



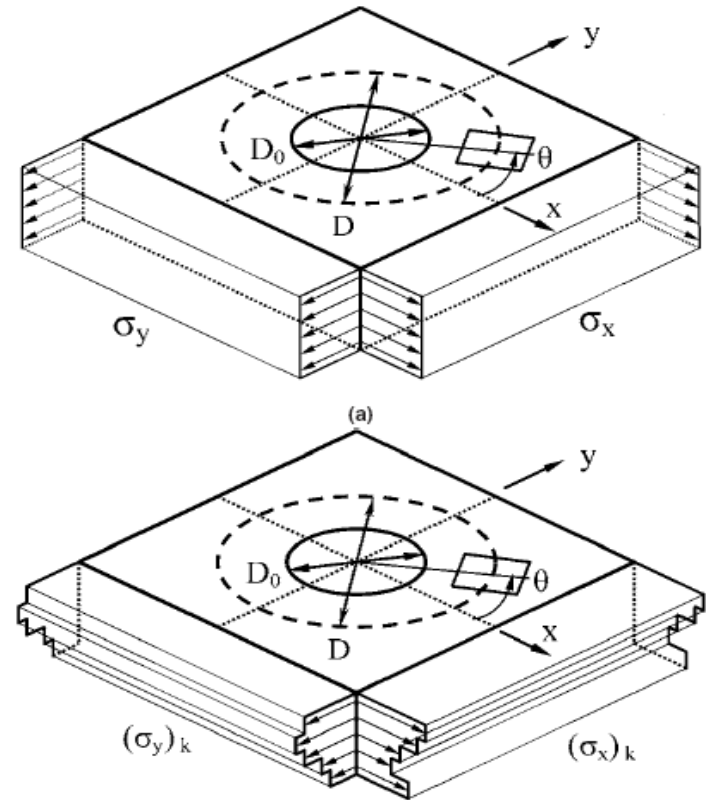
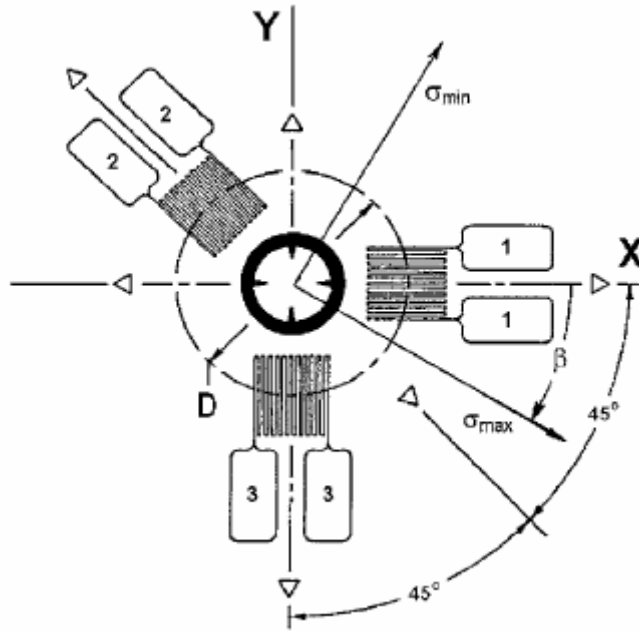
Validazione sperimentale di una rosetta a 6 griglie per ridurre l'errore di eccentricità nella misura delle tensioni residue

M. Beghini, L. Bertini, C. Santus
Dipartimento di Ingegneria Meccanica
Università di Pisa

A. Benincasa, L. Bertelli, E. Valentini
SINT Technology srl
Calenzano (FI)

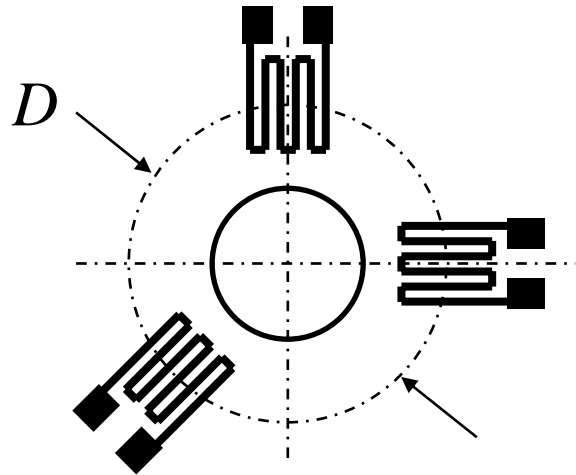


Il metodo del foro, *Hole Drilling Method*



ASTM E837 - 08e1 "Standard Test Method for Determining Residual Stresses by the Hole-Drilling Strain-Gage Method", 2008.

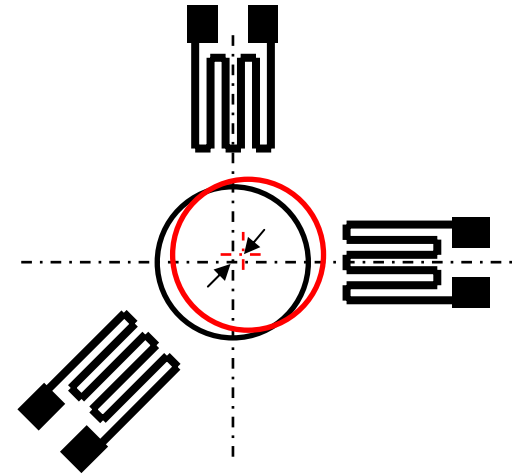
Eccentricità foro - rosetta



ASTME837-08e1

$ecc. < 0.004D = 0.02 \text{ mm}$

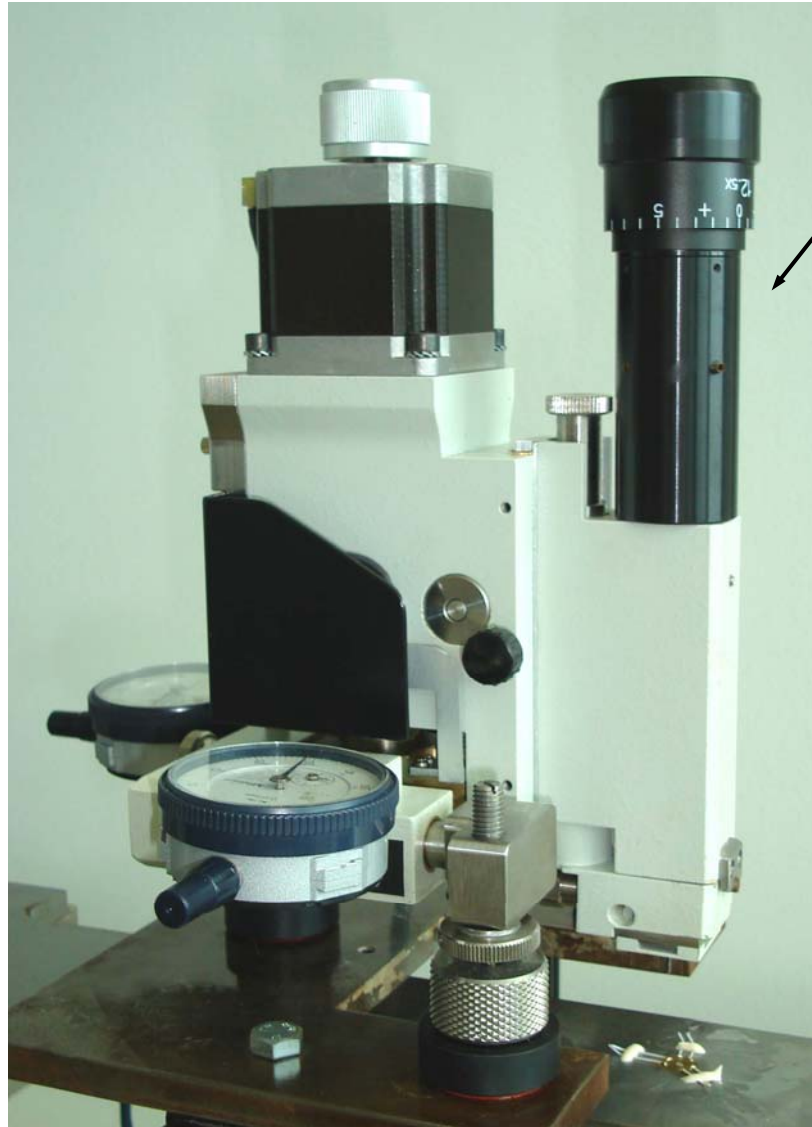
$(D = 5.1 \text{ mm})$



$ecc. 0.05 \text{ mm} - 0.1 \text{ mm}$

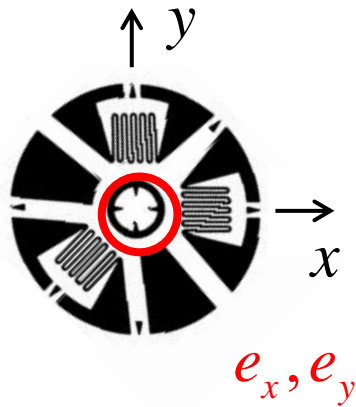
da compensare

RESTAN – MTS 3000, SINT Technology



Sistema ottico
per la riduzione
dell'eccentricità

Compensazione dell'effetto di eccentricità



Rosetta standard 3 griglie,
algoritmo di determinazione della Tens. Res. che
ammette l'eccentricità come parametro geometrico.

