



UNIVERSITY OF CAMBRIDGE

NITROCELLULOSE

Supply
Ageing
Characterisation



Tuesday 24th and Wednesday 25th
April 2007

AWE Aldermaston • England

**Towards Characterisation
of Aged EDC37**

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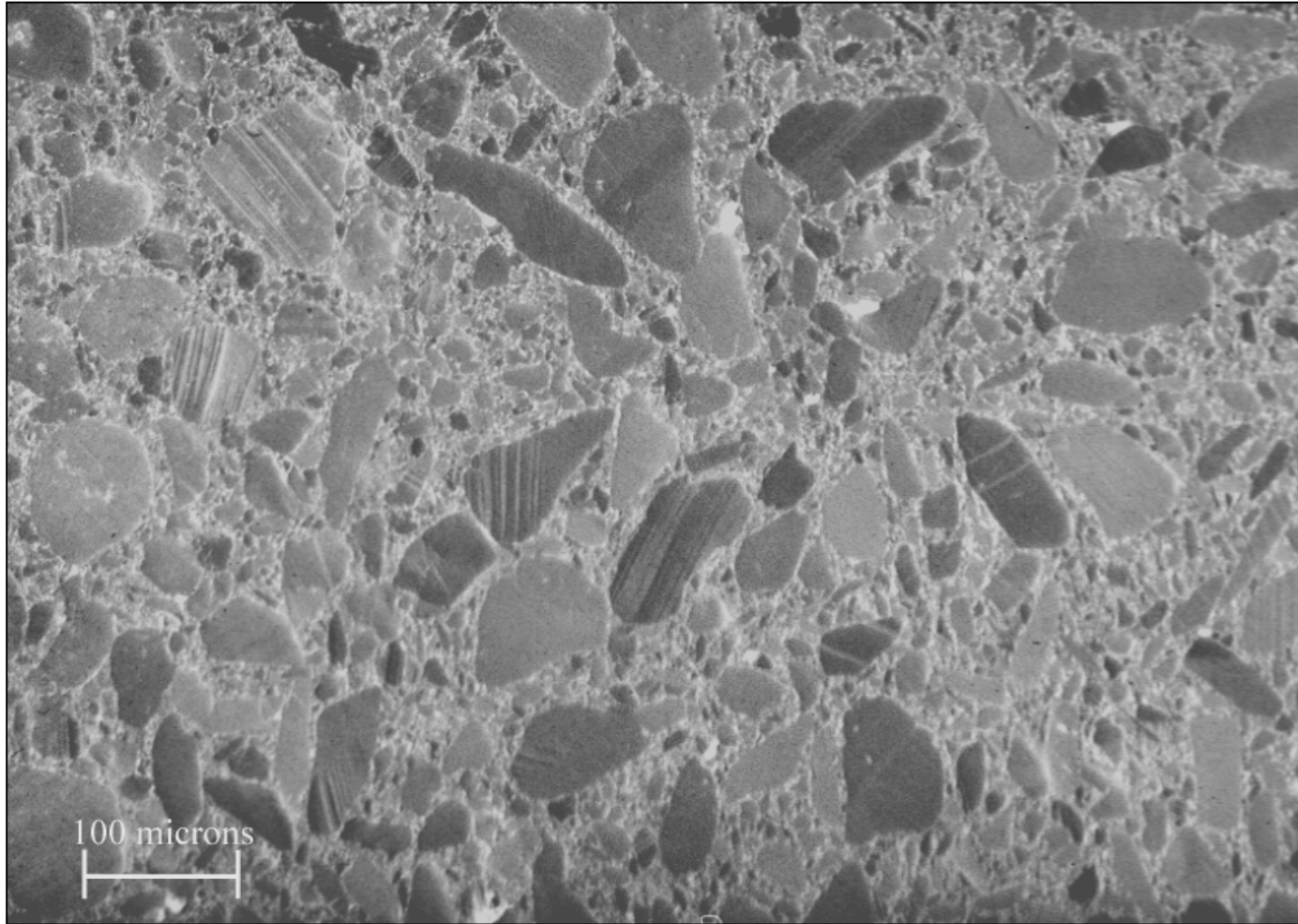
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Overview

- Introduction
- Previous research
- Current research
 - Strength – via Brazilian disc
 - T_G - via DMTA
 - Molecular weight
- Comparison of data
- Acknowledgements

Introduction

EDC37: microstructure



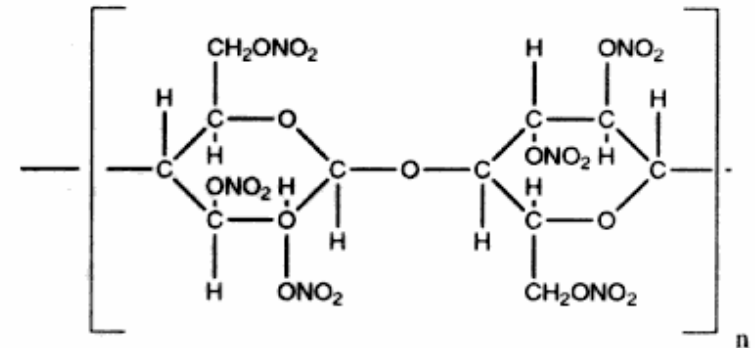
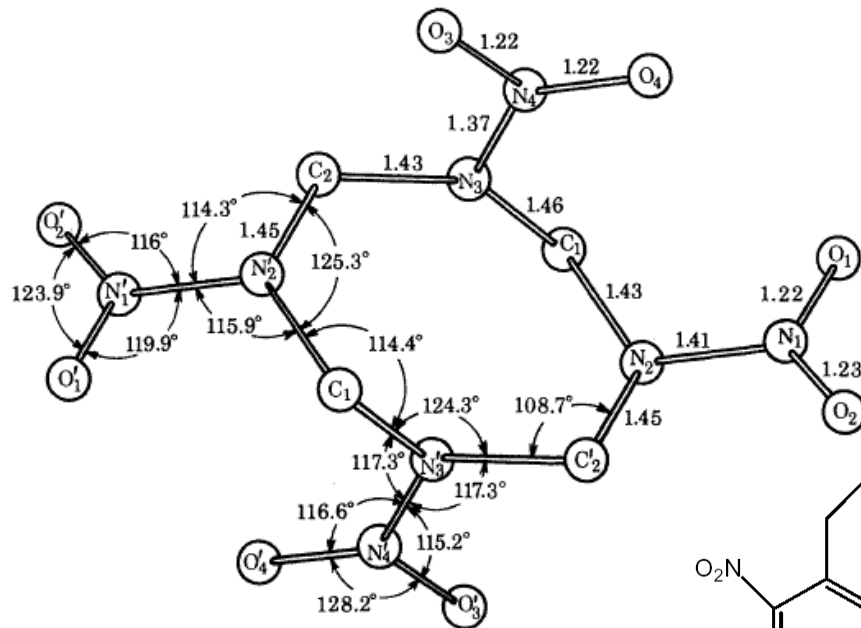
Density: 1.841 kg/m^3

