

Is Europe in Harmony?

**How the Harmonised Asphalt Standards are
being implemented across Europe**

Implications for Test Equipment Manufacturers

Keith Cooper. Cooper Research Technology Limited

Decisions

- **Do we make EN equipment?**

Once a new technology rolls over you, if you're not part of the steamroller, you're part of the road



EN 12697-25 Stiffness (IT-CY)

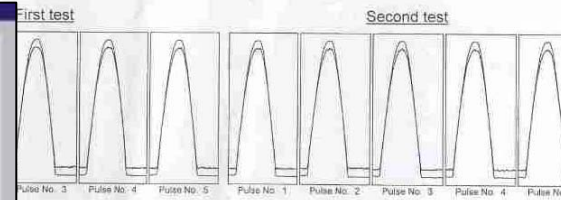
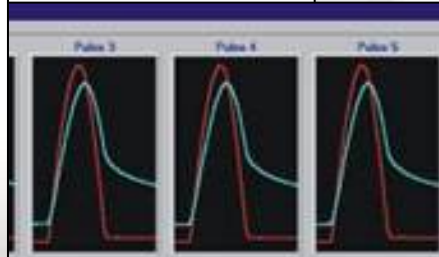


INDIRECT TENSILE STIFFNESS MODULUS TEST REPORT. Serial No. ABC123 (Stiffness modulus test to EN 12697-26:2004(E): Test carried out on NU-14)

Testing Laboratory Address

Date: 05/06/2006
 Operator: Operator
 Specimen ref: Specref
 Test temperature: 20°C
 Specimen diameter: 150 mms
 Specimen thickness: 50 mms
 Poisson's ratio: 0.50
 Target risetime: 124 m.secs
 Target horiz defm: 7 microns

| | | |
|---|---|-------------|
| Date of issue: jún052006 | Client: | Client name |
| Type & origin of bituminous mixture | Binder course from the mixing plant. Crushed granite. | |
| Method of manufacture of the bituminous mixture | Made in batch plant ABC123 | |
| Method of compaction | Compacted by gyratory compactor | |
| Bulk density: 2.345(gm/cm ³) | Determined by method: Determined by gravimetric means | |



