ANALYSIS OF CONFINED CIRCULAR COLUMN

A Project Report

Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of

BACHELOR OF TECHNOLOGY

in

CIVIL ENGINEERING

by

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled ***"Analysis of Confined Circular Column"*** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Rohit Kumar (141664); Deepak Bargoti (141626) and Ankush Jindal (141619)** during a period from July 2017 to May 2018 under the supervision of Dr. Gyani Jail Singh (Assistant Professor), Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: -

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DECLARATION

This is to declare that this report has been written by us. No part of the report is plagiarized from other sources. All information included from other sources has been duly acknowledged. We aver that if any part of the report is found to be plagiarized, we are shall take full responsibility for it

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(Rohit kumar; Deepak Bargoti; Ankush Jindal)

ABSTRACT

Traditional steel ties reinforcement cannot provide superior confinement for reinforced concrete (RC) columns due to the constraints on tie spacing and disturbance of concrete continuity. This project presents a practical confinement configuration consisting of single welded wire mash (WWM) layer in additional to regular tie reinforcement. The WWM layer is warped over the longitudinal reinforcement and under the longitudinal reinforcement. The proposed transverse reinforcement, with various volumetric ratios of ties, was investigated in sixty four circular short RC column specimens categorized in two groups according to their warping. The specimens were cast in vertical position simulating the construction field and they will be tested under concentric compression till failure. The results indicated that the columns, confined with proposed lateral reinforcement, revealed significant improvement in the strength and ductility. Also, high reduction in ties volumetric ratio with no loss in ultimate load could be achieved by installing the WWM layer.

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Chapter 1

INTRODUCTION

1.1 GENERAL

The most basic material used for the construction of structures is reinforced concrete which is designed according to some standard specifications given in the code to meet required service life. On the basis of specifications the loads are calculated and factor of safety is applied on the load to design various elements of the structure like slabs, columns and beams. Rehabilitation of existing reinforced concrete columns could also be needed for various reasons. Several older buildings need rehabilitation and structural strengthening to permit for sustained service if a modification within the use or the occupants is planning to improve the load carrying capability caused by poor concrete as proven by low cylinders results. In the case of the latter, the structural column may have to be removed and re-placed resulting in significant money prices and time implications. Therefore, the foremost sensible resolution to lessen the danger of structural collapse is by external strengthening. Significant advances within the understanding of structural behavior have occurred over the past 50 years. However, the shortage of strict criterion for older and deficient concrete components has created them significantly vulnerable to failure. a typical description downside found in older concrete columns is wide spaced cross ties or links. This result in poor confinement and support to longitudinal reinforcement needed to delay the strength degradation of concrete underneath final load conditions and permit a ductile response. Failure of a column may be ruinous and will cause partial or maybe complete structural collapse. Column confinement to enhance their auxiliary execution can be connected utilizing remotely connected transverse reinforcement designs, for example, jackets, collars, straps or wraps which can counterbalance critical material and work costs and additionally the interruption of the utilization and task of the structure.

1.2 CONFINEMENT OF CONCRETE

A noteworthy issue with more established concrete columns is the absence of horizontal confinement. As weaker concrete basic individuals, especially columns kept by binds or spirals respond to Poisson type sidelong development, an expansion in the degree and scope of horizontal steel around the concrete will enhance the flexibility and strength.

Confinement can be separated into two sorts, passive and active. The previous alludes to parallel reinforcement responding to concrete sidelong extension which causes a confinement pressure under loading because of Poisson's impact and smaller scale breaking. In active confinement the confining pressure connected to prestress the component along the side preceding loading, applies a little sidelong stress on the concrete with the outcome being an expansion in the loading limit.

The significant contrast amongst passive and active limited concrete is the horizontal pressure applied on the segment before concentric loading, as represented in Figure 1.1 Confinement in reinforced concrete columns is normally given by a mix of longitudinal bars tied with parallel reinforcement as roundabout loops or spirals, steel jackets, fiber reinforced polymers, and material reinforced mortars, fiber ropes and steel reinforced grout. The zone encased by the sidelong reinforcement is alluded to as the concrete center.

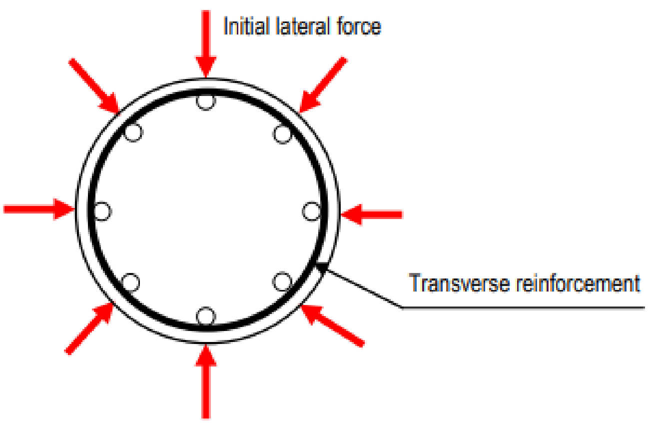

Figure 1.1 Transverse reinforcement in active state

1.3 CONFINEMENT OF REINFORCEMENT

confinement reinforcement is typically incorporated into the form of closed loop ties, welded hoops or continuous spirals so that as lateral load is connected to the basic framework the horizontal reinforcement opposes the parallel extension of the concrete by giving parallel protection, along these lines expanding the limit and flexibility of the concrete segment. This approach is important in limit plan strategies, in which originators guarantee a sufficient flexible reaction of extension section basic areas while avoiding improvement of bothersome disappointment instruments all through the structure. Diverse rules and particulars propose distinctive techniques for figuring the proper measure of transverse reinforcement for confinement purposes.

