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APPENDICES

APPENDIX A
TEST SETUP OF APPLIED LATERAL FORCE

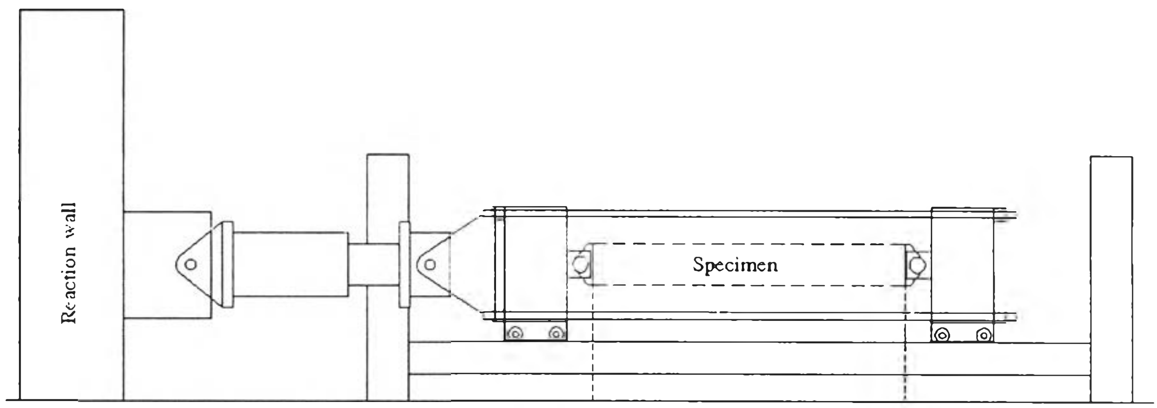


Fig. A.1 Test setup of applied lateral force

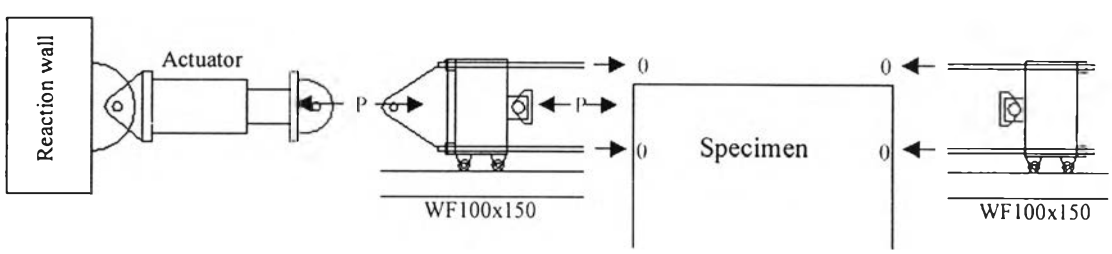


Fig. A.2 Free body diagram when actuator pushes the specimen

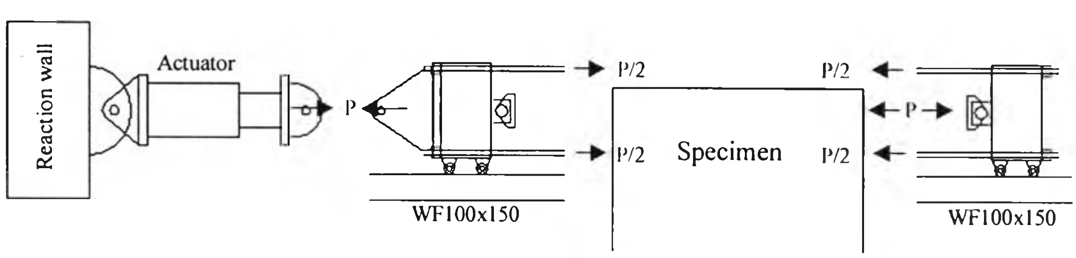


Fig. A.3 Free body diagram when actuator pulls the specimen