% mass: HMX/binder 91/9

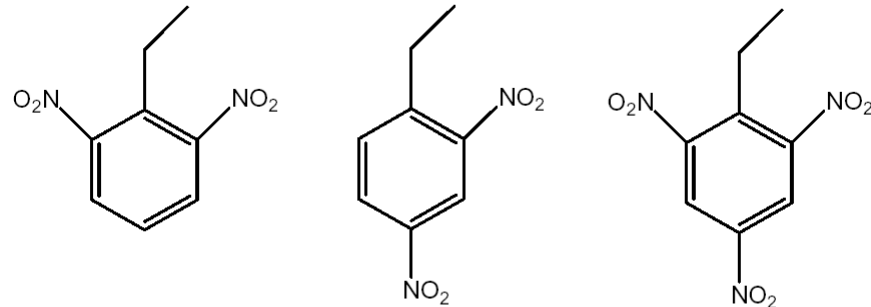
EDC37 T_G : $-63 \text{ }^\circ\text{C}$ (210 K)

EDC37: components

91 % wt. HMX (Cyclotetramethylene)
Palmer and Field (1982)



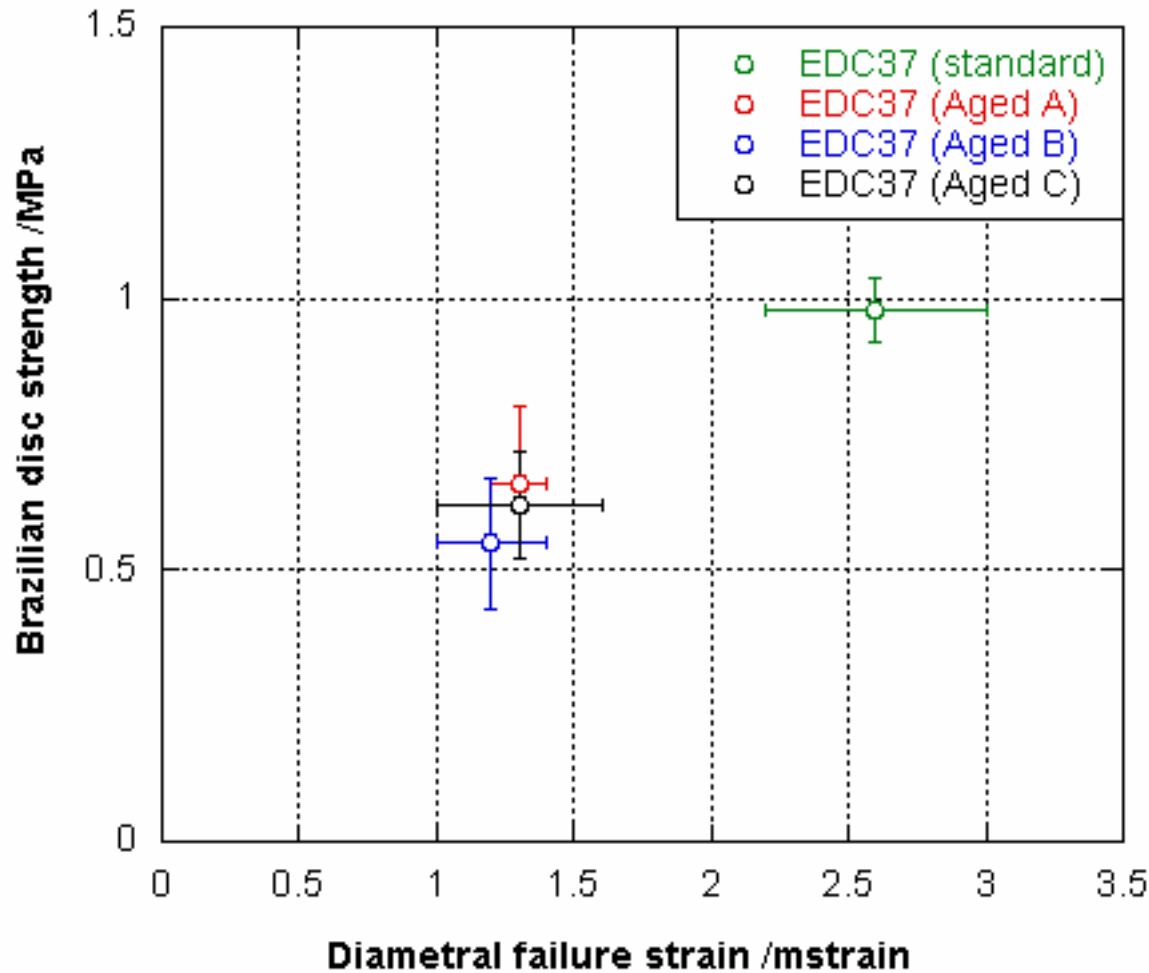
1 % wt. Nitrocellulose
Rae (2000)



8 % wt. K10 Nitroplasticiser
(2, 4- & 2, 6-dinitroethylbenzene
and 2, 4, 6-trinitroethylbenzene)
Provatis (2000)

Previous Cavendish research

Previous Cavendish research



Reduction in strength after elevated temp. for 12 years, Rae (2000).

