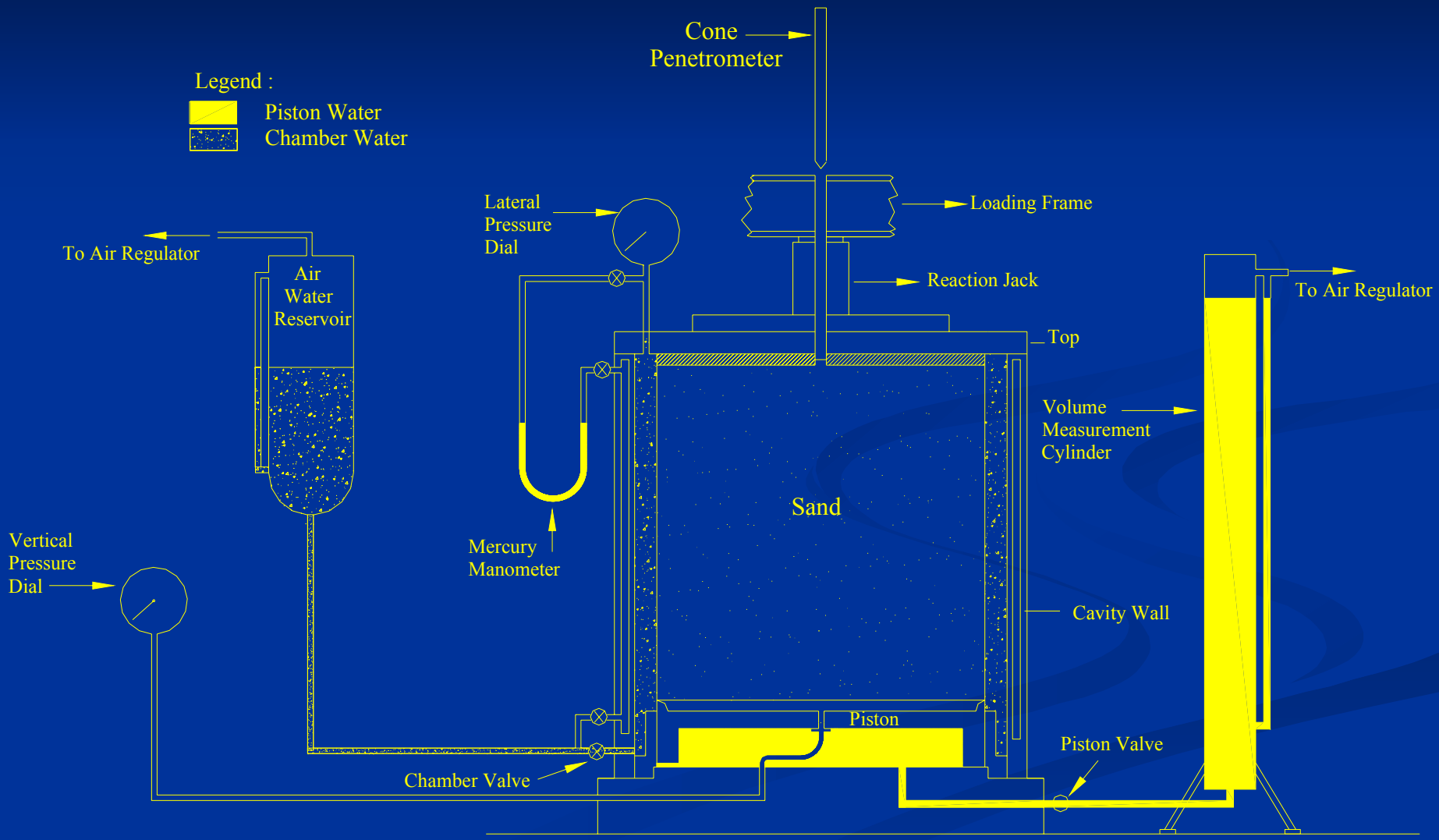
Local Displacement Measurement and Physical Modeling

An-Bin Huang
National Chiao Tung University
Hsin Chu, TAIWAN

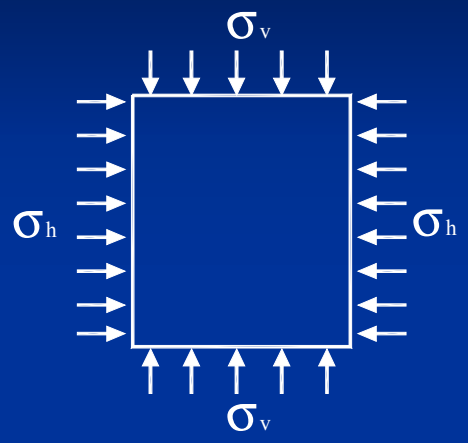
Why LDM?

- Minimization (elimination !) of boundary effects in CPT chamber calibration tests
- Meet "The Burland's Challenge"
- Gaining popularity in triaxial tests

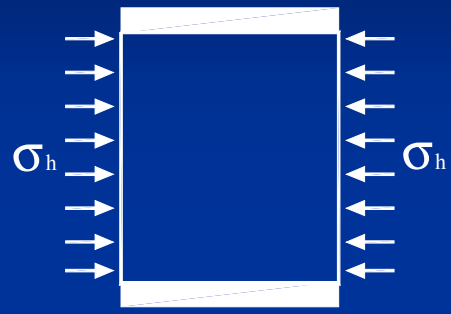
Conventional Calibration Chamber



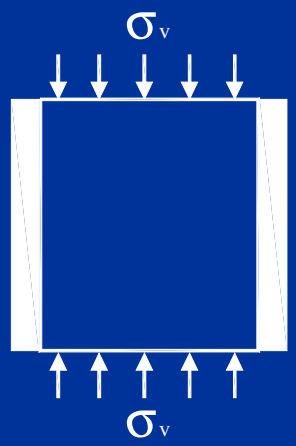
Boundary Conditions



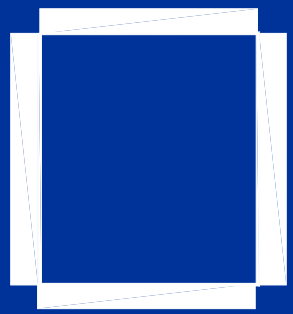
(a) B1



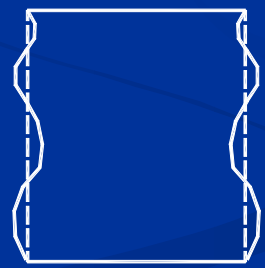
(b) B4



(c) B3 (ideal)