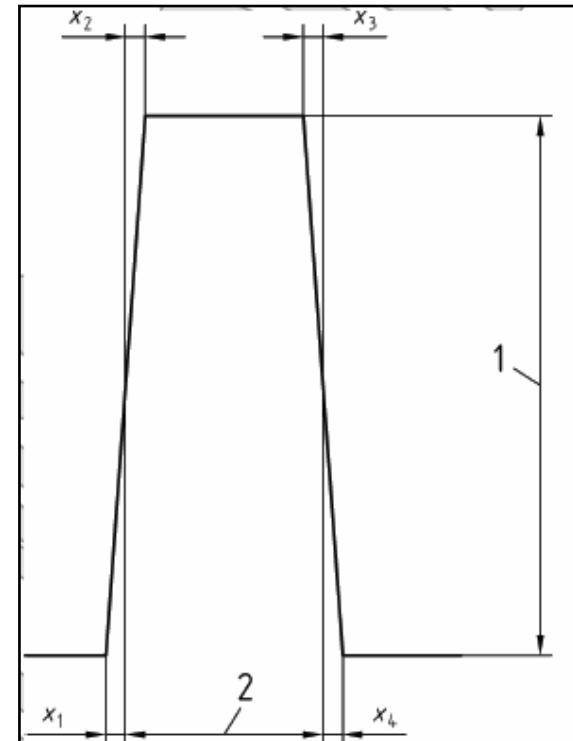
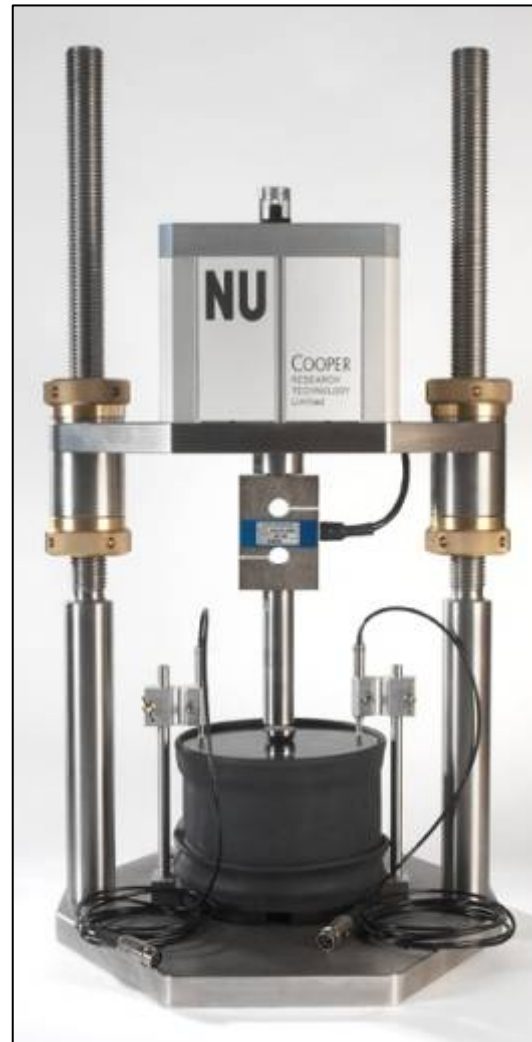
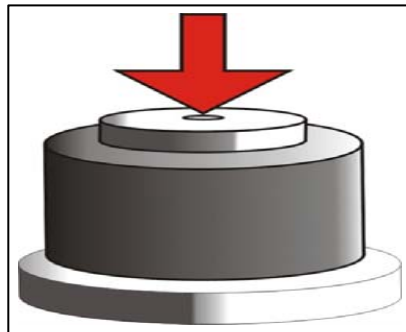
| Pulse No. | Rise Time (ms) | Stiffness modulus (MPa) 1st diameter | | Pulse No. | Vertical Strain (%) | Horizontal Strain (%) | List area factor | Pulse drift (microns) | | Rise Time (m.secs) | Stiffness modulus (MPa) 2nd diameter | | |
|-----------|----------------|--------------------------------------|--------|-----------|---------------------|-----------------------|------------------|-----------------------|----------|--------------------|--------------------------------------|--------|----------|
| | | Actual | Target | | | | | Measured | Adjusted | | Target | Actual | Measured |
| 1 | 124 | 124.0 | 2947 | 1 | 1.33 | 112.4 | 0.50 | 0.06 | 7.0 | 7.0 | 124 | 120.0 | 2932 |
| 2 | 124 | 123.0 | 2911 | 2 | 1.33 | 112.3 | 0.50 | 0.06 | 7.0 | 7.1 | 124 | 123.0 | 2892 |
| 3 | 124 | 124.0 | 2964 | 3 | 1.32 | 112.2 | 0.50 | 0.06 | 7.0 | 7.0 | 124 | 121.0 | 2926 |
| 4 | 124 | 124.0 | 2952 | 4 | 1.32 | 112.4 | 0.50 | 0.06 | 7.0 | 6.9 | 124 | 124.0 | 2947 |
| 5 | 124 | 124.0 | 2927 | 5 | 1.32 | 112.2 | 0.50 | 0.06 | 7.0 | 7.0 | 124 | 123.0 | 2925 |
| Mean | 124 | 124.4 | 2951 | Mean | 1.32 | 112.4 | 0.50 | 0.06 | 7.0 | 7.0 | 124 | 122.6 | 2922 |