Current research – Samples

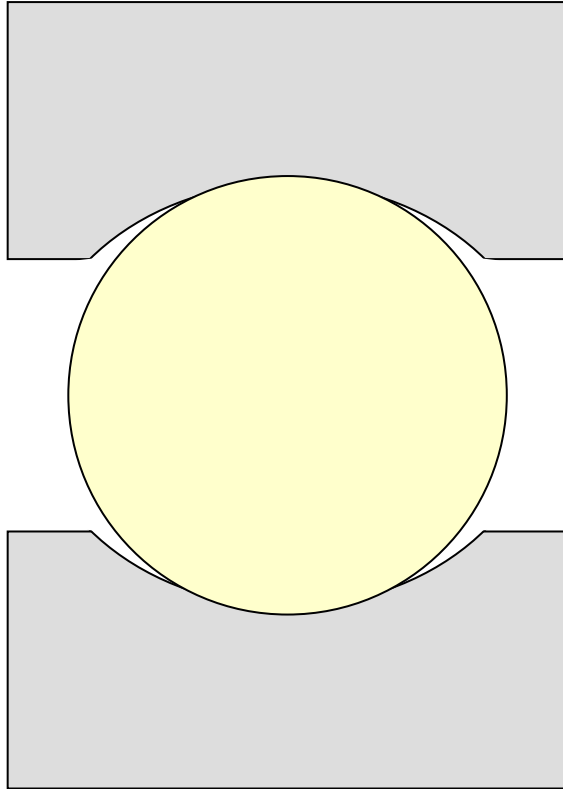
Current research – Samples

Samples were 8 mm dia 3 mm thick discs

Non-isothermally aged – Ask AWE for details

Current research – Brazilian disc

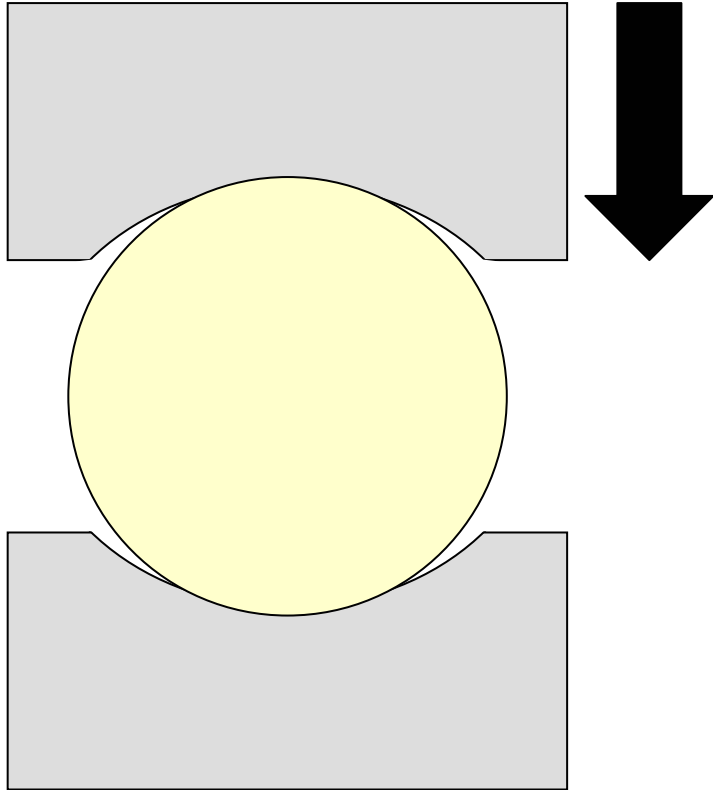
Brazilian test



Tensile failure through compression,
in a predictable location

Brazilian test

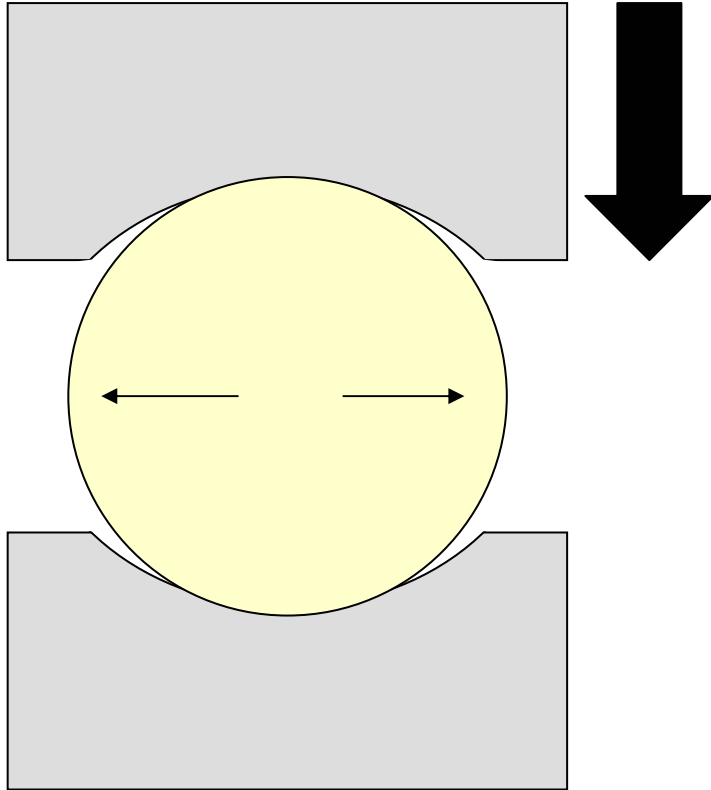
Brazilian test



Tensile failure through compression,
in a predictable location

Brazilian test

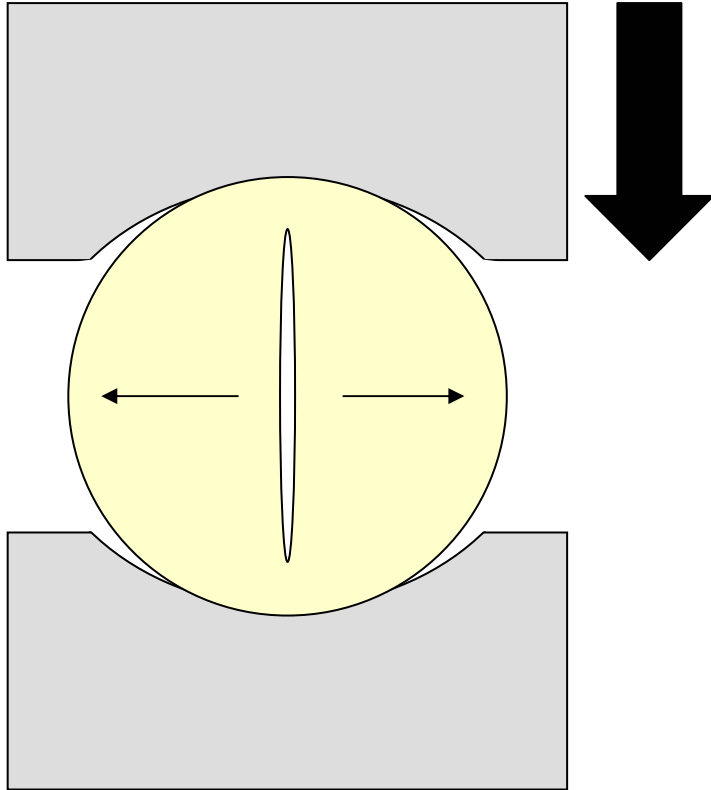
Brazilian test



Tensile failure through compression,
in a predictable location

Brazilian test

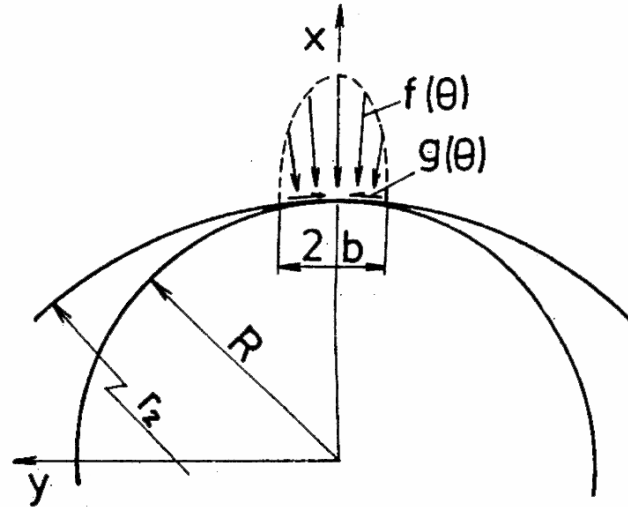
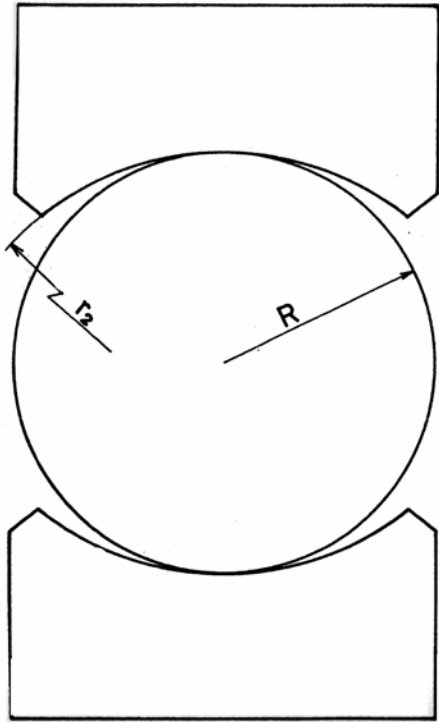
Brazilian test