Influence Functions

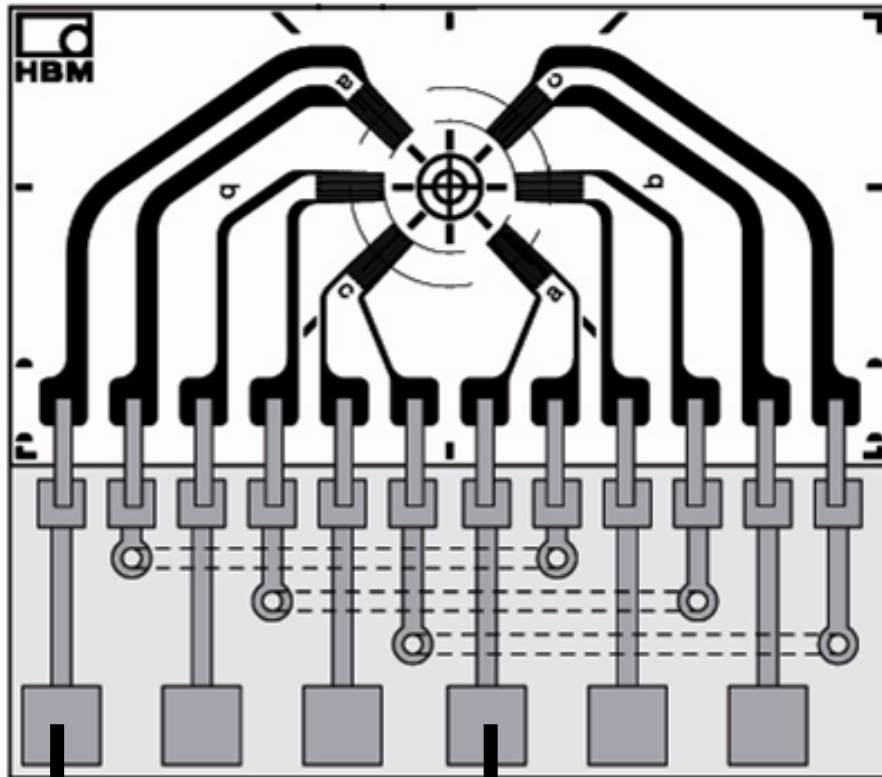


M. Beghini, L. Bertini, L.F. Mori. "Evaluating Non-Uniform Residual Stress by the Hole-Drilling Method with Concentric and Eccentric Holes. Part I. Definition and Validation of the Influence Functions". *Strain*, 46(4), p. 324–336, 2010.

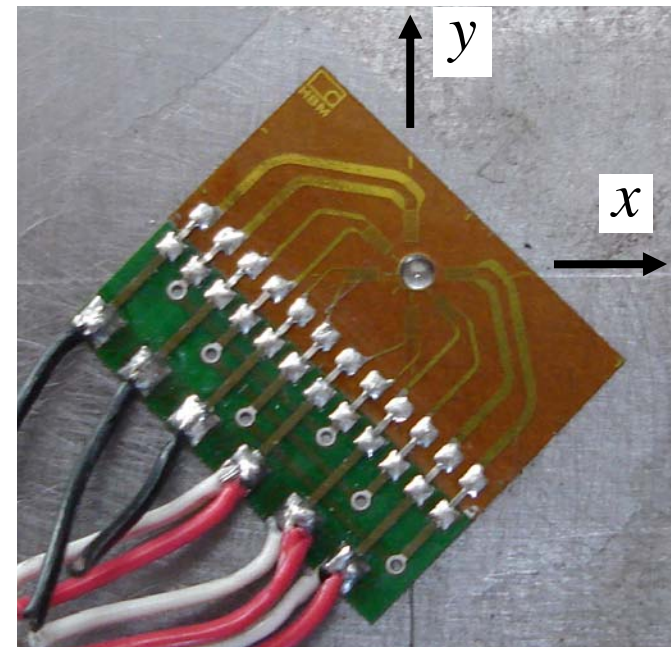
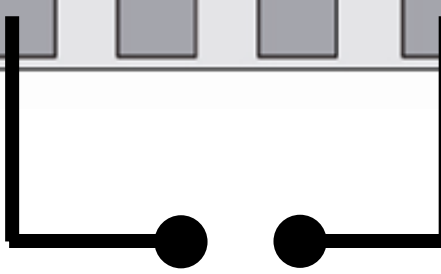


M. Beghini, L. Bertini, L.F. Mori. "Evaluating Non-Uniform Residual Stress by the Hole-Drilling Method With Concentric and Eccentric Holes. Part II: Application of the Influence Functions to the Inverse Problem". *Strain*, 46(4), p. 337–346, 2010.

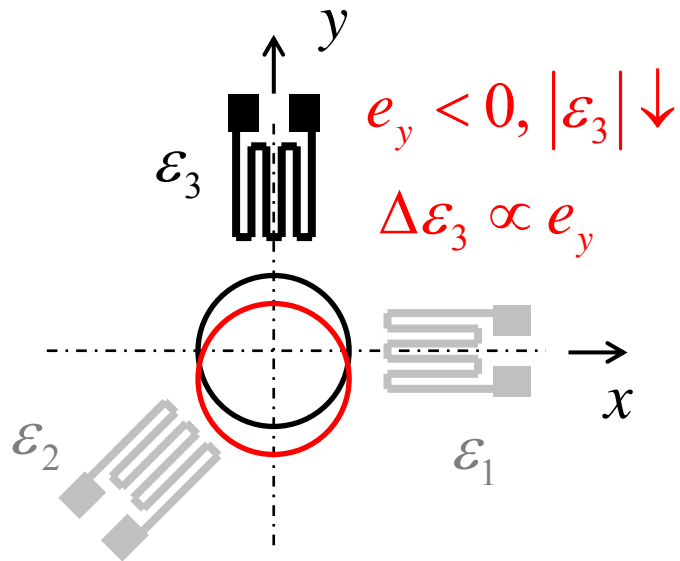
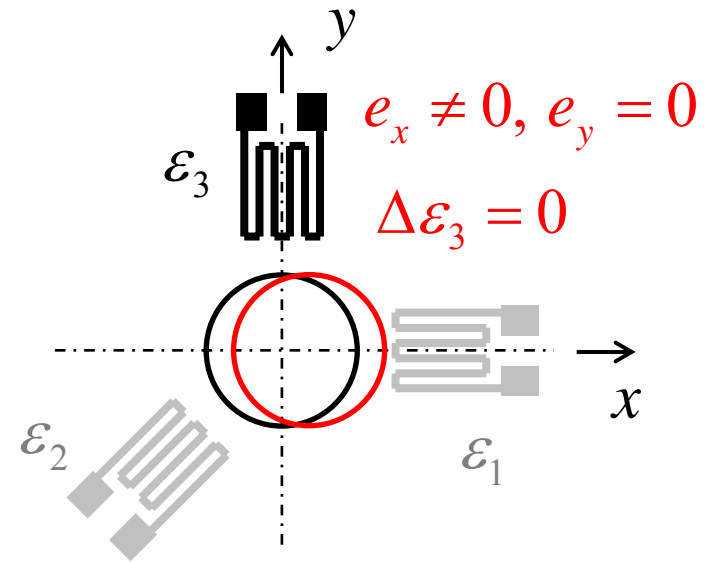
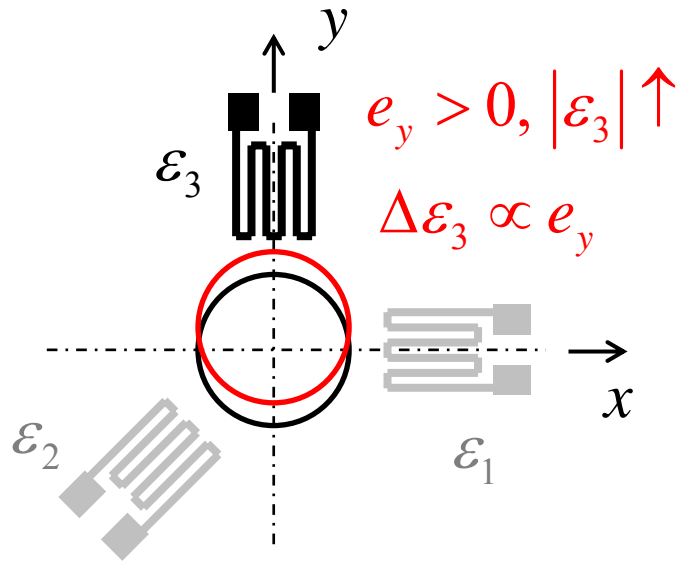
Rosetta a 6 griglie



