APPENDIX

Appendix A

Materials Testing

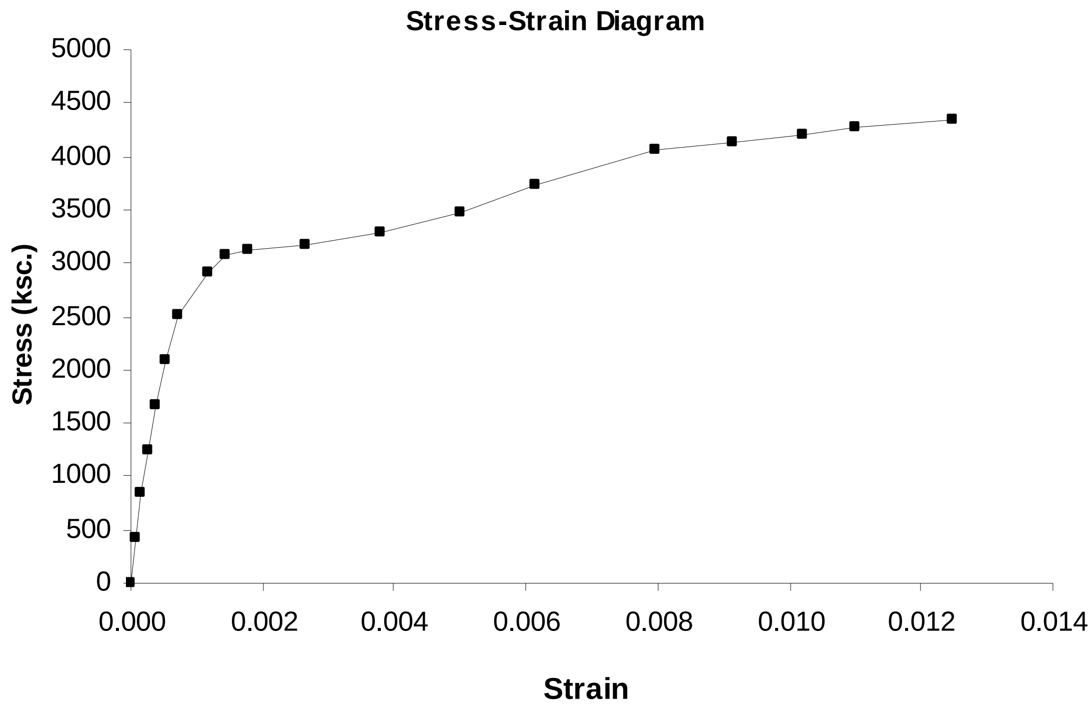
Appendix Table A1 Compressive Strength of concrete samples.

Specimens	Compressive Force (kg) Sample No. 1	Sample No. 2	Sample No. 3	Average P_c (kg)	Average Strength (ksc)
RB6(7.5)	44,350	49,400	48,800	47,517	269
RB6(10)	42,930	48,120	43,760	44,937	254
CDR6/2(7.5)	50,890	42,590	44,170	45,883	260
CDR6/2(10)	47,480	52,400	50,650	50,177	284
CDR6(10)	57,730	63,070	54,080	58,293	330
No Tie bar	62,750	63,280	63,400	63,143	357

Remark: P_c is average compressive force of concrete cylinder

Appendix Table A2 Tensile strength of round bar, RB6 (SR24)

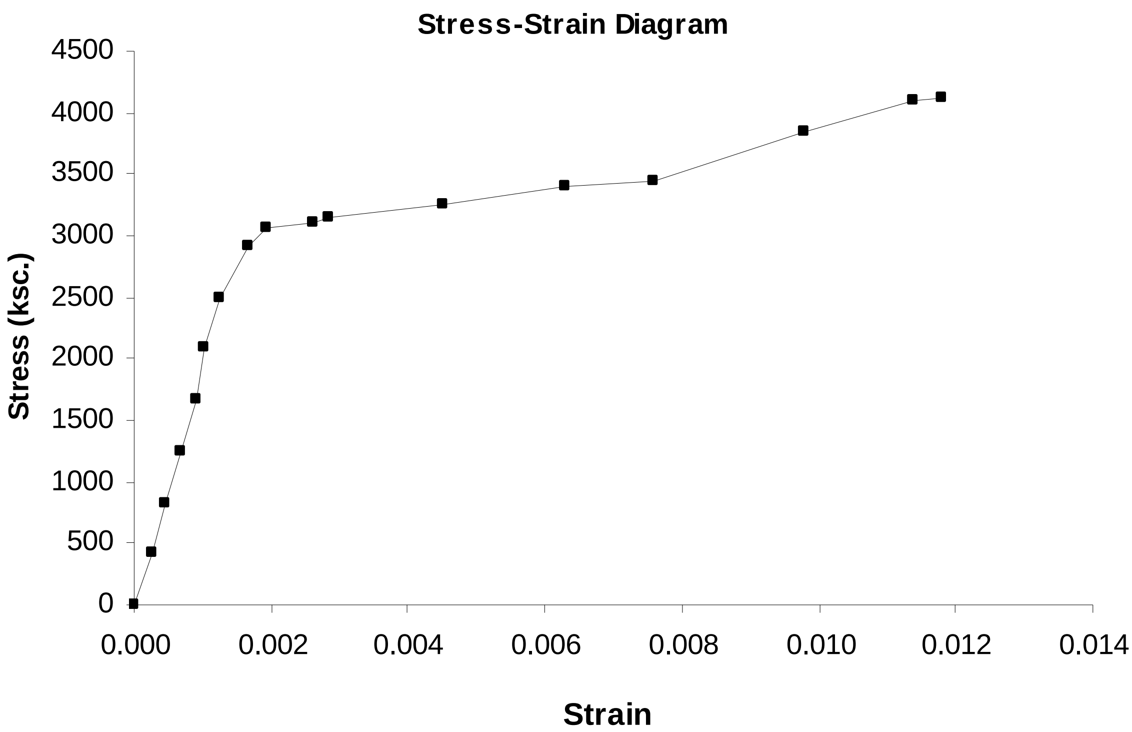
No of specimens	Yield load (kg)	Ultimate load (kg)	Yield strength (ksc)	Ultimate Strength (ksc)	Young's Modulus (ksc)
1	737	1,040	3,102	4,377	1.90×10^6
2	758	1,103	3,190	4,642	2.13×10^6
3	725	1,026	3,051	4,318	1.86×10^6
Average	740	1,056	3,114	4,445	1.97×10^6