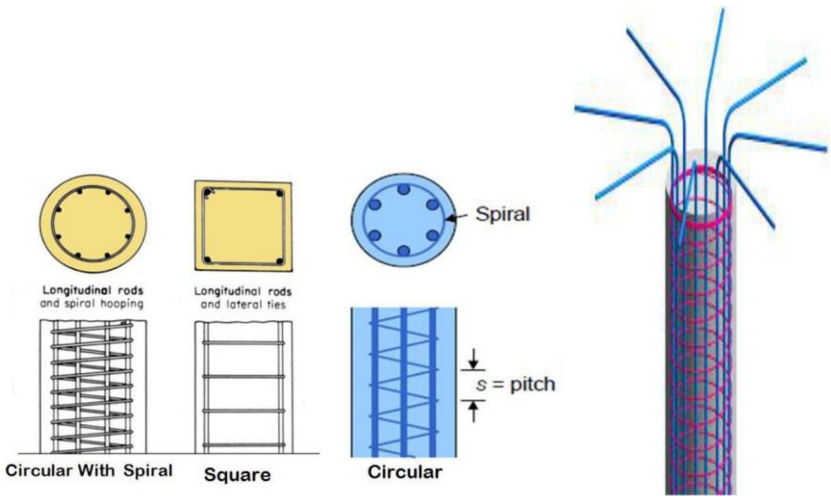

Figure 1.2 Types of Reinforcement confinement

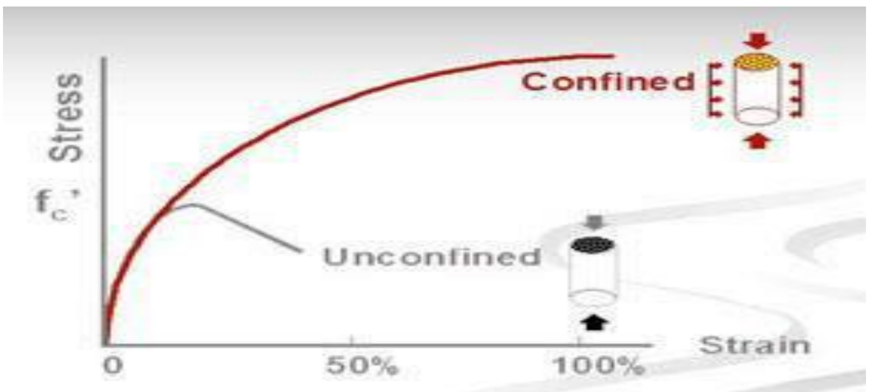

Figure 1.3 effect of confinement

Chapter 2

LITERATURE REVIEW AND OBJECTIVE

2.1 GENERAL

Around 50-60 literature reviewed has been done which conclude that various methods are used to increase the strength and ductility of the column using confinement

2.2 LITERATURE REVIEWS ON CONFINING METHODS

2.2.1 REINFORCED CONCRETE JACKETS

All or any part of the column can be connected to jackets. This technique is exceptionally successful for improving the strength, firmness and flexibility and is suggested for extremely harmed columns. In any case, In structures where repair or an adjustment being used is arranged and changes to the increase load taking ability of existing columns is required, the method of applying outside reinforcement relies upon the ideal worldwide mediation methodology for the particular building.

2.2.2 STEEL JACKETING

In this method thin steel plates (steel encasement) or tie plates (steel confine) are fixed around the column with angles of steel at each corner, clasped to the concrete and welded together. Sufficient fixing of the jackets can be guaranteed by methods for heat tensioning.

The utilization of steel jackets can improve the shear strength of columns extensively. Notwithstanding, because of their low flexural firmness they normally have poor confinement effectiveness for rectangular and square columns. This restricts the adequacy of the framework for expanding the deformability of the columns.

2.2.3 SPIRAL REINFORCEMENT

This strategy comprises of mild steel settled around the harmed component which are warmed and pounded in situ to frame a spiral. They can be welded onto steel points settled on the corners. Warming of the bars is fundamental to guarantee that they are adequately fit in with the current column interface with a specific end goal to create confining force.

2.2.4 HIGH STRENGTH FIBER COMPOSITES

High strength fiber composites are utilized as a contrasting option to steel jacketing. The high strength fiber is soaked in a unique epoxy arrangement which enables them to be wrapped around columns and auxiliary individuals. FRP jackets are more powerful in confining round columns in light of the fact that the fibers make a uniform confining pressure in round columns which is a capability of the hoop strength of the coat. The confining pressure for square cross areas is not as successful as it shifts from most extreme at the corners to least at the inside which does not accommodate well with the low flexural unbending nature of the FRP composite. Be that as it may, the utilization of unstressed high strength fiber composite jackets can improve the malleability and increment the shear strength of columns to the degree that fragile shear disappointments cannot occur.

2.2.5 STEEL COLLAR

Steel collar ties are put around the column and are thickly separated over the harmed territory. Corners of existing columns are ensured by steel edges and a light wire work is set on each of the four edges with a gunite coat of no less than 50mm. As the collars are screw fixed, the pressure constrain in the steel collar applies an active confining stress on the column. Remotely collared columns can show an enhanced execution contrasted with expectedly reinforced ones as the territory of limited concrete is expanded and spalling can be averted. By expanding the collar separating, the confinement adequacy is diminished.

The active pressure can enhance the load taking limit up to the peak but increments in post peak degradation due to fast spalling of the concrete in the middle.

2.3 LITERATURE REVIEW ON EXISTING WORK ON CONFINEMEN

Rodriguez and Park (1994) exhibited that concrete jacketing is an efficient technique to reinforce the strength, stiffness and plasticity of the concrete column. However, while the rehabilitation technique has established to be effective it's extraordinarily laboured intensive. Keeping in mind the end goal to guarantee appropriate obligation of the coat, the surface of the current column requires roughening and broad cleaning to guarantee that all harmed concrete is removed. In option it requires penetrating into the current column to permit entry of included reinforcement in the concrete coat. The expanded work brings about a high cost and extensive disturbance to building use amid application. Increments in the measurements of the column after application can likewise be a restriction to its utilization.

Xiao and Wu (2003) showed when flexibility is the primary factor in repair and restoration of a particular part, the steel jacketing strategy is generally proficient. The downsides of utilizing steel jacketing incorporate the quality affirmation required with welding to guarantee a satisfactory security is made with the concrete interface. The strategy of remotely applying spiral reinforcement through warmth treatment and pounding has comparative disadvantages to steel jacketing.

Mirmiran and Shahawy (1998) stated two principle burdens related with the utilization of FRP are the high costs engaged with their generation and the absence of demand in the fibers which hinders its full use. In a comparative way the utilization of square collars is constrained by its shape and by the cost of produce of the collared pieces.

Tamuzs et al (2006) examined the mechanical behavior of concrete chambers limited with carbon-fiber epoxy tapes with various thickness and pre-stress levels subject to monotonic compressive loading. They found a non-straight stress-strain conduct with huge pliability and increments in ultimate strength. Over the ultimate strength, prolonged destruction and plastic deformation due to presence of residual strains.

Yan et al (2007) had done work on fiber reinforcement strengthening utilizing jackets and demonstrated that they are more powerful in round columns than square or rectangular areas following tests on shape-altered concrete columns utilizing posttensioned FRP shells. The creators found that this course of action altered the confinement from a passive to an active state with enhanced ultimate compressive strain limits of both.

Valdmanis et al (2007) dissected the mechanical behavior of concrete bound via carbon fiber-reinforced polymer (CFRP) sheets.. The creators presumed that a diminishment of 0.50 ought to be connected to the CFRP tensile strength in the ultimate strength a way to make precise strength forecasts.

Janke et al (2009) institute that pre-stressed outside confinement of concrete pressure individuals enhanced the concretes leftover limit and was especially compelling in cyclic loading tests contrasted with the unstressed case.

Rousakis and Tourtouras (2014) contemplated the impact of high augmentation limit fiber ropes as a methods for remotely confining reinforcement in reinforced concrete or square plain columns. The outcomes showed that the novel system performed attractively under loading with high pretension levels conceivable without friction between the outside wrapping and the concrete. Be that as it may, after the ropes were unwrapped after testing, broad splitting of the concrete center was distinguished alongside clasping of various steel bars. Regardless this all strengthened reinforced concrete columns exhibited enhanced stress– strain conduct by limiting untimely bucking of the steel bars with a continuation of the elastic behavior of the column by 39% in terms of load.

Shinde and Bhusari (2015) conducted experiment on 30 specimens underneath uniaxial compression cylindrical specimen of one hundred twenty diameter and 600 mm height. Experiment was conducted to indicate the result of confinement to enhance the ultimate strength with single and double layer of mesh as compared to unconfined specimens.