Griglie opposte collegate in serie

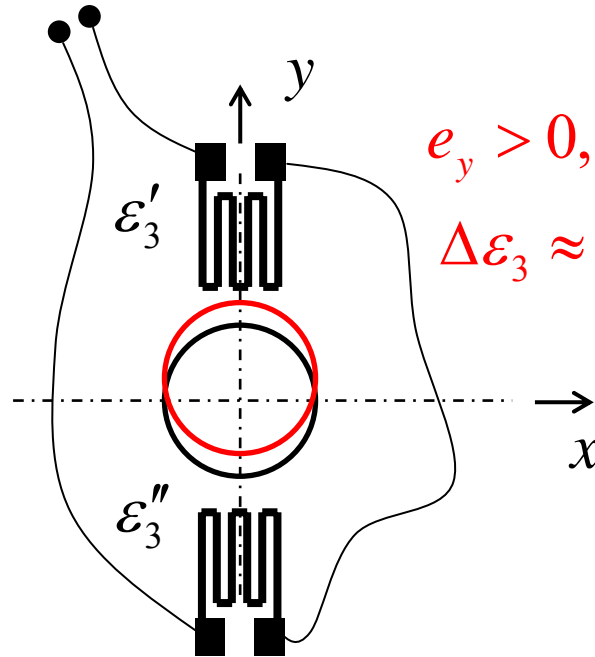


Effetto al *prim'ordine* dell'eccentricità



Principio della rosetta a 6 griglie

$$\varepsilon_3 = \varepsilon'_3 + \varepsilon''_3$$

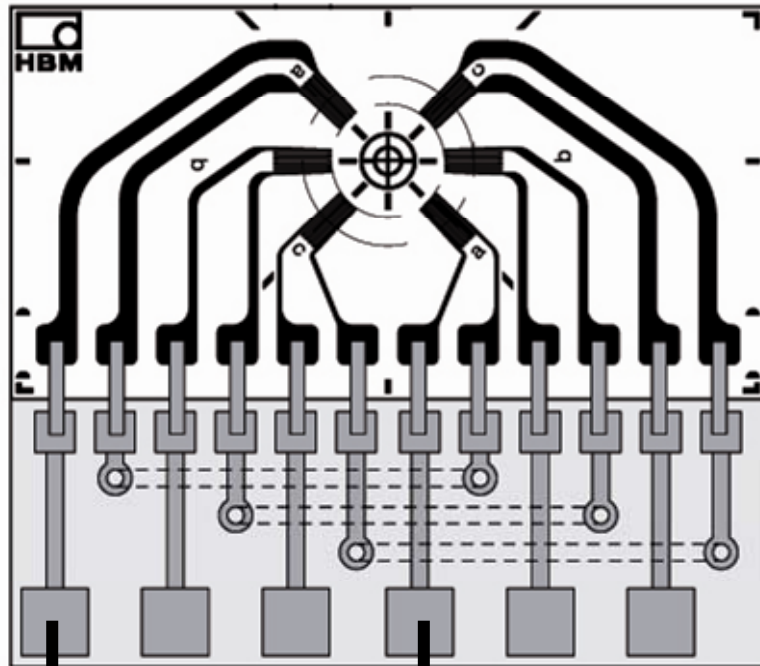


$$e_y > 0, \varepsilon'_3 \uparrow, \varepsilon''_3 \downarrow, \\ \Delta\varepsilon_3 \approx 0$$



M. Beghini, L. Bertini, L.F. Mori. "Evaluating Non-Uniform Residual Stress by the Hole-Drilling Method With Concentric and Eccentric Holes. Part II: Application of the Influence Functions to the Inverse Problem". *Strain*, 46(4), p. 337–346, 2010.

Principio della rosetta a 6 griglie



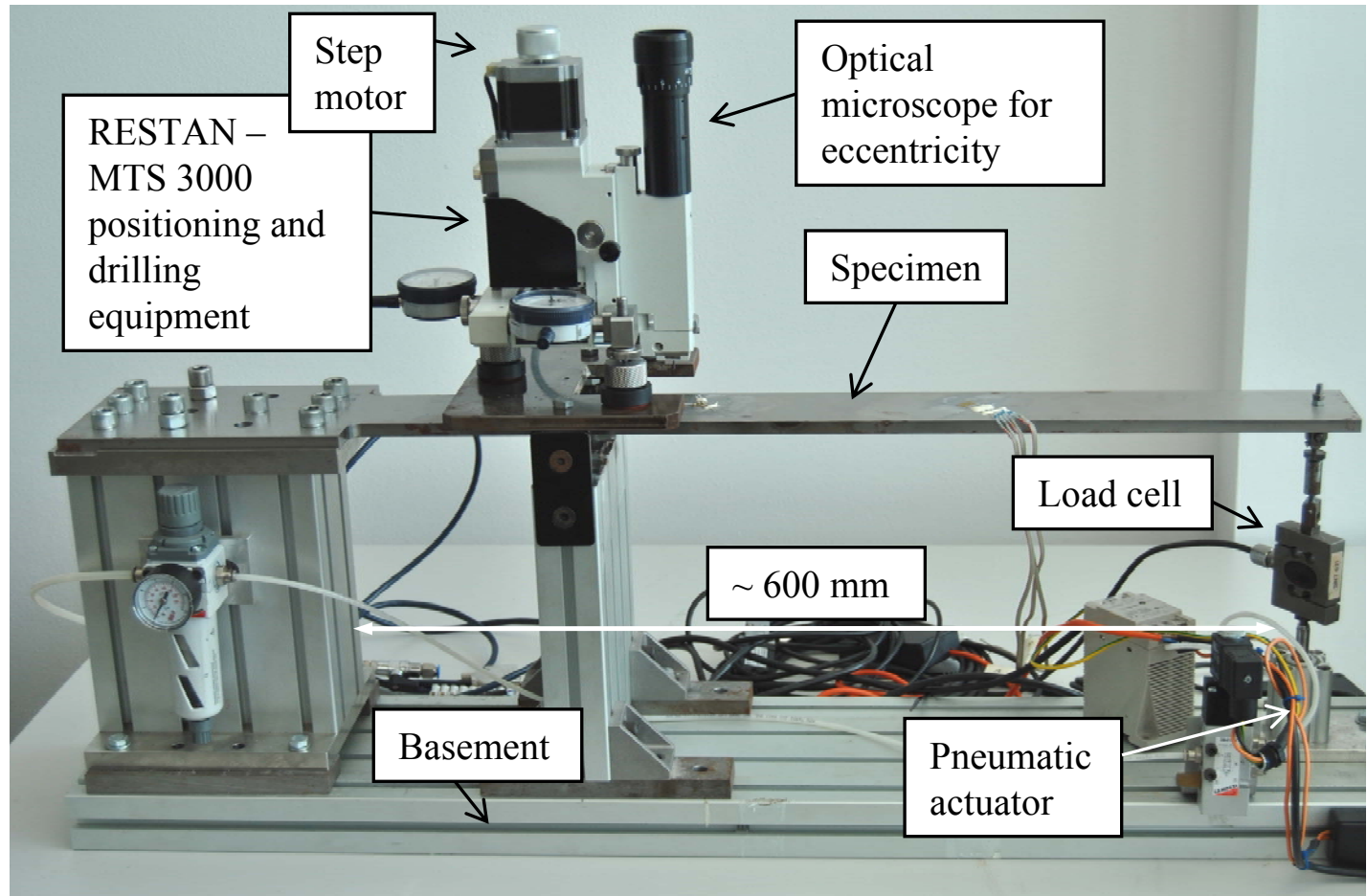
Autocompensazione
dell'effetto di eccentricità