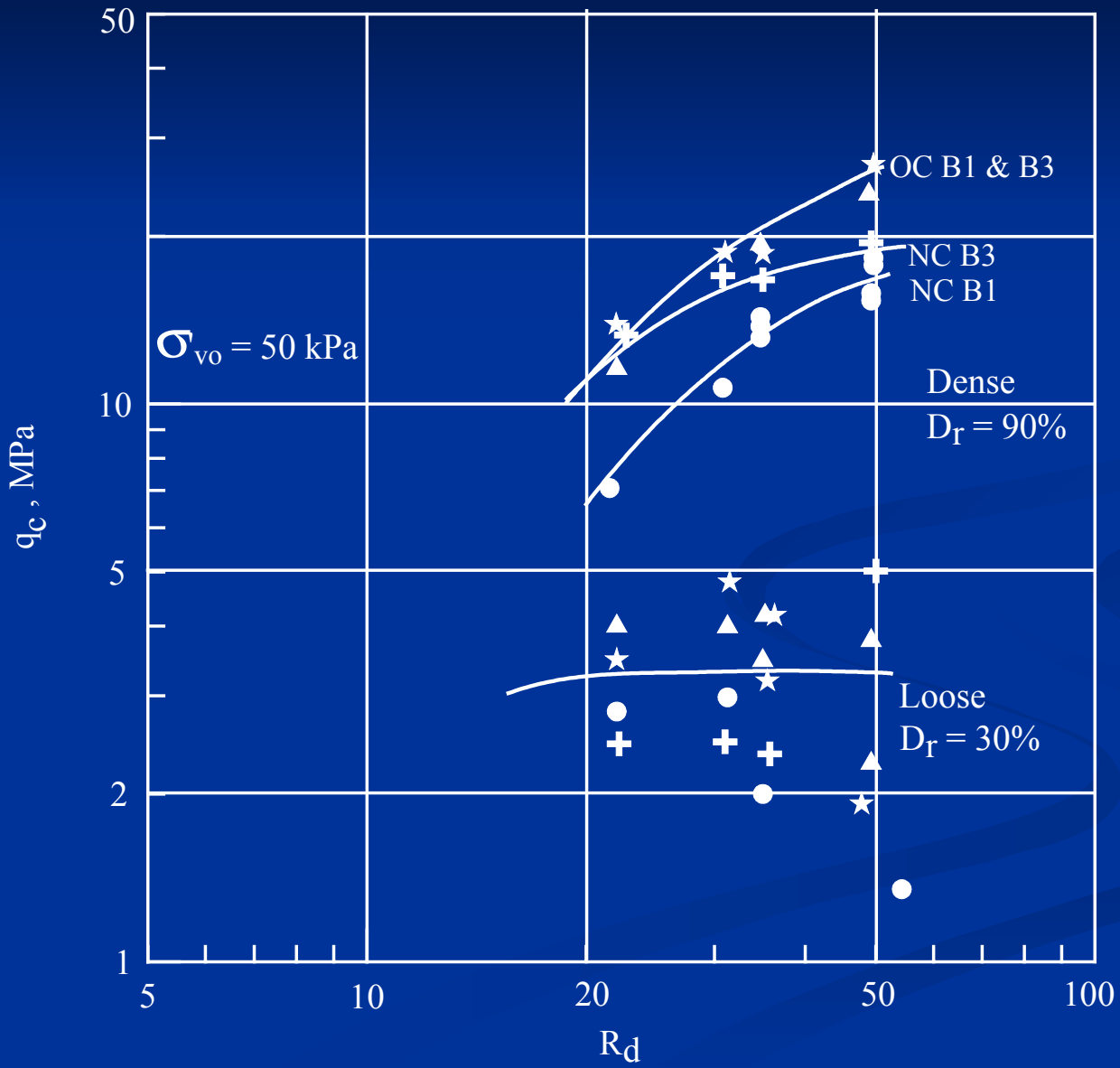


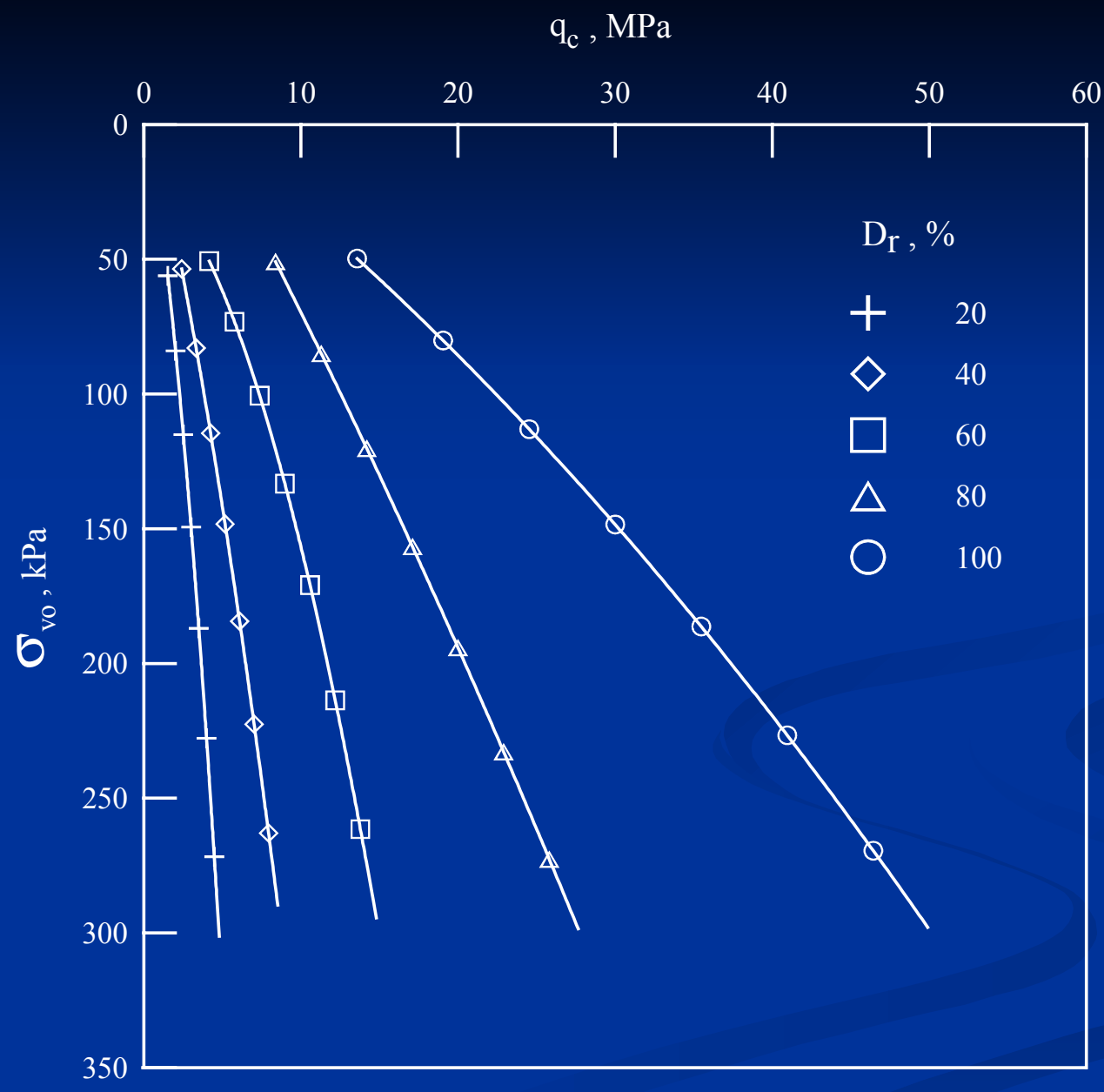
(d) B2 (ideal)



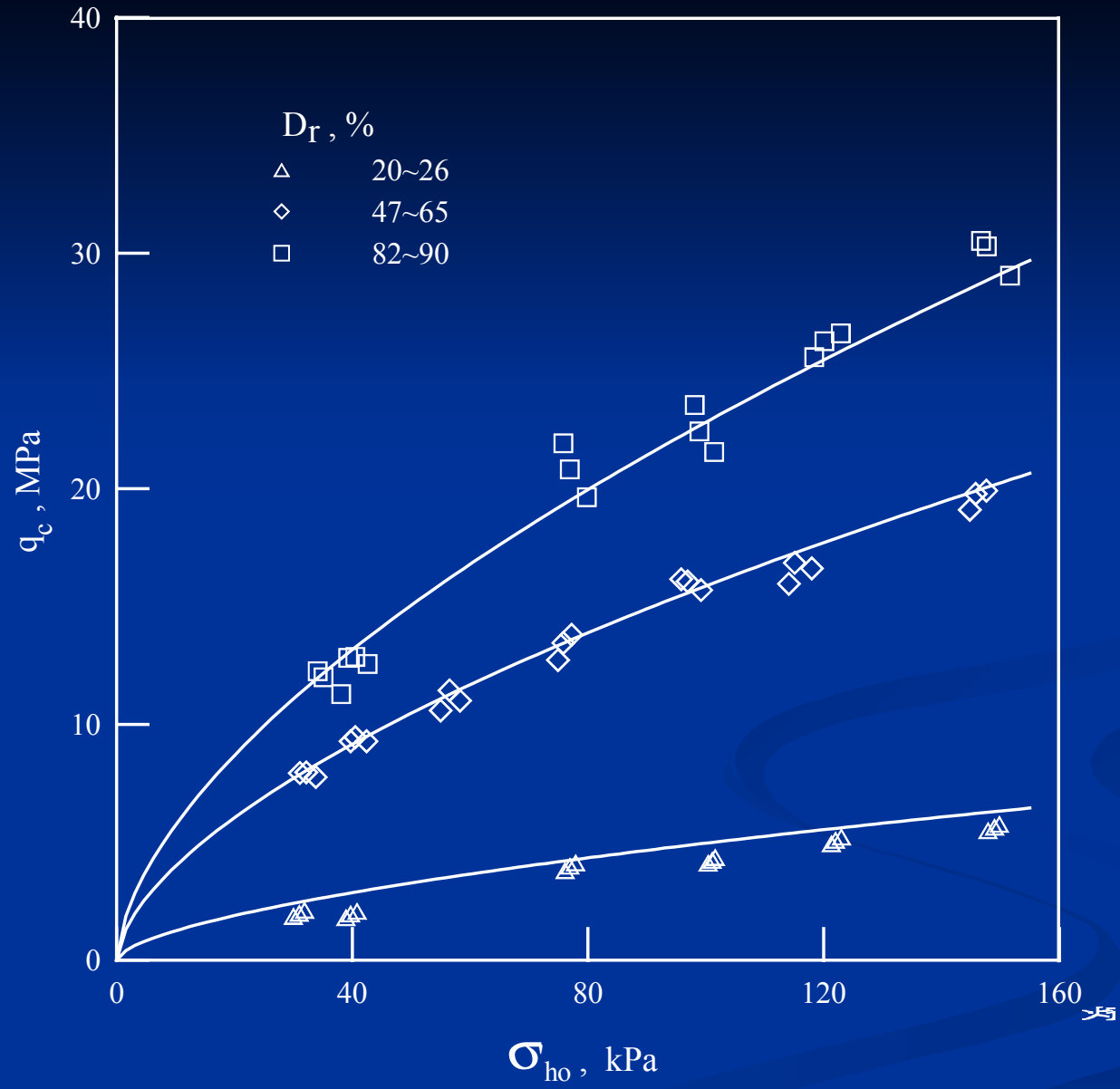
(e) B2/B3 (actual)

