"The Comparative Study of F-M Diagram For Strengthing the Capacity of RC Column"

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Abstract: *For the Damaged Existing RC Column under the Earthquake, or else, its become very vital to retrofit, to repair, to strengthen the capacity in any way so that it could sustain. In this study on basis of F-M curve of RC column, the % Increment in Moment capacity is been presented. So, For Strengthing the capacity of RC Column Casing is been provided along the Periphery of column & various Model of Unconfined & confined RC Column is been analyised & compared to each other for 2 inch, 1 inch & without cover with & without 6mm, 8mm & 10mm Casing. Finally, the results obtained conclude that by providing the casing strength increased approximately 1,5+ times then non-casing column.*
Keywords: *Column, Retrofit, F-M Curve, Unconfined & confined concrete column.*

I. Introduction

Concrete structures are commonly used for various types of structures all over the world, including a wide range of buildings, bridges, dams, etc. Moreover, they are designed and constructed in different climates and seismic zones. In general, overall performance and behavior of concrete structures under applied loads depends on the response of their force resisting systems.

In this study, Firstly , SAP 2000 section designer results of square column is been verified with the result of literature available, and their accuracy is also been checked, then Various RC column are modelled in Section Designer with varying parameters.

The dominant method used in strength assessment of columns is the axial force-bending moment interaction response, as authorized by the code ACI. However, this method does not consider the effects of confining material, and the predictions using the method prescribed by the code lead to extremely conservative results.

In general, all of these methods are based on strain compatibility and force equilibrium. However, results using these methods defer widely, and there is a need to find a method that can provide a reasonably accurate and realistic prediction of the capacity and performance of a RC column. This is critical for replacement, retrofit or repair of an existing and apparently deficient column.

II. Method Adopted For Obtaining F-M Diagram

Analytical methods for obtaining F-M diagrams:

As it was stated earlier, various analytical methods can be used to evaluate the behavior of reinforced concrete columns under applied loads. In this section, the procedure needed to obtain axial load-bending moment (F-M) diagrams, which are used as the capacity indicators of RC columns, is described.

1.   **Simplified method for unconfined concrete:** This method which is recommended by ACI code considers the concept of "equivalent stress block". Based on this concept, the strain at the most compressed edge of the cross section is assumed to be constant and equal to 0.003; this is said to be the ultimate compressive strain of the unconfined concrete. For obtaining F-M diagrams based on this method, compressive strain at the extreme fiber is taken to be constant while the strain at the tension reinforcement is variable.

2.   **Simplified method for confined concrete:** This method also uses the concept of "equivalent rectangular stress block"; however, the parameters of this stress block are different from those of the ACI equivalent stress block since confinement is considered in this method. In this method, the ultimate compressive strain is found from the stress-strain model used for confined concrete, and the other parameters of equivalent rectangular stress block are obtained.

SAP 2000, Section Designer:- In the software the above material properties i.e. stress & strain other parameter is to be given as input and then various modeling of RC column is to be done. Which will generate the F-M Diagram of particular column and thus different F-M diagram can be obtained by doing so.
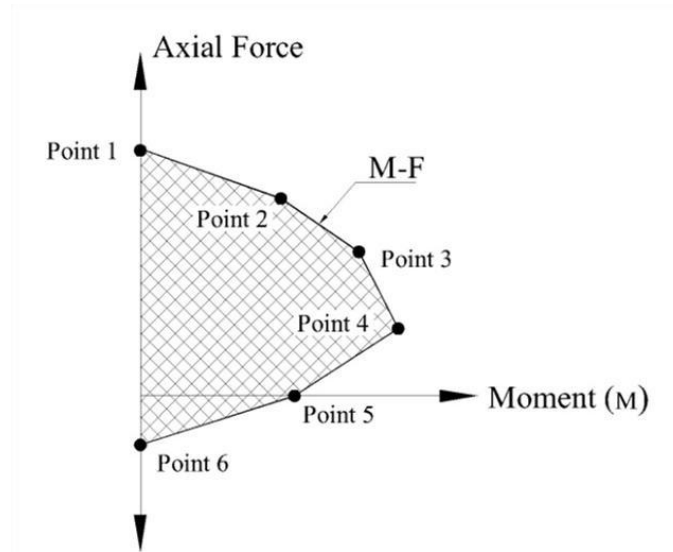
Figure 1 . Six important points on F-M diagram for concrete column..

