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PACIFIC GAS AND ELECTRIC COMPANY

GENERAL COMPUTATION SHEET

SHEET NO. 1 OF 3 SHEETS

JOB FILE NO. DCL Copy

LOCATION

SUBJECT STIFFNESS OF REINFORCING BAR SYSTEM

2 copies to Dr. Kuo 8/18/71

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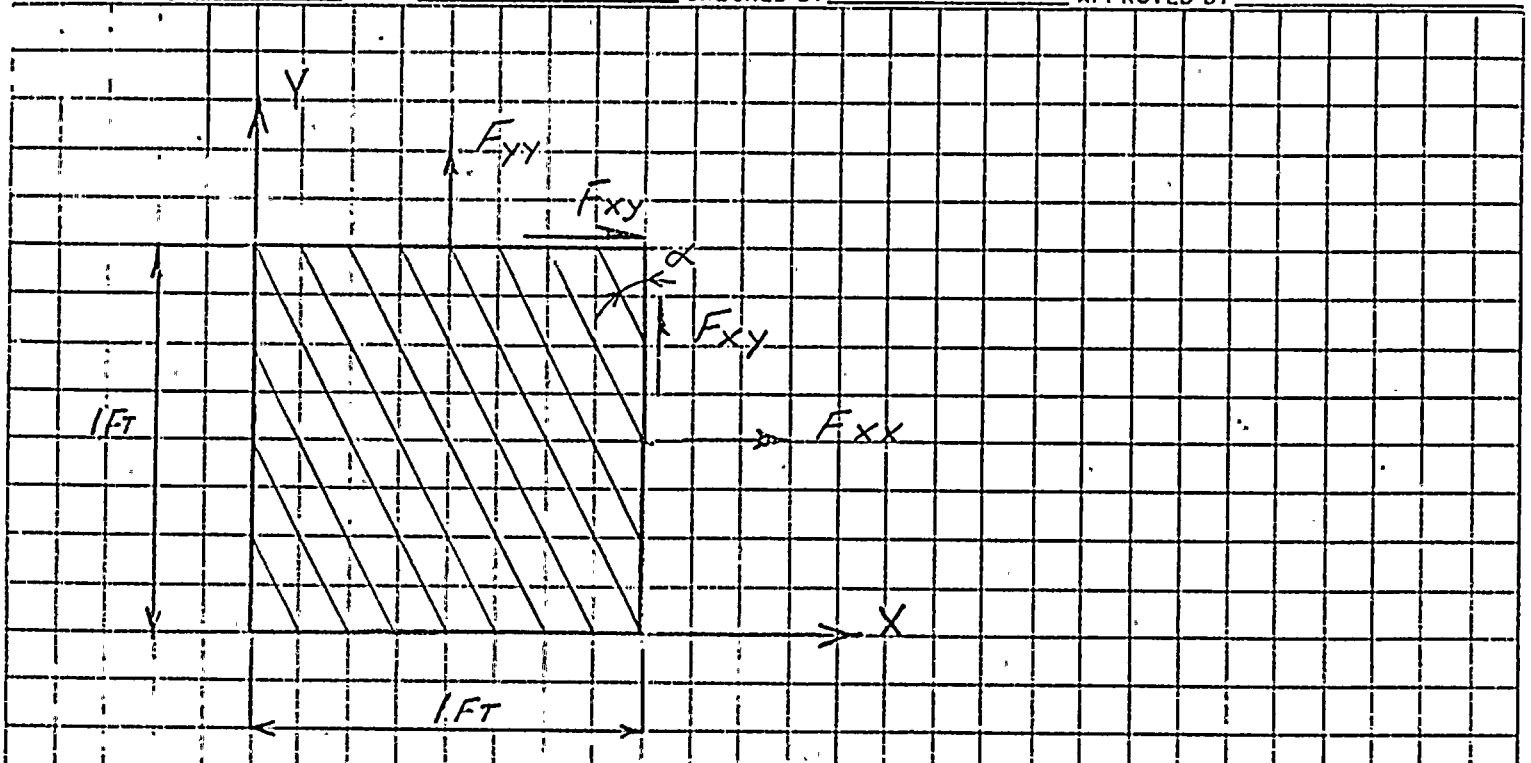

1) CONSIDER A 1FT SQUARE ELEMENT CONSISTING OF RE-BARS INCLINED AT AN ANGLE α WITH RESPECT TO Y AXIS.