Boundary Effects

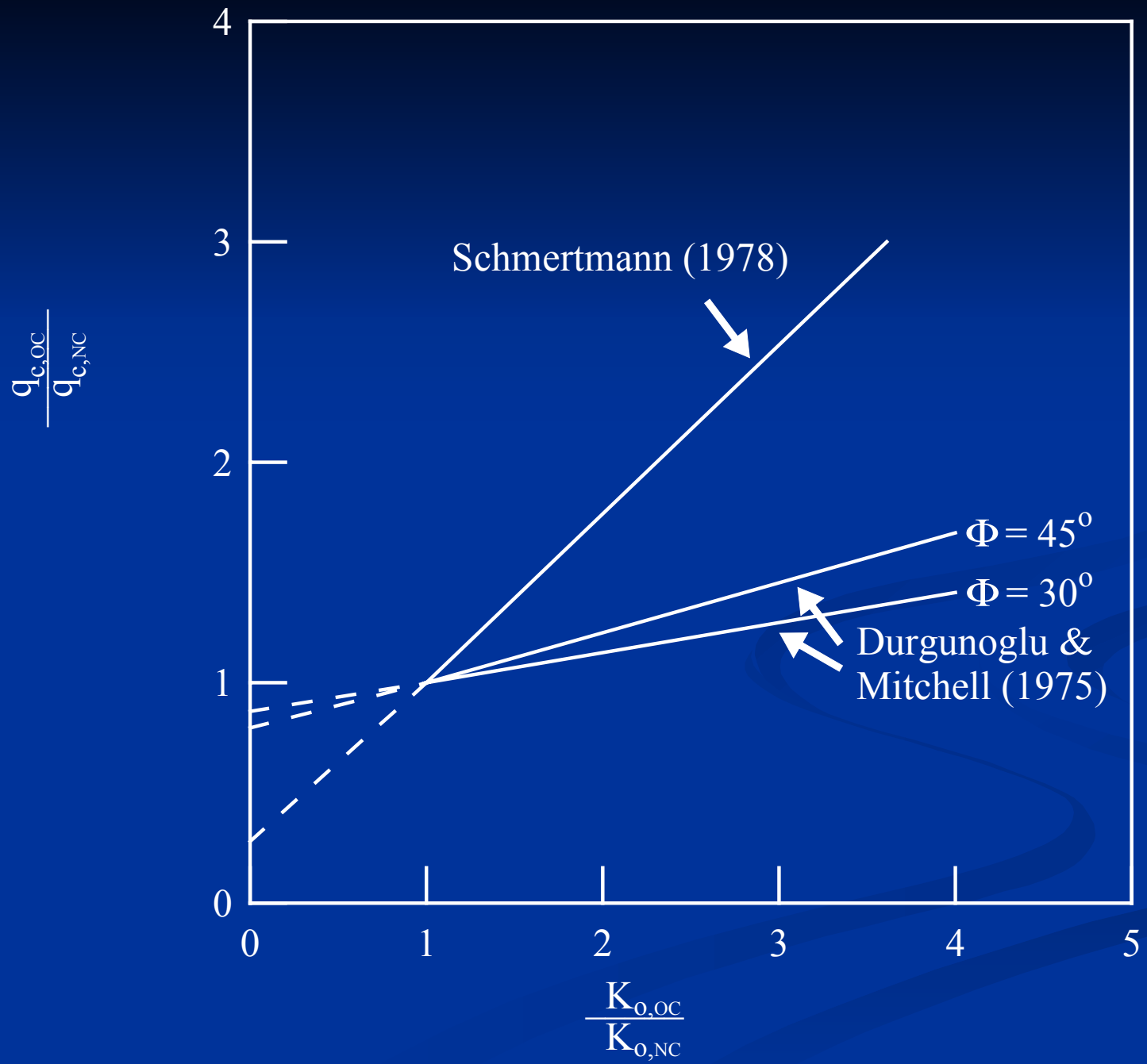




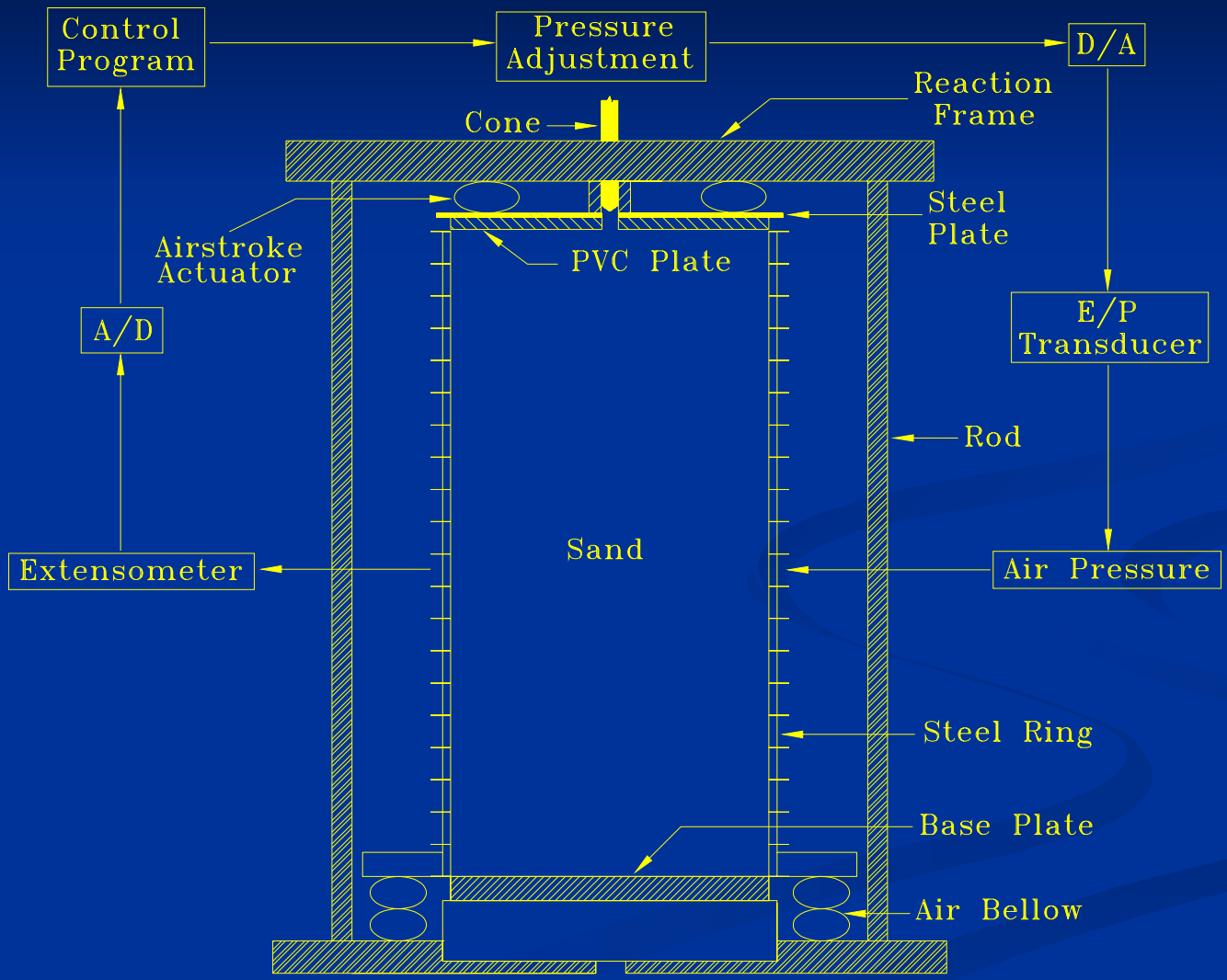
Schmertmann, 1976



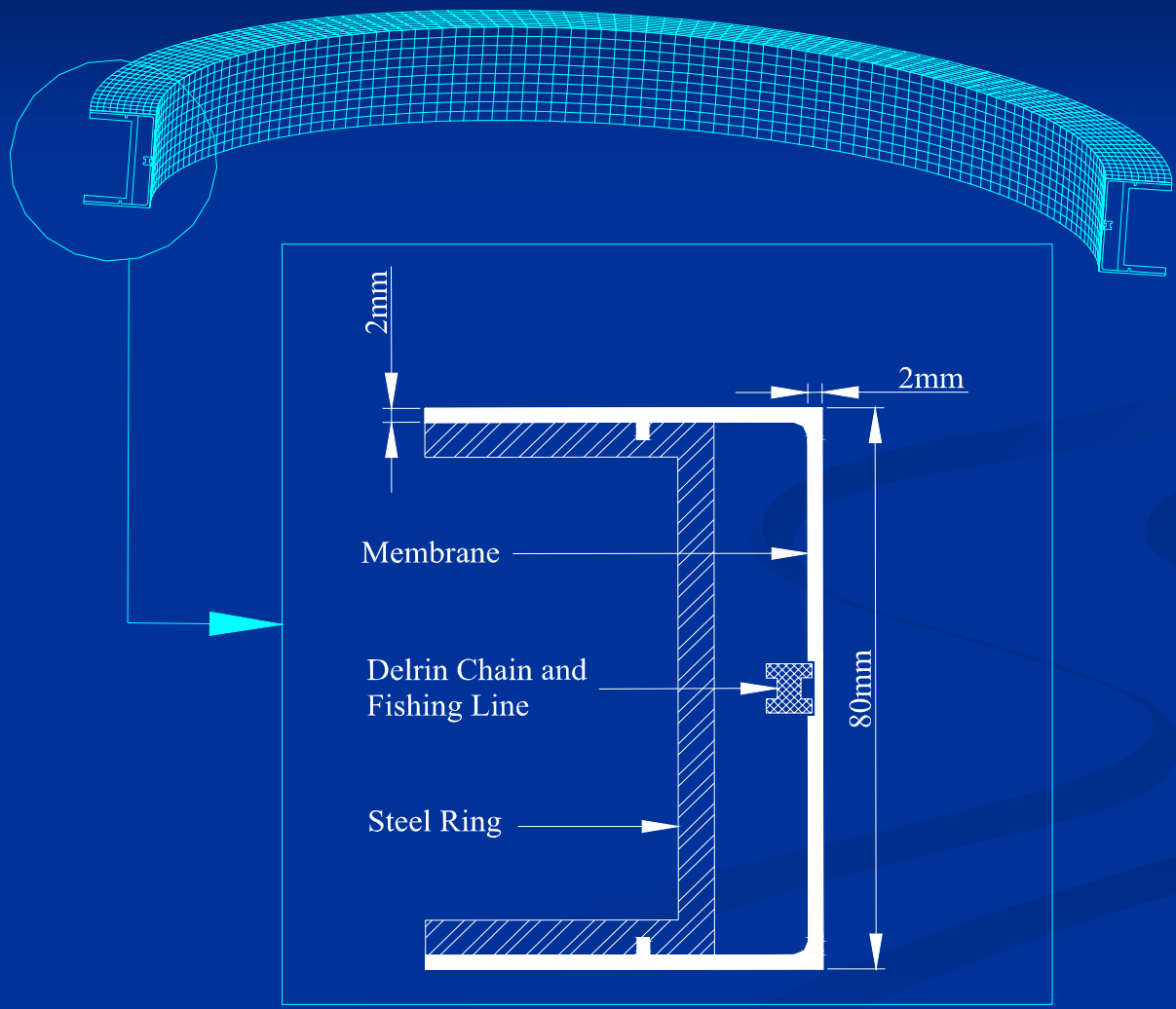
Houlsby and Hitchman, 1988


4
3
2
1
0
0
1
2
3
4
5
Schmertmann (1978)
Φ = 45°
Φ = 30°
Durgunoglu &
Mitchell (1975)
$\frac{q_{c,OC}}{q_{c,NC}}$
$\frac{K_{o,OC}}{K_{o,NC}}$