Different orientation of mesh varied from 90°, 80°, 70°, 60°, 45°. They observed that the initial cracks formed at 20 to 35% of ultimate load for single and double layer. In first case the load carrying capacity of confined specimen was increased in a range of 17, 25, 36, 40, and 47 % as compared to controlled specimens in single layer. In second case in which double layer is used the increasing trend was found to be 50, 52, 54, 54 and 56 % .in each case the orientation was varied from 90°, 80°, 70°, 60°, 45°.

It was concluded that double layer welded wire mesh give nearly double strength than single layer of welded wire mesh. This is due to large confining pressure exerted on cone content. The strength of specimen also varied when mesh angle varies from 90° to 45°. Also the effect of mesh in single layer was 36% more as compared to double layer.

2.4 OBJECTIVE

1) To analyze the confined circular columns under uni-axial loading

2) To observe the effect of confinement:

a) With varying water cement ratio
b) With varying transverse reinforcement for cement water ratio.

CHAPTER 3

EXPERIMENTAL PROGRAM

3.1 GENERAL

For this experimental program we required aggregate both fine and coarse aggregate, cement as a binder and water. Mashing is done on the external and internal part of the reinforcement for the confinement.

ACI method of mix Concrete mix design were made from article 211.1

Over 35 sample were tested in UTM

Deflection with load were taken from the testing

3.2 GI WIRE MASH

Specifications:

Standard Mesh for Concrete Reinforcement The mesh was manufactured according to Indian standard. Mesh was drawn from cold reduced deformed steel wires GI wire mesh was used to confine reinforcement and concrete. The specification of GI mesh used was shown below in table 3.1

Table 3.1 specification of GI mesh

Diameter	1.45 mm
Mesh size	2 inch x 2 inch

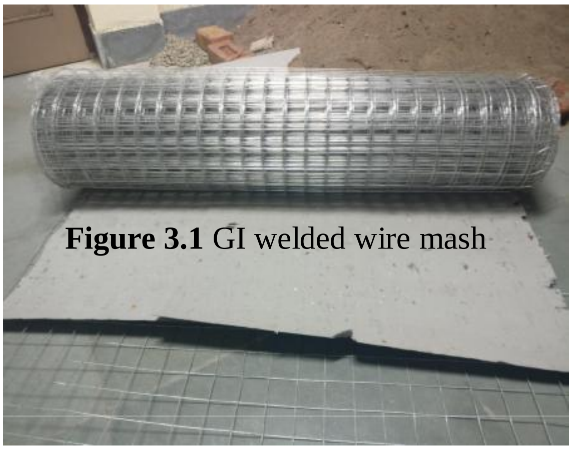

Figure 3.1 GI welded wire mash

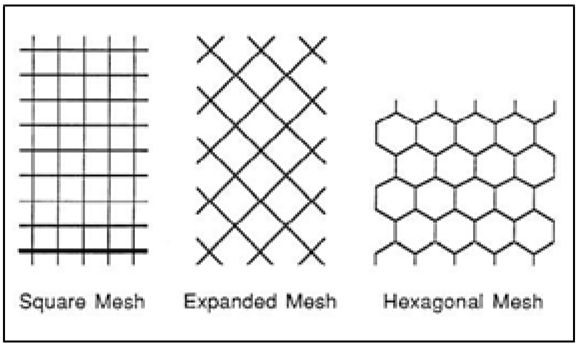

Figure 3.2 Types of wire mesh

3.3 Cement

OPC 43 Grade; Confirming to IS 8112 (1989)

Figure 3.3 OPC cement

3.4 Reinforcements

3.4.1 HYSD Bars Fe 500; Confirming IS 1786 (2008) as a main reinforcement

Figure 3.4 HYSD Bars Fe 500

3.4.2 Mild Steel Bars Fe 250; Confirming IS 280 (2006)

Figure 3.5 Mild Steel Bars Fe 250

3.5 Water Potable water, free from organic matter, silt, oil, sugar, chloride and acidic material as per Indian Standard was used for the entire concreting and mortar application.

3.6 Aggregates

3.6.1 Fine aggregate

Local sand were used as fine aggregate in concrete mix. The physical properties and sieve analysis results of sand are shown in Table 3.1

Table 3.2 specification of fine aggregate

Specific gravity	2.7
Water absorption	2.05
Fineness modules	2.8

3.6.2 Coarse aggregate

Crushed stone aggregate of 10mm and 20mm size in ratio of 1:1 were used for concrete. The physical properties and sieve analysis results of coarse aggregate are shown in Table 3.2

Table 3.3 specification of course aggregate

Specific gravity	2.65
Dry-rodded density	1.56 Ton/m3
Crushing value	26.36%
Water absorption	1.4

3.7 Methodology

- 6 mould of 900 mm height and 150 mm diameter were constructed
    - 2 mould is used for unconfined column
    - 2 mould used for external confined column,
    - 2 mould used for internal confined column
- 4#12 Φ mm HYSD are used in single column on four corner as vertical reinforcement.
- Mash size (50x50) were used for confining inner and outer part of reinforcement
- Lateral ties were used as horizontal reinforcement.
- Column is casted with different water cement ratio and also by changing the spacing of circular stirrups from 220mm to 900mm.
- Concrete were full compacted by needle vibrator.
- Along with it 3 cylinders of each water cement were also casted to check the strength of concrete.
- Sample were tested after 30days of water bath curing