Appendix Figure A1 Stress and strain curve of round bar RB6mm.
(Average from 3 samples)

Appendix Table A3 Tensile strength of round bar, RB9 (SR24)

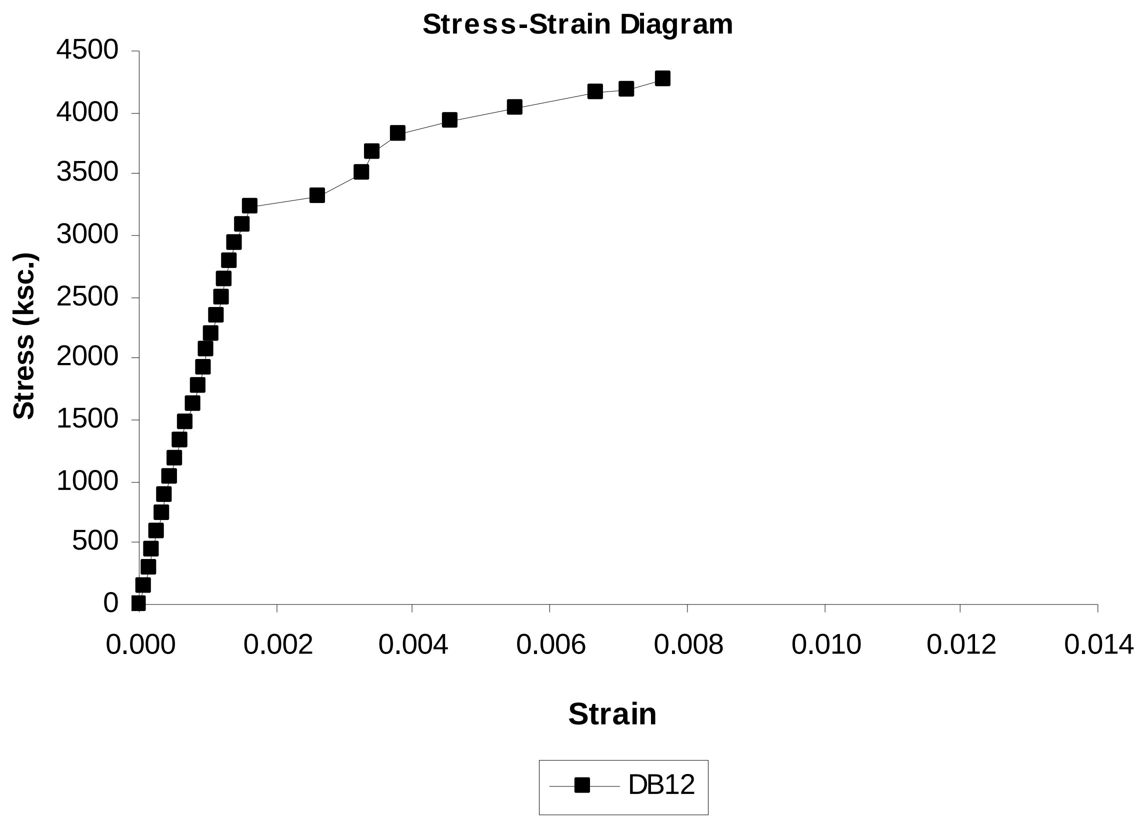
No of specimens	Yield load (kg)	Ultimate load (kg)	Yield strength (ksc)	Ultimate Strength (ksc)	Young's Modulus (ksc)
1	5,315	6,766	3,160	4,023	1.62×10^6
2	5,024	7,114	2,987	4,230	1.91×10^6
3	5,207	6,956	3,096	4,136	1.83×10^6
Average	5,182	6,945	3,081	4,130	1.78×10^6



Appendix Figure A2 Stress and strain curve of round bar RB9mm.
(Average from 3 samples)

Appendix Table A4 Tensile strength of deformed bar, DB12 (SD30)