An Axisymmetric Field Simulator

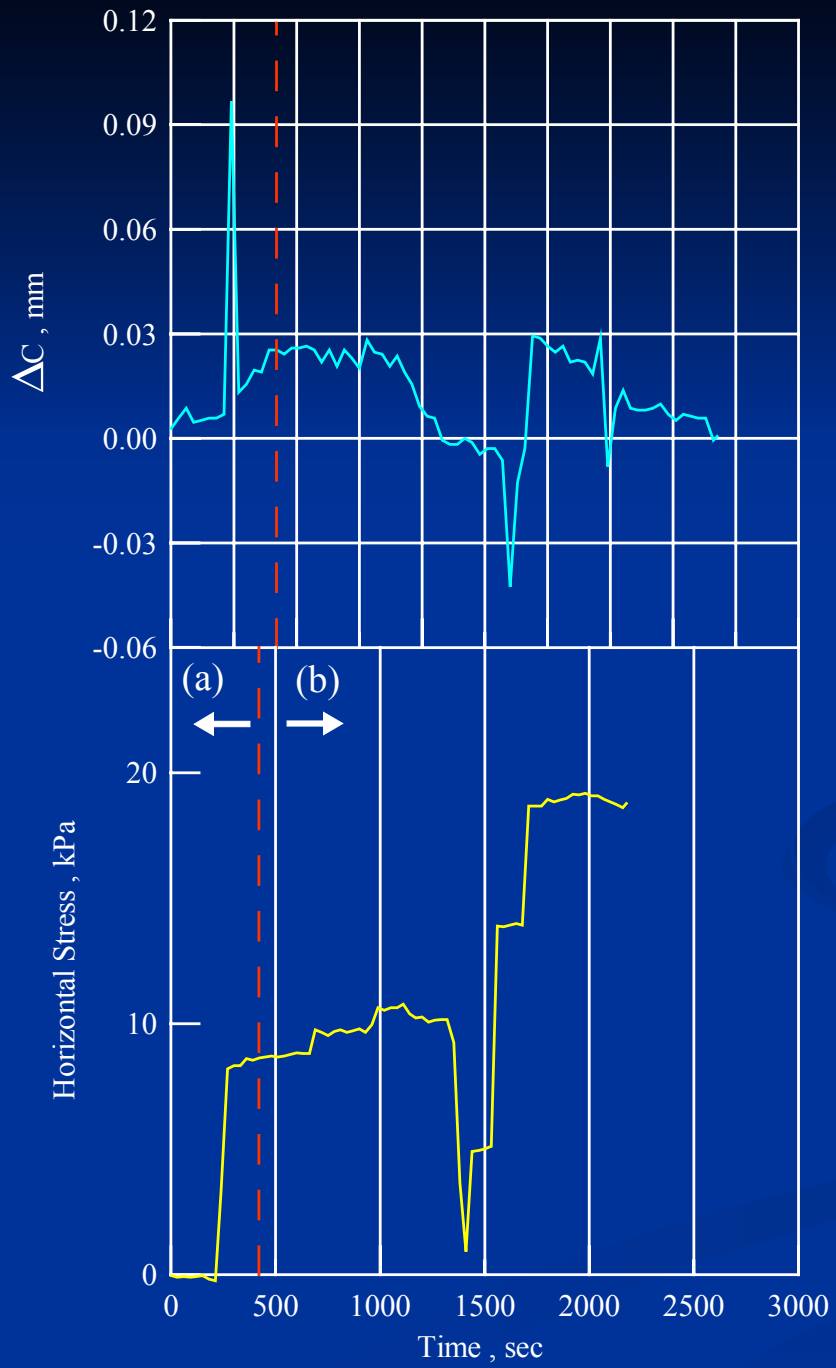


LDM of the Ring





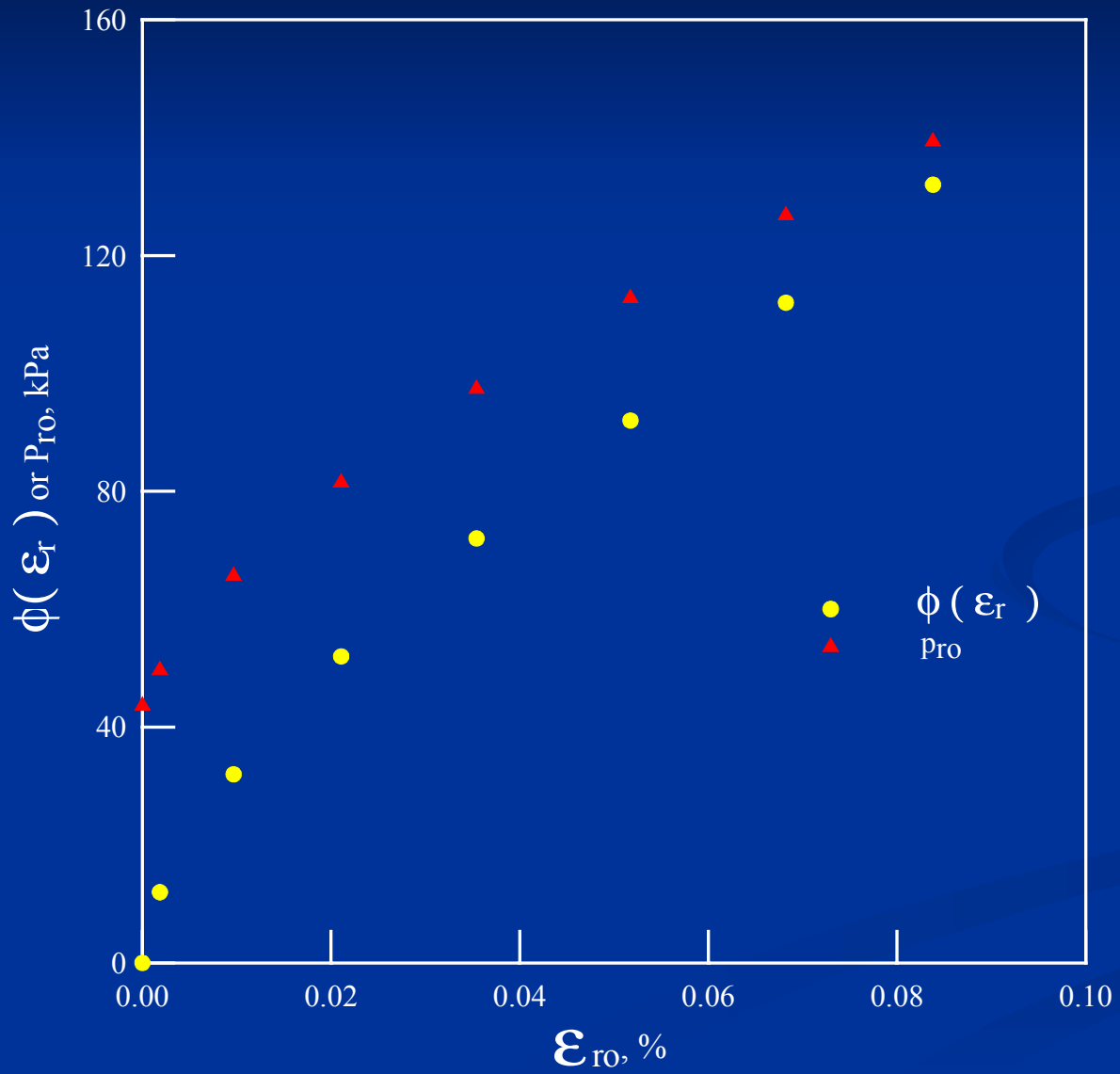




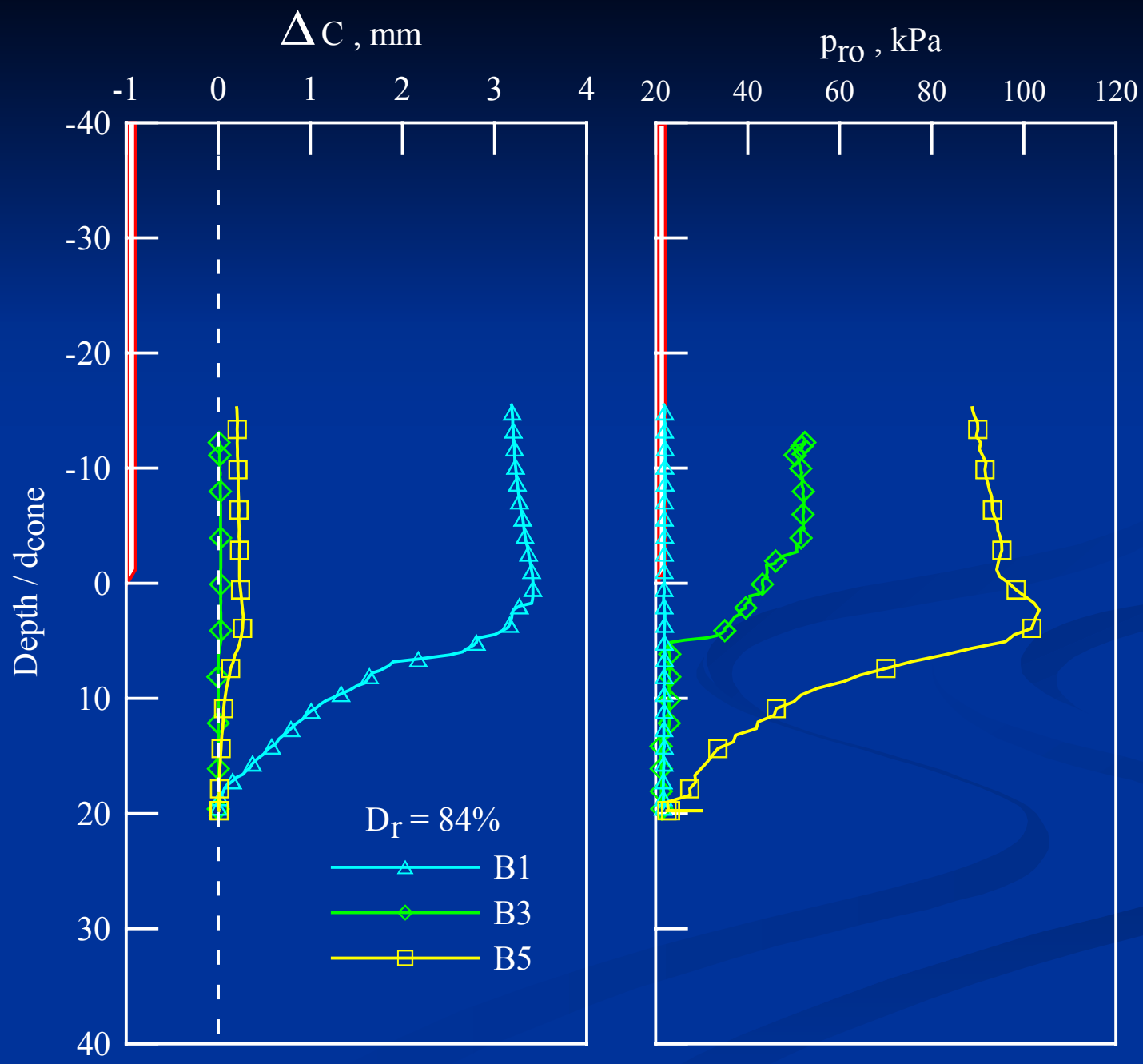
a – pluviation

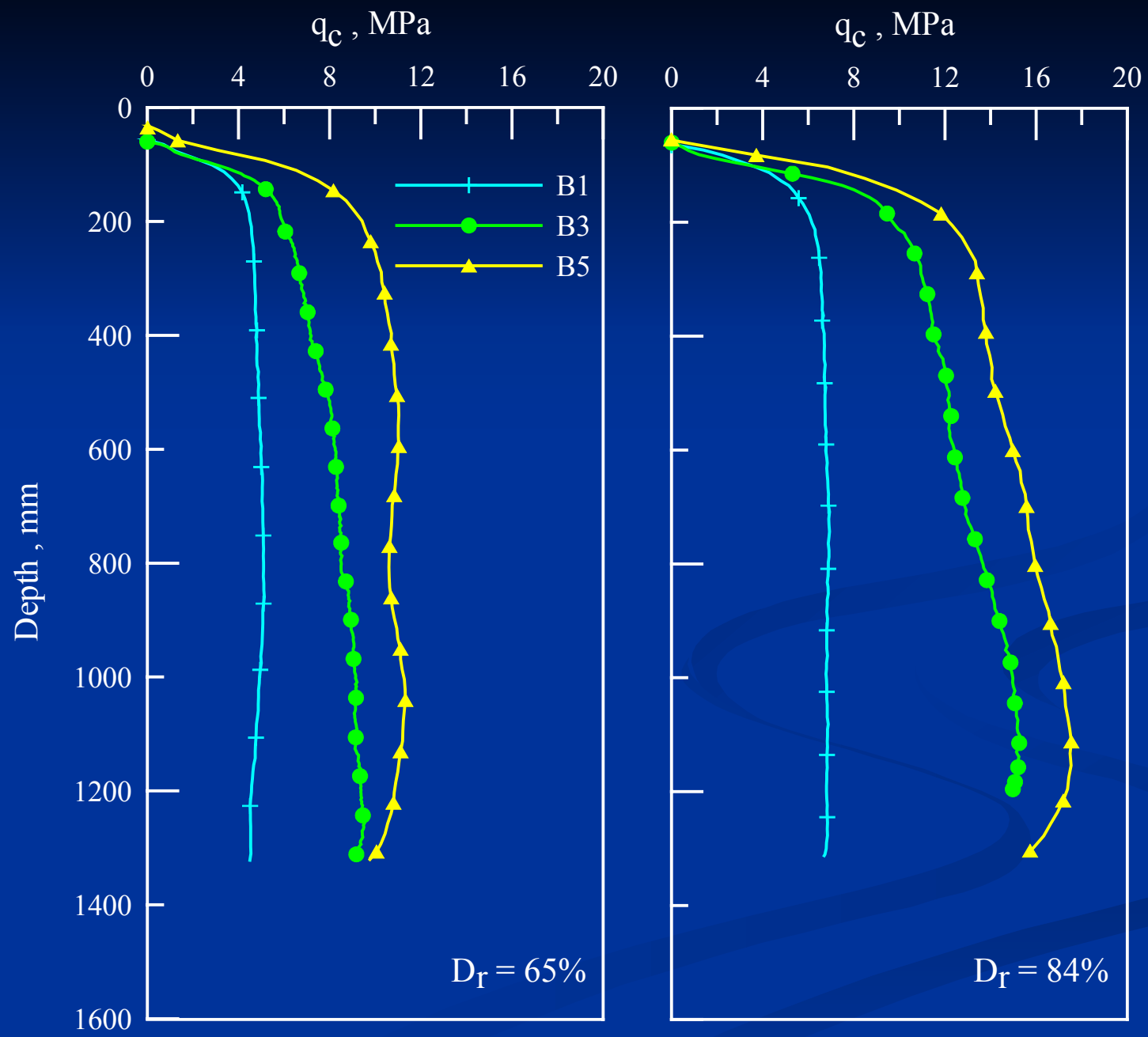
b - compression

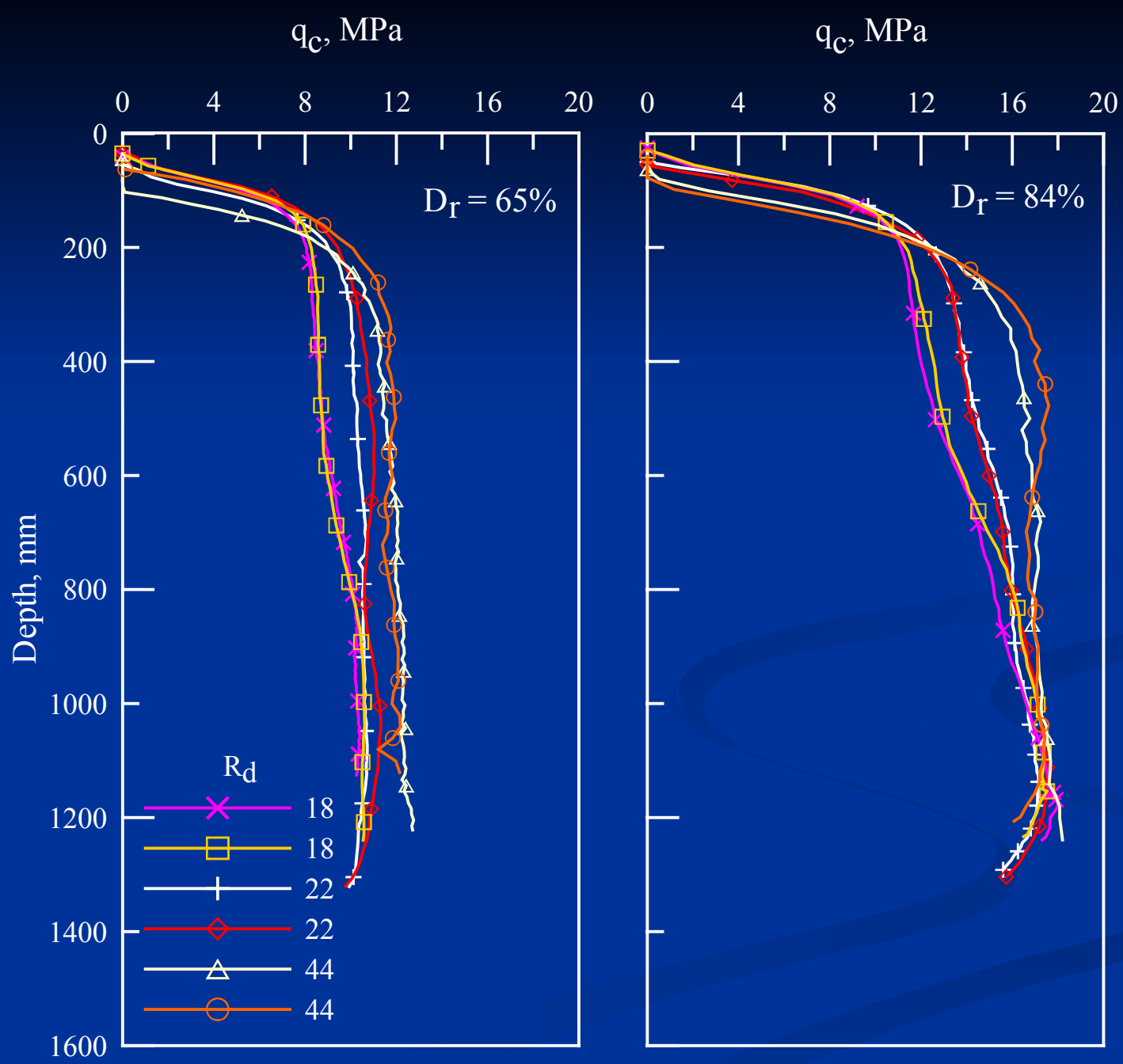
Cavity Expansion Vs Lateral Stress-Strain Relationship