NOTATION: A - AREA OF RE-BARS PER FOOT MEASURED PERPENDICULAR TO BARS

f - STRESS IN REINFORCING BARS

ε - STRAIN IN REINFORCING BARS

F_{xx}, F_{yy}, F_{xy} - MEMBRANE FORCES

ε_{xx}, ε_{yy}, γ_{xy} - ELEMENT STRAINS

AREA OF RE-BARS CROSSING HORIZONTAL AND VERTICAL BOUNDARY OF THE ELEMENT IS $A\cos\alpha$ AND $A\sin\alpha$ RESPECTIVELY. RE-BAR STRESS - MEMBRANE FORCE RELATIONSHIP IS AS FOLLOWS:

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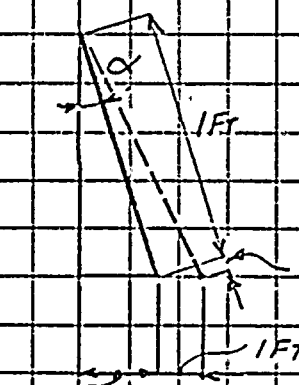
$F_{xx} = fA \sin^2\alpha$

$F_{yy} = fA \cos^2\alpha$

$F_{xy} = fA \sin\alpha \times \cos\alpha$

2) CONSIDER 1FT LENGTH OF RE-BAR. RELATIONSHIPS OF RE-BAR STRAINS TO ELEMENT STRAINS ARE AS SHOWN:

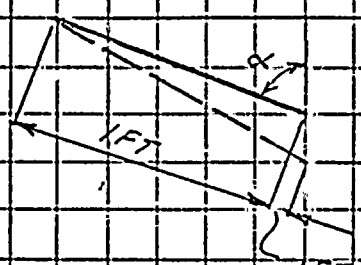
a) $\varepsilon_{xx} \neq 0$, $\varepsilon_{yy} = \gamma_{xy} = 0$



$1FT \times \varepsilon = 1FT \times \sin^2\alpha \times \varepsilon_{xx}$ (ELONGATION OF 1FT LONG BAR DUE TO ε_{xx})

$$\varepsilon_{xx} = \frac{\varepsilon}{\sin^2\alpha}$$

b) $\varepsilon_{yy} \neq 0$, $\varepsilon_{xx} = \gamma_{xy} = 0$



$$\varepsilon_{yy} = \frac{\varepsilon}{\cos^2\alpha}$$

$1FT \times \varepsilon = 1FT \times \cos^2\alpha \times \varepsilon_{yy}$ (ELONGATION OF 1FT LONG BAR DUE TO ε_{yy})

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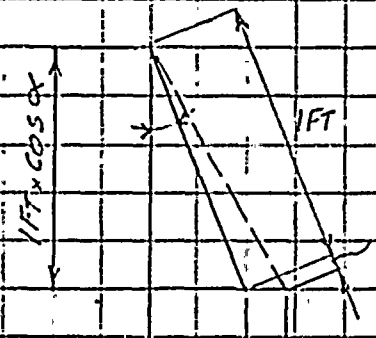
c) $\gamma_{xy} \neq 0$, $\varepsilon_{xx} = \varepsilon_{yy} = 0$



$1FT \times \sin\alpha \times \cos\alpha \times \gamma_{xy} = 1FT \times \varepsilon$ (ELONGATION OF 1FT LONG BAR DUE TO γ_{xy})

$1FT \times \cos\alpha \times \gamma_{xy}$

$1FT \times \sin\alpha$

$$\gamma_{xy} = \frac{\varepsilon}{\sin\alpha \times \cos\alpha}$$

3) STIFFENESS COEFFICIENTS

$$K_{x\text{-}x} = \frac{F_{xx}}{\varepsilon_{xx}} = \frac{f A \sin^2\alpha}{\varepsilon/\sin^2\alpha} = \frac{EA \sin^4\alpha}{}$$

$$K_{x\text{-}y} = \frac{F_{yy}}{\varepsilon_{xx}} = \frac{f A \cos^2\alpha}{\varepsilon/\sin^2\alpha} = \frac{EA \sin^2\alpha \times \cos^2\alpha}{}$$

$$K_{x\text{-}s} = \frac{F_{xy}}{\varepsilon_{xx}} = \frac{f A \sin\alpha \times \cos\alpha}{\varepsilon/\sin^2\alpha} = \frac{EA \sin^3\alpha \times \cos\alpha}{}$$

$$K_{y\text{-}y} = \frac{F_{yy}}{\varepsilon_{yy}} = \frac{f A \cos^2\alpha}{\varepsilon/\cos^2\alpha} = \frac{EA \cos^4\alpha}{}$$

$$K_{y\text{-}s} = \frac{F_{xy}}{\varepsilon_{yy}} = \frac{f A \sin\alpha \times \cos\alpha}{\varepsilon/\cos^2\alpha} = \frac{EA \sin\alpha \times \cos^3\alpha}{}$$

$$K_{s\text{-}s} = \frac{F_{xy}}{\gamma_{xy}} = \frac{f A \sin\alpha \times \cos\alpha}{\varepsilon/\sin\alpha \times \cos\alpha} = \frac{EA \sin^2\alpha \cos^2\alpha}{}$$