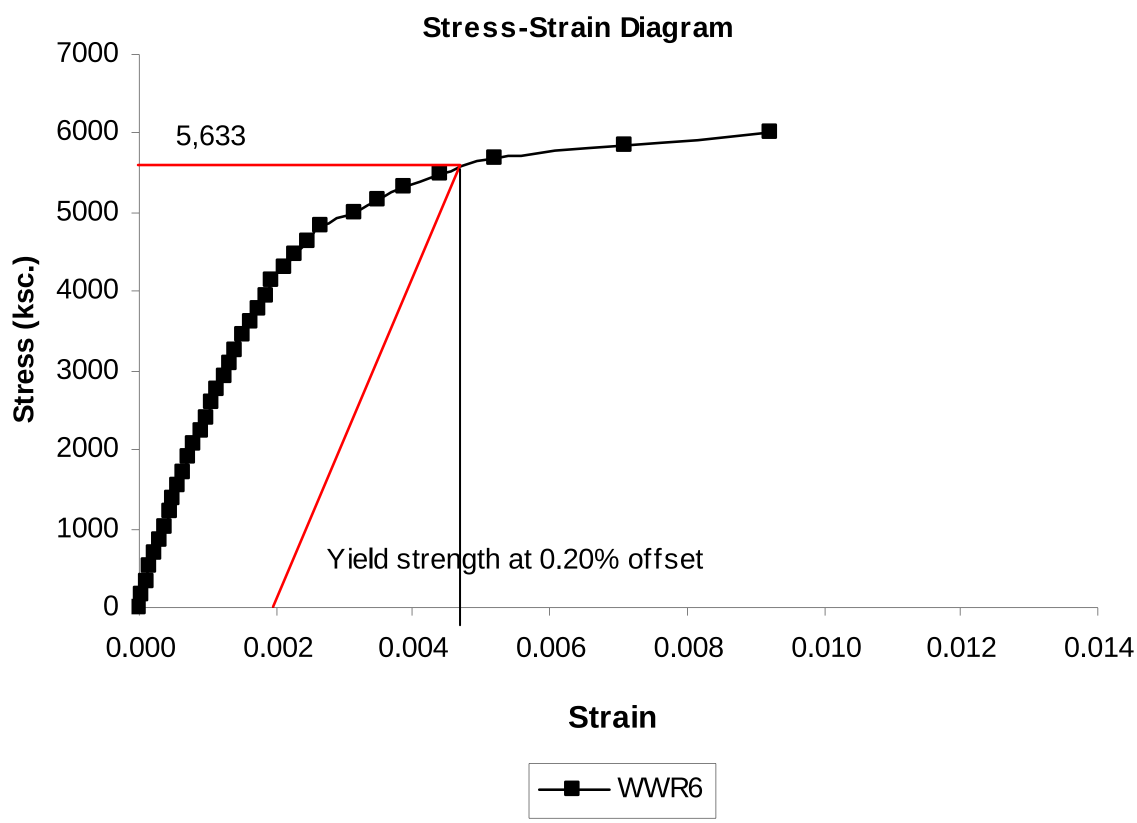
No of specimens	Yield load (kg)	Ultimate load (kg)	Yield strength (ksc)	Ultimate Strength (ksc)	Young's Modulus (ksc)
1	3,080	4,048	3,240	4,259	1.98 x 106
2	3,150	4,130	3,314	4,345	2.03×10^6
3	3,000	4,015	3,156	4,224	1.93×10^6
Average	3,076	4,064	3,236	4,276	1.98×10^6



Appendix Figure A3 Stress and strain curve of deformed bar DB12mm. (Average from 3 samples)

Appendix Table A5 Tensile strength of welded wire reinforcement, CDR6

No of specimens	Yield load (kg)	Ultimate load (kg)	Yield strength (ksc)	Ultimate Strength (ksc)	Young's Modulus (ksc)
1	1,577	1,817	5,580	6,217	2.04×10^6
2	1,611	1,930	5,700	6,604	2.05×10^6
3	1,588	1,798	5,620	6,152	1.98×10^6
Average	1,592	1,848	5,633	6,324	2.02×10^6



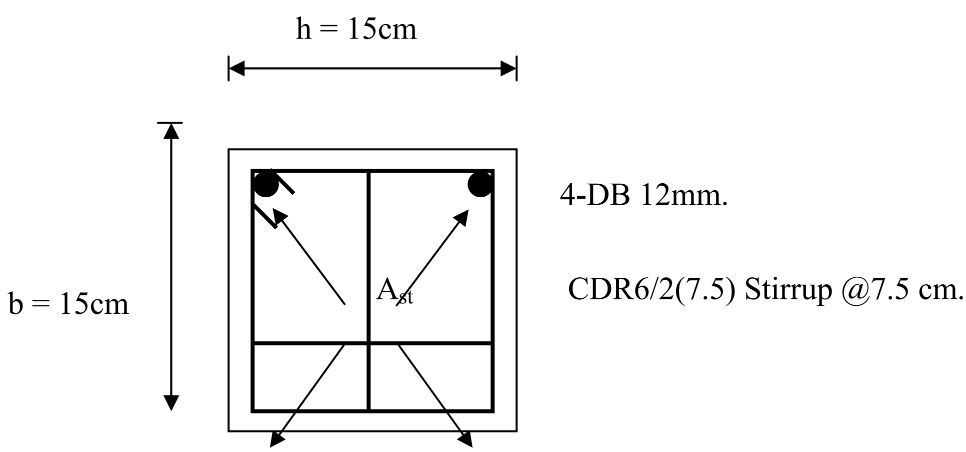
Appendix Figure A4 Stress and strain curve of welded wire reinforcement CDR6 (Average from 3 samples)