Tensile failure through compression,
in a predictable location

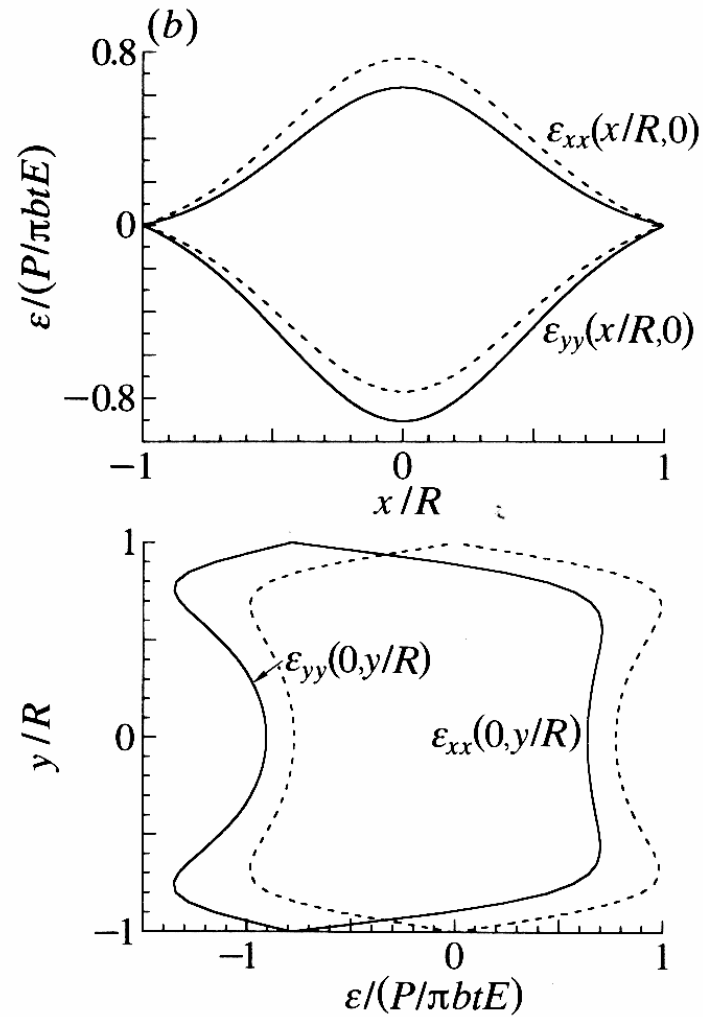
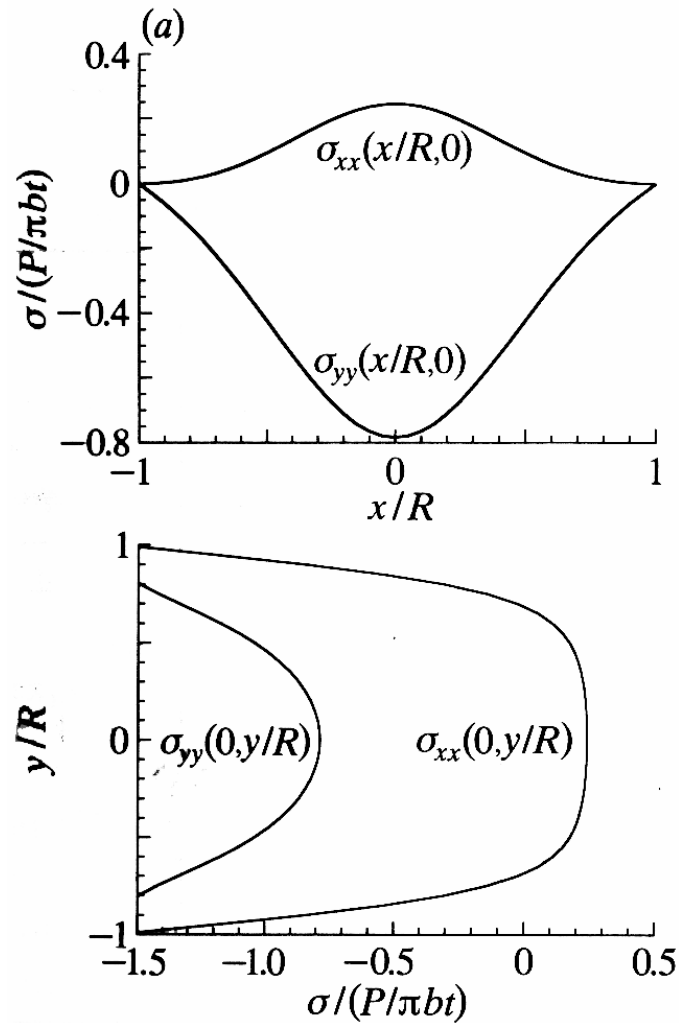
Brazilian test

Modern beginnings



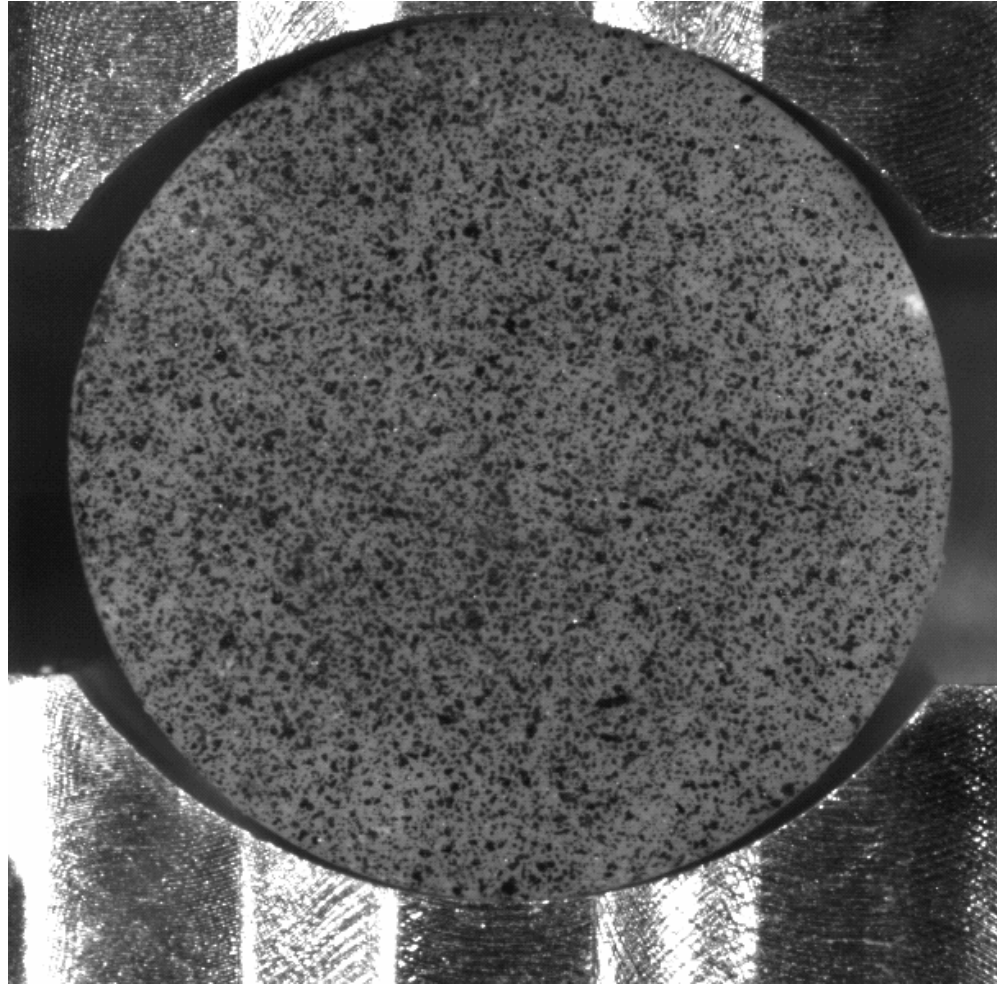
Use of curved anvils reduces the shear stress at the contact points and prevents premature rupture: Awaji and Sato (1979).