| Operator | Horizontal drift (microns) | Pulse shape factor (%) | Stiffness modulus (MPa) | |
|----------|----------------------------|------------------------|-------------------------|------|
| Measured | Adjusted | Measured | Adjusted | |
| 1.26 | 10.1 | 0.823 | 496.0 | 1079 |
| 1.26 | 10.1 | 0.823 | 496.5 | 1076 |
| 1.26 | 10.1 | 0.823 | 497.6 | 1083 |
| 4 | 9.95 | 0.825 | 494.5 | 1078 |
| 5 | 9.84 | 0.828 | 495.7 | 1073 |
| Mean | 9.95 | 0.823 | 496.0 | 1072 |

(rise) time (ms) : 123.5
 deformation (µm) : 7.0
 stiffness modulus (MPa) : 2927
 stiffness modulus (MPa) : 3023

| | |
|-----------------|--------------------|
| Test report | Signed (jún052006) |
| John Technician | |

EN 12697-25 Cyclic compression



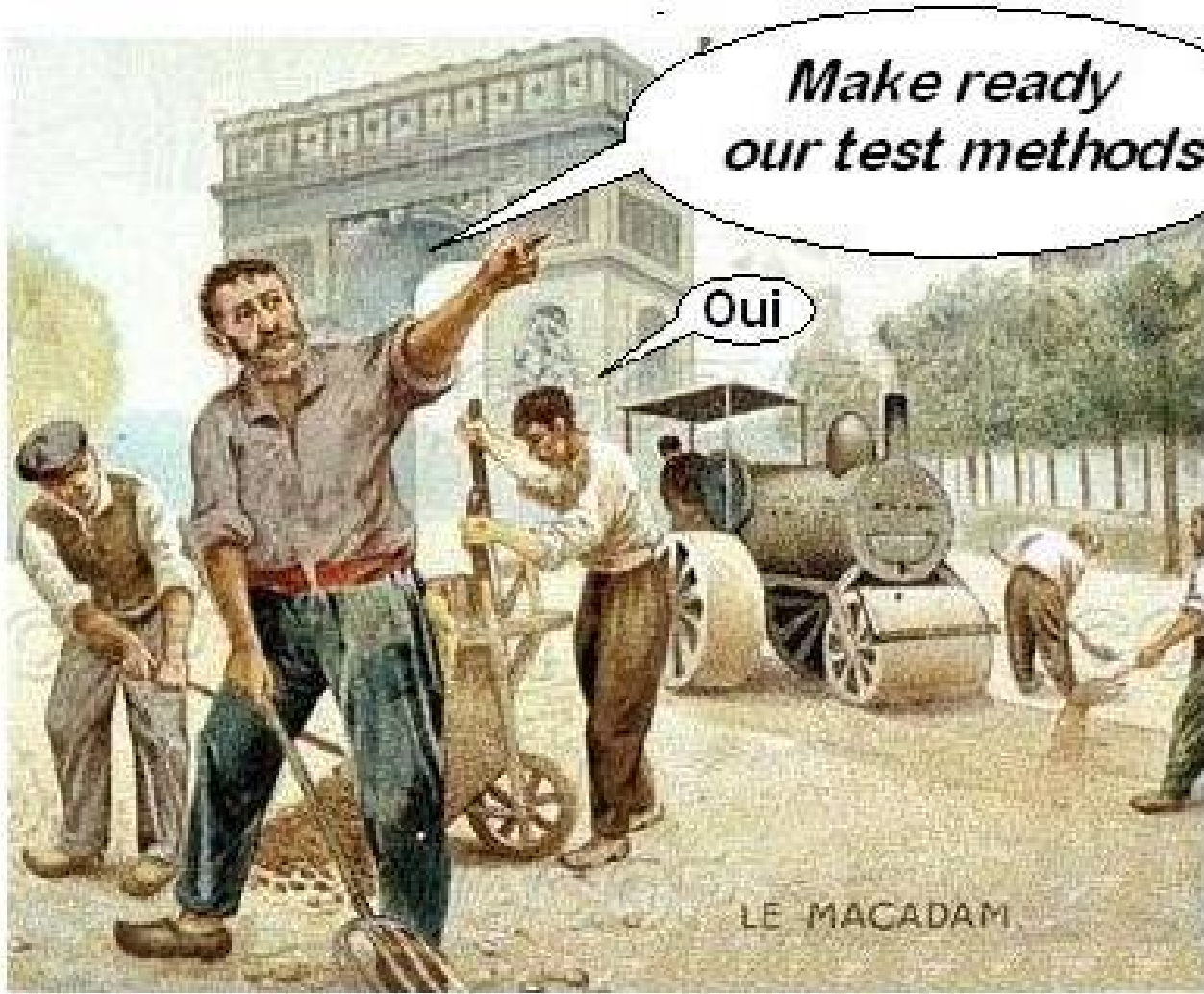
EN 12697

32 Wheeltracking
Small size device – Procedure B

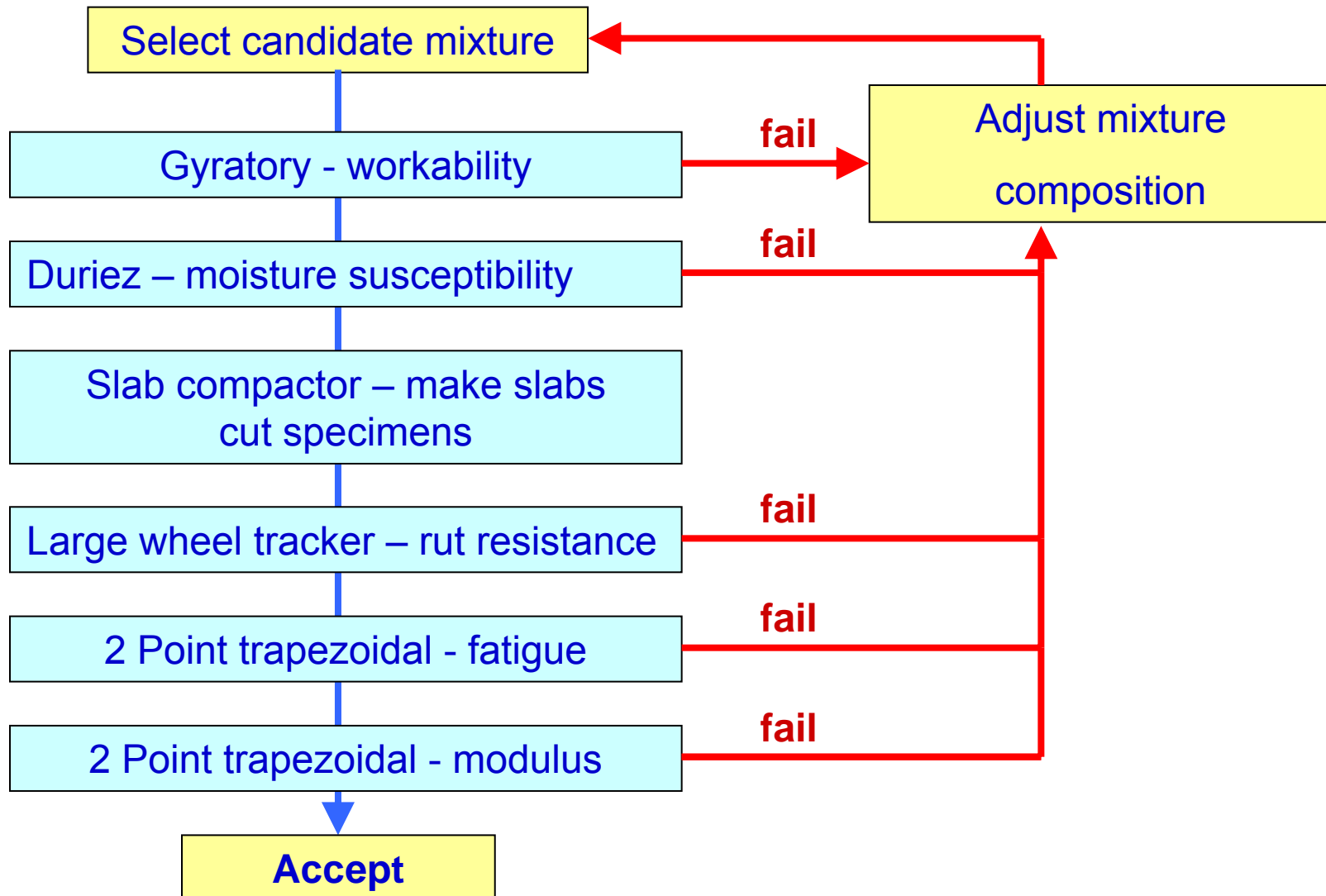


22 Slab compaction
Smooth steel roller



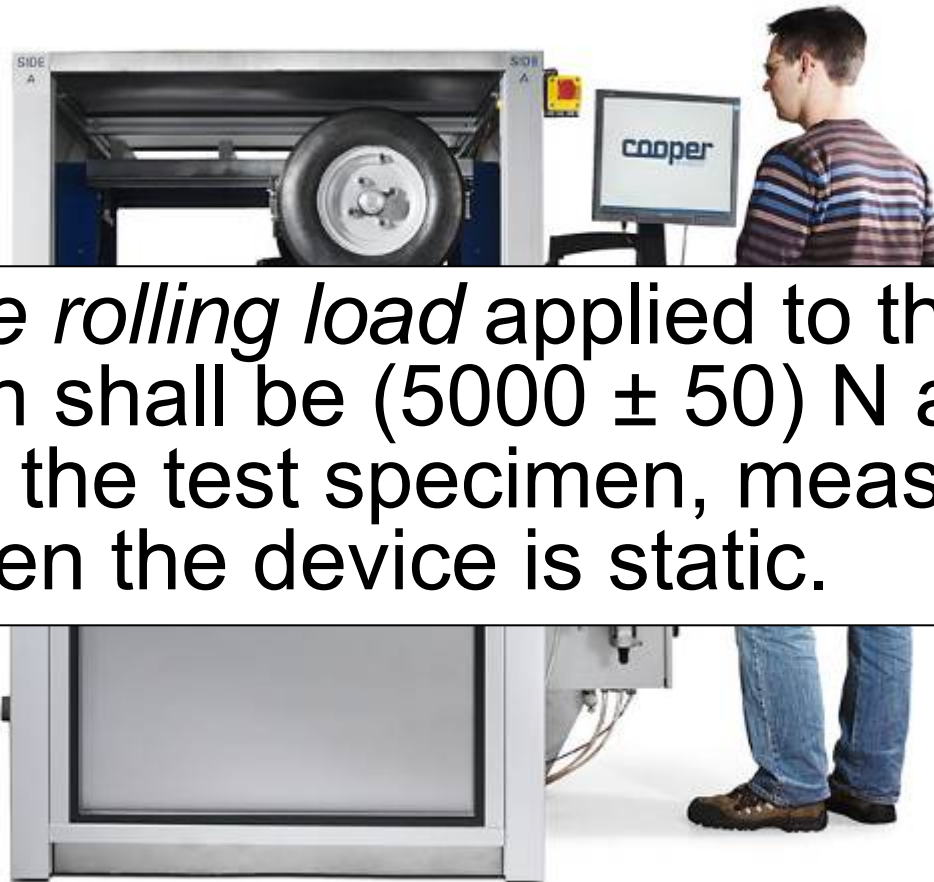


French mixture design procedure



EN 12697-22 Wheeltracking

Large size device



6.1.1.4 *The rolling load* applied to the test specimen shall be (5000 ± 50) N at the centre of the test specimen, measured **at least** when the device is static.