Appendix B

Theoretical and calculation of axial force and deformation

1. Analysis of confinement concrete column by Saatcioglu Method

2.1 Lateral force of confined column can be predicted from Equation (4) to (9) by Saatcioglu.



$$f_c = f'_{cc}\left[2\left(\frac{\varepsilon_c}{\varepsilon_1}\right)-\left(\frac{\varepsilon_c}{\varepsilon_1}\right)^2\right]^{1/(1+2K)} \le f'_{cc}$$

$$f'_{cc} = f_{co} + k_a f_{le} ; k_1 = 6.7(f_{le})^{-0.17} ; f_{le} = k_2 f_l$$

$$k_2 = 0.26\sqrt{\left(\frac{b_c}{s}\right)\left(\frac{b_c}{s_l}\right)\left(\frac{1}{f_l}\right)} \le 1.0$$

$$f_l = \frac{\sum A_s f_{yt} \sin\alpha}{sb_c} \qquad f'_{co} = 0.85 f'_c$$

$$\varepsilon_1 = \varepsilon_{01}(1+5K) \qquad K = \frac{k_1 f_{le}}{f_{co}}$$

$$\varepsilon_{85} = 260\rho\varepsilon_1 + \varepsilon_{0.85} \qquad \rho = \frac{\sum A_s}{s(b_{cx}+b_{cy})}$$

Where

f'_{cc} = Confined concrete strength in member (MPa)

f_l = Average lateral confinement pressure (MPa)

f'_{co} = Unconfined concrete strength in members (Mpa)

k_1 = Coefficients of lateral pressure

k_2	=	Coefficients of confined column
A_{sh}	=	Area of transverse reinforcement (cm^2)
	=	0.283 mm^2
f_{yh}	=	yield strength of transverse reinforcement
	=	5,633 ksc.
b_c	=	Width of column (cm.)
	=	8.8 cm.
s	=	Longitudinal spacing of transverse reinforcement (m.)
	=	0.075 m.
s_1	=	Spacing of Longitudinal reinforcement (m.)
	=	0.076 m.
fc'	=	293 ksc.
E_{sh}	=	2.02x10^6 ksc.
Ec	=	$15210\sqrt{f_c'}$ = 2.60x10^5 ksc.

Substitution all of data to above equation yield

$$f_l = \frac{\sum A_s f_{yt} \sin\alpha}{sb_c} = (4\text{x}0.283)(5633)/((7.5)(8.8)) = 96.61 \text{ ksc or } 9.477 \text{ MPa}$$

$$f'_{co} = 0.85 f'_c = 0.85(260) = 221 \text{ ksc.} = 21.68 \text{ MPa}$$

$$k_2 = 0.26\sqrt{\left(\frac{b_c}{s}\right)\left(\frac{b_c}{s_l}\right)\left(\frac{1}{f_l}\right)} \le 1.0 = 0.26\sqrt{\left(\frac{0.088}{0.075}\right)\left(\frac{0.088}{0.076}\right)\left(\frac{1}{9.477}\right)} = 0.098$$

$$k_1 = 6.7(k_2 f_l)^{-0.17} = 6.7((0.098)(9.477))^{-0.17} = 6.784$$

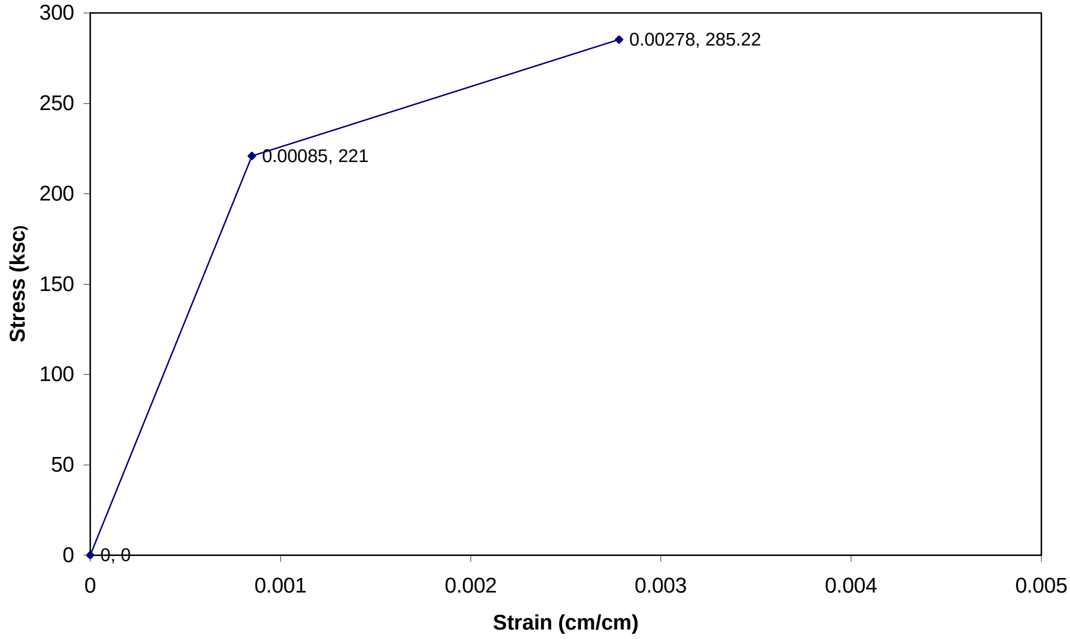
$$f'_{cc} = f'_{co} + k_1 k_2 f_l = 21.68 + ((6.784)(0.098)(9.477)) = 27.98 \text{ MPa} = 285.22 \text{ ksc.}$$