APPENDIX B

TEST SETUP OF AXIAL LOAD

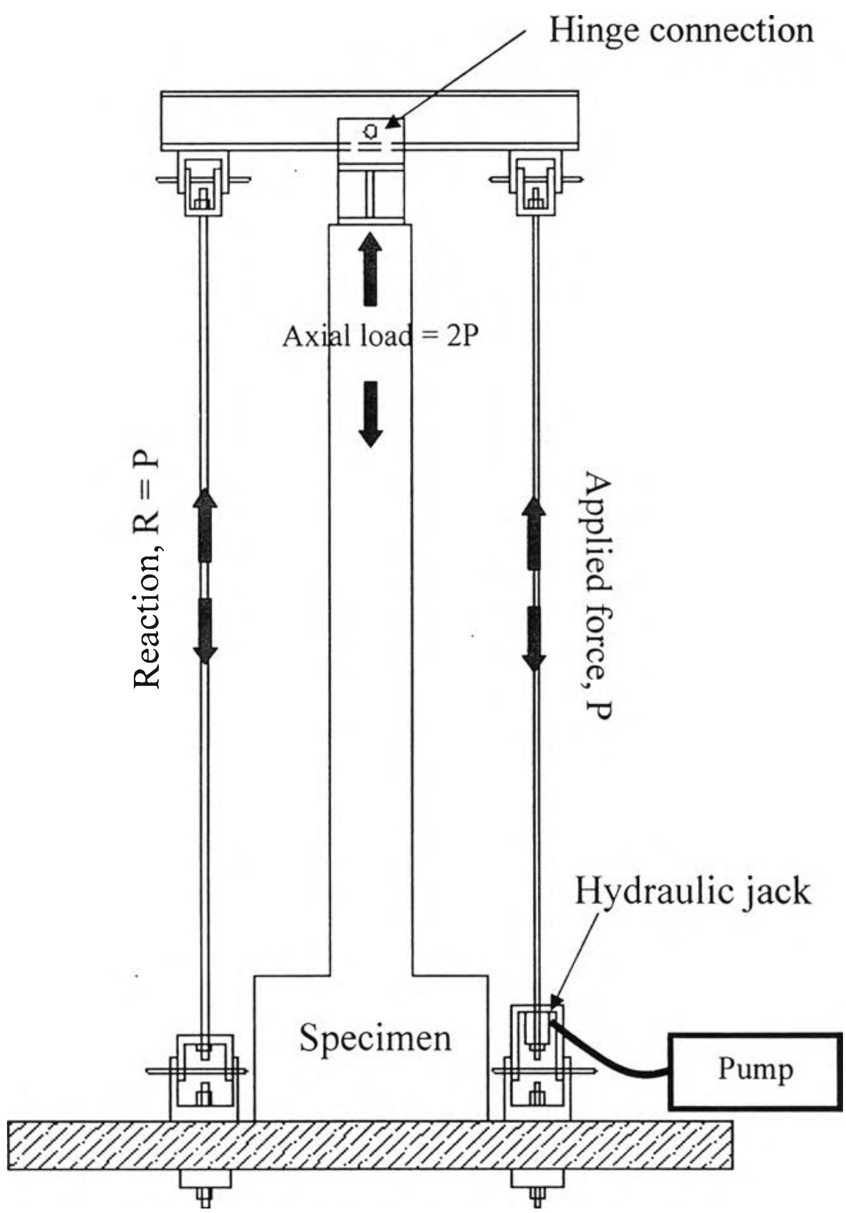


Fig. B.1 Free body diagram for an apply of axial load

APPENDIX C
TEST SETUP OF FIXING THE SPECIMEN TO TESTING FLOOR

The specimen is fixed to the rigid testing floor by bolting the large girders that placed on the specimen to the rigid testing floor as shown in Fig. C.1. The prestressing force is about 450 kN at each hole.