Griglie opposte
collegate in serie



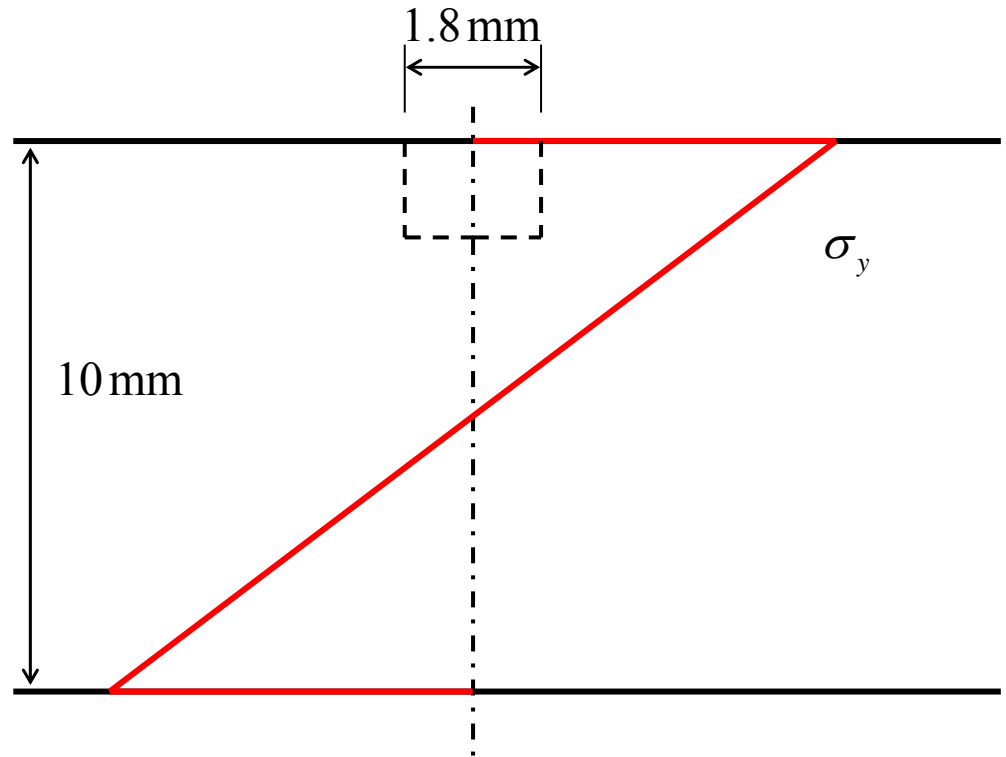
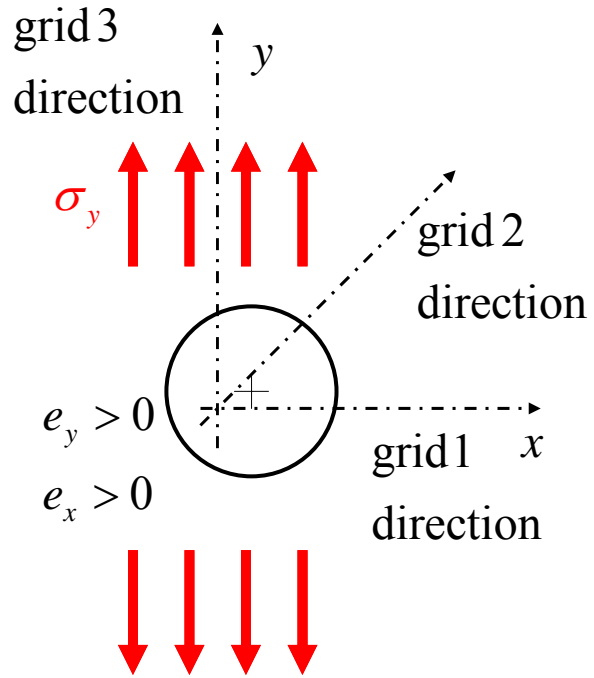
M. Beghini, L. Bertini, L.F. Mori. "Evaluating Non-Uniform Residual Stress by the Hole-Drilling Method With Concentric and Eccentric Holes. Part II: Application of the Influence Functions to the Inverse Problem". *Strain*, 46(4), p. 337–346, 2010.

Banco a flessione per la verifica del metodo del foro

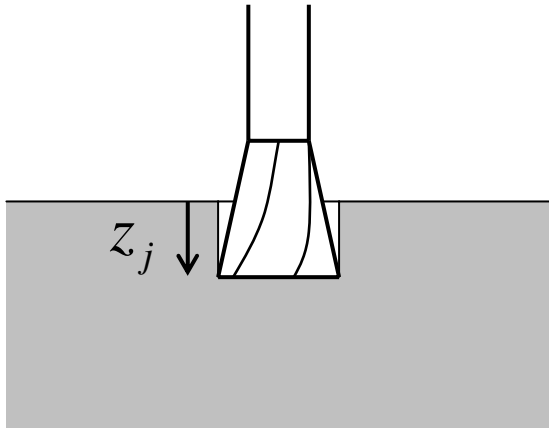


E. Valentini, M. Beghini, L. Bertini, C. Santus, M. Benedetti . "Procedure to Perform a Validated Incremental Hole Drilling Measurement: Application to Shot Peening Residual Stresses". Strain, 2010 (In Press).

Tensione monoassiale di flessione di riferimento



Disaccoppiamento deformazioni rilassate di flessione



A ciascun incremento di profondità si acquisisce le deformazioni rilassate **con** e **senza** carico di flessione

$$\varepsilon_i(z_j), \varepsilon_i^F(z_j),$$

$$i = 1, 2, 3$$

$$j = 1, 2, \dots, n$$

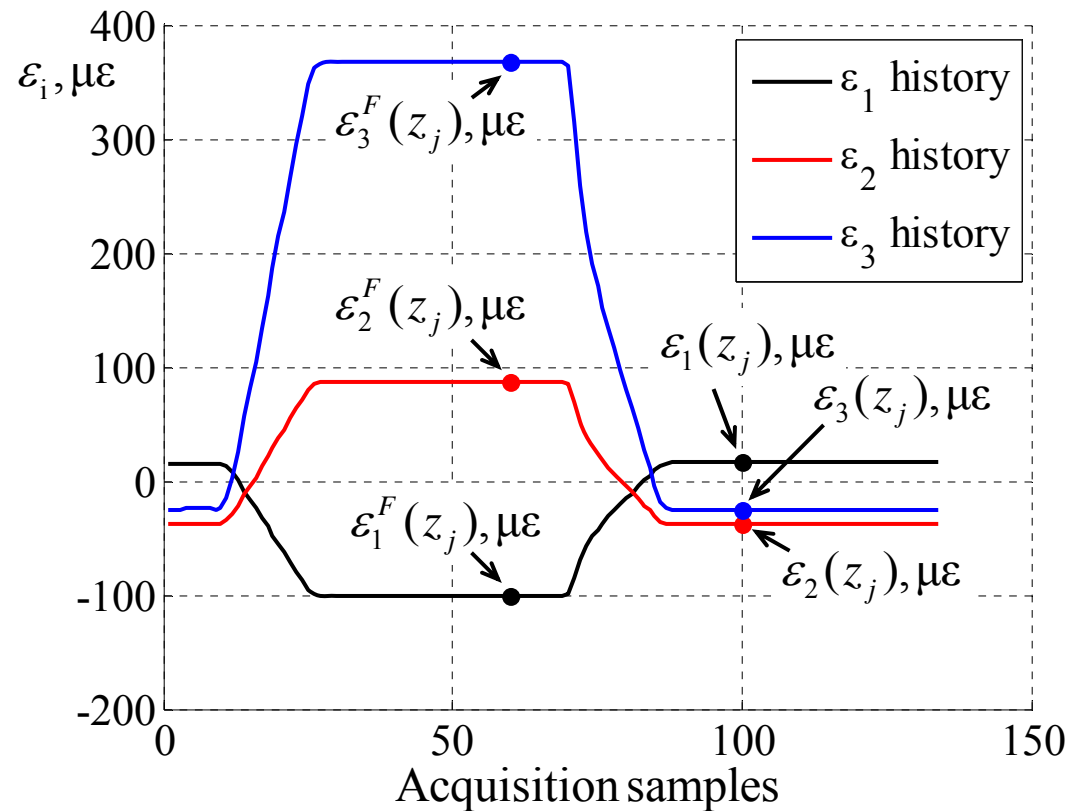
Disaccoppiamento deformazioni rilassate di flessione

$$\varepsilon_i^{\text{RS}}(z_j) = \varepsilon_i(z_j)$$

$$\varepsilon_i^{\text{Be}}(z_j) = \varepsilon_i^F(z_j) - \varepsilon_i(z_j) - \varepsilon_i^F(0)$$

