









Table 3: Specimen details and compressive load and strength test results for confined specimens only

Sample No	Column Series Designation	Column specimens dimensions (mm)			Slenderness (h/D) ratio	Average load (kN)	Average strength (N/mm <sup>2</sup> )
		Outer diameter, D	Height, h	Tube thickness, t			
GROUP I	C/C20/110/2	110	220	2.5	2	167.3	17.6
	C/C20/110/3		330		3	161.8	17.0
	C/C20/83/2	83	166	3.0	2	131.1	24.2
	C/C20/83/3		249		3	121.9	22.5
	C/C20/83/4		332		4	119.7	22.1
	C/C20/55/2	55	110	2.5	2	60.1	25.3
	C/C20/55/3		165		3	58.8	24.7
	C/C20/55/4		220		4	54.7	23.0
GROUP II	C/C25/110/2	110	220	2.5	2	181.3	19.1
	C/C25/110/3		330		3	171.8	18.1
	C/C25/83/2	83	166	3.0	2	140.6	26.0
	C/C25/83/3		249		3	133.2	24.6
	C/C25/83/4		332		4	130.2	24.1
	C/C25/55/2	55	110	2.5	2	67.5	28.4
	C/C25/55/3		165		3	64.0	26.9
	C/C25/55/4		220		4	55.1	23.2
GROUP III	C/C30/110/2	110	220	2.5	2	195.3	20.5
	C/C30/110/3		330		3	180.2	19.0
	C/C30/83/2	83	166	3.0	2	144.8	26.8
	C/C30/83/3		249		3	135.5	25.0
	C/C30/83/4		332		4	132.5	24.5
	C/C30/55/2	55	110	2.5	2	69.6	29.3
	C/C30/55/3		165		3	66.0	27.8
	C/C30/55/4		220		4	62.6	26.3

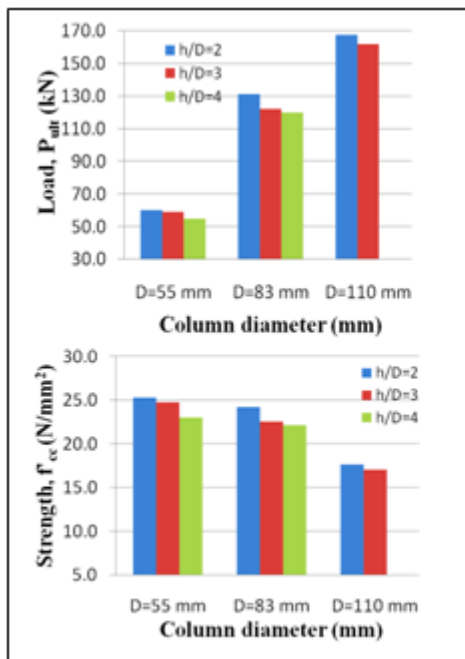


Figure 4: Group I specimen (concrete C20)

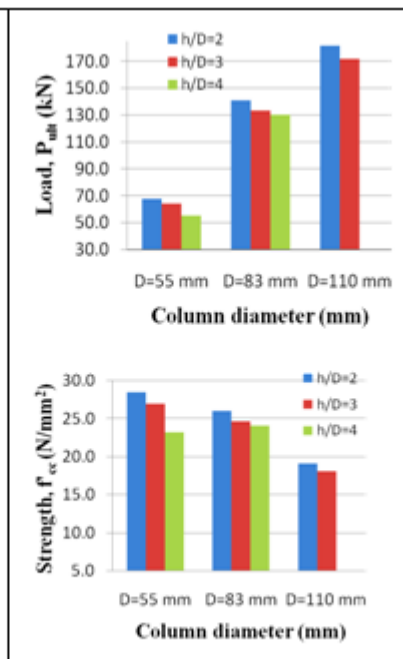


Figure 5: Group II specimens-C25

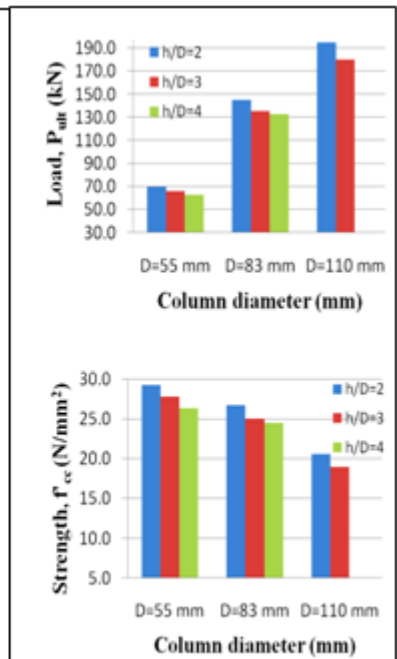
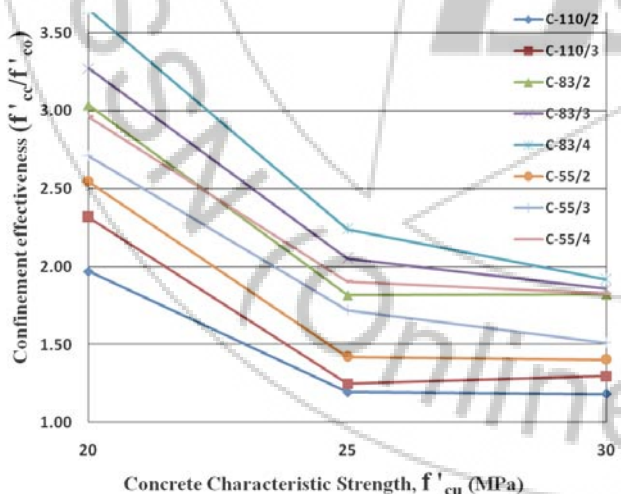