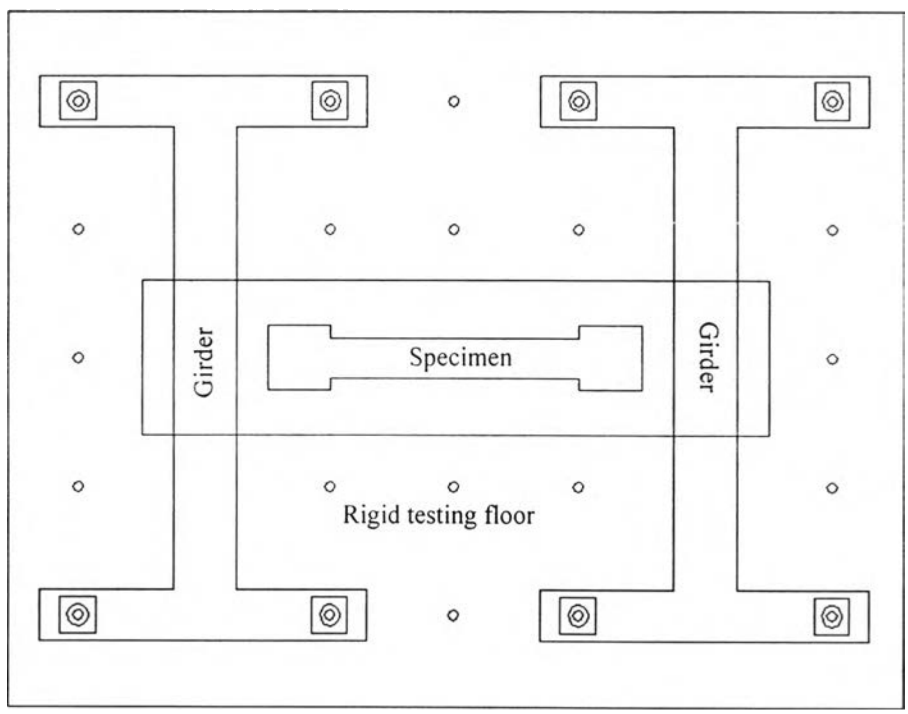
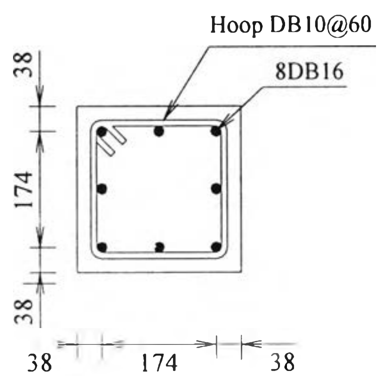


Fig. C.1. Fixing the specimen to testing floor

APPENDIX D
CONCRETE MODELS



(dimensions in mm)

