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Strain Compatibility:

$\varepsilon_{ij} = \frac{1}{2}(U_{i,j}+U_{j,i}) = \frac{1}{2}\left(\frac{\partial U_i}{\partial x_j} + \frac{\partial U_j}{\partial x_i}\right)$ $-6\ Equations$

Normal Strain:

$\varepsilon_{11} = \frac{\partial U_1}{\partial x_1}$,

$\varepsilon_{22} = \frac{\partial U_2}{\partial x_2}$,

$\varepsilon_{33} = \frac{\partial U_3}{\partial x_3}$

Shear Strains:

$\varepsilon_{12} = \frac{1}{2}\left(\frac{\partial U_1}{\partial x_2} + \frac{\partial U_2}{\partial x_1}\right)$,

$\varepsilon_{13} = \frac{1}{2}\left(\frac{\partial U_1}{\partial x_3} + \frac{\partial U_3}{\partial x_1}\right)$,

$\varepsilon_{23} = \frac{1}{2}\left(\frac{\partial U_2}{\partial x_3} + \frac{\partial U_3}{\partial x_2}\right)$

$-6\ Strain\ Components$

$-3\ Displacement\ Components$......($u_1$, u_2, u_3 /u, v, w)

$$\frac{\partial^2 \varepsilon_{11}}{\partial x_2^2} = \frac{\partial^3 U_1}{\partial x_1\, \partial x_2^2}$$

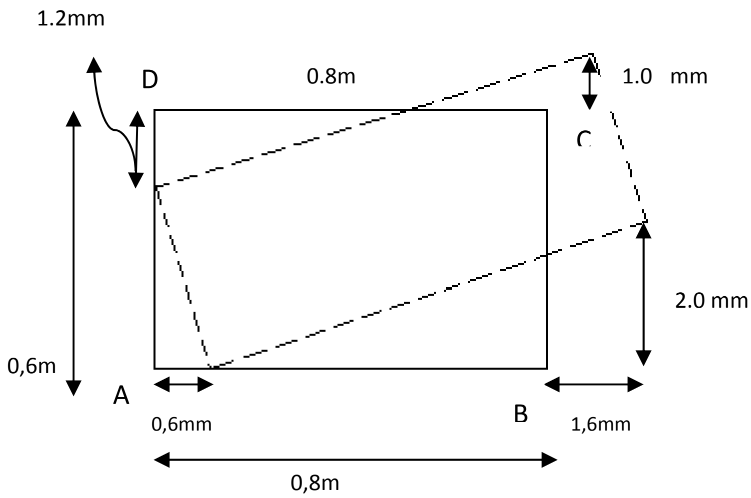
$$\frac{\partial^2 \varepsilon_{22}}{\partial x_1^2} = \frac{\partial^3 U_2}{\partial x_2 \partial x_1^2}$$

$$\frac{\partial^2 \varepsilon_{12}}{\partial x_1 \partial x_2} = \frac{1}{2}\left(\frac{\partial^3 U_1}{\partial x_1 \partial x_2^2} + \frac{\partial^3 U_2}{\partial x_2 \partial x_1^2}\right)$$

$$\frac{\partial^2 \varepsilon_{11}}{\partial x_2^2} + \frac{\partial^2 \varepsilon_{22}}{\partial x_1^2} = 2\left(\frac{\partial^2 \varepsilon_{12}}{\partial x_1 \partial x_2}\right)$$ ....strain compatibility in 2D

$$\varepsilon_{11,22} + \varepsilon_{22,11} = 2\,(\varepsilon_{12,12})$$ .....**

Ex//: A 0,8 m by 0,6 m rectangle ABCD is drawn on a thin plate prior to loading. Subsequent to loading, the deformed geometry is shown by dashed lines. Determine the components of plane strain at point A.



$$\varepsilon_{xx} = \frac{\partial U}{\partial x} = \frac{U_A - U_B}{\Delta x} = \frac{1{,}6mm - 0{,}6mm}{800mm} = 1250\mu$$

$$\varepsilon_{yy} = \frac{\partial V}{\partial y} = \frac{V_D - V_A}{\Delta y} = \frac{-1{,}2mm - 0}{600mm} = -2000\mu$$