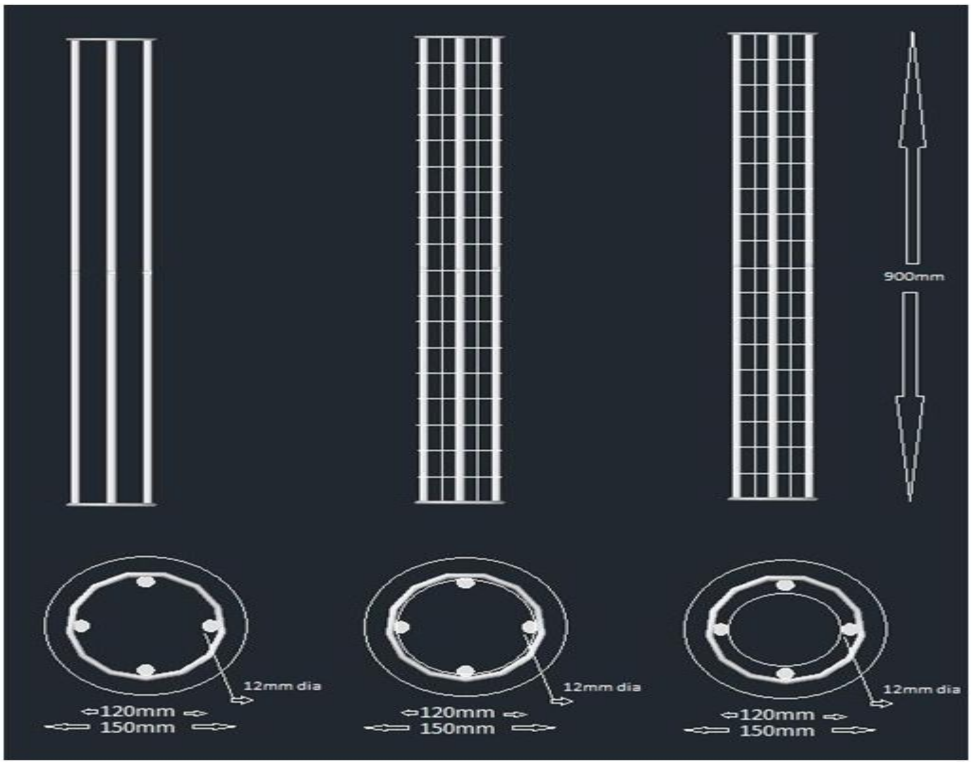

Figure 3.6 moduling of 2 ring columm

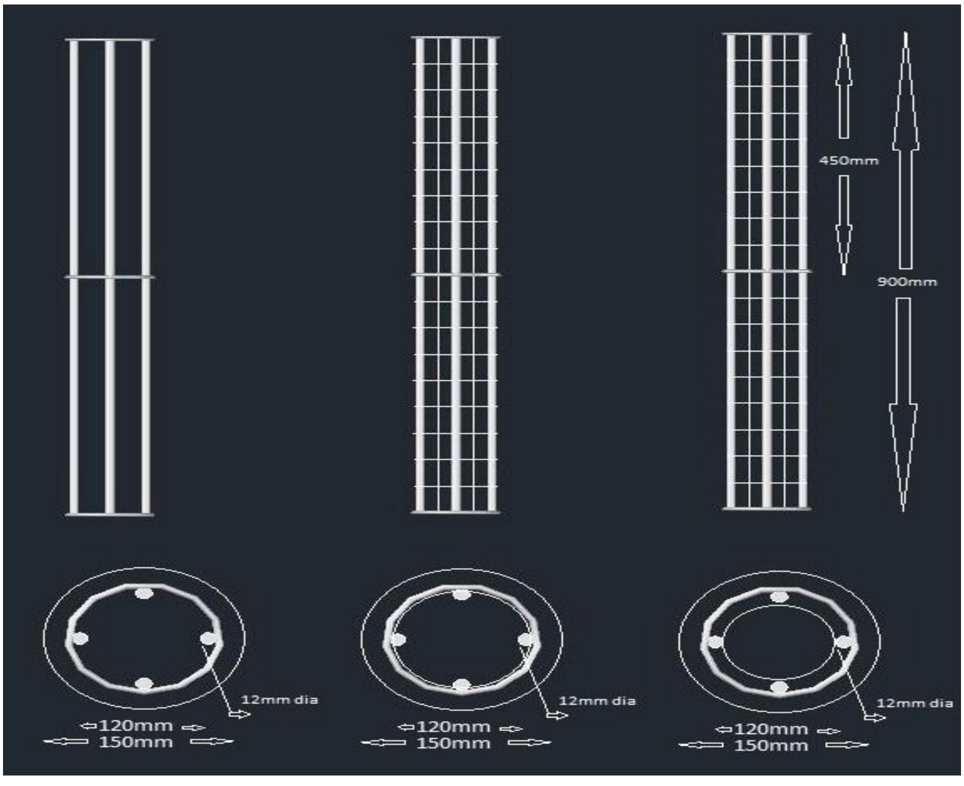

Figure 3.7 moduling of 3 rings columm

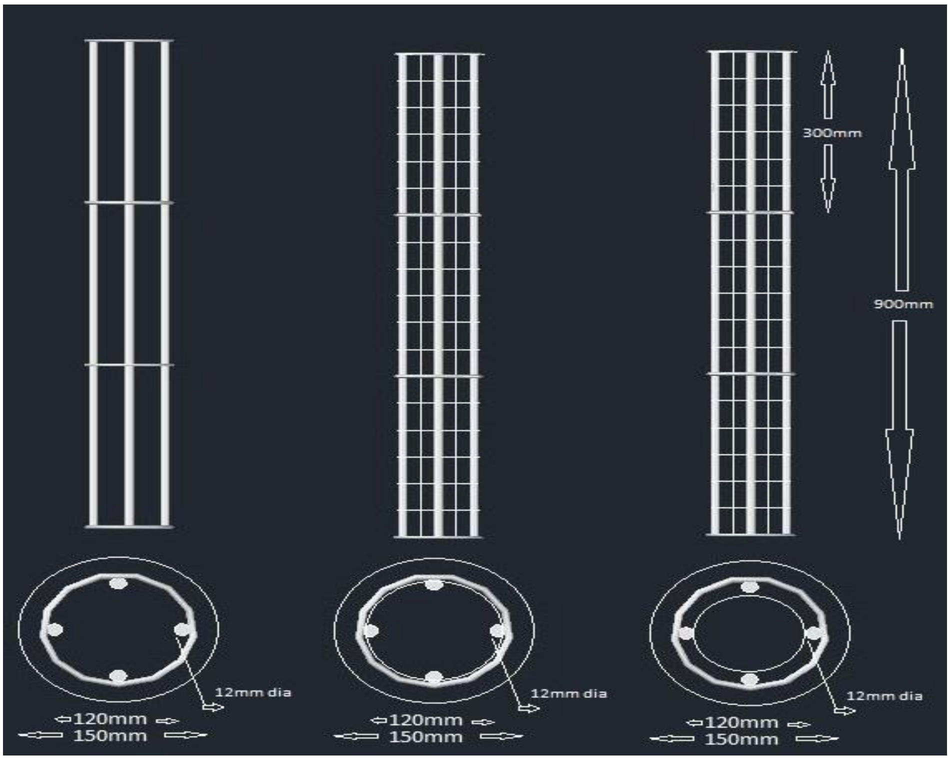

Figure 3.8 moduling of 4 rings columm

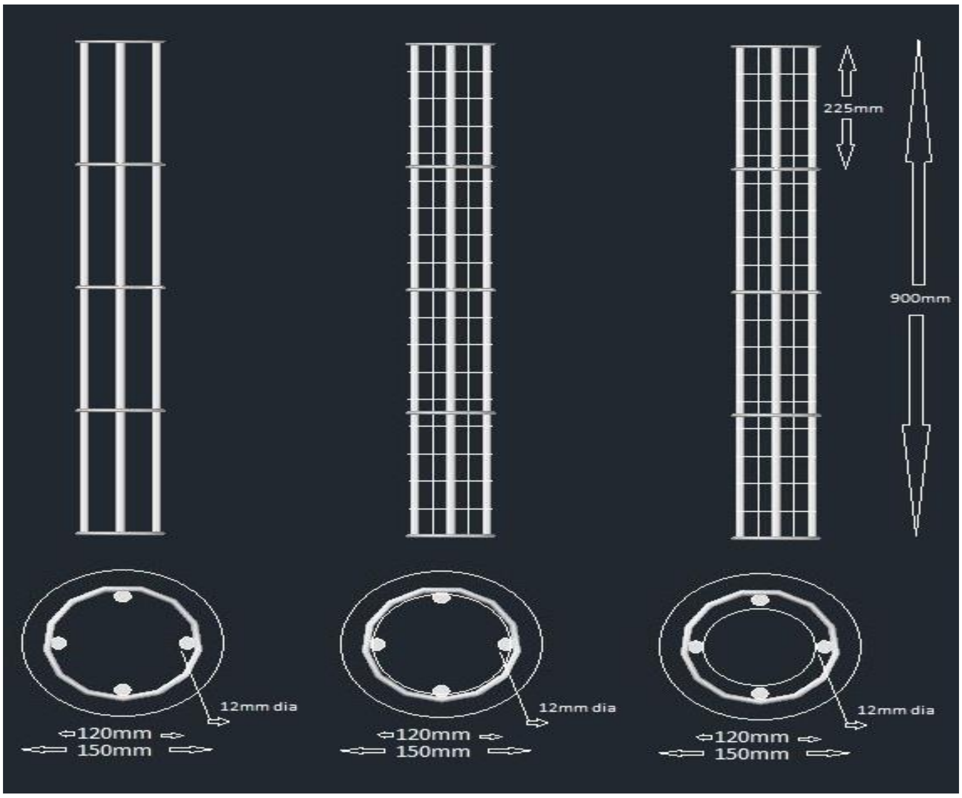

Figure 3.9 moduling of 5 rings columm

Inner confined outer confined non confined

Figure 3.10 Experimental setup

Figure 3.11: mould for casting

Table 3.4 Work Procedure

Column Confinement								
Set No.	Unconfined Sample	External Confined	Internal Confined	No of Bar (12 mm 4)	Circular Ring (115mm Dia.)	No of Stirrups Per Sample	W/C	Steel Binding (mm)
1	2	2	2	24	30	5	0.62	1.5
2	2	2	2	24	24	4	0.62	1.5
3	2	2	2	24	18	3	0.62	1.5
4	2	2	2	24	12	2	0.62	1.5
5	2	2	2	24	30	5	0.55	1.5
6	2	2	2	24	30	5	0.45	1.5

Table 3.5 Mix design

W/C	Slump	Water Content (Kg)	Actual Water (Kg)	Cement (Kg.)	Coarse Agreegate (Kg)	Fine Sand	Correction (Water Absorption in Kg)		Specific Garvity Sand (2.8)	Dry Density (CA)	%Correction	
							CA	FA			CA	FA
0.62	150-180	210	240.36	338.7	961	845.3	13.45	16.91	0.62	1.55	0.014	0.02
0.55	150-180	210	239.50	381.8	961	802.2	13.45	16.04	0.62	1.55	0.014	0.02
0.48	150-180	210	238.38	437.5	961	746.5	13.45	14.93	0.62	1.55	0.014	0.02
Adjustment in Cement Consumption												