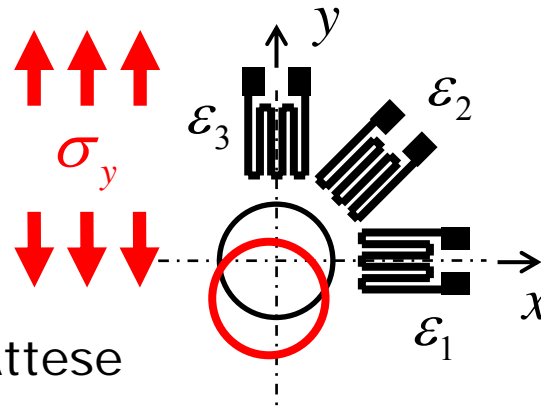
$$i = 1, 2, 3$$

$$j = 1, 2, \dots, n$$

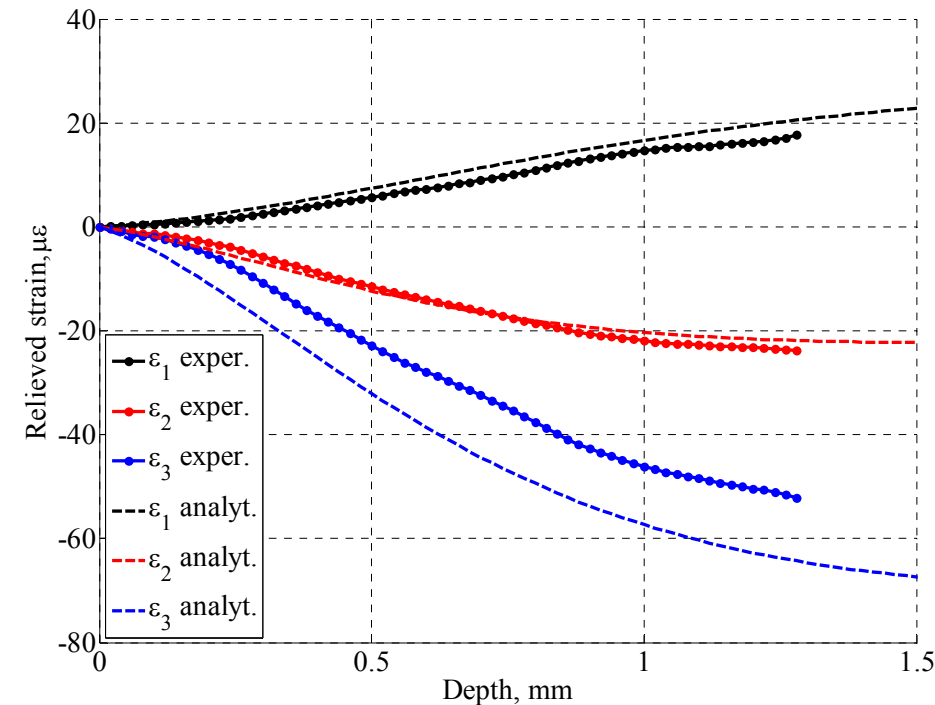


Risultati

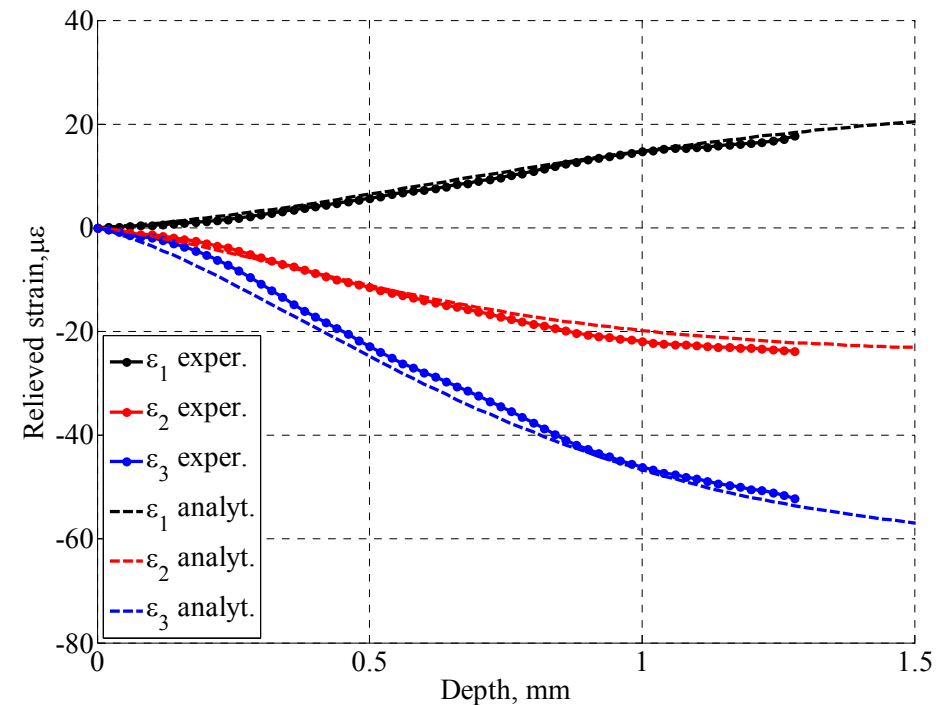
Rosetta a 3 griglie, eccentricità prevalente secondo la direzione del carico



Def. ril. Sperimentale / Attese



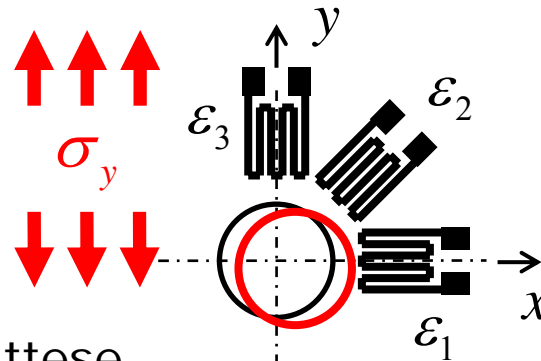
Senza correzione analitica



Con correzione analitica

Risultati

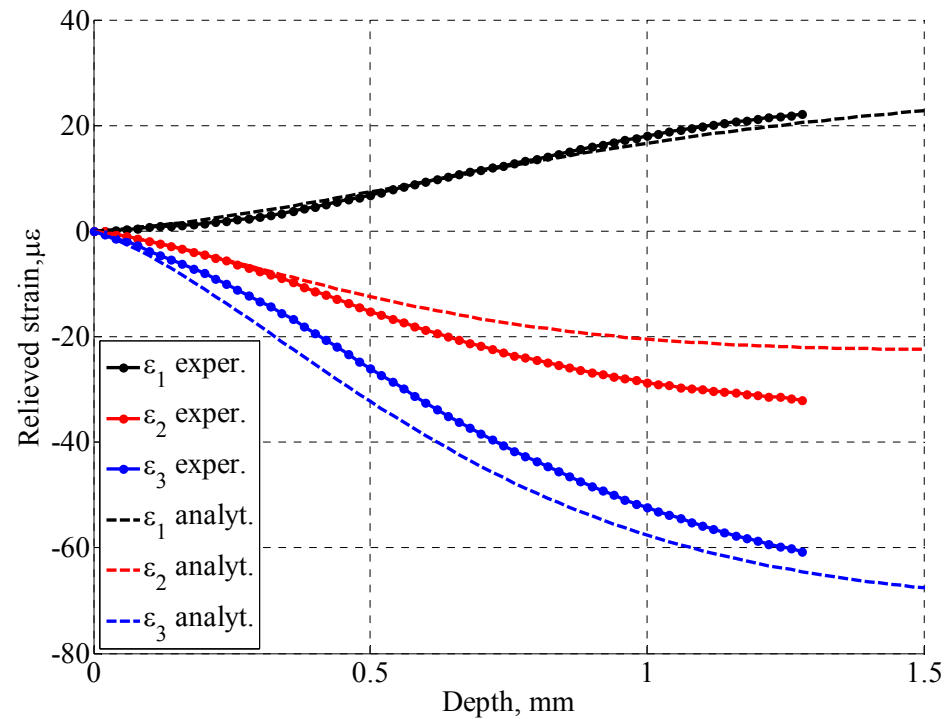
Rosetta a 3 griglie, eccentricità prevalente dir. perpendicolare al carico