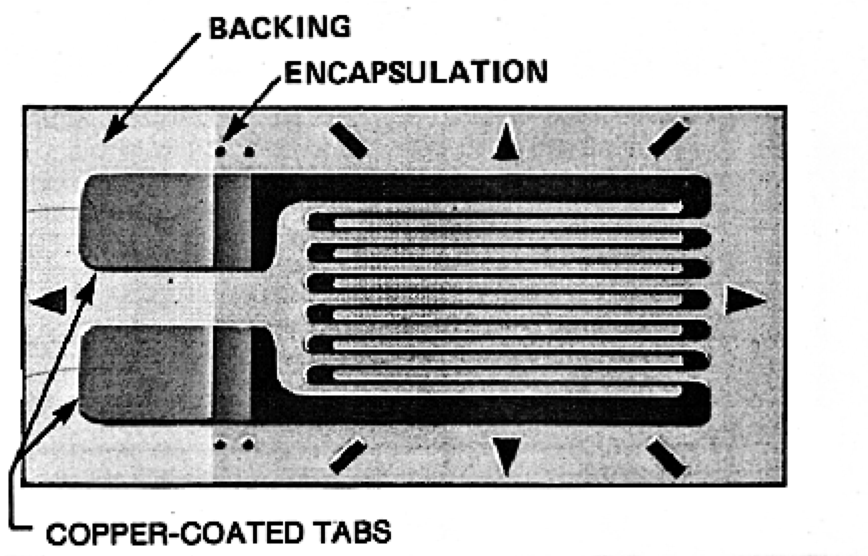
$$\gamma_{xy} = \frac{\partial U}{\partial y} + \frac{\partial V}{\partial x} = \frac{U_D - U_A}{\Delta y} + \frac{V_B - V_A}{\Delta x} = \frac{0 - 0{,}6mm}{600mm} + \frac{2mm - 0}{800mm} = 1500\mu$$

Strain Gages:

History of Strain Gages:

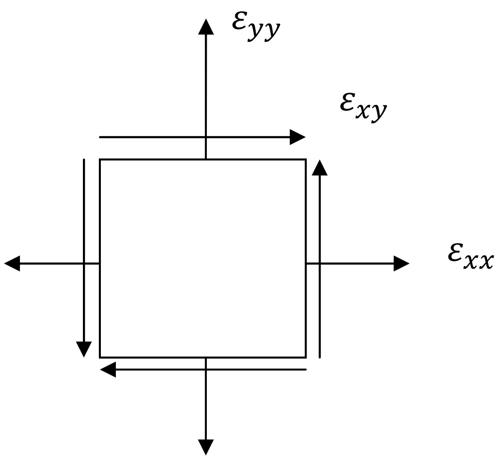
A strain gauge (alternatively: strain gage) is a device used to measure the strain of an object. Invented by Edward E. Simmons and Arthur C. Ruge in 1938, the most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the object by a suitable adhesive, such as cyanoacrylate. As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the strain by the quantity known as the gauge factor.

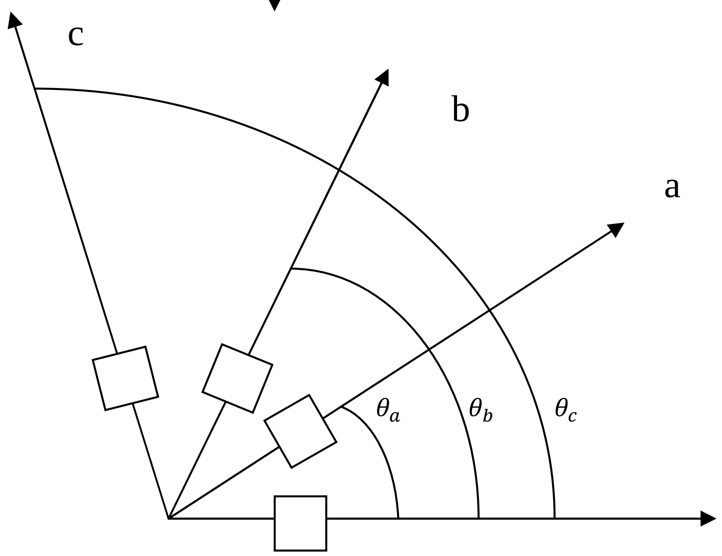
Edward E. Simmons Jr. (1911 in Los Angeles, California – May 18, 2004, in Pasadena, California) was an electrical engineer and the inventor of the bonded wire resistance strain gauge. Simmons attended the California Institute of Technology, where he received a B.S. in 1934 and an M.S. in 1936. He continued to work for the Institute under Assistant Professor Donald Clark. In 1938, Simmons invented the strain gauge. Caltech claimed the patent on the strain gauge, but Simmons took his case to the Supreme Court of California, and won patent rights in 1949. The Franklin Institute awarded Simmons the Edward Longstreth medal in 1944. Simmons became notably eccentric later in life, dressing in quasi-medieval attire, including tights, a tutu, a turban, and white women's sandals. He was commonly known among Caltech students as the "Millikan Man," due to his habit of wandering the campus late at night, particularly in the vicinity of Millikan Library. He was known among staff of Caltech as "Renaissance Ralph", and was generally shunned by staff, who were uncertain of his status relative to the institute. One other nickname on campus was "Dr. Strange Gauge". Simmons was repeatedly picked up by Pasadena police who found him wandering nude in the vicinity of Caltech. He died of cancer in 2004.