III.   Parameter of Column

In the study, the F-M Diagram is obtained by SAP2000, Section Designer. We took an Circular Section for Example of 2without diameter with varying the cover like 2 inch, 1 inch, & without .then casing is been provide likewise 6mm, 8mm & 10mm for unconfined & confined.
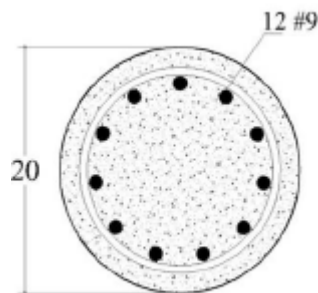

Figure 2 . Column Cross- Section

f 'c= 4000 psi, f y = 60000 psi. clear cover = 2 in,1 inch, zeros inch. Es = 29000 Ksi. 12 # 9 longitudinal bars # 3 @ 4 in. stirrups Casing-6mm, 8mm, 10mm.

IV.   Result and F-M Diagram

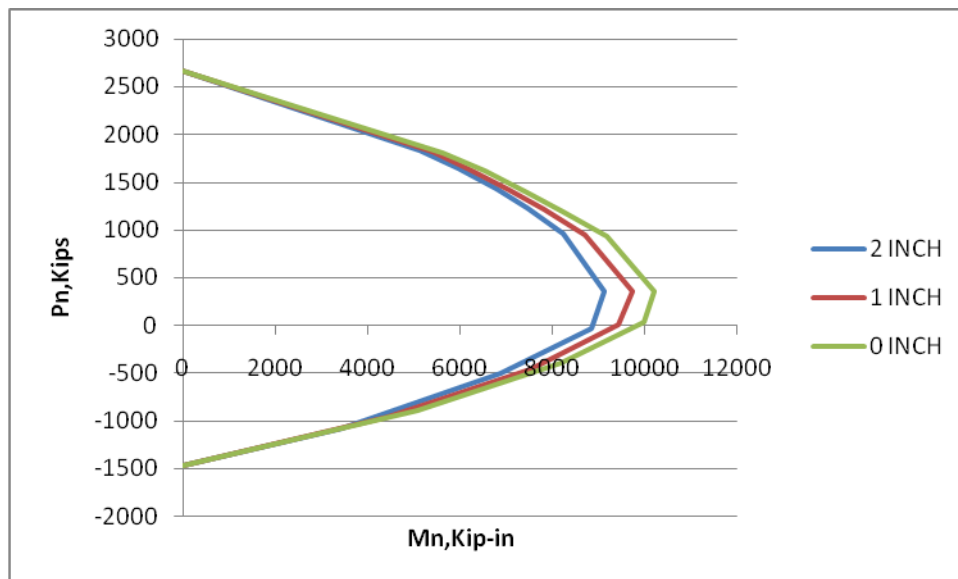|	Unconfined Circular column with 6 mm Casing					
	2 inch cover		1 inch cover		*without* cover	
S.No	Moment	Load	Moment	Load	Moment	Load
1	0	2670	0	2670	0	2670
2	4960.968	1817	5263.163	1815	5631.563	1807
3	5724.536	1635	6089.474	1626	6534.493	1617
4	6564.632	1424	6974.446	1412	7461.522	1399
5	7291.361	1215	7729.791	1203	8234.209	1192
6	8102.722	949.9507	8601.261	940.9366	9167.441	933.1821
7	9035.308	350.3135	9663.357	349.054	10205	354.0309
8	8779.103	-41.8616	9376.022	-0.596	9970.202	35.494
9	6879.627	-521.724	7491.534	-460.41	8186.317	-395.145
10	3863.818	-1031.84	4432.794	-960.2	5081.928	-895.447
11	0	-1468.96	0	-1468.96	0	-1468.96

