

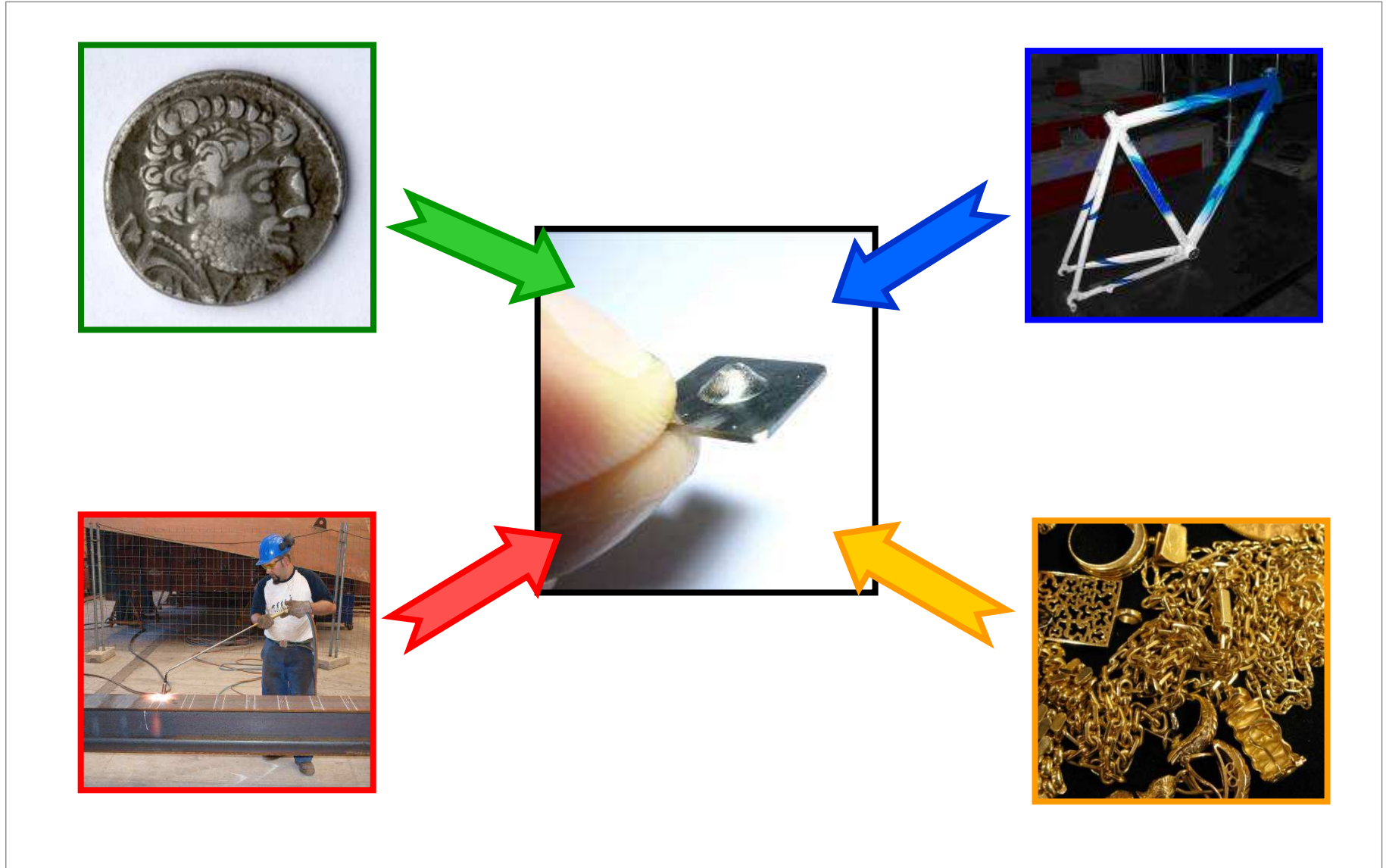


1st SSTT INTERNATIONAL CONFERENCE, OSTRAVA, 31ST AUGUST 2010

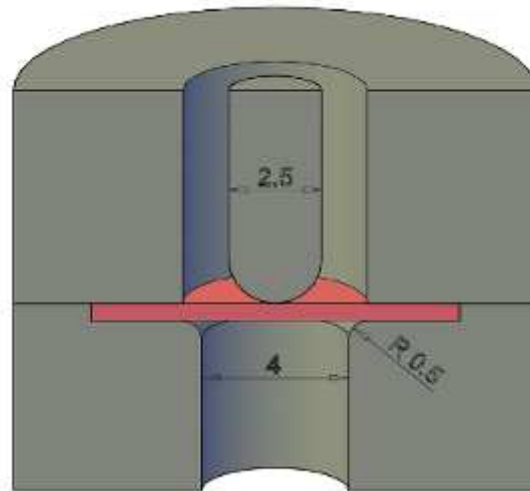
FROM ARCHAEOLOGY TO PRECIOUS METALS: FOUR APPLICATIONS OF SMALL PUNCH TEST

R. Lacalle, J.A. Álvarez, S. Cicero,
F. Gutiérrez-Solana

LADICIM

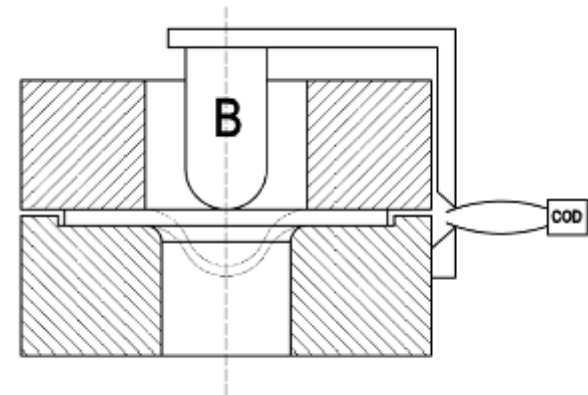


EXPERIMENTAL DEVICE

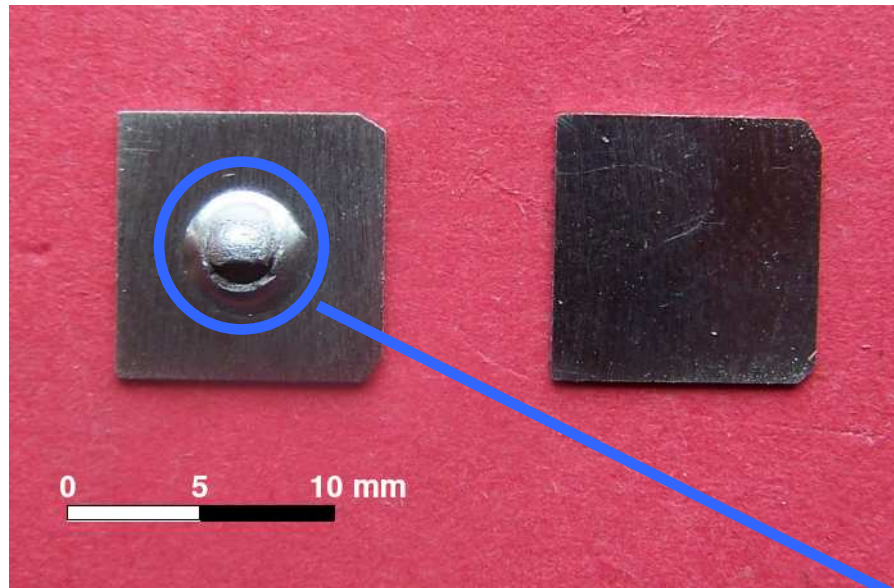


- Lower die hole: 4 mm
- Punch radius: 1.25 mm

*European Code of Practice
CWA 15627*



SPECIMEN CONFIGURATION



- Square 10 x 10 mm
- Thickness: 0.5 mm



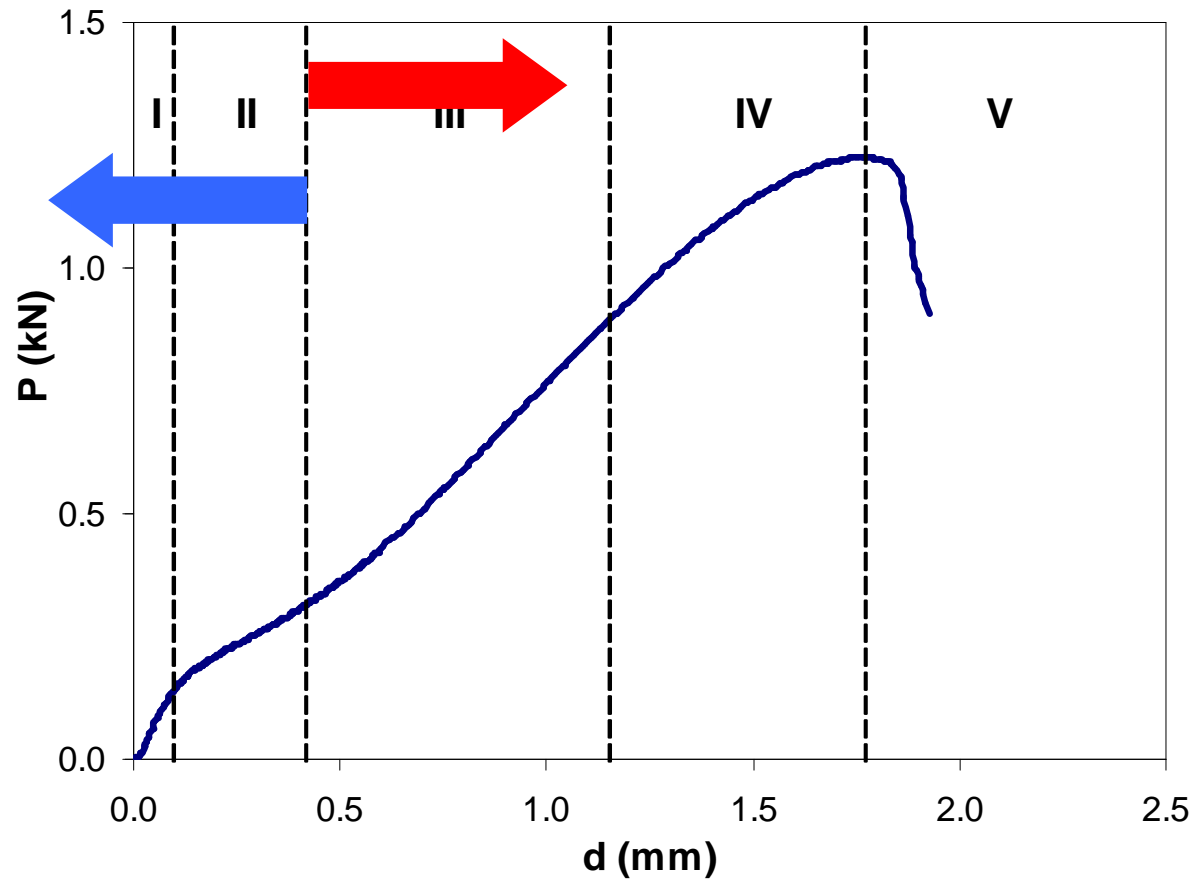