0.62	150-180	217.4	247.33	350.6	961	826.1	13.45	16.52	0.62	1.55	1.035	
0.55	150-180	210.0	239.50	381.8	961	802.2	13.45	16.04	0.62	1.55	1	
0.48	150-180	210.0	238.38	437.5	961	746.5	13.45	14.93	0.62	1.55	1	

Figure 3.12 Casting of column

Figure 3.13 Casted sample

Figure 3.14 Curing of sample

3.8 TESTING

UTM (Universal Testing Machine)

Compression Test: In it object is placed between two level plates and object is compressed by applying the load until the failure of object occur. It measures applied load and displacement corresponding to that load. (Ie.100kN at 10mm displacement)

Figure 3.15 testing of column

Figure 3.16 sample to be tested

Figure 3.17 Tested column

Figure 3.18: Failure of column

Figure 3.19 failure of column

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The results obtained by testing samples are discussed in this section and Load-deflection curve were prepared of all unconfined specimens of different rings i.e. (uCW0.62X5, uCW0.62X4, uCW0.62X3, uCW0.62X2) and confined specimens i.e. (iCW0.62X5, iCW0.62X4, iCW0.62X3, iCW0.62X2, eCW0.62X5, eCW0.62X4, eCW0.62X3, eCW0.62X2, iCW0.55X5, iCW0.55X5,eCW0.48X5, eCW0.48X5).Every specimen were tested under concentric loading and ultimate load capacity were observed.