EN12697-33 Slab compaction

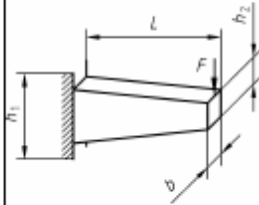

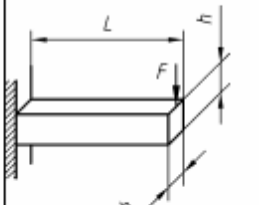

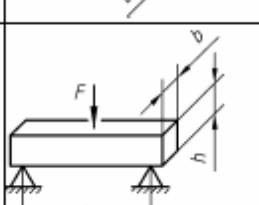

Pneumatic tyred slab compactor

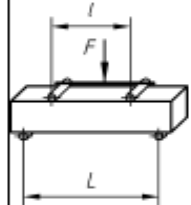


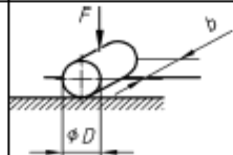

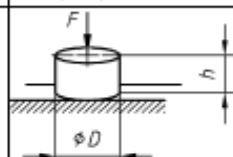

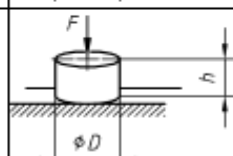



Which equipment do we make?

BS EN12697-26 Stiffness - Test methods

Table 2 — Form and mass factors for different specime

| Type of loading | | Form factor, γ L^{-1} |
|-----------------|---|--|
| 2PB-TR |  |  $\frac{h_2}{h_1}$ |
| 2PB-PR |  |  $\frac{L^3}{h^3}$ |
| 3PB-PR |  |  $= \frac{L^3}{4bh^3}$ |

| Type of loading | | Form factor, γ L^{-1} |
|-----------------|---|---|
| 4PB-PR |  |   |
| IT-CY |  |  |
| DTC-CY |  |  $\frac{1}{h}$ |
| DT-CY DT-PR |  |  |

EN12697-24 Fatigue

Four point bending



D.2.1 Test machine (Four point bending fatigue)

Equipment that shall be capable of applying a **sinusoidal** load to a specimen by a suitable mechanism via two inner clamps mounted on the specimen (Figure D.1). The frequency of the load, f_0 , shall be in the range **0 to 60** Hz with an accuracy of **0,1** Hz.