Thus $f'_{cc} = 1.25 f'_{co}$ Yield strain of transverse reinforcement = f_{yh}/E_{sh} = 0.00278

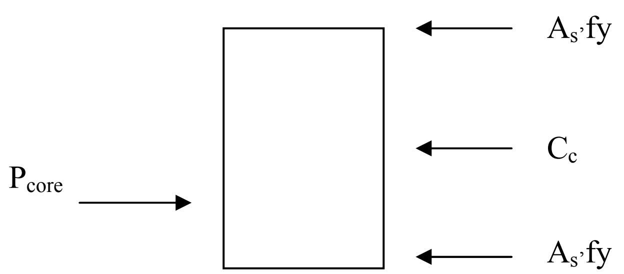
Poisson's ratio μ = 0.15

Thus strain in concrete = (f_{yh}/E_{sh})/ μ = 0.01859

and strain at 0.85 fc' = 0.85 fc'/Ec = 0.85(260)/2.60x10^5 = 0.00085



Appendix Figure B1 Relationship between stress and strain of confined column by Saatcioglu's method



Equilibrium condition External force = Internal force

$$P_{core} = f'_{cc} A_{core} + A_{st} f_y$$

$$P_{core} = (285.22)(8.8 \text{ x } 8.8) + (3.801 \text{ x } 3{,}236)$$

$$P_{core} = 34{,}388 \text{ kg.}$$

$$\frac{f'_{cc}}{f'_{co}} = 285.22 / 221 = 1.29$$

Maximum Axial force for core of column confined by CDR6/2(7.5) by Saatcioglu's method

2. Analysis of confinement concrete column by Mau, Holland and Hong

They provided the formula to predict confined stress provided by WWF to the concrete as below.

$$\frac{f_{cp}}{f_{co}} = 1 + 2\frac{\rho E_{sl}}{f_{co}}\left(1 - \frac{S}{D}\right) \qquad (10)$$

Where

f_{cp} = The peak compressive stress of reinforced column

f_{co} = Average compressive strength of plain concrete column

= 45,883 kg

S = Longitudinal spacing of WWF

= 7.5 cm.

D = Width of test column

= 15 cm.

ρ = Volumetric ratio of WWF

= 0.009

E_{sl} = Young's modulus of the wires

= 2.02 x 10^6 ksc

$$\frac{f_{cp}}{f_{co}} = 1 + 2\frac{0.009x2.02x10^6}{45{,}883}\left(1 - \frac{7.50}{15.0}\right)$$

$$\frac{f_{cp}}{f_{co}} = 1.396$$

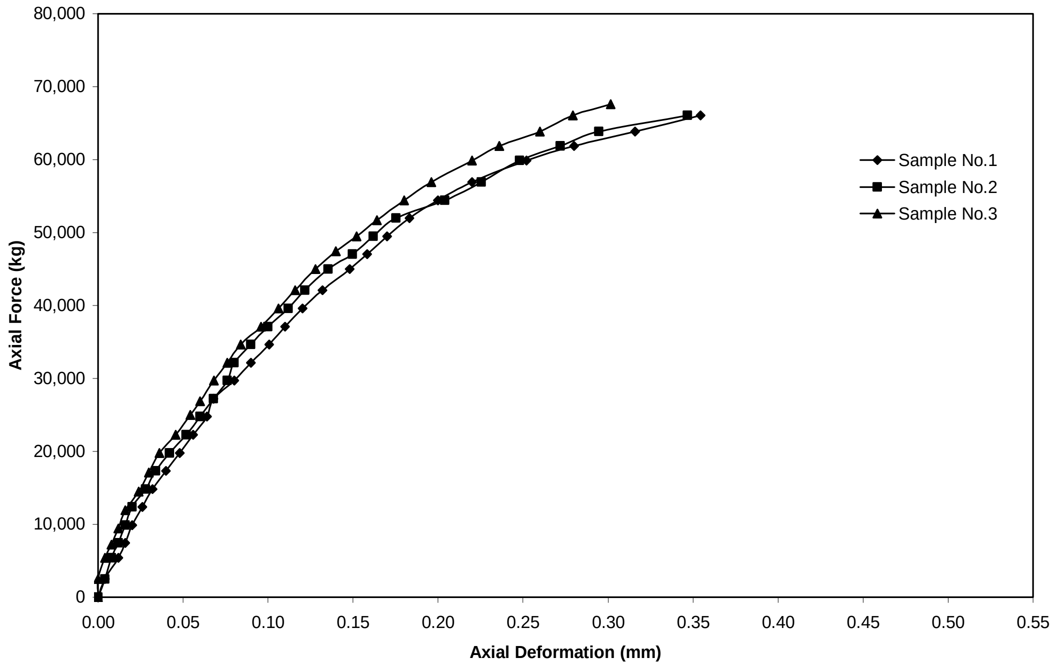
$$f_{cp} = 1.396x45{,}883 = 64{,}052 \text{ kg.}$$

Maximum force for reinforced column confined by WWR6/2(7.5) = 64,052 kg.