Concrete properties

$f_c' = 27.3$ MPa, $\varepsilon_0 = 0.002$

$E_c = \dfrac{2f_c'}{\varepsilon_0} = 27{,}300$ MPa

$f_{cr} = 0.31\sqrt{f_c'} = 1.62$ MPa

$\varepsilon_{cr} = \dfrac{f_{cr}}{E_c} = 0.00006$

Stirrup properties

$f_{yh} = 451.3$ MPa

$E_s = 200{,}000$ MPa

Unconfined concrete

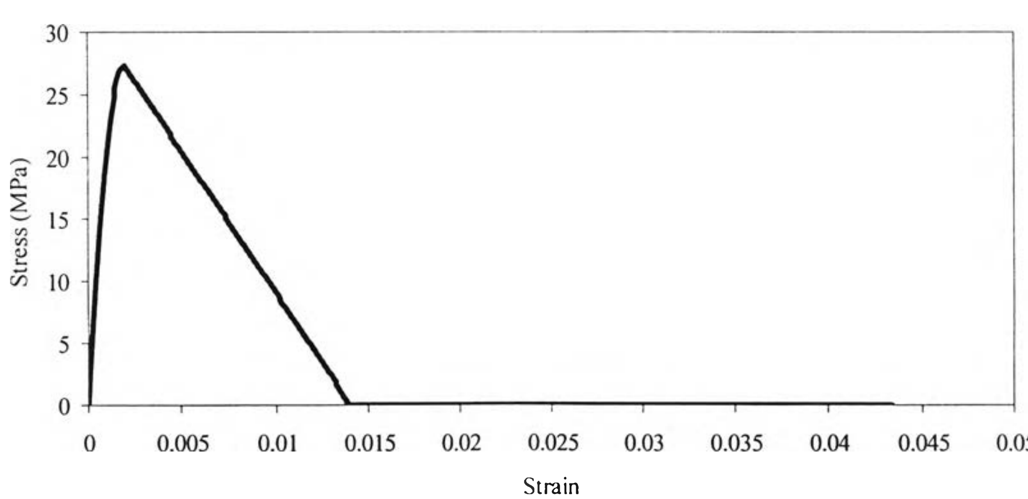
The strain at peak stress, $\varepsilon_0 = 0.002$

The ultimate strain, $\varepsilon_{cu} = 0.0038$

The unconfined concrete model is (Hognestad 1951)

$$f_c = f_c'\left[\frac{2\varepsilon}{\varepsilon_0} - \left(\frac{\varepsilon}{\varepsilon_0}\right)^2\right] \quad , \varepsilon < \varepsilon_0$$

$$= f_c'\left[1 - 0.15\left(\frac{\varepsilon - \varepsilon_0}{\varepsilon_{cu} - \varepsilon_0}\right)\right], \varepsilon > \varepsilon_0$$



Confined concrete model

Equivalent confining pressure, f_{le}

$$f_{le} = k_2 f_l$$

$$f_l = \frac{f_{yh} A_{sh}}{s b_c} = \frac{451.3 \times \left(\frac{2 \times \pi \times 1^2}{4} \right)}{6 \times 20} = 5.91 \text{ MPa}$$

$$k_2 = 0.26 \sqrt{\frac{b_c}{s}} \sqrt{\frac{b_c}{s_l}} \sqrt{\frac{1}{f_l}}$$

$$= 0.26 \times \sqrt{\frac{20}{6}} \times \sqrt{\frac{20}{10}} \times \sqrt{\frac{1}{5.91}}$$

$$= 0.276$$

$$f_{le} = 0.276 \times 5.626 = 1.63 \text{ MPa}$$

Strength of confined concrete, f'_{cc}

$$k_1 = 6.7 f_{le}^{-0.17} = 6.165$$

$$f'_{cc} = f'_c + k_1 f_{le} = 37.35 \text{ MPa}$$

Strain at peak confined stress, ε_1

$$K = \frac{k_1 f_{le}}{f'_c} = 0.368$$

$$\varepsilon_1 = \varepsilon_0 (1 + 5K) = 0.00568$$

Strain at 15 % dropped from peak confined stress

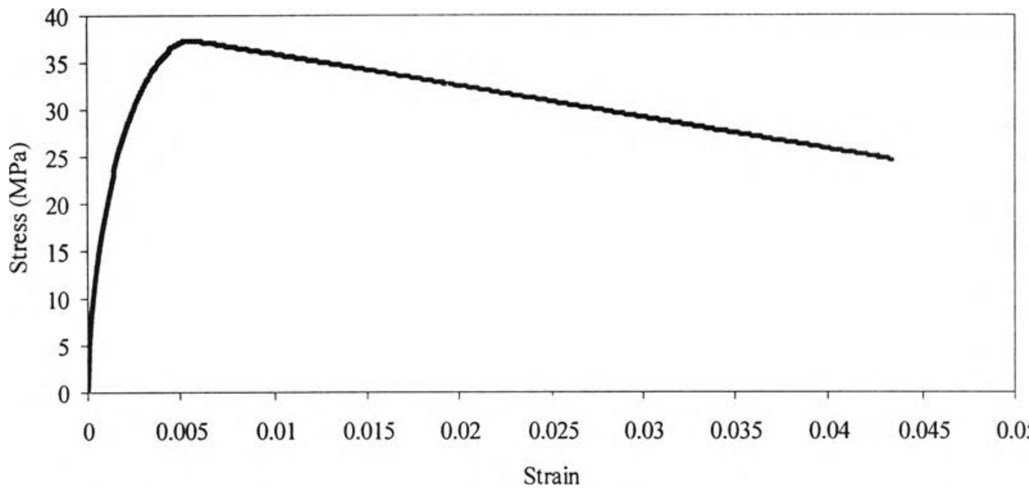
$$\rho = \frac{A_{sh}}{s b_c} = 0.0131$$