Table.1:- Caltrans Unconfined Circular column for 6mm casing cover wise Result by SAP 2000
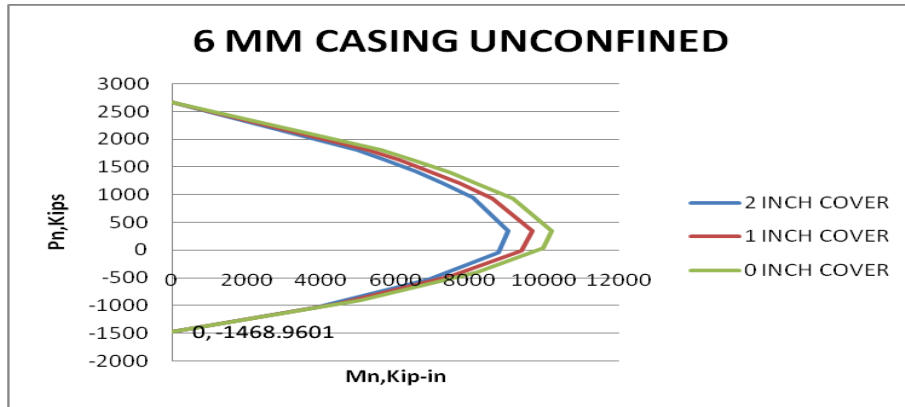
Figure:-3:- Unconfined F-M curve Based on the Cover for 6 mm Casing

|	Confined Circular column with 6 mm Casing					
	2 inch cover		1 inch cover		without cover	
S.No	Moment	Load	Moment	Load	Moment	Load
1	0	2670	0	2670	0	2670
2	5118.343	1836	5394.327	1826	5631.563	1807
3	5948.582	1642	6205.888	1637	6534.493	1617
4	6786.853	1432	7079.863	1423	7461.522	1399
5	7446.235	1233	7828.15	1213	8234.209	1192
6	8241.703	967.9602	8692.121	950.5527	9167.441	933.1821
7	9119.21	364.709	9731.188	356.9647	10205	354.0309
8	8830.125	-27.7821	9419.738	4.0238	9970.202	35.494
9	6874.296	-504.659	7507.541	-459.612	8186.317	-395.145
10	3447.639	-1079.45	4439.813	-959.441	5081.928	-895.447
11	0	-1468.96	0	-1468.96	0	-1468.96

Table.2:- Confined Circular column for 6mm casing cover wise Result by SAP 2000

Figure:-4:- Confined F-M curve Based on the Cover for 6 mm Casing

	Unconfined concrete column with 8 mm casing					
	2 inch cover		1 inch cover		without cover	
S.No	Moment	Load	Moment	Load	Moment	Load
1	0	2921	0	2921	0	2921
2	5693.345	1971	5994.828	1969	6360.323	1960
3	6576.733	1769	6938.006	1760	7378.977	1751
4	7558.369	1535	7965.676	1523	8447.961	1510
5	8453.368	1298	8889.03	1286	9390.339	1275
6	9465.635	995.1608	9965.128	986.7005	10528	978.8461
7	10551	343.9643	11178	342.4496	11725	347.6774
8	10272	-91.1508	10867	-50.0474	11460	-13.9667
9	8195.643	-619.1	8794.821	-559.465	9495.398	-493.136
10	4828.071	-1182.42	5403.562	-1109.53	6042.223	-1045.36
11	0	-1720.34	0	-720.34	0	-1720.34

Table.3:- UnConfined Circular column for 8 mm casing cover wise Result
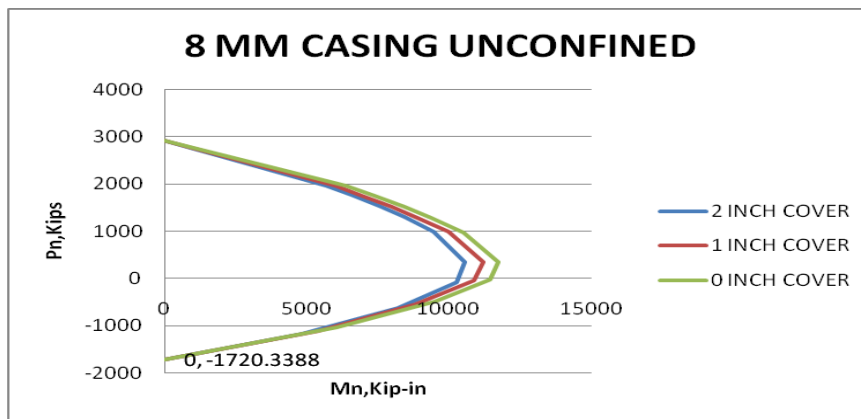
Figure:-5:- Unconfined F-M curve for 8mm Casing Based on cover