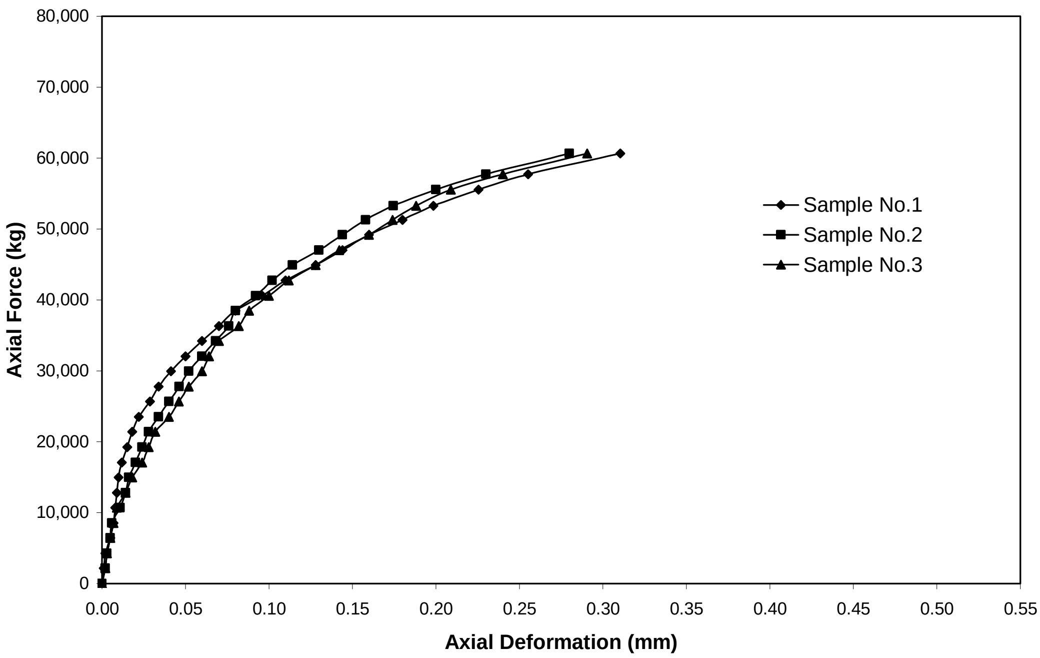
The expression $\left(1 - \frac{S}{D}\right)$ is to represent the effect of spacing in reducing the effective confining stress in concrete column.