Modern beginnings



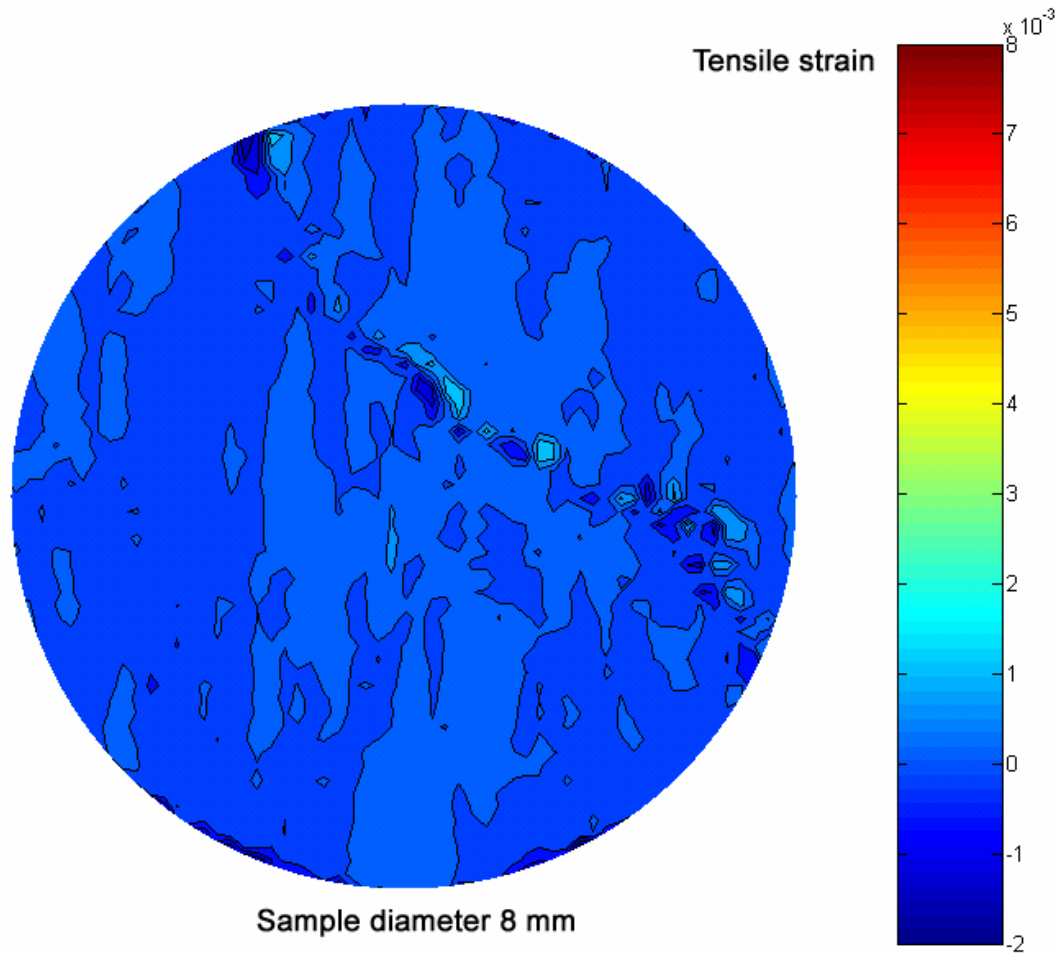
Stress and strain fields: Palmer *et al.* (1993).