4.2 Result of Confined and Un-Confined column

4.2.1 Water-Cement ratio (0.62)

4.2.1.1 Five Rings

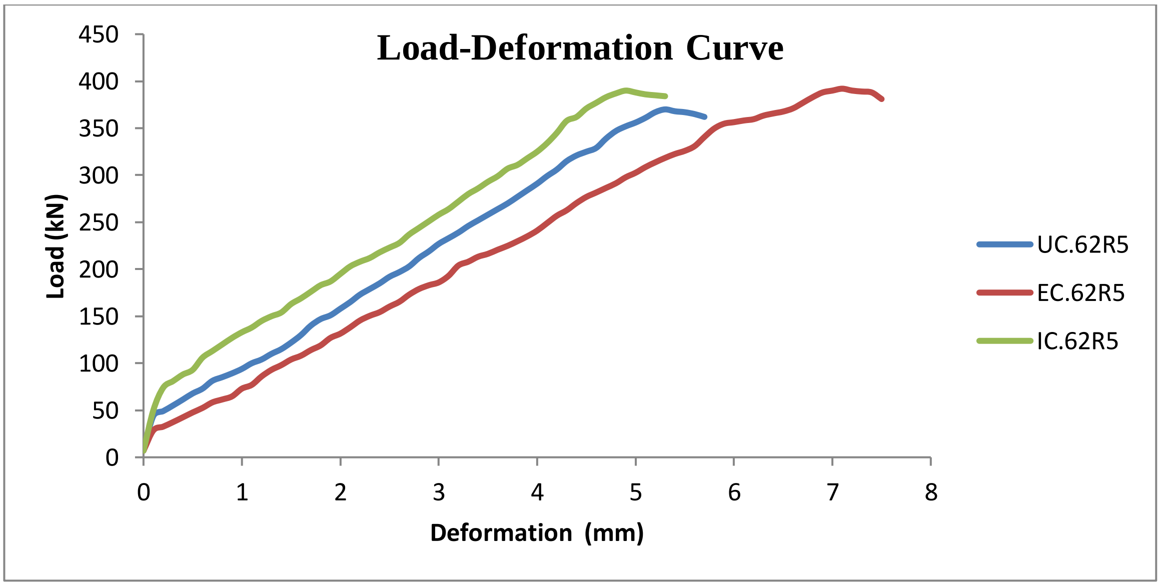

Figure 4.1 Load-Deformation Curve for 5 rings

4.2.1.2 Four Rings

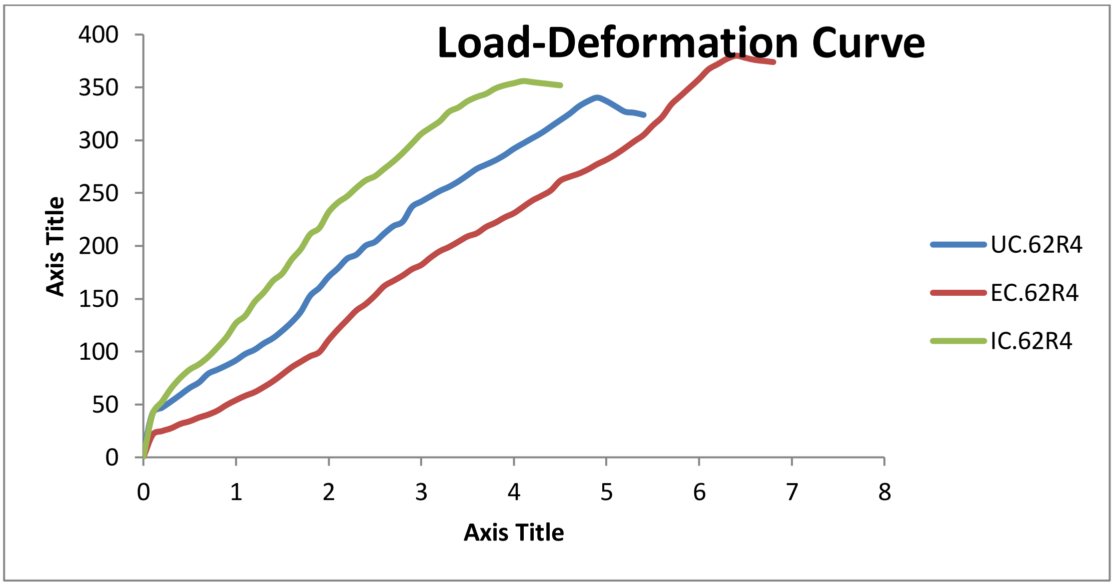

Figure 4.2 Load-Deformation Curve for 4 rings

4.2.1.3 Three Rings

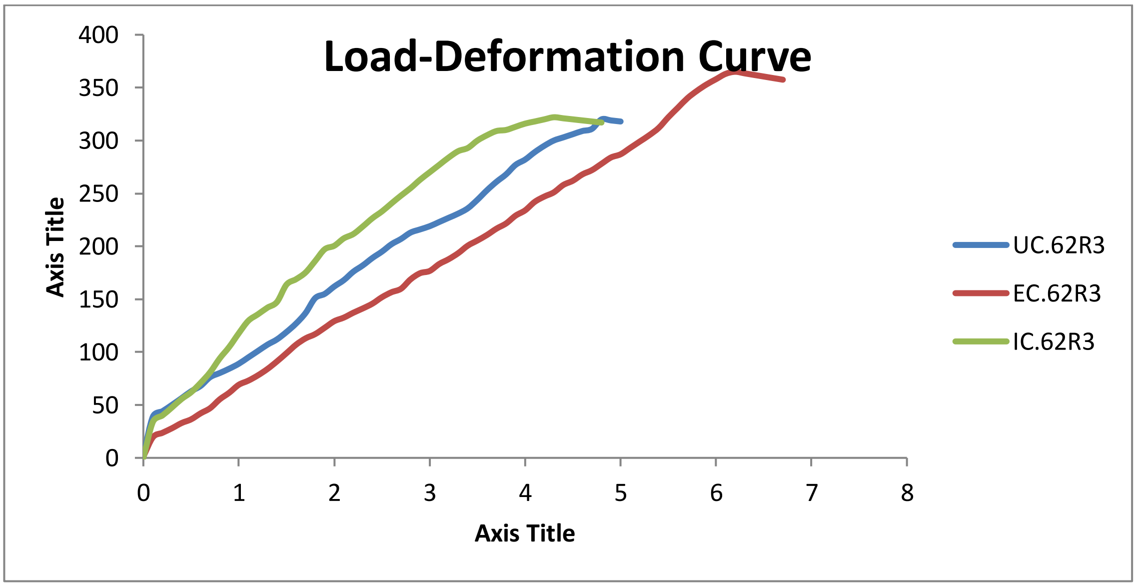

Figure 4.3 Load-Deformation Curve for 3 rings

4.2.1.4 Two Rings

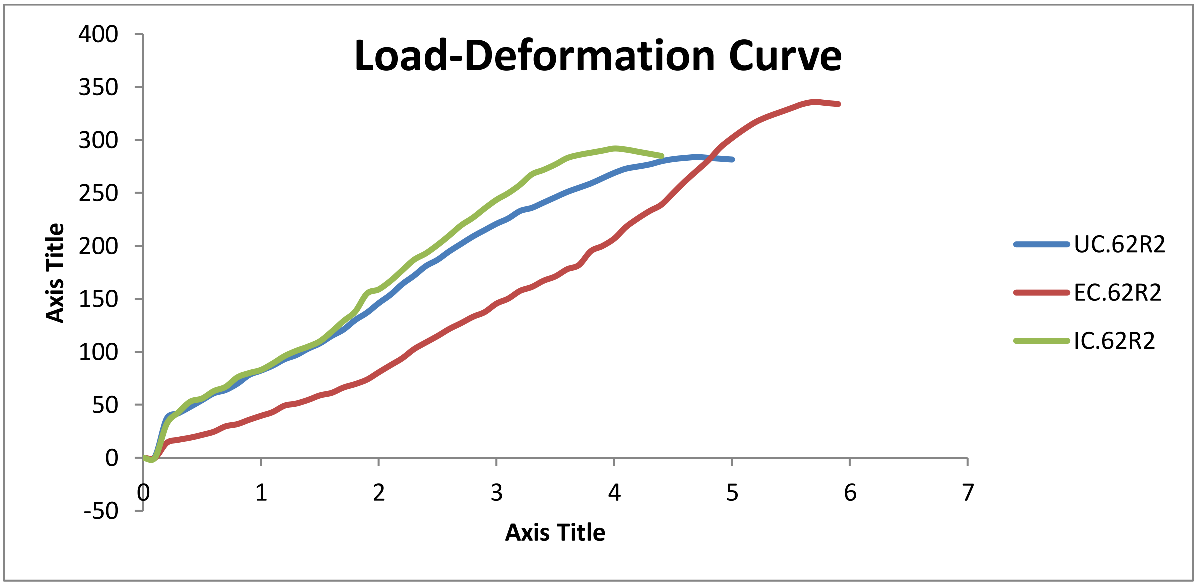

Figure 4.4 Load-Deformation Curve for 2 rings

4.2.2 Water-Cement ratio (0.55)

4.2.2.1 Five Rings

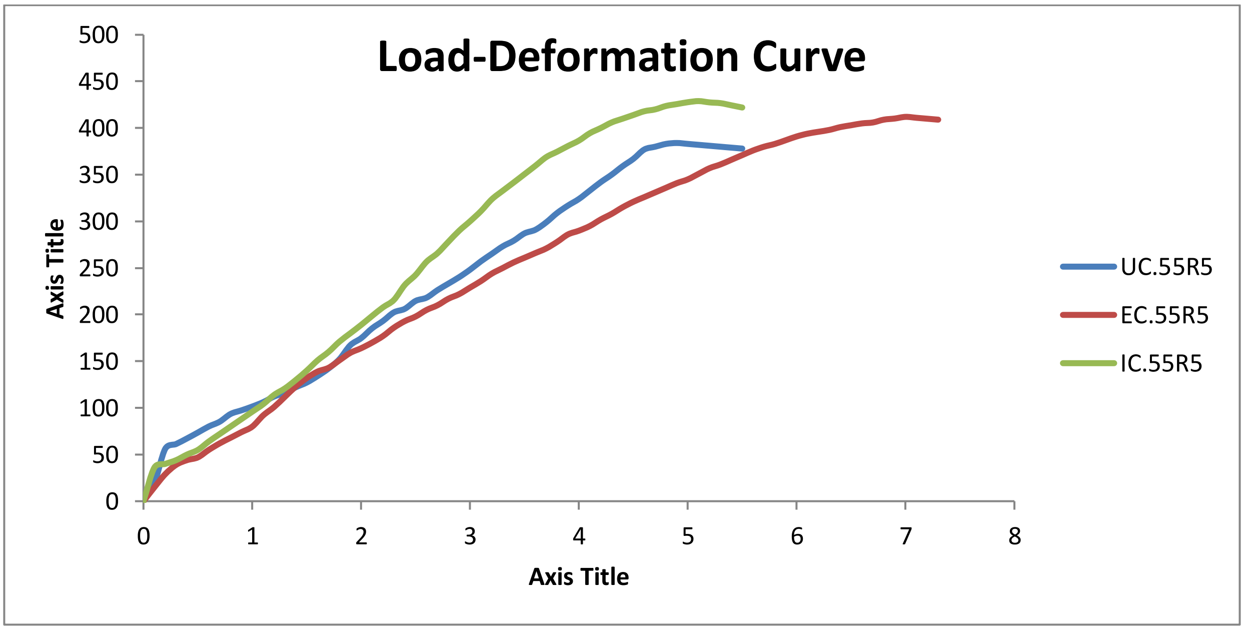

Figure 4.5 Load-Deformation Curve for 5 rings

4.2.3 Water-Cement ratio (0.48)

4.2.3.1 Five Rings

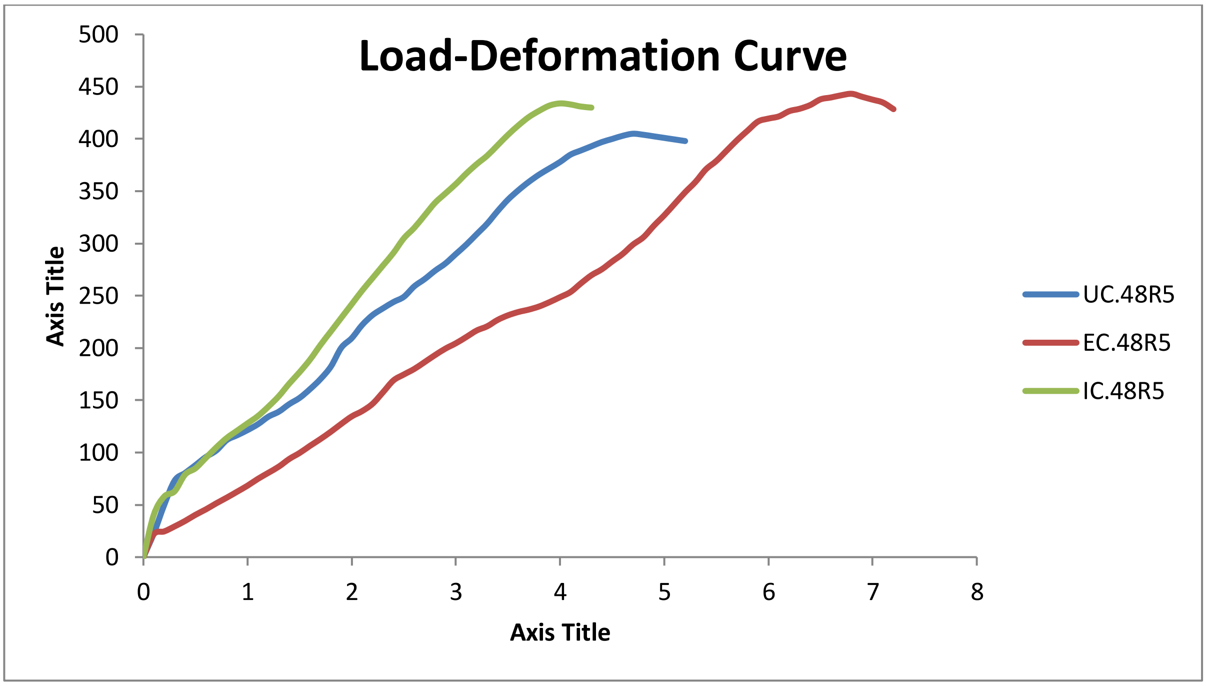

Figure 4.6 Load-Deformation Curve for 5 rings

TABLE 4.1: By Varying Different Water-Cement Ratio

Def	UC.62R5	EC.62R5	IC.62R5	UC.55R5	EC.55R5	IC.55R5	UC.48R5	EC.48R5	IC.48R5
0	0	0	0	0	0	0	0	0	0
0.1	21	25	27	19	14.9	36	23	22	41
0.2	44	29	50	56	29	40	50	25	58
0.3	49	33	74	61	39	44	73	29	63
0.4	55	37	81	67	44	50	80	35	79
0.5	61	42	88	74	47	55	88	41	85
0.6	68	48	93	80	55	64	96	46	95
0.7	73	53	106	85	62	72	102	52	105
0.8	81	58	113	94	68	80	112	57	114
0.9	85	62	120	97	74	88	117	63	121
1	89	65	127	102	80	96	121	68	128
1.1	94	73	133	106	92	104	127	75	135
1.2	100	77	138	112	101	114	134	81	144
1.3	104	86	145	116	112	121	139	87	154
1.4	110	93	150	122	123	130	146	94	166
1.5	115	98	154	127	132	140	152	100	177
1.6	122	104	163	134	139	151	161	106	189
1.7	130	108	169	142	143	160	170	113	203
1.8	140	114	176	152	151	171	182	120	216
1.9	147	119	183	168	159	180	200	128	229
2	151	127	187	175	164	189	209	135	242
2.1	158	132	195	185	170	199	222	140	255
2.2	165	138	203	193	177	208	232	147	267