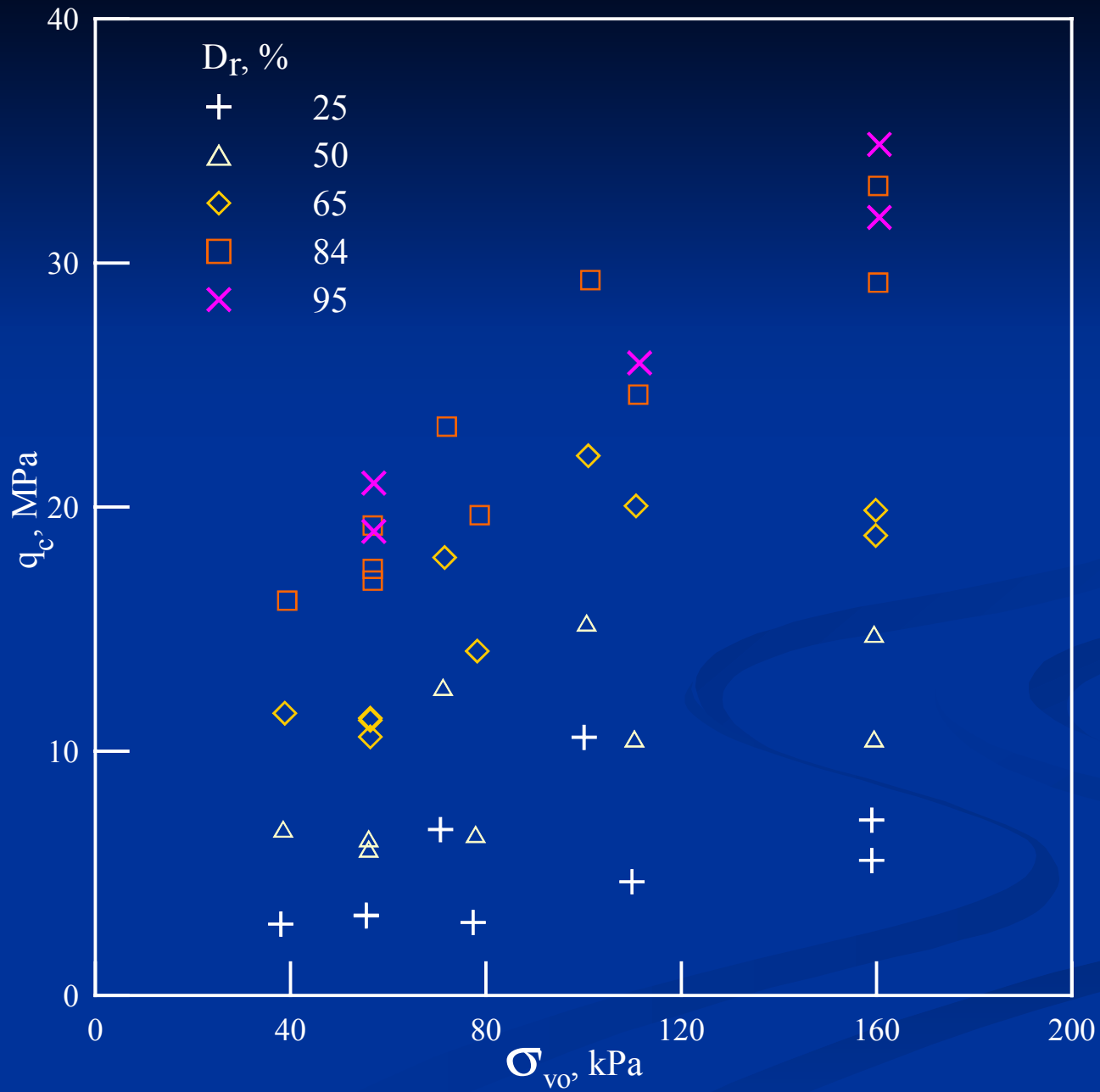


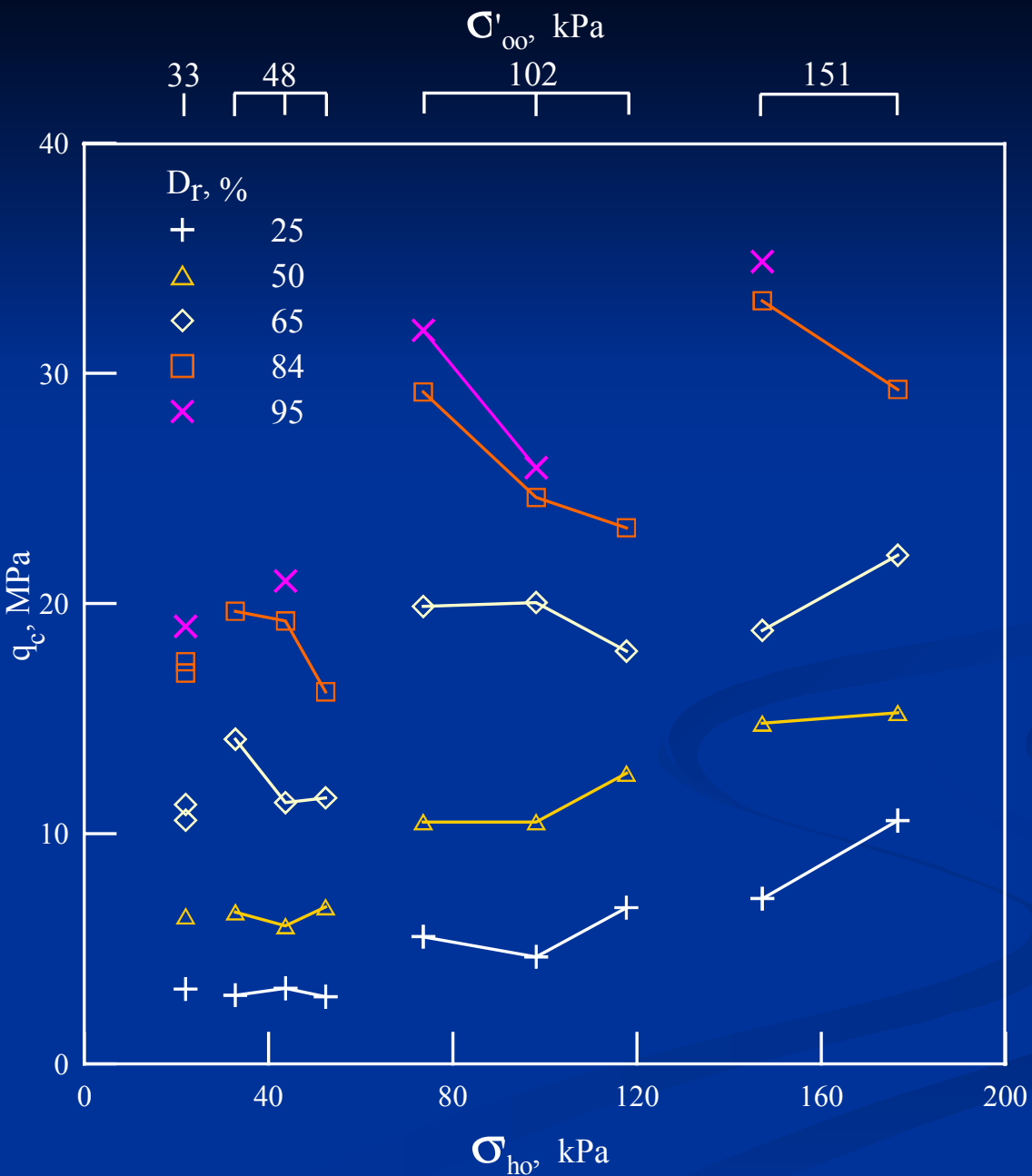
$$P_{ro} = \int_0^{\varepsilon_{ro}} \frac{\phi(\varepsilon_r)}{2\varepsilon_r} d\varepsilon_r + \sigma_{ho}$$

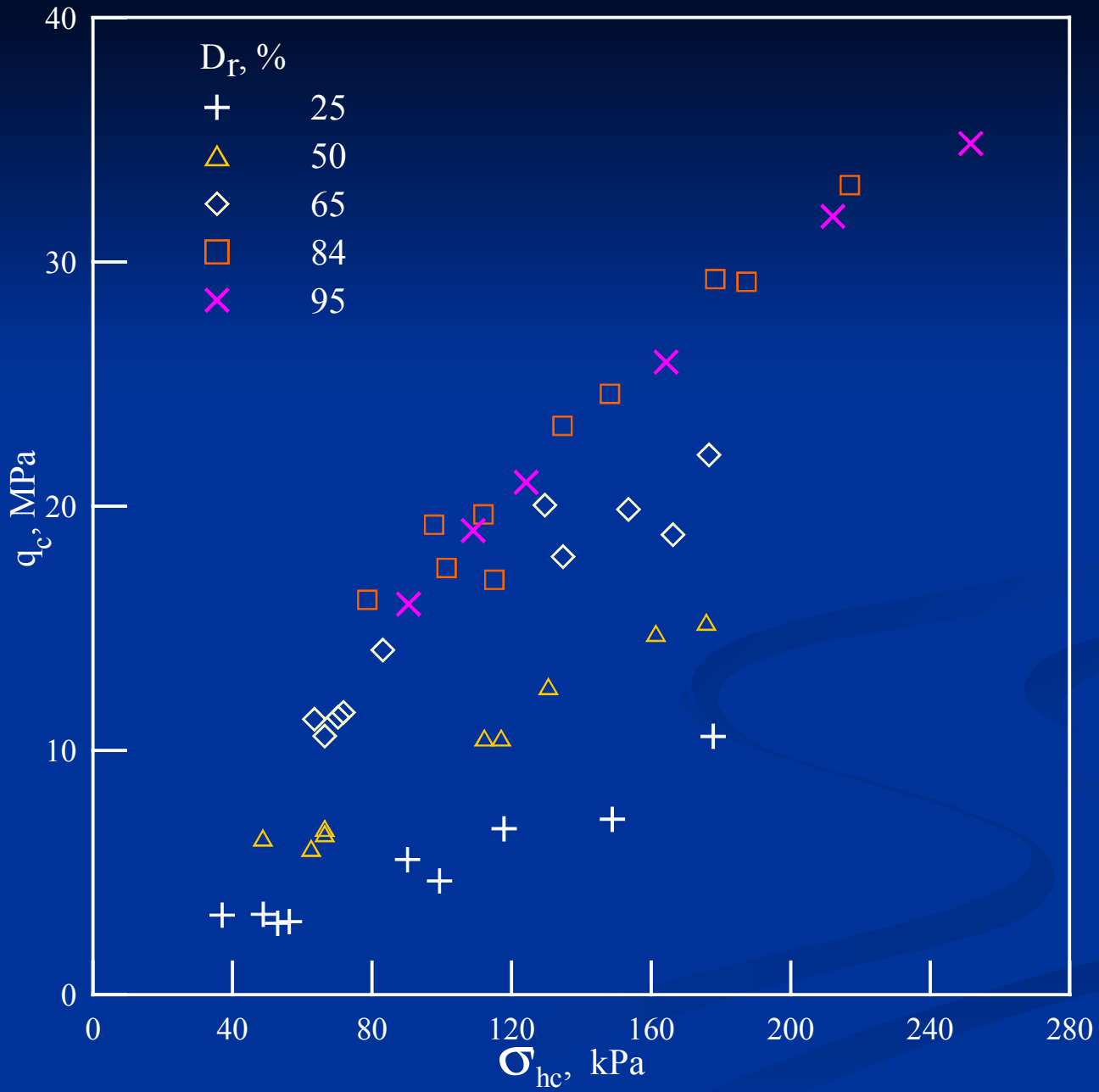

ΔC , mm
-1
0
1
2
3
4
p_{ro} , kPa
20
40
60
80
100
120
-40
-30
-20
-10
0
10
20
30
40
Depth / d_{cone}
D_r = 84%
B1
B3
B5


q_c , MPa
0
4
8
12
16
20
Depth , mm
0
200
400
600
800
1000
1200
1400
1600
B1
B3
B5
D_r = 65%
q_c , MPa
D_r = 84%