**Easy to machine from
prismatic bars (i.e. broken
Charpy Specimens)**

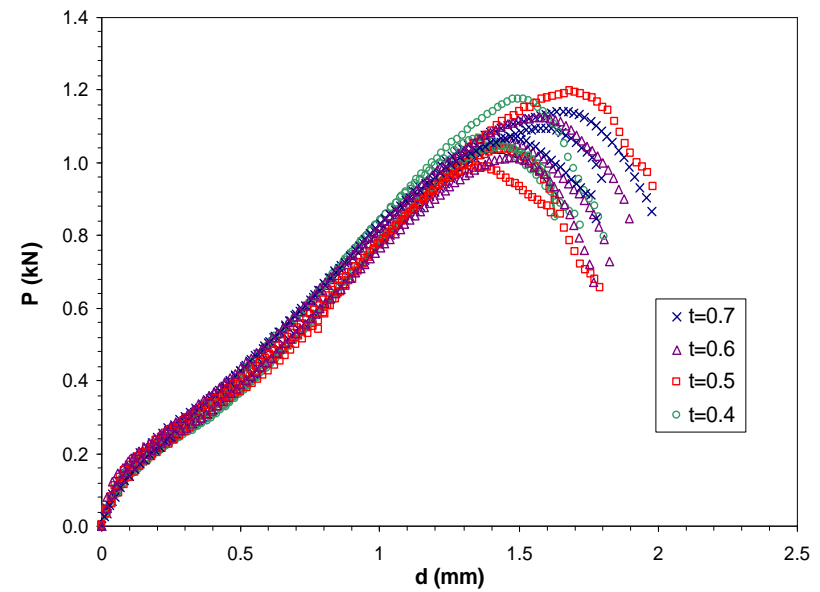
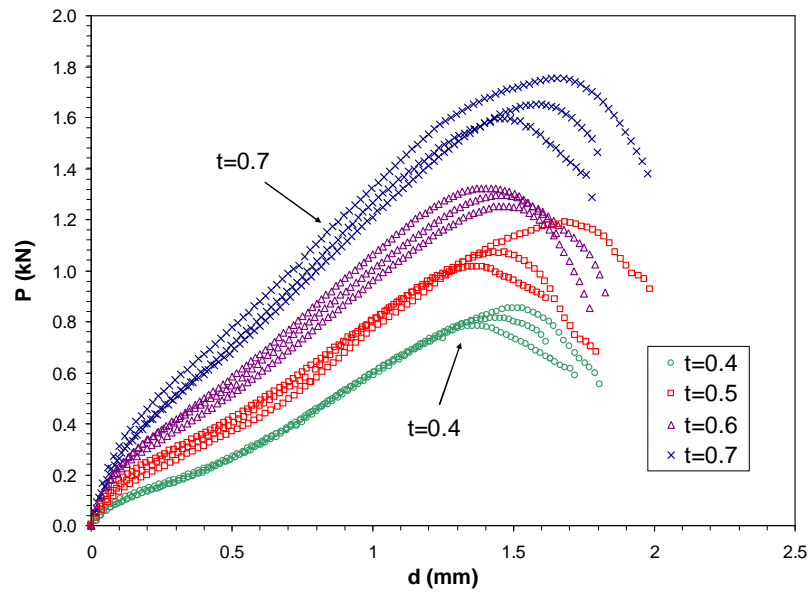
*European Code of Practice
CWA 15627*

RECENT RESEARCH UNIVERSITY OF CANTABRIA ON SMALL PUNCH TEST:

- **NORMALISATION of Small Punch curve**
- **YIELD STRESS and TENSILE STRENGTH correlations**
- **FRACTURE MECHANICS approaches**

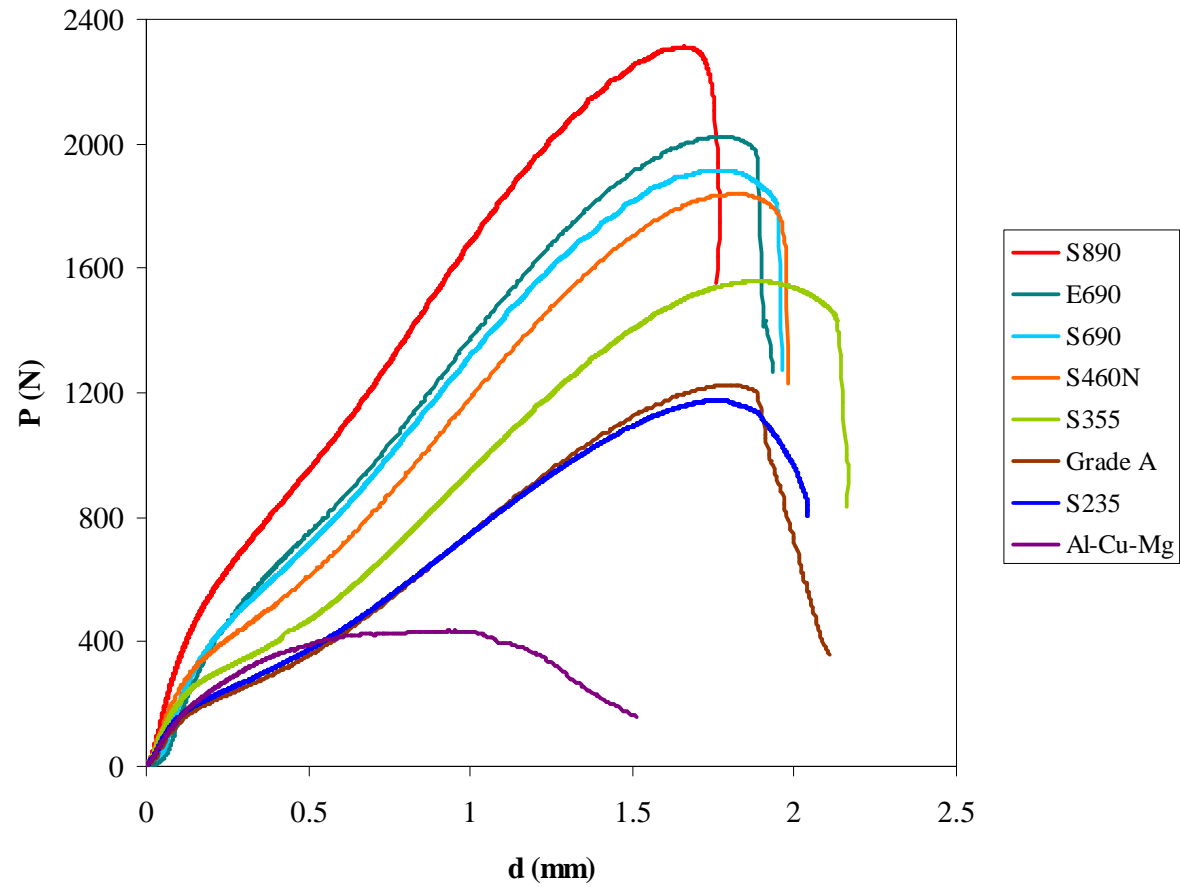
PLATE MEMBRANE





$$P_{0.5} = 0.5^2 \cdot \frac{P}{t^2} \quad P < P_{II-III}$$

$$P_{0.5} = 0.5^2 \cdot \frac{P_{II-III}}{t^2} + 0.5 \cdot \frac{P - P_{II-II}}{t} \quad P < P_{II-III}$$