Brazilian disc results



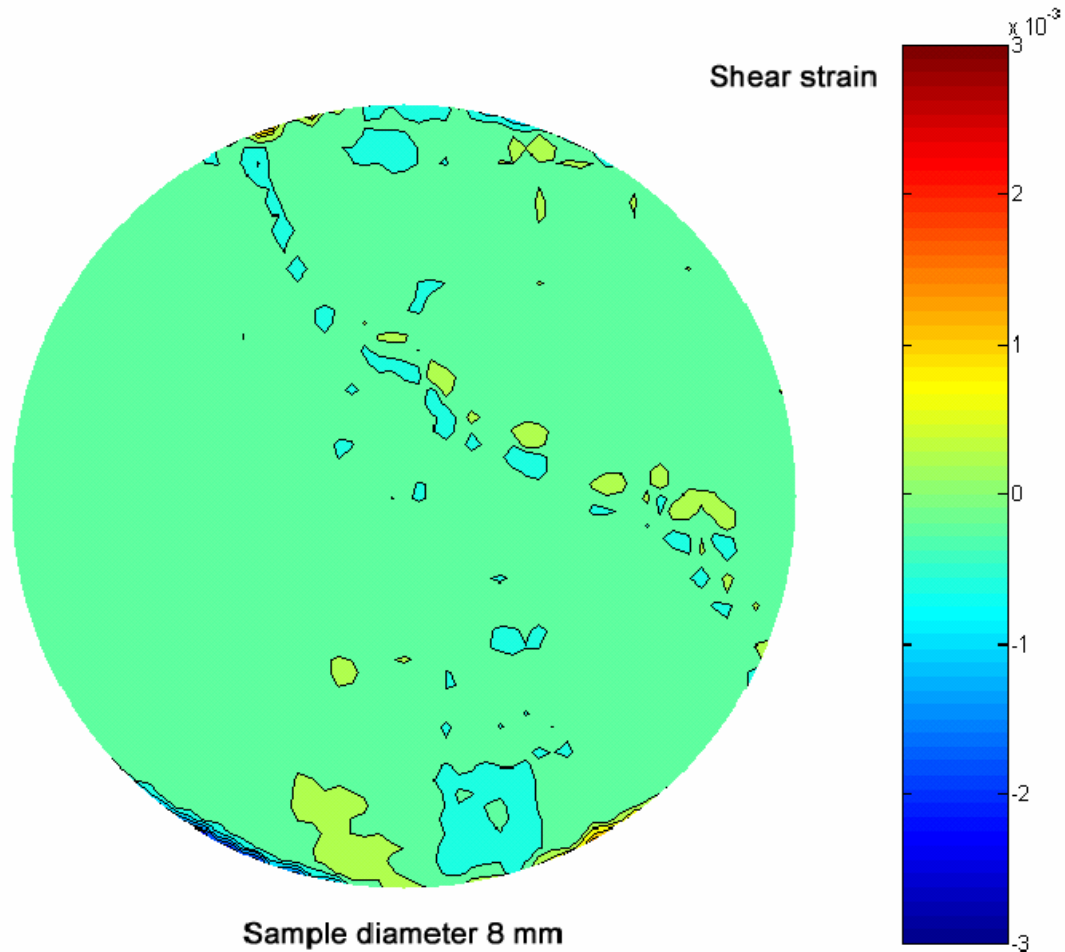
Sample B17: raw data

Brazilian disc results



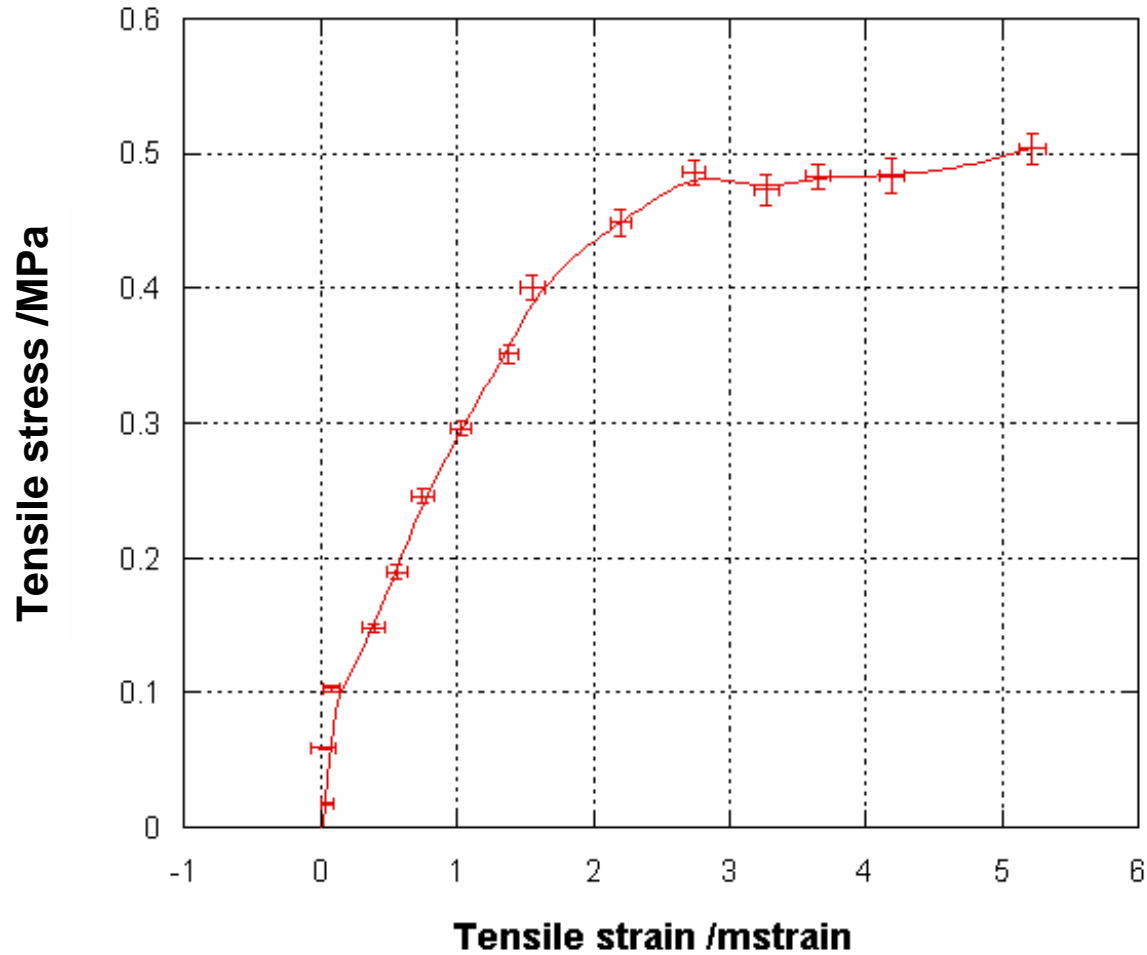
Sample B17: tensile strain

Brazilian disc results



Sample B17: shear strain

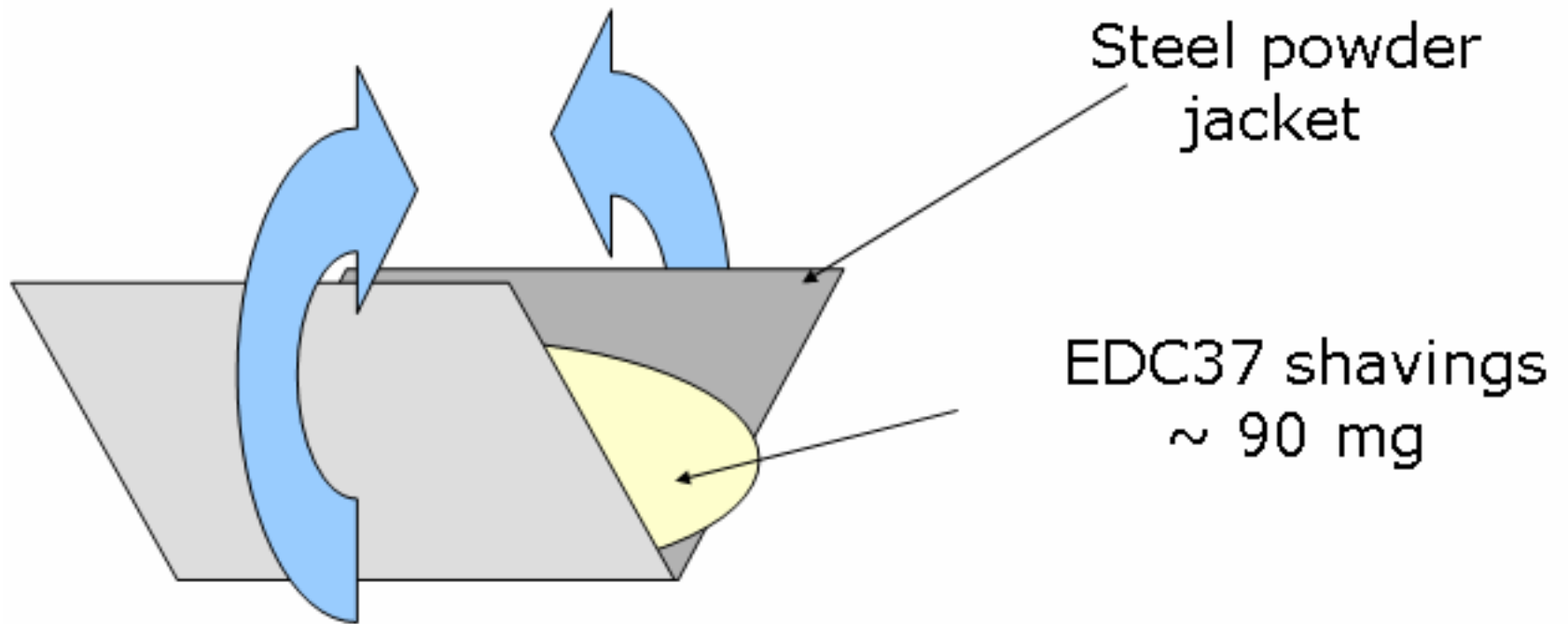