Appendix C

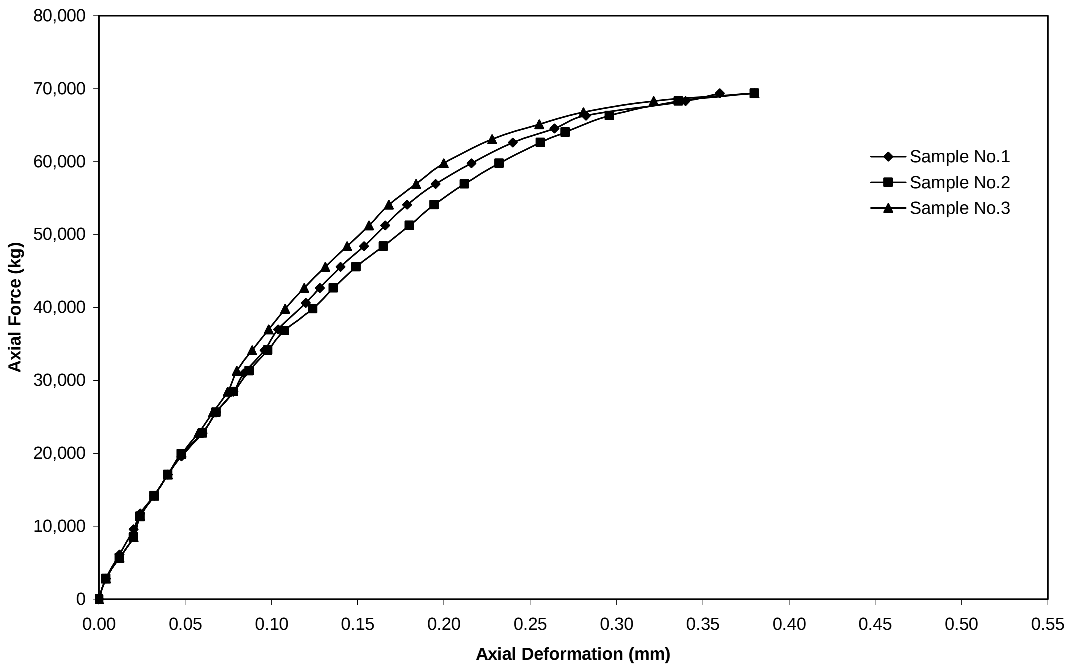
Experimental Results



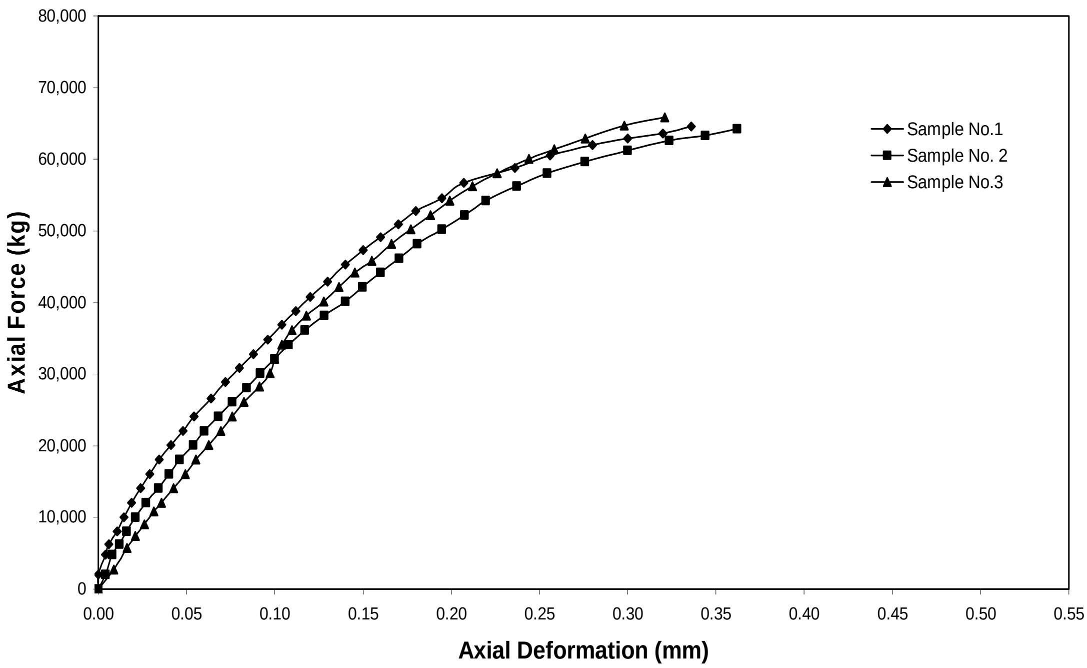
<u>Appendix Figure C1</u> Relationship between axial force and axial deformation of concrete column confined by RB6 (7.5)



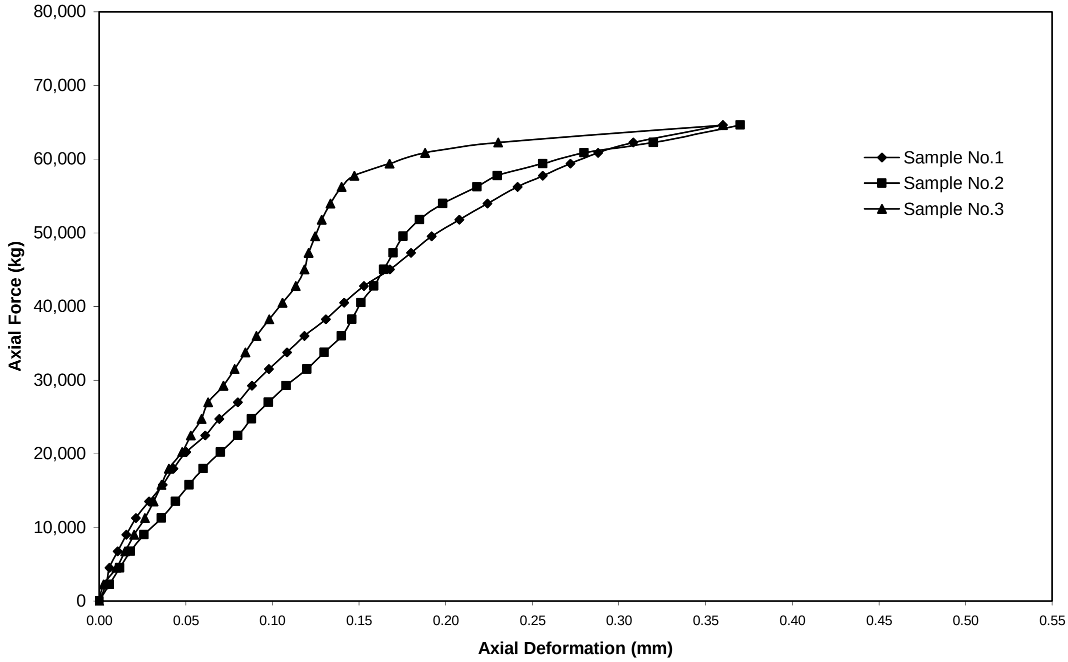
<u>Appendix Figure C2</u> Relationship between axial force and axial deformation of concrete column confined by RB6 (10.0)