2.3	173	145	208	202	186	216	238	158	279
2.4	179	151	212	206	193	232	244	169	291
2.5	185	154	218	205	198	243	249	175	305
2.6	192	160	223	218	205	257	259	180	315
2.7	197	165	228	226	210	268	266	187	327
2.8	203	173	237	233	217	278	274	193	339
2.9	212	179	244	240	222	290	281	199	348
3	219	183	251	248	229	300	290	205	357
3.1	227	186	258	257	236	311	299	210	367
3.2	233	193	264	267	244	324	309	217	376
3.3	239	204	272	273	250	333	319	221	384
3.4	246	208	280	279	256	342	331	227	394
3.5	252	213	286	287	261	351	342	231	404
3.6	258	216	293	291	266	360	351	235	413
3.7	264	221	299	299	271	369	359	237	421
3.8	270	225	307	309	278	375	366	240	427
3.9	277	230	311	317	286	381	372	244	432
4	284	235	318	324	290	387	378	248	434
4.1	291	241	325	333	295	395	385	254	433

4.2	299	249	334	342	302	400	389	262	431
4.3	306	257	345	350	308	406	393	270	430
4.4	315	263	358	359	315	410	397	275	
4.5	321	271	362	367	321	414	400	283	
4.6	325	277	371	377	326	418	403	290	
4.7	329	281	377	380	331	420	405	299	
4.8	339	287	383	383	336	424	404	306	
4.9	347	291	387	384	341	426	402.5	317	
5	352	298	390	383	345	428	401	327	
5.1	356	303	388	382	351	429	399.5	338	
5.2	361	309	386	381	357	427	398	349	
5.3	367	314	385	380	361	426		359	
5.4	370	318	384	379	366	424		371	
5.5	368	323		378	371	422		379	
5.6	367	326			376			389	
5.7	365	331			380			399	
5.8	362	341			383			408	
5.9		350			387			417	
6		355			391			419	
6.1		356			394			420	
6.2		358			396			427	
6.3		360			398			429	
6.4		363			401			432	
6.5		366			403			438	
6.6		368			405			440	
6.7		371			406			442	
6.8		377			409			443	
6.9		383			410			440	
7		388			412			438	
7.1		390			411			434	
7.2		392			410			428	
7.3		390			409			428	
7.4		389			406				
7.5		388			403				
7.6		381							