Brazilian disc results



Sample B17: tensile stress-strain

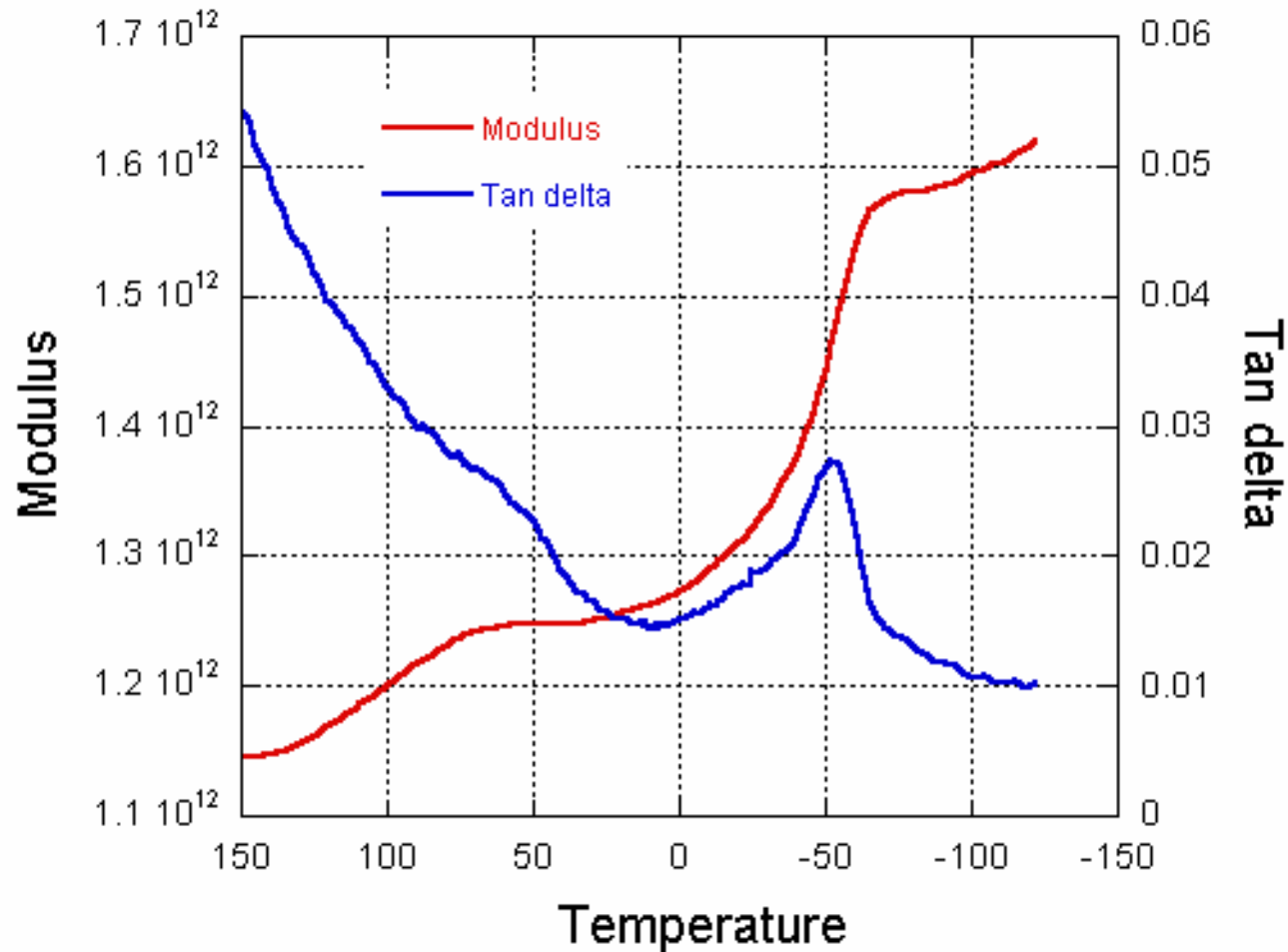
Current research – T_G

Current research – T_G



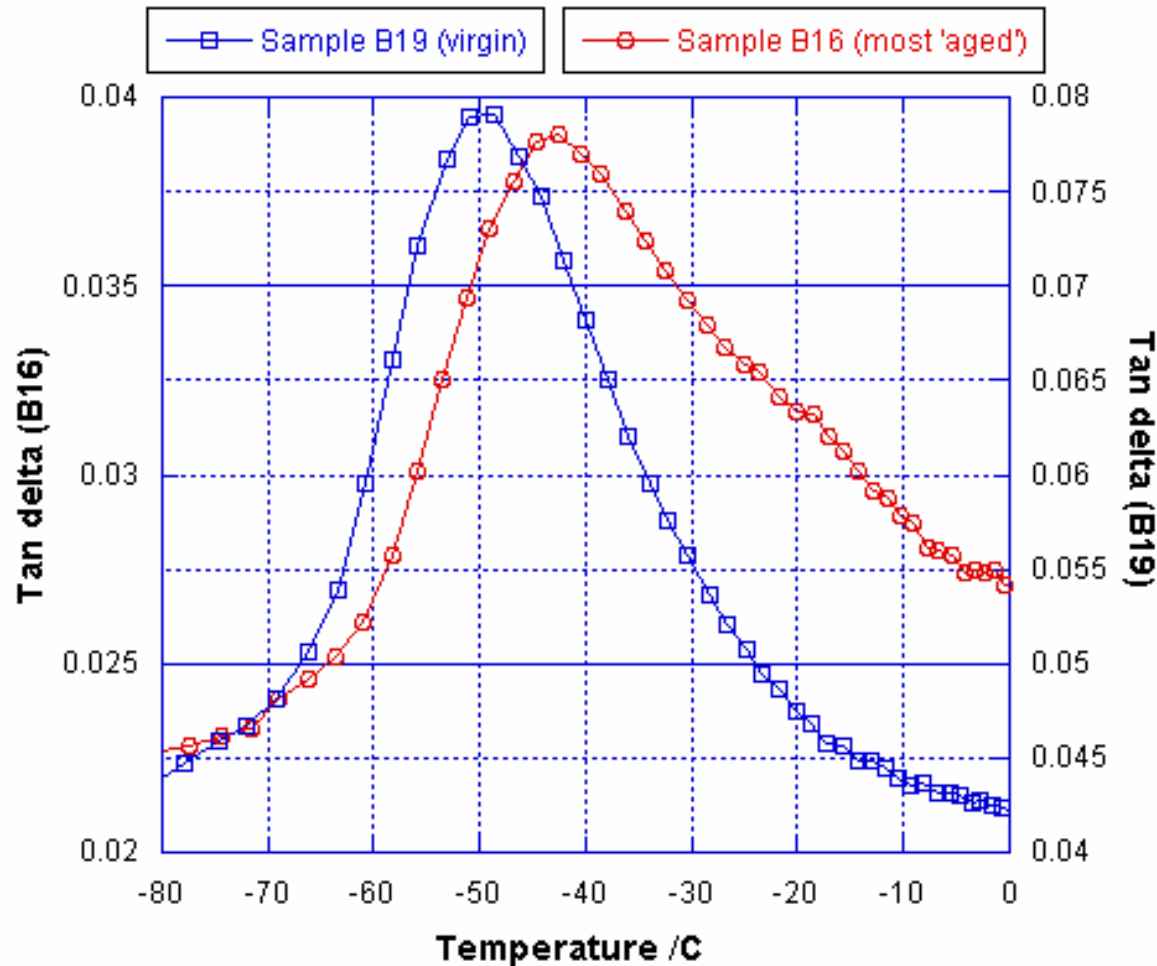
Low mass powder samples, evaluated at 1Hz.