	Confined concrete column with 8 mm casing					
	2 inch cover		1 inch cover		without cover	
S.No	Moment	Load	Moment	Load	Moment	Load
1	0	2921	0	2921	0	2921
2	5849.305	1989	6124.925	1980	6360.323	1960
3	6796.916	1777	7053.285	1771	7378.977	1751
4	7779.061	1543	8069.582	1534	8447.961	1510
5	8605.929	1315	8985.841	1295	9390.339	1275
6	9601.062	1013	10054	995.9978	10528	978.8461
7	10631	357.8768	11243	350.0551	11725	347.6774
8	10319	-77.7391	10909	-45.6302	11460	-13.9667
9	8183.341	-603.245	8811.807	-558.427	9495.398	-493.136
10	4426.793	-1228.34	5405.705	-1109.3	6042.223	-1045.36
11	0	-1720.34	0	-1720.34	0	-1720.34

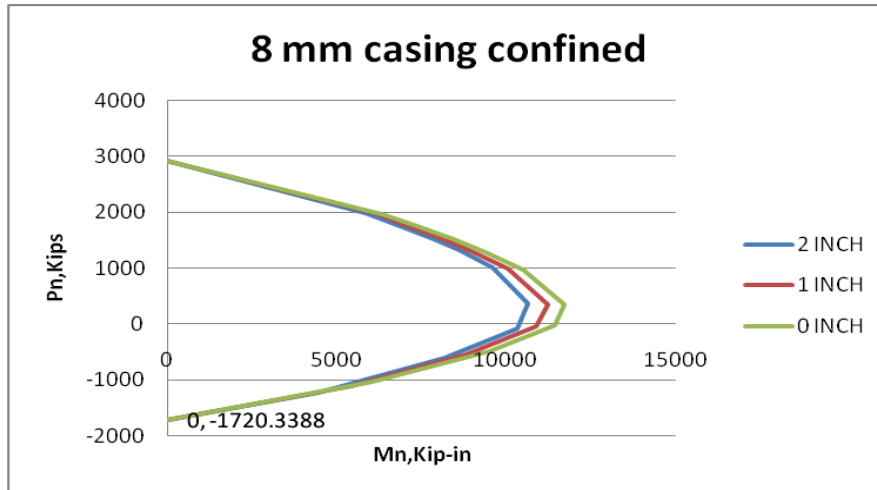**Table.4:-** Confined Circular column for 8 mm casing cover wise Result

Figure:-6:- confined F-M curve for 8mm Casing Based on cover

	Unconfined concrete column with 10 mm casing					
	2 inch cover		1 inch cover		Without cover	
S.No	Moment	Load	Moment	Load	Moment	Load
1	0	3177	0	3177	0	3177
2	6442.07	2128	6744.025	2126	7106.563	2118
3	7450.199	1907	7807.839	1898	8244.703	1889
4	8577.92	1649	8982.779	1637	9460.218	1624
5	9647.072	1382	10080	1370	10578	1359
6	10868	1041	11368	1033	11929	1025
7	12108	336.7743	12734	335.275	13287	340.7274
8	11806	-142.069	12400	-101.124	12988	-65.4237
9	9543.509	-719.445	10130	-661.465	10836	-594.064
10	5807.958	-1337.55	6386.698	-1263.76	7018.346	-1199.79
11	0	-1976.89	0	-1976.89	0	-1976.89

Table.5:- Unconfined Circular column for 10 mm casing cover wise Result
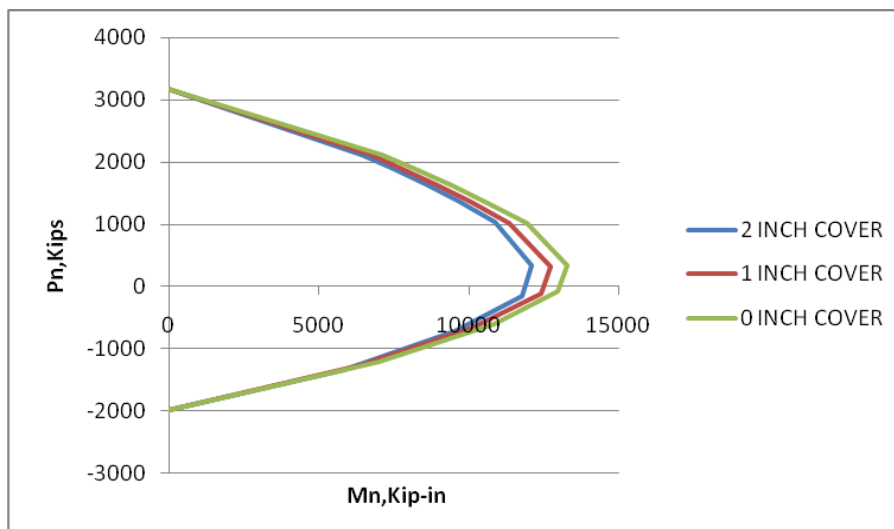
Figure:-7:- Unconfined F-M curve for 10mm Casing based on cover