EN 12697 – 24 Resistance to fatigue

3 Terms, definitions, symbols and abbreviations

| | | | |
|---|---|--|--|
| <p>3.5 Four-point bending test on prismatic shaped specimens</p> <p>3.5.1 (complex) stiffness ratio $S = S_{max} \times e^{\phi}$ of the specimen</p> <p>NOTE The stiffness ratio S is defined for specimens subjected to sinusoidal loading.</p> <p>3.5.2 initial (complex) stiffness values for the initial modulus ϕ_0 in degrees of the complex modulus</p> <p>3.5.3 fatigue life $N_{i,j}$ number of cycles for specimen i at the set of test conditions j (e.g. $f=50$) at the set of test conditions, or constant force level</p> <p>3.5.4 test condition k set of conditions at which the test is performed (e.g. temperature θ and the energy per cycle)</p> <p>3.5.5 average fatigue life of a specimen $\bar{N}_{i,k}$ value defined according to:</p> $\bar{N}_{i,k} = \frac{\sum_{e=1}^m \ln(N_{i,k,e})}{m}$ <p>14</p> | <p>3.5.6 standard deviation of natural logarithm of the stiffness ratio</p> $S_{j,k} = \frac{1}{(m-1)} \times \sum_{e=1}^m (\ln(N_{i,k,e}) - \bar{\ln(N_{i,k})})^2$ <p>3.5.7 total length L_{tot} total length of the prismatic specimen</p> <p>3.5.8 effective length L distance between the two loading points</p> <p>3.5.9 width B width of the prismatic specimen</p> <p>3.5.10 height H height of the prismatic specimen</p> <p>3.5.11 mid-span length a distance between the two loading points</p> <p>3.5.12 co-ordinate x distance between the loading point and the end of the specimen</p> <p>3.5.13 co-ordinate x distance between x and the end of the specimen</p> <p>3.5.14 co-ordinate x_s co-ordinate x where the sensor is placed</p> <p>3.5.15 density ρ geometrical density of the specimen</p> $\rho = \frac{M_{geom} \times 10^9}{(H \times L \times B)}$ <p>3.5.16 mass M_{geom} total mass of the prismatic specimen</p> <p>3.5.17 damping coefficient δ coefficient needed for the calculation of the stiffness ratio</p> <p>NOTE This coefficient is defined for a specimen with zero value).</p> | <p>3.2 Two-point bending test on trapezoidal specimens</p> <p>3.2.1 constant relative to maximum strain K_E constant that enables the head displacement z of the trapezoidal specimen of dimensions $[B, b, e, h]$, to which a bending strain level ϵ is applied, to be converted into maximum strain</p> <p>NOTE K_E and its relationship with the parameters mentioned above is the following:</p> $K_E \times z = \epsilon \quad (1)$ $K_E = \frac{B^2 \times (B-b)^2}{4b \times h^2 \times [(b-B) \times (3B-b) + 2B^2 \times \ln(B/b)]} \quad (2)$ <p>EN 12697-24:2004 (E)</p> <p>3.2.2 Symbols</p> <p>The symbols are as follows, with a strain of 1 microstrain (μstrain) being equal to 10^{-6} by convention:</p> <p>i is the index of the specimen for an element test (varies from 1 to n)</p> <p>h_i is the height, in metres (m)</p> <p>B_i is the large base, in metres (m)</p> <p>b_i is the small base, in metres (m)</p> <p>e_i is the thickness, in metres (m)</p> <p>v_i is the void content of the specimen i by geometric method, in per cent (%)</p> <p>K_{Ei} is the constant, relative to the maximum strain, in inverse metres (m^{-1})</p> <p>z_i is the amplitude of displacement imposed at the head of specimen i, in metres (m)</p> <p>ϵ_i is the maximum relative strain of specimen i corresponding with the displacement imposed at the head</p> <p>N_i is the conventional fatigue life of specimen i</p> <p>a is the ordinate of the fatigue line according to the equation $\log(N) = a + (1/b) \log(\epsilon)$</p> <p>$r_2$ is the linear correlation coefficient ($\log(N_i)$, $\log(\epsilon_i)$)</p> <p>$1/b$ is the slope of the fatigue line</p> <p>$\log(\epsilon)$ is the average value of $\log(\epsilon_i)$</p> <p>$S_{\log(\epsilon)}$ is the standard deviation of $\log(\epsilon_i)$</p> <p>$S_{\log(N)}$ is the standard deviation of $\log(N_i)$</p> <p>ϵ_0 is the strain corresponding with 10^6 cycles</p> <p>s_N is the estimation of the residual standard deviation of the decimal logarithms of fatigue lives</p> <p>$\Delta\epsilon_0$ is the quality index of the test</p> <p>n is the number of specimens</p> | <p>EN 12697-24:2004 (E)</p> <p>mass of the moving parts of the sensor, in grams (g)</p> <p>equivalent mass, in grams (g)</p> <p>length of life for specimen number i the chosen failure criteria j and the set of test conditions k as</p> <p>number of load applications at conventional failure when the modulus of the (complex) stiffness modulus has decreased to half its initial value</p> <p>level of the loading mode test condition corresponding to 10^6 cycles for the fatigue life according to the chosen failure criteria, k</p> <p>confidence interval relative to Q</p> <p>initial value of the calculated modulus</p> <p>estimation of the standard deviation of the residual dispersion of the natural logarithms of lives, σ_N</p> <p>coefficient for the system losses in the interpretation equations for Young's modulus</p> <p>frequency of the sinusoidal load applications</p> <p>slope of the fatigue line</p> <p>correlation coefficient of the regression</p> <p>distance from end of sample, in millimetres (mm)</p> <p>distance from the end of the specimen to where the sensor is placed, in millimetres (mm)</p> <p>initial strain amplitude measured at the 100^{th} load cycle</p> <p>test frequency</p> <p>test temperature, in degrees Celsius ($^{\circ}\text{C}$)</p> <p>res (mm)</p> <p>being tested, in millimetres (mm)</p> <p>res (mm)</p> <p>n millimetres (mm)</p> <p>millimetres (mm)</p> <p>at the masses of the mounted clamps, in grams (g)</p> <p>the mass of the adhesive, and the mass of the load cells (g)</p> |
|---|---|--|--|

