



## Structural effects in concrete fracture testing

the softening behaviour entails:

- uneven stress patterns (strength  $\neq F_{\max} / A$ )
- remarkable axial and bending instability

fixed-ends direct tension is the most objective test but its implementation is challenging

## Direct tension test

### axial instability

the elastic energy stored in the sample and in the press frame is sufficient to break the specimen

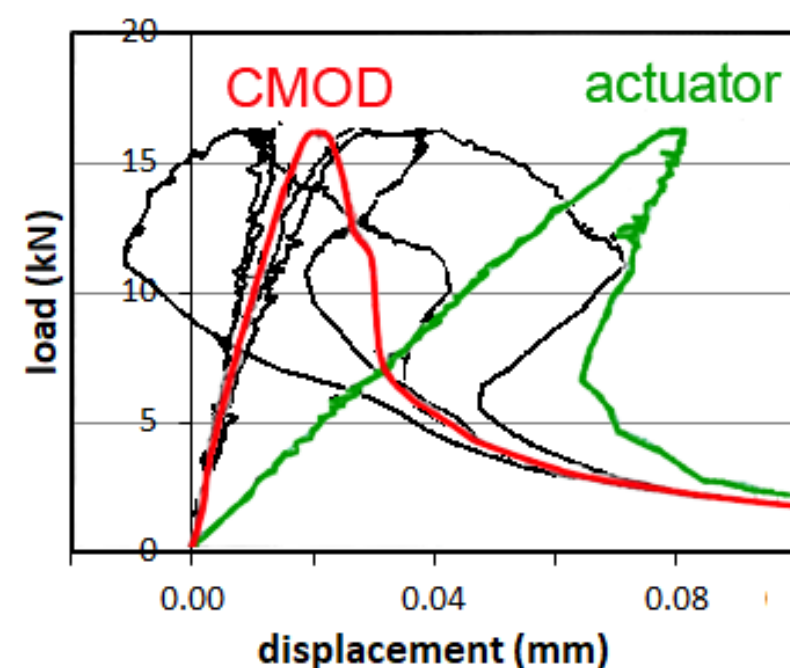
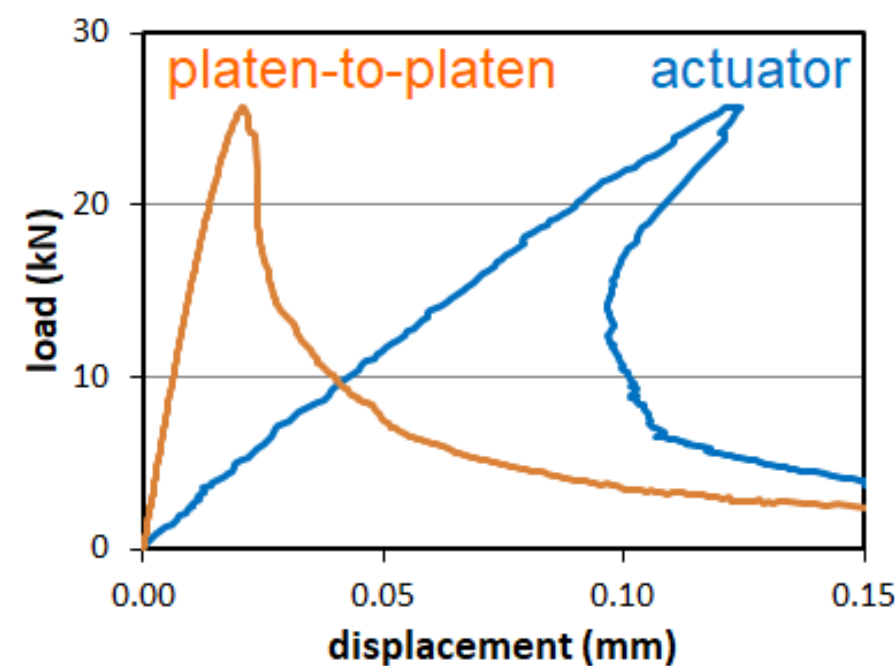
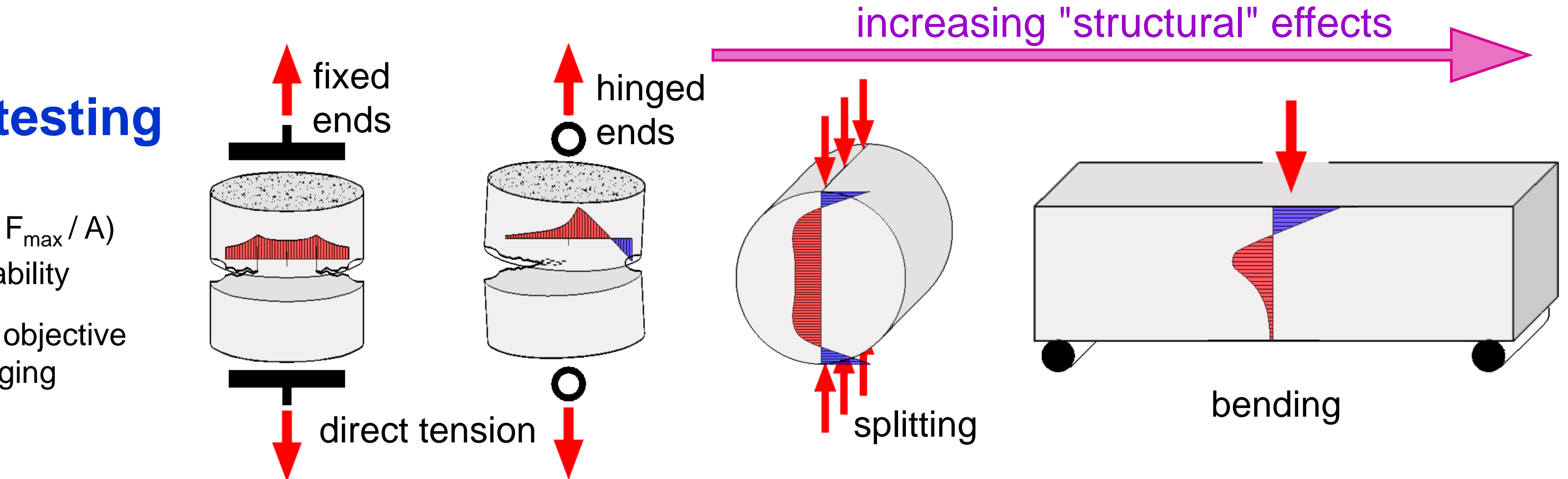
$$\frac{K}{EA} > \frac{1}{\frac{EA}{hA_c} \left| \frac{dw}{d\sigma} \right| - 1} \rightarrow K \approx \text{MN/mm}$$