| S.No	Confined concrete column with 10 mm casing					
	2 inch cover		1 inch cover		without cover	
	Moment	Load	Moment	Load	Moment	Load
1	0	3177	0	3177	0	3177
2	6597.748	2146	6873.05	2136	7106.563	2118
3	7666.502	1914	7921.98	1909	8244.703	1889
4	8795.709	1656	9085.175	1647	9460.218	1624
5	9797.403	1399	10175	1379	10578	1359
6	11000	1058	11455	1042	11929	1025
7	12184	350.1995	12797	342.5763	13287	340.7274
8	11848	-129.326	12440	-96.9104	12988	-65.4237
9	9524.296	-704.777	10148	-660.196	10836	-594.064
10	5421.838	-1381.75	6387.384	-1263.68	7018.346	-1199.79
11	0	-1976.89	0	-1976.89	0	-1976.89

Table.6:- Confined Circular column for 10 mm casing cover wise Result
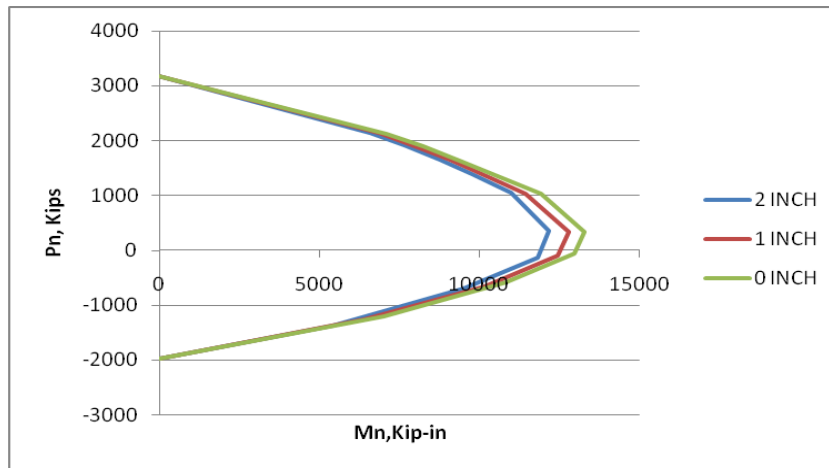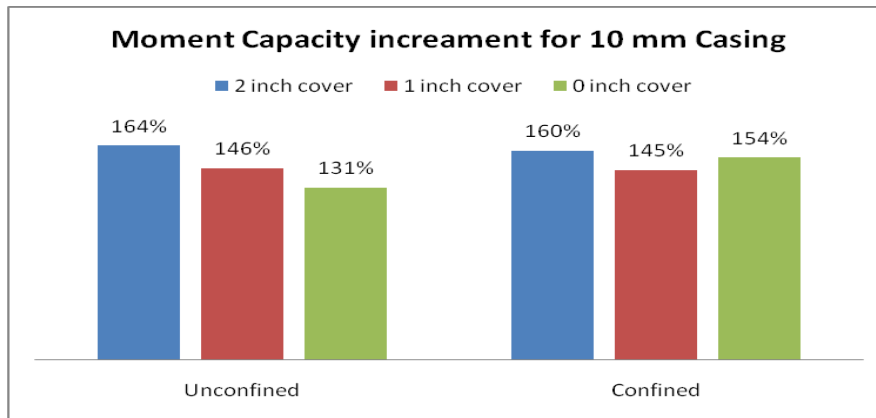