Two point bending test equipment

BS EN 12697-26 Stiffness

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

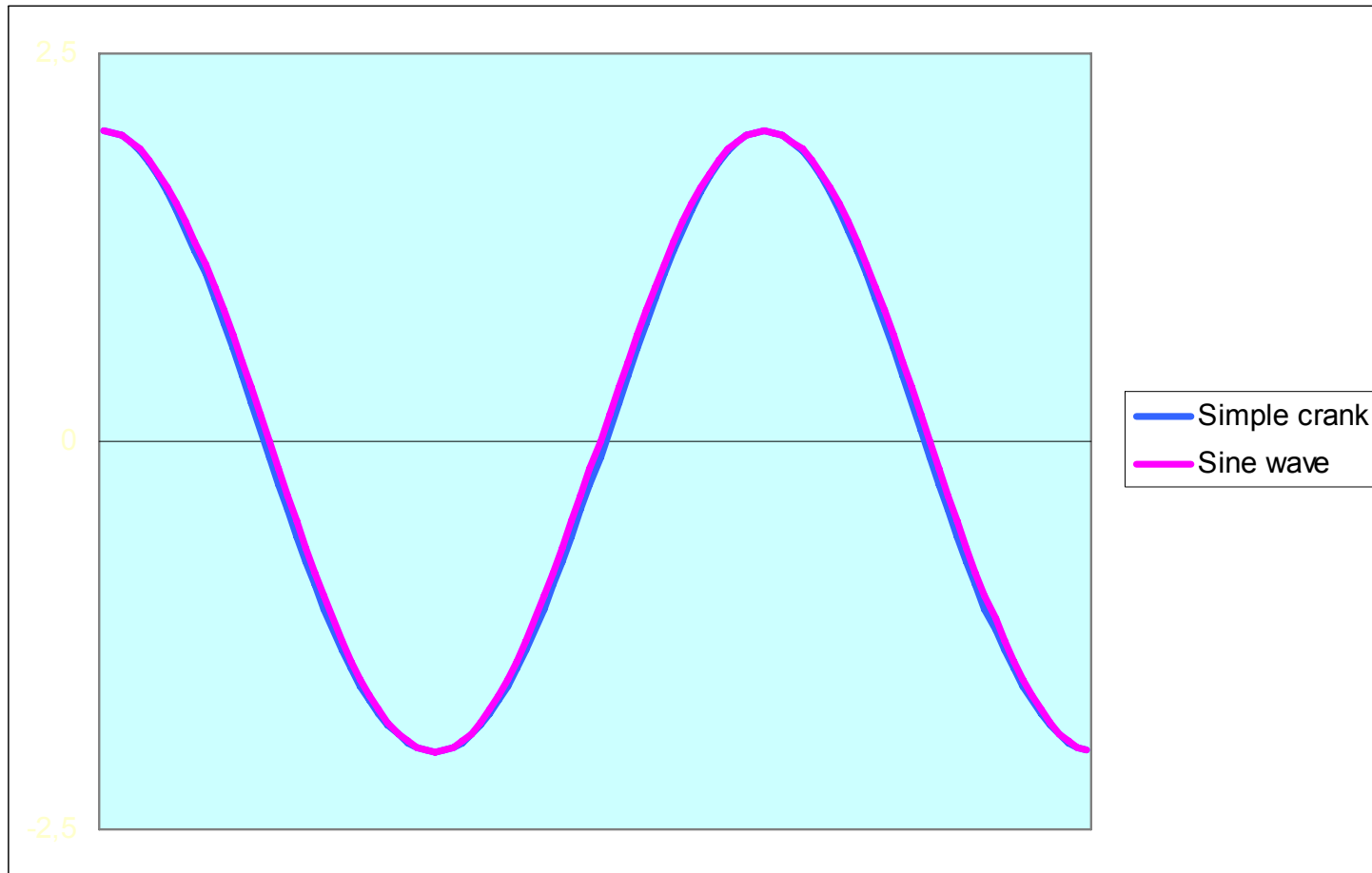
3.1.1

complex modulus

relationship between stress and strain for a linear visco-elastic material submitted to a **sinusoidal** load waveform at time, t , where applying a stress $\sigma \times \sin(\omega t)$ results in a strain $\epsilon \times \sin(\omega \times (t - \phi))$ that has a phase angle, ϕ , with respect to the stress.