Figure 6: Group III specimens-C30

Figures 4, 5, 6: Variation of Load capacity,  $P_{ult}$ , and compressive strength,  $f_{cc}$ , with change in concrete strength, diameter and heights for UPVC-concrete confined columns

Table 4: Summary of experimental results in terms of Column load capacity, column strength and confinement effectiveness

Column's - Dia/slenderne ss ratio	Tube thickness, t, (mm)	Concrete strength, $f'_{cu}$ (MPa)	Column Load capacity (kN)		Column strength, Mpa		Confinement effectiveness ( $f'_{cc}/f'_{co}$ )
			Confined $P_{cc}$	Unconfined, $P_{co}$	Confined $f'_{cc}$	Unconfined $f'_{co}$	
C-110/2	2.5	20	167.3	77.4	17.6	8.9	1.97
		25	181.3	138.2	19.1	16.0	1.20
		30	195.3	150.3	20.5	17.4	1.18
C-110/3	2.5	20	161.8	63.7	17.0	7.4	2.32
		25	171.8	125.2	18.1	14.5	1.25
		30	180.2	126.4	19.0	14.6	1.30
C-83/2	3.0	20	131.1	37.2	24.2	8.0	3.04
		25	140.6	66.6	26.0	14.3	1.82
		30	144.8	68.4	26.8	14.7	1.82
C-83/3	3.0	20	121.9	32.1	22.5	6.9	3.27
		25	133.2	55.9	24.6	12.0	2.05
		30	135.5	62.8	25.0	13.5	1.86
C-83/4	3.0	20	119.7	28.2	22.1	6.1	3.65
		25	130.2	50.0	24.1	10.7	2.24
		30	132.5	59.4	24.5	12.8	1.92
C-55/2	2.5	20	60.1	19.5	25.3	9.9	2.55
		25	67.5	39.3	28.4	20.0	1.42
		30	69.6	41.0	29.3	20.9	1.40
C-55/3	2.5	20	58.8	17.9	24.7	9.1	2.71
		25	64.0	30.7	26.9	15.7	1.72
		30	66.0	36.1	27.8	18.4	1.51
C-55/4	2.5	20	54.7	15.3	23.0	7.8	2.96
		25	55.1	23.9	23.2	12.2	1.91
		30	62.6	28.3	26.3	14.4	1.83



Figures 7: The relationship between confinement effectiveness and concrete strength

The measure of how well a certain material confines concrete is referred to as confinement effectiveness which is defined as  $f'_{cc}/f'_{co}$ , where  $f'_{cc}$  = compressive strength of confined concrete;  $f'_{co}$  = compressive strength of unconfined concrete. From the results as presented in table 4 and figure

7, it is clear that plastic pipes are effective in confining concrete, as evidenced by the increased compressive stress. The enhancement in strength due to confinement of circular columns is substantial. Depending on the level of confinement, strength is increased anywhere from 1.18 to 3.65 times the unconfined strength. Figure 9 shows a general trend where confinement effectiveness curve goes down with increase in the grade of concrete. This is typical for all column specimens tested regardless of their diameter, height or tube thickness. This is due to the fact that the higher the grade of concrete, the more brittle it is. It is postulated that lower strength concrete is less stiff (as indicated by its low elastic modulus which is usually related to the compressive strength of concrete), and is therefore able to 'flow' thus interacting with concrete tube more effectively, with consequent increase in composite action. Another observation from figure 9 is that the confinement effectiveness increase with increase in slenderness ratio. This is depicted by the upward shift of the curves when the slenderness ratio is increased with diameter kept constant. This can be explained in the context that as slenderness ratio increases, the load carrying capacity and consequently the column compressive stress reduces. However the reduction in compressive load and stress is more pronounced in unconfined columns than in confined columns and therefore

the ratio of the stresses will be higher for longer columns due to the greater difference in stress than for short columns. A notable observation is how the confinement effect for the 83mm-diameter columns set was higher than the other column. This is attributed to the fact that the tube thickness was higher (3.0mm) as compared to the other columns (2.5mm).

## 5. Conclusion and Recommendations

This paper reports the results of an experimental programme which investigated the effect, on compressive strength, of using unplasticized polyvinyl (UPVC) tubes in confining short concrete columns. It was found out that plastic pipes are effective in confining concrete, as evidenced by the increased compressive stress. The enhancement in strength due to confinement of circular columns is substantial and depending on the level of confinement, strength is increased anywhere from 1.18 to 3.65 times the unconfined strength values. It was evident that confinement effectiveness is dependent on the strength of concrete where the former reduces with the increase of the concrete strength due to the brittle behaviour of high strength concrete. Low strength concrete tends to be more ductile suggesting the potential of an earthquake resistant composite column system. The tube thickness also affects the confinement effect of the plastic tubes and this research recommends that further research should be conducted with varying tube thicknesses to establish the actual contribution it makes in column confinements.

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