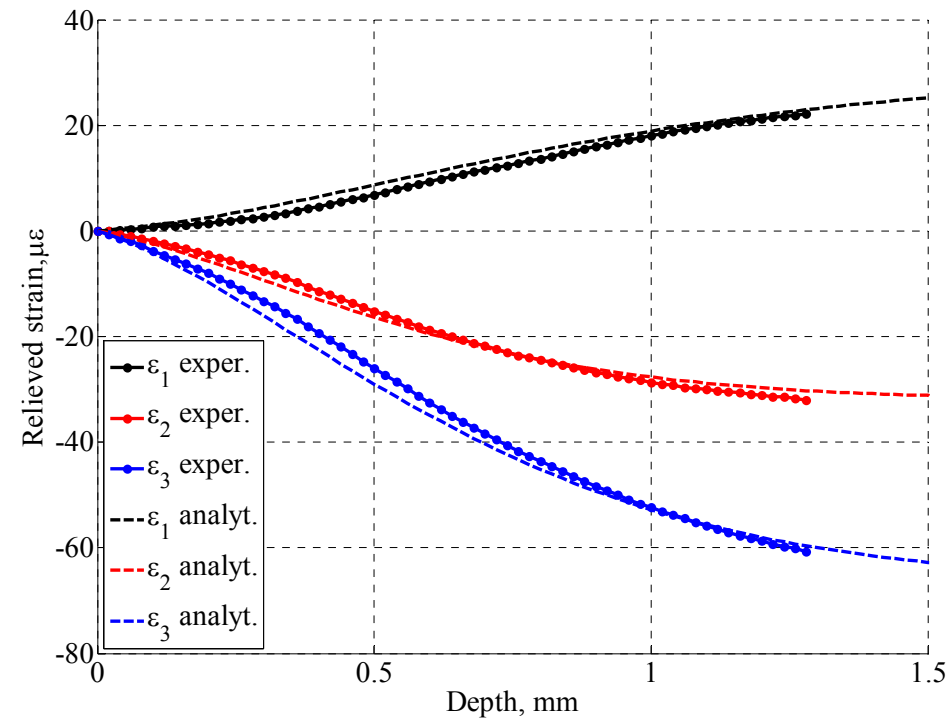
$$e_x = 0.14 \text{ mm}$$

$$e_y = -0.07 \text{ mm}$$

Def. ril. Sperimentale / Attese



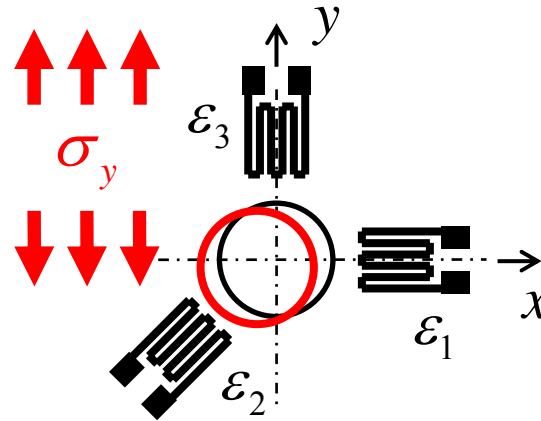
Senza correzione analitica



Con correzione analitica

Risultati

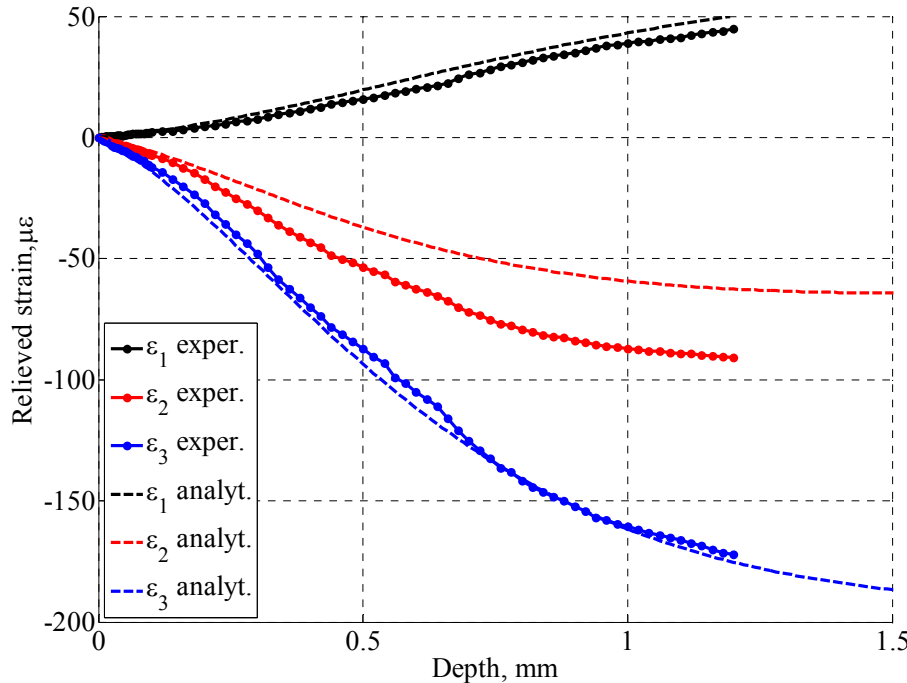
Rosetta a 3 griglie, eccentricità prevalente dir. perpendicolare al carico