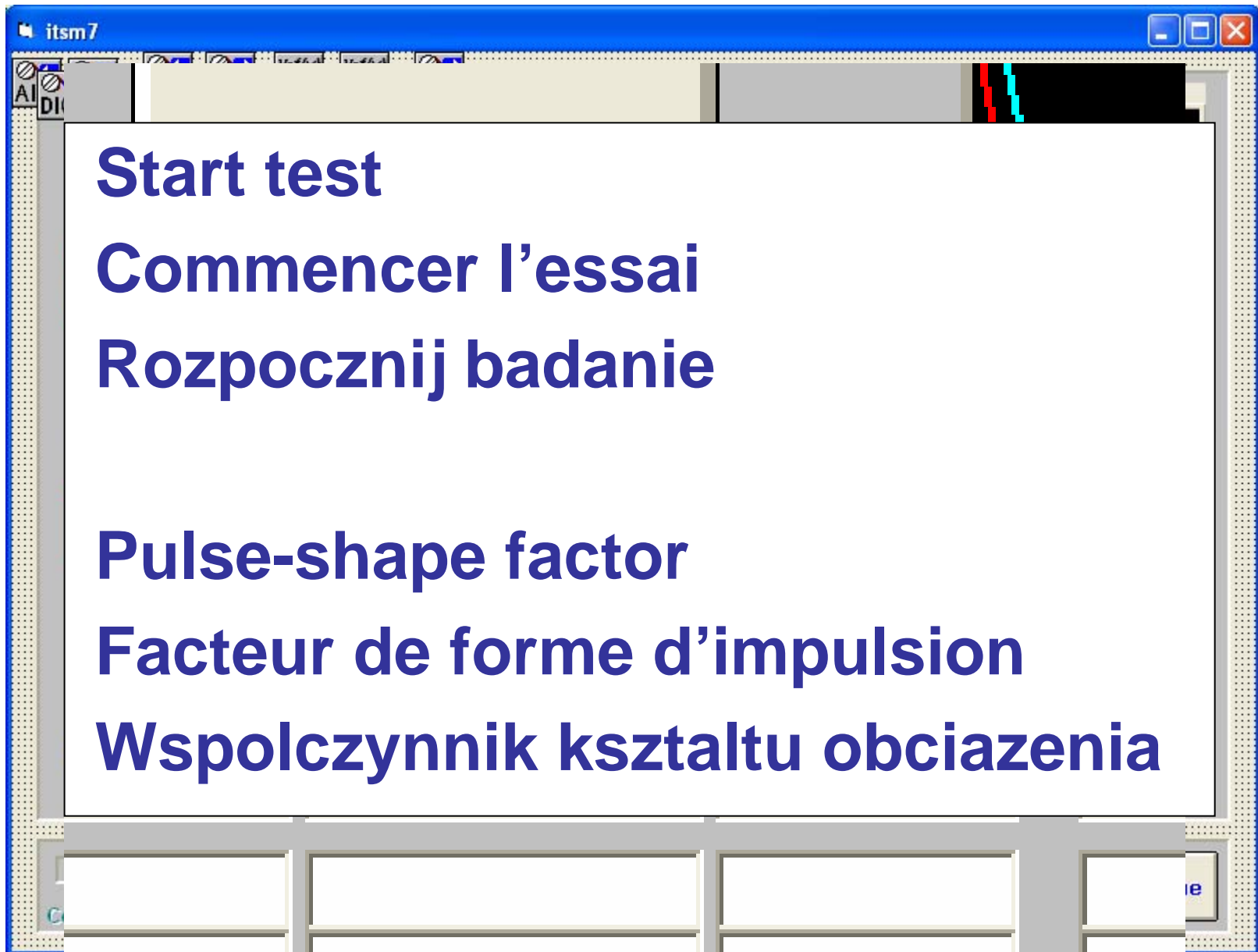
— Simple crank
— Sine wave

Sinusoidal or not sinusoidal?

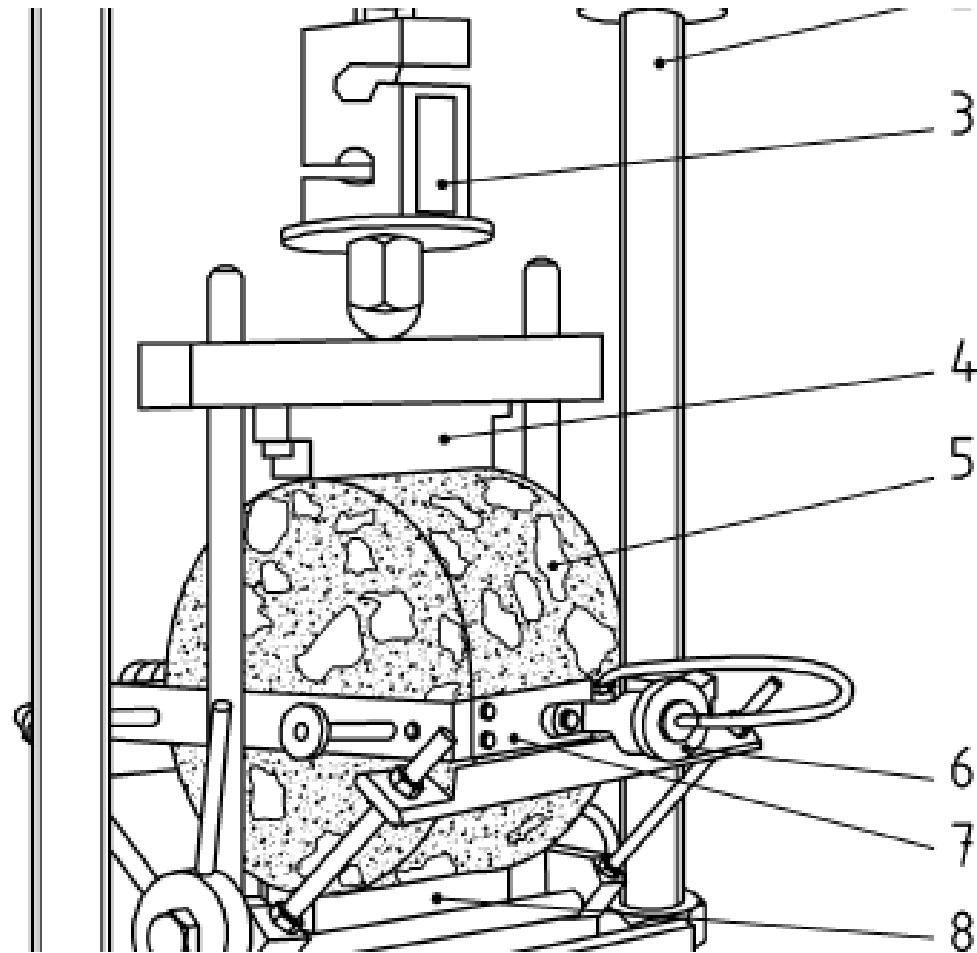


Two point trapezoidal bending





Loading strips



The three Rs

- Reliability
 - Repeatability
 - Reproduceability
- = Round robin test**