Current research – T_G



Typical EDC37 DMTA result: relaxation spectrum

Current research – T_G



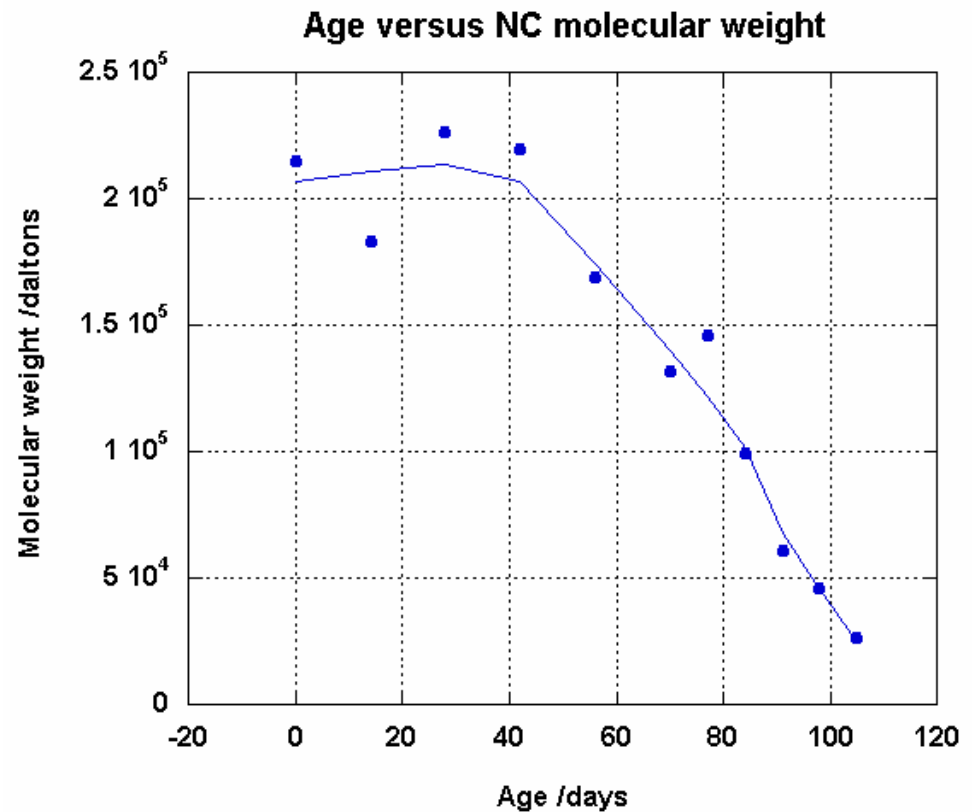
Glass transition temperature *increases* with age

Current research – molecular weight

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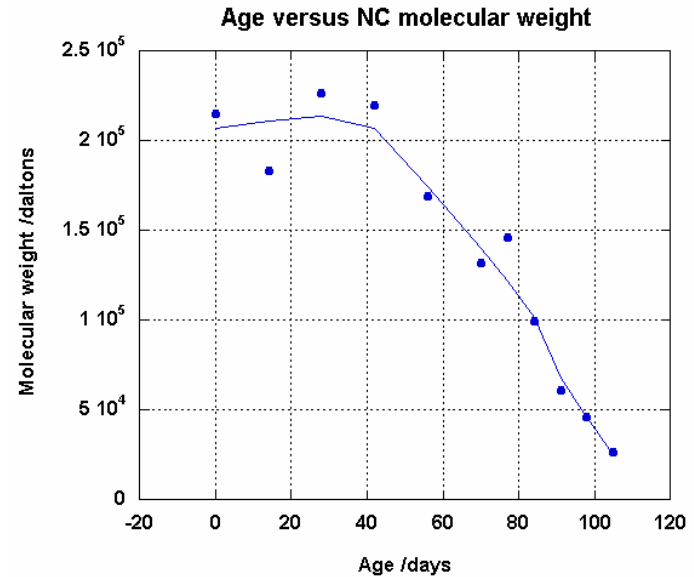
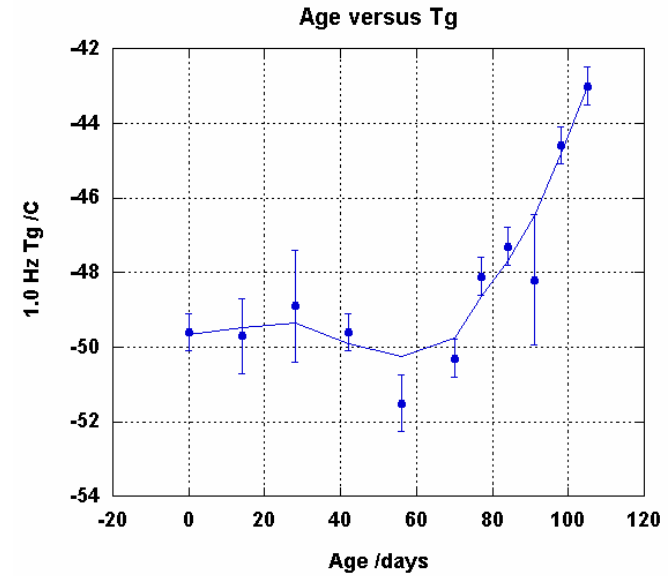
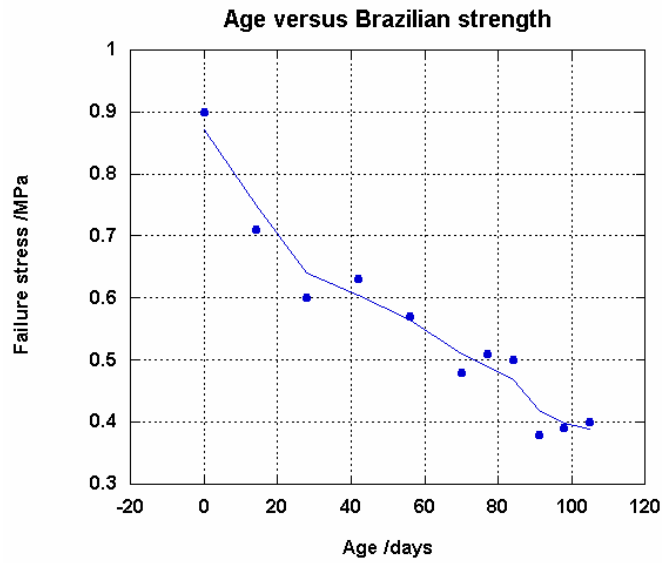
Size Exclusion Chromatography

Sample number	Age /days	Molecular weight /Daltons
B19	0.0000	2.1470e+05
B10	14.000	1.8310e+05
B21	28.000	2.2610e+05
B11	42.000	2.1950e+05
B12	56.000	1.6910e+05
B14	70.000	1.3170e+05
B13	77.000	1.4590e+05
B17	84.000	99300
B15	91.000	60500
B22	98.000	46200
B16	105.00	26100



Current research – overview

Current research – overview



Conclusions

Conclusions

- The point approach
 - Brazilian disc for strength
 - DMTA for T_G
 - Molecular weight measured
- Each technique applied *all* samples
- See reduction in strength with age
- See reduction in molecular weight and at the same time an *increase* in T_G
- More research to follow

Acknowledgements

- DM Williamson thanks AWE & EPSRC
- WG Proud thanks QinetiQ
- Many thanks to Cavendish Laboratory workshop

References

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- Rae P.J. 2000 PhD thesis, University of Cambridge