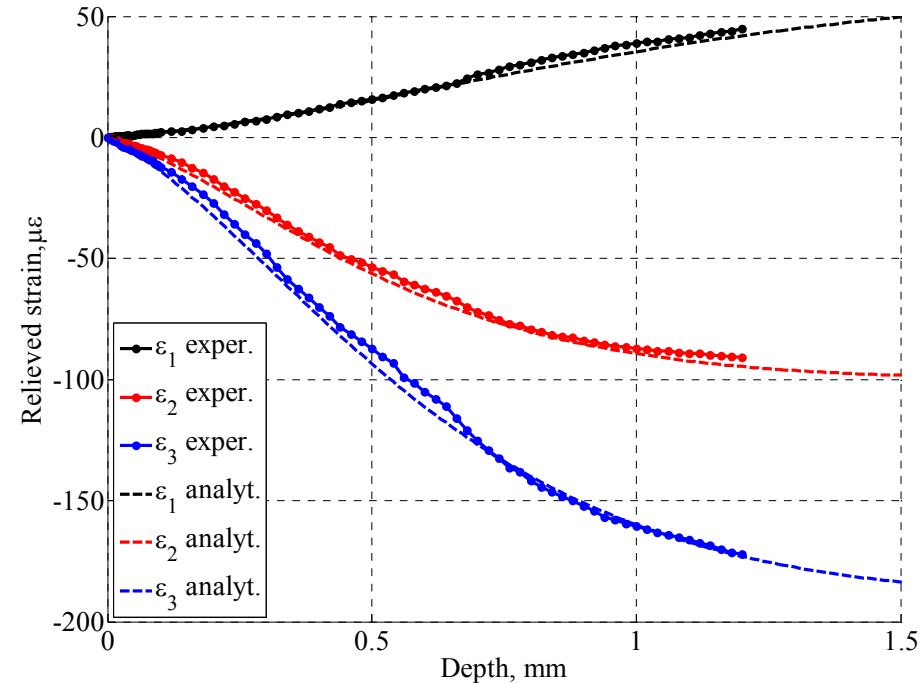
$$e_x = -0.22 \text{ mm}$$

$$e_y = 0.03 \text{ mm}$$

Def. ril. Sperimentale /
Attese



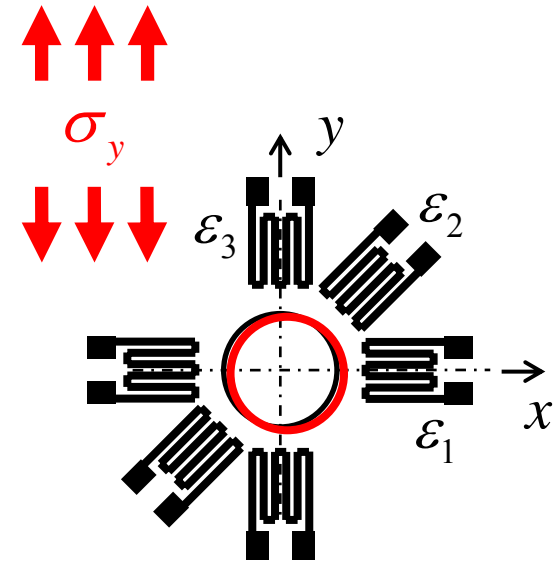
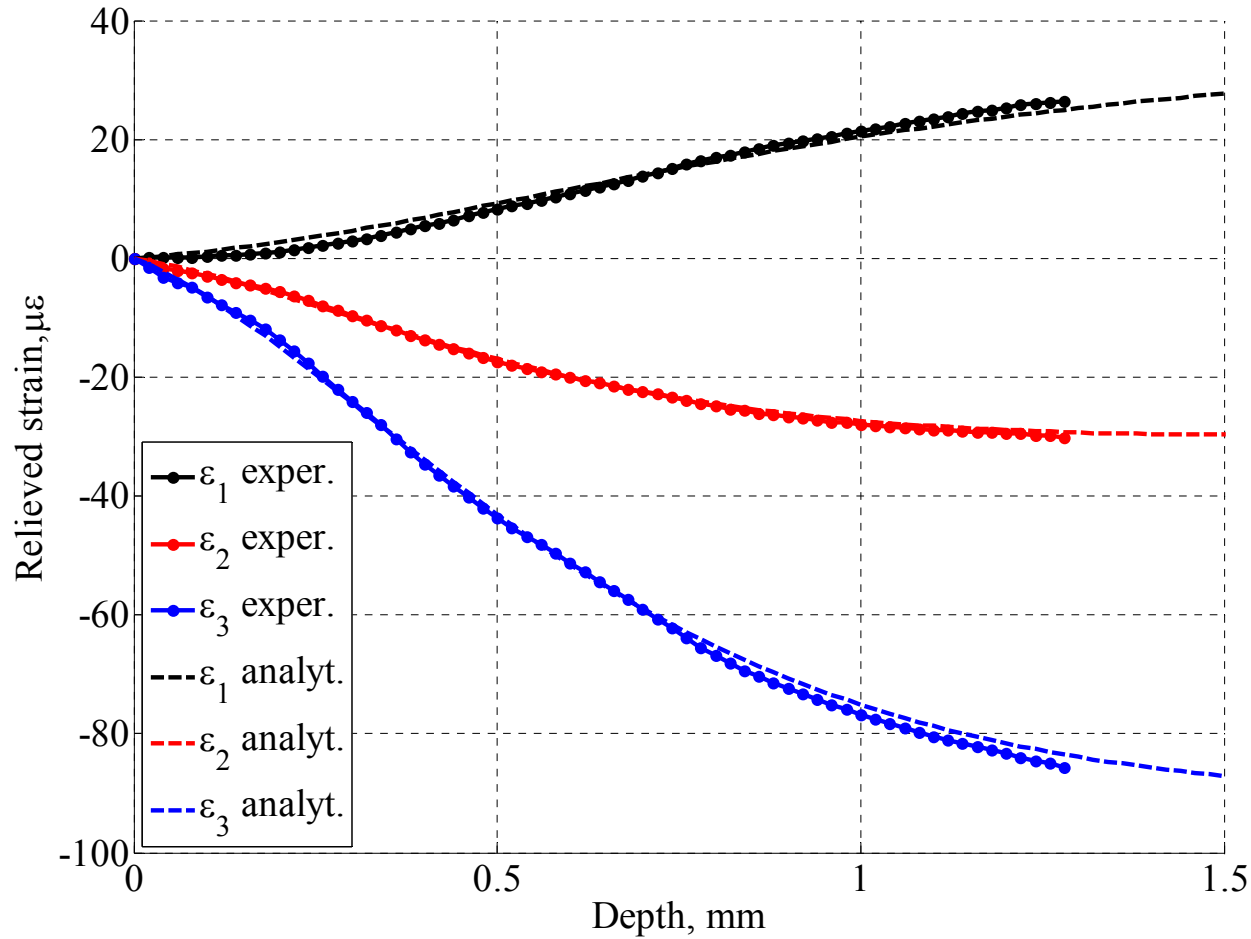
Senza correzione analitica



Con correzione analitica

Risultati

Rosetta a 6 griglie, eccentricità trascurabile



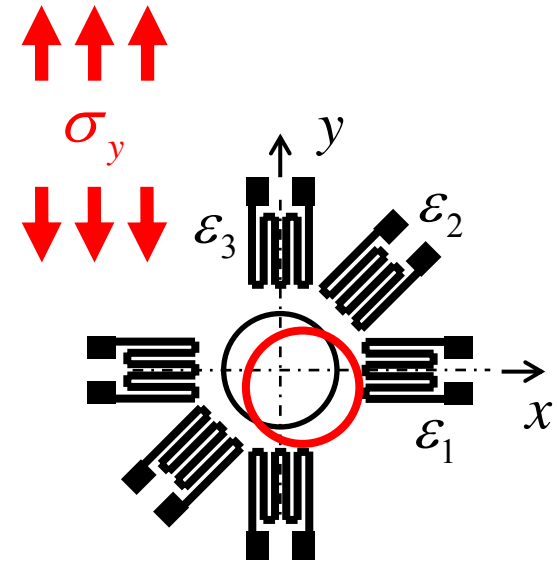
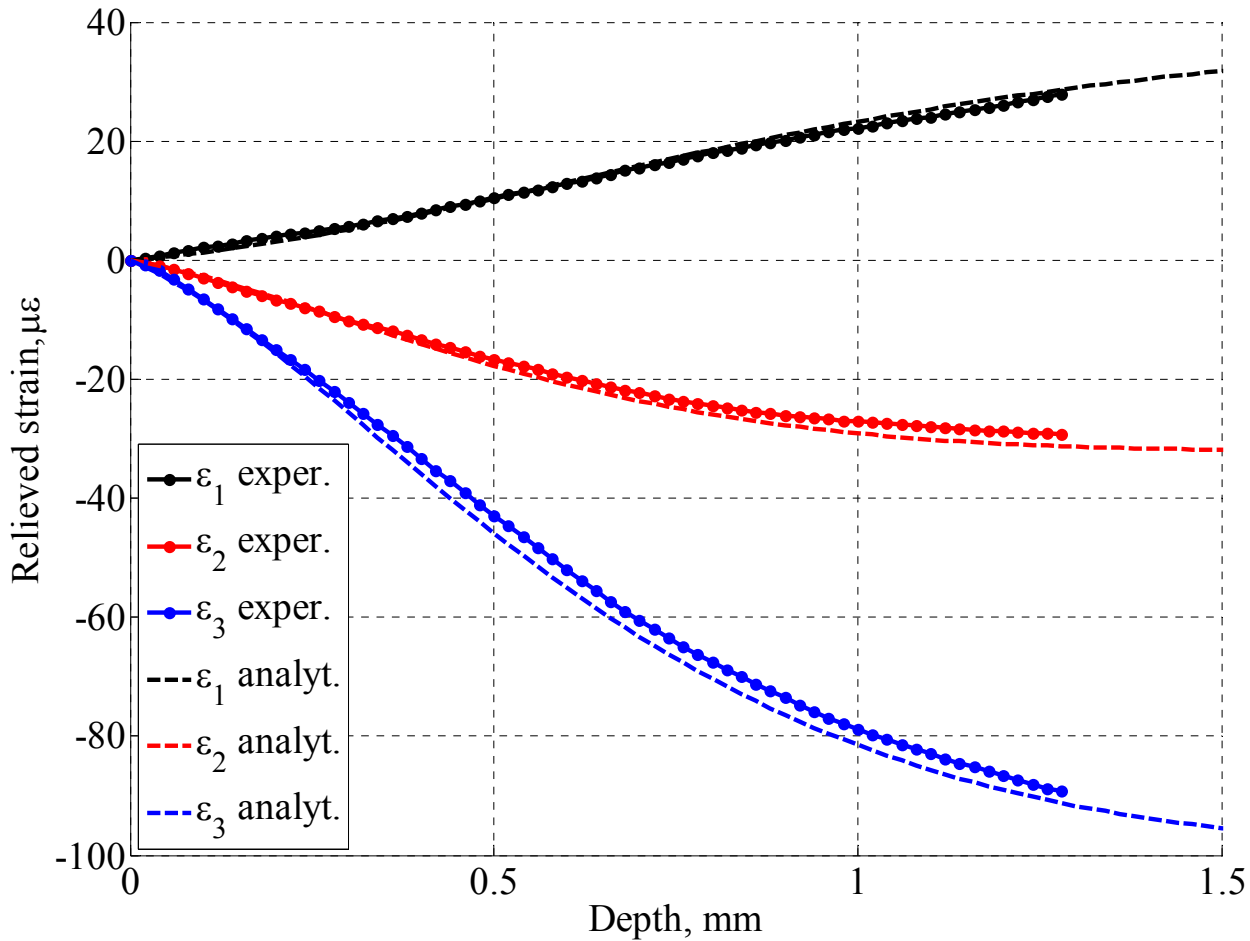
$$e_x = 0.03 \text{ mm}$$