$$\varepsilon_{85} = 260 \rho \varepsilon_1 + 0.003 = 0.0223$$

The confined concrete model is (Saatcioglu and Razvi 1992)

$$f_c = f'_{cc} \left[\frac{2\varepsilon}{\varepsilon_1} - \left(\frac{\varepsilon}{\varepsilon_1} \right)^2 \right]^{1/(1-2K)} \quad , \varepsilon < \varepsilon_1$$

$$= f'_{cc} \left[1 - 0.15 \left(\frac{\varepsilon - \varepsilon_1}{\varepsilon_{85} - \varepsilon_1} \right) \right] \quad , \varepsilon > \varepsilon_1$$



Concrete model in tension

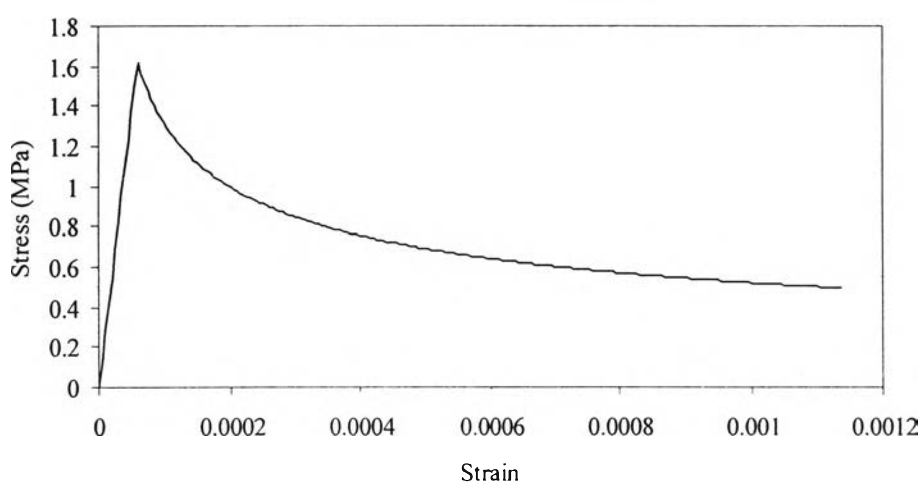
The tensile strength, f_{cr} = 1.62 MPa

The crack strain, ε_{cr} = 0.00006

The concrete model in tension is (Bearbi and Hsu 1994)

$$f_c = E_c\varepsilon, \qquad ,\varepsilon < \varepsilon_{cr}$$

$$= f_{cr}\left(\frac{\varepsilon_{cr}}{\varepsilon}\right)^{0.4} \qquad ,\varepsilon > \varepsilon_{cr}$$



VITA

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I was born in Chiang Rai, the northernmost part of Thailand, on December 11, 1977. The elementary and secondary schools where I studied in Chiang Rai were Anuban Chiang Rai and Samakkhi Witthayakhom, respectively. Then, I moved to Bangkok to study the Bachelor of Civil Engineering at Chulalongkorn University and I finished it in 1999. This year, I received a Royal Golden Jubilee Ph.D program (RGJ) scholarship from Thailand Research Fund (TRF) to further a study in Ph.D. program which this dissertation is in partial fulfillment of the requirements.