8 MATERIALS TESTED (7 STEELS AND ALUMINIUM ALLOY)

Indentation

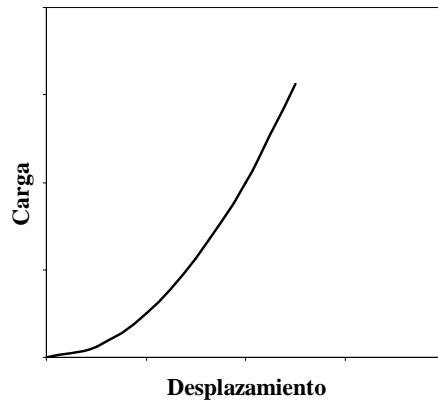
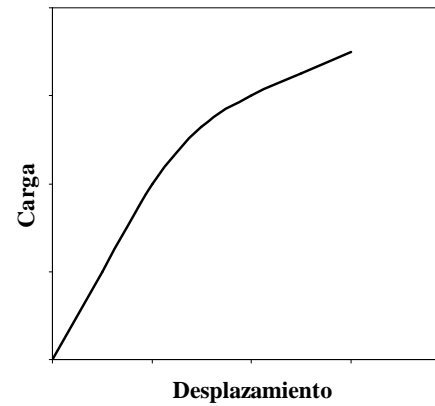