Figure:-8:- confined F-M curve for 10 mm Casing Based on cover
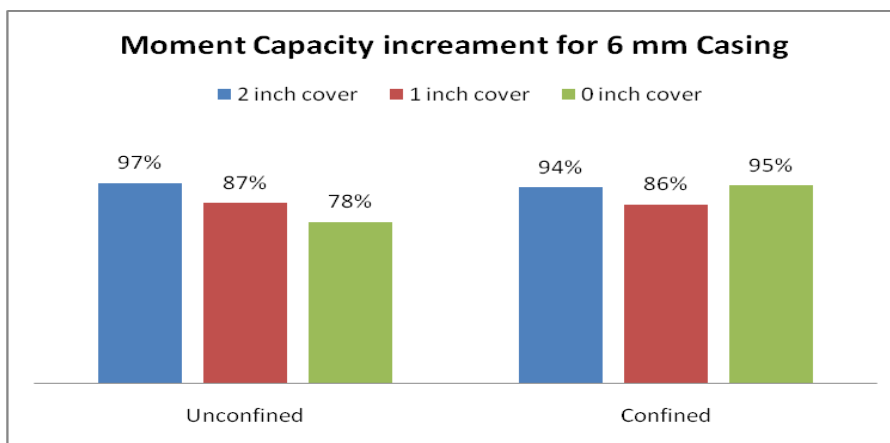
Figure:-9: % of Moment Capacity Increased when 6 mm casing provide for Unconfined & confined circular column
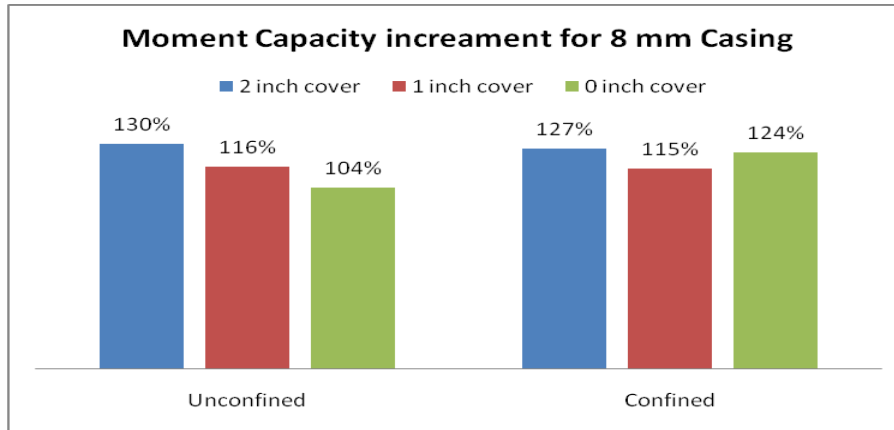
Figure:-10:- % of Moment Capacity Increased when 8 mm casing provide for Unconfined & confined circular column

Figure:-11:- % of Moment Capacity Increased when 6 mm casing provide for Unconfined & confined circular column

V. Conclusion

On the basis of F-M Diagram, Result's & Coordinate point For F-M Curve, the conclusion occurs that, for the damaged column under the effect of earthquake or else, Capacity of the damaged column can be strengthen by providing the casing at the periphery of column. The damaged column can be Retrofitted , Repaired, Strengthened by providing the casing on column. Various result comes out form the study:-

➢ **97 %** for Unconfined & **94 %** for confined of Moment Capacity Increased when **6 mm** casing provide for 2without diameter circular column having **2 inch** cover

➢ **87 %** for Unconfined & **86%** for confined of Moment Capacity Increased when **6 mm** casing provide for 2without diameter circular column having **1 inch** cover

➢ **78 %** for Unconfined & **95%** for confined of Moment Capacity Increased when **6 mm** casing provide for 2without diameter circular column having **without** cover.

➢ **130 %** for Unconfined & **127%** for confined of Moment Capacity Increased when **8 mm** casing provide for 2without diameter circular column having **2 inch** cover.

➢ **116 %** for Unconfined & **115%** for confined of Moment Capacity Increased when **8 mm** casing provide for 2without diameter circular column having **1 inch** cover.

➢ **104 %** for Unconfined & **124%** for confined of Moment Capacity Increased when **8 mm** casing provide for 2without diameter circular column having **without** cover.

➢ **164 %** for Unconfined & **160%** for confined of Moment Capacity Increased when **10 mm** casing provide for 2without diameter circular column having **2 inch** cover.

➢ **146 %** for Unconfined & **145%** for confined of Moment Capacity Increased when **10 mm** casing provide for 2without diameter circular column having **1 inch** cover.

➢ **131%** for Unconfined & **154%** for confined of Moment Capacity Increased when **10 mm** casing provide for 2without diameter circular column having **without** cover.

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