### rotational instability

not uniform crack opening generates a bending moment that fosters this non-uniformity

$$\frac{K_{\text{rot}}}{EI} > \frac{1}{\frac{EI}{hI_c} \left| \frac{dw}{d\sigma} \right| - 1} \rightarrow K_{\text{rot}} \approx \text{MNm/rad}$$

active control is required to prevent both instabilities



## Bending test

- easy implementation with closed-loop compression machines
- biased value of strength, fair estimate of fracture energy
- inverse analysis required to infer the constitutive curve
- good for toughness testing of fibre-reinforced concrete

in case of long reinforcing fibre, the standard samples (150x150x600mm) are heavy (32kg) and difficult to install

the traditional universal test frame is not optimal in terms of test stability due to deformation of its components (pulled columns, bent cross-head and base beam to load a small sample)



## The 3ACTION testing machine

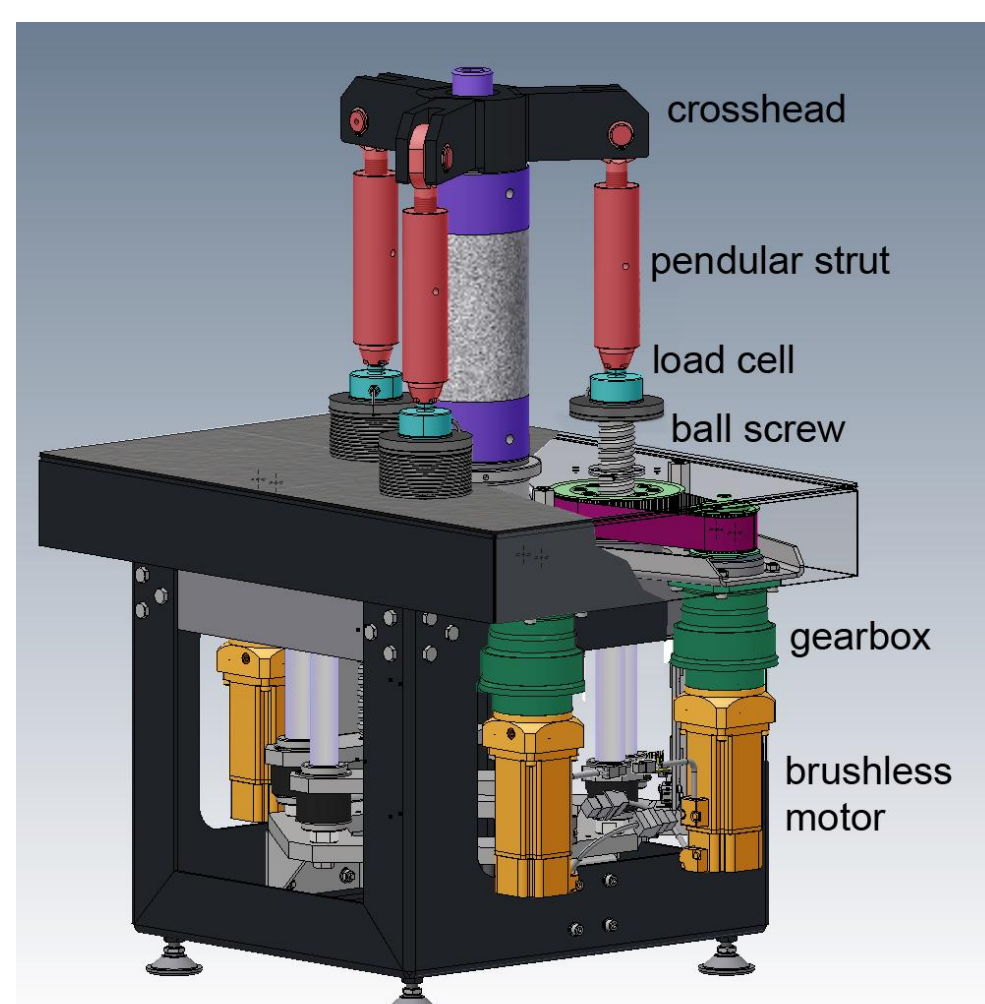
3 independent actuators that push the crosshead upwards (no loading frame !)