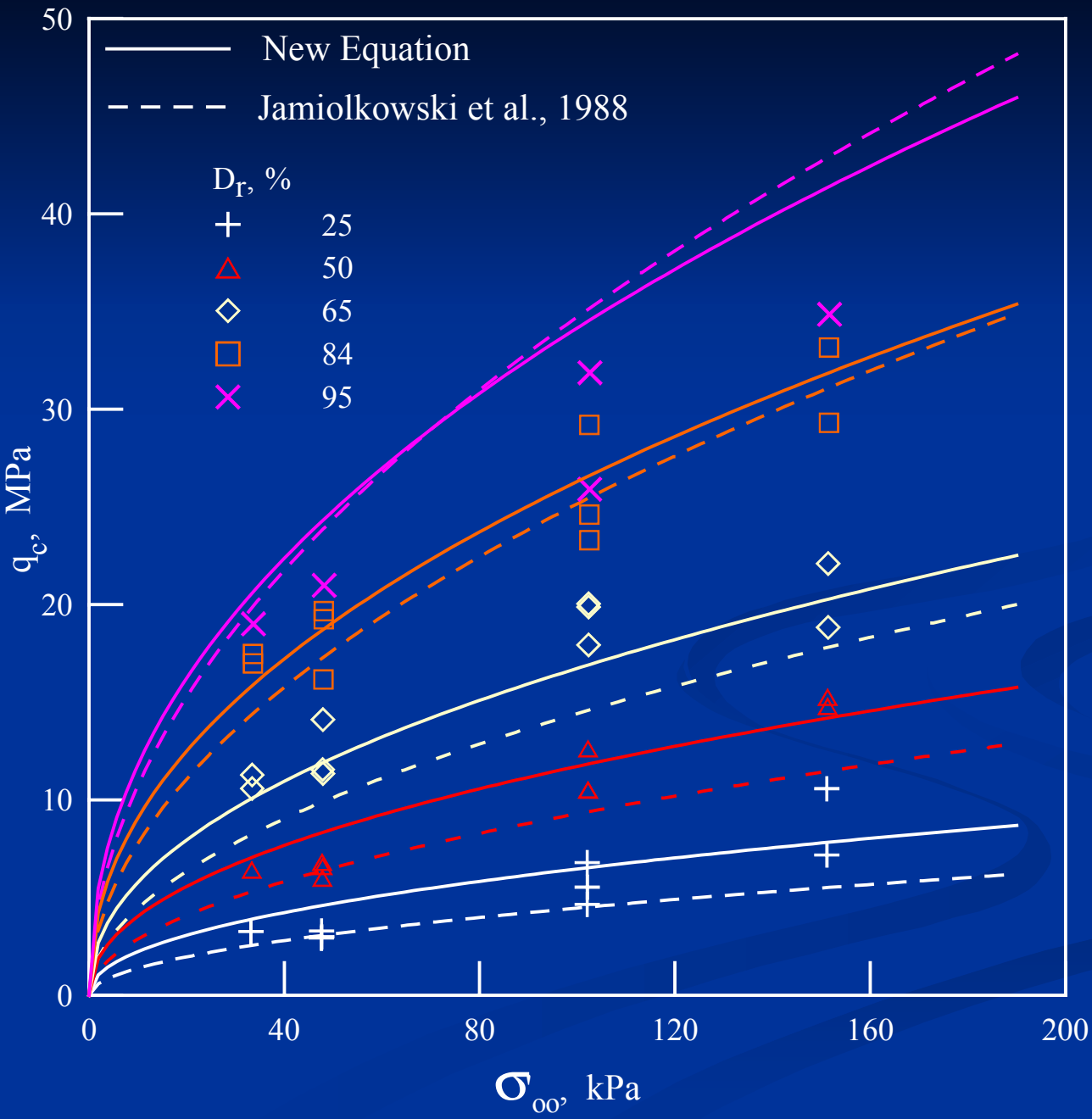

q_c, MPa
0
4
8
12
16
20
Depth, mm
0
200
400
600
800
1000
1200
1400
1600
D_r = 65%
D_r = 84%
R_d
18
18
22
22
44
44


40
30
20
10
0
q_c, MPa
D_r, %
25
50
65
84
95
0
40
80
120
160
200
σ_{vo}, kPa

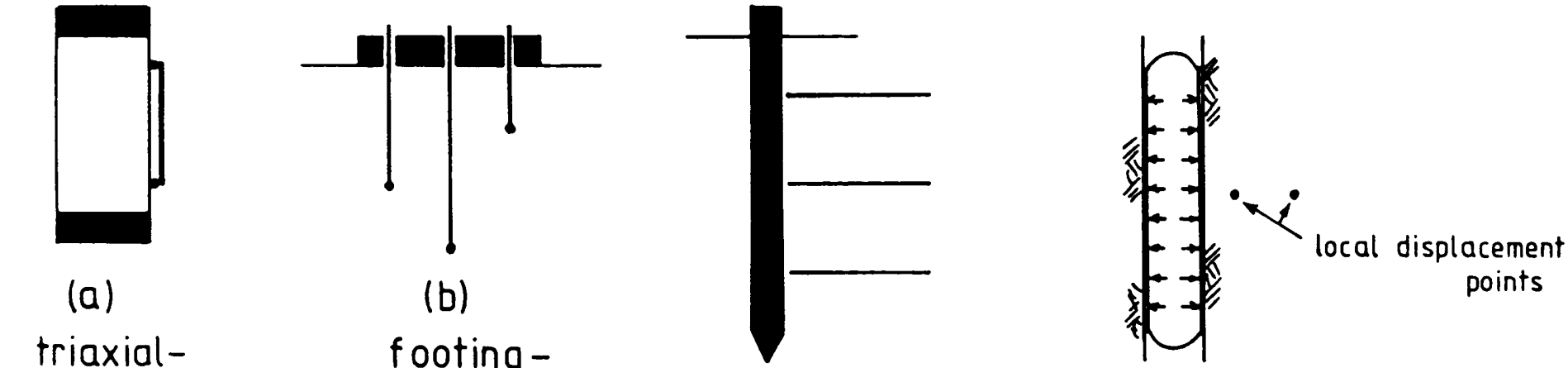

σ'oo, kPa
33
48
102
151
Dr, %
25
50
65
84
95
qc, MPa
0
10
20
30
40
0
40
80
120
160
200
σho, kPa


D_r, %
25
50
65
84
95
q_c, MPa
σ_{hc}, kPa
0
10
20
30
40
0
40
80
120
160
200
240
280