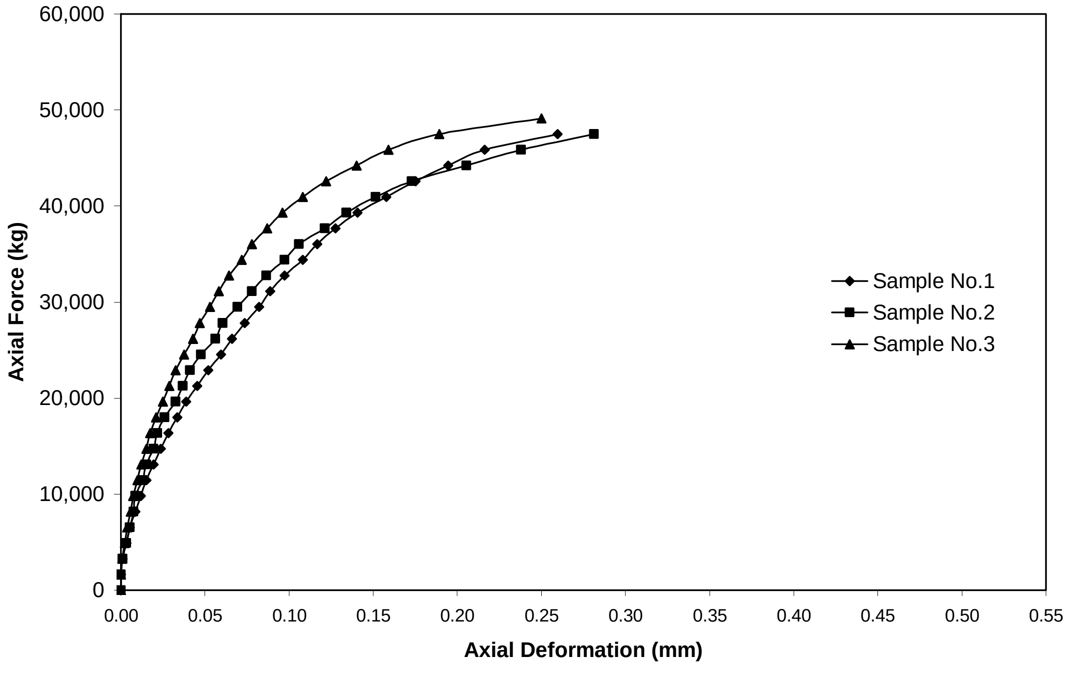
Appendix Figure C3 Relationship between axial force and axial deformation of concrete column confined by CDR6/2 (7.5)



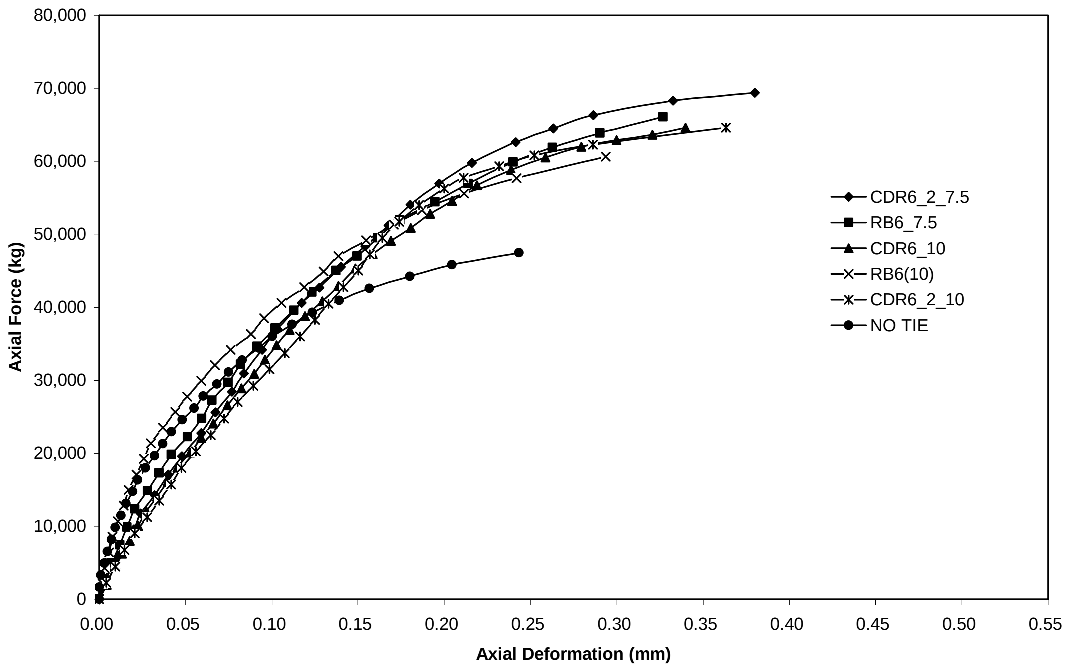
Appendix Figure C4 Relationship between axial force and axial deformation of concrete column confined by CDR6/1 (10.0)



Appendix Figure C5 Relationship between axial force and axial deformation of concrete column confined by CDR6/2 (10.0)



Appendix Figure C6 Relationship between axial force and axial deformation of No Tie bar concrete column



<u>Appendix Figure C7</u> Relationship between axial force and axial deformation of concrete column confined by RB6 (7.5), RB6 (10), CDR6/2(7.5), CDR6/1(10), CDR6/2(10), No Tie