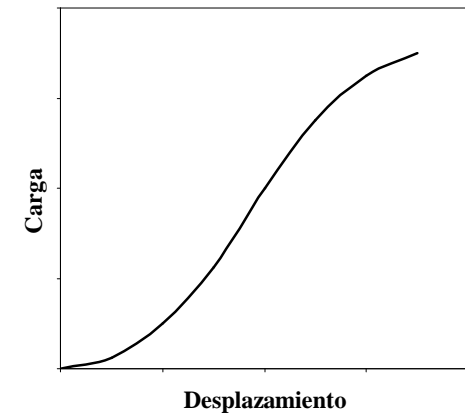
Plate behaviour

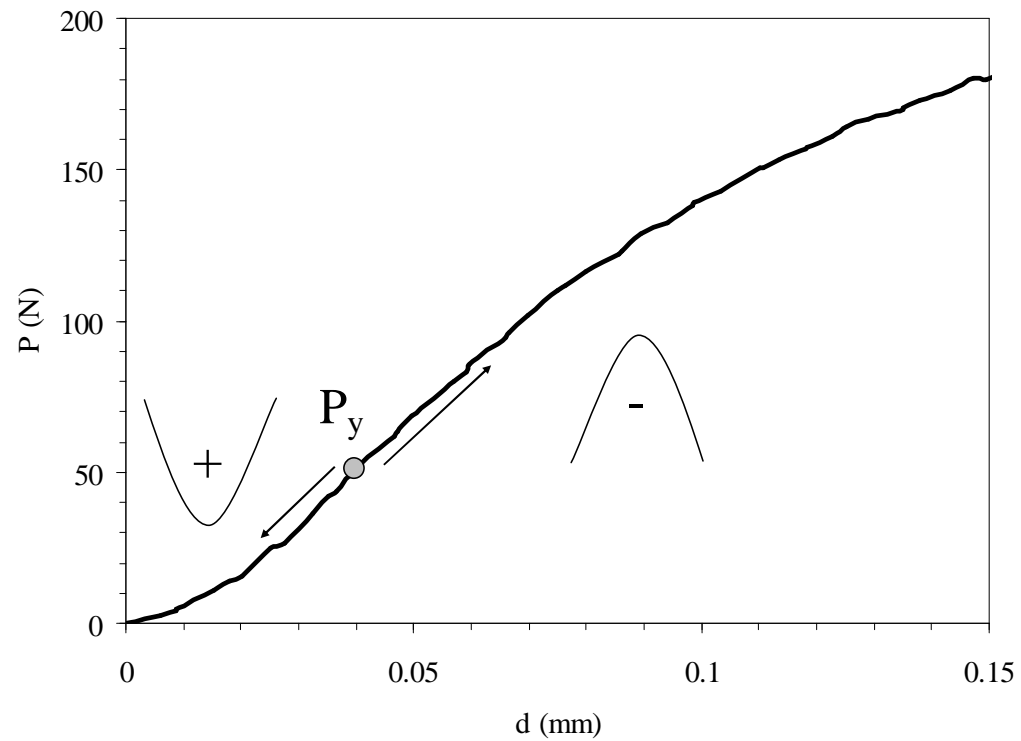


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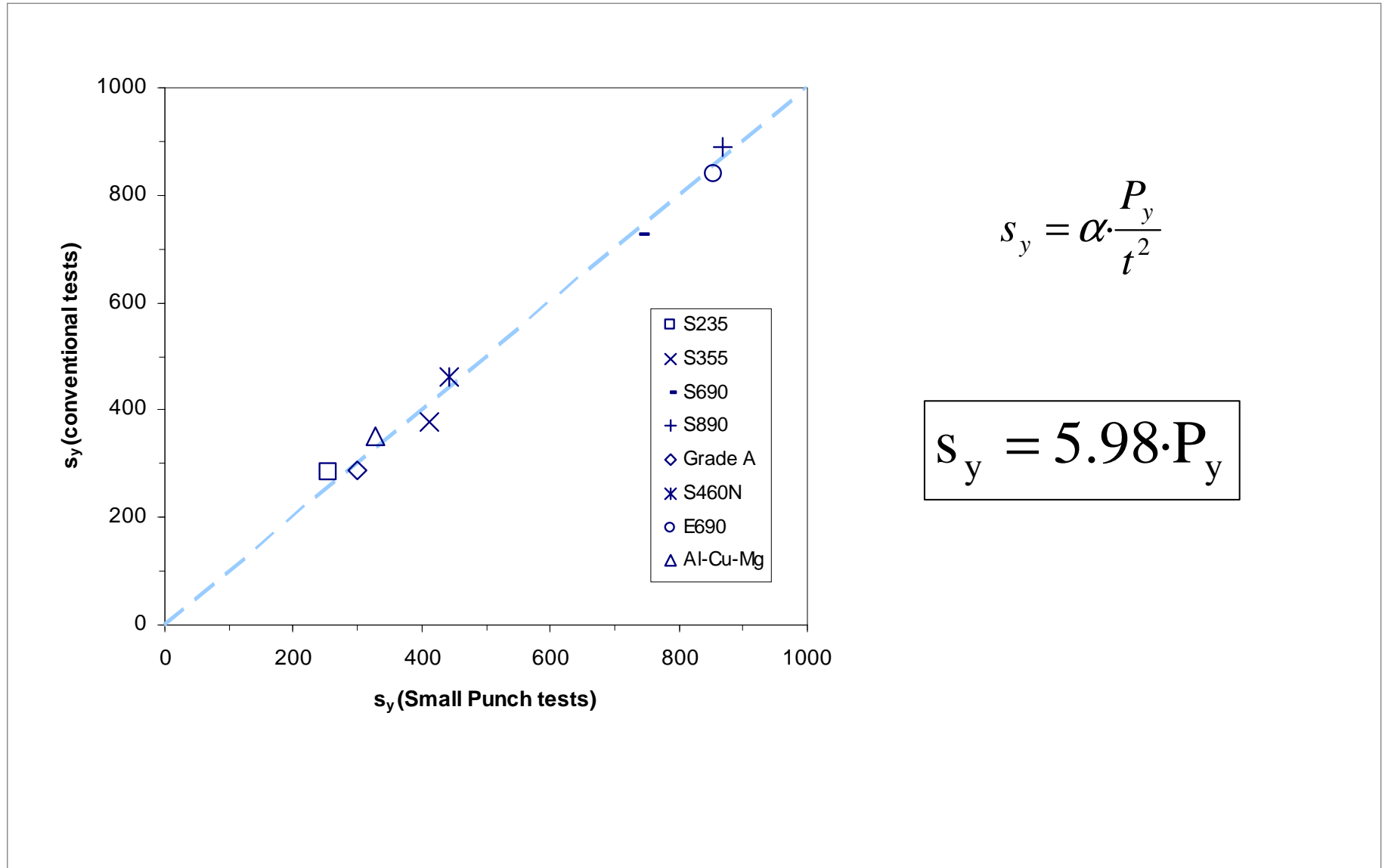
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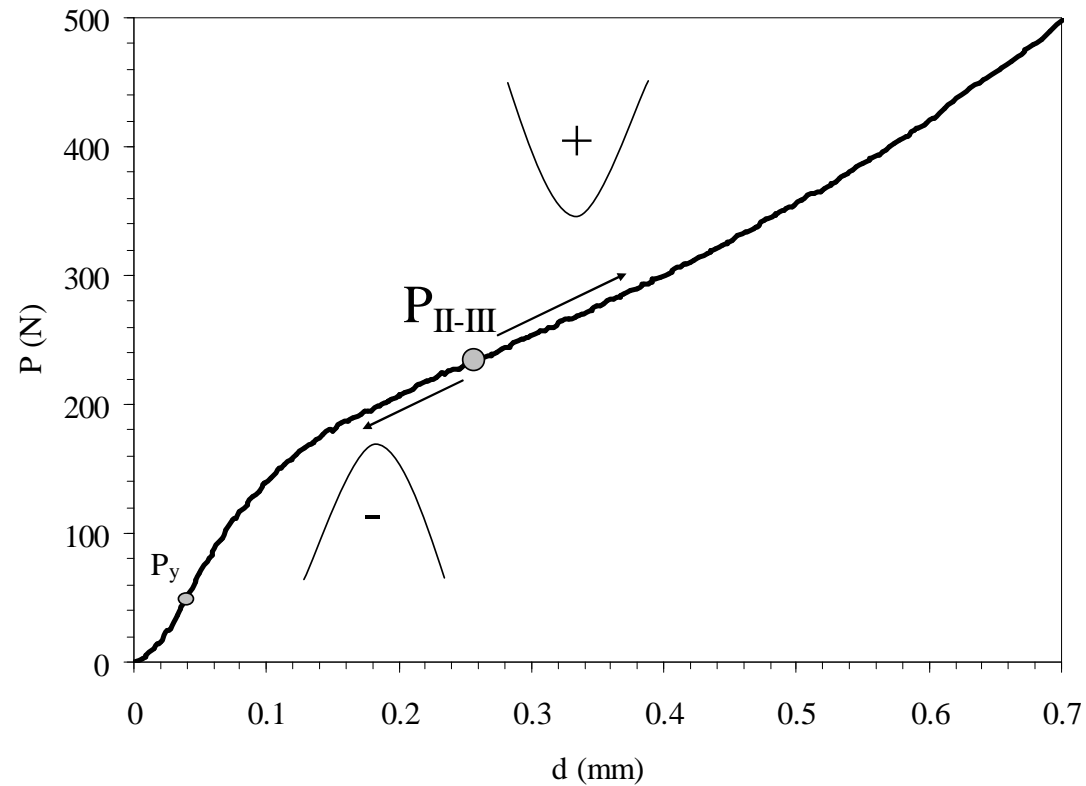
Test curve



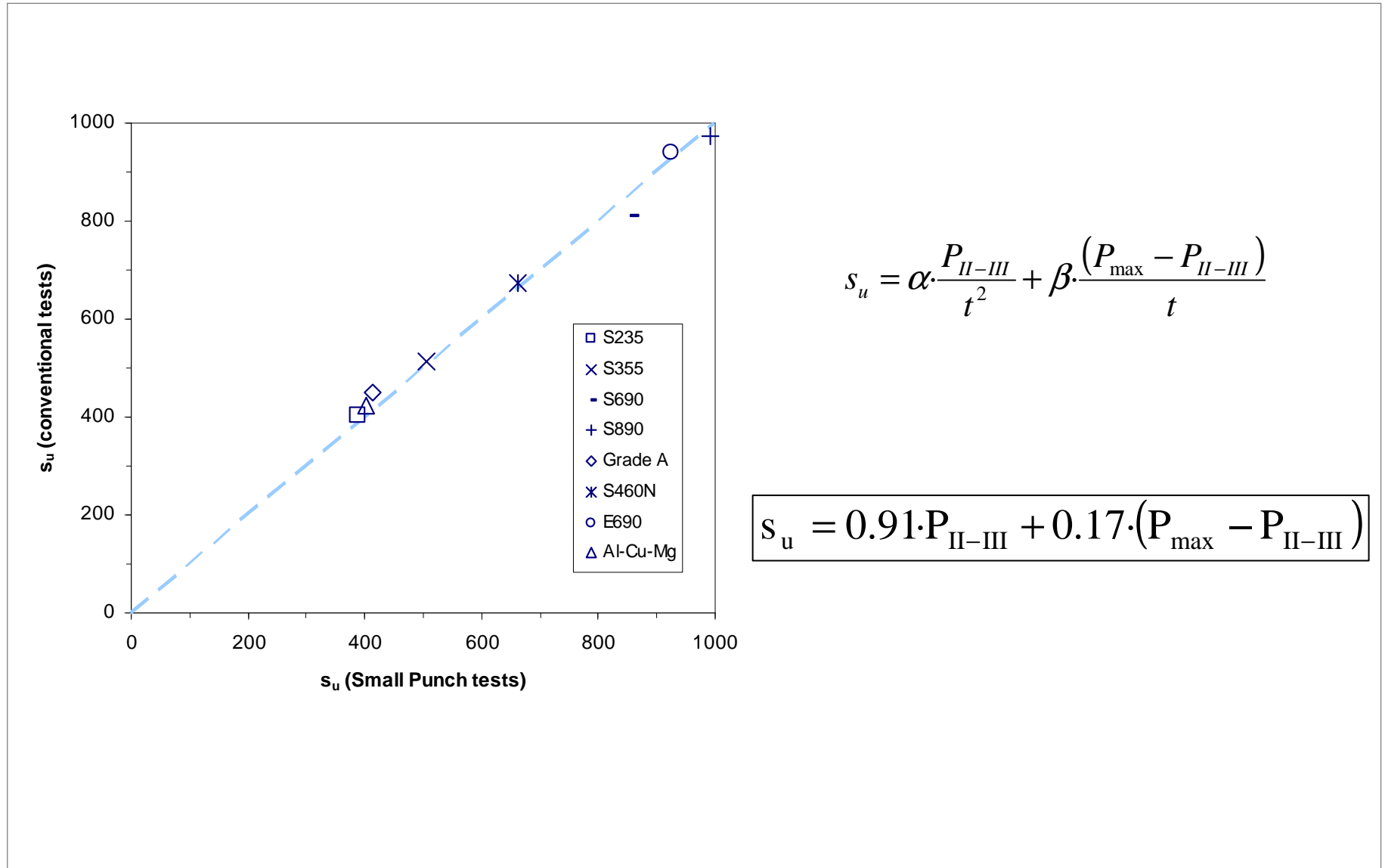


Determination of P_y as the corresponding to 1st inflection point





Correlation based on P_{II-III} (transition between plate and membrane behaviour) and P_{max}