$$q_c = 425 * (\sigma_{oo}')^{0.462} * \exp(2.378 * Dr)$$

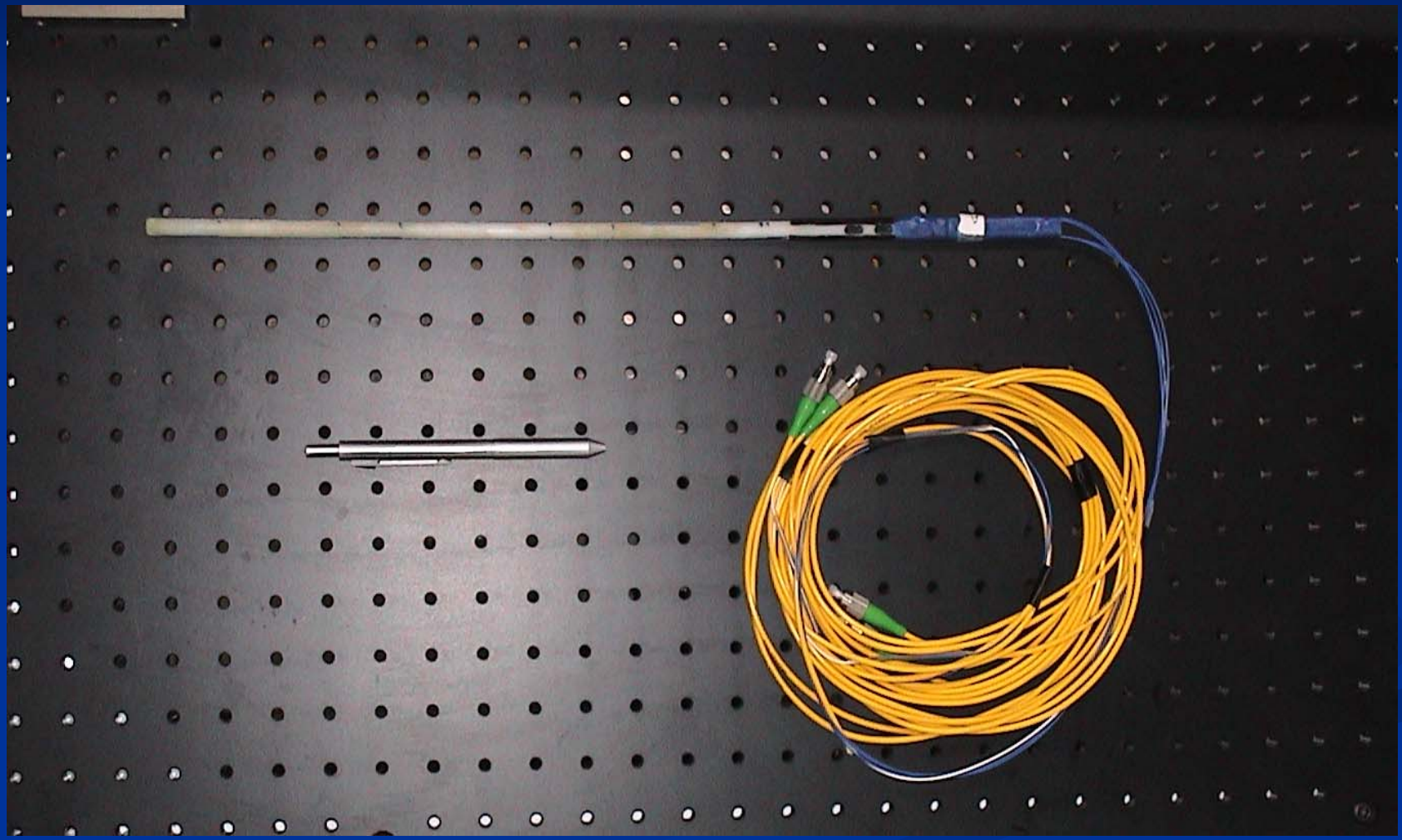


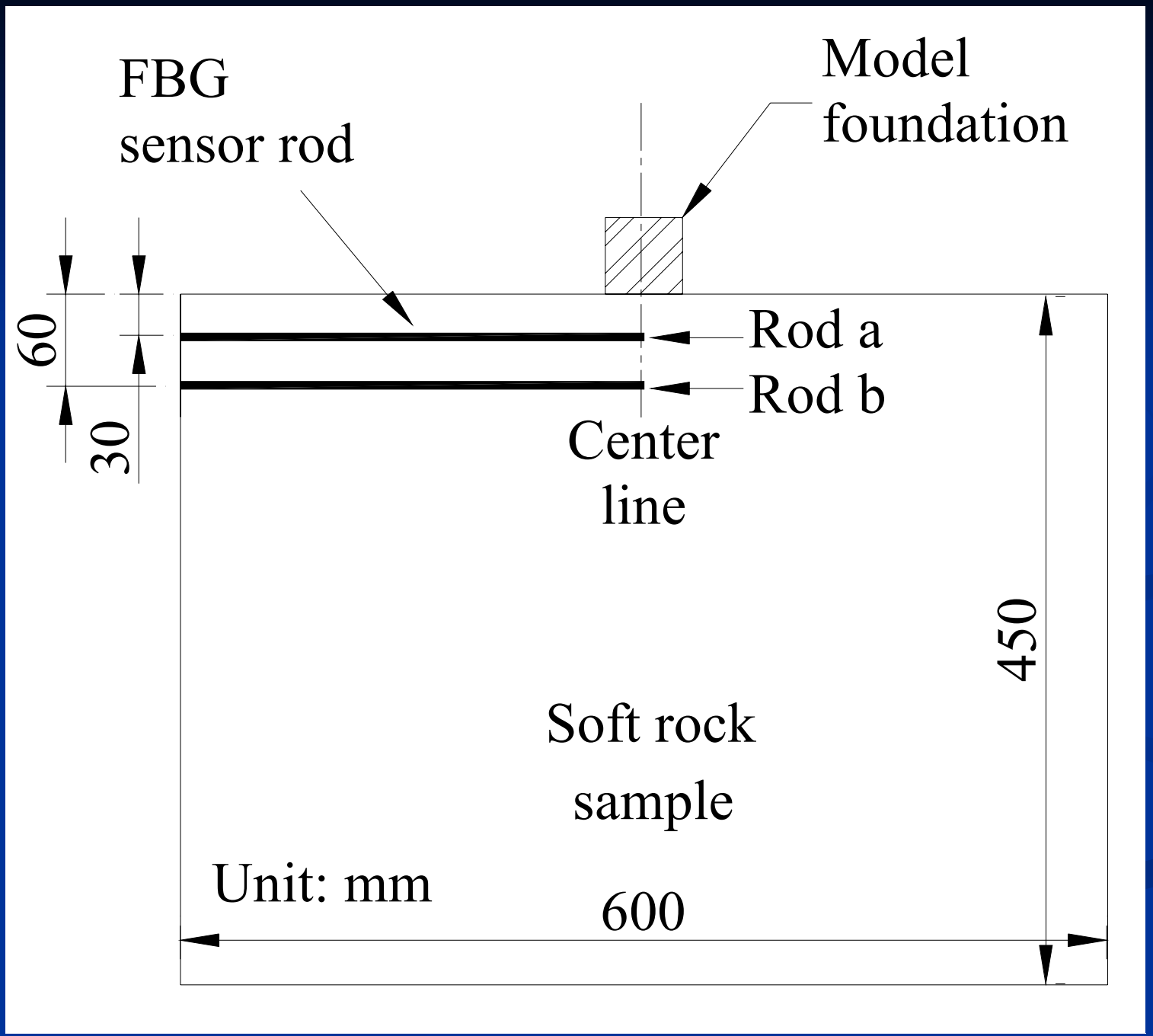
"The Burland's Challenge"