electromechanical actuators designed for high acceleration

samples are glued separately and then bolted to the machine

double-hinged struts prevent any shear stress

feedback provided by high resolution, low noise LVDTs



## Ease of testing



the glued steel block is screwed to the baseplate

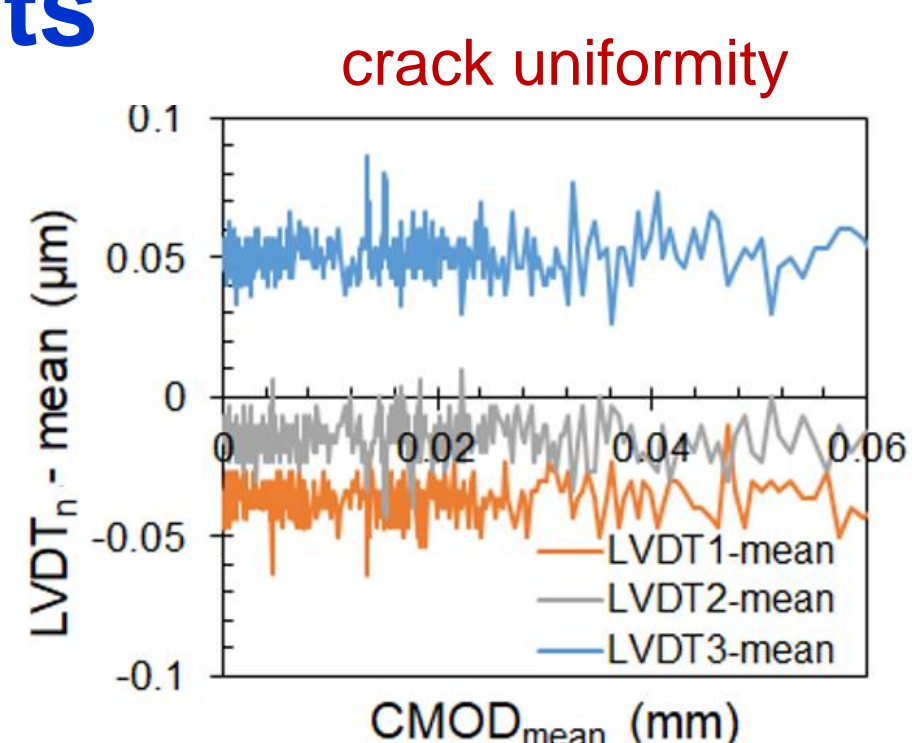
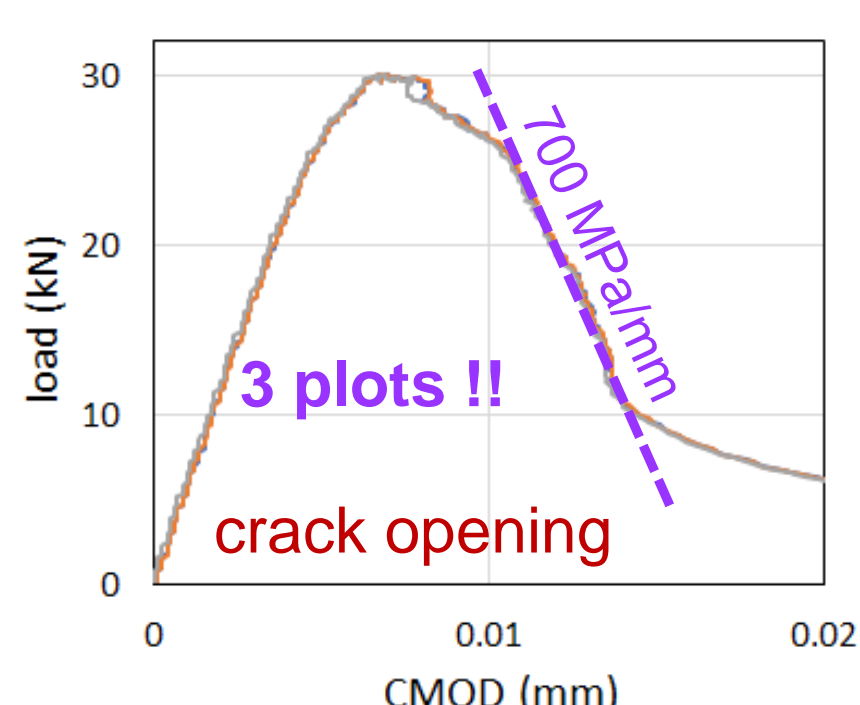