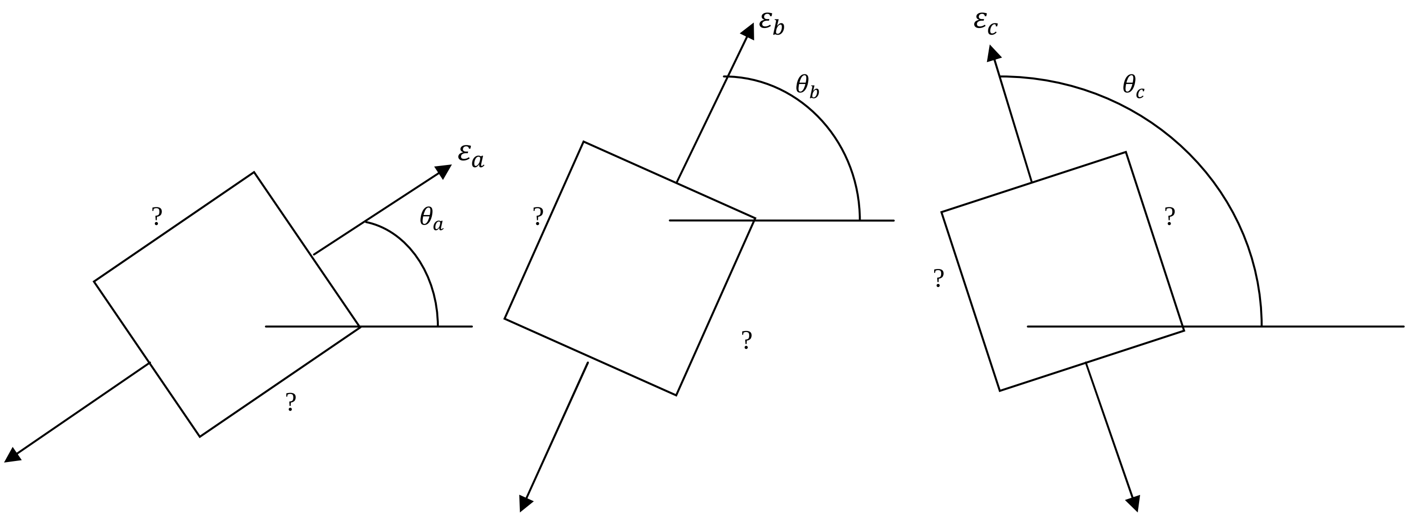



Strain gages can measure extension and contraction along the length.

-Use a strain gage rosette:





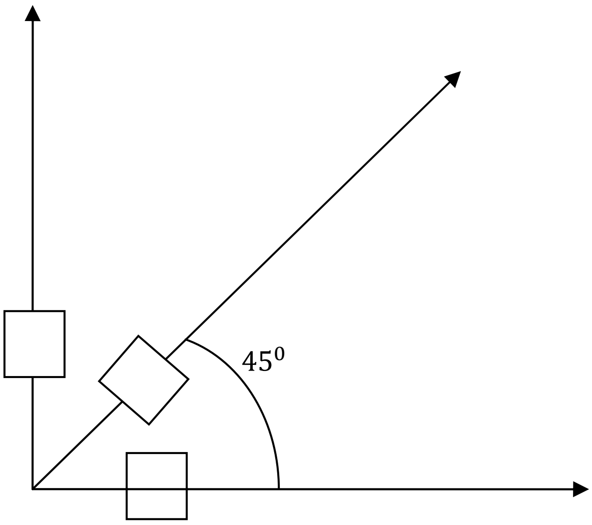


$$\varepsilon_a = \varepsilon_{xx}\, cos^2\, \theta_a + \varepsilon_{yy}\, cos^2\, \theta_a + 2\, \varepsilon_{xy} sin\theta_a cos\theta_a$$

$$\varepsilon_b = \varepsilon_{xx}\, cos^2\, \theta_b + \varepsilon_{yy}\, cos^2\, \theta_b + 2\, \varepsilon_{xy} sin\theta_b cos\theta_b$$

$$\varepsilon_c = \varepsilon_{xx}\, cos^2\, \theta_c + \varepsilon_{yy}\, cos^2\, \theta_c + 2\, \varepsilon_{xy} sin\theta_c cos\theta_c$$

Rectangular Rosette or 45^0 Strain Rosette:



Principal strains for strain gages:

$$\varepsilon_{1,2} = \frac{1}{2}\left(\varepsilon_a + \varepsilon_c \pm \sqrt{(\varepsilon_a - \varepsilon_c)^2 + (2\varepsilon_b - \varepsilon_a - \epsilon_c)^2}\right)$$

Principal planes for strain gages:

$$\tan 2\theta_p = \frac{2\varepsilon_b - \varepsilon_a - \varepsilon_c}{\varepsilon_a - \varepsilon_c}$$