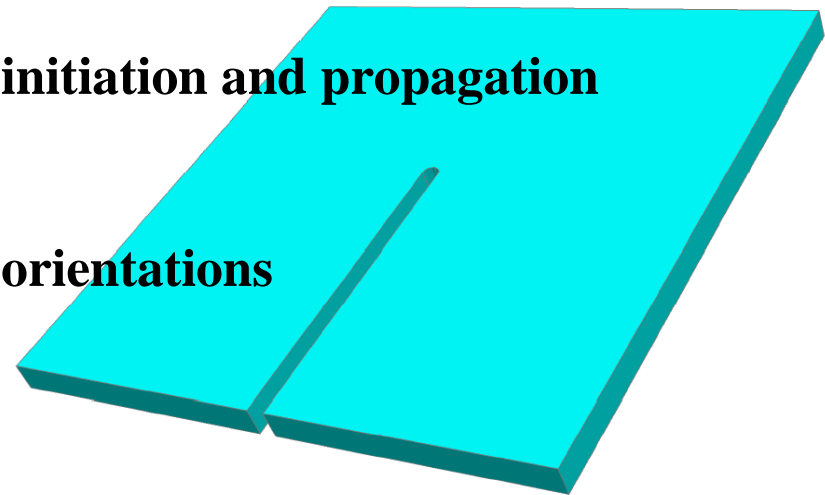


$$s_u = \alpha \cdot \frac{P_{II-III}}{t^2} + \beta \cdot \frac{(P_{\max} - P_{II-III})}{t}$$

$$s_u = 0.91 \cdot P_{II-III} + 0.17 \cdot (P_{\max} - P_{II-III})$$

USE OF NOTCHED SPECIMENS

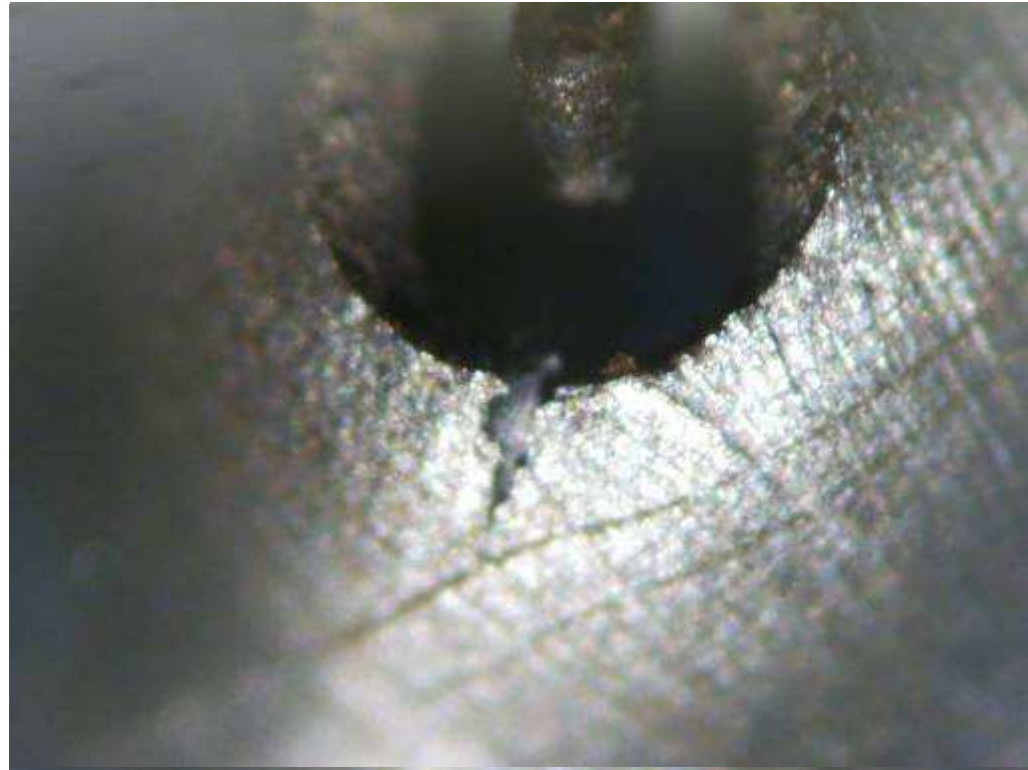
- **Fracture mechanics conditions → Defect**
- **Possibility for controlling crack initiation and propagation**
- **Characterisation of all material orientations**





- **Square 10 x 10 mm**
- **Lateral notch by wire electron cutting**
- **Notch radius: 0.15 mm**
- **Notch length \approx 5 mm**

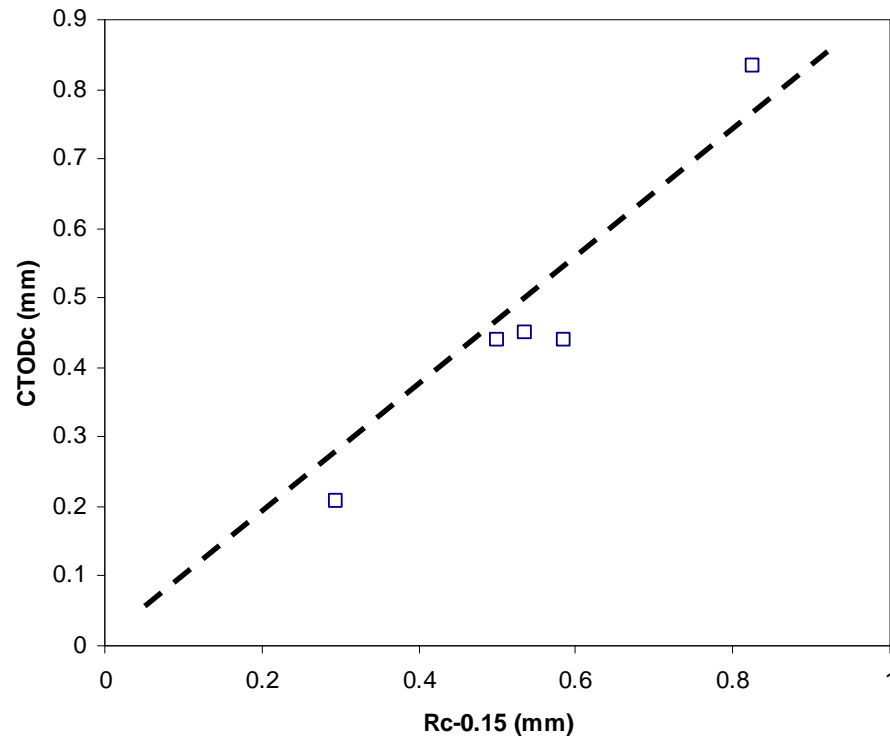
CTOD APPROACH



CTOD APPROACH



CORRELATION BETWEEN CURVATURE AND CTOD_c



CTOD_c

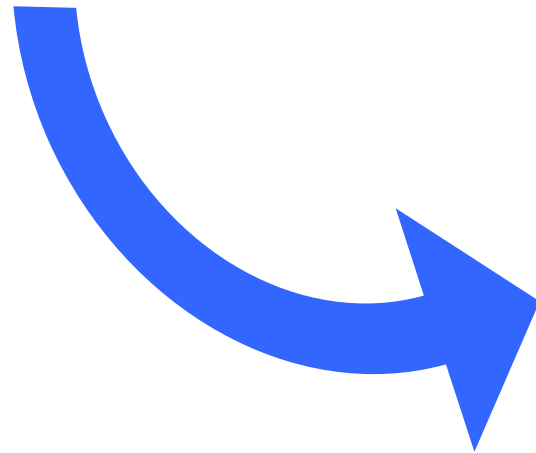


J_{Ic}

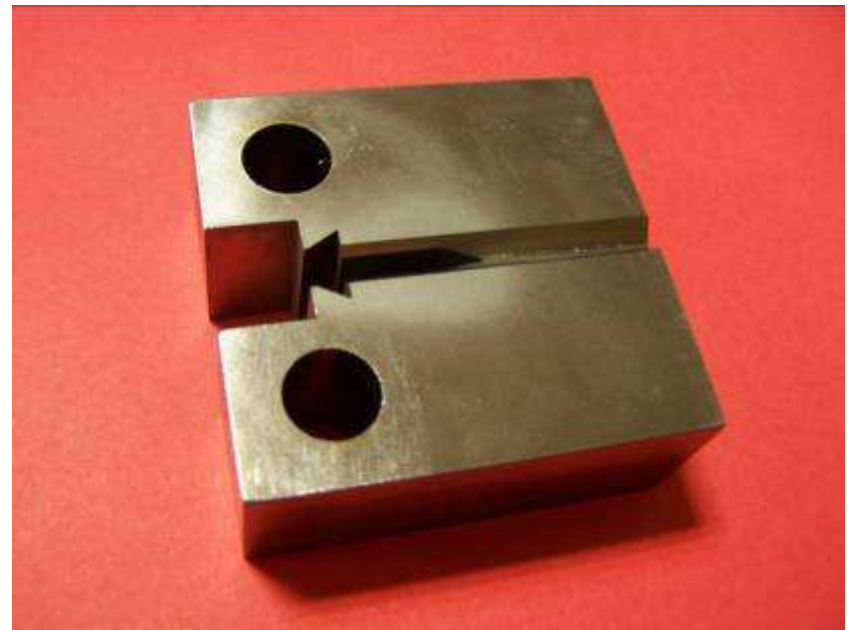
OBJECTIVE:

Characterisation of a bronze and a cast iron from a pre-roman site.



