D

DEFLEX®-3D VISUALISATION OF THE EFFECT OF PRESSURE ON THE SURFACE PROFILE OF A DIAPHRAGM (SMI008)

*ONLY COMPATIBLE WITH DEFLEX®-3D

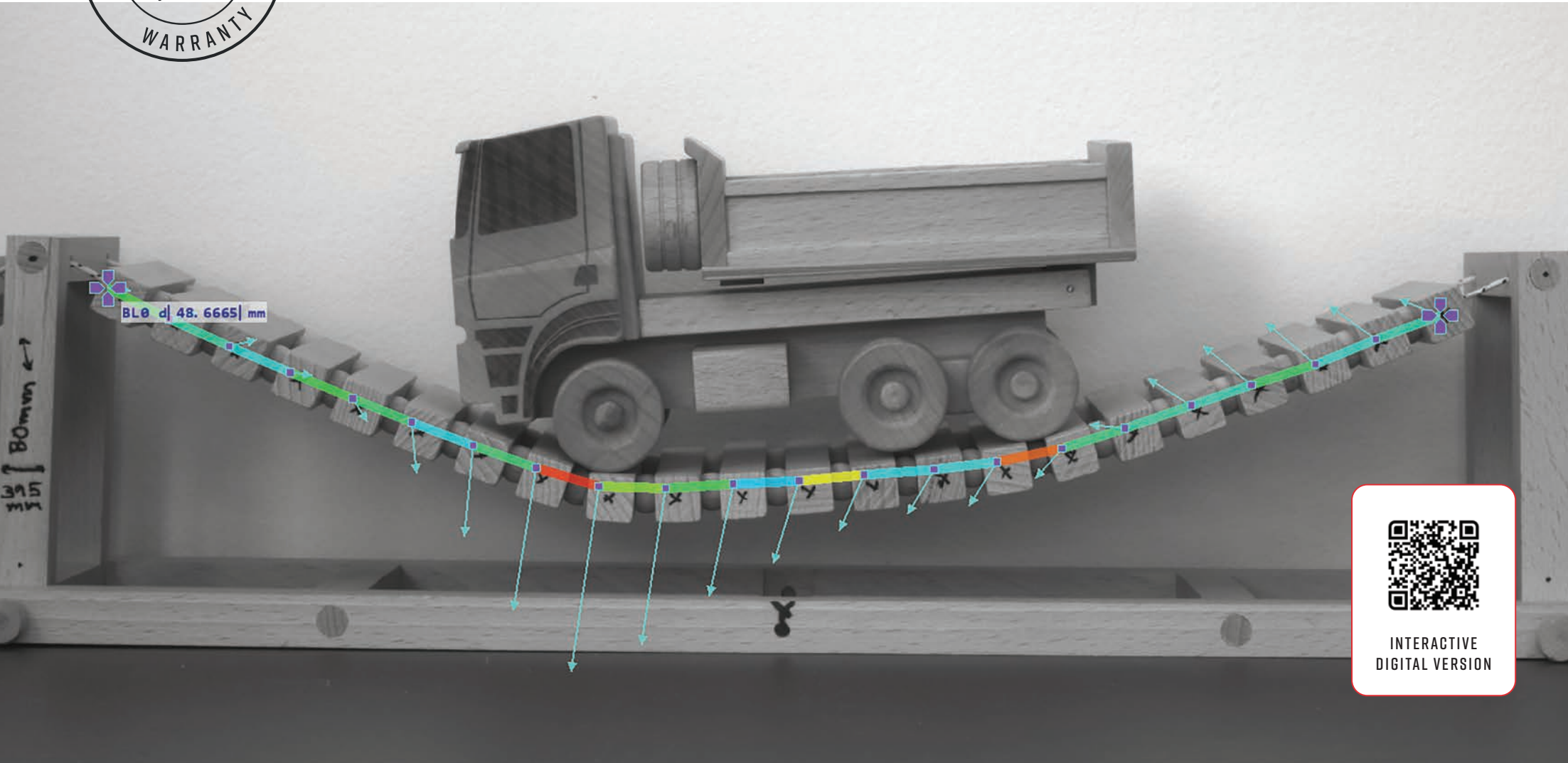|	NEXT GENERATION STRUCTURES			THEORY OF MACHINES	MATERIALS TESTING AND PROPERTIES		
DEFLEX®-2D AND DEFLEX®-3D COMPATIBLE PRODUCTS	DEFLECTION OF BEAMS AND CANTILEVERS STS4	UNSYMMETRICAL BENDING AND SHEAR CENTRE STS7*	TWO-PINNED ARCH STS10	FREE VIBRATIONS TM161*, TM163* TM164–TM167	UNIVERSAL TESTING MACHINE SM1000	TORSION TESTING MACHINE SM1001*	DIAPHRAGM SM1008*
	FIXED ARCH STS11	EULER BUCKLING OF STRUTS STS12*	CURVED BARS AND DAVITS STS14	FREE AND FORCED VIBRATIONS TM1016V	BENCHTOP TENSILE TESTING MACHINE SM1002	UNSYMMETRICAL CANTILEVER SM1003*	BEAM APPARATUS SM1004
	PLASTIC BENDING OF BEAMS STS15	PLASTIC BENDING OF PORTALS STS16	FRAME DEFLECTIONS AND REACTIONS STS18	SIMPLE SUSPENSION BRIDGE STS19	EULER BUCKLING APPARATUS SM1005*	CREEP MACHINE SM1006	MATERIALS LABORATORY WITH DATA CAPTURE MF40 MKII
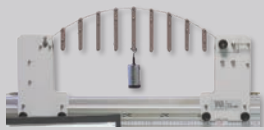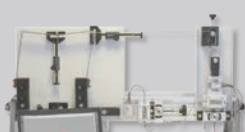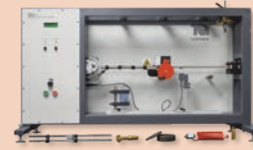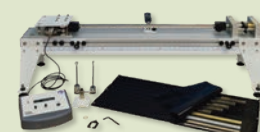
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