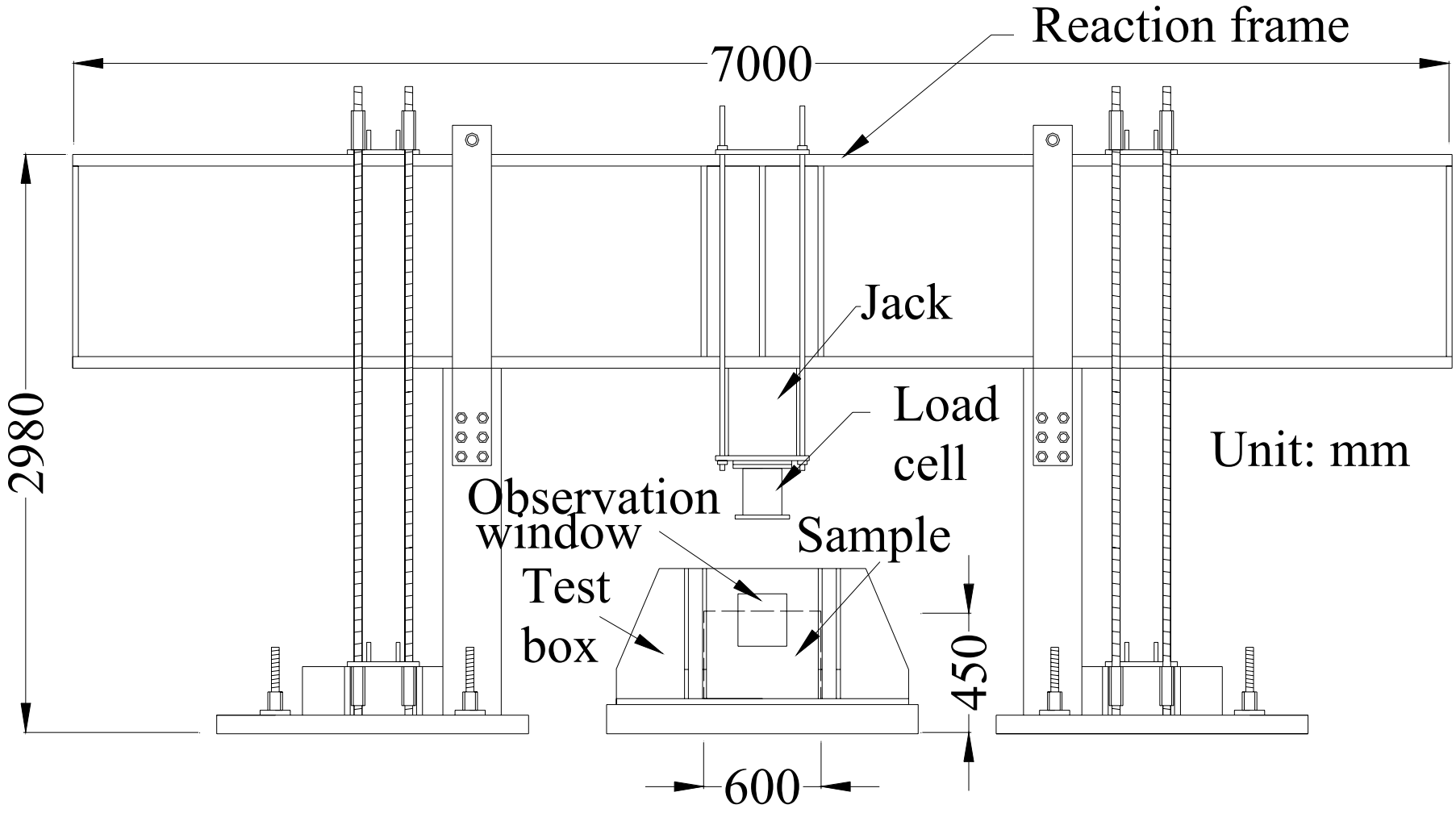
Burland, 1995

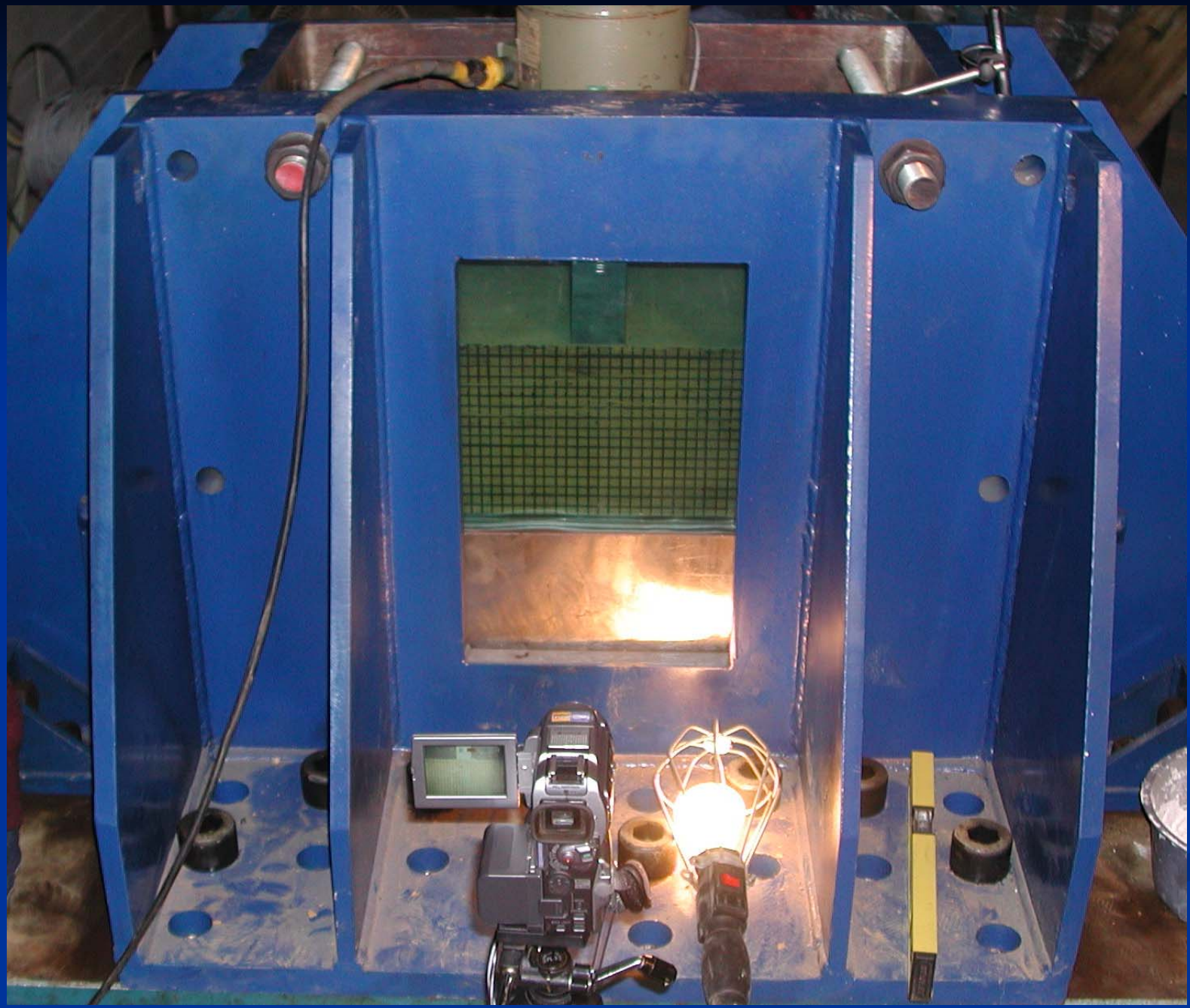
LDM w/ Fiber Optic Sensors



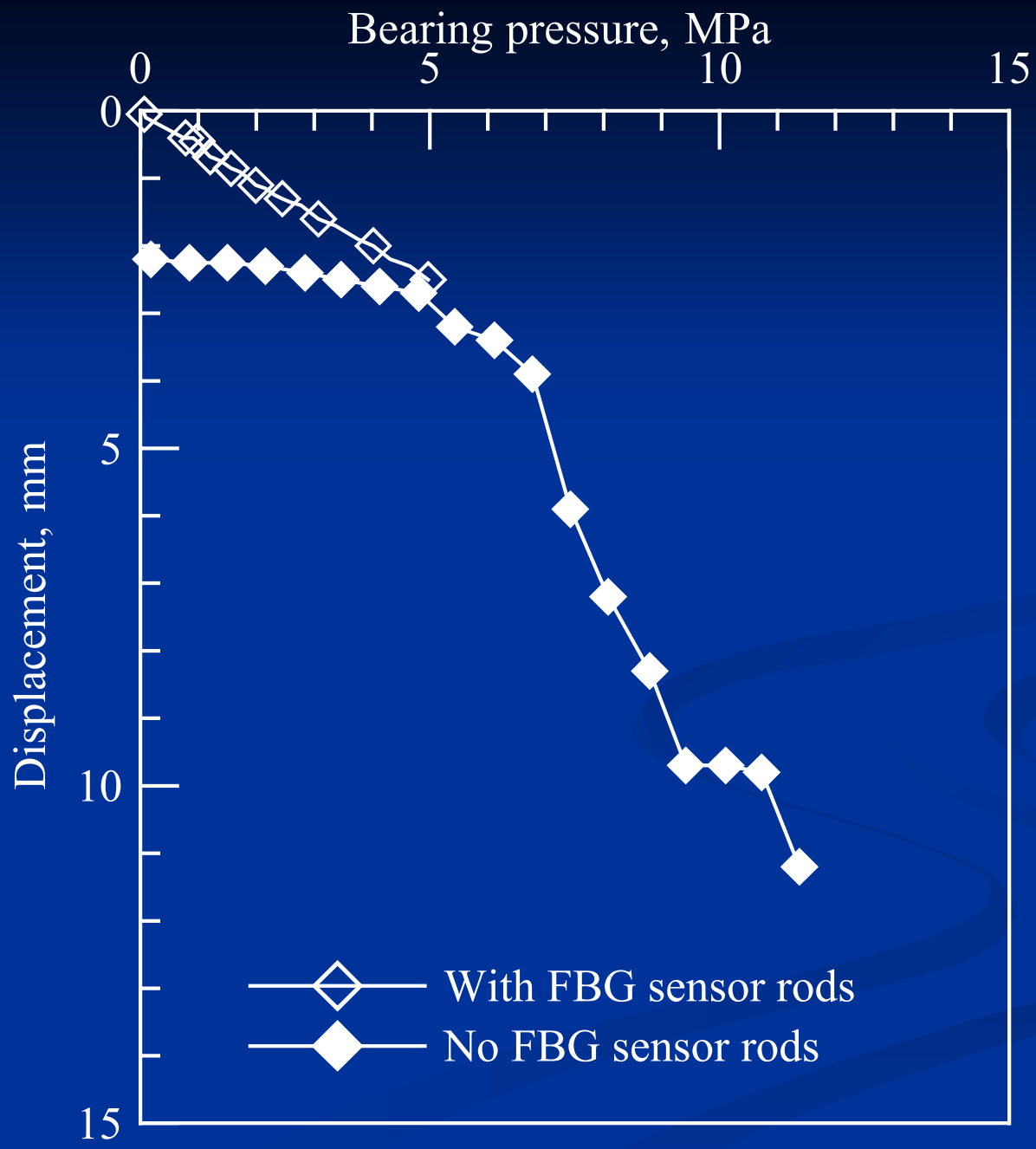

FBG
sensor rod
Model
foundation
60
30
Rod a
Rod b
Center
line
450
Soft rock
sample
Unit: mm
600

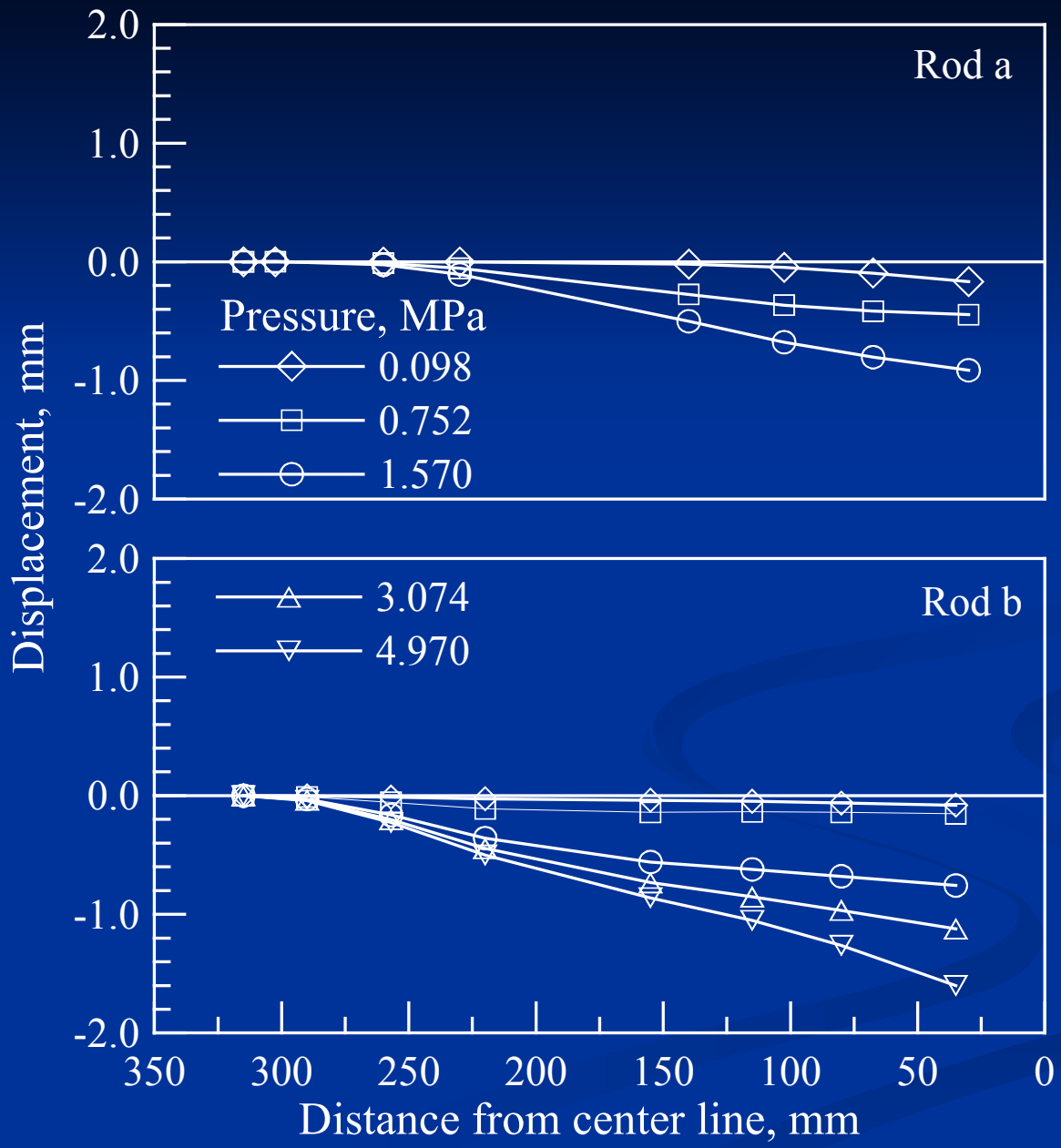
Model Load Test w/ Local Displacement Monitoring

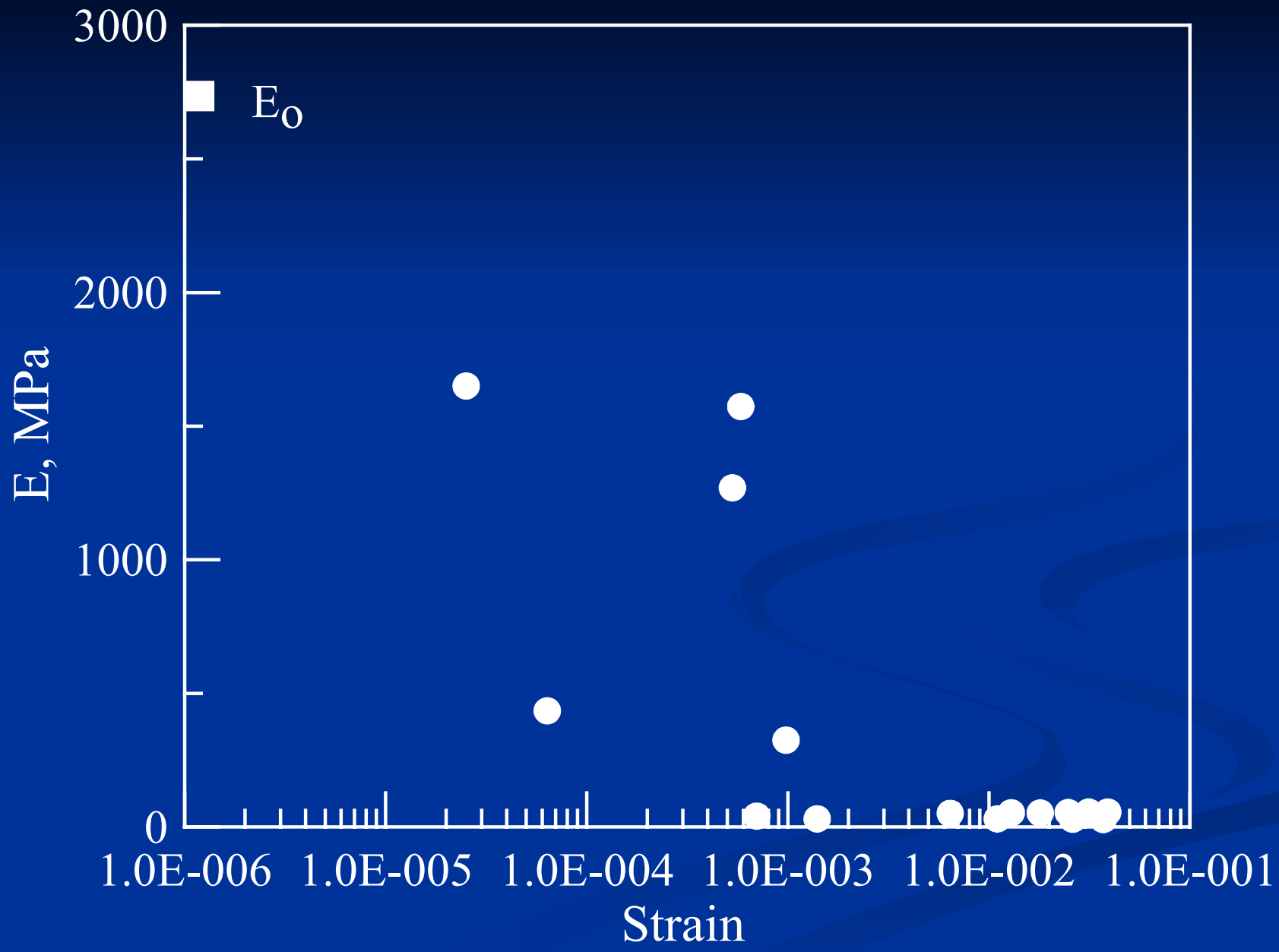







Bearing pressure, MPa
0
5
10
15
0
5
10
15
Displacement, mm
With FBG sensor rods
No FBG sensor rods


Rod a
Rod b
Pressure, MPa
0.098
0.752
1.570
3.074
4.970
Displacement, mm
Distance from center line, mm
2.0
1.0
0.0
-1.0
-2.0
350
300
250
200
150
100
50
0


3000
2000
1000
0
E, MPa
E_o
1.0E-006
1.0E-005
1.0E-004
1.0E-003
1.0E-002
1.0E-001
Strain

Conclusions

- LDM as a means to minimize/elimination of boundary effects in physical modeling
- Fiber optic sensor as an effective tool for LDM
- Boundary + material behavior measurements w/LDM
- Fiber optic sensors can be equally applicable under high g's