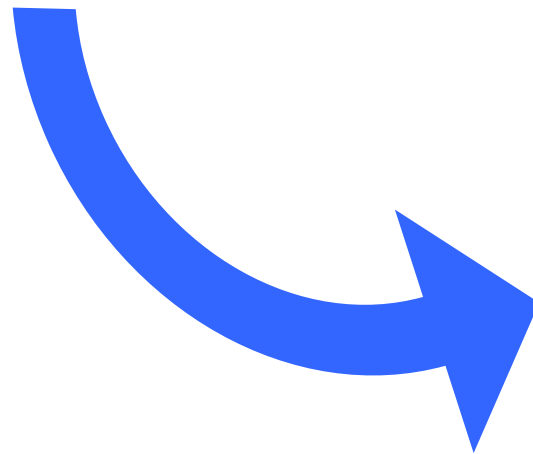


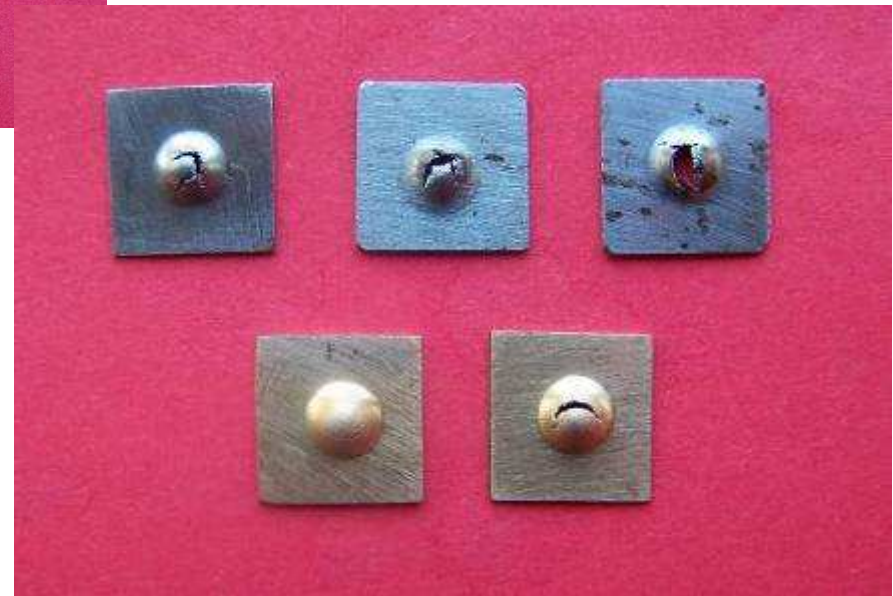
ALTERNATIVE A:
CONVENTIONAL SPECIMENS

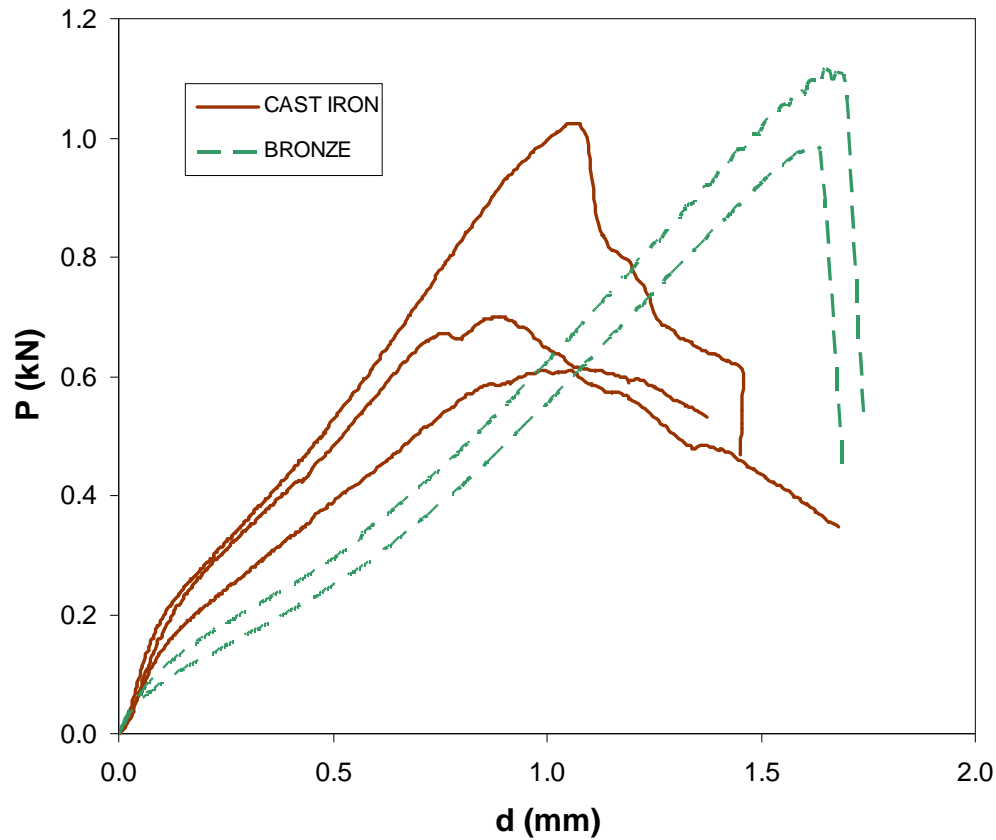




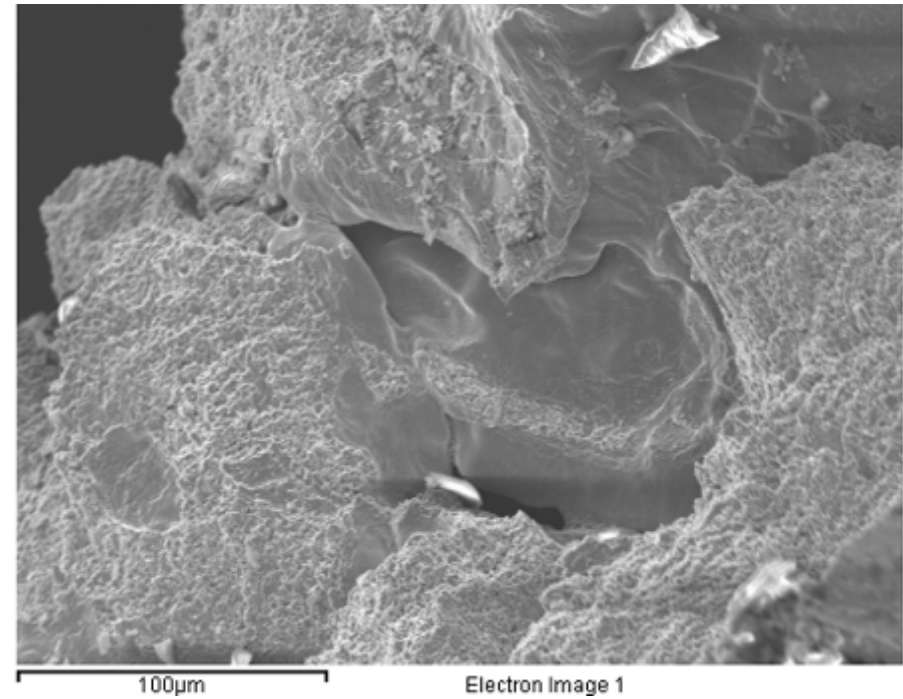
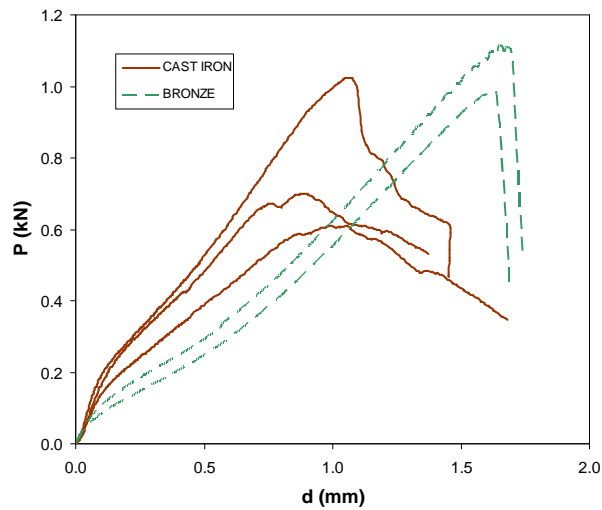
ALTERNATIVE B:
SMALL PUNCH SPECIMENS







Specimen	s_y (MPa)	s_u (MPa)
Cast iron 1	173	354
Cast iron 2	155	392
Cast iron 3	185	405
Bronze 1	108	295
Bronze 2	94	328



CAST IRON → Scattering

Lack of fussion

OBJECTIVE:

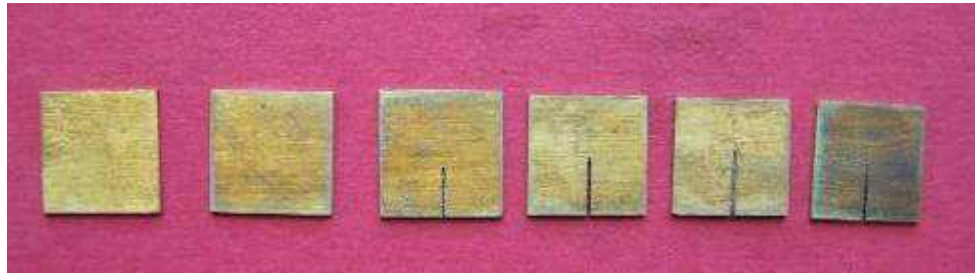
To compare mechanical properties of a 18 karats and 24 karats golds





24 KARATS:

99.99 PURITY GOLD

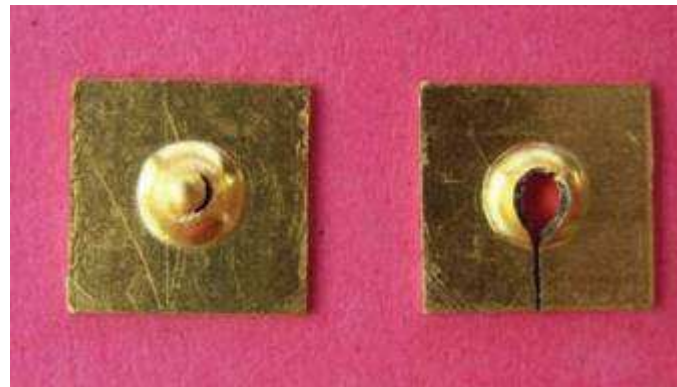


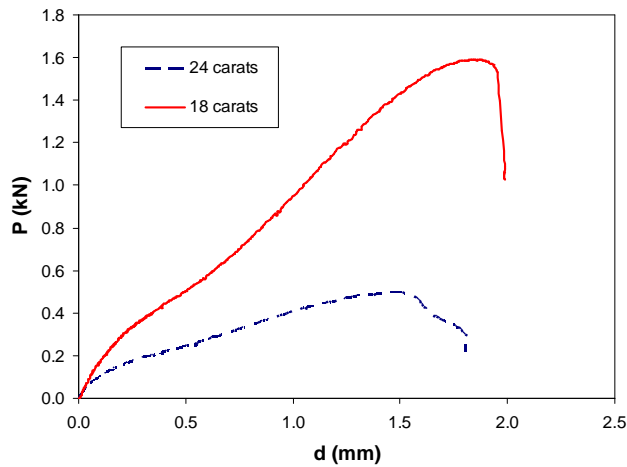
18 KARATS:

75% Au

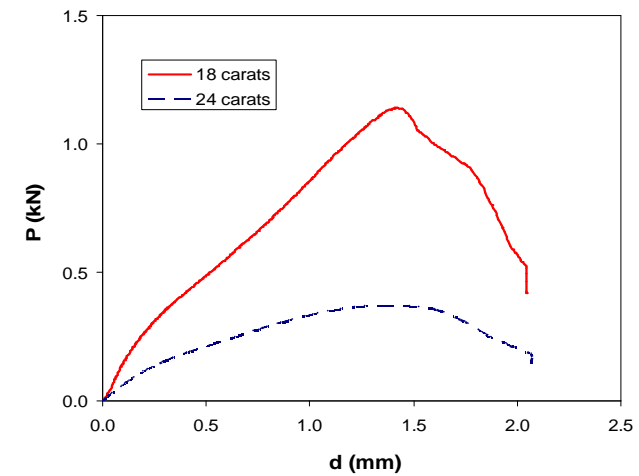
12.5% Ag

12.5% Cu





Conventional specimens



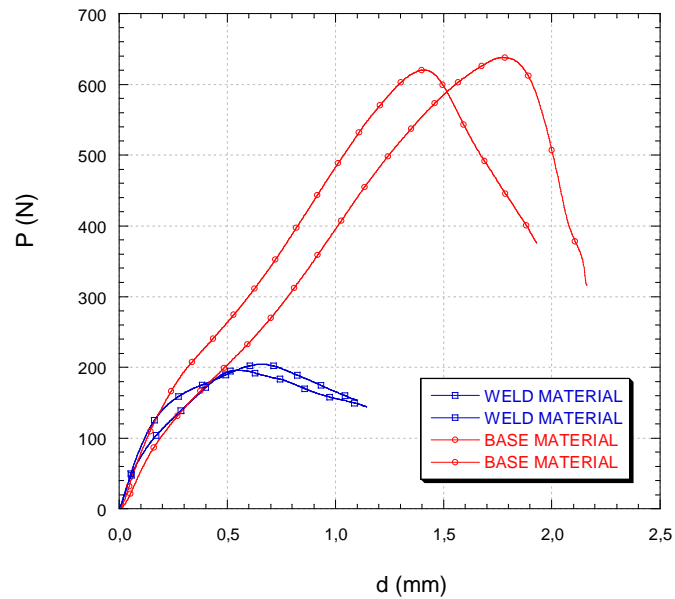
Notched specimens

Specimen	s_y (MPa)	s_u (MPa)	J_c (kN/m)
18-carats (average values)	354	635	183
24 carats (average values)	64	228	116

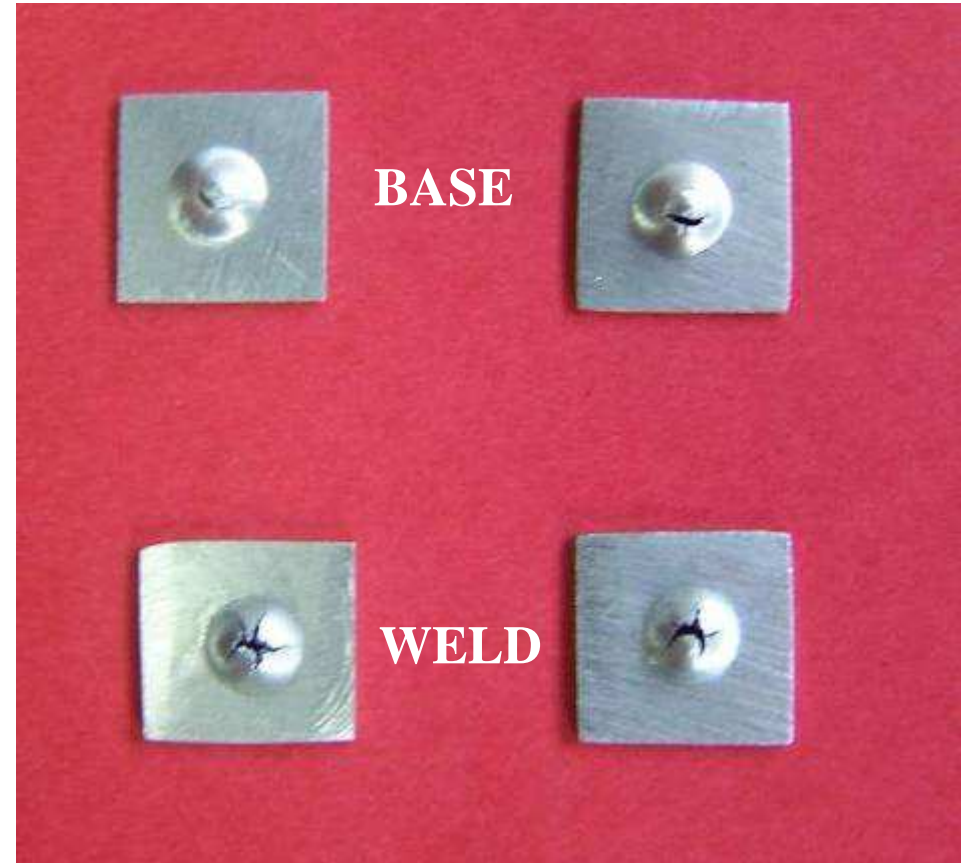
OBJECTIVE:

**To characterise base and
weld material of an
aluminium bike frame**





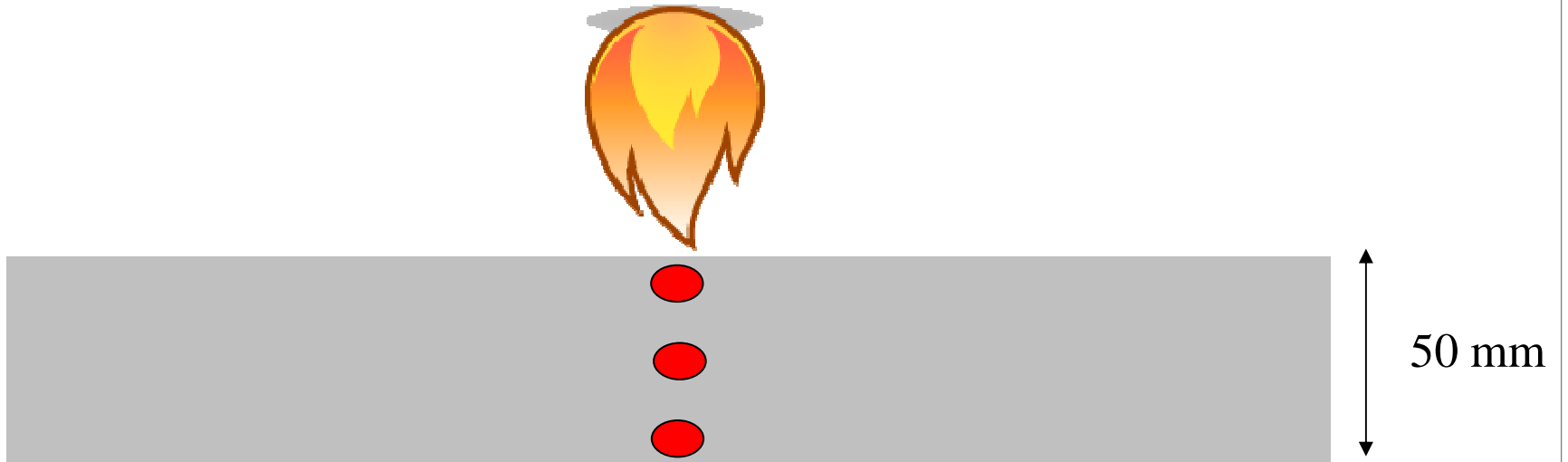
Specimen	s_y (MPa)	s_u (MPa)
Base metal 1	218	252
Base metal 2	220	284
Weld 1	112	179
Weld 2	130	166



OBJECTIVE:

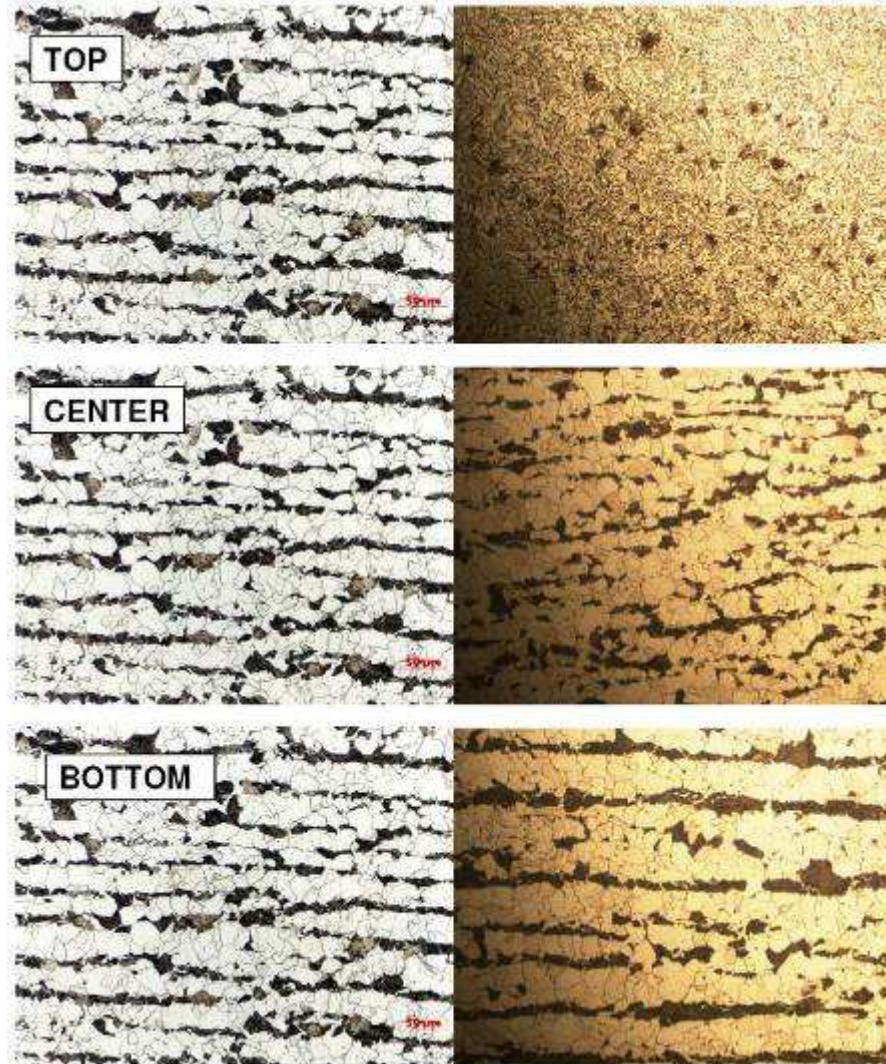
To estimate the evolution of mechanical properties of steel profiles after flame straightening



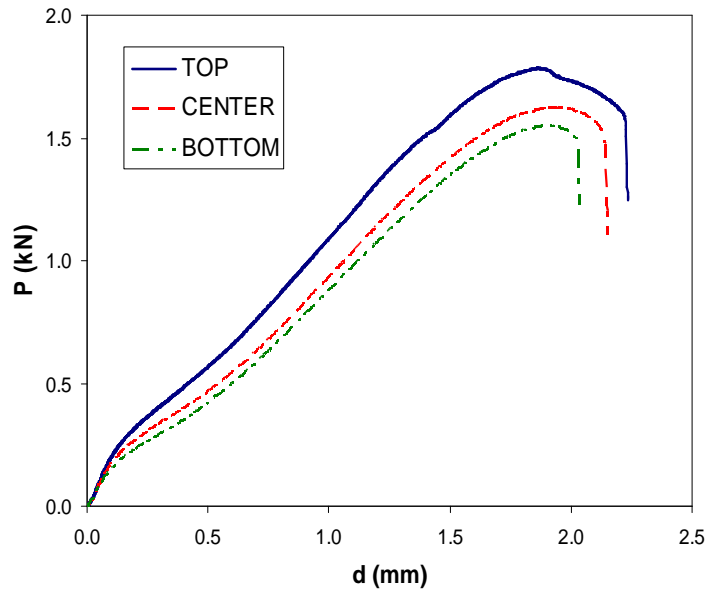


- **S355 steel**
- **Thickness: 50 mm**
- **Maximum surface temperature ≈ 900 °C (thermocouples)**

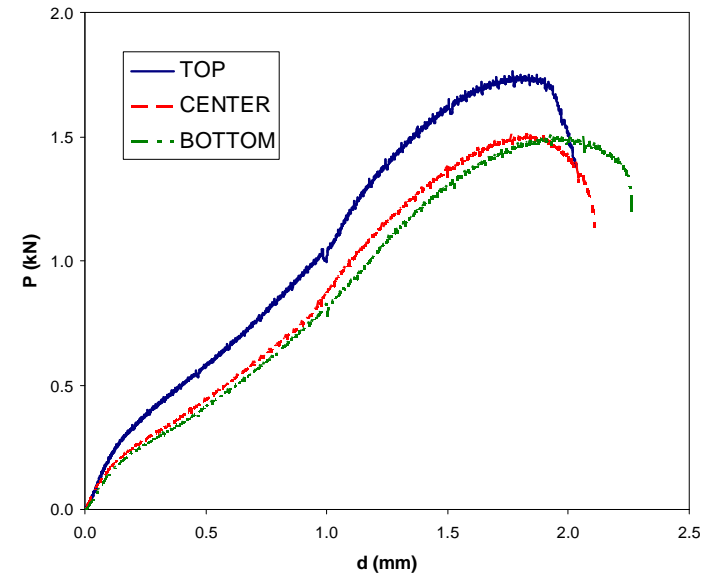
AS RECEIVED



**AFTER FLAME
STRAIGHTENING**



Conventional specimens



Notched specimens

Specimen	s_y (MPa)	s_u (MPa)	J_c (kN/m)
TOP	542	644	205
CENTER	398	560	197
BOTTOM	350	502	186
<i>Material in as-received state</i>	<i>351</i>	<i>513</i>	<i>190</i>

- **Simple methodologies have been proposed for the estimation of mechanical properties (yield stress, ultimate tensile strength and fracture toughness) from Small Punch tests.**
- **These approaches have been validated by testing 8 materials in a wide range of mechanical resistances.**
- **The methodologies have been successfully applied for the characterisation of metallic materials in four situations where it was impossible to perform conventional tests.**

**THANK YOU
VERY MUCH
FOR YOUR
ATTENTION!!!**