$$e_y = -0.025 \text{ mm}$$

Nessuna correzione analitica

Risultati

Rosetta a 6 griglie, eccentricità elevata



$$e_x = 0.23 \text{ mm}$$

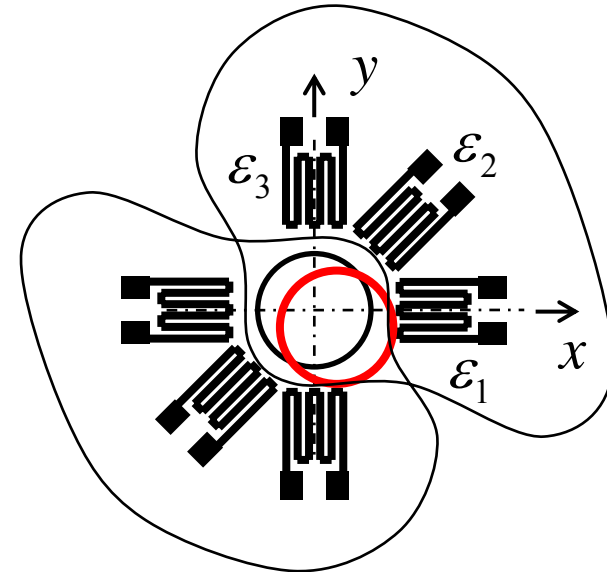
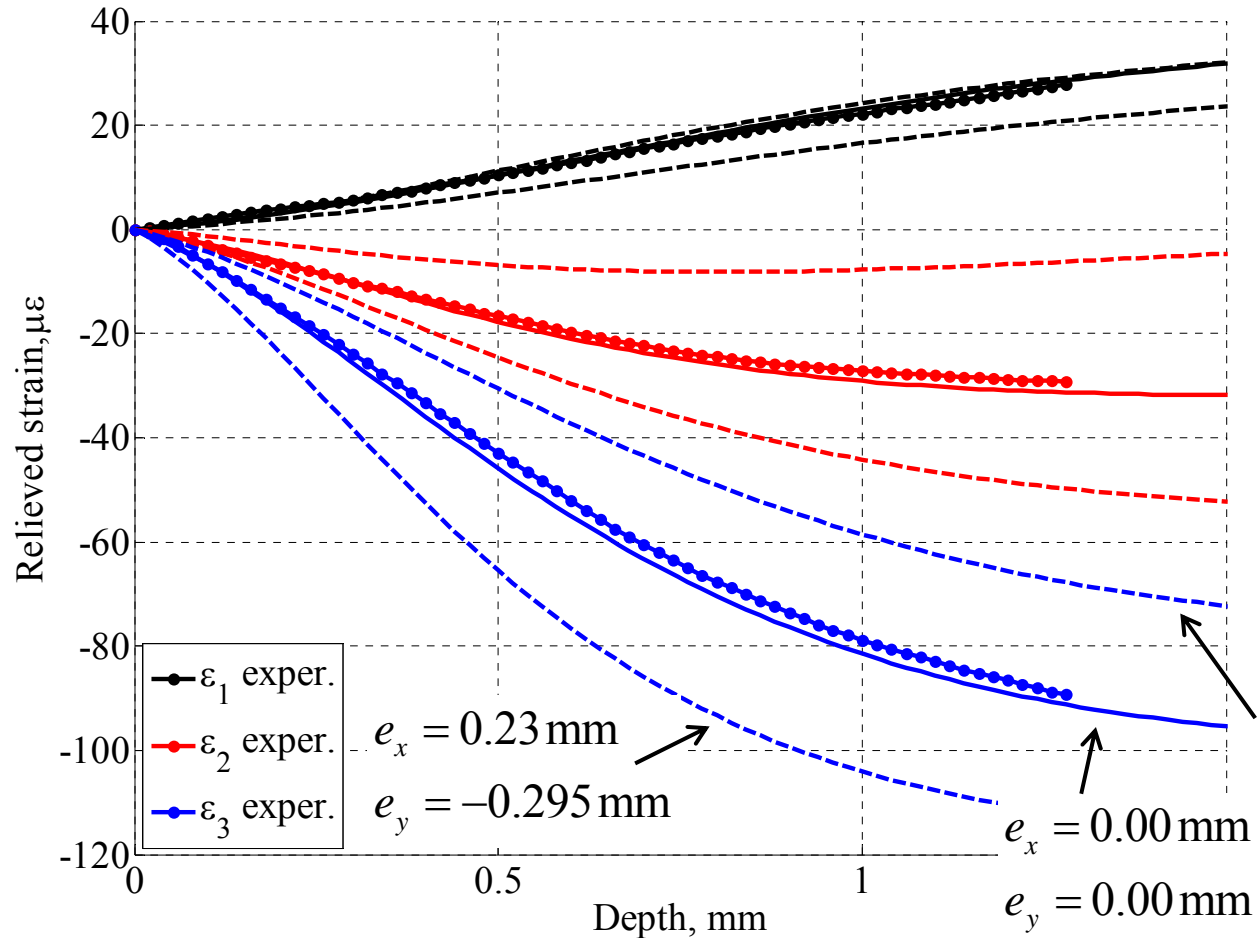
$$e_y = -0.295 \text{ mm}$$

Nessuna correzione analitica. Autocompensazione

Risultati

Rosetta a 6 griglie, eccentricità elevata

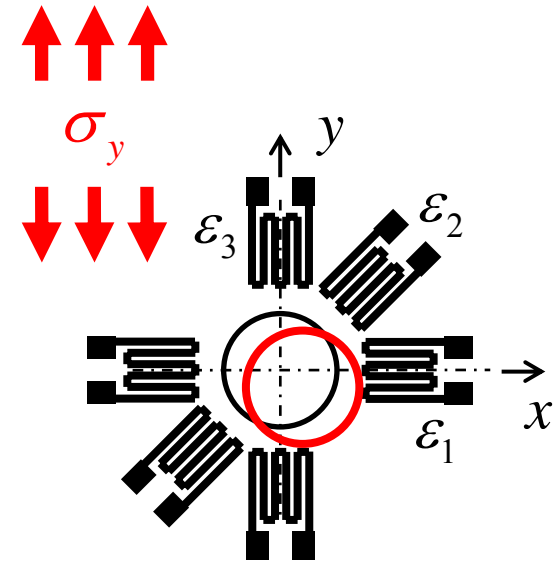
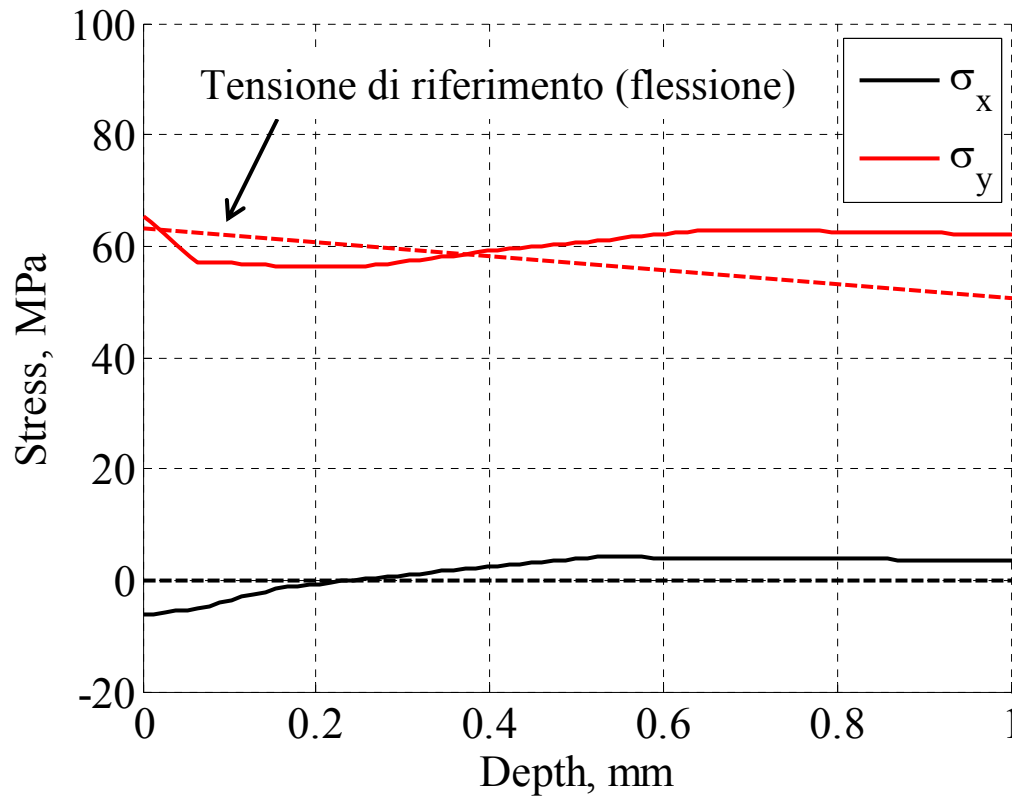
Media di due rosette diametralmente opposte



Risultati

Rosetta a 6 griglie, eccentricità elevata

Ricostruzione della distribuzione di tensione



$$e_x = 0.23 \text{ mm}$$

$$e_y = -0.295 \text{ mm}$$

Conclusioni

- Errore di eccentricità compensabile mediante:
 - comune rosetta a 3 griglie, correzione analitica
 - rosetta autocompensante a 6 griglie
(3 coppie diametralmente opposte)

- Verifica della compensazione dell'eccentricità mediante banco a flessione, per avere tensione di riferimento

- Vantaggi rosetta a 6 griglie:
 - minore tempo e semplificazione della prova
 - eliminazione fattore di rischio sulla misura dell'eccentricità

- Svantaggi
 - maggiore ingombro della rosetta
 - maggiore costo