the LVDT ring supports are mounted



the cross-head is bolted the struts are engaged to the load cells

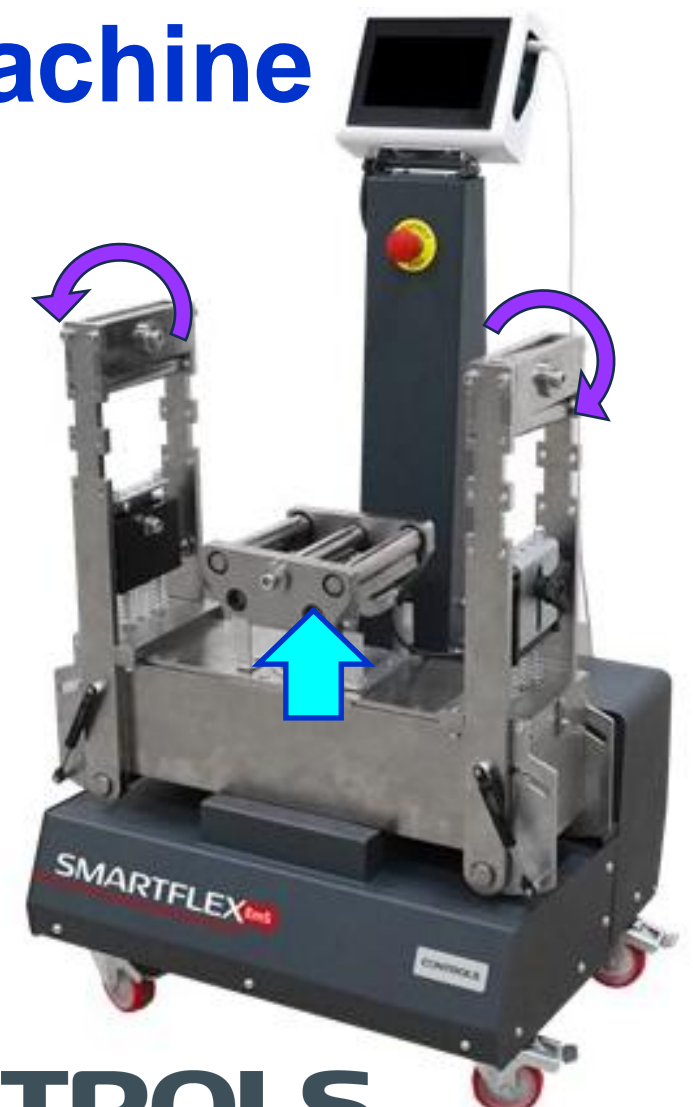
## High quality of results



## The SMARTFLEX<sup>EmS</sup> testing machine

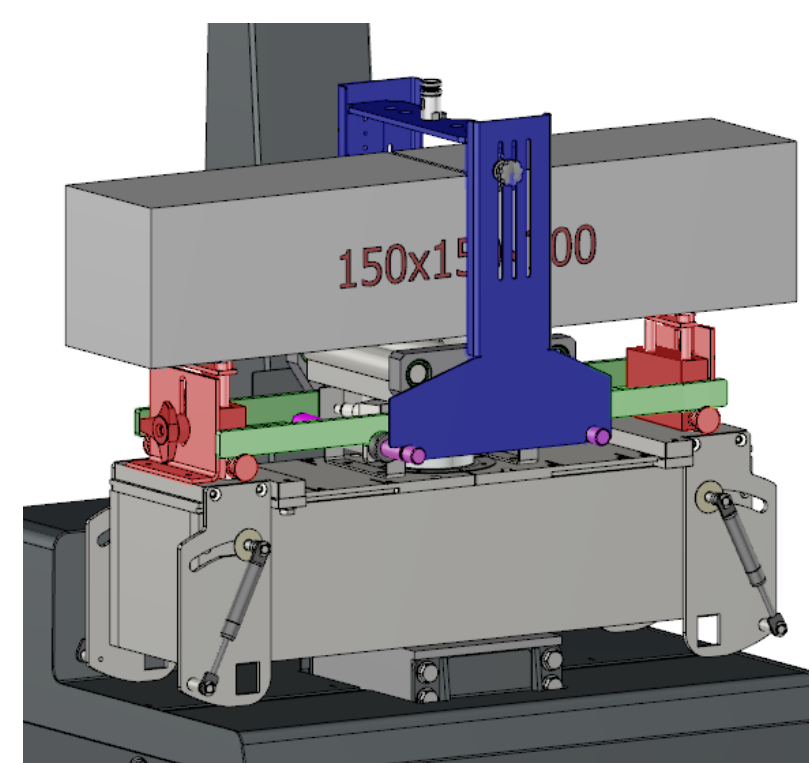
reverse loading scheme, bringing in several pros:

- easy installation of the specimens thanks to the pendular roller supports
- easy positioning of deflection and crack-opening sensors in a safe position
- visibility of the crack during testing
- lower impact of frame deformability
- stiff and clean electromechanical actuator
- movable equipment, allowing in-situ tests on early age concrete

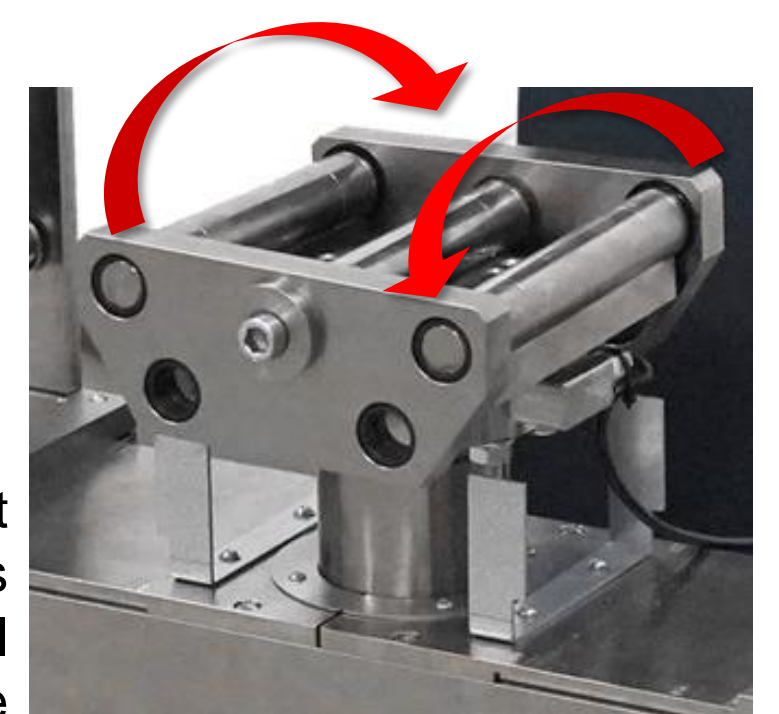


CONTROLS

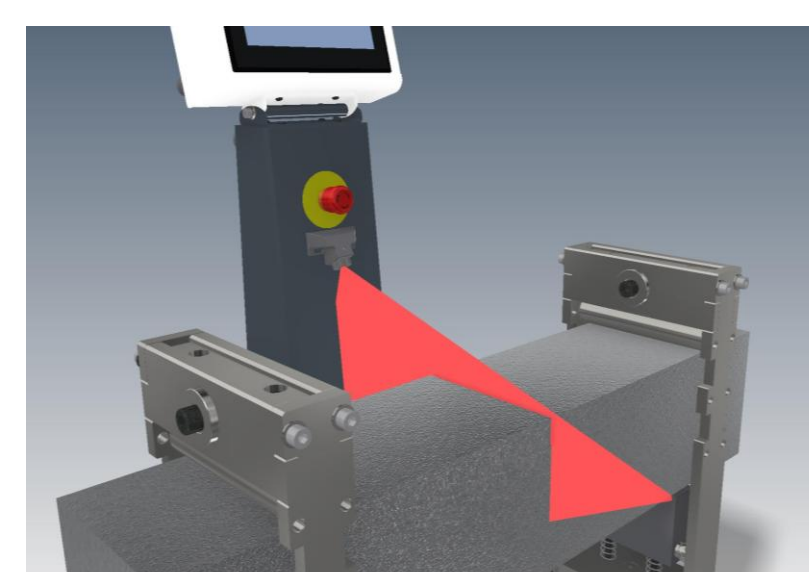
## Innovative construction solutions



integrated deflection measurement frame



ASTM compliant oscillating rollers with minimal added space



laser beam for sample centering



implementation of test standards via a user-friendly touchscreen