TABLE 4.2: By Varying Different Ties Spacing

Def	UC.62R4	EC.62R4	IC.62R4	UC.62R3	EC.62R3	IC.62R3	UC.62R2	EC.62R2	IC.62R2
0	0	0	0	0	0	0	0	0	0
0.1	22	21	41	39	20	34	1	0	0
0.2	73	25	52	44	24	40	37	14	32
0.3	80	28	65	50	28	48	42	17	43
0.4	88	32	75	56	33	56	48	19	53
0.5	95	32	83	63	36	62	54	22	56
0.6	102	38	88	68	42	71	61	25	63
0.7	112	40	95	76	47	81	64	30	67
0.8	116	44	104	80	55	94	70	32	76
0.9	121	50	114	84	62	105	78	36	80
1	127	54	127	89	69	118	83	40	83
1.1	134	58	134	95	73	130	87	43	89
1.2	139	62	147	101	78	136	93	50	96
1.3	146	66	156	107	84	142	97	51	101
1.4	152	72	167	112	91	147	103	55	105
1.5	161	79	174	119	99	164	108	58	110
1.6	171	85	187	127	107	169	115	61	119
1.7	182	91	197	137	113	175	121	66	129
1.8	200	96	211	151	117	186	130	70	138
1.9	209	100	217	155	123	197	137	73	155
2	222	111	232	162	129	201	146	81	159
2.1	232	121	241	168	133	207	154	87	167
2.2	243	130	247	176	137	212	164	94	177
2.3	247	139	255	182	141	219	172	103	187
2.4	257	145	262	189	145	226	181	109	193
2.5	262	153	266	195	152	233	187	115	201
2.6	271	162	273	202	157	241	195	122	210
2.7	278	167	280	207	160	248	202	127	220
2.8	223	172	288	213	169	255	209	133	226
2.9	237	178	297	216	175	263	215	138	236
3	242	182	306	219	177	270	221	146	244
3.1	247	189	312	223	183	277	226	150	250
3.2	252	195	318	227	188	284	233	158	258
3.3	256	199	327	231	194	290	236	161	268
3.4	261	204	331	236	201	293	241	167	272
3.5	267	209	337	244	206	300	246	171	277
3.6	273	212	341	253	211	305	251	178	283
3.7	277	218	344	261	217	309	255	182	286
3.8	281	222	349	268	222	310	259	195	288
3.9	286	227	352	277	229	313	264	200	290
4	292	231	354	282	234	316	269	207	292
4.1	297	237	356	289	242	318	273	218	291

4.2	302	243	355	295	247	320	275	226	289
4.3	307	248	354	300	251	322	277	233	287
4.4	313	253	353	303	258	321	280	239	285
4.5	319	262	352	306	262	320	282	250	
4.6	325	265		309	268	319	283	261	
4.7	332	268		311	272	318	284	271	
4.8	337	272		320	278	317	282	281	
4.9	340	277		319	284		281	293	
5	337	282		318	287		280	302	
5.1	332	287			293			310	
5.2	327	293			299			317	
5.3	326	299			305			322	
5.4	324	305			312			326	
5.5		314			322			330	
5.6		322			331			334	
5.7		334			340			336	
5.8		342			347			335	
5.9		350			353			334	
6		358			358				
6.1		367			363				
6.2		372			365				
6.3		377			363				
6.4		380			362				
6.5		378			361				
6.6		376			359				
6.7		375			357				
6.8		374			356				

Table 4.3: Results by varying ties spacing

No Of Rings		Non confined	External confined	Inner confined
5 Rings	Load (force in KN)	370	392	390
	Deformation (Axial displacement in mm)	5.3	7.1	4.9
4 Rings	Load (force in KN)	340	380	356
	Deformation (Axial displacement in mm)	4.9	6.4	4.1
3 Rings	Load (force in KN)	311	365	322
	Deformation (Axial displacement in mm)	4.7	6.2	4.3
2 Rings	Load (force in KN)	284	336	292
	Deformation (Axial displacement in mm)	4.6	5.7	4

Table 4.4: Results by varying water cement ratio

w/c Ratio		Non confined	External confined	Inner confined
0.62	Load (force in KN)	370	392	390
	Deformation (Axial displacement in mm)	5.3	7.1	4.9
0.55	Load (force in KN)	384	412	408
	Deformation (Axial displacement in mm)	4.9	7	5.1
0.48	Load (force in KN)	405	440	434
	Deformation (Axial displacement in mm)	4.7	6.8	4

Table 4.5: Results for the strength of concrete

w/c Ratio	Cube strength
0.62	24.7
0.55	30.1
0.48	34.5

CHAPTER 5

CONCLUSION

The experiments were conducted to study the effect of confinement by varying transverse reinforcements. Based on above results following conclusions can be drawn

Table 5.1: Results by varying ties spacing

No Of Rings		Non confined	External confined	Internal confined	% increase In external confinement	% increase In internal confinement
5 Rings	Load (force in KN)	370	392	390	5.945946	5.405405
	Deformation (Axial displacement in mm)	5.3	7.1	4.9		
4 Rings	Load (force in KN)	340	380	356	11.76471	4.705882
	Deformation (Axial displacement in mm)	4.9	6.4	4.1		
3 Rings	Load (force in KN)	311	365	322	17.36334	3.536977
	Deformation (Axial displacement in mm)	4.7	6.2	4.3		
2 Rings	Load (force in KN)	284	336	292	18.14346	2.672293
	Deformation (Axial displacement in mm)	4.6	5.7	4		

Table 5.2: Results by varying water cement ratio

w/c Ratio		Non confined	External confined	Internal confined	% increase In external confinement	% increase In internal confinement
0.62	Load (force in KN)	370	392	390	5.945946	5.405405
	Deformation (Axial displacement in mm)	5.3	7.1	4.9		
0.55	Load (force in KN)	384	412	408	7.291667	6.25
	Deformation (Axial displacement in mm)	4.9	7	5.1		
0.48	Load (force in KN)	405	440	434	8.641975	7.160494
	Deformation (Axial displacement in mm)	4.7	6.8	4		

From the above that we can conclude that:-

- Confinement help us to improve strength, ductility and stiffness
- External Confinement effects become more effective when decrease the water-cement ratio, as for more the strength of concrete is the more will be the effect of confinement
- External Confinement effects become more effective when we increase the spacing of ties, as for more the spacing between the ties is the more will be the effect of confinement will give
- internal Confinement effects become more effective when decrease the water-cement ratio, as for more the strength of concrete is the more will be the effect of confinement
- internal Confinement effects become more effective when we decrease the spacing of ties, as for less the spacing between the ties is the more will be the effect of confinement will give

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